

AP as it is widely available, the examination can be performed with minimal patient preparation, and the examination does not use sedation, contrast material, or ionizing radiation (4,21–23). The major advantages of ultrasound over other imaging modalities are availability and portability. The latter allows bedside imaging of critically ill and difficult-to-transport patients. Ultrasound can, however, be limited in patients with large body habitus, or with excessive bowel gas. In addition, ultrasound may underestimate or poorly delineate the extent of extrapancreatic sequelae of AP (24).

A right upper quadrant ultrasound examination typically does not provide full imaging of the pancreas and will not evaluate other areas of the abdomen for potential pancreatitis complications. A complete abdominal ultrasound allows evaluation of both upper quadrants and the pancreas, and may include assessment of the lower quadrants for fluid.

Ultrasound examinations are ideally performed fasting (≥ 4 hours) to reduce bowel gas that can obscure the pancreas and to distend the gallbladder. When the patient is able, drinking water immediately prior to the examination to distend the stomach with fluid and displace gastric air may provide an improved acoustic window for imaging the pancreas. A complete ultrasound examination should assess pancreatic size, contour, echogenicity, pancreatic duct diameter (and for duct filling defects), and should assess for peripancreatic edema and pancreatic or peripancreatic fluid collections (25). In addition, the gallbladder should be assessed for calculi (an etiology of pancreatitis), and the biliary tree should be assessed for dilation and calculi (4,22,26). Color Doppler along with gray-scale imaging can evaluate the peripancreatic vascular structures for complications, such as splenic vein or portal vein thrombosis and can assess vascularity of the pancreas.

Contrast-enhanced ultrasound (CEUS), which involves the intravenous administration of contrast material consisting of microbubbles, has been explored for assessment of both AP and CP but is not yet accepted as standard of care, so its role in pediatric pancreatitis remains to be defined (27,28).

Computed Tomography

The major advantage of CT versus other noninvasive imaging modalities is that the examinations are short and can generally be achieved without sedation or anesthesia. For this reason, CT is the modality of choice for acute assessment of traumatic injury of the pancreas. Body habitus and air-filled bowel loops are not limiting factors for CT (compared with ultrasound).

CT for pediatric pancreatitis should utilize intravenous (IV) contrast material, which optimizes assessment of the solid organs and vasculature. CT with IV contrast material can be performed as a single (arterial or portal venous phase) or multiphase examination. When performed as a single-phase examination for pancreatic indications, portal venous phase imaging is most common. Intravenous iodinated contrast material carries a very low risk of allergic-like reactions. Risk of exacerbation of renal dysfunction in children with estimated glomerular filtration rate less than $60 \text{ mL/min/1.73 m}^2$ should be balanced with the potential benefit of the examination (29).

Use of oral contrast material for CT in pancreatitis is inconsistent; specific recommendations do not exist for children. In adults, oral water is recommended for imaging of pancreatitis (20). A potential benefit of positive oral contrast, which is high in attenuation, is distinguishing fluid collections from bowel loops but oral contrast material can be difficult for pediatric or acutely ill patients to consume and prolongs the preparatory phase of the CT examination.

Limiting CT to the abdomen only is discouraged. CT limited to the abdomen allows assessment of the pancreas, adjacent vessels, and surrounding structures but does not allow assessment for extension of complications (eg, fluid collections) into the lower

abdomen and pelvis. CT of the abdomen and pelvis allows assessment of the pancreas and the full extent of associated complications.

Magnetic Resonance Imaging and Magnetic Resonance Cholangiopancreatography

MRI has the best soft tissue contrast of available cross-sectional imaging modalities. This soft tissue contrast optimizes parenchymal characterization and visualization and characterization of ducts and fluid collections. MRCP, which is sometimes arbitrarily distinguished from other MRI examinations, simply reflects a type of MRI sequence that utilizes heavy T2-weighting to accentuate fluid-filled structures including the pancreatic and biliary ducts. Like CT, body habitus and air-filled bowel loops are not limitations for MRI. Potential need for sedation or general anesthesia in the pediatric population to accomplish relatively long examinations is the primary disadvantage of MRI.

Given its superior soft tissue contrast, MRI is the preferred imaging modality for ARP, CP, and autoimmune pancreatitis where characterization of both the pancreatic parenchyma and duct is important (30). Protocol guidelines exist for adults but have not been formalized for children (20). An MRCP sequence should be included in most pancreatic MRI examinations. IV gadolinium-based contrast material can be useful for characterization of the vasculature and for diagnosis of autoimmune pancreatitis but is not required for routine assessment of CP. IV contrast material is not required to acquire an MRCP sequence and hepatobiliary contrast material can compromise MRCP sequences.

Use of intravenous secretin as an adjunctive medication may improve visualization of the pancreatic duct and allows assessment of exocrine function (31–39). According to adult studies, secretin improves visualization of the pancreatic duct by MRCP with a higher diagnostic accuracy of detecting pancreas divisum (34–37). The reported sensitivity and specificity of diagnosing pancreas divisum with secretin-MRCP falls in the range of 73% to 100% and 97% to 100%, respectively (40).

Timing of Imaging

Optimal timing of imaging, particularly relative to an attack of AP, depends on the unique patient situation. Few studies have published pediatric data specific to this question, but adult data suggest that imaging within the first 48 hours of an attack of AP infrequently alters management and poorly predicts the severity of organ failure (41). However, if imaging is necessary to make a diagnosis or to manage a patient, it should not be deferred. In patients with suspected or known CP where imaging confirmation of findings of CP is needed, imaging when the patient does not have superimposed AP is preferred to prevent obscuration of findings by acute inflammation.

General Imaging Technique Summary Statements and Recommendations

1. CT should be performed with intravenous contrast material as a single portal venous phase examination unless specific arterial detail is needed (Table 3).
GRADE: 1C, agreement 100% (11/11; 6, strongly agree; 5, agree; average score = 4.5)
2. When imaging with MRI, intravenous contrast material is not always needed but contributes to the diagnosis and definition of necrosis, assessment of the vasculature, and the diagnosis of autoimmune pancreatitis.
GRADE: 2C, agreement 100% (11/11; 3, strongly agree; 8, agree; average score = 4.3)