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SPECIAL SECTION: PANCREATITIS

Role of extrapancreatic necrosis volume in determining early prognosis in patients with acute pancreatitis

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Abstract

Purpose This study aims to evaluate the capacity of the clinical and radiological findings and the extrapancreatic necrotic tissue volume in early (2–6 days) computerized tomography (CT) images of patients diagnosed with AP to predict reliably the temporary or permanent organ failure and other local or systemic complications due to pancreatitis.

Materials and methods Adult patients who were diagnosed with AP based on Revised Atlanta classification and underwent abdomen CT scans between May 2015 and May 2018 were examined retrospectively. Extrapancreatic necrosis volume was compared to various clinical parameters that indicate the prognosis of AP such as C-reactive protein (CRP) at 48–72th h, organ failure, infection, requirement for percutaneous or surgical intervention, length of hospital stay, and mortality, and to various imaging-based scoring systems such as the computerized tomography severity index (CTSI) and the modified CTSI (mCTSI). The receiver operating characteristic (ROC) curve was used to estimate the optimal threshold for predicting clinical prognosis.

Results Extrapancreatic necrosis volume had moderate positive correlation with length of hospital stay ($p = 0.0001$) and CRP (at 48–72th h) ($p = 0.0001$) and strong positive correlation with CTSI ($p = 0.0001$), mCTSI ($p = 0.0001$), and white blood cell count ($p = 0.0001$).

Conclusion Extrapancreatic necrosis volume was found to be particularly better in predicting organ failure and infection compared to the imaging-based scoring systems (Balthazar, CTSI, and mCTSI) and the laboratory-based scoring systems (CRP at 48–72th h).

Keywords Acute pancreatitis · Extrapancreatic necrosis volume · Infection · Organ failure

Introduction

Acute pancreatitis (AP) is an inflammatory disease with a broad clinical spectrum resulting in various complications ranging from temporary local abdominal discomfort to irreversible systemic complications and sometimes death [1]. Gallstones and alcohol are the top two factors in the etiology of AP [2]. There is an increase in the worldwide incidence of AP due to the rise in the prevalence of gallstones and obesity, and an aging population [3]. Early diagnosis of the severity and clinical course of the disease is of great importance in AP. In 15–20% of the cases, the clinical course of the disease is quite severe with high mortality. Early diagnosis and timely medical and surgical intervention in this subgroup of patients may decrease the mortality rate. Various scoring systems based on clinical and laboratory findings, radiological risk factors, pain severity, and various serum markers have been developed to determine clinical severity and prognosis in AP. Most prominent scoring systems are Ranson Criteria, Acute Physiology and Chronic Health Disease Classification System II (APACHE II) score, Bedside Index of Severity in Acute Pancreatitis (BISAP), and Atlanta and Balthazar classifications. C-reactive protein

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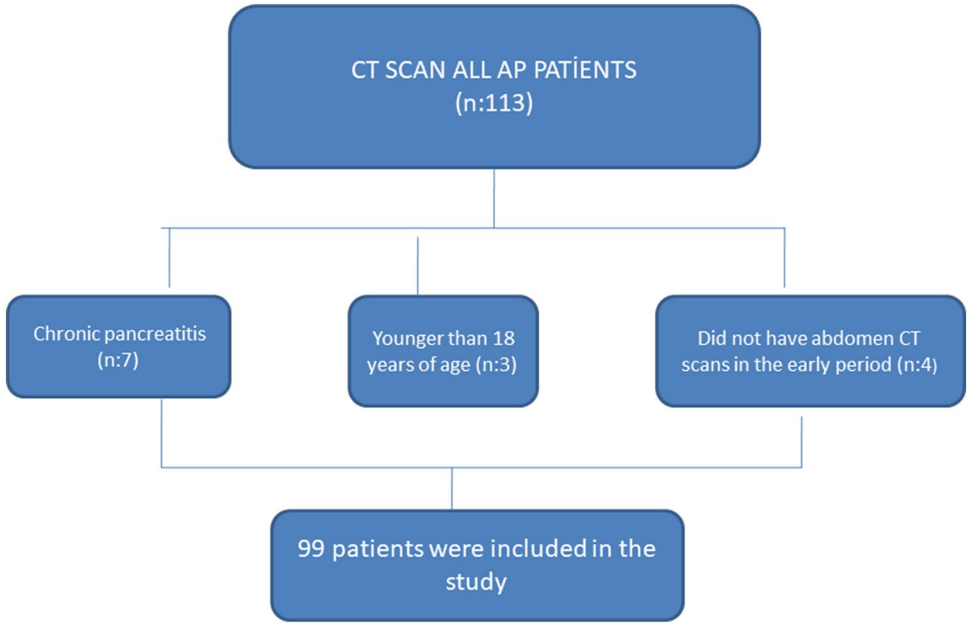

Fig. 1 Flow chart for inclusion and exclusion of patients

(CRP), which is the most frequently studied acute phase reactant, is not practical since it produces meaningful results in 72 h [4]. Computed tomography (CT) or magnetic resonance imaging (MRI) does not provide sufficient information to determine the severity since necrosis does not develop in the early period [4]. In general, AP-specific scoring systems have limited diagnostic value. This study aims to evaluate the capacity of the clinical and radiological findings and extrapancreatic necrotic tissue volume in early (2–6 days) CT images of patients diagnosed with AP in order to reliably predict the temporary or permanent organ failure and other local or systemic complications due to pancreatitis. Extrapancreatic necrosis volume was compared to various clinical parameters that indicate the prognosis of AP such as the CRP at 48–72th h, organ failure, infection, requirement for surgical or percutaneous intervention, length of hospital stay, and mortality, and to various imaging-based scoring systems such as the computerized tomography severity index (CTSI) and the modified CTSI (mCTSI). The receiver operating characteristic (ROC) curve was used to estimate the optimal threshold for predicting clinical prognosis.

Materials and methods

The study included 113 patients, who were diagnosed with acute pancreatitis between May 2015 and May 2018 at Akdeniz University Medical School Hospital, and were retrospectively evaluated. Patients who met at least two of the three criteria from Revised Atlanta classification, who had abdomen CT scans in the early period (2–6 days) and after the onset of symptoms, and who were older than 18 years of age are included in this study. Seven patients were excluded due to the chronic pancreatitis, 4 patients were excluded because they did not have abdomen CT scans in the early period, and 3 patients were excluded because they were younger than 18 years of age. In total, 99 patients diagnosed with AP, between the ages of 22 and 84 (mean 51.5), 37 women and 62 men who also met the above criteria, were included in the study (Fig. 1).

The CT examinations were performed with 16-detector or 128-detector multidetector CT devices (Toshiba Medical Systems, Activion 16, Japan or Siemens, Somatom Definition Edge, Germany, respectively). Only two of the examinations were not contrast-enhanced; of those who received intravenous contrast media, 54 patients were examined with contrast-enhanced triphasic and non-contrast CT scan protocol and 43 with single phase CT. Portal venous phase CT images in the axial plane were evaluated by two radiologists with 4 and 13 years of experience. Extrapancreatic necrosis volumes were measured manually by using another workstation (Vitrea, Vital Images, Minnetonka, Minnesota) and calculated by using the "organ selection tool" option of the specialized software. On axial abdominopelvic CT images, extrapancreatic necrosis tissue is marked by using a plus sign (+) provided by the software. After the marking, similar density areas are determined, and the image is formed by the software. All volumetric evaluations were performed by two radiologists in consensus. The radiologists checked the images that were formed by the software for any mistakes, correcting and reforming the images when necessary in consensus. Images were manually edited in each section by using the "edit tool" to avoid peritoneal fluid and other organs. Then, using the subtracted 3D volume images

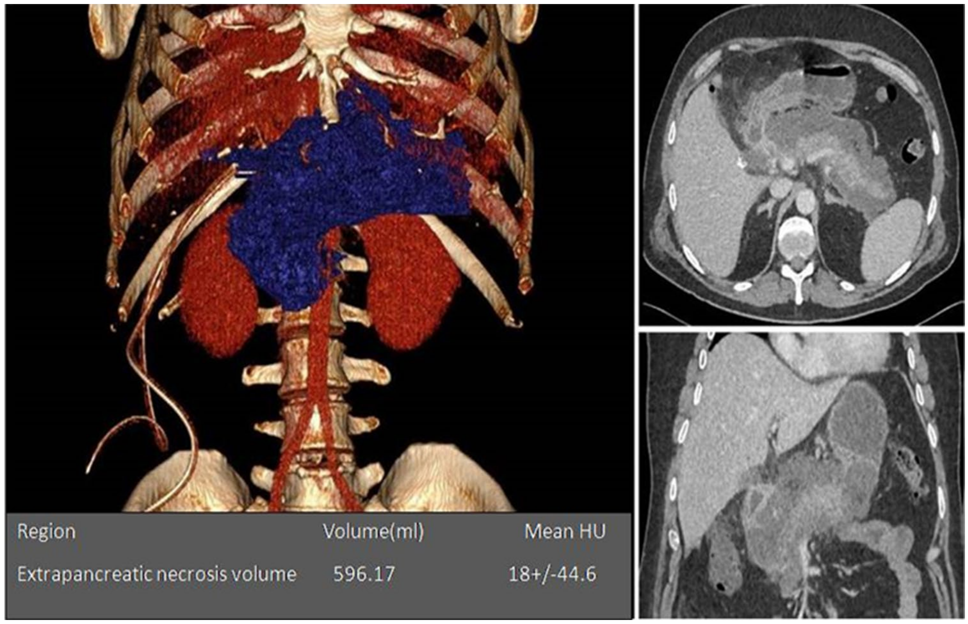

Fig. 2 A 60-year-old male patient with history of gallbladder stone is accepted into internal medicine ward due to vomiting and high serum lipase. After failure to respond to conservative treatment, CT was performed. The CT and volumetric images of the patient in the axial and coronal planes are shown

created, the extrapancreatic necrosis volumes were automatically calculated in milliliters by the program.

Necrotic tissues with peripancreatic or associated retroperitoneal fat tissue inflammation and liquid and solid components were considered as extrapancreatic necrotic tissue. Peritoneal fluid was not included in the measurements, and the results were expressed in milliliters (Fig. 2). In addition, the patients' CT images were examined to record pancreatic and peripancreatic morphological findings, parenchymal and extraparenchymal complications, and to calculate the Balthazar, CTSI, and mCTSI scores.

The demographic data (age, gender, etc.), duration of hospitalization, etiology of AP, laboratory findings (CRP, lipase, white blood cell count—WBC), and the infection, multi-organ failure, percutaneous/surgical intervention, and mortality data were recorded from the data management system of the hospital (MIAMED, version 1.0.1.3295). Revealing the infecting microorganism by Gram staining or culture, persistent fever history, and a WBC count above 15,000/mm^3 was considered as an indication of infection. The criteria that were used for organ failure were as follows: for the cardiovascular system, a hypotension requiring vasoactive drug; for the renal system, a serum creatinine level of > 1.3 mg/dL or a requirement for hemodialysis/peritoneal dialysis; for the respiratory system, an arterial oxygen pressure of < 60 mmHg; for the neurological system, a Glasgow Coma Scale of < 6; and for the hematological system, a platelet count of < 100.000/mL.

Extrapancreatic necrosis volume was compared to various clinical parameters that indicate the prognosis of AP such as the CRP at 48–72th h, organ failure, infection, a need for surgical or percutaneous intervention, length of hospital stay, and mortality, and to various imaging-based scoring systems such as the CTSI and the mCTSI (Fig. 3). The receiver operating characteristic (ROC) curve was used to estimate the optimal threshold for predicting clinical prognosis.

Statistical analysis

Statistical analyses were performed using SPSS program (version 23.0, SPSS Inc., Chicago, IL, USA). The normal distribution of the data was analyzed by visual (histogram and probability graphs) and analytical methods (Kolmogorov–Smirnov or Shapiro–Wilk test). Descriptive data were presented as mean, median, or frequency. Patients were divided into two groups as mild/moderate or severe based on CTSI and mCTSI. The comparison of extrapancreatic necrosis volume in these groups or in the groups based on clinical status (infection, organ failure, or mortality) was performed with the Mann–Whitney *U* test (due to non-normal distribution). The relationship between extrapancreatic necrosis volume and the demographic findings (age and length of hospitalization), laboratory findings (CRP, lipase, and WBC count), and imaging-based scoring systems (CTSI and mCTSI) were analyzed with Spearman correlation coefficient. The relation between CRP and extrapancreatic necrosis volume was investigated by using a CRP cutoff value of 15 mg/dL and by comparing the medians for the groups below and above the cutoff values using Mann–Whitney *U* test. The diagnostic value of the parameters (extrapancreatic necrosis volume, CRP, CTSI, mCTSI, and Balthazar score) that were used in the prediction of infection and organ failure in AP cases was evaluated by ROC-curve and AUC (area

Fig. 3 Baseline demographic and clinical characteristics of patients who underwent CT for acute pancreatitis. *Data are means, with ranges in parentheses. †Data are the mean ± the standard deviation

Patient characteristics	
Age (y)*	51,5 (min 22-max 84)
Women	37 (37,4%)
Men	62 (62,6%)
Female-to-male ratio	0.6
Cause of acute pancreatitis	
Gallstone	51 (51,5%)
Alcohol abuse	6 (6,1%)
After endoscopic retrograde cholangiopancreatography	5 (5,1%)
Hypertriglyceridemia	15(15,1%)
Unknown	22 (22,2%)
Laboratory findings	
CRP(mg/dl) †	16,3±8 (min 1-max 40)
Lipase(U/L)	773,1±996,2 (min 9-max5600)
White blood cell count - WBC(BIN/mm3)	14,2±5,4 (min 4-max 28)
Clinical outcomes	
Duration of hospitalization (d)*	10.0 (min 0–max 47)
Infection	41 (41.41%)
Organ failure	7 (7,07%)
Need for intervention	20 (21.1%)
Percutaneous catheter drainage	8 (8.08%)
Surgical necrosectomy	2 (2.02%)
ERCP	10 (10.1%)
Death	4 (4.04%)
CT scanning	
Contrast enhancement used	97 (97%)
CTSI	
Mild (0–3)	63 (63.6%)
Moderate (4–6)	22 (22.2%)
Severe (7–10)	12(12.1%)
mCTSI	
Mild (0–2)	20 (20.2%)
Moderate (4–6)	57 (57.5%)
Severe (8–10)	20 (20.2%)

under the curve) analyses. The results were considered statistically significant when $p < 0.05$.

Results

The study included 99 patients diagnosed with AP according to the revised Atlanta classification. Of these, 37 (37.4%) were female, and 62 were male (62.6%) with a male-to-female ratio of 0.6. Mean age was 51.5 (min 22–max 84) years. Biliary pathologies (cholelithiasis and choledocholithiasis) were involved in the etiology of AP in 51 patients (51.5%), chronic alcohol consumption in 6 patients (6.1%), post-endoscopic retrograde cholangiopancreatography (ERCP) complications in 5 patients (5.1%), and hypertriglyceridemia in 15 patients (15.1%). An etiological cause was not found in 22 patients (22.2%); pancreatic head ductal adenocarcinoma was detected in one of the patients in the idiopathic group.

The mean duration of hospital stay was 10.03 days (min 0–max 47 days). The mean CRP value was 16.30 mg/dL (min 1–max 40 mg/dL), the mean leukocyte count was $14.27 \times 1000/\text{mm}^3$ (min 4–max $28 \times 1000/\text{mm}^3$), and the mean lipase level was 773.19 U/L. Infection was detected in

41 patients based on the criteria defined in Methods section. Due to the complications of AP, two patients underwent fine needle aspiration (FNA) for sampling; one patient underwent cholecystectomy; five patients underwent ERCP; two patients underwent percutaneous abscess drainage accompanied by imaging; two patients underwent percutaneous abscess drainage and laparoscopic pancreatic necrosectomy; one patient underwent percutaneous abscess drainage, ERCP, and cholecystectomy; three patients underwent ERCP and cholecystectomy; and one patient underwent ERCP and FNA. Of 7 patients who had organ failure, three patients had multi-organ failure (MOF), one had adult respiratory distress syndrome (ARDS), two had acute renal failure (ARF)(longer than 48 h), and one had ARF(longer than 48 h) and ARDS. Four patients died of complications as a result of AP: due to sepsis and MOF in three cases and due to ARDS in one case.

In our study, 63 patients had mild AP, 22 patients had moderate AP, and 12 patients had severe AP based on CTSI; however, 20 patients had mild AP, 57 patients had moderate AP, and 20 patients had severe AP based on mCTSI. Pancreatic necrosis (PN) was below 30% in 13 patients, between 30–50% in 2 patients, and above 50% in 8 patients based on CTSI; based on mCTSI, 13 patients had a PN rate of below 30%, and 10 patients had a PN rate of above 30%. Observed extrapancreatic complications were as follows: pleural effusion in 10 patients, peritoneal fluid in 13 patients, pleural effusion and peritoneal fluid in 22 patients, splenic vein thrombosis and pleural effusion in two patients, splenic vein thrombosis and peritoneal fluid in two patients, and splenic and superior mesenteric vein thrombosis and pleural fluid in one patient. A total of 50 patients had extrapancreatic complications.

Evaluation of extrapancreatic necrosis

The mean extrapancreatic necrosis volume was 246.42 mL (median 120.24 mL, range 2–2135 mL). The mean extrapancreatic necrosis volumes were 181.2 mL based on CTSI and 164.7 mL based on mCTSI in the mild/moderate AP groups. In the severe AP groups, the mean extrapancreatic necrosis volumes were 767.4 mL based on CTSI and 569 mL based on mCTSI. The severity of the disease, as determined by CTSI or mCTSI was found to increase with extrapancreatic necrosis volume ($p<0.001$).

No significant correlation was found between extrapancreatic necrosis volume and the patient's age or lipase level ($p>0.05$). A moderate positive correlation was found between extrapancreatic necrosis volume and duration of hospitalization ($r=0.479$, $p=0.0001$). A moderate positive correlation was found between extrapancreatic necrosis volume and CRP ($r=0.622$, $p=0.0001$). The Santorini consensus and the World Association guidelines recommend a cutoff of 15 mg/dL for CRP. Having CRP > 15 mg/dL in the first 48 h differentiates severe AP from mild AP [5]. The CRP values were below a cutoff level of 15 mg/dL in 36 patients and above this level in 63 patients. Mean extrapancreatic necrosis volume was 86.7 mL in those with CRP < 15 mg/dL and 337.6 mL in those with CRP > 15 mg/dL. A strong positive correlation was found between extrapancreatic necrosis volume and WBC count ($r=0.609$, $p=0.0001$) (Table 1).

Table 1 The relationship between extrapancreatic necrosis volume and demographic data, laboratory findings, and imaging-based scoring systems

Variable	Extrapancreatic necrosis volume	
	r	*p**
Duration of hospitalization	0.479	0.0001
Age	– 0.094	0.357
CRP	0.622	0.0001
Lipase	– 0.064	0.530
WBC	0.609	0.0001
CTSI	0.763	0.0001
mCTSI	0.731	0.0001

CRP C-reactive protein, *WBC* white blood cell count, *CTSI* computerized tomography severity index, *mCTSI* modified CTSI

*Spearman correlation analysis

Extrapancreatic necrosis volume was found to increase significantly in the presence of infection or organ failure($p<0.0001$ or $p<0.001$, respectively) (Figs. 4, 5). Mortality was also found to increase significantly with extrapancreatic necrosis volume ($p<0.006$) (Fig. 6 and Table 2).

The diagnostic values of the parameters for the prediction of infection in AP cases were evaluated by ROC and AUC analyses (Table 3). The mCTSI had the highest AUC value in predicting the development of infection (0.905, 95% CI 0.84–0.96), which was followed by extrapancreatic necrosis volume (0.871, 95% CI 0.80–0.93).

In the prediction of infection in patients with AP, the ROC-curve analysis indicated a threshold value of 112 mL for extrapancreatic necrosis volume with a sensitivity of 87% and a specificity of 74%. The ROC curve of the parameters used to predict infection is shown in Fig. 7.

Extrapancreatic necrosis volume had the highest AUC value in predicting the development of organ failure (0.884, 95% CI 0.75–1.0) (Table 4). The ROC curve of the parameters used to predict organ failure in patients with AP is shown in Fig. 8. The ROC-curve analysis indicated a threshold value of 287 mL for extrapancreatic necrosis volume to predict organ failure with a sensitivity of 86% and a specificity of 74%.

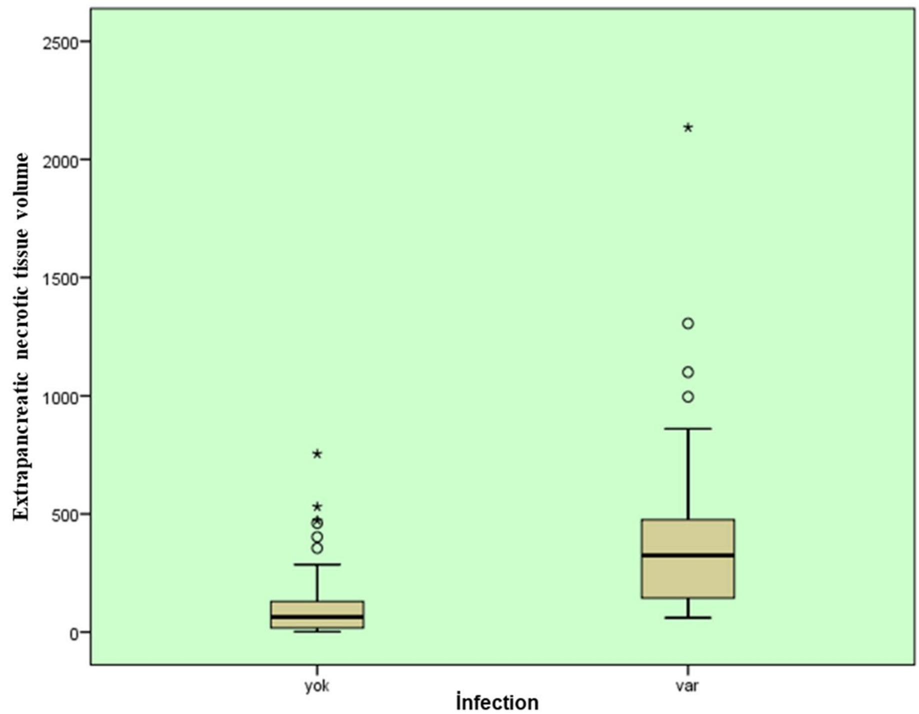

Fig. 4 The relationship between extrapancreatic necrosis volume and infection status

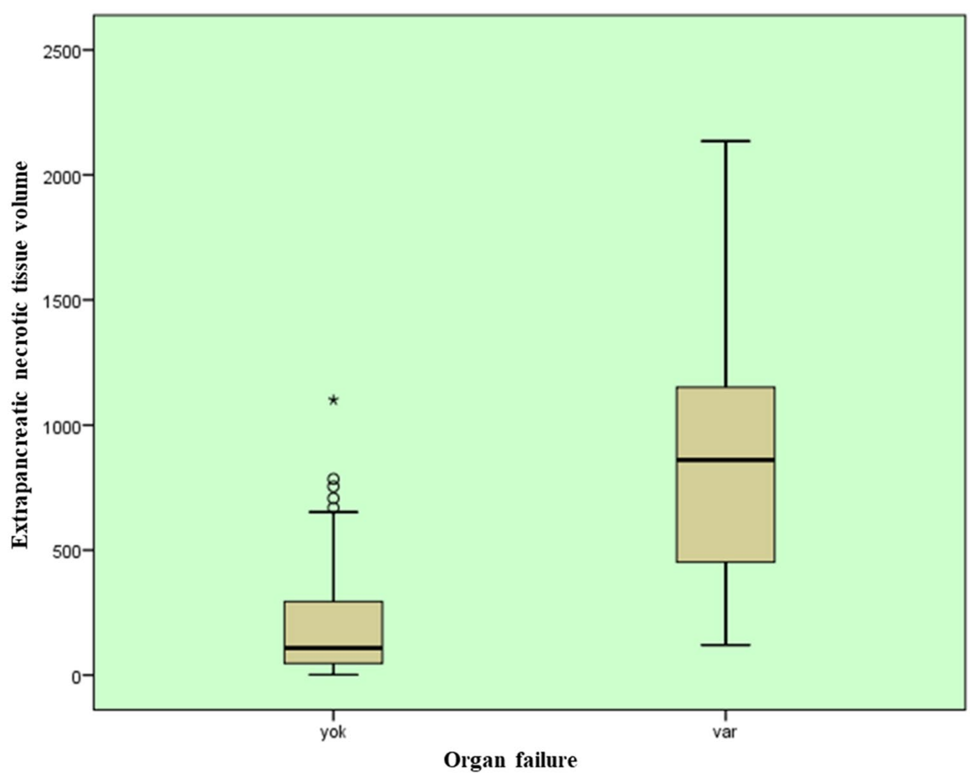

Fig. 5 The relationship between extrapancreatic necrosis volume and organ failure

Discussion

Extrapancreatic fat necrosis has become an area of increasing research and clinical interest. Studies suggest that the incidence of peripancreatic necrosis is similar to that of pancreatic necrosis [6]. However, there are little data on the association between extrapancreatic necrosis volume and disease severity. Here we postulate that extrapancreatic necrosis volume in early CT may be a new and simpler

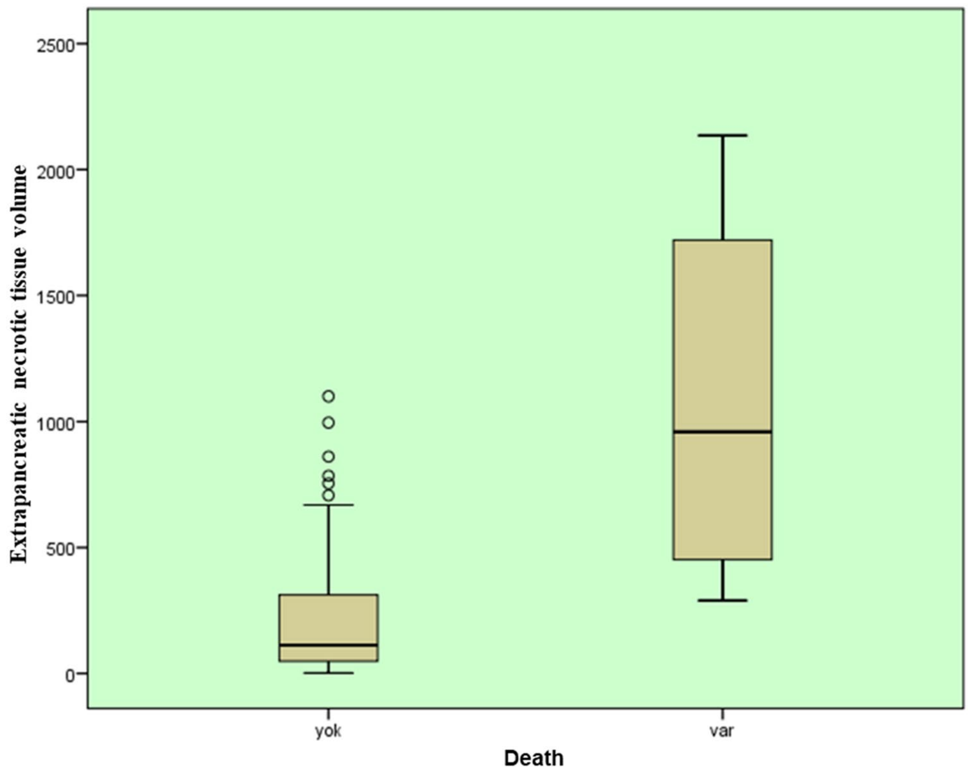

Fig. 6 The relationship between extrapancreatic necrosis volume and mortality

Table 2 The relationship between extrapancreatic necrosis volume and various clinical findings

Finding	Extrapancreatic necrosis volume		p*
	Mean ± SD	Median (min–max)	
Infection			
No	113.13 ± 151.12	63.46 (2–755)	0.0001
Yes	434.97 ± 401.08	324.54 (60–2135)	
Organ failure			
No	196.46 ± 215.203	108.12 (2–1100)	0.001
Yes	902.98 ± 678.612	860.95 (120–2135)	
Death			
No	211.07 ± 237.020	112.21 (2–1100)	0.006
Yes	1085.92 ± 817.745	959.64 (289–2135)	

SD standard deviation

*Mann–Whitney *U* test

Table 3 The ROC analysis of parameters used to predict infection in patients with AP

Parameter	AUC	95% CI	p
Extrapancreatic necrosis volume	0.871	0.80–0.93	< 0.001
CRP	0.857	0.78–0.93	< 0.001
CTSI	0.838	0.75–0.91	< 0.001
mCTSI	0.905	0.84–0.96	< 0.001
Balthazar score	0.783	0.69–0.87	< 0.001

AUC area under the curve in receiver operating characteristic curve, *CI* confidence interval, *CRP* C-reactive protein, *WBC* white blood cell count, *CTSI* computerized tomography severity index, *mCTSI* modified CTSI

method to determine the severity of AP. The CRP is the most useful biochemical marker used to determine the severity and complications of AP [4, 7]. A significant disadvantage of CRP is that it does not peak immediately after the AP symptoms, but it is delayed as much as 72 h after the complications [4, 7]. Nevertheless, elevated CRP is widely used in determining the severity of AP in the first 48 h since it is the cheapest and the most reliable test [8]. In our study, a moderate positive correlation was found between extrapancreatic necrosis volume and the CRP levels ($r = 0.622$ $p = 0.0001$).

In patients who were diagnosed with severe AP according to the Revised Atlanta Classification and had organ failure lasting more than 48 h, the AUC values in the ROC curve were 0.786 (95% CI 0.66–0.91) for CRP (48–72 h) and 0.884 (95% CI 0.75–1.0) for extrapancreatic necrosis volume, which is indicative of its usefulness in determining the severity of AP. After its onset, determination of the severity of acute pancreatitis is difficult in the early phase. Therefore, there is real need for a simple and inexpensive method that can precisely evaluate the severity of acute pancreatitis. In our clinic, CT scans are performed in order to evaluate severe AP patients determined by CRP or other predictors or to evaluate patients who are not responsive

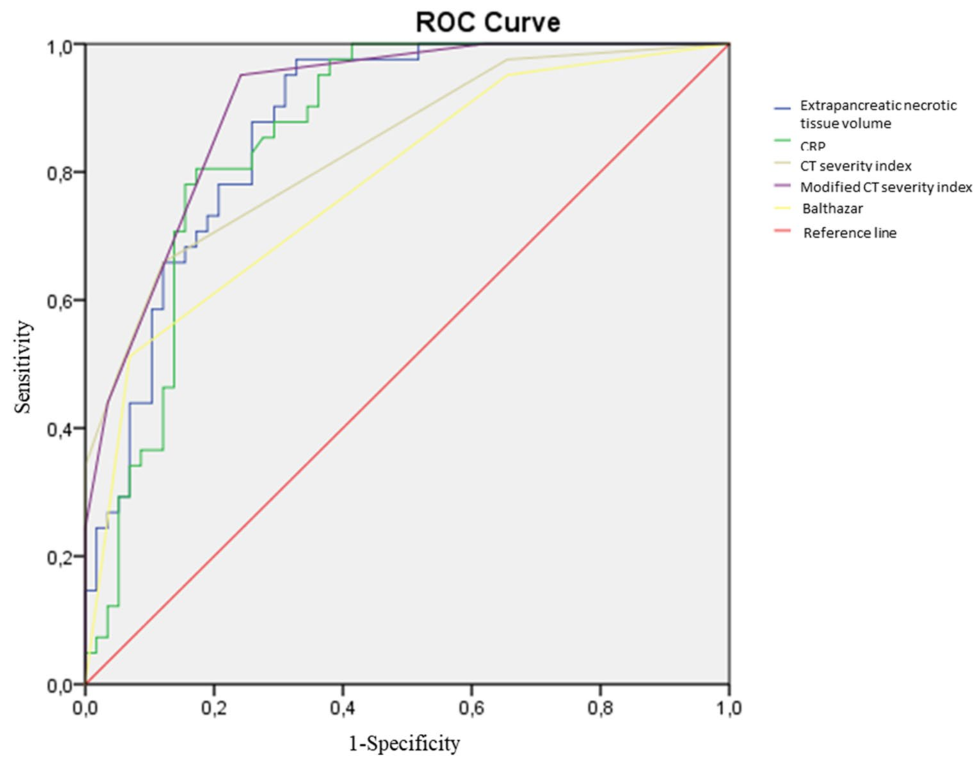

Fig. 7 The ROC curves for various parameters in patients with infection

Table 4 The ROC analysis of parameters used to predict organ failure in patients with AP

Parameter	AUC	95% CI	*p*
Extrapancreatic necrosis volume	0.884	0.75–1.0	0.001
CRP	0.786	0.66–0.91	0.012
CTSI	0.878	0.73–1.0	0.001
mCTSI	0.870	0.75–0.98	0.001
Balthazar score	0.783	0.62–0.94	0.013

AUC area under the curve in receiver operating characteristic curve, *CI* confidence interval, *CRP* C-reactive protein, *WBC* white blood cell count, *CTSI* computerized tomography severity index, *mCTSI* modified CTSI

to conservative treatment. This causes CT scans to be performed on the same day or later compared to CRP between 48 and 78 h. CRP measurement is a cheap and easily accessible method that should be prioritized in severe pancreatitis cases compared to CT.

Pancreatic parenchymal necrosis is a well-known risk factor for morbidity and mortality [1]. Contrast-enhanced abdominal CT (portal phase) is required to assess parenchymal necrosis. One of the advantages of measuring the extrapancreatic necrosis volume is that it does not require the use of a contrast agent. Imaging for early necrosis in AP is usually indicated only in deteriorating or critically ill patients [1, 9]. There are also studies suggesting that the CT scan should be done at least 72 h after the onset of symptoms or 5 to 7 days after hospitalization because it takes at least 48–72 h for pancreatic necrosis to develop [1, 2]. In a study comparing the AP patients with extrapancreatic necrosis only to those with pancreatic necrosis (regardless of having extrapancreatic necrosis), Bakker et al. [6] found that the complications such as organ failure, developing infected necrosis, percutaneous/surgical intervention, and death were less frequent in the former group ($p < 0.001$). However, the rate of complications was similar in the presence of infected extrapancreatic or peripancreatic necrosis. In a similar study comparing the patients with peripancreatic necrosis only to those with pancreatic necrosis only, Koutroumpakis et al. [10] had similar findings to the results of Bakker et al. in terms of the need for intervention, development of infected necrosis, and duration of hospitalization. In addition, the clinical course of patients with limited peripancreatic necrosis was similar to that of patients with interstitial pancreatitis, whereas patients with extensive peripancreatic necrosis were similar to those with pancreatic necrosis [10]. Rana et al. compared a group of patients with extrapancreatic necrosis to those with edematous pancreatitis and found organ failure and persistent organ failure to be more common among patients with extrapancreatic necrosis [11]. They also compared the group of patients with isolated extrapancreatic necrosis to those with combined pancreatic and peripancreatic necrosis and found that the acid, pleural effusion, and need for intervention were more common in the latter group.

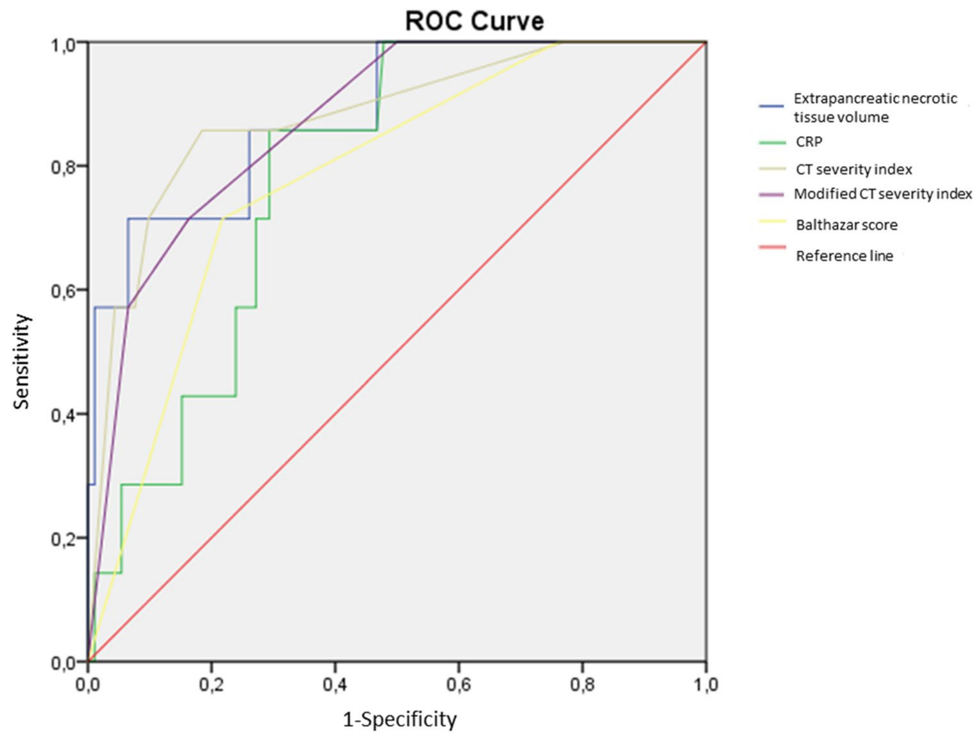

Fig. 8 The ROC curves for various parameters in patients with organ failure

In a study by Sakorafas et al., patients with only extrapancreatic necrosis had similar requirements for intensive care as those with pancreatic necrosis, but the length of hospital stay was shorter and mortality was lower in the former group [12]. In our study, extrapancreatic necrosis volume is compared to laboratory and radiological classifications; however, no additional evaluations are done with respect to association and development with pancreatic necrosis. This is an important limitation of our study and it needs to be validated with a prospective evaluation based on these findings.

In our study, the mean extrapancreatic necrosis volume was 246.4 mL (median 120.24 mL, range 2–2135 mL), which was 114 mL (median 12 mL, range 0–1596 mL) in a study by Meyrignac [13]. We attribute the higher mean volume in our study to the fact that CT imaging is less commonly used in patients with mild AP, and our study included complicated patients with moderate and severe AP. A significant relationship was found between extrapancreatic necrosis volume and infection ($p < 0.0001$), organ failure ($p < 0.001$), and mortality ($p < 0.006$). Meyrignac et al. similarly found significant relationships between increased extrapancreatic necrosis volume and infection ($p < 0.001$), organ failure ($p < 0.001$), percutaneous/surgical interventions ($p < 0.001$), and mortality ($p < 0.001$) [13].

A moderate positive correlation was found between extrapancreatic necrosis volume and the duration of hospitalization ($r = 0.479$ $p = 0.0001$). Meyrignac et al. found a strong positive correlation ($r = 0.75$, $p = 0.0001$). Significant results were also found related to the length of hospital stay, organ failure, the risk of developing pancreatic necrosis, the need for percutaneous/surgical intervention and intensive care unit, and mortality in a study by Val et al. [14]. In the last classification of AP based on the Revised Atlanta Classification, the main criterion for identifying severe AP has been identified as organ failure [15]. Isenman et al. indicated infected necrosis as the main determinant of organ failure [16]. We suggest that, as a new and simpler method, extrapancreatic necrosis volume in the initial CT examination may be the sole objective criterion to determine the severity of AP. It provides a higher positive likelihood and diagnostic odds ratio than do the original Balthazar score, the CTSI, or even CRP level.

We used the ROC curve to estimate the optimal threshold for predicting clinical prognosis and found two distinct extrapancreatic necrosis volume values for predicting the development of infection and organ failure. The threshold value for predicting the development of infection was 112 mL with a sensitivity of 87% and a specificity of 74%. The threshold value for predicting the development of organ failure was 287 mL with a sensitivity of 86% and a specificity of 74%. In the study by Meyrignac et al., the threshold for predicting the development of infection or organ failure was accepted as 100 mL with a sensitivity of 81% and a specificity of 86% for infection and a sensitivity of 95% and a specificity of 83% for organ failure [13]. In a similar study, Val et al. determined a threshold extrapancreatic necrosis volume of 119.11 mL [14]. We attribute the higher threshold values in our study to the lower number of patients, the inclusion of predominantly moderate and severe cases, and the fact that the CT examinations were performed comparatively later periods (2nd–6th days) than in other studies. In predicting infection, the AUC values were highest for the mCTSI followed by extrapancreatic necrosis volume; extrapancreatic necrosis volume had the highest AUC values for predicting organ failure. In the study by Meyrignac et al., extrapancreatic necrosis volume had the highest AUC value for predicting the development of organ failure and infection [13]. We also found similar AUC values for extrapancreatic necrosis volume, CRP, CTSI, and Balthazar score in predicting the development of infection or organ failure. In the study by Val et al., the AUC value of extrapancreatic necrosis volume was 0.78 for predicting the need for intensive care, 0.88 for predicting infected pancreatic necrosis, and 0.91 for predicting the need for percutaneous/surgical intervention; however, the BISAP score had the highest AUC value for organ failure (0.66) [14]. We found similar AUC values for extrapancreatic necrosis volume to those found by Val et al. for predicting the development of infection; however, extrapancreatic necrosis volume had the highest AUC value for predicting the development of organ failure.

Our study had some limitations. Only patients with abdominal CT in the early period were included in the study, which introduced a selection bias. We made no distinction between mild and moderate AP, limiting the classification to mild/moderate or severe AP. However, classification has no proven benefit for the distinctive treatment of these patients.

Conclusion

Acute pancreatitis is a disease with a broad clinical spectrum ranging from simple abdominal discomfort that can spontaneously dissolve to local and systemic complications that may cause death. The severe systemic inflammatory response and multi-organ failure may result in morbidity and mortality in 15–20% of cases. Early intervention in this patient group can be life-saving. Currently, there are several scoring systems to determine AP severity based on clinical, laboratory, and imaging findings. In this retrospective study of 99 cases, we compared extrapancreatic necrosis volume to scoring systems based on imaging (Balthazar, CTSI, and mCTSI) or laboratory test (CRP at 48–72 h). Extrapancreatic necrosis volume was found to provide notably better results in predicting the development of infection and organ failure. These results are promising, but there is a need for further prospective studies or studies with larger sample sizes.

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