



Acute pancreatitis: an update on the revised Atlanta classification

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Abstract

Acute pancreatitis (AP) is the most common gastrointestinal disease resulting in hospitalization in the United States with reports of over 270,000 hospitalizations and costs up to 2.6 billion dollars per year. AP is highly variable in disease course and outcome. Established in 1992, the original Atlanta classification system aimed to categorize the wide spectrum of AP by creating consensus-based terminology for AP types, severity, and complications. Though the original system standardized terminology, certain terms and definitions (i.e. pancreatic abscess) were unclear and often misused. The 2012 revised Atlanta classification (RAC) system updated terms, clarified definitions, and incorporated the medical community's improved understanding of the physiology of AP. The resulting RAC effectively defined the morphologic types of pancreatitis, provided a more standardized system for disease severity grading, further classified the local retroperitoneal complications, and established objective measures to describe this highly variable but common disease. This review provides an update on the recent literature evaluating the RAC, discusses both the strengths and shortcomings of the RAC system (including problematic interobserver agreement), and considers improvements for future classification systems.

Keywords Acute pancreatitis · Revised Atlanta classification · Severity grading · Imaging appropriateness

Introduction

Acute pancreatitis (AP) is the most common gastrointestinal disease resulting in hospitalization in the United States with reports of over 270,000 hospitalizations and costs up to 2.6 billion dollars per year [1, 2]. AP is a highly variable disease, ranging from brief, self-resolving episodes to multimonth-long admissions complicated by multiorgan failure and widespread infection. Gallstones are the most common cause of AP in the United States, followed by alcohol [3]. The 1992 original Atlanta classification system for AP created consensus-based terminology for types, severity, and complications of AP. After 20 years of application, the revised Atlanta classification (RAC) was established to clarify terminology and more specifically categorize AP and its complications. In the time since the RAC was

established, the literature has revealed its strengths primarily in its well-defined diagnostic criteria, outline of temporal relationships for local complications, and distinct three-tiered severity grading. Though the literature has edified the RAC's strengths, it has also uncovered apparent shortcomings including interobserver variability in interpreting local complications, limitations of a three-tiered severity grading system that does not incorporate infection, and a non-uniform system for determining organ failure and severity.

Purpose of the original Atlanta classification

Established in 1992, the original Atlanta classification system for AP created consensus-based terminology for types, severity, and complications of AP. These definitions were determined by 40 diverse pancreatitis professionals including gastroenterologists, radiologists, and surgeons, among others over the course of a 3-day meeting. The purpose was to create “a clinically-based classification system for AP” to be used not only by radiologists, but also by managing physicians and researchers alike [4].

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Why revision was necessary

After the original Atlanta classification, improved understanding of disease evolution and progression, advances in imaging, and misuse of terminology indicated to the pancreas community a need for revision. While advances in contrast-enhanced computed tomography (CECT) and magnetic resonance imaging (MRI) have improved radiologic identification and characterization of AP, better defined clinical parameters and acumen for diagnosing pancreatitis reduced the need for early imaging except in select cases [5, 6]. Additionally, persistently ambiguous terminology from the original classification and heterogeneous use of terms became a means of controversy within the field [7]. In 2012, 20 years after the original classification was established, the revised Atlanta classification (RAC) was published [8]. The RAC updates terminology, definitions, and types of complications of AP (Table 1). With a similar purpose, the RAC aimed to clarify the previously established universal classification system while integrating updated terminology of local complications and severity grading.

Changes in revision from original

The RAC updates were created to improve the universal usability of the system. The RAC defines diagnostic criteria for AP, including establishing onset, distinguishes between morphologic types, divides the disease course into distinct phases, establishes specific severity categories, and clarifies the terminology for local retroperitoneal complications identified by imaging.

Diagnosis and types

The RAC establishes a clear definition of AP diagnostic criteria. AP is diagnosed by any two of the following criteria: (1) characteristic epigastric abdominal pain, (2) serum lipase and/or amylase greater than 3 times the upper limit of normal, and (3) evidence of AP on imaging [8]. Thus, the diagnosis of AP no longer warrants imaging confirmation if the first two clinical criteria are met.

The original Atlanta classification also failed to provide a distinction between types of AP, stating only that “pathologic changes in AP represent a continuum, with interstitial edema and minimal histologic evidence of necrosis at the minor end of the scale and confluent macroscopic necrosis

Table 1 Revised Atlanta classification (RAC) terminology and corresponding definitions

RAC terminology	
Term	Definition
Onset	Time of onset of <i>abdominal pain</i>
Early phase	< 1 week after onset
Late phase	> 1 week after onset
Acute complication	Occurs < 4 weeks after onset. Includes acute peripancreatic fluid collection and acute necrotic collection
Delayed complication	Occurs > 4 weeks after onset. Includes pancreatic pseudocyst and walled-off necrosis
Mild AP	No organ failure, usually short course and self-resolving
Moderately severe AP	Transient (< 48 h) organ failure and/or local complications
Severe AP	Persistent (> 48 h) organ failure, often includes local and systemic complications
Interstitial edematous AP	Type of AP characterized by diffuse inflammation and enlargement of the pancreas. CECT with <i>homogenous enhancement</i> of parenchyma often with peripancreatic fat stranding. Lower mortality, usually mild and self-limiting
Necrotizing AP	Type of AP characterized by necrosis of pancreatic parenchyma and peripancreatic tissues. CECT with <i>unenhanced/minimally enhanced</i> hypodense areas within the parenchyma, in peripancreatic tissues only, or both. Higher mortality and level of severity
Acute peripancreatic fluid collection	Acute complication of interstitial edematous AP characterized by a collection of homogenous fluid <i>without necrosis or a defined wall</i>
Acute necrotic collection	Acute complication of necrotizing AP characterized by a collection of <i>both fluid and necrosis without a defined wall</i>
Pancreatic pseudocyst	Delayed complication of interstitial edematous AP characterized by a <i>well-defined, encapsulated collection of homogenous fluid with little-to-no necrosis</i>
Walled-off necrosis	Delayed complication of necrotizing AP characterized by <i>well-defined encapsulated collection of fluid and necrosis of the pancreatic parenchyma, the peripancreatic retroperitoneal fat, or both</i>

AP acute pancreatitis, CECT contrast-enhanced computed tomography

at the other extreme” [4]. The RAC divides AP into two morphologic types: interstitial edematous AP and necrotizing AP (Fig. 1). It subsequently emphasizes differences in severity and outcomes by type. Interstitial edematous AP represents 85% of AP with a low mortality rate of only 3% [9]. It is characterized by diffuse inflammation and enlargement of the pancreas with homogenous pancreatic parenchymal enhancement on CECT, usually with stranding of peripancreatic fat [8, 10]. It is classically mild and self-limited, often resolving within 1 week without intervention [8]. Complications of interstitial edematous AP are usually local and include acute peripancreatic fluid collection (APFC) and sometimes subsequent pancreatic pseudocyst.

Necrotizing AP represents 15% of AP with a much higher mortality rate of 17%, which rises to 30% if infected necrosis is present [9]. Necrotizing AP involves necrosis of pancreatic parenchyma and peripancreatic tissues with unenhanced or minimally enhanced hypodense areas within the parenchyma, in the peripancreatic tissues only, or most often both on CECT [10]. Clinical complications of necrotizing AP are many, including local complications such as acute necrotic collection (ANC) and subsequent walled-off necrosis (WON), and systemic complications including organ failure, pancreatic and/or extra-pancreatic infection, and exacerbation of pre-existing disease [11, 12].

Phases

The RAC additionally establishes two distinct phases of AP that have important management implications, an early phase and a late phase. The early phase is the first week following onset of clinical symptoms. The late phase is the time after the first week. Each phase is characterized by distinct clinical, radiologic, and pathologic features and challenges.

Early phase

The early phase is defined by a systemic inflammatory response to pancreatic injury and typically lasts 1 week. Early phase assessment includes recording the time of onset, evaluating if the patient meets diagnostic criteria, and, most importantly, determining the presence and duration of organ failure. Onset is defined as the initial onset of abdominal pain and serves as an important measure for duration of organ failure [8]. Organ failure is defined as cardiovascular, respiratory, and/or renal failure. The RAC recommends use of the modified Marshall scoring system over the Sequential Organ Failure Assessment (SOFA) score, which is applied only in critical care settings [8]. The modified Marshall score utilizes FiO₂ (respiratory), serum creatinine (renal) and systolic blood pressure (cardiovascular) to assign a score. A score greater than or equal to 2 qualifies as organ failure [8, 13]. A meta-analysis by Petrov et al. showed a mortality rate of 30% in patients with AP and organ failure [14]. Making a definitive diagnosis of acute pancreatitis and excluding other common pathologies with upper abdominal pain (cholecystitis, peptic ulcer disease, etc.) is important in order to begin treatment promptly [15]. Importantly, cross sectional imaging is less useful during the early phase, particularly within the first 72 h, as the extent of disease and local complications are evolving and may not be fully apparent (Fig. 2) [6, 16].

Late phase

The late phase involves continued monitoring for local complications and worsening systemic disease. Patients with moderately severe and severe pancreatitis tend to have more local and systemic complications, with organ failure most common in severe cases. Imaging, particularly CECT, has

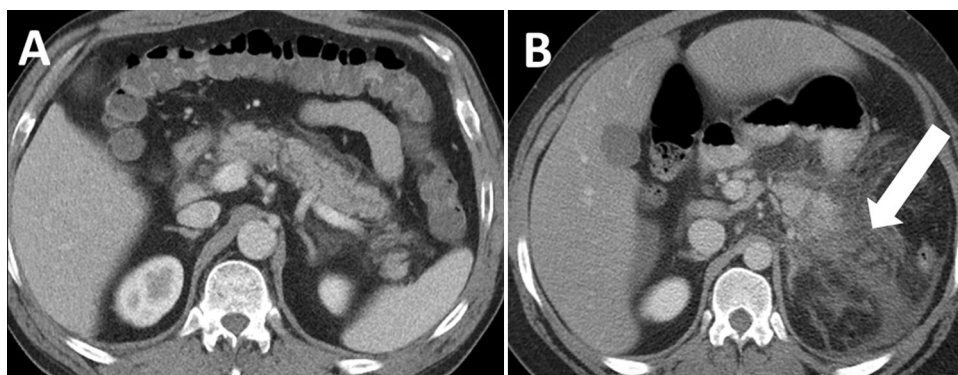


Fig. 1 Interstitial edematous AP compared to necrotizing AP. **a** Intravenous contrast-enhanced CT (CECT) axial image in a 49-year-old man with ethanol induced acute pancreatitis with onset 2 days prior shows a diffusely edematous pancreas with peripancreatic stranding, consistent with interstitial edematous AP. **b** CECT axial image in a

27-year-old man with 1 week history of abdominal pain demonstrates a diffusely edematous pancreas with peripancreatic stranding but also geographic, markedly diminished enhancement in the pancreatic tail (arrow), consistent with acute necrotizing pancreatitis



Fig. 2 Increased value of imaging over time. **a** CECT obtained 1 day after symptom onset in a 56-year-old man shows peripancreatic fat stranding and fluid most consistent with acute interstitial edematous pancreatitis. Areas of hypoenhancement or necrosis are not seen. **b** Six days after onset, the patient developed bilateral flank pain and Grey Turner sign. CECT now shows severe necrotizing pancreatitis

with only a small amount of residual enhancing pancreatic parenchyma in the head/uncinate process. **c** Three weeks after onset, CT demonstrates ANCs. The largest collection extends into the left retroperitoneum and measures 28.9×12.2 cm. No residual enhancing pancreatic tissue is identified

value during the late phase as local complications become more evident with time. Persistent organ failure and systemic complications are continually managed while imaging aids medical decision-making. By defining specific phases and emphasizing the importance of diagnosis and severity grading, the RAC offers greater guidance for clinical and imaging decision-making and provides an objective framework for the management of a highly variable disease.

Severity grading

Arguably the most impactful change in the revised criteria, the RAC establishes a three-tiered severity grading system. The grading system is divided into mild, moderately severe, and severe AP based on the presence and duration of organ failure. Mild AP is defined by no organ failure and typically has a short, self-resolving course. Moderately severe AP is defined by transient organ failure (present for less than 48 h) and/or local complications. Severe AP is defined by persistent organ failure (present for greater than 48 h) often with local and systemic complications [8]. Persistent organ failure is associated with higher mortality and increased risk of local complications, thus requiring management that is more aggressive [12, 17].

Approximately, 15–20% of AP episodes will progress to severe AP [3]. The majority of severe AP have necrotizing AP, whereas only 1–3% of interstitial edematous AP progress to severe cases [18]. Severe AP has a mortality of 15–30% compared to mild AP which has a mortality of 0–1% [19]. In the setting of severe necrotizing AP, infected necrosis can further increase mortality twofold [14]. This updated severity grading and implementation of evidence-based organ failure scoring systems have created an objective and consistent stratification to guide disposition and management; in contrast the original classification

described “mild AP” and “severe AP” based on the presence (severe) or absence (mild) of organ failure.

Local complications

The original Atlanta classification defined local complications such as “acute fluid collections”, “acute pseudocyst” and “pancreatic abscess” [4]. While the establishment of universal terminology was valuable, misuse of these terms and poor interobserver agreement made a revision necessary [20–22]. Local complications are identified and monitored by imaging, particularly CECT. They can be divided into acute (<4 weeks after onset) vs. delayed (>4 weeks after onset) complications, and are typically dependent on whether interstitial edematous AP or necrotizing AP were present at the outset.

Acute

The original classification described “acute fluid collections” as an early complication of AP yet did not differentiate the contents of such fluid collections. As defined by the RAC, acute local complications occur within 4 weeks from onset and include APFC and ANC [8]. APFC occurs in interstitial edematous AP and is characterized by a collection of homogenous fluid without evidence of necrosis or a defined wall (Fig. 3). ANC occurs in necrotizing pancreatitis and is characterized by a collection of both fluid and necrosis without a defined wall (Fig. 4). When the necrosis involves the pancreatic parenchyma, distinguishing a collection as an ANC is easier than when the ANC is limited to the peripancreatic tissues alone (Fig. 3b).

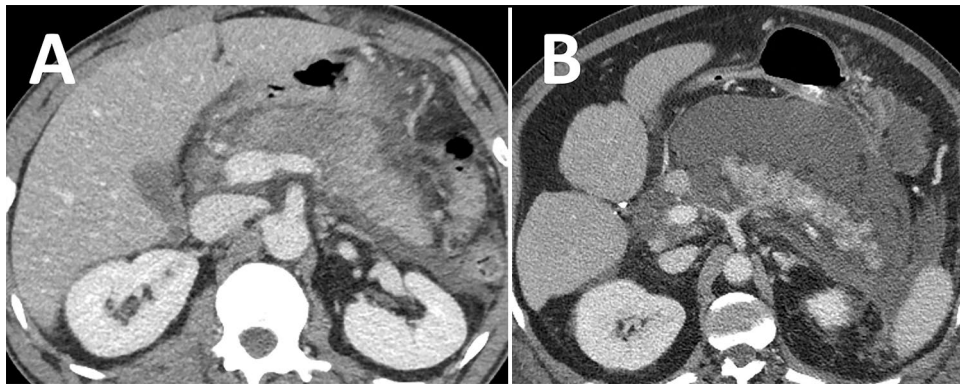


Fig. 3 Acute peripancreatic fluid collections (APFC). Two examples of patients with interstitial edematous AP with APFCs. **a** Axial CECT image in a 46-year-old man 1 day after symptom onset shows an APFC surrounding the pancreas and tracking into the left anterior

pararenal space. **b** In a different patient, a 58-year-old man 5 days after symptom onset, an APFC is seen surrounding the pancreas and incorporating foci of retroperitoneal fat suggesting that extra-pancreatic necrosis is developing

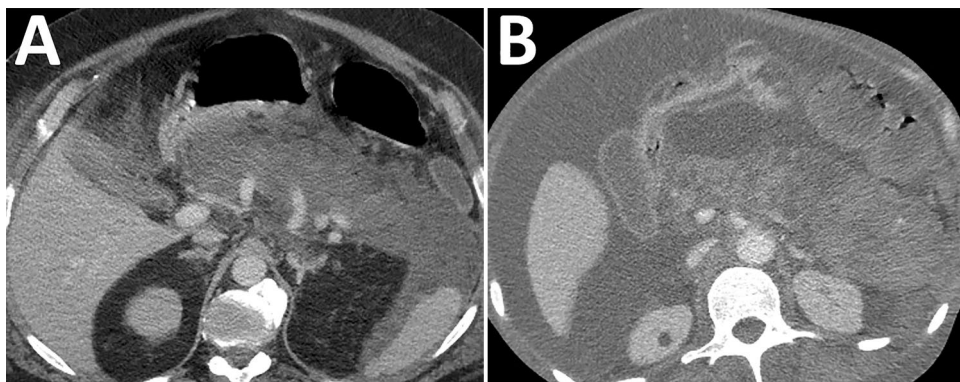


Fig. 4 Acute necrotic collections (ANC). Two examples of patients with necrotizing AP with ANC. **a** Axial CECT image in a 58-year-old man obtained 7 days after symptom onset demonstrates replacement of the entire pancreas with a non-enhancing, hypodense collection with poorly defined margins, consistent with an ANC. **b** Axial image

CECT in a 28-year-old woman obtained 2 weeks after symptom onset demonstrates severe necrotizing AP with associated surrounding hemorrhage, hemoperitoneum, and a low attenuation collection anterior to the pancreatic head

Delayed

Late complications arise greater than 4 weeks after onset and include pancreatic pseudocyst and walled-off necrosis. A pancreatic pseudocyst occurs in interstitial edematous AP and is characterized by a well-defined, encapsulated collection of homogenous fluid with little-to-no necrosis (Fig. 5). Walled-off necrosis is present in necrotizing AP and is characterized by a well-defined encapsulated collection of fluid and necrosis of the pancreatic parenchyma, the peripancreatic retroperitoneal fat, or both (Fig. 6). The original Atlanta classification and the RAC describe the composition and timing of pseudocyst development (> 4 weeks after onset) similarly; however, use of the term “acute” in the original classification is not consistent with this longer course of development and was dropped. Possibly the most controversial term established in the original Atlanta classification,

“pancreatic abscess” was previously described as a well-circumscribed non-necrotic collection of pus, typically developing greater than 4 weeks after onset [4]. This was a separate entity from infected necrosis in that it required positive bacterial or fungal cultures *in the absence of* a necrotic source. Often the term pancreatic abscess was inaccurately used to describe an infected necrotic collection. In practice, a true pancreatic abscess is very rare [22]. Thus, the term pancreatic abscess has been abandoned in the RAC.

Application

Though not intended as a management guide, the RAC has affected practice by emphasizing: (1) diagnostic criteria, (2) severity grading, and (3) classification of local complications.

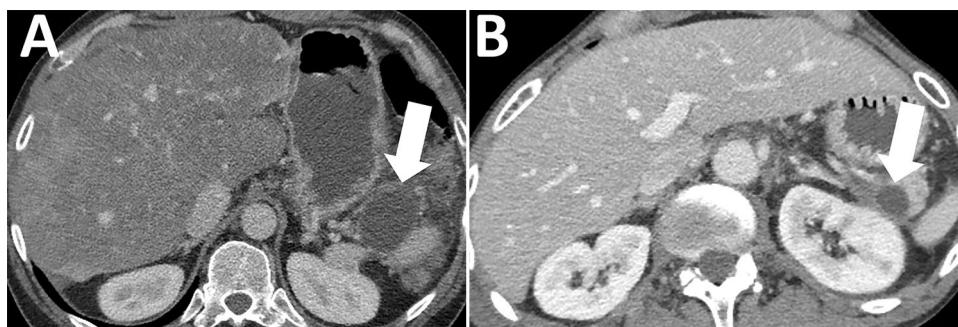
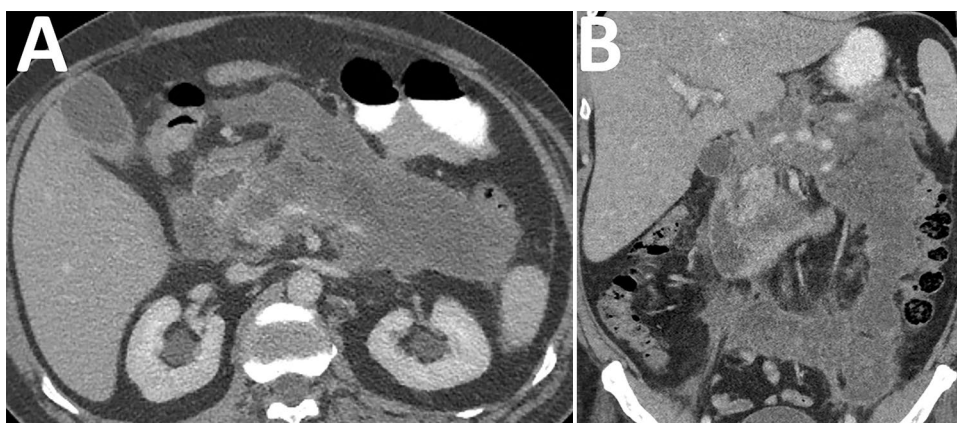


Fig. 5 Pancreatic pseudocyst. Two patients with interstitial edematous AP with development of pancreatic pseudocysts. **a** Axial CECT image obtained 1 month after symptom onset in a 49-year-old man shows a well-demarcated uniform low attenuating lesion in the

pancreatic tail consistent with a pancreatic pseudocyst (arrow). **b** 52-year-old male with history of interstitial edematous AP onset 6 weeks earlier reveals a 1.7 cm pseudocyst (arrow) in the pancreatic tail

Fig. 6 Walled-off necrosis (WON). 52-year-old male 5 weeks after onset of necrotizing AP with WON involving the pancreatic body and tail that extends towards the splenic hilum laterally and along the left anterior pararenal space inferiorly seen on **a** axial CECT and **b** coronal reformatted image



Establishing a definitive diagnosis

The RAC's diagnostic criteria of AP provide an objective outline that physicians, radiologists, and researchers can apply easily. These criteria allow practitioners to diagnose AP without imaging, sparing the patient from unnecessary radiation exposure and reducing healthcare costs. Both the American College of Gastroenterology and the American College of Radiology Appropriateness Criteria recommend performing CECT and/or magnetic resonance imaging (MRI) only in patients with an unclear diagnosis or who do not improve within 48–72 h of admission [23, 24]. Additionally, studies show that early imaging rarely affects management in uncomplicated cases [6, 25]. In a study excluding patients with severe pancreatitis, Reynolds et al. showed that while 63.3% of patients with suspected pancreatitis were imaged, imaging affected management in only 1.2% of patients [16]. Despite these criteria set forth in the RAC, Shinagare et al. showed that over half of patients who met AP diagnostic criteria without imaging, underwent imaging regardless [5] and others stress

that physicians need to actively apply specified diagnostic criteria in their medical decision-making [26].

Severity guides management

Given that the RAC severity grading system in the first week is primarily based on the presence or absence of organ failure, it is imperative to assess organ failure status at presentation. The RAC recommends use of the modified Marshall scoring system to determine organ failure. A variety of other scoring systems are often applied to predict severity and guide early management, including the Acute Physiology and Chronic Health Evaluation (APACHE) II, Ranson criteria, Computed Tomography Severity Index (CTSI), Bedside Index of Severity in AP (BISAP), and Systemic Inflammatory Response System (SIRS) criteria. Organ failure in AP is associated with higher mortality and can occur early or late in disease [14, 17, 27]; and different scoring systems may be used at different times in the patient's illness. Despite widespread use of prediction scores, there is no standardized severity prediction scoring system and the clinical utility of these systems is unclear [28]. However scored, all cases of

severe AP should be managed in an intensive care or high acuity unit with close monitoring [29, 30]. Contrast this to mild AP, which is typically managed with supportive care only.

Ignatavicius et al. showed that compared to the two-tiered original Atlanta classification, the RAC three-tiered system is more accurate and better at predicting complications, treatment needs, and outcomes in patients with AP [31]. Also established in 2012, the determinant based classification (DBC) of AP is based on local (necrosis, infection) and systemic (organ failure) determinants to divide severity into four groups: mild, moderate, severe, and critical [32]. This classification is based on similar principles to the RAC, and both have been shown to predict mortality and ICU admission better than the original Atlanta classification [33]. Despite similar results, the DBC is less frequently used as it is dependent on imaging, whereas the RAC suggested Marshall score is easily applied in the clinical setting alone [34].

Clarifying complications

The updates in classification and terminology of local complications have clarified confusing and misused terms

from the original classification. Studies have shown inter-observer agreement to be fair to moderate for classifying local complications [35–37]. This represents an improvement from the original Atlanta classification, which had poor interobserver agreement for identification of peripancreatic fluid collections [20]. The timing of imaging is also an important consideration. Sharma et al. showed that local complications are detected more frequently when CECT is performed greater than 5 days after onset and that performing earlier CECT does not affect overall surgical management or mortality [25]. In addition to CECT, MRI is an effective method for evaluating small collections, establishing relationship of collections to ductal anatomy, and most importantly for identification of pancreatic fat and debris within necrotic collections that appear uniformly low in attenuation on CT [38, 39]. Kamal et al. found that interobserver agreement for walled-off necrosis or pseudocyst was fair using CT but moderate using MRI [39]. Thus, MRI in addition to CECT can improve characterization of complicated pancreatic fluid collections and in particular help guide management (Fig. 7).

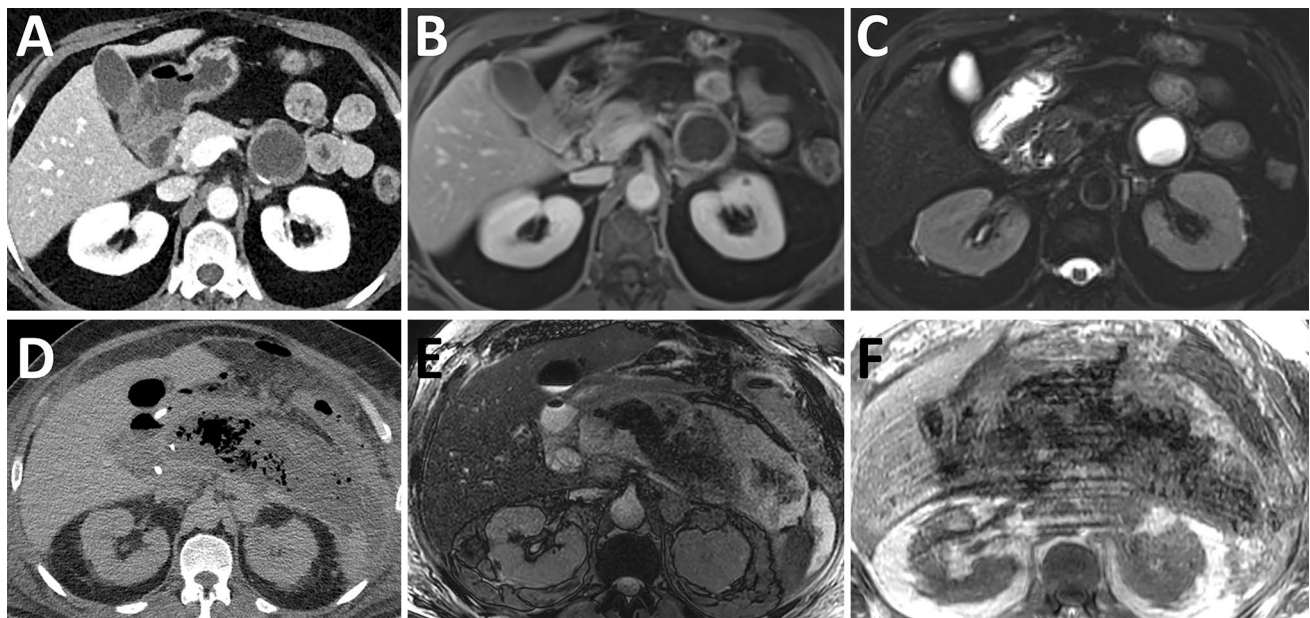


Fig. 7 MRI in addition to CECT can improve characterization of complicated pancreatic fluid collections. Top row, 60-year-old female with history of interstitial edematous AP. **a** Axial CECT 7 months after symptom onset shows a 3.8×3.8 cm cystic lesion in the tail of the pancreas with thin peripheral calcification posteriorly. **b** T1-weighted and **c** T2-weighted axial MR images of the abdomen with and without contrast, respectively, confirm that the lesion is a pancreatic pseudocyst. Axial T1 post gadolinium image reveals a well-defined wall and axial T2 weighted image demonstrates a fairly uniform hyperintense lesion within the pancreatic tail with minimal amount of dependent debris. Bottom row, 64-year-old man with acute

necrotizing pancreatitis onset 6 weeks prior, now unable to receive iodinated IV contrast secondary to renal failure. **d** Axial unenhanced CT image shows a gas and fluid density collection replacing the pancreas, consistent with infected walled-off necrosis. **e** The extent of necrosis of the gland within the complex collection is more completely demarcated on the balanced turbo field echo axial image where the pancreatic sequestrum is seen amongst the fluid and retroperitoneal fat also incorporated into the collection; note that the gas is less well depicted on this series but easily detected on **f**, the unenhanced T1 mDIXON image

Shortcomings of the RAC

Though the RAC has made improvements in diagnosis, classification, and management of AP, further refinements may be made. While the RAC clarifies terminology of local complications, interobserver agreement has been less than optimal and variable among studies. Sternby showed only fair interobserver agreement for fluid collections [37], Badat et al. showed moderate interobserver agreement for detection of local complications within the first 4 weeks of disease, and Bouwense et al. reported good agreement [35, 36]. Further evaluation of interobserver agreement using larger sample sizes may shed light on the variations in results, as each of these studies evaluated a set of less than 400 CTs. Additionally, experts have better interobserver agreement than nonexpert radiologists and clinicians for determining local complications [36, 37]. However, since the purpose of the RAC was to establish a universal classification system, the usability of the system could be improved so that experts and nonexperts alike can utilize the terms accurately.

Severity grading affects management and risk stratification; however, severity prediction scoring systems are left to the discretion of the managing practitioner. This may create high variability in the initial (first 48 h) assessment and management decisions for patients. Multiple studies have shown APACHE II to be superior to others, with a higher predictive value and accuracy [40–42]. However, there is evidence that BISAP may be easier to apply in the emergency setting than APACHE II due to its simplicity [43]. Other studies have shown that APACHE II and BISAP perform similarly for predicting severity and mortality [44, 45]. Alternatively, the International Association of Pancreatology and the American Pancreatic Association recommend SIRS to predict severe AP on admission [30]. A systematic review by Di et al. evaluated 18 scoring systems, concluding that variations in sensitivity and specificity across studies make the utility of them uncertain [28]. In current practice, the decision regarding the severity prediction tool used is left to the discretion of the provider. Given the conflicting evidence, application of a universal prediction tool could be considered.

Suggestions have also been made to expand the severity grading system. Talukdar et al. showed that patients with early severe AP and patients with moderately severe AP with infected necrosis have disease that behaves more aggressively than the groups to which they were originally assigned [46]. Additionally, Choi et al. determined that mortality significantly increases in patients with severe AP plus infected necrosis vs. those without infected necrosis [47, 48]. Thus, the severity grading system may benefit from further stratification based on the presence of infected necrosis that develops over time.

Future directions

Future directions for the RAC include development of a standard severity prediction scoring system, an expanded severity grading system with assessment at other time points, and imaging techniques with better-defined descriptions of retroperitoneal collections that aid in consistent interpretations across all experience levels and medical disciplines. Larger studies and meta-analyses on severity prediction models could provide insight into the best model for guiding patient disposition. An expanded severity grading system including stratification for infected necrosis may improve our understanding and expectations regarding patient outcomes [47, 48]. Further, while the usability of the current system is far superior to the older Atlanta classification, there is variability among general and subspecialty radiologists and other clinicians in the interpretations of fluid collections and complications [36, 37]. Establishing widespread use of terminology and simplifying identification of such complications could improve medical communication and research goals.

Compliance with ethical standards

Conflict of interest The authors have no conflict of interest to disclose.

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