American College of Radiology
ACR Appropriateness Criteria®
Acute Pancreatitis

Variant: 1 Suspected acute pancreatitis. First time presentation. Epigastric pain and increased amylase and lipase. Less than 48 to 72 hours after symptom onset. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
US abdomen	Usually Appropriate	O
US duplex Doppler abdomen	May Be Appropriate	O
MRI abdomen without and with IV contrast with MRCP	May Be Appropriate	O
MRI abdomen without IV contrast with MRCP	May Be Appropriate	O
CT abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢
US abdomen with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 2 Suspected acute pancreatitis. Initial presentation with atypical signs and symptoms; including equivocal amylase and lipase values (possibly confounded by acute kidney injury or chronic kidney disease) and when diagnoses other than pancreatitis may be possible (bowel perforation, bowel ischemia, etc.). Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI abdomen without and with IV contrast with MRCP	Usually Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
US abdomen	May Be Appropriate	O
US duplex Doppler abdomen	May Be Appropriate	O
MRI abdomen without IV contrast with MRCP	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
US abdomen with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 3 Acute pancreatitis. Critically ill, systemic inflammatory response syndrome (SIRS), severe clinical scores (eg, Acute Physiology, Age, and Chronic Health Evaluation [APACHE]-II, Bedside Index for Severity in AP [BISAP], or Marshall). Greater than 48 to 72 hours after onset of symptoms.

Procedure	Appropriateness Category	Relative Radiation Level
MRI abdomen without and with IV contrast with MRCP	Usually Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
US duplex Doppler abdomen	May Be Appropriate	O
MRI abdomen without IV contrast with MRCP	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
US abdomen	Usually Not Appropriate	O
US abdomen with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 4 Acute pancreatitis. Continued SIRS, severe clinical scores, leukocytosis, and fever. Greater than 7 to 21 days after onset of symptoms.

Procedure	Appropriateness Category	Relative Radiation Level
MRI abdomen without and with IV contrast with MRCP	Usually Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
US abdomen	May Be Appropriate	O
US duplex Doppler abdomen	May Be Appropriate	O
MRI abdomen without IV contrast with MRCP	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
US abdomen with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 5 Known necrotizing pancreatitis. Significant deterioration in clinical status, including abrupt decrease in hemoglobin or hematocrit, hypotension, tachycardia, tachypnea, abrupt change in fever curve, or increase in white blood cells.

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
US abdomen	May Be Appropriate	O
US duplex Doppler abdomen	May Be Appropriate	O
MRI abdomen without and with IV contrast with MRCP	May Be Appropriate	O
MRI abdomen without IV contrast with MRCP	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
US abdomen with IV contrast	Usually Not Appropriate	O

Variant: 6 Acute pancreatitis. Known pancreatic or peripancreatic fluid collections with continued abdominal pain, early satiety, nausea, vomiting, or signs of infection. Greater than 4 weeks after symptom onset.

Procedure	Appropriateness Category	Relative Radiation Level
MRI abdomen without and with IV contrast with MRCP	Usually Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
US abdomen	May Be Appropriate	O
US duplex Doppler abdomen	May Be Appropriate	O
MRI abdomen without IV contrast with MRCP	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
US abdomen with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢

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Summary of Literature Review

Introduction/Background

Acute pancreatitis (AP), an inflammatory process affecting the pancreas, is the third most frequent gastrointestinal cause of hospital admissions in the United States [1]. AP results in approximately 300,000 hospital admissions each year, with associated costs of approximately $2.6 billion [1,2]. The incidence of AP is increasing and is estimated at 40 per 100,000 people.

The clinical diagnosis of AP requires 2 of the following 3 features: 1) abdominal pain consistent with AP (acute onset of persistent, severe, epigastric pain often radiating to the back); 2) serum lipase or amylase levels at least 3 times the upper limits of normal; and 3) characteristic findings of AP on contrast-enhanced CT, MRI, or transabdominal ultrasound (US) [3]. As such, if the abdominal pain is characteristic of pancreatitis and the amylase or lipase levels are not elevated to at least 3 times above normal, imaging is required for diagnosis. Imaging is also performed in AP to investigate the etiology, complications, and extent of disease. Imaging AP requires an understanding of the disease subtypes, evolution, and associated complications. Familiarity with the appropriate radiologic nomenclature as defined by the Atlanta symposium in 1992 and, more recently, modified by the Acute Pancreatitis Classification Working Group in 2008 is also essential [3].

Special Imaging Considerations

Radiographs

Conventional radiographs and upper gastrointestinal series currently have a limited role in the evaluation of a patient with AP. Radiographic signs of AP, such as dilated air-filled duodenum or jejunum, are secondary and nonspecific. Similarly, thickened rugal or duodenal folds or dilation of the duodenal C-loop are nonspecific findings of AP seen on upper gastrointestinal series or follow-through studies. Occasionally, radiographs may be useful when obtained for evaluation of nonspecific abdominal pain, as one can quickly assess for the presence of bowel obstruction or calcified gallstones in the gallbladder or common bile duct. Radiographs can also be useful for evaluating the presence of biliary or pancreatic duct stents.

Discussion of Procedures by Variant

Variant 1: Suspected acute pancreatitis. First time presentation. Epigastric pain and increased amylase and lipase. Less than 48 to 72 hours after symptom onset. Initial imaging.

Variant 1: Suspected acute pancreatitis. First time presentation. Epigastric pain and increased amylase and lipase. Less than 48 to 72 hours after symptom onset. Initial imaging. A. CT Abdomen and Pelvis

In a large majority of patients, the diagnosis of AP can be made based on the clinical findings of typical abdominal pain and elevated serum lipase or amylase levels to at least 3 times the upper limits of normal. In these patients, CT performed either with or without intravenous (IV) contrast in the acute setting (<48–72 hours after the onset of symptoms) does not improve clinical outcomes, rarely changes management, underestimates the development and extent of necrosis, and is not

superior to clinical scoring systems for predicting disease severity [1,4-8]. Therefore, CT may not provide additional information in patients with an unequivocal clinical presentation and appropriately elevated amylase and lipase. Rare exceptions would include if an US is performed for evaluation of gallstones and it is nondiagnostic, possibly because of obesity, gas, etc, and an MRI could not be performed.

Variant 1: Suspected acute pancreatitis. First time presentation. Epigastric pain and increased amylase and lipase. Less than 48 to 72 hours after symptom onset. Initial imaging. B. MRI Abdomen

Although MRI abdomen without and with IV contrast helps assess the severity of AP, in patients with typical abdominal pain and appropriately elevated serum amylase or lipase, MRI in the acute setting (<48–72 hours after the onset of symptoms) is not necessary for diagnosis. However, the addition of MR cholangiopancreatography (MRCP) may have a role in the acute setting for the identification of choledocholithiasis and triaging those patients requiring urgent endoscopic retrograde cholangiopancreatography (ERCP).

Patients with acute biliary pancreatitis may undergo early ERCP for removal of stones causing common bile duct obstruction to reduce disease severity and risk of complications [9,10]. The appropriate timing of ERCP is controversial [9,11]. Some authors argue that if ERCP has to be performed in patients with gallstone-related AP, it should be performed within 72 hours to have the highest chance of mitigating the pancreatic inflammatory process and reducing systemic complications [10]. However, the majority of patients with gallstone pancreatitis suffer from transient obstruction with spontaneous resolution [9]. Approximately half of the patients with cholestatic liver biochemistry and a dilated common bile duct on US or CT did not have a common bile duct stone detected during ERCP [10].

Because ERCP is an invasive procedure that can sometimes lead to complications, including perforation and hemorrhage, accurately identifying those patients with choledocholithiasis who are most likely to benefit from early therapeutic ERCP is important. MRCP images of the biliary system are more sensitive and specific than US for the detection of choledocholithiasis [9,12]. MRCP has a high concordance rate with ERCP for the detection of biliary origin of AP [9]. As such, MRCP prior to ERCP in patients at high risk for choledocholithiasis is common, replacing diagnostic ERCP in many cases. There is conflicting evidence regarding whether the selective use of MRCP in patients at high risk for choledocholithiasis reduces hospital stay and resultant hospital charges [9,13].

MRCP has the added advantage of detecting anatomic anomalies that may contribute to the etiology of AP, such as pancreas divisum or bile ductor pancreatic duct strictures. Therefore, for the assessment of biliary pathology on MRCP, MRI without IV contrast with MRCP may serve as a problem-solving tool.

Variant 1: Suspected acute pancreatitis. First time presentation. Epigastric pain and increased amylase and lipase. Less than 48 to 72 hours after symptom onset. Initial imaging. C. US Abdomen

Gallstones are the leading cause of AP in the Western world [14]. Patients with symptomatic gallstones have an annual risk of developing AP between 0.04% and 1.5% [12]. Every patient presenting with AP and no obvious alternative etiology should undergo transabdominal US to assess for gallstones as the possible cause [12]. Approximately 20% of the time, the pancreas demonstrates features of AP on US, including diffuse glandular enlargement, hypoechoic

echotexture of the pancreas consistent with edema, and ascites. However, US is limited by overlying bowel gas or adynamic ileus in the majority of patients with AP [15]. The primary usefulness of US in patients with AP is to identify gallstones or biliary ductal dilatation with sensitivity for the detection of gallstones in patients with acute biliary pancreatitis of about 70% [12]. US has limited sensitivity (25%–60%) for visualizing choledocholithiasis in the distal common bile duct [12]; furthermore, smaller gallstones (≤5 mm) are associated with recurrent pancreatobiliary complications [14]. Therefore, in the absence of another likely etiology, the presence of cholelithiasis or sludge in the gallbladder on US in a patient with a firm clinical or biochemical diagnosis of AP is sufficient evidence for the diagnosis of biliary pancreatitis. Conversely, the absence of gallstones is indicative that the cause of AP is nongallstone related.

Variant 1: Suspected acute pancreatitis. First time presentation. Epigastric pain and increased amylase and lipase. Less than 48 to 72 hours after symptom onset. Initial imaging. D. US Abdomen with IV Contrast

Contrast-enhanced US (CEUS) is emerging as a potential option for focal evaluation of the pancreas, and it is well suited to the evaluation of perfusion with its use of intravascular contrast agents [15]. However, the use of microbubble contrast for this indication is currently not approved by the FDA, and its use would be considered off-label. Additionally, in a majority of patients, the diagnosis of AP can be made based on the clinical findings of typical abdominal pain and elevated serum lipase or amylase levels to at least 3 times the upper limits of normal or greater. Therefore, CEUS may not provide additional information in patients with an unequivocal clinical presentation and appropriately elevated amylase and lipase. Similar to grayscale US, CEUS is limited by bowel gas, which can be particularly problematic in patients with AP and frequently associated paralytic ileus.

Variant 1: Suspected acute pancreatitis. First time presentation. Epigastric pain and increased amylase and lipase. Less than 48 to 72 hours after symptom onset. Initial imaging. E. US Duplex Doppler Abdomen

Adding spectral, color, and power Doppler US to traditional grayscale US adds hemodynamic information concerning vessel patency and flow direction and may be useful for differentiating vascular from nonvascular structures, particularly differentiating hepatic arteries and portal veins from bile ducts. Every patient presenting with AP and no obvious alternative etiology should undergo transabdominal US to assess for gallstones as the possible cause [12]. Spectral, color, and power Doppler should be used as necessary to differentiate vascular from nonvascular structures in this instance. However, beyond evaluating for gallstones in the large majority of patients, the diagnosis can be made based on typical clinical symptoms and laboratory findings of an amylase and/or lipase level elevated to 3 times the upper limit of normal, or greater, without additional cross-sectional imaging [1].

Variant 2: Suspected acute pancreatitis. Initial presentation with atypical signs and symptoms; including equivocal amylase and lipase values (possibly confounded by acute kidney injury or chronic kidney disease) and when diagnoses other than pancreatitis may be possible (bowel perforation, bowel ischemia, etc.). Initial imaging.

Variant 2: Suspected acute pancreatitis. Initial presentation with atypical signs and symptoms; including equivocal amylase and lipase values (possibly confounded by acute kidney injury or chronic kidney disease) and when diagnoses other than pancreatitis may be possible (bowel perforation, bowel ischemia, etc.). Initial imaging.
A. CT Abdomen and Pelvis

In patients with acute abdominal pain, there are often multiple potential etiologies to consider, including peptic ulcer disease, bowel perforation, and mesenteric ischemia, among others. Laboratory studies, specifically serum amylase and lipase, can help differentiate AP from these other considerations. Although serum amylase level is the most commonly used biochemical marker of AP, levels of amylase less than 3 times that of normal levels at the time of diagnosis can be related to rapid clearing. In contrast, serum lipase rises later but may be a more reliable marker of AP because of its longer half-life [16]. Additionally, significantly lower serum amylase and lipase levels have been observed in patients with alcoholic AP, perhaps as a result of poor pancreatic exocrine function [14]. Elevated triglyceride levels are also known to interfere with the serum amylase assay; conversely, both amylase and lipase may be elevated in patients with renal insufficiency without AP [16].

In equivocal presentations of pancreatitis without diagnostic clinical or biochemical findings, imaging is required for the diagnosis of AP [3]. CT abdomen and pelvis with IV contrast is currently the modality of choice for evaluating patients with suspected AP because of its rapid acquisition time. Findings on CT of AP include diffuse (occasionally localized) edematous enlargement of the pancreas with inflammatory changes of the peripancreatic fat with mild stranding or haziness. There may also be some peripancreatic free fluid and discrete fluid collections. In the acute setting (<48–72 hours from symptom onset), the pancreas may show relatively homogeneous enhancement or the appearance of patchy enhancement secondary to edema. Impaired pancreatic perfusion and widespread necrosis may take several days to evolve; therefore, early CT abdomen and pelvis with IV contrast imaging may underestimate or miss entirely pancreatic and peripancreatic necrosis. Although the early findings of AP, such as peripancreatic standing and the presence of fluid collections, may be evident on an unenhanced CT examination, CT abdomen and pelvis with IV contrast is preferred for evaluation of equivocal presentations of AP because contrast may assist in identifying necrosis and excluding other etiologies of abdominal pain.

CT abdomen and pelvis without IV contrast can help in making the diagnosis of AP by assessing the presence of peripancreatic stranding and fluid collections. However, stratification of disease severity cannot be performed because of the lack of assessment of pancreatic necrosis. Given the limitations of early CT with or without IV contrast for stratification of disease severity, performing both CT abdomen and pelvis without and with IV contrast does not add to the diagnosis of AP, and CT abdomen and pelvis with IV contrast is preferred to exclude other etiologies of abdominal pain.

Limitations of CT include relatively poor sensitivity for identifying ductal abnormalities, detecting subtle pancreatic parenchymal changes, and identifying noncalcified gallstones and choledocholithiasis.

Variant 2: Suspected acute pancreatitis. Initial presentation with atypical signs and symptoms; including equivocal amylase and lipase values (possibly confounded by acute kidney injury or chronic kidney disease) and when diagnoses other than pancreatitis may be possible (bowel perforation, bowel ischemia, etc.). Initial imaging.

B. MRI Abdomen

For meeting the imaging diagnostic criteria for AP, MRI abdomen without and with IV contrast with MRCP is at least equal and arguably superior to CT, particularly given the higher soft-tissue contrast resolution. Limitations of MRI include greater frequency of motion-related artifacts and a longer imaging time compared with that of CT. This is an important consideration in an acutely ill

patient in whom the study may be degraded by large-volume ascites and breathing-related artifacts, especially in the presence of abdominal pain and pleural effusions. Benefits include good sensitivity even without the administration of an IV contrast agent (making it a useful alternative for patients with renal impairment or allergy to iodine-based CT contrast agents). Although MRI without IV contrast with MRCP provides information about the presence of biliary stones and fluid collections, pancreatic necrosis cannot be accurately assessed in the absence of IV contrast.

The MRI findings of AP are typically an enlarged, edematous gland that is low signal on T1-weighted images and high signal on T2-weighted images. MRI can detect trace amounts of peripancreatic fluid, which is high signal on T2-weighted images and offers higher sensitivity than CT for the diagnosis of subtle, early changes of AP [17,18]. MRI is particularly well suited for pregnant women, patients with renal compromise, and younger patients with suspected AP, especially since studies have shown that patients who undergo early CT for AP are more likely to have repeat CT scans during the same admission [6,8].

MRI has an added advantage for noninvasive evaluation of the pancreatic parenchyma, biliary and pancreatic ducts, adjacent soft tissues, vascular structures, and composition of AP-associated fluid collections in a single examination [17,19,20]. However, MRI abdomen without and with IV contrast with MRCP does not provide coverage and adequate evaluation of the bowel to assess an alternative diagnosis of bowel ischemia, perforation, etc.

Variant 2: Suspected acute pancreatitis. Initial presentation with atypical signs and symptoms; including equivocal amylase and lipase values (possibly confounded by acute kidney injury or chronic kidney disease) and when diagnoses other than pancreatitis may be possible (bowel perforation, bowel ischemia, etc.). Initial imaging.
C. US Abdomen

US is often the first-line imaging modality in most centers for the evaluation of acute abdominal pain because it is reproducible and can be accomplished at the bedside [15]. Approximately 20% of the time, the pancreas demonstrates features of AP on US, including diffuse glandular enlargement, hypoechoic echotexture of the pancreas consistent with edema, and ascites. US can also be useful for the diagnosis of an alternative etiology of abdominal pain, such as acute cholecystitis. However, US is limited by overlying bowel gas or adynamic ileus in the majority of patients with AP [15]. The primary use of US in patients with AP is to identify gallstones or biliary ductal dilatation.

Variant 2: Suspected acute pancreatitis. Initial presentation with atypical signs and symptoms; including equivocal amylase and lipase values (possibly confounded by acute kidney injury or chronic kidney disease) and when diagnoses other than pancreatitis may be possible (bowel perforation, bowel ischemia, etc.). Initial imaging.
D. US Abdomen with IV Contrast

CEUS is emerging as a potential option for focal evaluation of the pancreas, and it is well suited to the evaluation of perfusion with its use of intravascular contrast agents [15]. However, the use of microbubble contrast for this indication is currently not approved by the FDA, so its use would be considered off-label. Furthermore, CEUS is a focused examination, and in patients with an equivocal presentation of pancreatitis for whom diagnoses other than pancreatitis may be possible, a focused examination may be inadequate. Finally, similar to grayscale US, CEUS is limited by bowel gas, which can be particularly problematic in patients with AP and frequently associated paralytic ileus.

Variant 2: Suspected acute pancreatitis. Initial presentation with atypical signs and symptoms; including equivocal amylase and lipase values (possibly confounded by acute kidney injury or chronic kidney disease) and when diagnoses other than pancreatitis may be possible (bowel perforation, bowel ischemia, etc.). Initial imaging.

E. US Duplex Doppler Abdomen

Adding color Doppler US to traditional grayscale US adds hemodynamic information concerning vessel patency and flow direction. In evaluating patients with acute abdominal pain, US is often the first-line imaging modality because it is reproducible and can be accomplished at the bedside [15]. Although the primary utility of US in patients with AP is to identify gallstones or biliary ductal dilatation, in patients with acute abdominal pain atypical for pancreatitis, a complete abdominal US examination may be performed to evaluate multiple potential etiologies. A complete abdominal US examination includes evaluation of the aorta, major hepatic and perihepatic vessels, including the inferior vena cava, the hepatic veins, the main portal vein, and, if possible, the right and left branches of the portal vein. Evaluation of these vessels is necessary for exclusion of other potential etiologies of the patient's abdominal pain most commonly pertaining to the liver, such as acute hepatitis, Budd Chiari syndrome, etc.

Variant 3: Acute pancreatitis. Critically ill, systemic inflammatory response syndrome (SIRS), severe clinical scores (eg, Acute Physiology, Age, and Chronic Health Evaluation [APACHE]-II, Bedside Index for Severity in AP [BISAP], or Marshall). Greater than 48 to 72 hours after onset of symptoms.

In AP, systemic inflammatory response syndrome (SIRS) is the main cause of early complications, and superimposed infection and fluid collections are the cause of late complications [2]. SIRS is present if 2 or more of these clinical criteria are met: 1) heart rate >90 beats/min; 2) core temperature <36° C or >38° C; 3) white blood cell count <4,000 or >12,000/mm^3; or 4) respirations >20/min or $PC0_2$ <32 mmHg [3]. Organ failure is likely to develop in the setting of persistent SIRS. The presence, extent, and duration of organ failure determine the severity of pancreatitis in the early phase (first week). Organ failure can be diagnosed by systolic blood pressure <90 mmHg, PaO_2 ≤60 mmHg, serum creatinine >2 mg/dL, or gastrointestinal bleeding >500 mL/day [15]. Organ failure is considered transient if it resolves within 48 hours and persistent if it persists beyond 48 hours. Moderately severe AP has transient organ failure and is associated with a low mortality rate (approximately 2%) [18]. Patients with persistent organ failure are classified as having severe AP, which has a mortality rate of approximately 10% to 50% [3,18].

Even in cases of severe AP, clinical scoring methods are used to direct patient care independent of imaging in the early phase. Frequently used clinical scoring methods include the Ranson, Acute Physiology, Age, and Chronic Health Evaluation (APACHE)-II, Marshall, and the Bedside Index for Severity in AP (BISAP). Imaging is generally not necessary to document local complications in the early phase. This is because, even though pancreatic necrosis is a well-established risk factor for morbidity and mortality, the presence and extent of pancreatic and peripancreatic necrosis may not be reliably demonstrated on imaging before 5 to 7 days into the clinical course because both necrotic and edematous pancreatic parenchyma show heterogeneous enhancement. In addition, the extent of morphologic changes seen on imaging does not correlate well with the severity of organ failure [3]. Furthermore, even if imaging identifies the presence of fluid collections or pancreatic necrosis in the first week, typically no interventions for these complications are pursued in the early phase [3,18].

Variant 3: Acute pancreatitis. Critically ill, systemic inflammatory response syndrome (SIRS),

severe clinical scores (eg, Acute Physiology, Age, and Chronic Health Evaluation [APACHE]-II, Bedside Index for Severity in AP [BISAP], or Marshall). Greater than 48 to 72 hours after onset of symptoms.

A. CT Abdomen and Pelvis

Although it is generally not necessary to document local complications in the early phase with imaging, CT abdomen and pelvis with IV contrast is the primary imaging modality used in the assessment of a critically ill patient, particularly if cross-sectional imaging was not obtained earlier in the clinical course for AP diagnosis. CT abdomen and pelvis with IV contrast has shown consistent clinical value in predicting disease severity and outcomes in AP. The CT severity index is an imaging prognosticator based on the combined assessment of peripancreatic fluid collections and the degree of pancreatic necrosis. A higher CT severity index score is associated with increased morbidity and mortality. A modified CT severity index includes extrapancreatic complications (such as ascites) and vascular complications in the grading system. By including these additional factors, the modified CT severity index has a stronger correlation with patient outcome [2].

CT abdomen and pelvis with IV contrast to evaluate for pancreatic necrosis, is more reliable when performed 5 to 7 days after presentation, as impaired pancreatic perfusion, edema, and pancreatic necrosis evolve over several days and earlier imaging may underestimate necrosis [2,3]. Similarly, CT abdomen and pelvis with IV contrast is also frequently used for the evaluation of acute peripancreatic fluid collections. Most fluid collections develop in the early phase of pancreatitis and approximately half spontaneously resolve. These acute peripancreatic collections do not have a solid component or a discrete wall and are usually found in the lesser sac and anterior pararenal space. They are usually sterile, rarely become infected, and do not typically necessitate early (if any) intervention [18,21]. Moreover, because patients who undergo early CT for AP are more likely to have repeat CT scans during the same admission [6,8], waiting 5 to 7 days to evaluate the severity and complications of AP with CT abdomen and pelvis with IV contrast is recommended, even in patients with suspected severe AP.

In the presence of suspicion for severe disease, the utility of CT abdomen and pelvis without IV contrast is limited to the detection of fluid collections as it cannot assess the presence of pancreatic necrosis. Similarly, adding a noncontrast phase by performing CT abdomen and pelvis without and with IV contrast does not add additional diagnostic information.

Variant 3: Acute pancreatitis. Critically ill, systemic inflammatory response syndrome (SIRS), severe clinical scores (eg, Acute Physiology, Age, and Chronic Health Evaluation [APACHE]-II, Bedside Index for Severity in AP [BISAP], or Marshall). Greater than 48 to 72 hours after onset of symptoms.

B. MRI Abdomen

MRI abdomen without and with IV contrast with MRCP has comparable diagnostic and prognostic value to CT abdomen without and with IV contrast in AP [22] and can be used to assess the severity of AP and its local complications. An MRI severity index based on the degree of pancreatic and peripancreatic fluid and the extent of pancreatic necrosis significantly correlates with CT severity index, the clinical variables associated with the severity of AP, and the clinical outcome [22]. Local complications seen on MRI in the acute period (48–72 hours after symptom onset), such as pararenal space involvement, gallbladder abnormalities, and visible pancreatic duct disruption, correlate with the severity of AP according to MRI severity index and may be supplementary signs of AP severity [22-24].

In a severely ill patient who may not be able to stay still through a fairly long MRI without and with IV contrast with MRCP, an MRI without IV contrast with MRCP may be performed, as a motion-degraded MRI may not add additional diagnostic value. An MRI abdomen without IV contrast with MRCP could detect the presence of pancreatic necrosis. Diffusion-weighted imaging may be used as an alternative to contrast to assess the presence of necrotizing pancreatitis in some cases. Additionally, MRCP can assist in the diagnosis of delayed passage of choledocholithiasis, potentially avoiding unnecessary ERCP [11].

Variant 3: Acute pancreatitis. Critically ill, systemic inflammatory response syndrome (SIRS), severe clinical scores (eg, Acute Physiology, Age, and Chronic Health Evaluation [APACHE]-II, Bedside Index for Severity in AP [BISAP], or Marshall). Greater than 48 to 72 hours after onset of symptoms.

C. US Abdomen

Traditional grayscale and color Doppler US is limited in the assessment of AP disease severity, as it cannot reliably distinguish interstitial from necrotizing pancreatitis because it does not allow for the assessment of parenchymal perfusion.

Variant 3: Acute pancreatitis. Critically ill, systemic inflammatory response syndrome (SIRS), severe clinical scores (eg, Acute Physiology, Age, and Chronic Health Evaluation [APACHE]-II, Bedside Index for Severity in AP [BISAP], or Marshall). Greater than 48 to 72 hours after onset of symptoms.

D. US Abdomen with IV Contrast

CEUS is emerging as a potential option for focal evaluation of the pancreas, and it is well suited to the evaluation of pancreatic perfusion with its use of intravascular contrast agents [15]. US severity indexes based on CEUS have shown a strong correlation with CT severity index and can be used in its place. Like CT, CEUS evaluation in the acute setting is limited by impaired pancreatic perfusion, edema, and the evolution of pancreatic necrosis over several days. Too-early imaging may underestimate necrosis. As with grayscale US, CEUS is limited by bowel gas, which can be particularly problematic in patients with AP and frequently associated paralytic ileus.

Variant 3: Acute pancreatitis. Critically ill, systemic inflammatory response syndrome (SIRS), severe clinical scores (eg, Acute Physiology, Age, and Chronic Health Evaluation [APACHE]-II, Bedside Index for Severity in AP [BISAP], or Marshall). Greater than 48 to 72 hours after onset of symptoms.

E. US Duplex Doppler Abdomen

Color Doppler US is limited in the assessment of AP disease severity because of its inability to reliably assess parenchymal perfusion.

Variant 4: Acute pancreatitis. Continued SIRS, severe clinical scores, leukocytosis, and fever. Greater than 7 to 21 days after onset of symptoms.

The late phase of AP occurs after the first week and is characterized by local complications, including infection and fluid collections and persistent SIRS [2,3,18]. Mild disease resolves within the first week, so the late phase only applies to patients with moderately severe or severe pancreatitis. Organ failure is likely in the setting of persistent SIRS, and persistent organ failure defines severe AP. Persistent organ failure continues to be the main determinant of severity in the late phase; however, local and systemic complications have important implications for management and are characterized by imaging. Imaging plays a major role in the late phase for assessing severity (including identifying the presence and extent of necrotizing pancreatitis and its

complications), guiding interventional, endoscopic, or surgical treatment, and monitoring treatment response.

Although leukocytosis and fever are clinical hallmarks of infection, imaging is also important for the evaluation of superimposed infection. It is imperative to identify superimposed infection, as the presence of infection within areas of necrosis is associated with an extremely high mortality [3]. The presence and extent of pancreatic and peripancreatic necrosis increases the likelihood of infection and infection within areas of pancreatic necrosis portends an increased risk of death, which is exacerbated by persistent organ failure. By comparison, infected necrosis without persistent organ failure has a lower mortality rate than infected necrosis with persistent organ failure [3,21].

In the absence of infection, patients with peripancreatic (extrapancreatic) necrosis without concomitant pancreatic parenchymal necrosis have a better prognosis than patients with pancreatic parenchymal necrosis. It has been suggested that, given the improved prognosis, extrapancreatic necrosis should be considered a separate clinical entity in AP [25]. In the presence of infection; however, the rates of complication and mortality for patients with only extrapancreatic necrosis are similar to those for patients with pancreatic parenchymal necrosis with or without extrapancreatic necrosis [25].

In the late phase (after the first week) of moderately severe or severe pancreatitis, local complications fully develop, and it is important to characterize these complications, as they may require different interventions to avoid increased morbidity or mortality. Imaging plays a major role in identifying the presence and extent of pancreatic and peripancreatic necrosis and characterizing local complications in the late phase.

Variant 4: Acute pancreatitis. Continued SIRS, severe clinical scores, leukocytosis, and fever. Greater than 7 to 21 days after onset of symptoms.
A. CT Abdomen and Pelvis

In the acute phase, it may not be possible to differentiate an acute peripancreatic fluid collection from an acute necrotic collection, as they both appear as fluid density on CT. However, after the first week in the late phase, it is easier to distinguish whether a collection is associated with pancreatic or peripancreatic necrosis. Pancreatic necrosis on CT abdomen and pelvis with IV contrast is characterized by single or multiple areas of nonenhancing pancreatic parenchyma, whereas peripancreatic fat necrosis usually appears as a low attenuation collection. False-positive results for pancreatic necrosis using enhancement on CT are due to reversible reduced perfusion and edema or fluid in the pancreatic parenchyma [21]. Infected pancreatic necrosis usually arises in the second to third week, and signs of infection on CT include gas within areas of necrosis or fluid collections.

CT abdomen and pelvis with IV contrast is the most commonly obtained imaging test to detect the presence of peripancreatic collections [26]. Acute peripancreatic fluid collections do not have a solid component and have a density of 0 to 30 HU on CT. They also lack a discrete wall, are usually sterile, and rarely become infected. Although the majority of acute peripancreatic fluid collections are peripancreatic in the lesser sac or anterior pararenal space, some may track down into the pelvis or superiorly into the mediastinum. Therefore, CT of both the abdomen and pelvis may be warranted. More than half of acute peripancreatic fluid collections resolve without intervention in the first several weeks, and intervention is rarely pursued to avoid potentially infecting a typically

sterile collection. The remaining acute peripancreatic fluid collections that do not resolve become pseudocysts after 4 weeks and are characterized by a fibrous capsule. CT is the most common modality for identifying pseudocysts and their relationship to surrounding structures prior to intervention.

Acute necrotic collections are associated with pancreatic or peripancreatic necrosis and contain varying amounts of fluid and necrotic material and are of varying sizes and shapes [3]. On CT, these collections have heterogeneous, varied densities (fluid, fat, and solid material) with no or an incompletely defined wall. It can be challenging to distinguish collections that contain varying amounts of fluid and necrotic debris from pure fluid containing acute peripancreatic fluid collections on CT abdomen and pelvis with IV contrast and necrotic material within collections is often overlooked. The presence of fat globules on CT is usually associated with the presence of large amounts of debris within a collection [26]. MRI and possibly US are better at demonstrating debris and necrotic material within these collections [21,26,27]. Accurate identification of necrotic debris is important for characterization; however, it is particularly important if drainage is considered, as residual, unrecognized debris after standard drainage increases the risk of infection. Acute necrotic collections may also be associated with disruption of the main pancreatic duct within the parenchymal necrosis, and CT has reduced sensitivity for identifying ductal abnormalities.

CT abdomen and pelvis without IV contrast can help in the detection of fluid collections that may or may not be infected. Although, it cannot assess the presence of rim enhancement, which adds to the specificity of the diagnosis of an infected collection, in the presence of clinical concern, CT abdomen and pelvis without IV contrast can help preprocedural planning. Smaller fluid collections may sometimes be difficult to distinguish from adjacent fluid-filled bowel loops. CT abdomen and pelvis without and with IV contrast does not add to the diagnostic information.

Variant 4: Acute pancreatitis. Continued SIRS, severe clinical scores, leukocytosis, and fever. Greater than 7 to 21 days after onset of symptoms.

B. MRI Abdomen

MRI abdomen without and with IV contrast with MRCP is comparable to CT abdomen and pelvis with IV contrast for the diagnosis of necrotizing pancreatitis [21]. Pancreatic necrosis is identified as areas of low signal compared with the normal increased signal of the pancreas on fat-saturated T1-weighted unenhanced images and as focal regions of nonenhancement with IV contrast. On T2-weighted images, necrosis can be low signal intensity or hyperintense when liquefied.

Fluid-sensitive MRI sequences, including T2-weighted imaging and MRCP, are superior to CT for depiction of necrotic debris within fluid collections [21,26], and MRI with MRCP is well suited for evaluation of pancreatic duct disruption, which most commonly occurs as a complication of necrotizing pancreatitis [22]. Necrosis (typically of the central gland) may lead to an isolated, functional, upstream pancreatic segment that is not connected to the downstream pancreatic duct. Collections resulting from continued ductal secretions from viable pancreatic parenchyma in the area of disrupted duct typically fail to spontaneously resolve. Conservative treatment strategies or drainage will most likely fail in the setting of a disconnected pancreatic duct or lead to persistent pancreatic fistula formation; therefore, early diagnosis of this condition leads to reduced morbidity and may mitigate unnecessary drainage procedures. MRI abdomen without IV contrast with MRCP provides more definitive evaluation of the contents of peripancreatic fluid collection and pancreatic ductal integrity when compared with CT.

Limitations of MRI include motion artifacts that are due to longer scan times (especially in acutely ill patients who are unable to hold still) and decreased sensitivity for the detection of gas bubbles for imaging identification of infection.

Variant 4: Acute pancreatitis. Continued SIRS, severe clinical scores, leukocytosis, and fever. Greater than 7 to 21 days after onset of symptoms.
C. US Abdomen

Traditional grayscale US is limited in the assessment of necrotizing pancreatitis because it does not allow for the assessment of parenchymal perfusion. Transabdominal US is used for characterization of peripancreatic fluid collections by evaluating for internal, necrotic debris. It is particularly helpful for guiding diagnostic and therapeutic intervention for large pseudocysts; however, it is limited for the identification of small collections [21]. Gas bubbles within pancreatic and peripancreatic fluid collections may be seen on transabdominal US; however, CT is more commonly used for the imaging diagnosis of infection.

Variant 4: Acute pancreatitis. Continued SIRS, severe clinical scores, leukocytosis, and fever. Greater than 7 to 21 days after onset of symptoms.
D. US Abdomen with IV Contrast

CEUS is emerging as a potential option for focal evaluation of the pancreas. CEUS is well suited to the evaluation of pancreatic parenchymal perfusion, given its use of intravascular contrast agents [15]. Although CEUS can also be used to evaluate complications of pancreatitis, such as splenic artery aneurysm [28], evaluation of local complications and extrapancreatic necrosis may be limited by the focal nature of this examination. Similar to grayscale US, CEUS is limited by bowel gas, which can be particularly problematic in patients with AP and frequently associated paralytic ileus.

Variant 4: Acute pancreatitis. Continued SIRS, severe clinical scores, leukocytosis, and fever. Greater than 7 to 21 days after onset of symptoms.
E. US Duplex Doppler Abdomen

Color Doppler US may be combined with traditional grayscale US for evaluation of vascular complications, such as arterial pseudoaneurysms or thrombosis of the portal venous system.

Variant 5: Known necrotizing pancreatitis. Significant deterioration in clinical status, including abrupt decrease in hemoglobin or hematocrit, hypotension, tachycardia, tachypnea, abrupt change in fever curve, or increase in white blood cells.

Variant 5: Known necrotizing pancreatitis. Significant deterioration in clinical status, including abrupt decrease in hemoglobin or hematocrit, hypotension, tachycardia, tachypnea, abrupt change in fever curve, or increase in white blood cells.
A. CT Abdomen and Pelvis

The diagnosis of infected necrosis or fluid collection can be suspected clinically and may be confirmed by fine-needle aspiration for culture. Because aspiration introduces the risk of infection, CT abdomen and pelvis with IV contrast may be obtained when infection is suspected clinically to assess for the presence of gas within areas of necrosis or fluid collections; although, this is of limited utility for identifying early infection [29].

Extraluminal pancreatic enzymes in AP can damage adjacent blood vessels, resulting in vasculitis and pseudoaneurysm formation. An abrupt decrease in hemoglobin or hematocrit is suspicious for pseudoaneurysm rupture. Given speed of acquisition, CT abdomen and pelvis with IV contrast with

both arterial and venous phase imaging is the preferred imaging modality for assessment of suspected pseudoaneurysm rupture.

CT abdomen and pelvis without IV contrast may help in the detection of hemorrhage as high-density fluid without localization of an active source. Similarly, adding a noncontrast phase by performing CT abdomen and pelvis without and with IV contrast does not add additional diagnostic information.

Variant 5: Known necrotizing pancreatitis. Significant deterioration in clinical status, including abrupt decrease in hemoglobin or hematocrit, hypotension, tachycardia, tachypnea, abrupt change in fever curve, or increase in white blood cells.
B. MRI Abdomen

MRI is well suited for the follow-up of pancreatic collections; however, in most cases, fine-needle aspiration sampling and microbiological examination of the collection is necessary to definitively diagnose infection; although, this method is invasive and carries a risk of secondary infection. More recently, peripheral restricted diffusion on diffusion-weighted imaging and central low apparent diffusion coefficient has been demonstrated to identify the presence of infection within AP-associated collections with higher sensitivity and accuracy than gas bubbles on CT [29]. However, clinical suspicion and fine-needle aspiration with fluid analysis remain the gold standard for treatment determination.

Hemorrhagic fluid collections may be more easily recognized on MRI than CT because of the presence of T1 hyperintense methemoglobin, low-signal-intensity hemosiderin rim on T2-weighted images, and signal abnormalities related to hemorrhage that persist longer on MRI than CT. However, in the setting of an abrupt decrease in hemoglobin or hematocrit, an acute bleeding episode would be suspected, and MRI without and with IV contrast with MRCP is currently limited by longer acquisition times. In these patients, who may be unstable in the setting of an acute bleeding episode, a more rapid CT examination is preferred.

Variant 5: Known necrotizing pancreatitis. Significant deterioration in clinical status, including abrupt decrease in hemoglobin or hematocrit, hypotension, tachycardia, tachypnea, abrupt change in fever curve, or increase in white blood cells.
C. US Abdomen

Gas bubbles within necrotic collections and pancreatic and peripancreatic fluid collections may be seen on transabdominal US; however, CT is more commonly used for the imaging diagnosis of infection, particularly because it may be challenging to differentiate gas in overlying stomach/bowel from gas in a collection by US.

Variant 5: Known necrotizing pancreatitis. Significant deterioration in clinical status, including abrupt decrease in hemoglobin or hematocrit, hypotension, tachycardia, tachypnea, abrupt change in fever curve, or increase in white blood cells.
D. US Abdomen with IV Contrast

Although CEUS can be used to evaluate complications of pancreatitis, such as splenic artery aneurysm [28], in the setting of an abrupt decrease in hemoglobin or hematocrit, CT angiography is the preferred imaging modality given its rapid acquisition and vascular mapping for interventional or surgical treatment planning.

Variant 5: Known necrotizing pancreatitis. Significant deterioration in clinical status, including abrupt decrease in hemoglobin or hematocrit, hypotension, tachycardia,

tachypnea, abrupt change in fever curve, or increase in white blood cells.
E. US Duplex Doppler Abdomen

Color Doppler US may be used with traditional grayscale US for evaluation of vascular complications, such as arterial pseudoaneurysms or thrombosis of the portal venous system. Pseudoaneurysms, which most frequently involve the splenic, gastroduodenal, and pancreaticoduodenal arteries, may be identified on a Doppler US examination; however, in the setting of an abrupt decrease in hemoglobin or hematocrit, CT angiography is the preferred imaging modality for assessment of suspected pseudoaneurysm rupture.

Variant 6: Acute pancreatitis. Known pancreatic or peripancreatic fluid collections with continued abdominal pain, early satiety, nausea, vomiting, or signs of infection. Greater than 4 weeks after symptom onset.

Local complications in AP include pancreatic or peripancreatic fluid collections. The classification of these fluid collections depends on timing and the presence of necrosis. Acute peripancreatic fluid collections usually develop in the early phase of interstitial edematous pancreatitis and may turn into a pancreatic pseudocyst as a delayed (>4 weeks) complication. A pseudocyst has a well-defined wall and does not contain solid material. In necrotizing pancreatitis, a collection in the early phase is an acute necrotic collection and develops into walled-off necrosis, which is surrounded by a detectible capsule, after 4 weeks [3].

Differentiating walled-off necrosis from pseudocysts that do not contain debris has important implications for management, as residual necrotic debris after drainage may lead to secondary infection. Pseudocysts can be drained by simple percutaneous or endoscopic techniques, as they are composed almost exclusively of fluid. Conversely, walled-off necrosis requires surgical debridement, direct endoscopic necrosectomy, insertion of larger caliber metallic cystgastrostomy stents, or ongoing percutaneous irrigation and drainage of necrotic debris [30]. Although increased clinical severity, particularly persistent organ failure, may suggest that collections likely represent walled-off necrosis, definitive characterization and intervention planning/selection are best accomplished with imaging.

Variant 6: Acute pancreatitis. Known pancreatic or peripancreatic fluid collections with continued abdominal pain, early satiety, nausea, vomiting, or signs of infection. Greater than 4 weeks after symptom onset.
A. CT Abdomen and Pelvis

CT of the abdomen and pelvis with IV contrast is historically the most commonly obtained initial test to evaluate the presence of pancreatic or peripancreatic fluid collections. It is also often used to follow-up symptomatic collections and for intervention planning. However, CT is limited in the quantification of debris and differentiation of pseudocysts from walled-off necrosis. The best indication of debris containing collections on CT is increased frequency of fat density globules within the collections. The absence of fat globules within a collection does not exclude the possibility of necrosis; however, the presence of fat globules suggests a debris-containing, necrotic collection [26]. CT abdomen and pelvis with IV contrast is useful for detection of an infected collection, which has the imaging features of an enhancing wall and gas bubbles within the collection. However, air bubbles may not be seen with an infected collection, and the diagnosis is ultimately made by fine-needle aspiration and fluid analysis. CT abdomen and pelvis with IV contrast may also be helpful in the detection of a fistulous communication between a fluid collection and an adjacent bowel loop.

CT abdomen and pelvis without IV contrast can help diagnose the presence of large fluid collections that may be symptomatic and may help in preprocedural planning if percutaneous drainage or cyst gastrostomy is contemplated. Smaller fluid collections may sometimes be difficult to discern between fluid-filled bowel loops on an examination performed without IV contrast. Fluid collections are identifiable on a CT abdomen and pelvis examination performed with IV contrast and adding a noncontrast phase by performing CT abdomen and pelvis without and with IV contrast does not add additional diagnostic information.

Variant 6: Acute pancreatitis. Known pancreatic or peripancreatic fluid collections with continued abdominal pain, early satiety, nausea, vomiting, or signs of infection. Greater than 4 weeks after symptom onset.

B. MRI Abdomen

The contents of pancreatic and peripancreatic collections can be most accurately assessed by fluid sensitive MRI sequences on MRI abdomen without IV contrast with MRCP. T2-weighted imaging provides superior soft-tissue differentiation when compared with CT and allows for more consistent quantification of debris. As such, MRI is more useful for predicting whether these collections can be drained by endoscopic, percutaneous, or surgical drainage procedures. Therefore, when imaging is considered for evaluation of symptomatic organized pancreatic or peripancreatic fluid collections, particularly when intervention is contemplated, MRI should be considered in place or as a follow-up to a contrast-enhanced CT [31].

MRI abdomen without and with IV contrast with MRCP is also well suited for evaluation of pancreatic duct disruption, which most commonly occurs as a complication of necrotizing pancreatitis [22]. Necrosis (typically of the central gland) may lead to an isolated, functional, upstream pancreatic segment that is not connected to the downstream pancreatic duct. Conservative treatment strategies or drainage will most likely fail in the setting of a disconnected pancreatic duct or lead to persistent pancreatic fistula formation; therefore, early diagnosis of this condition leads to reduced morbidity and may mitigate unnecessary drainage procedures. MRI with MRCP provides more definitive evaluation of pancreatic ductal integrity when compared with CT. Visualization of the pancreatic duct may be improved by using a synthetic analog of the hormone secretin, which is sometimes administered to augment the MRCP. Furthermore, although ERCP is considered the gold standard for detection of pancreatic ductal disruption, MRI abdomen without and with IV contrast with MRCP has the advantage of being able to evaluate both the main pancreatic duct and the pancreatic parenchyma simultaneously, as compared with combining CT abdomen and pelvis without and with IV contrast with ERCP. MRI abdomen without and with IV contrast with MRCP also avoids the potential complications associated with ERCP, such as post-ERCP pancreatitis [26,32]. For follow-up imaging evaluation in a patient with known pancreatic or peripancreatic fluid collections, MRI abdomen without and with IV contrast with MRCP is preferred, as it allows for the noninvasive evaluation of the pancreatic parenchyma, biliary and pancreatic ducts, and vascular structures as well as the assessment of fluid and debris content of collections in a single examination.

Variant 6: Acute pancreatitis. Known pancreatic or peripancreatic fluid collections with continued abdominal pain, early satiety, nausea, vomiting, or signs of infection. Greater than 4 weeks after symptom onset.

C. US Abdomen

Transabdominal US is used for characterization of peripancreatic fluid collections by evaluating for internal, necrotic debris. It is particularly helpful for guiding diagnostic and therapeutic intervention

for large pseudocysts; however, it is limited for the identification of small collections [21].

Variant 6: Acute pancreatitis. Known pancreatic or peripancreatic fluid collections with continued abdominal pain, early satiety, nausea, vomiting, or signs of infection. Greater than 4 weeks after symptom onset.
D. US Abdomen with IV Contrast

In the evaluation of known peripancreatic fluid collections associated with a(n) episode(s) of AP, the addition of contrast to the US examination adds little to no additional information.

Variant 6: Acute pancreatitis. Known pancreatic or peripancreatic fluid collections with continued abdominal pain, early satiety, nausea, vomiting, or signs of infection. Greater than 4 weeks after symptom onset.
E. US Duplex Doppler Abdomen

It is not necessary to add color Doppler to a traditional grayscale US examination for characterization of peripancreatic fluid collections, unless it is needed for differentiation of vascular from nonvascular structures.

Summary of Recommendations

- **Variant 1**: US abdomen is usually appropriate for the initial imaging of suspected acute pancreatitis presenting for the first time with epigastric pain and increased amylase and lipase before 48 to 72 hours after symptom onset.
- **Variant 2**: CT abdomen and pelvis with IV contrast and MRI abdomen without and with IV contrast with MRCP are usually appropriate for the initial imaging of suspected acute pancreatitis with initial presentation of atypical signs and symptoms including equivocal amylase and lipase values (possibly confounded by acute kidney injury or chronic kidney disease) and when diagnoses other than pancreatitis may be possible (bowel perforation, bowel ischemia, etc.). These procedures are complementary (ie more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care).
- **Variant 3**: CT abdomen and pelvis with IV contrast and MRI abdomen without and with IV contrast with MRCP are usually appropriate for the evaluation of acute pancreatitis greater than 48 to 72 hours after onset of symptoms in patients who are critically ill, have systemic inflammatory response syndrome (SIRS), have severe clinical scores (eg. Acute Physiology, Age, and Chronic Health Evaluation [APACHE]-II, Bedside Index for Severity in AP [BISAP], or Marshall). These procedures are complementary (ie more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care).
- **Variant 4**: CT abdomen and pelvis with IV contrast and MRI abdomen without and with IV contrast are usually appropriate for the evaluation of acute pancreatitis greater than 7 to 21 days after the onset of symptoms in patients with continued SIRS, severe clinical scores, leukocytosis and fever. These procedures are complementary (ie more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care).
- **Variant 5**: CT abdomen and pelvic with IV contrast is usually appropriate for the evaluation of known necrotizing pancreatitis with significant deterioration in clinical status, including abrupt decrease in hemoglobin or hematocrit, hypotension, tachycardia, tachypnea, abrupt

change in fever curve, or increase in white blood cells.

- **Variant 6**: CT abdomen and pelvic with IV contrast and MRI abdomen without and with IV contrast with MRCP are usually appropriate for the evaluation of acute pancreatitis greater than 4 weeks after symptom onset in patients with known pancreatic or peripancreatic fluid collections with continued abdominal paid, early satiety, nausea, vomiting or signs of infection. These procedures are complementary (ie more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care).

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose,

which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document [33].

Relative Radiation Level Designations		
Relative Radiation Level*	**Adult Effective Dose Estimate Range**	**Pediatric Effective Dose Estimate Range**
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv
*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."		

References

1. Jin DX, McNabb-Baltar JY, Suleiman SL, et al. Early Abdominal Imaging Remains Over-Utilized in Acute Pancreatitis. Dig Dis Sci. 62(10):2894-2899, 2017 Oct.
2. Shyu JY, Sainani NI, Sahni VA, et al. Necrotizing pancreatitis: diagnosis, imaging, and intervention. Radiographics. 34(5):1218-39, 2014 Sep-Oct.
3. Banks PA, Bollen TL, Dervenis C, et al. Classification of acute pancreatitis--2012: revision of the Atlanta classification and definitions by international consensus. Gut. 62(1):102-11, 2013 Jan.
4. Balthazar EJ. Acute pancreatitis: assessment of severity with clinical and CT evaluation. Radiology. 2002;223(3):603-613.
5. Dachs RJ, Sullivan L, Shanmugathasan P. Does early ED CT scanning of afebrile patients with first episodes of acute pancreatitis ever change management?. EMERG. RADIOL.. 22(3):239-43, 2015 Jun.
6. Dobbs NW, Budak MJ, Weir-McCall JR, Vinnicombe SJ, Zealley IA. Acute pancreatitis: a comparison of intervention rates precipitated by early vs guideline CT scan timing. Clin Radiol. 71(10):993-6, 2016 Oct.
7. Bollen TL, Singh VK, Maurer R, et al. A comparative evaluation of radiologic and clinical scoring systems in the early prediction of severity in acute pancreatitis. Am J Gastroenterol.

2012;107(4):612-619.

8. Shinagare AB, Ip IK, Raja AS, Sahni VA, Banks P, Khorasani R. Use of CT and MRI in emergency department patients with acute pancreatitis. Abdom Imaging. 40(2):272-7, 2015 Feb.
9. Mofidi R, Lee AC, Madhavan KK, Garden OJ, Parks RW. The selective use of magnetic resonance cholangiopancreatography in the imaging of the axial biliary tree in patients with acute gallstone pancreatitis. Pancreatology. 2008;8(1):55-60.
10. van Santvoort HC, Bakker OJ, Besselink MG, et al. Prediction of common bile duct stones in the earliest stages of acute biliary pancreatitis. Endoscopy. 43(1):8-13, 2011 Jan.
11. Cavdar F, Yildar M, Tellioglu G, Kara M, Tilki M, Titiz MI. Controversial issues in biliary pancreatitis: when should we perform MRCP and ERCP?. Pancreatology. 14(5):411-4, 2014 Sep-Oct.
12. Cucher D, Kulvatunyou N, Green DJ, Jie T, Ong ES. Gallstone pancreatitis: a review. Surg Clin North Am. 94(2):257-80, 2014 Apr.
13. Anand G, Patel YA, Yeh HC, et al. Factors and Outcomes Associated with MRCP Use prior to ERCP in Patients at High Risk for Choledocholithiasis. Can J Gastroenterol Hepatol. 2016:5132052, 2016.
14. Cho JH, Kim TN, Kim SB. Comparison of clinical course and outcome of acute pancreatitis according to the two main etiologies: alcohol and gallstone. BMC Gastroenterol. 15:87, 2015 Jul 25.
15. Turkvatan A, Erden A, Turkoglu MA, Secil M, Yener O. Imaging of acute pancreatitis and its complications. Part 1: acute pancreatitis. [Review]. Diagn Interv Imaging. 96(2):151-60, 2015 Feb.
16. Wu BU, Conwell DL. Acute pancreatitis part I: approach to early management. Clin Gastroenterol Hepatol. 2010;8(5):410-416, quiz e456-418.
17. Manikkavasakar S, AlObaidy M, Busireddy KK, et al. Magnetic resonance imaging of pancreatitis: an update. [Review]. World Journal of Gastroenterology. 20(40):14760-77, 2014 Oct 28.World J Gastroenterol. 20(40):14760-77, 2014 Oct 28.
18. Zhao K, Adam SZ, Keswani RN, Horowitz JM, Miller FH. Acute Pancreatitis: Revised Atlanta Classification and the Role of Cross-Sectional Imaging. [Review]. AJR Am J Roentgenol. 205(1):W32-41, 2015 Jul.
19. Aydin H, Tatar IG, Hekimoglu B. The role of diffusion weighted MR imaging in the diagnosis of acute pancreatitis. Int J Emerg Ment Health. 16(2):308-14, 2014.
20. Hocaoglu E, Aksoy S, Akarsu C, Kones O, Inci E, Alis H. Evaluation of diffusion-weighted MR imaging in the diagnosis of mild acute pancreatitis. Clin Imaging. 39(3):463-7, 2015 May-Jun.
21. Zaheer A, Singh VK, Qureshi RO, Fishman EK. The revised Atlanta classification for acute pancreatitis: updates in imaging terminology and guidelines. Abdom Imaging. 38(1):125-36, 2013 Feb.
22. Peng R, Zhang XM, Ji YF, et al. Pancreatic duct patterns in acute pancreatitis: a MRI study. PLoS ONE. 8(8):e72792, 2013.

23. Ji YF, Zhang XM, Li XH, et al. Gallbladder patterns in acute pancreatitis: an MRI study. Acad Radiol. 19(5):571-8, 2012 May.

24. Li XH, Zhang XM, Ji YF, et al. Renal and perirenal space involvement in acute pancreatitis: An MRI study. Eur J Radiol. 81(8):e880-7, 2012 Aug.

25. Bakker OJ, van Santvoort H, Besselink MG, et al. Extrapancreatic necrosis without pancreatic parenchymal necrosis: a separate entity in necrotising pancreatitis?. Gut. 62(10):1475-80, 2013 Oct.

26. Kamal A, Singh VK, Akshintala VS, et al. CT and MRI assessment of symptomatic organized pancreatic fluid collections and pancreatic duct disruption: an interreader variability study using the revised Atlanta classification 2012. Abdom Imaging. 40(6):1608-16, 2015 Aug.

27. Sternby H, Verdonk RC, Aguilar G, et al. Significant inter-observer variation in the diagnosis of extrapancreatic necrosis and type of pancreatic collections in acute pancreatitis - An international multicenter evaluation of the revised Atlanta classification. Pancreatology. 16(5):791-7, 2016 Sep-Oct.

28. Cai DM, Parajuly SS, Ling WW, Li YZ, Luo Y. Diagnostic value of contrast enhanced ultrasound for splenic artery complications following acute pancreatitis. World J Gastroenterol. 20(4):1088-94, 2014 Jan 28.

29. Islim F, Salik AE, Bayramoglu S, Guven K, Alis H, Turhan AN. Non-invasive detection of infection in acute pancreatic and acute necrotic collections with diffusion-weighted magnetic resonance imaging: preliminary findings. Abdominal Imaging. 39(3):472-81, 2014 Jun.

30. Rana SS, Sharma V, Sharma R, Gupta R, Bhasin DK. Endoscopic ultrasound guided transmural drainage of walled off pancreatic necrosis using a "step - up" approach: A single centre experience. Pancreatology. 17(2):203-208, 2017 Mar - Apr.

31. Dhaka N, Samanta J, Kochhar S, et al. Pancreatic fluid collections: What is the ideal imaging technique?. [Review]. World J Gastroenterol. 21(48):13403-10, 2015 Dec 28.

32. Jang JW, Kim MH, Oh D, et al. Factors and outcomes associated with pancreatic duct disruption in patients with acute necrotizing pancreatitis. Pancreatology. 16(6):958-965, 2016 Nov - Dec.Pancreatology. 16(6):958-965, 2016 Nov - Dec.

33. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: https://edge.sitecorecloud.io/americancoldf5f-acrorgf92a-productioncb02-3650/media/ACR/Files/Clinical/Appropriateness-Criteria/ACR-Appropriateness-Criteria-Radiation-Dose-Assessment-Introduction.pdf.

Disclaimer

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may

influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

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