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Revised Atlanta classification for CT pancreatic and peripancreatic collections in the first month of acute pancreatitis: interobserver agreement

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Abstract

Purpose To assess interobserver agreement when using the revised Atlanta classification (RAC) to categorize pancreatic and peripancreatic collections during the first month of acute pancreatitis (AP), and to correlate type of collection to outcome.

Material and methods This retrospective study of 115 consecutive patients admitted for 123 AP episodes, 178 CTs performed within the first month showed peripancreatic abnormalities. Each AP episode was classified as mild, moderately severe, or severe based on the RAC. Two radiologists, blinded to clinical data, used RAC criteria to retrospectively categorize the collections as acute peripancreatic fluid collections (APFC) or acute necrotic collections (ANC). Interobserver agreement was assessed based on Cohen's κ statistics and compared according to CT timing.

Results Interobserver agreement for categorizing peripancreatic collections was moderate ($\kappa = 0.45$) and did not improve with time to CT (κ values, 0.53 < day 3, 0.34 on days 3–6, and 0.43 ≥ day 7). For detecting parenchymal necrosis, interobserver agreement was also moderate ($\kappa = 0.45$). AP was less severe in patients with APFC versus ANC ($p = 0.04$).

Conclusion Our finding of moderate interobserver agreement when using the RAC to categorize pancreatic and peripancreatic collections by CT indicates that the accurate diagnosis of APFC or ANC by CT in the first 4 weeks after symptom onset is often challenging.

Key Points

- *Interobserver agreement was moderate for categorizing peripancreatic collections.*
- *Interobserver agreement did not improve with time from onset to CT.*
- *Interobserver agreement was moderate for detecting parenchymal necrosis.*

Keywords Acute necrotizing pancreatitis · Multidetector computed tomography · Interobserver variability · Outcomes assessment · Pancreatitis

Abbreviations

ANC	Acute necrotic collection
AP	Acute pancreatitis
APFC	Acute peripancreatic fluid collection
CT	Computed tomography
IEP	Interstitial edematous pancreatitis
RAC	Revised Atlanta classification
WON	Walled-off necrosis

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Introduction

Acute pancreatitis (AP) is a common and potentially severe condition. Establishing the diagnosis and prognosis of AP relies particularly on imaging studies and, more specifically, on computed tomography (CT) [1]. The Atlanta classification issued in 1992 [2] used CT findings to classify the manifestations of AP, introducing

standardized terms to designate each and thereby facilitating communication among the various specialists involved in managing patients with AP. However, sources of confusion were identified and poor interobserver agreement reported [3]. Additional reasons for revising the classification were advances in imaging techniques and the introduction of new radiological, endoscopic, and surgical treatment methods [4–6]. The revised Atlanta classification (RAC) was issued in 2012 [7, 8]. It introduces new terminology to designate AP types and stages, collections that develop during AP, and degrees of severity.

The RAC differentiates interstitial edematous pancreatitis (IEP) and necrotizing pancreatitis, which in turn is classified as parenchymal necrosis, peripancreatic necrosis, or both. Pancreatic and peripancreatic collections are named based on two criteria, namely, whether they develop within or after the first 4 weeks and whether they contain fluid only or also solid material [6]. Acute peripancreatic fluid collection (APFC) designates a collection containing fluid only that developed within the first 4 weeks. An acute necrotic collection (ANC) contains both fluid and necrotic material and develops within the first 4 weeks. Collections present after the first 4 weeks and having a well-defined wall are pseudocysts if they contain fluid only and a walled-off necrosis (WON) if they also contain solid material. APFCs and pseudocysts occur in patients with IEP, whereas ANCs and WON are manifestations of necrotizing pancreatitis.

Differentiating fluid collections from collections containing necrotic material, most notably APFCs vs. ANCs during the first month after AP onset, is crucial to determine the type of pancreatitis, optimize outcome prediction, and make the best treatment decisions [9, 10]. The distinction is particularly important in the absence of parenchymal necrosis, as it determines whether the patient has IEP or peripancreatic necrosis alone, two conditions with markedly differing outcomes [11, 12]. During the first week of AP, separating APFCs from ANCs may be challenging [13], because both types of collection may present as more or less homogeneous hypoattenuating areas without contrast enhancement. A 2016 report indicated poor interobserver agreement when the RAC was used to define the type of AP, detect peripancreatic necrosis, and determine the features of collections [14]. In this study, agreement improved with time from symptom onset to CT scanning; however, time to CT was up to 3 months, and the radiologists were not blinded to this variable.

The objective of this study was to assess interobserver agreement when using the RAC to categorize pancreatic and peripancreatic collections on CT scans of patients with AP of less than 4-week duration. We also evaluated potential correlations between type of collection and disease severity.

Materials and methods

This retrospective study was approved by our institutional review board, which waived the requirement for informed consent, in accordance with French legislation on retrospective studies of anonymized data.

Patients

Between January 2014 and December 2015, 352 CTs were performed in 195 consecutive patients older than 18 years and admitted to our hospital for AP. According to the RAC [7], we defined AP as the presence of at least two of the following three features: abdominal pain consistent with AP, serum lipase activity at least 3-fold higher than the upper limit of normal, and imaging findings typical for AP. Of the 352 CTs, 277 were obtained within the first 4 weeks of AP and were reviewed by a radiologist (IB, with 20 years of experience in abdominal CT), who excluded the 82 CTs without peripancreatic abnormalities, 3 CTs performed to assess autoimmune pancreatitis and 14 unenhanced CTs, leaving 178 CTs for the study. Figure 1 is the patient flow chart. The 178 CTs were obtained in 115 patients, including 6 with two AP episodes and 1 with three AP episodes, separated by at least 6 months, with a normal CT in the interval.

The following data were collected from the medical records: sex, age, admission date, time of abdominal pain onset, serum lipase activity upon admission, hospital stay length, cause of AP, need for invasive intervention, organ failure, and in-hospital mortality.

The cases with collections visible by CT were divided into three groups depending on whether time from symptom onset to CT: 0–3, 3–7, and > 7 days.

Each AP episode was classified as mild, moderately severe, or severe based on criteria adapted from the RAC [7]. Patients with mild AP had no organ failure, local complications (e.g., symptomatic collections and venous thrombosis), or systemic complications. Moderately severe AP was defined as the presence of transient organ failure (including systemic inflammatory response syndrome) or of local or systemic complications without persistent organ failure (< 48 h). Persistent organ failure lasting for more than 48 h was the defining characteristic of severe AP.

CT imaging

The entire abdomen and pelvis was scanned, using a 64-detector machine (Lightspeed VCT 64; GE Medical Systems) with 1.375 pitch, 0.7 tube rotation time, 120 kV, and 130 to 700 mA depending on body habitus. Patients without contraindications received an intravenous iodinated contrast agent (Iomeprol, Iomeron 300, Bracco Imaging; or

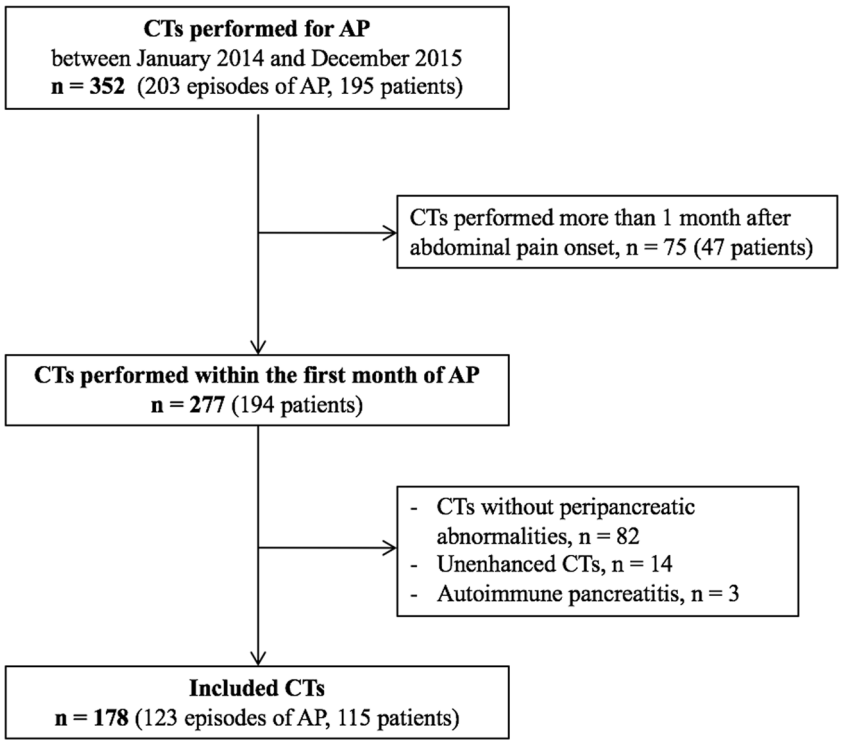

Fig. 1 Flow chart

Iopromide, Ultravist 300, Bayer) in a dose of 1.5 mL/kg at a flow rate of 3 mL/s.

Images were first acquired without contrast material and with a nominal section thickness of 0.625 mm, reconstruction section thickness of 1.25 mm, and 1.25-mm increment. Then, enhanced images were acquired at the pancreatic phase (45 s after injection) and portal phase (70 s after injection), with a nominal section thickness of 0.625 mm, reconstruction section thickness of 1.25 mm, and 1.25-mm increment. Oral contrast material was not used.

Most CTs ($n = 145$, 81%) were triphasic, 23 (13%) were biphasic (unenhanced and portal phase), and 10 (6%) were acquired only in the portal phase. It is our practice to perform an unenhance phase in patients with AP to readily detect biliary stones or parenchymal pancreatic calcifications, and an arterial phase to look for pseudoaneurysms.

Interpretation of CT images

Two senior abdominal radiologists (IM, with 10 years of experience, and LC, with 9 years of experience, hereafter designated readers 1 and 2, respectively) independently reviewed each CT on a dedicated picture archiving and communication system unit (Carestream Vue, version 11.3; Carestream Health). Multiplanar reconstructions were performed using the axial, coronal, and sagittal planes. The radiologists knew that the patients had AP but were unaware of other patient data, including the degree of AP severity.

The CT images were screened for the following signs: peripancreatic fat stranding without collection; peripancreatic collections (existence and number); location and size of the largest collection; content of the collections recorded as homogeneous or heterogeneous; visible collection wall with its features; most appropriate term for designating the collection according to the RAC (APFC or ANC); surface area of parenchymal necrosis (< 30%, 30–50%, or > 50% of total surface area); overall volume of the pancreas; pancreatic calcifications; dilation of the main pancreatic duct recorded as focal or diffuse; pancreatic tumor; and portal, splenic or mesenteric venous thrombosis.

Interobserver disagreements about the presence of fat stranding or peripancreatic collection ($n = 12$, 12/178, 7%) and about the most appropriate term for the collection ($n = 33$, 33/133, 25%) were resolved by consensus developed with a third abdominal radiologist (MZ, 28 years of experience).

Statistics

SAS software version 9.3 (SAS Institute) was used for the statistical analyses. Continuous variables were described as mean and standard deviation if normally distributed and as median and interquartile range otherwise. Categorical variables were described as number and percentage.

Interobserver agreement for each CT finding was assessed by computing the kappa coefficient for binary variables and the weighted kappa coefficient for multi-class variables between the 2 radiologists. Results were interpreted as follows:

$\kappa = 0$–0.20, slight agreement; $\kappa = 0.21$–0.40, fair agreement; $\kappa = 0.41$–0.60, moderate agreement; $\kappa = 0.61$–0.80, substantial agreement; and $\kappa = 0.81$–1.00, almost perfect agreement [15]. The agreement rate between the readers was also calculated for each screened CT sign. Agreement rate regarding the most appropriate term for the collection was assessed according to days from symptom onset to CT (0–2, 3–7, or > 7) by applying the chi-squared test. Consensus reading was not used to compute interobserver agreement but to determine the type of collection when the two readers disagreed. This determination was used for the statistical analysis of correlations between type of collection and clinical outcome.

Associations between the most appropriate term for the collection on the first CT scan in each patient ($n = 123$ CTs) and AP severity were evaluated separately for each reader and for the consensus using the chi-squared test. McNemar's exact test was applied to compare the distribution of AP severity classes for each type of collection, between each individual reader and the consensus.

All statistical tests were two-sided and p values < 0.05 were considered to indicate significant differences.

Results

Patients

We included 115 patients, 69 males and 46 females, who ranged in age from 20 to 92 years (mean age, 58.2 ± 17.3 years; median age, 60; interquartile range (IQR), 45–70 years) and experienced a total of 123 AP episodes. The main causes of AP were gallstones ($n = 39$, 32%) and alcohol abuse ($n = 39$, 32%). The other causes were complications of endoscopic retrograde cholangiopancreatography ($n = 14$, 11%), pancreatic tumor ($n = 4$, 3%), surgery ($n = 4$, 3%), and miscellaneous conditions (hypertriglyceridemia, drugs, and sphincter Oddi dysfunction) ($n = 9$, 7%). No cause was identified in 14 (11%) patients.

Median hospital stay length was 8 days (IQR 5–14 days). Mean time from pain onset to first CT was 3.2 days (median, 3 (2, 3) days). Mean serum lipase activity was 3243 IU/L (median 1491 (411–5116) IU/L). A single patient had infection of a peripancreatic collection. Six (4.5%) patients died during their hospitalization.

Interobserver agreement

Table 1 reports the κ values reflecting interobserver agreement for each CT finding. Agreement was substantial for presence of a collection ($\kappa = 0.80$). Moderate agreement was found for content of the largest collection ($\kappa = 0.51$), most appropriate term for the collection ($\kappa = 0.45$), and parenchymal necrosis ($\kappa = 0.45$).

Table 2 shows the results obtained when interobserver agreement for the most appropriate term for the collection was assessed according to the time from pain onset to CT. The κ values ranged from 0.34 to 0.53 and the percentage of agreement from 65 to 87%. Agreement was lowest between days 3 and 7. Agreement did not vary significantly with time to CT ($p = 0.07$).

Type of collection and clinical outcome

Of the 123 episodes of AP, 6 (5%) did not have an assessment of AP severity, due to missing clinical data. Of the remaining 117 CT scans, 87 (75%) were obtained during mild AP, 25 (21%) during moderately severe AP, and 5 (4%) during severe AP.

The consensual reading detected at least one parenchymal or peripancreatic collection for 97 (97/123; 79%) CTs, including 40 with APFCs and 57 with ANCs. Regarding the consensual reading, the proportion of mild AP episodes was 84% (32/38) when APFCs were seen and 62% (33/53) when ANCs were seen. Corresponding proportions for moderately severe AP were 11% (4/38) and 32% (17/53). These clinical outcome distributions translated into greater severity in patients with ANCs compared to APFCs (Fig. 2), with a nonsignificant trend for reader 2 ($p = 0.09$) and significant differences for reader 1 ($p = 0.03$) and the consensus ($p = 0.04$). No significant differences for clinical outcome distributions were found between the consensus and reader 1 or between the consensus and reader 2 ($p = 0.46$ and $p = 0.71$, respectively) (Figs. 3, 4, 5, and 6).

Discussion

Interobserver agreement was only moderate when the RAC was used to classify pancreatic and peripancreatic collections seen on CT scans during the first month of AP. No improvement in interobserver agreement occurred with increasing time from AP onset to CT. Finally, the type of collection seemed to be associated with AP severity.

Our findings are consistent with a study comparing local radiologists and an expert radiologist, who used the RAC to read CTs obtained within 3 months of AP onset [14]. Interobserver agreement was only fair for peripancreatic necrosis ($\kappa = 0.326$), features of collections ($\kappa = 0.408$), and the most appropriate term for designating collections ($\kappa = 0.356$). In this study [14], agreement was better for CTs obtained at least 2 weeks after AP onset. In contrast, in our study, agreement did not improve with increasing time to CT. This apparent discrepancy may be related to the time frame difference, with CTs included only within the first 4 weeks in our study compared to 3 months in the earlier study. Within 4 weeks, only two types of collections can be found, APFCs and ANCs.

Table 1 Interobserver agreement for CT findings

CT findings	Reader 1	Reader 2	*N* (seen by both readers)	Agreement (%)	Kappa	95% CI
Presence of a collection	141	137	133	166/178 (93.3)	0.80	(0.70–0.91)
Number of collections				86/133 (64.7)	0.70*	(0.62–0.78)
1	35	36	22			
2	39	34	16			
3	18	14	6			
> 3	49	53	42			
Content of the largest collection				105/133 (78.9)	0.51	(0.35–0.67)
Homogeneous	39	47	27			
Heterogeneous	102	90	78			
Presence of a wall	39	55	36	111/133 (83.5)	0.64	(0.51–0.77)
Wall margins				30/36 (83.3)	0.63	(0.37–0.89)
Complete	10	14	9			
Incomplete	26	22	21			
Most appropriate term for the collection				100/133 (75.2)	0.45	(0.30–0.59)
APFC	55	26	24			
ANC	78	107	76			
Parenchymal necrosis	28	41	19	147/178 (81.8)	0.45	(0.29–0.61)
< 30%	22	39				
30–50%	4	2				
> 50%	2	0				
Parenchymal calcifications[$]	29	26	20	161/176 (91.5)	0.68	(0.52–0.83)
Main pancreatic duct dilatation	18	35	17	159/178 (89.3)	0.59	(0.42–0.75)
Type of dilatation				12/17 (70.6)	0.41	(0.01–0.84)
Focal	9	22	6			
Global	9	13	6			
Pancreatic tumor	13	17	9	166/178 (93.3)	0.56	(0.34–0.78)
Portal venous thrombosis	16	9	8	169/178 (95)	0.62	(0.39–0.84)

CT computed tomography, *95% CI* 95% confidence interval

*Weighted kappa

[$] 2 CTs did not include unenhanced acquisitions

When examined after a longer interval, however, patients may have pseudocysts and/or WON, which may be easier to identify. Furthermore, the readers in the earlier study were not blinded to time to CT. However, our finding of worse agreement between days 3 and 7 is unexpected. One possible explanation is selection bias, with a higher proportion of patients with CT within the first 3 days developing ANC.

The low contrast resolution of CT raises challenges in detecting necrotic material within collections. Some measure of subjectivity is involved in assessing whether the content of a collection is homogeneous or heterogeneous as defined in the RAC. The CT findings defined in the RAC to differentiate APFC from ANC are insufficiently precise and do not permit an accurate characterization of peripancreatic collections. This

Table 2 Interobserver agreement for the most appropriate term for designating a collection (APFC or ANC) according to time from pain onset to CT

Timing of CT	Number of CTs	Number of CTs showing collections	Agreement (%)	Kappa	95% CI
0–72 h	63	50	39/50 (78%)	0.53	[0.31–0.76]
Day 3–day 7	76	52	34/52 (65%)	0.34	[0.15–0.52]
> day 7	39	31	27/31 (87%)	0.43	[− 0.02–0.89]
Total	178	133			

CT computed tomography, *95% CI* 95% confidence interval

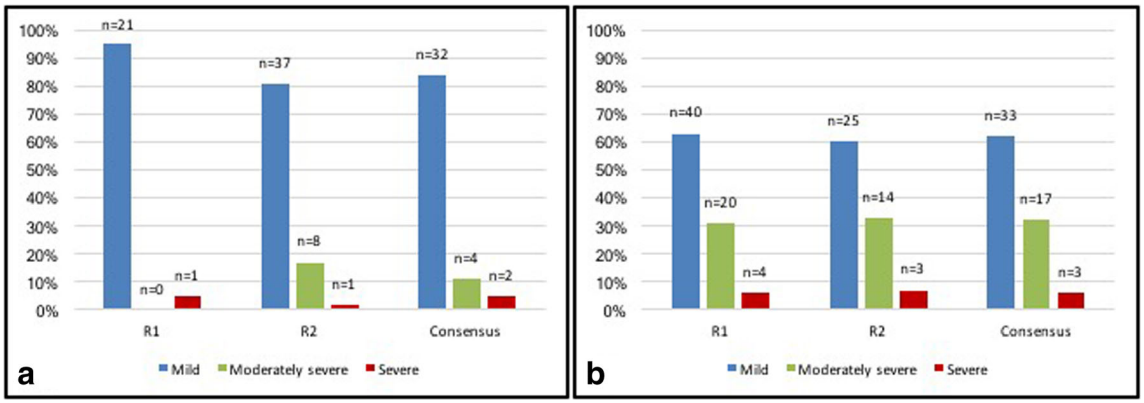

Fig. 2 Percentage of APFCs (**a**) and ANCs (**b**) depending on disease severity. R1: reader 1; R2: reader 2. APFC, acute pancreatic fluid collection; ANC, acute necrotic collection

fact may be the main source of disagreement among observers, as it hinders the distinction between IEP with APFC and necrotizing pancreatitis with peripancreatic necrosis alone. This distinction is important, as the two conditions differ in their prognosis: a good outcome can be expected with IEP, whereas the prognosis of peripancreatic necrosis alone is more severe, although better than that of parenchymal necrosis [11, 12, 16]. Magnetic resonance imaging (MRI) has been found more sensitive than CT for detecting necrotic material [17]. In addition, interobserver agreement was better with MRI than with CT ($\kappa = 0.469$ versus $\kappa = 0.257$) for characterizing peripancreatic collections, particularly after the first month [18].

Previous work has established that the distinction between APFC and ANC is not reliable in the first days, leading to the suggestion that collections identified during this period should be designated "indeterminate peripancreatic collections" [14].

The type of collection seemed to be associated with clinical AP severity in our study. Thus, unsurprisingly, APFCs were more common in mild AP. ANCs were more common than APFCs in the groups with moderately severe and severe AP. In an earlier study [14], the association between AP type (IEP or parenchymal necrosis alone) and clinical outcome was stronger when the CTs were read by an expert instead of local radiologists.

Interobserver agreement in our study was only moderate for detecting absence of parenchymal contrast enhancement. This sign, which indicates parenchymal necrosis, is often the key to diagnosing acute necrotizing pancreatitis and may help to characterize a peripancreatic collection, since any collection in a patient with parenchymal necrosis should be classified as an ANC [7]. However, unenhanced pancreatic areas larger than 3 cm or involving more than 30% of the gland are well known to be diagnosed with greater accuracy than smaller lesions [13], and in our study, parenchymal necrosis usually involved less than 30% of the gland. In the earlier study involving local radiologists [14], mean interobserver agreement was good for detecting parenchymal necrosis but the κ values varied

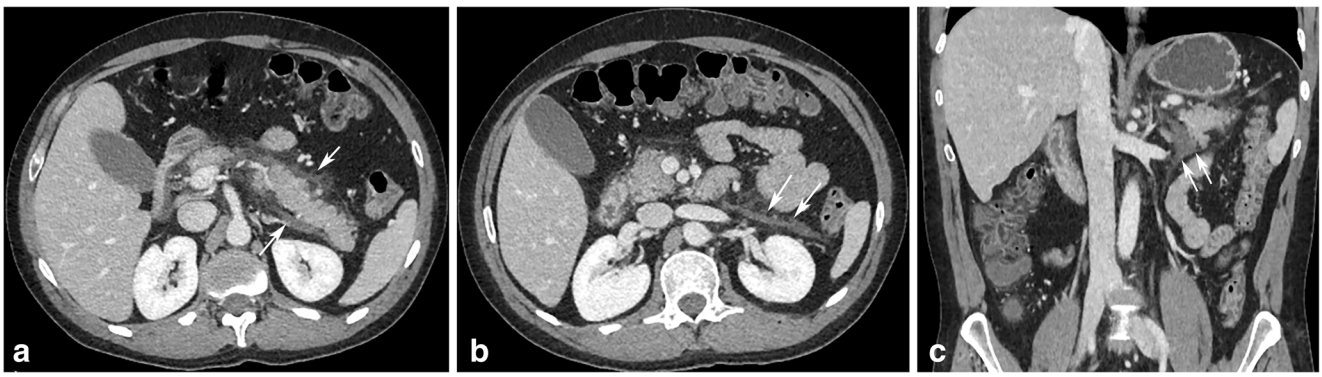

Fig. 3 Acute peripancreatic fluid collections (APFCs): agreement between the two readers. Contrast-enhanced CT images at the portal phase in a 24-year-old man with AP. Axial (**a**, **b**) and coronal images (**c**) on day 1 show homogeneous peripancreatic collections, with fluid density, adjacent to the pancreas (arrows). The two readers agreed on the absence of parenchymal necrosis and on the classification of the collections

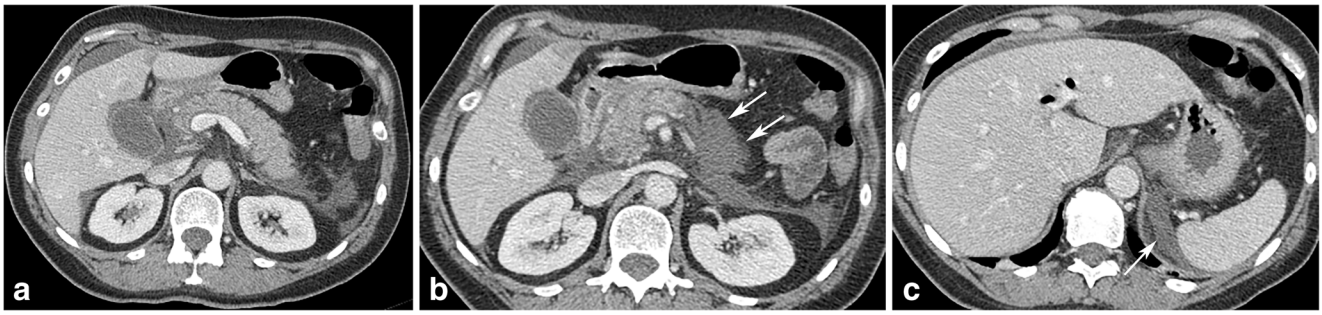

Fig. 4 Acute peripancreatic fluid collections (APFCs): disagreement between the two readers. Contrast-enhanced CT images at the portal phase on day 1 of AP in a 51-year-old woman. Axial images show homogeneous peripancreatic collections (arrows) extending toward the left anterior pararenal space. Both readers agreed on the absence of parenchymal necrosis. Reader 1 classified the collections as ANCs and reader 2 as APFCs. The consensus meeting with the expert radiologist led the collections to be classified as APFCs. Clinically, the AP was classified as moderately severe but the patient was discharged on day 3

widely across individual readers, from 0.319 to 0.731. In the future, the development of advanced techniques such as spectral imaging and perfusion imaging may improve agreement. For instance, perfusion CT obtained within 72 h of severe AP onset performed well in predicting parenchymal necrosis, with 87.5% sensitivity and 100% specificity compared to conventional contrast-enhanced CT obtained after 3 weeks [19]. Similar findings were reported in 2007 for perfusion CT [20] and in 2014 for subtraction CT mapping [21]. Dual-energy CT provides better contrast resolution that may help to detect parenchymal necrosis [22].

Agreement between readers was moderate for detecting parenchymal calcifications and pancreatic duct dilatation. These results may have been influenced by the low prevalence of both signs.

Our study has several limitations. First, the design was retrospective. Second, no reference standard was used to determine the best terms for collections. Accurately determining the content of the collections (i.e., fluid and/or

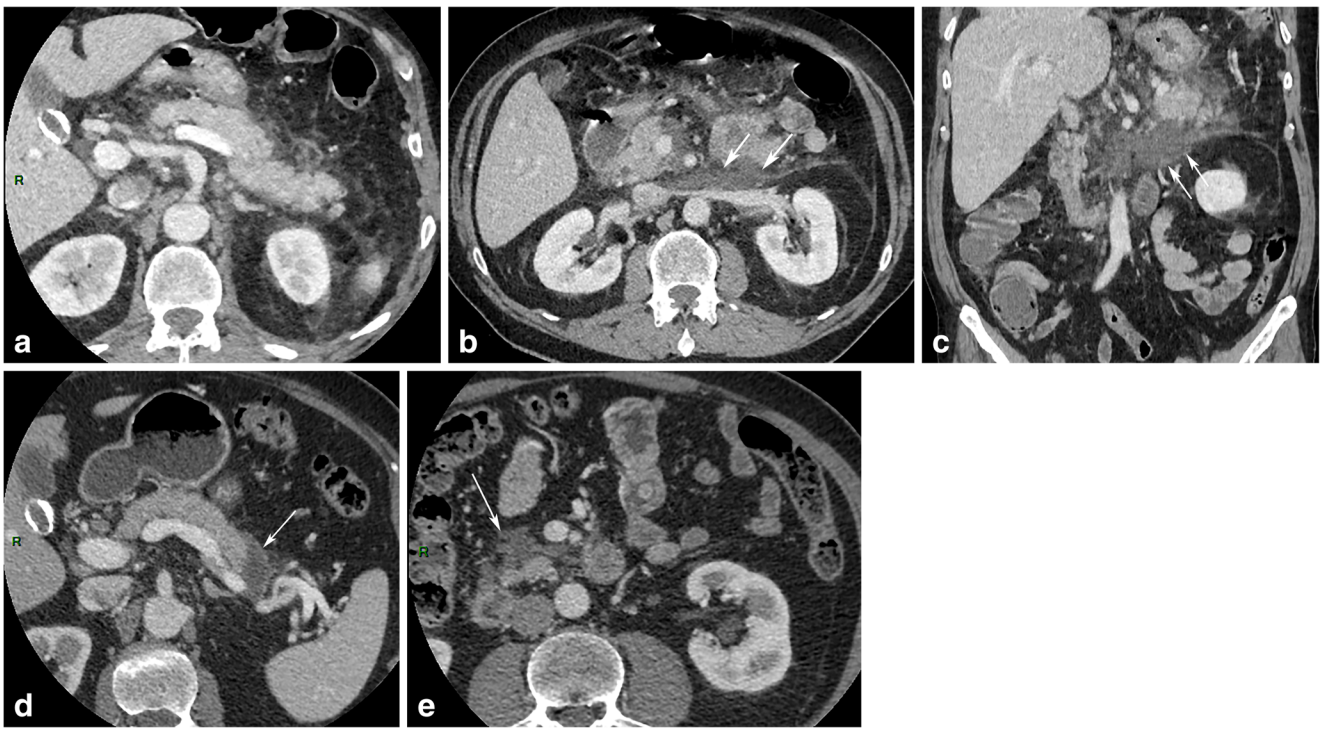

Fig. 5 Acute necrotic collections (ANCs): disagreement between the two readers. Contrast-enhanced CT images at the pancreatic phase (**a**, **d**, **e**) and portal phase (**d**, **c**) of AP in a 74-year-old man. On day 4, axial (**a**, **b**) and coronal images (**c**) show slightly heterogeneous, peripancreatic collections (arrows). Both readers agreed on the absence of parenchymal necrosis. Reader 1 classified the collections as ANCs and reader 2 as APFCs. The follow-up CT (**d**, **e**) performed 5 weeks after AP onset shows walled-off necrosis (arrows) indicating necrotizing AP

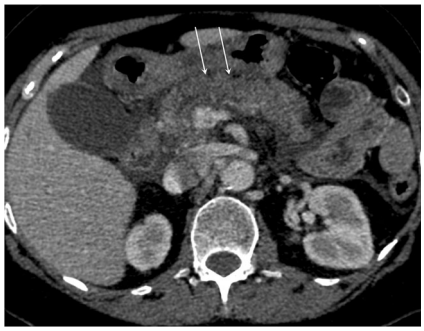

Fig. 6 Parenchymal necrosis: disagreement between the two readers. Contrast-enhanced CT image at the portal phase on day 1 of AP in a 68-year-old woman. According to reader 1, there is parenchymal necrosis in the pancreas body (arrows). For reader 2, there is not parenchymal necrosis. The consensus meeting led to the presence of necrosis. Clinically, the AP was classified as mild, and the endoscopic ultrasonography shows parenchymal necrosis

solid) would have required routine aspiration, which would have been unethical, or MRI, which was not available at the time. Follow-up investigations are not a good reference standard in this case. For instance, resolution of a collection after 4 weeks does not prove that the collection was an APFC. Third, flares of AP in patients with chronic pancreatitis were not excluded. This point may have induced classification bias, as collections may have developed during earlier flares. However, as only 9% of our patients had chronic pancreatitis, any bias would not have substantially affected our findings. Fourth, 63 patients (35%) were examined by CT in the first 3 days, suggesting that selection bias may have occurred if early CT was performed because of more severe clinical picture. The recommended time for assessing AP by CT is 72 h after symptoms onset [6]. Earlier CT has low yield and no implications for clinical management [23].

In conclusion, our study shows a moderate interobserver agreement when using the RAC to categorize pancreatic and peripancreatic collections by CT, suggesting a need for either developing a new semiology to characterize peripancreatic collections by CT or for using another imaging modality such as MRI to better analyze collection contents.

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Compliance with ethical standards

Guarantor The scientific guarantor of this publication is Marc Zins.

Conflict of interest The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

Statistics and biometry One of the authors has significant statistical expertise.

Informed consent Written informed consent was waived by the Institutional Review Board.

Ethical approval Institutional Review Board approval was obtained.

Methodology
- retrospective
- observational
- performed at one institution

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