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Predictive value of modified CT severity index (MCTSI) combined with clinical indicators in the condition of acute pancreatitis

K. Xu[1], J. Zhou[1], H. Tu[1], Ch. Feng[1], J. Qiao[1], N. Shi[1], Y. Wang[2*]

[1]Gastroenterology Department, Affiliated Hospital of Jiangnan University, Wuxi 214000, Jiangsu Province, China
[2]Department of Pharmacy, Affiliated Children's Hospital of Jiangnan University, Wuxi 214000, China

► ***Original article***

Corresponding author:
Yan Wang, M.D.,
E-mail:
18626326208@163.com

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ABSTRACT

Background: To investigate the predictive value of Modified CT Severity Index (MCTSI) score combined with clinical indicators on the severity of early acute pancreatitis (AP). ***Materials and Methods:*** We collected 180 cases of AP patients admitted to our hospital from January 2020 to December 2023, and divided them into 32 cases of severe acute pancreatitis group (SAP group) and 148 cases of non-SAP group (non-SAP group) according to the severity of the disease. Comparing the clinical indexes of the two groups, the variables were included in logistic regression analysis to explore the independent risk factors of SAP, and were incorporated into R software to construct a predictive Nomogram model, and the predictive efficacy was evaluated by using subjects' work characteristic curves (ROC), and plotting calibration curves. ***Results:*** MCTSI score (OR=6.358, 95% CI:3.214-15.348), C-reactive protein (CRP) (OR=3.061, 95% CI:1.325-7.730), blood creatinine (Cr) (OR=1.032, 95% CI:1.020-1.041), and calcium (Ca2+) (OR=0.040, 95% CI:0.008-0.173) were independent risk factors for the occurrence of SAP (P<0.05). (95% CI:0.008-0.173) were independent risk factors for the occurrence of SAP (P<0.05). The results of ROC curve analysis showed that the Nomogram model had a high predictive value for the occurrence of SAP, with an area under the curve (AUC) of 0.910, which was significantly higher than the MCTSI score (AUC of 0.809), CRP (AUC of 0.790), Cr (AUC of 0.736), and Ca2+ (AUC of 0.781). ***Conclusion:*** The construction of a Nomogram model by combining MCTSI score, CRP, Cr, and D-D has an important application in the early prediction of AP severity.

INTRODUCTION

Acute Pancreatitis (AP), a common digestive emergency, is notable for its rapid progression. The root cause of this condition is the abnormal activation of pancreatic enzymes within the pancreas, which is often triggered by multiple factors, ultimately resulting in the pancreas and its surrounding tissues being subjected to their own digestive enzymes, which in turn triggers an inflammatory response [1]. In recent years, the incidence of acute pancreatitis has shown a significant increase worldwide, approaching 34 per 100,000 people according to statistics [2]. In order to deal with this condition more precisely, the medical community has subdivided acute pancreatitis into three types: mild, moderately severe, and severe according to the Atlanta criteria [3], of which mild acute pancreatitis accounts for about 80% to 85% [4]. The condition of these patients is relatively mild and self-limiting, and patients often have a better prognosis. However, there are still about 5% to 10% of patients with mild acute pancreatitis, the condition may change into severe acute pancreatitis, which can lead to serious consequences, resulting in multiple organ failure and other serious complications, and the mortality rate of patients is as high as 30% to 50% [5]. In view of the high severity and mortality of acute pancreatitis, early assessment of the severity of the patient's condition is very critical, which not only helps doctors to formulate a more accurate treatment plan, but also effectively reduces the complication rate and mortality of severe acute pancreatitis [6-7].

In dealing with acute pancreatitis, it is not only necessary to rely on scoring systems and clinical indicators, but also to achieve early and accurate assessment of patient's condition through these tools [8]. Among them, the modified CT severity index (MCTSI) score is valuable in the assessment of AP severity and diagnosis and treatment, which can deeply understand the inflammatory state and necrosis of the pancreas and its surrounding tissues [9]. In the early stage of AP, the predictive ability of the MCTSI score is limited by the atypical imaging presentation. However, when the MCTSI score is combined with clinical indicators, its predictive efficacy will be significantly improved [10]. At present, the role of MCTSI score combined with clinical indicators in the assessment of early AP patients has rarely been reported, so the present study was

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conducted to investigate the predictive value of MCTSI score combined with clinical indicators on the severity of early AP patients, with a view to providing a basis for the assessment of the condition of AP patients and clinical treatment.

MATERIALS AND METHODS

Basic information

We collected 180 cases of AP patients admitted to our hospital from January 2020 to December 2023 and retrospectively analysed their clinical data. Inclusion criteria: (1) All of them met the relevant diagnostic criteria of SP: patients had typical abdominal pain manifestations; serum lipase activity was detected at a level exceeding the upper limit of normal by more than three times; and the presence of AP imaging changes was shown by abdominal imaging. (2) Age ≥18 years old; (3) complete CT or related clinical data within 48h of admission; (4) patients were informed of the study method and purpose and signed an informed consent form. Exclusion criteria: (1) pregnant or lactating women with concomitant AP; (2) patients with concomitant AP after RCP; (3) patients with other lesions of the pancreas; (4) patients with severe hepatic and renal dysfunction; (5) patients with underlying chronic diseases that could not be effectively controlled; (7) patients with missing clinical and related imaging data within 48h of admission; and (8) patients with malignant tumors. The above patients were divided into 32 cases of severe acute pancreatitis group (SAP group) and 148 cases of non-SAP group (including mild acute pancreatitis and moderate severe acute pancreatitis) according to the classification criteria of the 2012 Atlanta Revised Classification and Definition of Acute Pancreatitis. The study was reviewed and approved by the Medical Ethics Committee of our hospital, approval number: S20191215.

Methods

Gender, age, comorbidities (hypertension, diabetes mellitus, hyperlipidaemia, etc.) were recorded in both groups. Within the golden 72 hours after the onset of the patients, breath-hold conventional plain scanning was performed for all patients using 16-row spiral CT (GE, USA). The tube voltage was set at 120 kV, tube current at 240 mAs, and both layer thickness and layer spacing were 3 mm to ensure the accuracy of the scan. Contrast agent (UVicin 370 mg/ml, 70 ml, injection flow rate of 6.0 ml/s) was injected into the patients through an anterior elbow vein to capture images of the arterial, parenchymal and portal venous phases. The dose is precisely calculated based on the patient's body weight to ensure that each patient receives an optimal scan. The scan covers a wide area from the apex of the diaphragm to the bilateral anterior superior iliac spines. Immediately after scanning, the images were transferred to the picture archiving and communication system (PACS) workstation, where they were independently reviewed by two senior radiologists and a comprehensive assessment of the condition was made based on the MCTSI scoring criteria [11] (table 1). In case of disagreement, an in-depth discussion was held to reach a final consensus. The relevant laboratory tests after admission were collected, including serum C-reactive protein (CRP), procalcitonim (PCT), hemoglobin (Hb), hematocrit (HCT), white blood cell count (WBC), neutrophil count (NEU), bloodureanitrogen (BUN), creatinine (Cr), D-dimer (DD), albumin (ALB), alanine aminotransferase (ALT), and other parameters. Albumin (ALB), alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), and so on.

Table 1. MCTSI scoring criteria.

norm	Rating (score)
pancreatic inflammation	
Normal Pancreas	0
Pancreatic deformity or presence of peripancreatic inflammatory reaction	2
Presence of peripancreatic fluid or fat necrosis	4
pancreatic necrosis	
no	0
≤30%	2
>30%	4
Presence of extra-pancreatic complications (including pleural or abdominal effusion, vascular complications, gastrointestinal complications, etc.)	2

Statistical methods

SPSS26.0 software was used for data analysis. Measurement data were expressed as ($\bar{x}\pm s$) and independent samples t-test was used between groups, and counting data were expressed as number of cases (%), and χ^2 test was used. Single-factor and multifactorial logistic regression analyses were carried out on the clinical data of the two groups of patients, to screen the independent risk factors for the occurrence of SAP, and R software was used to construct a column-line graph model for the prediction of the occurrence of SAP, and the subject's work characteristic curves (ROCs) were used, The predictive efficacy of the model was analyzed using ROC and calibration curves. Bootstrap method was used to repeat the self-sampling of the samples 1000 times for internal validation. $p<0.05$ was considered statistically significant.

RESULTS

Comparison of relevant data between the two groups

Univariate analysis showed that MCTSI score, serum CRP, PCT, WBC, NEU, BUN, Cr, D-D, Ca2+, ALB, ALT, AST, ALP levels were compared between the two groups. Among them, the MCTSI score of SAP group was higher than that of non-SAP group

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(P<0.05), serum CRP, PCT, WBC, NEU, BUN, Cr, D-D, AST, levels were higher than that of non-SAP group (P<0.05), and serum Ca2+, ALB, ALT, ALP levels were lower than that of non-SAP group (P < 0.05), as shown in table 2.

Table 2. Comparison of clinical data between the two groups.

considerations	SAPgroup (n=32)	Non-SAP group (n=148)	t/χ^2	P
Age (years)	52.36±4.18	51.93±4.11	0.535	0.593
Gender [n (%)]			0.956	0.328
male	22 (68.75)	88 (59.46)		
female	10 (31.25)	60 (40.54)		
MCTSI (score)	6.99±1.22	4.65±1.03	11.265	<0.001
complication				
hypertensive	13 (40.63)	46 (31.08)	1.088	0.297
diabetes	11 (34.38)	36 (24.32)	1.378	0.241
hypertriglycer-idemia	12 (37.50)	39 (26.35)	1.611	0.204
CRP (mg/L)	46.82±11.50	27.91±5.85	13.543	<0.001
PCT (ng/mL)	3.16±1.35	1.42±0.89	9.055	<0.001
WBC (10^9/L)	14.22±3.15	12.37±2.86	3.258	0.001
NEU (%)	87.63±2.90	83.94±2.18	8.153	<0.001
HCT (%)	42.85±6.54	43.17±7.04	0.236	0.814
BUN (mmol/L)	7.05±2.14	4.81±0.86	9.682	<0.001
Cr (μmol/L)	96.78±12.34	68.90±4.32	22.085	<0.001
D-D (g/mL)	2.58±1.20	1.63±0.22	9.037	<0.001
Ca^{2+} (mmol/L)	1.79±0.12	2.06±0.07	17.107	<0.001
ALB (g/L)	29.63±2.31	33.67±2.78	7.664	<0.001
ALT (U/L)	50.27±13.74	60.79±15.96	3.460	<0.001
AST (U/L)	61.47±16.97	55.85±12.33	2.175	0.031
ALP (U/L)	78.39±15.02	86.31±18.93	5.020	<0.001

Note: MCTSI: modified CT severity index; CRP: C-reactive protein; PCT: procalcitonin; Hb: haemoglobin; HCT: haematocrit; WBC: white blood cell count; NEU: neutrophil count; BUN: urea nitrogen; Cr: creatinine; DD: D-dimer; ALB: albumin; ALT: alanine aminotransferase; AST: alanine aminotransferase; ALP: alkaline phosphatase.

Analysis of typical cases

Figure 1 shows CT scan images of a female, 42 years old, diagnosed with biliary pancreatitis, 4 days after the onset of the disease. As seen CT images showed diffuse swelling of the pancreas, surrounded by more homogeneous fluid density shadows, and a MCTSI score of 4.

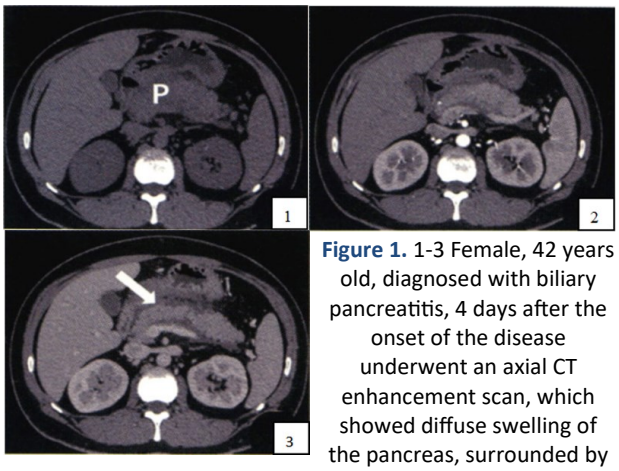

Figure 1. 1-3 Female, 42 years old, diagnosed with biliary pancreatitis, 4 days after the onset of the disease underwent an axial CT enhancement scan, which showed diffuse swelling of the pancreas, surrounded by more homogeneous fluid density shadows, and a MCTSI score of 4.

Results of multifactor logistic regression analysis

The results of multifactorial logistic regression analysis showed that the MCTSI score was elevated (OR=6.358, 95% CI:3.214-15.348), CRP level was elevated (OR=3.061, 95% CI:1.325-7.730), and Cr level was elevated (OR=1.032, 95% CI:1.020-1.041), decreased Ca2+ levels (OR=0.040, 95% CI:0.008 to 0.173) were independent risk factors for the development of SAP (P<0.05) (table 3).

Table 3. Multifactorial logistic regression analysis of SAP occurrence.

norm	B	SE	wald	P	OR	95%CI
MCTSI score (elevated)	1.876	0.413	18.594	<0.001	6.358	3.214~15.348
CRP (elevated)	1.248	0.463	7.960	<0.001	3.061	1.325~7.730
Cr (elevated)	0.034	0.009	21.963	<0.001	1.032	1.020~1.041
Ca^{2+} (lower)	-3.189	0.742	17.493	<0.001	0.040	0.008~0.173
constant	1.642	1.580	1.067	5.131		0.324

Note: B: partial regression coefficient value; SE: standard error; waldχ2: Wald chi-square value; OR: odds ratio; 95% CI: 95% confidence interval.

A line graph model for predicting the risk of SAP occurrence

Variables with statistically significant differences in comparisons in the univariate analysis were included in logistic regression analysis to mine independent risk factors for SAP, and independent risk factors such as MCTSI score, CRP level, Cr level, and Ca2+ level were included in the rms software to construct a Nomogram model for predicting the occurrence of SAP, and the results are shown in figure 2 to further validate the accuracy of the Column Line Chart model. Bootstrap self-sampling method was used to carry out 1000 samples for internal validation, and with the help of rms package, the C-index of the column-line diagram prediction model was calculated to be 0.819 (95% CI: 0.755-0.887), and the results of the H-L goodness-of-fit test showed that there was no statistical significance in the difference between the model and the ideal model (χ2=0.304, P=0.849), suggesting a good consistency, (figure 3).

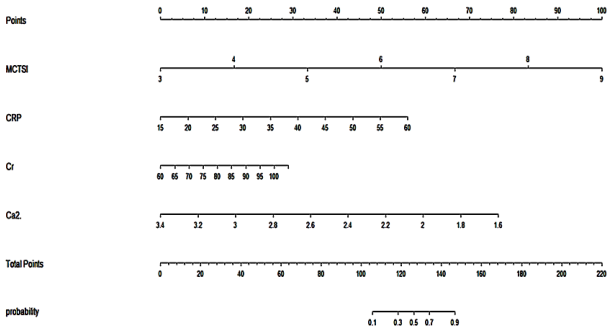

Figure 2. Column line diagram model for predicting the occurrence of SAP. Note: Points: scores; Total Points: total scores; probability: probabilities.

Comparison of the predictive ability of each independent risk factor with the Nomogram model for SAP

The results of the ROC curve analysis showed that

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the Nomogram model had a high predictive value for the occurrence of SAP, with an area under the curve (AUC) of 0.910, which was significantly higher than that of the MCTSI score (AUC of 0.809), CRP (AUC of 0.790), Cr (AUC of 0.736), and Ca2+ (AUC of 0.781) (figure 4 and table 4).

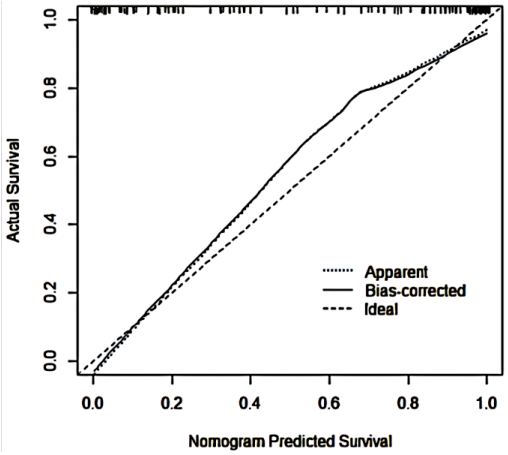

Figure 3. Calibration curves. The Ideal line shows the ideal prediction performance, the Apparent line shows the model prediction performance, and Bias-corrected shows the model prediction bias. Bias-corrected shows the prediction bias of the model, and the high agreement between the prediction curve (Apparent) and the ideal curve (Ideal) suggests that the model has better prediction ability.

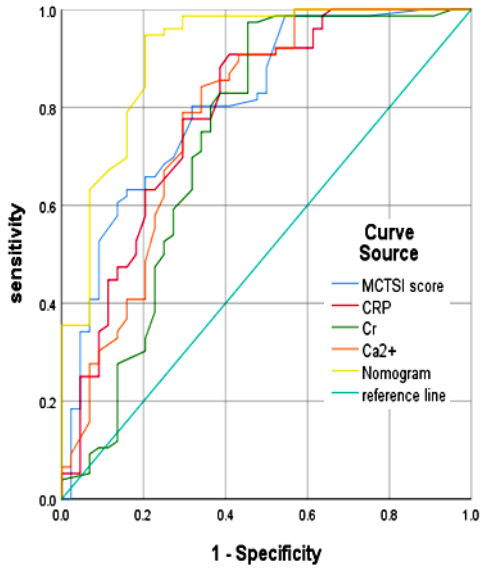

Figure 4. ROC curves of SAP predicted by factors and Nomogram model. sensitivity: sensitivity; specificity: specificity; curve source: curve source; reference line: reference line.

Table 4. Predictive ability of each independent risk factor with Nomogram model for SAP.

considerations	AUC	standard error	Progressive significance	95%CI	
				lower limit	limit
MCTSI score	0.809	0.042	0.000	0.727	0.891
CRP	0.790	0.045	0.000	0.701	0.879
Cr	0.736	0.054	0.000	0.630	0.842
Ca^{2+}	0.781	0.047	0.000	0.689	0.874
Nomogram	0.910	0.029	0.000	0.852	0.967

DISCUSSION

Acute pancreatitis is one of the more common acute abdominal conditions in clinical practice and its incidence is at a high level globally. There is no significant difference in the incidence of this disease between males and females, and the main incidence of the disease is concentrated in the middle-aged and elderly population [12]. Acute pancreatitis is divided into two types: mild and severe. In patients with mild acute pancreatitis, symptoms resolve rapidly with little risk of complications or organ failure. However, patients with severe disease face serious challenges, and may encounter multiple complications and even multi-organ failure at an early stage, resulting in high mortality rates and requiring timely and effective treatment to control the disease [13, 14]. In the diagnosis and evaluation of acute pancreatitis, the morphology of the pancreas and the lesions of the surrounding tissues can be observed by imaging, so as to determine the severity and prognosis of the disease [15-17]. Studies have pointed out that early and accurate prediction of the severity of acute pancreatitis, risk stratification of patients, and adoption of individualized treatment strategies are crucial for reducing the morbidity and mortality of patients with severe pancreatitis [18]. Therefore, there is a need to continuously explore new methods and tools to predict the severity of acute pancreatitis at an early stage by integrating multiple indicators in order to improve the accuracy and timeliness of early assessment of the disease and provide guidance for clinical intervention.

This study provides insight into the potential value of the MCTSI score in combination with multiple clinical indicators in predicting the severity of early acute pancreatitis (AP). The results of the study showed that MCTSI score, CRP, Cr, and Ca^{2+} were confirmed as independent risk factors for SAP. Among them, the constructed Nomogram model demonstrated high accuracy and reliability in the prediction of SAP, with an AUC value as high as 0.910, which significantly exceeded the predictive ability of a single index, and was consistent with previous reports [9], but this type of study failed to explore the predictive value of MCTSI score combined with multiple clinical indicators in the severity of SP. In recent years, the MCTSI score has attracted much attention due to its properties of simplifying the process and improving accuracy, and it is closely associated with patients' clinical outcomes such as risk of infection, length of hospital stays, organ function, and survival [19]. CRP is a non-specific acute phase response protein produced by the liver, and its level increases significantly when the body is exposed to a stimulus such as an infection, an injury, or an inflammation [20]. A large study noted that CRP levels were significantly higher in patients in the moderate severe acute pancreatitis + SAP group compared to

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patients with mild acute pancreatitis and its AUC value for predicting SAP reached 0.713, demonstrating its important role in the assessment of the condition [21]. Severe acute pancreatitis may lead to pancreatic necrosis and massive fluid loss, which in turn leads to elevated Cr levels [22]. A foreign prospective study showed that blood creatinine level within 48 hours of admission was valuable in predicting pancreatic necrosis in AP patients. When the blood creatinine value exceeded 1.8 mg/dL, its specificity for predicting pancreatic necrosis was 98.9% [23]. In addition, a study by Jinting *et al.* [24] also found that blood creatinine was of significant value in the prediction of non-mild AP, with an AUC value of 0.708, and that there was a significant correlation between the Cr level at admission and the MCTSI score. Notably, a study by Wiese *et al*. [25] further explored the role of blood creatinine in predicting infected pancreatic necrosis. They found that the efficacy of blood creatinine in predicting infected pancreatic necrosis was more prominent compared to other indicators such as CRP and albumin. This finding not only provides a new perspective for the prediction of AP, but also provides new ideas for clinical treatment.

Disruption of calcium homeostasis is extremely damaging to the pancreas; it triggers premature activation of digestive enzymes, leading to cellular vacuolization and necrosis. The pancreas and its surrounding adipose tissue dissolve in the presence of pancreatic lipase, forming free fatty acids and glycerol. These free fatty acids combine with calcium ions to form fatty acid calcium soaps, which in turn reduce blood calcium levels. It has been shown [26] that the reduction of parathyroid hormone is a key factor contributing to persistent hypocalcaemia in AP patients. Currently, there is a more in-depth understanding of the role that ca2+ plays in the pathogenesis of AP. It was further noted [27] that in SAP patients, damage to pancreatic adipose tissue leads to an increase in free fatty acids, which combine with calcium ions to form calcium saponification, which in turn triggers a decrease in blood calcium levels. In addition, as the fourth coagulation factor, ca2+ plays a key role in the course of AP. As the disease progresses, the body's coagulation system is activated, coagulation factors and calcium ions are consumed in large quantities, and blood calcium concentration further decreases. Therefore, ca2+ can be used as one of the important indicators to assess the severity of AP. In this study, Ca2+ was found to be an independent risk factor for the development of SAP, consistent with previous reports [28].

CONCLUSION

MCTSI score, CRP, Cr and Ca2+ are independent risk factors for the occurrence of SAP, according to which the construction of a line graph model for predicting the occurrence of SAP has a better diagnostic efficacy, and can provide guidance for the early prediction of the severity of the condition of the patients with acute pancreatitis, in this study, we constructed a nomogram model by using the MCTSI score and the clinical indicators such as CRP, Cr and Ca^{2+}. This study used MCTSI score and CRP, Cr, Ca^{2+} and other related clinical indicators to construct a nomogram model, which can provide valuable clinical references and further improve the participation of imaging physicians in the diagnosis and treatment of acute pancreatitis, which is of great significance in improving the diagnosis and treatment of acute pancreatitis in hospitals, especially in primary hospitals, and can provide help for more patients.

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Conflict of interest statement: all authors declare that there is no conflict of interest.

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Authors' Contribution: All data collection, paper writing, data analysis and paper revision were done by the authors themselves.

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