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Quantitative CT Markers for Early Prediction of Severity in Acute Pancreatitis: A Prospective Observational Study

Research Article

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Abstract

Objective: To evaluate quantitative CT markers in acute pancreatitis and identify the strongest predictor of severe disease and adverse outcomes.

Materials and Methods: This prospective observational study included 50 patients with clinically and biochemically confirmed acute pancreatitis who underwent contrast-enhanced CT (CECT) within 5–7 days after symptom onset (mean: 5 + 2 days). Quantitative parameters assessed were percentage pancreatic necrosis, extrapancreatic necrosis (EN) volume, peripancreatic fluid volume using 3D volumetry, and peripancreatic fat attenuation. Findings were correlated with the Revised Atlanta Classification and clinical outcomes.

Results: Severe acute pancreatitis was observed in 24% of patients. Extrapancreatic necrosis volume demonstrated the highest diagnostic accuracy for severe disease (area under the ROC curve [AUC] 0.89; cutoff >120 mL), outperforming pancreatic necrosis percentage and other quantitative markers.

Conclusion: Extrapancreatic necrosis volume is the most reliable quantitative CT marker for predicting severe acute pancreatitis and adverse clinical outcomes.

Keywords: Acute pancreatitis; Quantitative CT; Extrapancreatic necrosis; Severity prediction

Introduction

Acute pancreatitis is a common and potentially life-threatening abdominal emergency with a clinical spectrum ranging from mild self-limiting inflammation to severe necrotizing disease associated with multiorgan failure and high mortality [1,3] Early identification of patients at risk for severe disease is critical for optimizing clinical management, guiding intensive care unit (ICU) admission, and improving outcomes [1,4,7].

Conventional clinical scoring systems such as Ranson's criteria, BISAP, and APACHE II are widely used for prognostication; however, they require serial assessments and incorporate subjective or delayed parameters, limiting their utility in early decision-making. Imaging, particularly contrast-enhanced computed tomography (CECT), plays a pivotal role not only in confirming diagnosis but also in assessing disease severity, detecting complications, and guiding therapeutic interventions [1,6,7].

Traditional CT-based indices such as the CT Severity Index (CTSI) and Modified CTSI rely on semi-quantitative or categorical assessment of pancreatic inflammation and necrosis. However, these approaches may lack precision and reproducibility [6,7]. In recent years, there has been growing interest in quantitative imaging biomarkers that provide objective and reproducible metrics of disease burden.

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Extrapancreatic necrosis (EN), representing the extent of inflammatory spread beyond the pancreas, has emerged as a potential key determinant of disease severity [8,12]. Quantitative volumetric assessment of EN and associated inflammatory changes may offer superior predictive value compared to conventional parameters.

This study aims to evaluate quantitative CT markers in acute pancreatitis and identify the most reliable imaging predictor of severe disease and adverse clinical outcomes, thereby enhancing early risk stratification and clinical decision-making.

Materials and Methods

Ethics Statement

The study was approved by the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to inclusion in the study. All procedures were conducted in accordance with the ethical standards of the institutional research committee and with the Declaration of Helsinki. Patient confidentiality was strictly maintained, and all imaging and clinical data were anonymized.

Study Design

Prospective observational study.

Study Population

Fifty consecutive patients with acute pancreatitis were included.

Inclusion Criteria

Clinically and biochemically confirmed acute pancreatitis

CECT performed within 5-7 days of symptom onset

Exclusion Criteria

Chronic pancreatitis

Prior pancreatic surgery

Poor-quality CT images

CT Protocol

CECT was performed on a 128-slice multidetector CT scanner using a triphasic acquisition protocol. All contrast-enhanced CT scans were performed between 5–7 days after symptom onset, corresponding to the early necrotizing phase of acute pancreatitis. This timing was standardized to optimize detection of pancreatic and extrapancreatic necrosis.

Quantitative Parameters Assessed

Percentage pancreatic necrosis

Extrapancreatic necrosis (EN) volume

Peripancreatic fluid collection volume

Peripancreatic fat attenuation (in Hounsfield units)

Statistical Analysis

Logistic regression and receiver operating characteristic (ROC) curve analysis were performed. The area under the ROC curve (AUC) was calculated to assess diagnostic performance. An AUC closer to 1.0 indicated excellent predictive accuracy, whereas a value of 0.5 indicated no discriminatory ability.

A p-value < 0.05 was considered statistically significant. Optimal cutoff values were determined using the Youden Index (J = Sensitivity + Specificity – 1), selecting the threshold that maximized combined sensitivity and specificity for predicting severe acute pancreatitis.

Severity grading was performed according to the Revised Atlanta Classification (2012) [3], integrating clinical parameters such as organ failure with imaging findings including pancreatic necrosis, extrapancreatic necrosis, and peripancreatic collections.

Results

A total of 50 patients were included. The mean age was 44 years (range: 19–72 years), with male predominance (32 males, 18 females). Gallstone disease was the most common etiology (44%), followed by alcohol-related pancreatitis (36%). Other causes included idiopathic and miscellaneous etiologies (Table 1).

Based on the Revised Atlanta Classification,[3] 21 patients (42%) had mild acute pancreatitis, 17 (34%) had moderately severe disease, and 12 (24%) had severe acute pancreatitis. ICU admission was required in 14 patients (28%), interventional procedures were performed in 10 patients (20%), and 4 patients (8%) died (Table 2).

Quantitative CT analysis demonstrated that extrapancreatic necrosis volume was significantly higher in patients with severe disease. ROC analysis showed that EN volume had the highest diagnostic accuracy (AUC 0.89) at an optimal cutoff value of >120 mL, yielding 86% sensitivity and 82% specificity.

Peripancreatic fluid volume demonstrated good performance (AUC 0.83) at a cutoff >150 mL. Increased peripancreatic fat attenuation showed moderate predictive value (AUC 0.78; cutoff > –45 HU), while percentage pancreatic necrosis demonstrated lower accuracy (AUC 0.71; cutoff >30%).

An EN volume greater than 120 mL was strongly associated with severe acute pancreatitis. Similarly, peripancreatic fluid volume exceeding 150 mL and pancreatic necrosis greater than 30% were more frequently observed in severe cases. The diagnostic performance of all quantitative CT markers is summarized in (Table 3).

Table 1: Demographic and Etiological Profile of Study Population

Parameter	Value
Total patients	50
Mean age (years)	44 (Range: 19-72)
Gender (Male: Female)	32: 18
Gallstone etiology	22 (44%)
Alcohol-related	18 (36%)
Idiopathic	6 (12%)
Others	4 (8%)

Table 2: Severity Distribution and Clinical Outcomes

Parameter	Number (%)
Mild acute pancreatitis	21 (42%)
Moderately severe acute pancreatitis	17 (34%)
Severe acute pancreatitis	12 (24%)
ICU admission	14 (28%)
Intervention required	10 (20%)
Mortality	4 (8%)

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Table 3: Diagnostic Performance of Quantitative CT Markers

CT Parameter	AUC	Optimal Cutoff	Sensitivity/Specificity
Extrapancreatic necrosis volume	0.89	>120 mL	86% / 82%
Peripancreatic fluid volume	0.83	>150 mL	78% / 80%
Fat attenuation (HU)	0.78	> –45 HU	72% / 74%
Pancreatic necrosis (%)	0.71	>30%	65% / 70%

Patients with severe acute pancreatitis more frequently demonstrated extensive extrapancreatic necrosis, larger peripancreatic collections, and higher attenuation of surrounding fat, reflecting a more intense inflammatory response. These patients required more aggressive management, including ICU admission and interventional procedures such as percutaneous drainage. Mortality was observed exclusively in the severe group, underscoring the importance of early imaging-based risk stratification.

Representative Case Illustration

A 48-year-old male with a history of chronic alcohol use presented with acute onset severe epigastric pain radiating to the back, associated with vomiting. Laboratory evaluation revealed significantly elevated serum amylase and lipase levels.

Contrast-enhanced CT performed on day 5 of symptom onset demonstrated extensive areas of non-enhancing pancreatic parenchyma involving more than 60% of the gland, along with large-volume extrapancreatic necrosis extending into the anterior pararenal space and mesenteric root (Figure 3).

Quantitative volumetric analysis revealed extrapancreatic necrosis volume exceeding 150 mL and significant peripancreatic fluid collections (Figure 4).

The patient developed persistent organ failure requiring ICU admission and underwent percutaneous drainage for necrotic collections. The clinical course was complicated by prolonged hospitalization; however, the patient showed gradual recovery with multidisciplinary management.

This case highlights the strong correlation between increased extrapancreatic necrosis volume and severe disease, emphasizing its role as a reliable imaging biomarker for predicting adverse outcomes.

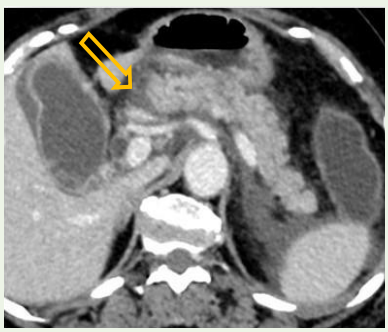

Figure 1: Contrast-enhanced CT showing preserved pancreatic enhancement with mild peripancreatic fat stranding (arrow), consistent with mild acute pancreatitis.

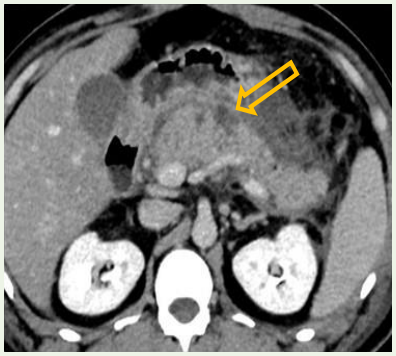

Figure 2: Axial pancreatic-phase contrast-enhanced CT image demonstrating non-enhancing pancreatic parenchyma (arrow) used for calculation of percentage pancreatic necrosis.

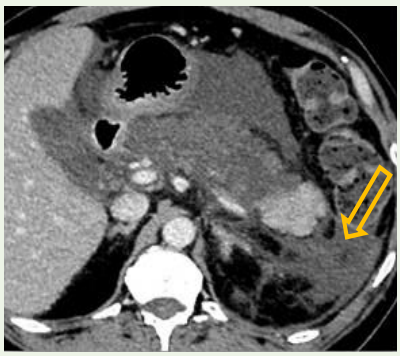

Figure 3: Contrast-enhanced CT image showing extensive extrapancreatic necrosis with inflammatory fat stranding and necrotic collection (arrow) in the retroperitoneal spaces, representing a severe case described in the Results section [8,12].

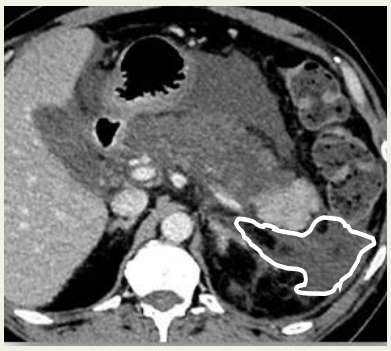

Figure 4: Three-dimensional volumetric assessment demonstrating quantitative measurement of extrapancreatic necrosis volume in the representative severe case using region-growing technique [8,12].

Discussion

Early prediction of disease severity in acute pancreatitis remains a major clinical challenge. Severe acute pancreatitis is associated with significant morbidity, prolonged hospitalization, increased need for interventions, and higher mortality [13,14]. Therefore, reliable early imaging biomarkers are essential for risk stratification and guiding management.

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In the present study, extrapancreatic necrosis (EN) volume demonstrated the highest diagnostic accuracy for predicting severe disease (AUC 0.89), outperforming traditional parameters such as percentage pancreatic necrosis and peripancreatic fat attenuation. These findings are consistent with emerging literature emphasizing the prognostic importance of extrapancreatic inflammatory burden [8,12].

Previous studies have highlighted that pancreatic necrosis alone may not fully reflect disease severity, as patients with limited parenchymal necrosis can still develop severe systemic complications due to widespread inflammatory response. EN represents the extent of inflammation extending into peripancreatic and retroperitoneal spaces, which plays a crucial role in triggering systemic inflammatory response syndrome (SIRS) [8] and organ failure.

Compared to conventional scoring systems such as CTSI and Modified CTSI [6,7] which rely on categorical grading, quantitative volumetric assessment provides continuous, objective data. This reduces interobserver variability and improves reproducibility[13], making it more suitable for standardized reporting.

Our study adds to the growing body of evidence by demonstrating a clear cutoff value (>120 mL) for EN volume with high sensitivity and specificity for predicting severe disease. This quantitative threshold may serve as a practical imaging biomarker in routine clinical practice.

Clinical Implications

The incorporation of quantitative EN volume assessment into routine CT reporting can significantly impact patient management. Patients identified as high-risk based on EN volume may benefit from early ICU admission, aggressive monitoring, timely intervention, and multidisciplinary care.

Contribution to Current Knowledge

This study reinforces that extrapancreatic inflammatory burden is a stronger predictor of severity than pancreatic necrosis alone and supports integration of quantitative imaging biomarkers into future severity scoring systems.

Despite its promising findings, further multicentric studies with larger sample sizes are required for validation.

Conclusion

Quantitative volumetric assessment of extrapancreatic necrosis provides superior predictive accuracy compared to traditional CT severity indices. Integration of this objective marker with established clinical and radiological classification systems may enhance early risk stratification and improve patient management.

Future integration of artificial intelligence–based automated volumetric analysis may further enhance the accuracy and clinical applicability of quantitative CT biomarkers.

Limitations

This study was limited by its single-center design and relatively small sample size. Quantitative measurements required manual segmentation, which may introduce observer variability. Lack of longitudinal follow-up imaging and correlation with serial biochemical inflammatory markers were additional limitations.

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