



Research article

The characteristics of acute necrotizing pancreatitis in different age stages: An MRI study



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ABSTRACT

Purpose: To study the characteristics of acute necrotizing pancreatitis (ANP) in different age stages and their correlations with the clinical outcomes using magnetic resonance imaging (MRI).

Method: MRI of 716 patients with acute pancreatitis was retrospectively reviewed to assess the incidence and characteristics of ANP. On MRI, ANP was classified into three subtypes: extrapancreatic necrosis (EPN) alone, pancreatic necrosis (PN) alone and combined necrosis. The extent of necrosis was also quantified on MRI. All patients were divided into three age groups, that is, young, middle-aged and elderly groups, and these characteristics of ANP were compared among the three age groups. The endpoints of patients' clinical outcome were compared among different age groups and different characteristics of ANP.

Results: Of the 716 patients, 129 (18 %) were identified as ANP on MRI. The prevalence of ANP in the elderly group was the highest (28.9 %, $p < 0.05$). The patients in the middle-age and the elderly groups exhibited a higher risk of combined necrosis (56.9 %, 55.8 %; respectively), and elderly patients more frequently had extensive extrapancreatic involvement compared with young patients (65.9 % vs 21.4 %; $p = 0.004$); however, PN alone was more common in young patients. These characteristics of ANP were significantly bound up with clinical outcomes.

Conclusions: Different subtypes of ANP have different outcomes. More importantly, age needs to be considered as a factor of special concern in development of ANP.

1. Introduction

Acute pancreatitis (AP) accompanied with a complex clinical course is one of the most common causes of acute abdomen, and its morbidity is still increasing year by year [1]. Most attacks of AP are mild and self-limiting, but approximately 20 % patients develop severe acute pancreatitis (SAP), which is closely associated with acute necrotizing pancreatitis (ANP) [2,3]. ANP can promote the development of organ failure; despite great progress in diagnostics and therapeutics in recent years, the mortality of ANP has remained very high (10 %–36 %), and secondary infection occurs in up to 30 %–70 % of ANP patients [4]. Thus, ANP has great clinical importance. Age is one of the indices used

to grade the severity of AP in clinical scoring systems such as the Ranson criteria [5], the Bedside Index for Severity in Acute Pancreatitis [6] and the Acute Physiology and Chronic Health Evaluation II [7]. In addition, in recent years, some researchers have studied the relationship between age and AP and found that different age stages have certain unique characteristics of AP, such as incidence, etiology, mortality [8–10], and there are also studies analyzing AP in certain age stage [11,12]. In clinical practice, we have found that the progression and prognosis of ANP are not completely the same in patients of different ages. However, whether age needs to be considered as a factor of special concern in development of ANP is not clear.

The recognition of ANP by means of clinical examination is

Abbreviations: AP, acute pancreatitis; SAP, severe acute pancreatitis; ANP, acute necrotizing pancreatitis; CT, computed tomography; MRI, magnetic resonance imaging; RAC, revised atlanta classification; EPN, extrapancreatic necrosis; PN, pancreatic necrosis; OF, organ failure; POF, persistent organ failure; MOF, multiple organ failure; CECT, contrasted enhanced CT

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unreliable, therefore, the importance of radiographic imaging for that purpose is clinically emphasized. It can objectively reflect the characteristics of ANP including the type and the extent of necrosis [13]. And a previous study have shown that morphologic features on computed tomography (CT) are independent and strong predictors of outcome in patients with ANP [14]. Although CT is the main imaging tool for evaluating AP, its performance is suboptimal for detecting necrosis, particularly during the early stage of disease and when the area of necrosis is small [15], and CT is subjective in diagnosing EPN [16], whereas owing to the intrinsic multiple imaging parameters MRI (even nonenhanced MRI) can more sensitively and accurately evaluate both the presence and the extent of necrosis area and is excellent for detecting different components of extrapancreatic collection (i.e., fluid accumulation, necrotic debris and hemorrhage) [17–21].

We conducted this study to investigate ANP by using MRI. Our purpose was (1) to study the characteristics of ANP in the early phase of disease (within two weeks after onset) in different age groups and (2) to explore the relationships between characteristics of ANP and clinical outcomes.

2. Materials and methods

2.1. Ethics statement

The Institutional Review Board and Ethics Committee of our institute approved this study and waived patients' informed consent due to the retrospective nature of this research.

2.2. Patients selection

By performing a database search, all consecutive in-patients were identified who were admitted to the unit and diagnosed with AP from January 2014 to October 2017. The diagnostic criteria for AP were based on the revised Atlanta classification (RAC) [13]. The inclusion criteria of this study were as follows: ① first attack of AP, ② 3.0-T enhanced MRI performed within two weeks after the onset of symptoms, and ③ adult patients (age greater than or equal to 18 years old). The exclusion criteria were as follows: ① AP caused by pancreatic tumors, ② patients with a history of chronic pancreatitis or signs of chronic pancreatitis (i.e., pancreatic calcifications and/or irregular pancreatic duct), ③ AP occurring in combination with chronic liver disease, ④ AP occurring in combination with infectious, neoplastic and hemorrhagic disease of the retroperitoneal space and/or of peritoneal origin, ⑤ patients with a history of pancreas-related invasive interventions, ⑥ patients with unclear MRI images due to motion artifact. Eventually, all enrolled patients were divided into young group (18–40 years old), middle-aged group (41–65 yrs) and elderly group (> 65 yrs) based on national condition of population in China (originate from the national bureau of statistics of China (NBS)).

2.3. MRI technique

All MRI examinations were performed with a 3.0-T scanner (Discovery MR 750; GE Medical Systems, Milwaukee, WI) in the supine position. The MRI scanning sequences included axial FRFSE T2WI, axial and coronal SSFSE T2WI, axial 3D LAVA-Flex before and after intravenous contrast administration (Gadolinium, 0.2 mmol per kg of body weight, 3 ml/s injection speed) obtained during arterial-, portal-, and balanced phase. The MRI parameters are shown in Table 1.

2.4. MR image review

The original MRI data were transferred to a workstation (GE, AW4.1, Sun Microsystems, Palo Alto, CA, USA) to be reviewed. All MR images were retrospectively reviewed by two professional abdominal radiologists with 5–6 years of experiences who were blinded to clinical

outcomes.

According to RAC [13], AP is classified into acute interstitial edematous pancreatitis and ANP, and ANP is classified into three subtypes: extrapancreatic necrosis (EPN) alone, pancreatic necrosis (PN) alone and combined necrosis. The hallmark of this form of ANP is the presence of tissue necrosis, either of the pancreatic parenchyma or the extrapancreatic tissues.

On MRI, pancreatic necrosis was diagnosed when focal or diffuse, hypointense areas on T1WI corresponding to hyperintense areas on T2WI and well-margined areas of non-enhancing pancreatic parenchyma in comparison to the signal intensity of the normal pancreatic parenchyma are present [22]. The extent of PN could be further quantified to less than 30 % (mild), 30 %–50 % (moderate), and > 50 % (severe) of the pancreatic gland, which is based on Balthazar's criteria and grade points [15].

MRI for the diagnosis of extrapancreatic necrosis used current criteria of CT [13,23], that is extrapancreatic morphological changes exceeding fat stranding manifested as a nonliquefied, ill-defined and heterogeneous extrapancreatic collection. T2WI sequence was sensitive to show liquid component which manifested as hyperintensity and was helpful to identify the mixed component in the liquid collection. Necrotic tissue manifested as hypointensity on T2WI sequence. The diagnosis of EPN required the combined use of axial T2-weighted sequences with fat suppression and T2-weighted sequences without fat suppression and it manifested as heterogeneous signal (mainly low signal or high-low mixed signal). EPN is quantified according to the involved range and affected location and coronal T2-weighted sequences was helpful to completely evaluate the involved range and location of EPN. According to the scanning range used in this study (from diaphragmatic plane to the lowest level of renal), the following locations were considered: peripancreatic space, paragastric, omental bursa, gastrosplenic ligament, hepatoduodenal and/or gastrohepatic ligament, root of the mesentery and left/right perirenal space. EPN was graded as "limited" when the maximum sectional of necrosis range < 5 cm or "extensive" when it measured > 5 cm or affected > 3 locations [24].

We compared various age groups for these characteristics of ANP and performed the same research based on etiology-groups.

2.5. Clinical data

The gender, etiology and clinical outcome for all patients were reviewed. The clinical outcomes referred to occurrence of organ failure, persistent organ failure (POF) and multiple organ failure (MOF) within two weeks after the onset of AP. Organ failure was defined as a score ≥ 2 in any organ system (including respiratory, renal, cardiovascular) of the Modified Marshall scoring system for organ dysfunction [13]. Presence of involvement of more than one system was labeled as MOF while if organ failure exceeded 48 h, it was defined as POF. We compared three age groups patients with ANP and different characteristics of ANP for outcomes.

2.6. Statistical analysis

When the two observers disagreed on a qualitative issue, they negotiated and reached an agreement; when they disagreed on a quantitative issue, the average value of their measurement was taken as the final result. Kappa tests were calculated to measure the agreement between the two observers. Agreement levels were defined as: κ value < 0.41 indicated poor agreement; κ value between 0.41 and 0.60 indicated moderate agreement; κ value between 0.61 and 0.80 indicated good agreement; and κ value > 0.80 indicated very good agreement. The quantitative variables were expressed as the means \pm standard or the median. The qualitative variables were expressed as the numbers and percentages. For comparison among different groups and pairwise comparison in multiple groups, the χ^2 test

Table 1
MRI parameters at 3.0-T.

MRI scanning sequences	TR(ms)	TE(ms)	Flip angle	Section thickness(mm)	Intersection gap(mm)	Matrix	FOV(cm)
AX FRFSE FS-T2WI	2200-2400	90-100	90°	5.0	0.5	256 × 192	36 × 34
AX SSFSE T2WI	6 seconds between images acquisitions	80-100	90°	5.0	0.5	320 × 256	39 × 33
COR SSFSE T2WI	6 seconds between images acquisitions	80-100	90°	5.0	0.5	320 × 256	39 × 33
AX 3D LAVA-Flex	4.2	2.6/1.3	12°	5.0	0	384 × 224	26-33
AX 3D LAVA C+*	4.2	2.6/1.3	12°	5.0	0	384 × 224	26-33

Note: * Dynamic enhanced imaging is indicated with *.

and Fisher's exact test were used for descriptive data. Pairwise comparisons of multiple groups was performed with the χ^2 divided method, and in order to ensure that the total probability (α) of type I error in the hypothesis test did not vary, the test level was redefined as p' (eg. in this study, there were three age groups, thus pairwise comparisons were performed 3 times, and $p' = 0.017$). All statistical analyses were performed using the statistical package for social sciences (SPSS) for Windows (Version 19.0, Chicago, IL, USA). A two-sided $p < 0.05$ was considered statistically significant.

3. Results

3.1. Study sample

A total of 716 patients with AP were enrolled in this study, consisting of 377 males and 339 females, and the average age was 53 yrs \pm 10 yrs (range of 18 yrs -87 yrs). Four hundred and forty-one (61.6 %) patients had biliary AP, 119 (16.6 %) had hyperlipidemic AP, 55 (7.7 %) had alcoholic AP and 101 (14.1 %) had an unknown cause. There were 144 patients in the young group, 423 patients in the middle-aged group and 149 patients in the old group, respectively. The median time between the onset of AP and the performance of MRI was 6 days.

Of the 716 patients, 129 (18.0 %) patients had necrotizing pancreatitis. The distribution of gender and etiology in these patients with ANP were shown in Table 2. There was not significant difference of gender in three age groups; however, etiology distribution was closely related to age.

3.2. Prevalence of ANP on MRI

The prevalence of ANP was 14.6 %, 15.4 % and 28.9 % in the young, middle-aged and elderly groups, respectively. The elderly group had a significantly higher prevalence of ANP than the young group ($p = 0.003$) and the middle-aged group ($p < 0.001$). However, no significant differences between the young group and the middle-aged group were found ($p = 0.821$) (Table 3).

3.3. Subtypes of ANP on MRI

Agreement between the two observers was good in terms of

Table 2
The comparison of gender and etiology in the three age groups.

Variables	Young group N(%)	Middle-aged group N(%)	Elderly group N(%)	P-value	p^1	p^2	p^3
Gender				0.130	/	/	/
male	13(61.9)	37(56.9)	17(39.5)				
female	8(38.1)	28(43.1)	26(60.5)				
Etiology				/	0.077	< 0.001	0.020
biliary	5(23.8)	33(50.8)	32(74.4)				
hyperlipidemic	9(42.9)	16(24.6)	3(7.0)				
alcoholic	5(23.8)	7(10.8)	1(2.3)				
Unknown	2(9.5)	9(13.8)	7(16.3)				

Notes: P, comparison between the three age groups; P^1 , comparisons between the young and the middle-aged groups; P^2 , comparisons between the young and the elderly groups; P^3 , comparisons between the middle-aged and the elderly groups.

identifying the subtype of ANP ($\kappa = 0.77$). Of the 129 patients with ANP, there were 37.2 %, 9.3 % and 53.5 % of patients with EPN alone (Fig. 1), PN alone (Fig. 2) and combined necrosis (Fig. 3), respectively (Table 3). The most common subtype of ANP in all three age groups was combined necrosis. However, the prevalence of combined necrosis in the middle-aged group and the elderly group was significantly higher than that in the young group (56.9 % vs 38.1 %, $p = 0.002$; 55.8 % vs 38.1 %, $p = 0.008$). However, the prevalence of PN alone in the young group was much greater than that in the middle-aged group (33.3 % vs 4.6 %) and the elderly group (33.3 % vs 4.7 %).

3.4. Semiquantitative analysis of necrosis on MRI

Agreement between the two observers was moderate in terms of identifying the extent of EPN ($\kappa = 0.57$) and moderate in terms of identifying the extent of PN ($\kappa = 0.59$). In terms of the extent of EPN, there was significant difference between the elderly group and the young group ($p = 0.004$). EPN in patients in the elderly group was more likely to be extensive (65.9 %, 27/41), whereas in patients in the young group it was often limited (78.6 %, 11/14) (Table 3). In terms of the extent of PN, the prevalence of moderate necrosis and severe necrosis in the young group were 46.7 % and 20.0 % respectively, which were significantly higher than those in the elderly group (11.5 %; 7.7 %, respectively) ($p = 0.010$)(Fig. 4).

3.5. Etiology-based characteristics of ANP

All patients were divided into four subgroups according to etiology. The data of the occurrence of ANP and the characteristics of ANP in four etiological subgroups were shown in Table 4. It was not found the significant correlation between etiology and the characteristic variables of ANP.

3.6. Clinical outcomes

Sixty-seven patients (51.9 %) developed organ failure, of these 43 (33.3 %) developed POF and 23 (17.8 %) developed MOF. The prevalence of OF and POF were significantly higher in the elderly group than that in the young group (69.8 % vs 23.8 %; 44.2 % vs 9.5 %, respectively) and were higher than that in the middle-aged group but

Table 3
The characteristics of acute necrotizing pancreatitis in different age groups (N = 129 patients).

MRI characteristics	young group	middle-aged group	elderly group	p ¹	p ²	p ³
proportion of ANP	14.6 % (21/144)	15.4 % (65/423)	28.9 % (43/149)	0.821	0.003	< 0.001
subtypes				0.002	0.008	> 0.05
EPN alone	6(28.6 %)	25(38.5 %)	17(39.5 %)			
PN alone	7(33.3 %)	3(4.6 %)	2(4.7 %)			
combined	8(38.1 %)	37(56.9 %)	24(55.8 %)			
extent of EPN				0.083	0.004	0.057
extensive	3(21.4 %)	29(46.8 %)	27(65.9 %)			
limited	11(78.6 %)	33(53.2 %)	14(34.1 %)			
extent of PN				0.565	0.010	0.044
mild	5(33.3 %)	20(50.0 %)	21(80.8 %)			
moderate	7(46.7 %)	14(35.0 %)	3(11.5 %)			
severe	3(20.0 %)	6(15.0 %)	2(7.7 %)			

Notes: ANP: Acute Necrotizing Pancreatitis; EPN: Extrapancreatic Necrosis; PN: Pancreatic Necrosis.

P¹, comparisons between the young and the middle-aged groups; P², comparisons between the young and the elderly groups; P³, comparisons between the middle-aged and the elderly groups.

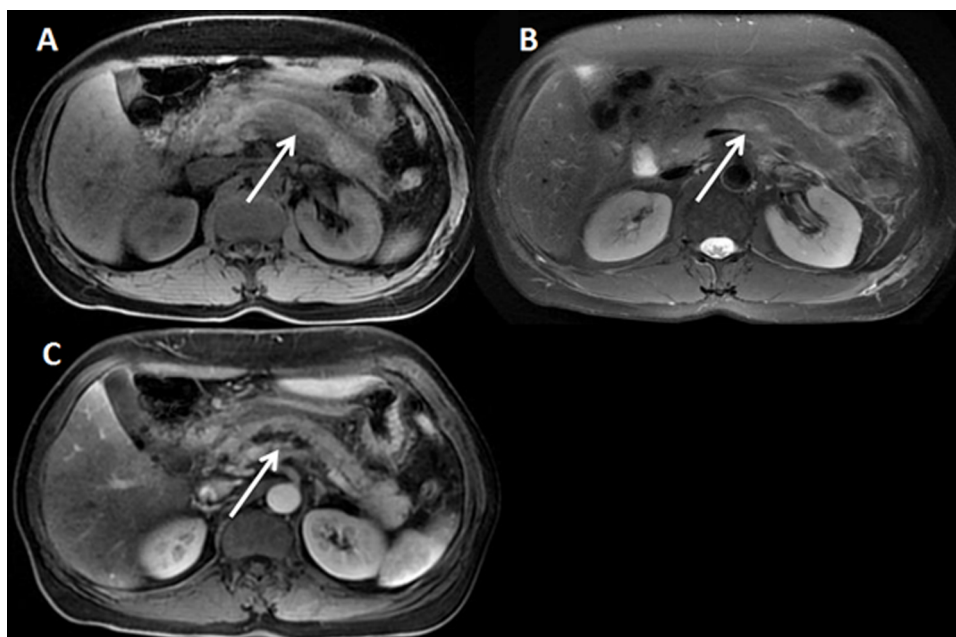


Fig. 1. Pancreatic Necrosis Alone.

A 35-year-old man with pancreatic necrosis alone. Local area of pancreas showed hypointensity on an axial LAVA T1WI (1A, white arrow), hyperintensity on an axial FRFSE T2WI (1B, white arrow) and non-enhanced area on Gd enhanced MR imaging(1C, white arrow).

did not reach statistical significance. The prevalence of MOF was significantly higher in the elderly group than those in other two groups (34.9 % vs 4.8 %; 34.9 % vs 10.8 %) (Table 5).

In terms of OF, POF and MOF, the patients with combined necrosis had higher prevalence than the patients with EPN alone, but it did not reach statistical significance. The patients with combined necrosis had significant risk of suffering OF (62.3 vs 25.0 %, $p = 0.025$) and POF (42.0 % vs 8.3 %, $p = 0.027$) than the patients with PN alone (Table 5). Compared with the patients with limited EPN, the patients with extensive EPN had significantly increased prevalence of OF (64.4 % vs 44.8 %, $p = 0.033$), POF (47.5 % vs 24.1 %, $p = 0.009$) and MOF (28.8 vs 10.3 %, $p = 0.012$). The patients having > 30 % PN had significantly higher risk of developing MOF (Table 6).

4. Discussion

In this study, we found that age was closely related to the characteristics of ANP, patients with ANP in the elderly group were at a higher risk of combined necrosis, and their extrapancreatic tissue was more likely to be involved, and the involvement tended to be extensive;

however, the prevalence of PN alone in young patients were much greater than those in elderly patients. These characteristic variables of ANP were closely related to clinical outcome. Based on our results, age needs to be considered as an important influence factor of characteristics of ANP and the elderly was a high-risk group associated with a more severe of ANP.

4.1. Prevalence of ANP and age

In terms of the prevalence of ANP in the enrolled patients with AP, the results of the published literature is different. Gasparoto et al. [3] reported 530 patients with AP in their single-center study, of whom 49 (9.2 %) had ANP (defined as PN based on contrasted enhanced CT and it was indicated 72 h after the onset). Verdonk et al. [25] reported 285 patients with AP in their multicenter study, of whom 159 patients (56 %) had ANP (defined as PN or/and EPN on CECT and it performed within 1–90 days). Our results with the prevalence of 18.0 % was higher than that in the study by Gasparoto et al. but much lower than that in the study by Verdonk et al. These discrepancies may be due to many causes, but the timing of CT/MRI assessment may be an

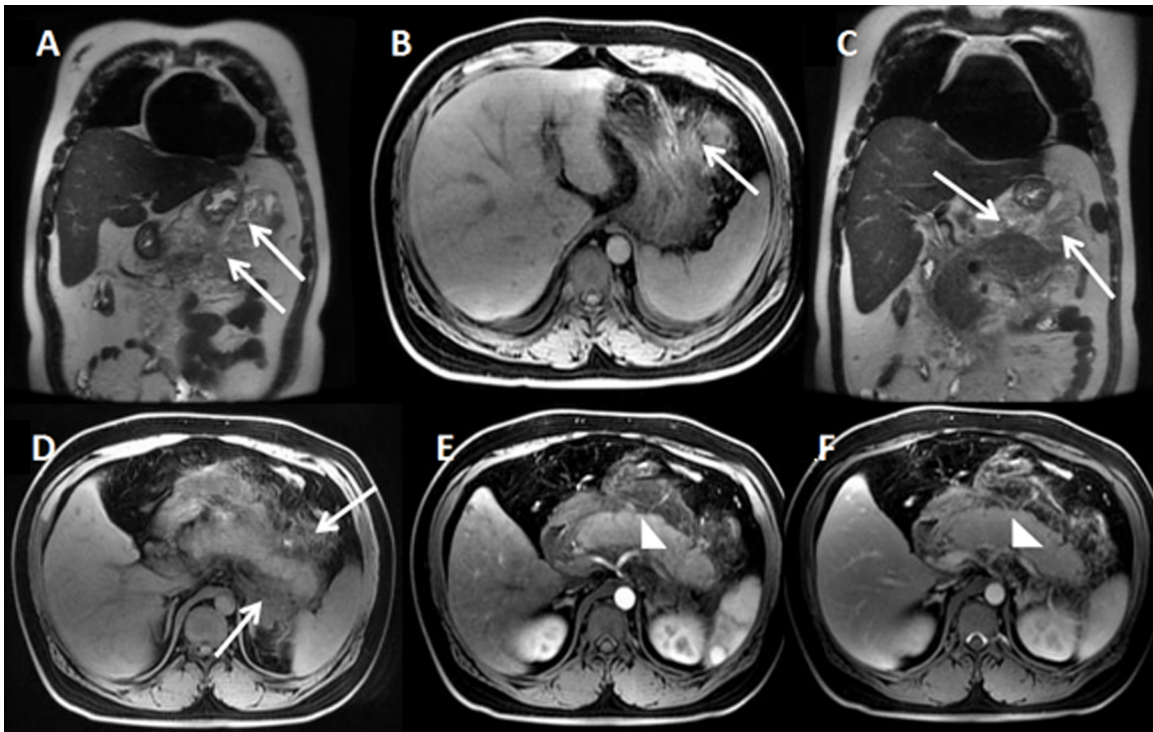


Fig. 2. Extrapancreatic Necrosis Alone.

A 52-year-old woman with extrapancreatic necrosis alone. Paragastric and peripancreatic areas showed heterogeneous and mixed signal on an axial SSFSE T2WI (2A, 2C, white arrows), mixed signal on an axial LAVA T1WI (2B, 2D, white arrows) and the pancreas enhanced normally during the arterial (2E, arrow head) and venous phases (2F, arrow head) after Gd enhanced MR imaging.

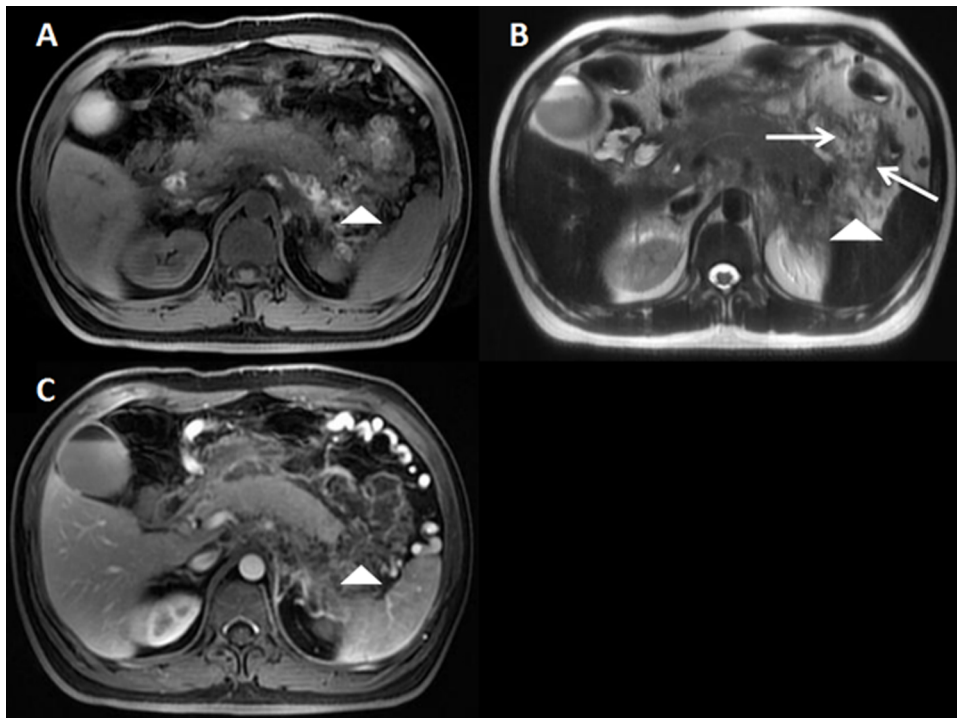


Fig. 3. Combined Necrosis.

A 69-year-old woman with combined necrosis. Pancreatic necrosis was mild and extrapancreatic necrosis was extensive. The appearance of pancreatic tail was unclear, which showed mixed signal on an axial LAVA T1WI (3A, arrow head), mixed signal on an axial SSFSE T2WI (3B, arrow head) and non-enhanced area on Gd enhanced MR imaging (3C, arrow head). Peripancreatic tissue showed heterogeneous and mixed collection on an axial SSFSE T2WI (3B, white arrows).

important factor. In this study, we mainly evaluated the prevalence of ANP in the early stage of disease (within two weeks after onset) as assessed by MRI.

In this study, we found that there was a significantly higher prevalence of ANP in the elderly than in younger and middle-aged patients. This finding is similar to that of a previous study [26] that evaluated

439 patients with AP and found that an age older than 70 years old was associated with ANP. A multicenter study, which included 639 patients, reported that the predominant cause of ANP was biliary factors (48 %) [27]. Of 129 patients with ANP in our study, the predominant cause was biliary (54.3 %) and the proportion of biliary factor in the elderly group was up to 74.4 %. But we did not find the significant difference

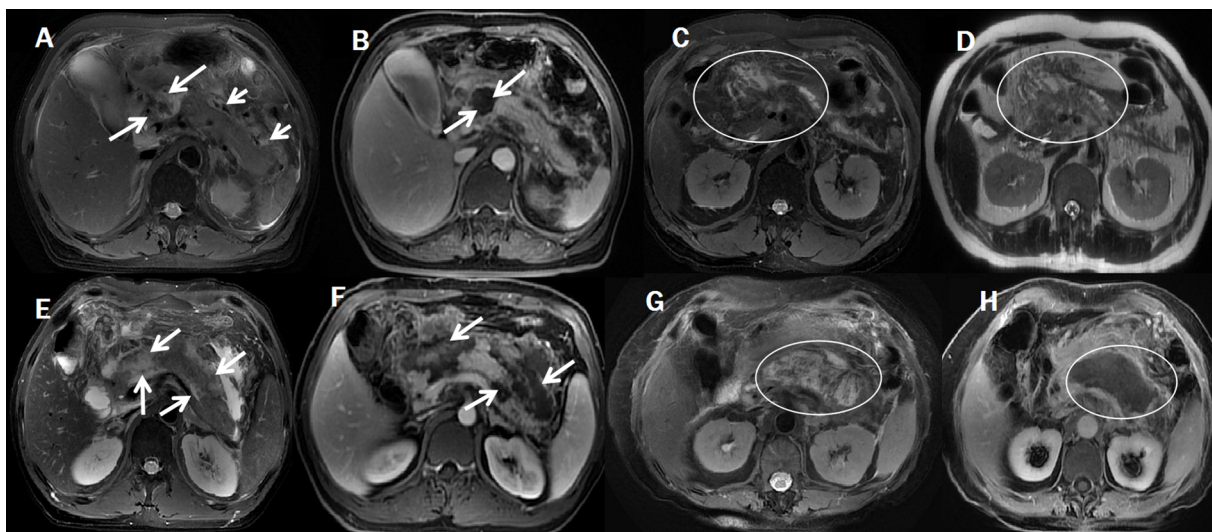


Fig. 4. Different Grades of ANP Extent.

Ⓐ 49-year-old man with limit EPN and mild (< 30 %) PN (4A, 4B). Peripancreatic area showed heterogeneous signal (4A, short arrows); the maximal short diameter of necrotic collection < 5 cm. Pancreatic head showed mixed signal (4A, FRFSE T2WI, long arrows) and non-enhanced area (4B, enhanced imaging, long arrows). Ⓑ 60-year-old man with extensive EPN (4C, 4D, oval). Omental bursa and root of the mesentery areas showed heterogeneous signal; the maximal short diameter of necrotic collection > 5 cm. Ⓒ 66-year-old man with moderate (30 %–50 %) PN (4E, 4F). Pancreatic parenchyma showed multiple high signal areas (4E, FRFSE T2WI, long arrows) and non-enhanced areas (4F, enhanced imaging, long arrows). Ⓓ 65 year-old woman with severe (> 50 %) PN (4G, 4H). Pancreatic parenchyma showed large area of mixed signal (4G, FRFSE T2WI, oval) and non-enhanced area (4H, enhanced imaging, oval).

between etiology and the prevalence of ANP in our study population. The result may be limited by the number of patients having ANP.

4.2. Subtypes of ANP and age

In their prospective multicenter cohort of 639 patients with ANP, Bakker et al. [23] reported that 315 (49.3 %) patients had EXPN alone, 320 (50.1 %) patients had combined necrosis and only 4 (0.6 %) patients had PN alone. Wang et al. [28] reported that in 334 patients with ANP who all underwent interventions in their retrospective study, the prevalence of EPN alone, combined necrosis and PN alone was 14.7 %, 84.4 % and 0.9 %, respectively. Koutroumpakis et al. [24] evaluated ANP both during the early phase and the late phase of disease and showed that 153 patients developed ANP, with a prevalence of EPN alone, combined necrosis and PN alone of 19.0 %, 63.4 % and 17.6 %, respectively. In this study, we identified the subtypes of ANP on MRI and showed that the prevalence of EPN alone, combined necrosis and PN alone was 37.2 %, 53.5 % and 9.3 % respectively. The prevalence of the three subtypes of ANP in our study was different from the above-mentioned three previous studies. One of reasons for this discrepancy may be the difference in the radiographic tool used to evaluate the

subtype. The three previous studies all used CT, but our study used MRI. In the evaluation of ANP, MRI is more sensitive and accurate than CT [15–21]. In addition, this discrepancy might have resulted from differences in patient characteristics or the time scale of study (e.g., early phase vs late phase), etc.

Interestingly, this study found for the first time that there was a close association between age and the subtypes of ANP, showing that elderly patients with ANP often had extrapancreatic fat tissue involvement and were at a higher risk of developing combined necrosis, whereas the prevalence of PN alone was more common in young patients than in the other two age groups. The mechanism underlying the greatly increased risk of combined necrosis in elderly patients is not completely clear. Most studies report more severe AP in the elderly and have described possible explanations [29–33]. Zhu et al. [29] found that elderly patients had a significantly higher risk of suffering from SAP and attributed it to an inevitable physiological process of senility in the elderly (i.e., senility of tissue cells and decline of organ function). In their animal experiment, Fu et al. [30] suggested that the more aggressive course in aging animals with AP was related to the loss of pancreatitis-associated protein protection. Combined necrosis is a severe condition associated with SAP [28], and these may also explain

Table 4

The characteristics of ANP based on etiology-subgroups.

MRI characteristics	biliary	hyperlipidemic	alcoholic	Unknown	P-value
proportion of ANP subtypes	15.9 %(70/441)	23.5 %(28/119)	23.6 %(13/55)	17.8 %(18/101)	0.172 0.122
EPN alone	29(41.1 %)	9(32.1 %)	4(30.8 %)	6(33.3 %)	
PN alone	2(2.9 %)	5(17.9 %)	3(23.1 %)	2(11.1 %)	
combined	39(55.7 %)	14(50.0 %)	6(46.2 %)	10(55.6 %)	
extent of EPN					P' > 0.013
extensive	43(63.2 %)	9(39.1 %)	2(20.0 %)	5(31.3 %)	
limited	25(36.8 %)	14(60.9 %)	8(80.0 %)	11(68.7 %)	
extent of PN					0.134
mild	27(65.9 %)	7(36.8 %)	4(44.4 %)	8(66.7 %)	
moderate	10(24.4 %)	9(47.4 %)	4(44.4 %)	1(8.3 %)	
severe	4(9.8 %)	3(15.8 %)	1(11.1 %)	3(25.0 %)	

Notes: ANP: Acute Necrotizing Pancreatitis; EPN: Extrapancreatic Necrosis; PN: Pancreatic Necrosis.

P', pairwise comparison in multiple groups.

Table 5
The comparison of three age groups patients with ANP and subtypes of ANP for outcomes.

Clinical outcomes	Age group N(%)			P-value	Subtype of ANP N(%)			
	young group	middle-aged group	elderly group		combined	EPN alone	PN alone	P-value
OF	5 (23.8)	32 (49.2)	30 (69.8)	0.041 ^a < 0.001 ^b 0.035 ^c	43(62.3)	21 (43.8)	3 (25.0)	0.06 ^d 0.025 ^e
POF	2 (9.5)	22 (33.8)	19 (44.2)	0.031 ^a 0.006 ^b 0.278 ^c	29(42.0)	13 (27.1)	1 (8.3)	0.097 ^d 0.027 ^e
MOF	1 (4.8)	7 (10.8)	15 (34.9)	0.673 ^a 0.009 ^b 0.002 ^c	17(24.6)	6 (12.5)	0(0)	0.155 ^d 0.062 ^e

Notes: ANP: Acute Necrotizing Pancreatitis; EPN: Extrapaneatic Necrosis; PN: Pancreatic Necrosis; OF: Organ Failure; POF: Persistent Organ Failure; MOF: Multi-Organ Failure; ^a, comparison between the young and the middle-aged groups; ^b, comparison between the young and the elderly groups; ^c, comparison between the middle-aged and the elderly groups; ^d, comparison between combined necrosis and EPN alone; ^e, comparison between combined necrosis and PN alone.

our results.

4.3. Extent of ANP and age

In this study, we found that elderly patients with EPN were often had extensive involvement on MRI, but in young patients with EPN, it tended to be limited. We also found that elderly patients had much higher risk of developing POF than young patients. We agree with Koutroumpakis et al. [24] that extensive EPN was associated with a high frequency of POF compared with limited EPN. Raizner et al. [12] reported 8 cases of PN (patients aged < 21 yrs), in whom the prevalence of mild, moderate and severe PN was 25.0 % (2/8), 25.0 % (2/8) and 50.0 % (4/8), respectively. Their results were compared with our results in the young group, in whom the prevalence of mild, moderate and severe necrosis was 33.3 %, 46.7 % and 20.0 %, respectively. In both the young patient groups of the above mentioned two studies, the proportion of moderate-severe PN cases was much higher than that of mild PN cases. This may suggests that compared with elderly patients with PN, young patients more frequently suffer from severe PN.

4.4. Characteristics of ANP and etiology

In consistent with previous studies [10,29], we also found that the etiology of AP was related to age of the patients, that is, biliary-related was the more common cause in elderly patients whereas hyperlipidemia and alcohol were the more common cause in young patients. Thus, in addition to age-based subgroups, we grouped the patients with ANP based on etiology and evaluated whether there was an effect of etiology on characteristics of ANP in our study population. However, it was not found that different etiology of ANP significantly differed in characteristics of ANP.

Table 6
The comparison of different extents of ANP for outcomes.

Clinical outcomes	Extent of EPN N(%)			P-value	Extent of PN N(%)			P-value
	Extensive EPN	Limit EPN			< 30 %	30 %–50 %	> 50 %	
OF	38 (64.4)	26 (44.8)	0.033	25 (54.3)	13 (54.2)	8 (72.7)	0.517	
POF	28 (47.5)	14 (24.1)	0.009	13 (28.3)	10 (41.7)	7 (63.6)	0.079	
MOF	17 (28.8)	6 (10.3)	0.012	3 (6.5)	9 (37.5)	5 (45.5)	0.002 ^f 0.005 ^g 0.721 ^h	

Notes: EPN: Extrapaneatic Necrosis; PN: Pancreatic Necrosis; OF: Organ Failure; POF: Persistent Organ Failure; MOF: Multi-Organ Failure; ^f, comparison between < 30 % and 30 %–50 % groups; ^g, comparison between < 30 % and > 50 % groups; ^h, comparison between 30 %–50 % and > 50 % groups.

characteristics in the late stage were not available. Third, the sample size in the three age groups was small.

5. Conclusion

In conclusion, there are various MRI characteristics of ANP in different age stages and these characteristics variables are closely related to clinical prognostic. Elderly patients are at a higher risk of developing ANP, which often manifests as combined necrosis, and they often have extensive extrapancreatic tissue involvement. However, PN alone is more common in young patients. Combined necrosis, extensive EPN and > 30 % PN have more severe clinical outcomes. Age needs to be considered as a factor of special concern in development of ANP, and particularly the elderly is a high-risk group associated with a more severe course of ANP.

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Declaration of Competing Interest

The retrospective study will require to collect the clinical data and MRI images of acute pancreatitis patients from January 2014 to October 2017. The data will be analyzed anonymously. This study has been approved by Ethics Committee of Affiliated Hospital of North Sichuan Medical College. Patient informed consent was waived. All authors declare that there is no conflict of interests regarding this article.

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