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# Imaging in Practice

## Imaging's roles in acute pancreatitis

A 50-YEAR-OLD MAN PRESENTS with severe upper-abdominal pain radiating to the back with associated nausea and vomiting. The patient has not had any prior episodes of abdominal pain. He has no history of surgery or significant medical problems.

The physical examination reveals mild abdominal guarding associated with epigastric tenderness. Laboratory work shows markedly elevated levels of serum amylase (2,000 U/L, normal range 25–85 ) and serum lipase (3,500 U/L, normal range 14–280). A diagnosis of acute pancreatitis is made.

Should the patient have any imaging tests? If so, which imaging tests are helpful in the management of acute pancreatitis?

### ROLE OF IMAGING IN ACUTE PANCREATITIS

Imaging in patients with suspected or confirmed acute pancreatitis serves five purposes:

- To confirm the diagnosis, especially when the presentation or laboratory values are confusing
- To detect gallstones as the possible cause
- To detect pancreatic necrosis
- To detect complications of acute pancreatitis, including pseudoaneurysms, abscesses, infected necrosis, or symptomatic pseudocyst
- To guide percutaneous aspiration or drainage.

The four main imaging methods available for the diagnosis and treatment of acute pancreatitis are ultrasonography, computed tomography (CT), magnetic resonance imaging (MRI), and cholangiography. In this review, we will address only ultrasonography, CT, and MRI.

**FIGURE 1.** Acute pancreatitis with acute fluid collections. Computed tomography after intravenous contrast enhancement shows acute fluid collections (arrows) and normal enhancing pancreatic parenchyma (arrowhead).

### ULTRASONOGRAPHY TO DETECT GALLSTONES

Ultrasonography's main role in acute pancreatitis is to detect gallstones as the likely cause. Less commonly, it is used to detect stones in the common bile duct,[1] but the diagnostic accuracy of ultrasonography of the distal common bile duct and pancreas is often limited by overlying bowel gas and adipose tissue.

An important consideration is that, in a patient with acute pancreatitis, a negative ultrasonographic study of the gallbladder does

not exclude stone disease, especially very small stones (< 3 mm) or sludge, as the cause. Assessment of the biliary tract is warranted in patients with suspected idiopathic pancreatitis once the acute symptoms have resolved.[2]

## CT WITH CONTRAST

When CT is used to evaluate the pancreas for the diagnosis of acute pancreatitis and its complications, iodinated contrast media enhancement is essential. There are concerns that iodinated contrast agents may worsen acute pancreatitis, but these are largely theoretical and are based in part on laboratory evidence in rats.[3,4] CT without contrast enhancement is generally suboptimal, and when pancreatic necrosis is suspected it is virtually useless.

With CT, it is important to scan during the arterial phase of contrast enhancement in order to detect arterial pseudoaneurysms. A more delayed, portal venous scan evaluates enhancement of the pancreatic parenchyma and can identify venous complications. Precontrast CT is rarely performed; thus, hemorrhagic pancreatitis is almost never detected on routine contrast-enhanced CT.

**Pancreatic necrosis is associated with death rates of 17.5% to 40%**

### Making the best use of CT in acute pancreatitis

Pancreatitis is most often diagnosed clinically when a patient presents with abdominal pain and has elevated levels of serum pancreatic enzymes, especially lipase. For patients who are suspected of having mild pancreatitis and who have no or only mild systemic organ dysfunction or systemic toxicity and a rapid response to treatment, ultrasonography of the gallbladder may be the only useful imaging test.[5]

CT can be used to confirm biochemical evidence of pancreatitis; however, the findings can be normal in 15% to 30% of cases.[6,7] CT performed at presentation is likely to be most useful in patients with severe or atypical presentations, and CT at admission may be helpful in differentiating acute pancreatitis from conditions such as perforated peptic ulcer, mesenteric ischemia, acute cholecystitis, and bowel obstruction or perforation.

## MAGNETIC RESONANCE TECHNIQUES

### When is MRI preferable to CT?

Although CT is the imaging study used most often in the diagnosis of acute pancreatitis and its complications, it may not be appropriate for every patient. For example, if the patient has a severe allergy to iodinated contrast media or has acute renal failure, then an option is MRI of the upper abdomen using gadolinium diethylenetriamine pentaacetic acid enhancement. On the other hand, MRI is not diagnostic in patients who cannot hold their breath or remain still during the procedure,[8] and it is contraindicated in patients with pacemakers and intracranial aneurysm clips.

MRI has some advantages over CT, including better detection of cholelithiasis, choledocholithiasis, and anomalies of the pancreatic duct, and MRI does not use ionizing radiation. However, identification of ductal anomalies is not as important in the setting of acute pancreatitis.

Despite any relative advantages or differences between CT and MRI, the findings of MRI and the reasons for performing it are essentially the same as for CT and are discussed in detail below.

### Magnetic resonance cholangiopancreatography

Magnetic resonance cholangiopancreatography (MRCP) is an excellent, noninvasive way to detect stones in the common bile duct.[1] However, it should only be used in acutely ill patients when persistent findings suggest biliary obstruction.

A caveat: the negative predictive value of MRCP in sick patients who are unable to hold their breath is probably much lower than in stable, asymptomatic patients.

As with CT, initial scanning should occur during the arterial phase of enhancement in order to detect arterial pseudoaneurysms.

## IMAGING FINDINGS IN PANCREATITIS

### Acute inflammatory changes, acute fluid collections, pseudocysts

Common CT findings in early acute pancreatitis include edematous enlargement of the

pancreas with soft-tissue changes extending into the anterior and lateral peripancreatic fat and with thickening of the fascial planes.

Peripancreatic fluid is also often seen early in the disease process, occurring in more than 50% of patients with moderate to severe acute pancreatitis.[6] Any peripancreatic fluid that develops within 4 weeks after acute pancreatitis is termed an *acute fluid collection* (FIGURE 1). Any collection that persists for more than 4 weeks is termed a *pseudocyst*.[9] Acute fluid collections often have irregular shapes and a poorly defined inflammatory wall, and most resolve spontaneously without intervention.[6]

## Pancreatic necrosis

Pancreatic necrosis occurs in 5% to 20% of patients with acute pancreatitis and increases the risk of complications and death.[6,10]

When to perform CT to detect pancreatic necrosis is controversial. Some centers perform CT early in all patients presenting with acute pancreatitis, while others perform CT only when patients present with severe acute pancreatitis, "severe" defined as meeting three or more of the 11 Ranson criteria or a score of 8 or more points on the Acute Physiology and Chronic Health Evaluation (APACHE-II). (Most of these patients have definable organ failure.)

However, because pancreatic necrosis occurs most often within 48 hours after the onset of symptoms,[6,10] the optimal time to detect necrosis with CT may be 4 days after the onset of symptoms.[6]

In pancreatic necrosis, the microcirculation is disrupted. Thus, after iodinated contrast is given, the necrotic gland does not enhance (FIGURE 2), whereas the normal pancreas enhances by more than 40 Hounsfield units (HU). Enhancement by less than 30 HU indicates pancreatic necrosis, although some surgeons would argue that this finding represents altered perfusion of the gland.[6]

CT has a positive predictive value of 100% when more than 50% of the pancreas is necrotic.[6] While experts may disagree over the clinical value of identifying necrosis with CT versus using classifications of clinical severity such as the Ranson criteria and the APACHE-II,[11] several studies[12–14] have found that a CT-based grading system—the CT severity index—can predict the risk of complications and death[6,12] better than the Ranson criteria or the APACHE-II,[12–14] and recent data[14] suggest that CT performed at admission is useful in predicting complications and death.[14]

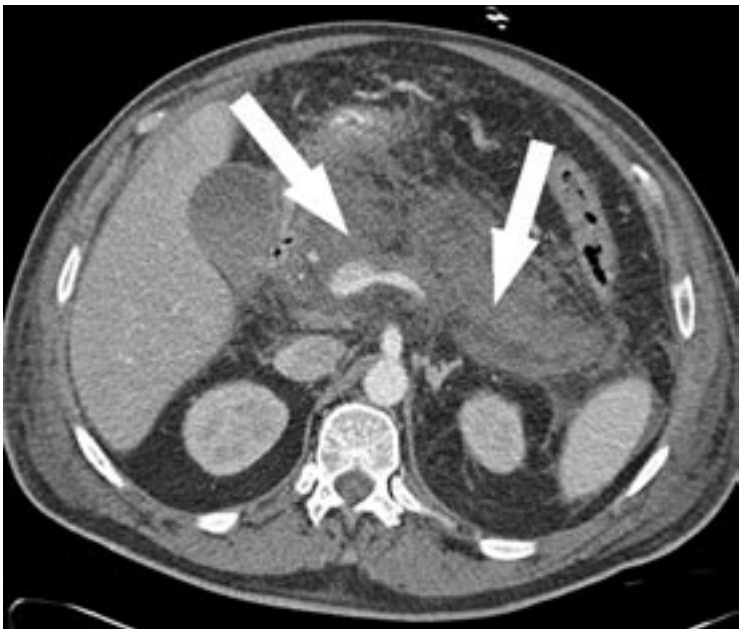

**FIGURE 2.** Acute pancreatitis with pancreatic necrosis. CT after intravenous contrast enhancement shows poorly enhancing pancreatic parenchyma (arrows). The extensive areas of poor enhancement indicate near total necrosis.

**Contrast-enhanced CT is the most useful study in severe pancreatitis**

## Infection vs sterile necrosis

Pancreatic necrosis is associated with death rates of 17.5% to 40%.[13,15] Infection develops in 30% to 70% of patients with acute pancreatic necrosis and accounts for about 80% of deaths from acute pancreatitis.[13] The contamination rate peaks 3 weeks after the onset of pancreatitis, and death from infection typically occurs after 3 weeks.[16] In acute pancreatitis, death from infection is now more common than early death due to inadequate resuscitation. By comparison, the death rate in patients with sterile acute pancreatic necrosis is 10%, and surgical intervention has not improved the clinical outcome for these patients.[13,17]

Unfortunately, distinguishing sterile pancreatic necrosis from infected necrosis on a clinical basis is difficult, as both conditions are associated with leukocytosis and fever, and CT cannot differentiate between the two unless

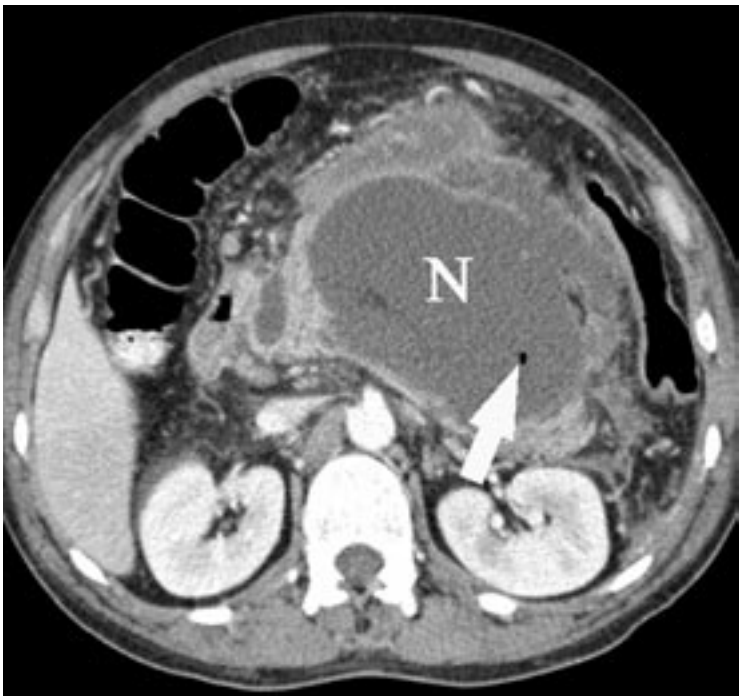


**FIGURE 3.** Acute pancreatitis with infected necrosis. On the intial episode of acute pancreatitis, the CT showed pancreatic necrosis. Here, enhanced CT performed 2 weeks later shows the necrotic portion of the pancreatic body and tail (N) containing a bubble of gas (arrow). On aspiration this was infected.

there is gas in the necrotic tissue (FIGURE 3).

## RECOMMENDATIONS FOR CT IN ACUTE PANCREATITIS

Despite disagreement over the use of contrast-enhanced CT in acute pancreatitis, we believe it is the most useful imaging study to evaluate a complicated or severe presentation of acute pancreatitis, and it also helps guide percutaneous treatment of the complications.

We recommend using CT in the following instances:

- **In any severely ill patient in whom necrosis is more likely.** These patients generally are in shock, require aggressive fluid resuscitation, have a rising serum creatinine level with decreasing urine output, have pulmonary insufficiency, and may have gastrointestinal bleeding.
- **After 4 days,** because delayed necrosis can occur 1 to 3 days after the onset of the illness.
- **If the diagnosis of acute pancreatitis is uncertain** or if the patient has a coexisting condition such as gangrenous cholecystitis.
- **To guide disposition of the patient**, such as when the clinician is not sure whether to admit the patient to the intensive care unit (ICU) or to a regular hospital floor.
- **In any patient who does not improve** or whose condition deteriorates despite medical management.

## IMAGING AND MANAGEMENT

Initial management should focus on resuscitating the patient. If the patient is acutely ill, consult a surgeon as soon as possible.

In patients with a high CT severity index at baseline, especially those with necrosis, close coordination of care between the medical intensive care unit, the surgeon, and the radiologist is essential.

Once CT is performed, the decision to perform repeat CT studies should be made very carefully, since the studies are expensive and may unnecessarily expose the patient to more ionizing radiation and contrast agents: we have seen numerous patients undergo repeat CT studies every 3 to 5 days without any change in management.

Generally, when the patient is scanned less than 7 to 10 days after the acute episode, management does not change. However, if the patient's condition does not improve or deteriorates over that period of time, repeat CT should be performed after consultation with the surgeon and the radiologist.

The surgeon should be informed in order to prepare for a possible necrosectomy. The radiologist should be informed in order to plan an aspiration or aspirations immediately after CT. There is no reason to repeat CT in a patient with acute pancreatitis unless the goal is to aspirate fluid or necrotic tissue for bacterial culture if infected pancreatitis is suspected.

Later CT evaluation may be useful in managing patients who develop new symptoms after the initial episode. In addition to infected necrosis, the later complications identified on CT include pancreatic pseudocyst, pancreatic abscess, a hemorrhagic acute fluid collection or pseudocyst, pseudoaneur-

ysm, and mesenteric venous thrombosis. Again, contrast-enhanced CT is recommended for a complete evaluation.

A small percentage (10% to 15%) of acute fluid collections persist, develop a capsule, and become pseudocysts[18]—well-defined collections of pancreatic fluid, surrounded by a fibrous wall and persisting for more than 4 weeks. Unfortunately, CT cannot distinguish a noninfected pseudocyst from an infected pseudocyst; however, gas within a collection strongly suggests infection.[19] The only method to reliably evaluate for infection is aspiration and laboratory analysis.

### Pancreatic abscess vs infected necrosis

It is important to distinguish a pancreatic abscess from infected necrosis. An infection documented at any time after the finding of pancreatic necrosis must be considered to be infected necrosis. An established infected collection that presents more than 1 month after the onset of pancreatitis in a patient with no prior evidence of necrosis should be considered a pancreatic abscess.

The prognosis and treatment are markedly different for the two entities. Unfortunately, much of the literature before 1992 combined these two entities. Abscess occurs in about 3% of patients with acute pancreatitis and can be managed via percutaneous or surgical drainage, whereas infected necrosis is typically managed surgically.

### Pseudoaneurysm

Another later complication of pancreatitis is pseudoaneurysm formation, resulting from the autodigestion of the vessel wall by pancreatic enzymes. The prevalence of pseudoaneurysm is unknown but has been estimated to be as great as 10% in acute pancreatitis.[20]

The splenic artery is the vessel most often involved, but the gastroduodenal, inferior pancreaticoduodenal, and superior pancreaticoduodenal arteries are also relatively commonly affected.[21]

A collection of hemorrhagic fluid suggests rupture of the pseudoaneurysm and should prompt angiography with the possibility of therapeutic embolization. Hemorrhage is easily identified on CT by highly attenuated material (> 20 HU) within a fluid collection (**FIGURE 4**).

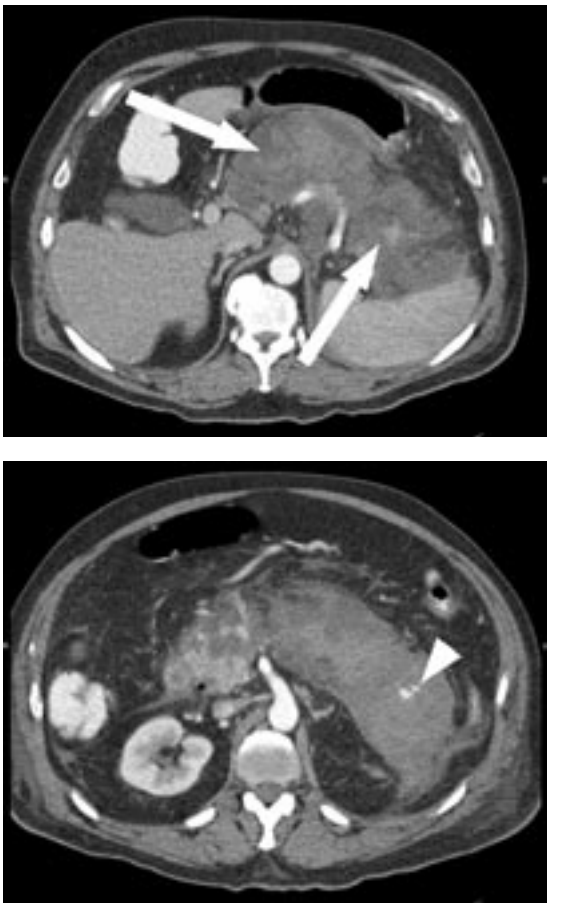

**FIGURE 4.** Acute pancreatitis with necrosis and an actively bleeding pseudoaneurysm. The enhanced CT scan (top) obtained in the arterial phase shows high-attenuation material (arrows) within the necrotic gland. Laterally, within the collection (bottom scan), there is an area with very high attenuation (arrowhead), indicating an active bleeding site.

**The decision to perform repeat CT studies should be made carefully**

### Imaging-guided percutaneous aspiration and placement of drainage catheter

Another use of contrast-enhanced CT is in guiding percutaneous aspiration and placement of a drainage catheter. Before any intervention is considered, a surgeon should be consulted, and realistic, definable goals should be set. The diagnosis of infected necrosis by aspiration and laboratory study helps to guide prompt and appropriate surgical intervention.[22]

With potentially infected necrosis, it is important to determine before needle placement whether the patient is a candidate for a necrosectomy or is too ill for such an extensive

procedure. There is evidence that aggressive, percutaneous drainage of infected necrosis with large-bore catheters, vigorously and continuously flushed, either will buy time for critically ill patients to recover enough to undergo surgery or, in some cases, will cure them.[23]

Often, when the radiologist aspirates infected necrosis, frank pus is found. The decision to place a drainage catheter should be made before the intervention so as not to delay patient disposition. In the case of an abscess, imaging-guided percutaneous drainage is a very effective means to achieve a cure.[24]

## Imaging-guided treatment of pseudocysts

Imaging-guided treatment of pancreatic pseudocysts is much more controversial. The literature is replete with series touting high success rates of surgical, endoscopic, and percutaneous methods, but often showing how poor another method performs.[25,26] In addition, studies have seriously questioned the dogma that all pseudocysts must be drained,[26,27] while others have shown that the natural history of asymptomatic pseudocysts is benign if they are not enlarging, and is not related to size.[28,29]

Many issues must be addressed before placing a percutaneous catheter in a pseudocyst. Many believe that the clinician should know the patient's ductal anatomy, downstream strictures, and ductal communication with the cyst before placing a catheter. The clinician should also be prepared to treat infection secondary to placement of the percutaneous catheter, since most patients develop one. Fortunately, these infections can usually be treated with oral antibiotics on an outpatient basis.

Lastly, before a percutaneous catheter is removed, a tube check (ie, radiography with dye injection) must be performed to determine whether the cyst connects to the duct.

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