PROVIDER LED ENTITY
Abdominal Pain AUC
2023 Update

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Appropriateness of advanced imaging procedures* in patients with nontraumatic abdominal pain and the following clinical presentations or diagnoses:

*Including MRI, MRCP, MR enterography, MR enteroclysis, MR angiography, CT, CT enterography, CT enteroclysis, CT angiography, scintigraphy, PET, PET/CT, and SPECT

Abbreviation list:

ACG	American College of Gastroenterology
ACR	American College of Radiology
AHRQ	Agency for Healthcare Research and Quality
AMI	Acute mesenteric ischemia
APA	American Pancreatic Association
AUC	Appropriate Use Criteria
CAGBD	Chronic acalculous gallbladder disease
CBDS	Common bile duct stones
CD	Crohn's disease
CT	Computed tomography
CTA	Computed tomography angiography
CECT	Contrast-enhanced computed tomography
EASL	European Association for the Study of the Liver
ERCP	Endoscopic retrograde cholangiopancreatography
EUS	Endoscopic ultrasound
HIDA	Hepatobiliary iminodiacetic acid
IBD	Inflammatory bowel disease
IOC	Intraoperative cholangiography
MDCT	Multidetector computed tomography
MRA	Magnetic resonance angiography
MRCP	Magnetic resonance cholangiopancreatography
MRI	Magnetic resonance imaging
NICE	National Institute for Health and Care Excellence
PET	Positron emission tomography
PLE	Provider Led Entity
PUD	Peptic ulcer disease
RUQ	Right upper quadrant
SBO	Small bowel obstruction
SIRS	Systemic inflammatory response syndrome
SNMMI	Society of Nuclear Medicine and Molecular Imaging
SVS	Society for Vascular Surgery
U/S	Ultrasound

Appropriate Use Criteria: How to Use this Document

The CDI Quality Institute follows the recommendation framework defined by the Appraisal of Guidelines for Research & Evaluation (AGREE II), AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) and a modified version of the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies) to evaluate the strength of recommendations concerning advanced imaging. Considerations used to determine a recommendation are listed below.

Primary recommendation (green): A strong recommendation for initial imaging for this presentation; there is confidence that the desirable effects of imaging outweigh its undesirable effects.

Alternative recommendation (yellow): A conditional recommendation for imaging; the desirable effects of imaging likely outweigh its undesirable effects, although some uncertainty may exist. The individual patient's circumstances, preferences, and values should be considered on a case-by-case basis. This may include: contraindication to the primary recommendation, specific clinical circumstances that require use of the alternative recommendation, or the primary recommendation has results that are inconclusive or incongruent with the patient's clinical diagnosis. Case-by-case indications to consider have been noted in brackets when appropriate.

Recommendation against imaging (red): The undesirable effects of imaging outweigh any desirable effects. Additionally, the recommendation may be impractical or not feasible in the targeted population and/or practice setting(s).

Nontraumatic Abdominal Pain AUC Summary:

Abdominal pain is a common clinical presentation in adult patients, encompassing a wide range of possible diagnoses. Patients may present with acute, intermittent, or chronic symptoms; they may complain of a localized or generalized pain; and/or they may complain of associated nausea, fever, or diarrhea. A focused history, physical examination, and laboratory testing can help to narrow differential considerations. Advanced imaging is often required, however, to make a definitive diagnosis and to guide treatment when the clinical picture remains unclear, when there is severe pain or distress, or when the patient presents with jaundice, fever, or an elevated white blood cell count.

- **Conventional radiography**, while not sensitive or specific, is often the first examination obtained. It can evaluate for typical bowel gas patterns associated with obstruction or constipation, for foreign bodies, or for free air.
- **Ultrasound** is the initial study of choice when there is pain in the right upper quadrant and suspicion of gallstone-related disease. It is also useful to detect and evaluate masses of the solid organs and pockets of free intraperitoneal fluid. Ultrasound is useful in assessing abdominal wall hernias and is often used as a front-line assessment of possible appendicitis or symptomatic AAA. Anatomy is often obscured by intestinal gas on ultrasound, and as a result, it may be of limited use in patients presenting with diffuse or poorly localized abdominal pain.
- **CT** is generally the preferred advanced imaging procedure in most patients presenting with non-traumatic abdominal pain, as it is both sensitive and specific for many pathologic entities. CT is accurate in the detection and evaluation of abscess, appendicitis, diverticulitis, bowel obstruction, perforation, and abscess.
- **MRI** may not always be readily available or may not be appropriate for patients presenting with acute pain and distress. However, it can be useful to characterize masses of the solid organs. It also has value in the management of patients with pancreatitis or inflammatory bowel disease.
- **Cholescintigraphy** may be used in patients presenting with right upper quadrant pain suggestive of cholecystitis, particularly when ultrasound is inconclusive.

PICO 1: Acute, diffuse (poorly localized) abdominal pain (including suspected abscess, incarcerated hernia, or post-surgical complication):

- Green – **CT abdomen and pelvis with IV contrast**
- Yellow – **MRI abdomen and/or pelvis without and with IV contrast**
- Yellow – **Ultrasound abdomen** and/or **ultrasound pelvis**
- Yellow – **CT abdomen and pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Yellow – **MRI abdomen and/or pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Yellow –**CT abdomen and pelvis without and with IV contrast**
  [patient with known cancer or liver disease]
- Red – **MRCP**
- Red – **PET** or **PET/CT**
- Red – **SPECT**
- Red – **Scintigraphy**
- Red – **MR or CT enterography; MR or CT enteroclysis**
- Red – **MR or CT angiography**

Level of Evidence: CT: moderate; MRI: low

Notes concerning use of contrast: The use of IV contrast increases the spectrum of detectable pathology in patients with nonlocalized abdominal pain, and is recommended in preference to other methods of contrast administration (Scheirey et al [*ACR*] 2018; Gans et al 2015).

Notes concerning applicability and/or patient preferences: In practice, the feasibility of MRI for acute abdominal pain will rely on institutional expertise, availability, and adoption of protocols that are aimed at rapid acquisition and multiorgan assessment (Scheirey et al [*ACR*] 2018).

Guideline and PLE expert panel consensus opinion summary:
Acute abdominal pain is a common complaint and can be caused by a variety of conditions (Gans et al 2015). Acute abdominal pain can often represent a diagnostic challenge, with an early and accurate diagnosis leading to better outcomes (Gans et al 2015). The range of pathology that can produce abdominal pain and fever with or without abscess is very broad and includes pneumonia, hepatobiliary disease, complicated pancreatic processes, nephrolithiasis, gastrointestinal inflammation or perforation, bowel obstruction or infarction, and abscess (Scheirey et al [*ACR*] 2018). Often the first-line modality, CT quickly evaluates the abdomen/pelvis, while ultrasound and MRI can be useful in select scenarios (Scheirey et al [ACR] 2018).

CT abdomen and pelvis
While sensitivity and specificity ranges are not routinely reported because of the wide spectrum of pathology encountered, sufficient data suggests that CT with IV contrast adds diagnostic value and helps direct management of nontraumatic abdominal pain (Scheirey et al [*ACR*] 2018; Gans et al 2015). In the setting of nonlocalized pain, CT of the abdomen and pelvis with IV contrast is usually appropriate to evaluate for abscess and a broad range of additional pathologies (Scheirey et al [*ACR*] 2018). If gastric disease is suspected, a CT abdomen and pelvis with IV contrast can be chosen if nonspecific symptoms

are encountered, as the addition of IV contrast significantly improves conspicuity of findings (Vij et al [ACR] 2021). CT is typically chosen over MRI for patient presenting with nonspecific symptoms when gastritis or peptic ulcer or duodenal ulcer is suspected, largely because of its ability to detect free air associated with a perforated ulcer and a short time interval to obtain the exam (Vij et al [ACR] 2021). Abdominal CT scanning may also be considered for select patients with suspected abdominal wall hernia to confirm the diagnosis or to aid with preoperative planning (Garcia et al [ACR] 2022; Earle et al 2016; moderate quality, strong recommendation). In the postoperative patient with nonlocalized pain and fever, CT of the abdomen and pelvis with IV contrast is appropriate to evaluate for postoperative abscess, leaks, or hemorrhage (Scheirey et al [*ACR*] 2018). CT of the abdomen and pelvis without IV contrast can be useful if the patient is unable to receive IV contrast (Scheirey et al [*ACR*] 2018).

MRI abdomen and/or pelvis

MRI of the abdomen and pelvis without and with IV contrast can be used to provide clinically useful information in the setting of nonlocalized abdominal pain (Scheirey et al [*ACR*] 2018). When optimized for the acute setting, MRI can be an accurate examination for detecting abdominal and pelvic abscesses (Scheirey et al [*ACR*] 2018). While the specific performance attributes are unknown, MRI of the abdomen may be appropriate in certain circumstances for imaging of a suspected abdominal wall hernia (Garcia et al [ACR] 2022). It can also be useful following negative ultrasound in the patient with obscure pain and/or swelling and suspicion for inguinal hernia (Simons et al 2009: grade C).

Nuclear medicine

In general, there are limited studies evaluating the use of nuclear medicine imaging in the setting of nonlocalized abdominal pain with or without fever (Scheirey et al [*ACR*] 2018; Vij et al [ACR] 2021).

Ultrasound

Ultrasound can be used to evaluate the painful abdomen (Gans et al 2015), but in general is less sensitive and specific than CT (Scheirey et al [*ACR*] 2018). Ultrasound may be able to depict portions of an abscess or malignancy, however, visualization may be limited in the presence of increased bowel gas or free intraperitoneal air (Scheirey et al [*ACR*] 2018). The ability of ultrasound to differentiate the abdominal wall from intraabdominal processes and distinguish the abdominal wall layers is well established (Garcia et al [ACR] 2022), and a preoperative abdominal ultrasound may be considered (as an alternative to CT) for selected patients with suspected abdominal wall hernia to confirm the diagnosis or to aid with preoperative planning (Garcia et al [ACR] 2022; Earle et al (2013); moderate quality, strong recommendation). In patients with epigastric pain, consideration should be given to a right upper quadrant (RUQ) ultrasound (US) to exclude hepatobilliary disease (PLE expert panel consensus opinion).

Conventional radiographs

Conventional radiography may be performed in the setting of acute abdominal pain; however, it has a limited role in the evaluation of nontraumatic abdominal pain in adults (PLE expert panel consensus opinion; Scheirey et al [*ACR*] 2018). The use of radiographs has shown high sensitivity (90%) for detecting intra-abdominal foreign bodies, but its low sensitivity for sources of abdominal pain and fever or abscess limits its role in this setting (Scheirey et al [*ACR*] 2018).

<u>Clinical and imaging notes:</u>

- Acute abdominal pain with fever raises clinical suspicion of an intra-abdominal infection, abscess, or other condition that may need immediate surgical or medical attention. When fever is present, the need for quick, definitive diagnosis is considerably heightened. Imaging is especially helpful in this scenario for the elderly (Scheirey et al [*ACR*] 2018).

- In neutropenic patients, abdominal pain remains a diagnostic challenge due to the lack of classic clinical and laboratory signs (Scheirey et al [*ACR*] 2018).
- CT should use the "as low as reasonably achievable" radiation dose (e.g., Mayo-Smith et al 2014).

Evidence update (2010-present):

Moderate Level of Evidence

Shaish et al (2023) conducted a multicenter retrospective study to determine the diagnostic accuracy of unenhanced abdominopelvic CT among 201 consecutive emergency department patients (mean age 50), using contrast-enhanced CT as the reference standard. Adult patients who underwent dual-energy contrast-enhanced CT for the evaluation of acute abdominal pain were included, with three blinded radiologists interpreting those scans to establish the reference standard by majority rule. IV and oral contrast media were then digitally subtracted using dual-energy techniques. Six different blinded radiologists from 3 institutions interpreted the resulting unenhanced CT examinations. Overall accuracy of unenhanced CT was 70%. False-negative (19%) and false-positive (14%) results were common. Interrater agreement for overall accuracy was moderate (Gwet agreement coefficient, 0.58). The authors conclude that unenhanced CT was approximately 30% less accurate than contrast-enhanced CT for evaluating abdominal pain in the ED. This should be balanced with the risk of administering contrast material to patients with risk factors.

Millet et al (2017) prospectively assessed the added-value of unenhanced abdominal CT on ED diagnosis and management accuracy in 401 elderly patients with nontraumatic acute symptoms. Consecutive patients $\geq$ 75 years with acute symptoms were included. CT was found to significantly improve diagnosis (85% vs. 76.8%) and management (95.8% vs. 88.5%) compared to current practice. In those where CT was not requested, CT led to diagnosis of acute unsuspected disorders in 30.3% of cases, and a change in management in 37.1% of cases. The authors conclude that unenhanced abdominal CT improves ED diagnosis accuracy and appropriate management in elderly patients presenting with acute symptoms compared to current practice.

Low Level of Evidence

Barat et al (2019) retrospectively compared diagnostic accuracy and inter-reader agreement of unenhanced vs. contrast-enhanced CT among 208 consecutive ED patients (age $\geq$ 75 years) with acute abdominal pain. Patients received both unenhanced and contrast-enhanced CT; three readers reviewed unenhanced, then unenhanced and contrast-enhanced images as a single set. Standard of reference was final diagnosis after evaluation. Diagnostic accuracy was 64% (95% CI: 62—66%) to 68% (95% CI: 66—70%) for unenhanced CT, and 68% (95% CI: 66—70%) to 71% (95% CI: 69—73%) for combined CT. Contrast-enhanced CT did not significantly improve diagnostic accuracy (P = 0.973—0.979). Intra-observer agreement was moderate to substantial (k = 0.513—0.711). Inter-reader agreement was substantial for both unenhanced (kappa = 0.745—0.789) and combined CT (kappa = 0.745—0.799). The authors conclude that unenhanced CT alone is accurate and associated with a high inter-reader agreement of acute abdominal pain, and can be a valuable tool for triaging.

Othman et al (2018) retrospectively evaluated a reduced-dose (100kVp) CT protocol compared to a blended 120 kVp protocol for assessing acute, nontraumatic abdominal pain. Two radiologists assessed both 100 kVp and 120kVp images among 112 consecutive patients. Image quality was high for both series without significant differences (P=0.157). Diagnostic accuracy was high for both series (120 kVp: area under the curve [AUC] = 0.950, sensitivity = 0.958, specificity = 0.941; 100 kVp: AUC = 0.910, sensitivity = 0.937, specificity = 0.882; P $\geq$ 0.516) with near perfect inter-rater agreement (Kappa =

0.939). Diagnostic confidence was high for both dose levels without significant differences (100 kVp 5, range 4–5; 120 kVp 5, range 3–5; P = 0.134). The 100 kVp series yielded 26.1% lower radiation dose compared to 120 kVp (5.72+/-2.23 mSv vs 7.75+/-3.02 mSv, P < 0.001). Image noise was significantly higher in reduced-dose CT (13.3+/-2.4 HU versus 10.6+/-2.1 HU; P < 0.001). The authors conclude that reduced-dose abdominal CT yields excellent imaging quality and high diagnostic accuracy for acute nontraumatic pain.

PICO 2: Right upper quadrant pain with suspected hepatobiliary disease:

- **Green – Ultrasound abdomen**
- **Yellow** - **Cholescintigraphy**
- **Yellow** - **MRI abdomen without and with contrast with MRCP**
- **Yellow** – **MRI abdomen without contrast with MRCP**
- **Yellow** - **CT abdomen with IV contrast**
- **Yellow** – **CT abdomen without IV contrast**
  [patient unable to receive IV contrast]
- **Yellow** – **CT abdomen without and with IV contrast**
  [patient with known cancer or liver disease]
- **Red** – **PET** or **PET/CT**
- **Red** – **SPECT**
- **Red** – **MR or CT enterography; MR or CT enteroclysis**
- **Red** – **MR or CT angiography**

Level of Evidence: MRI with MRCP, cholescintigraphy: moderate; CT: low

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Acute cholecystitis (AC) is the most common cause of right upper quadrant pain, and 95% of cases of AC have gallstones present (Russo et al [ACR] 2023). Information derived only from clinical history, physical examination, and routine laboratory tests does not yield sufficient diagnostic certainty, however, for making management decisions for conditions such as acute cholecystitis (Russo et al [ACR] 2023). Therefore, imaging studies play a major role in establishing a diagnosis of acute cholecystitis and assessing possible alternate diagnoses (Russo et al [ACR] 2023).

Ultrasound
Ultrasound is the first choice for investigation of biliary symptoms or right upper quadrant abdominal pain (Russo et al [ACR] 2023; PLE expert panel consensus opinion). Ultrasound has an accuracy for detecting gallbladder stones greater than 95% (*EASL* 2016: high quality evidence, strong recommendation) and should be offered to patients with suspected gallstone disease or suspected common bile duct (CBD) stones (*NICE* 2014; Williams et al 2017: low quality evidence, strong recommendation; *EASL* 2016: low quality evidence, weak recommendation). Similarly, ultrasound should be performed at the initial consultation for all cases in which acute cholecystitis (50-88% sensitivity and 80-88% specificity) or acute cholangitis is suspected, with (EASL 2017: grade 3 evidence, level 1 recommendation; Yokoe et al [*JSHBPS*] 2013: recommendation 1, level A; *EASL* 2016: moderate quality evidence, strong recommendation). In these patients, ultrasound can exclude mechanical bile duct obstruction, mass lesions (in and outside the liver) and abnormalities of the gallbladder (EASL 2017). In a patient initially presenting with jaundice, abdominal ultrasound can detect both cirrhosis and the presence of dilated intrahepatic/extrahepatic bile ducts (Hindman et al [*ACR*] 2019). While ultrasound is sensitive, non-invasive, and portable, its findings are operator-dependent, and abnormalities of bile ducts may be missed (EASL 2017). Normal ultrasound results do not preclude further investigation if clinical suspicion remains high (Williams et al 2017: low quality evidence, strong recommendation).

Cholescintigraphy
Cholescintigraphy is usually appropriate following a negative or equivocal ultrasound in the imaging of patients with right upper abdominal pain if there is a high suspicion of acute cholecystitis or obstructive biliary disease (Russo et al [ACR] 2023; Scheirey et al [*ACR*] 2018; Dillehay et al [*SNMMI*] 2017;). Direct comparisons of diagnostic accuracy of ultrasound and cholescintigraphy performed in multiple studies have confirmed the superior accuracy of cholescintigraphy for conditions such as acute cholecystitis (Russo et al [ACR] 2023). Ultrasound remains indicated as the initial study of choice, however, because of its sensitivity for gallstones and bile duct calculi, and its ability to diagnose other disorders which may be present in up to a third of patients presenting with right upper quadrant pain (Russo et al [ACR] 2023).

If there is a history of gallstones and suspicion for acute cholecystitis or acute cystic duct obstruction, hepatobiliary iminodiacetic acid [HIDA] scintigraphy can play a pivotal role in the management of patients (Dillehay et al [*SNMMI*] 2017). HIDA scintigraphy has a high sensitivity and specificity for acute cholecystitis with a pooled sensitivity and specificity for the detection of acute cholecystitis of 96% (range 78%-100%) and 90% (range 50%-100%), respectively (Dillehay et al [*SNMMI*] 2017). The accuracy of HIDA scintigraphy for the detection of acute acalculous cholecystitis is more limited, with reported sensitivity 67% to 100% and specificity from 58% to 88% (Dillehay et al [*SNMMI*] 2017). Evidence for the accuracy of HIDA imaging in the setting of painful acute biliary duct obstruction is also limited, with a sensitivity of 67-93% and a specificity of 64-67% (Dillehay et al [*SNMMI*] 2017).

CCK cholescintigraphy is indicated in the evaluation of patients with symptoms of recurrent biliary colic and no evidence of gallstones on ultrasound, and is considered to be a valuable test for in the diagnosis of chronic acalculous gallbladder disease (Dillehay et al [*SNMMI*] 2017). CCK cholescintigraphy may also be helpful to diagnose chronic cholecystitis in patients with an initial normal HIDA result. On the basis of moderate-level evidence demonstrating the utility of cholescintigraphy in the evaluation of chronic cholecystitis, HIDA with CCK is deemed to be appropriate in patients with abnormal ultrasound results and it may be appropriate in patients with normal ultrasound results (Dillehay et al [*SNMMI*] 2017).

MRI abdomen with MRCP
In the setting of right upper quadrant pain with suspected biliary disease following a negative or equivocal ultrasound, MRI with MRCP is usually an appropriate modality (Russo et al [ACR] 2023; *EASL* 2016: low quality evidence, weak recommendation). MRCP in cholestatic patients is a safe and accurate imaging method when performed by experienced practitioners, offering excellent soft tissue contrast and visualization of the gallbladder, biliary tree, and structures outside of the biliary tree (Russo et al [ACR] 2023; EASL 2017). MRI may better identify stones in the gallbladder neck or cystic duct, which are seen as filling defects on MRCP and T2-weighted images, and associated gallbladder wall abnormalities, including wall thickening and pericholecytic fluid (Russo et al [ACR] 2023).

MRI abdomen with MRCP is recommended in patients with unexplained cholestasis and can assess for intraluminal biliary pathology including choledocholithiasis as a cause of biliary pain or an etiology for acute pancreatitis. (Russo et al [ACR} 2023; EASL 2017: grade III evidence, level 1 recommendation). This is particularly true when ultrasound has not detected the stones, but the bile duct is dilated and/or liver function test results are abnormal (*NICE* 2014). MRCP results in excellent visualization of the biliary tree and can assess for intraluminal biliary pathology including choledocholithiasis (Russo et al [ACR] 2023). The sensitivity and specificity of MRCP to diagnose biliary obstruction has been reported to be 95% and 97% respectively, with a slightly lower sensitivity (92%) for the detection of biliary stones (Greenberg et al 2016*).

MRCP can also be used to confirm the presence of CBD stones in patients with intermediate risk of choledocholithiasis or suspicion of acute cholangitis (Buxbaum et al [ASGE] 2019: conditional recommendation, low quality of evidence; Kiriyama et al [*JSHBPS*] 2013: recommendation 2, level D; *EASL* 2016: moderate quality evidence, strong recommendation).

The use of MRI abdomen with MRCP is limited because of the length of the exam and because of claustrophobia in a significant number of patients. In addition, MRI may be contraindicated in some patients with electronic or metallic implants, and patient motion may limit image quality in patients in severe pain, in uncooperative patients or in patients with claustrophobia (Russo et al [ACR] 2023).

CT abdomen

In patients with acute biliary obstruction and suspected complicating conditions, a contrast-enhanced abdominal CT study is useful in defining the level of obstruction, likely cause, and coexistent complications (Hindman et al [*ACR*] 2019). CT is suggested as the most effective imaging method for the diagnosis and complications of acute cholangitis (Kiriyama et al [*JSHBPS*] 2013: recommendation 2, level D). CT can confirm or refute the diagnosis of acute cholecystitis in equivocal cases based on ultrasound or scintigraphy, with a negative predictive value near 90% (Russo et al [ACR] 2023). CT may also reveal complications of gangrene, gas formation, intraluminal hemorrhage, and perforation, and is a useful modality for preoperative planning (Russo et al [ACR] 2023).

There is limited data on the utility and value of noncontrast CT for biliary obstruction, except possibly in patients with prior chronic disease or neoplasia (Hindman et al [*ACR*] 2019). While some features and complications of acute cholecystitis can be detected on CT without IV contrast, other important features, such as wall enhancement and adjacent liver parenchymal hyperemia, cannot be detected (Russo et al [ACR] 2023). The addition of CT without contrast to a CT with IV contrast is not often helpful in assessing patients with right upper quadrant abdominal pain (Russo et al [ACR] 2023).

<u>Clinical and imaging notes:</u>

- Acute cholecystitis is the most frequent complication of gallstone disease, and the primary diagnostic concern in the setting of acute right upper quadrant pain. Imaging studies play a major role in establishing the diagnosis and assessing possible alternative diagnoses (Peterson et al [*ACR*] 2019).
- Acute cholecystitis should be suspected in a patient with fever, severe pain located in the right upper abdominal quadrant, nausea, vomiting, anorexia, and tenderness on palpation (Murphy's sign) (Russo et al [ACR] 2023; *EASL* 2016).
- Characteristic symptoms of gallbladder stones include episodic attacks of severe pain in the right upper abdominal quadrant or epigastrium for at least 15-30 minutes with radiation to the right back or shoulder and a positive reaction to analgesics (*EASL* 2016).

Acute cholangitis can be diagnosed by the presence of the Charcot triad: pain and tenderness in the right upper quadrant, high spiking fever, and jaundice. Patients with jaundice or acute cholangitis should be evaluated for common bile duct stones, as stones in the gallbladder, a dilated CBD, acute cholangitis and hyperbilirubinemia are strong predictors for CBD stones (*EASL* 2016).

<u>Evidence update (2015-present):</u>

Low Level of Evidence

Al-Jiffry et al (2016) conducted a prospective cohort study to develop and validate a clinical scoring system for predicting choledocholithiasis. 155 consecutive patients with symptomatic gallstones, biliary pancreatitis, obstructive jaundice, or cholangitis, who underwent biochemical testing and ultrasound, were enrolled. A predictive model was developed with imaging and laboratory data using ERCP or intraoperative cholangiography for confirmatory diagnosis. CBD acoustic shadowing or dilatation on ultrasound, alkaline phosphatase of $\geq$ 200 IU, elevated bilirubin levels, alanine transaminase of $\geq$ 220 IU, and male age of $\geq$ 50 years were significantly associated with choledocholithiasis and included in the scoring system. 96 patients (35%) had scores of $\geq$ 8 (high risk) and 88 (91.7%) had a CBD stone. 62 had a score of 4-7 (intermediate risk); these patients underwent MRCP, and ERCP if MRCP was positive. 43.5% of patients with intermediate risk were found to have a CBD stone. Seven patients with a normal CBD via ultrasound were subsequently found to have CBD stones via MRCP, and 16 with a dilated CBD via ultrasound had normal MRCP findings.

Ginsburg et al (2016) examined factors affecting total number of imaging studies performed for acute cholecystitis (AC) prior to surgery. Subjects with cholecystectomy and pathologic diagnosis of AC, and imaging studies (CT, ultrasound and/or cholescintigraphy) within 7 days of surgery were included. There were 219, 339, and 38 subjects in CT, ultrasound, and cholescintigraphy group, respectively. Prior to surgery, only one study was performed in 21.9% of CT group, 70.2% of ultrasound group, and 71.1% of cholescintigraphy group ($p < 0.0001$). Compared to ultrasound, the odds of undergoing additional study were 11.8x higher for CT group and 1.7x higher for cholescintigraphy group.

PICO 3: Abdominal pain with suspected or known acute pancreatitis, and any of the following:

- **Amylase and lipase levels are equivocal;**
- **Severe or atypical pain; or**
- **Further assessment > 48 hours after symptom onset is necessary:**

- Green - **CT abdomen and pelvis with IV contrast**
- Green – **MRI abdomen without and with IV contrast with MRCP**
- Yellow – **Ultrasound abdomen**
- Yellow - **MRI abdomen without IV contrast with MRCP**
  [patient unable to receive IV contrast]
- Yellow – **CT abdomen and pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Yellow – **CT abdomen and pelvis without and with IV contrast**
  [patient with known cancer or liver disease]
- Red – **PET** or **PET/CT**
- Red – **SPECT**
- Red – **Scintigraphy**
- Red – **MR or CT enterography; MR or CT enteroclysis**
- Red – **MR or CT angiography**

Level of Evidence: CT: low to moderate; MRCP: moderate; MRI: low

Notes concerning use of contrast: In patients undergoing CT to assess complications of acute pancreatitis, intravenous contrast should be given unless contraindicated (Greenberg et al 2016: high strength of evidence, strong guideline recommendation).

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
The clinical diagnosis of acute pancreatitis (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 (Porter et al [*ACR*] 2019; Crockett et al [AGA] 2018). 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 (Porter et al [*ACR*] 2019). Imaging is also performed to investigate the etiology, complications, and extent of disease (Porter et al [*ACR*] 2019).

CT abdomen and pelvis
CT abdomen and pelvis with IV contrast is usually appropriate for initial imaging of suspected acute pancreatitis when there is presentation of atypical signs and symptoms, including equivocal amylase and lipase values (Porter et al [*ACR*] 2019). If raised levels of blood lipase or amylase are not found, abdominal CT can confirm pancreatic inflammation (*NICE* 2018). CT with IV contrast is also appropriate 48-72 hours after onset of symptoms in patients who are critically ill or have severe clinical scores (Porter et al [*ACR*] 2019; *IAP/APA* 2013: GRADE 1C/strong agreement). Routine early CT in acute

pancreatitis is generally not recommended for the following reasons: (1) there is no evidence that early CT improves clinical outcome or that early detection of necrosis will influence treatment; (2) CT scoring systems are not superior to clinical scoring systems in predicting prognosis and severity of disease; and (3) there is evidence to suggest that an early inappropriate CT has low yield without direct management implications, does not improve clinical outcomes, and poses risks of contrast allergy and nephrotoxicity (*IAP*/*APA* 2013). Early CT may be appropriate, however, to rule out diagnoses other than pancreatitis (e.g., bowel ischemia or intra-abdominal perforations) in patients presenting with both acute pancreatitis and acute abdomen (Porter et al [*ACR*] 2019; *IAP*/*APA* 2013: GRADE 1C, strong agreement). Follow-up CT in acute pancreatitis is indicated when there is a lack of clinical improvement, clinical deterioration, or especially when invasive intervention is considered. (*IAP*/*APA* 2013: GRADE 1C, strong agreement).

MRI abdomen with MRCP
MRI abdomen without and with IV contrast with MRCP is usually appropriate for initial imaging of suspected acute pancreatitis when any of the following occur: presentation of atypical signs and symptoms (e.g., equivocal amylase and lipase values); when diagnoses other than pancreatitis may be possible (e.g., bowel perforation, bowel ischemia); or at 48-72 hours after onset of symptoms in patients who are critically ill or have severe clinical scores (Porter et al [*ACR*] 2019). For meeting the diagnostic criteria for acute pancreatitis, MRI with MRCP is at least equal to CT, particularly given the higher soft-tissue contrast resolution; however, limitations include availability, greater frequency of motion-related artifacts and longer imaging time (Porter et al [*ACR*] 2019; PLE expert panel consensus opinion). MRI may also be contraindicated in patients with certain electronic or metallic implants and image quality is susceptible to motion artifact particularly with patients in pain or patients with claustrophobia.

In patients with suspected biliary pancreatitis without cholangitis, MRCP (or EUS) may eliminate the need for ERCP and prevent its risks if no stones are detected (*EASL* 2016: low quality evidence, weak recommendation; *IAP/APA* 2013: GRADE 2C, strong agreement). MRCP is less invasive, less operator-dependent and more widely available than EUS; therefore, in clinical practice there is no clear superiority for either MRCP or EUS (*IAP/APA* 2013: GRADE 2C, strong agreement). Follow-up MRI in acute pancreatitis is indicated when there is a lack of clinical improvement, clinical deterioration, or especially when invasive intervention is considered (*IAP/APA* 2013: GRADE 1C, strong agreement).

Ultrasound
Ultrasound of the abdomen is usually appropriate for the initial imaging of suspected acute pancreatitis presenting for the first time with epigastric pain (Porter et al [*ACR*] 2019; PLE expert panel consensus opinion). Ultrasonography is useful at baseline in these patients to evaluate the biliary tract to determine if the patient has gallstones and/or a stone in the common bile duct (Greenberg et al 2016*: high strength of evidence, strong guideline recommendation; Tenner et al [ASG] 2013*: strong recommendation, low quality of evidence).

*This guideline did not pass the AGREE II Rigor of Development domain score cutoff, but was included because of its direct relevance to this clinical scenario.

<u>Clinical and imaging notes:</u>

- Most cases of acute pancreatitis (around 80%) are mild, with only interstitial changes of the pancreas without local or systemic complications (Crockett et al [AGA] 2018).
- Patients with acute pancreatitis should be evaluated for common bile duct stones (*EASL* 2016).

- It is recommended to perform multidetector CT with thin collimation and slice thickness (i.e., 5 mm or less), and 100-150 ml of non-ionic intravenous contrast material at a rate of 3 ml/s, during the pancreatic and/or portal venous phase (i.e., 50-70 s delay). During follow-up only a portal venous phase (monophasic) is generally sufficient (*IAP*/*APA* 2013).
- For MR, the recommendation is to perform axial FS-T2 and FS-T1 scanning before and after intravenous gadolinium contrast administration (*IAP*/*APA* 2013).
- Patients with asymptomatic pancreatic cysts that are diagnosed as pseudocysts on initial imaging and clinical history, or that have a very low risk of malignant transformation do not require further evaluation (Elta et al [ACG] 2018).

Evidence update (2014-present):

Moderate Level of Evidence

Jin et al (2018), in a retrospective study, developed a diagnostic model predictive of acute pancreatitis (AP) risk before imaging. A total of 319 ED patients with serum lipase elevated to 3 times the upper limit or normal or greater were identified, and AP diagnosis was established by review of records. A multivariable logistic regression model and corresponding point-based scoring system were developed to predict AP. The final model (area under curve, 0.92) included 8 predictors of AP: number of prior AP episodes; history of cholelithiasis; no abdominal surgery ≤ 2 months; time elapsed from symptom onset; pain localized to epigastrium (of progressively worsening severity); and extent of lipase elevation. At a diagnostic risk threshold of ≥ 8 points (≥ 99%), the model identified AP with a sensitivity of 45%, and a specificity and a positive predictive value of 100%. The authors conclude that, among ED patients with elevated lipase levels, this model helps identify AP risk before imaging (low level of evidence).

Low Level of Evidence

Chaffin et al (2022) conducted a prospective single-center study to study the impact of pain patterns and imaging on the diagnosis of acute pancreatitis (AP) among emergency department (ED) patients presenting with serum lipase > 3-fold the upper limit of normal. A total of 320 patients were included, and 85 (26.5%) had painless lipase evaluation. These patients had abdominal imaging less often (66%) than in those with abdominal pain (83%; p=0.001). The diagnosis of AP increased overall from 49% without imaging to 77% with imaging (<0.001). Imaging increased the diagnosis of AP in patients with painless lipase elevation from 7% without imaging to 29%; p=0.025) among those who were imaged. The authors conclude that painless lipase elevation > 3-fold the upper limit of normal is common in ED patients, and 1/3 to 1/4 of these may have AP. Abdominal imaging in such patients may help detect AP that otherwise eludes diagnosis.

PICO 4: Abdominal pain with suspected chronic pancreatitis*:

- Green – **CT abdomen and pelvis without and/or with IV contrast**
- Green – **MRI abdomen without and with IV contrast with MRCP**
- **Yellow – Ultrasound abdomen**
- **Yellow** - **MRI abdomen without IV contrast with MRCP**
  [patient unable to receive IV contrast]
- Red – **PET** or **PET/CT**
- Red – **SPECT**
- Red – **Scintigraphy**
- Red – **MR or CT enterography; MR or CT enteroclysis**
- Red – **MR or CT angiography**

*This scenario assumes that chronic pancreatitis has been previously undiagnosed.

Level of Evidence: CT: low to moderate; MRI with MRCP: low to moderate

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Chronic pancreatitis (CP) is characterized by chronic, progressive, pancreatic inflammation and scarring, irreversibly damaging the pancreas (Conwell et al [APA] 2014). In general, evaluation of a patient with suspected CP should progress from a least invasive to more invasive approach to establish a diagnosis, with a CT scan usually the initial imaging modality of choice (Conwell et al [APA] 2014). Confirming a diagnosis of CP is clear in highly suspicious patients (recurrent pancreatitis alcohol or smoking abuse) with steatorrhea, weight loss, and morphologic changes in the gland (Conwell et al [APA] 2014). Patients with previously diagnosed CP may present repeatedly to the emergency department, resulting in a need to conserve or limit routine CT imaging (PLE expert panel consensus opinion).

CT abdomen and pelvis
CT scan of the pancreas is useful for the first-line diagnosis of CP (Conwell et al [*APA*] 2014*; Gardner et al [*ACG*] 2020*: strong recommendation, low quality of evidence). CT (or ultrasound) is best for the late findings of chronic pancreatitis, but potentially limited in the diagnosis of early or mild pancreatitis (Conwell et al [*APA*] 2014*: conditional recommendation, moderate level of evidence). CT is also helpful for diagnosing complications of CP (Conwell et al [*APA*] 2014: strong recommendation, moderate level of evidence) and in diagnosing other conditions that can mimic CP (Conwell et al [*APA*] 2014*: conditional recommendation, low level of evidence).

MRI abdomen with MRCP
MRI can be used for the first-line diagnosis of CP (Gardner et al [*ACG*] 2020*: strong recommendation, low quality of evidence). When compared to ultrasound or CT, MRI is a more sensitive imaging tool for its diagnosis (Conwell et al [*APA*] 2014*: conditional recommendation, moderate level of evidence). The *American College of Gastroenterology* suggests performing secretin-enhanced MRCP when the diagnosis of CP following cross-sectional imaging (or EUS) is not confirmed and the clinical suspicion remains high (Gardner et al [*ACG*] 2020*: conditional recommendation, low quality of evidence). Patients with equivocal or mild CT imaging findings or refractory symptoms may be referred to specialized centers for additional studies such as MRI with secretin-enhanced MRCP, or endoscopic procedures (Conwell et al

[*APA*] 2014*: conditional recommendation, low level of evidence).

Ultrasound
Ultrasound is best for the late findings of chronic pancreatitis but may be limited in the diagnosis of early or mild pancreatitis (Conwell et al [APA] 2014: conditional recommendation, moderate level of evidence). Diagnosis of CP by ultrasound relies on changes in morphology of the pancreas, which is easily detected in the setting of advanced disease but challenging in early CP (Conwell et al [APA] 2014). Classic sonographic findings of CP include pancreatic calcification (Conwell et al [APA] 2014).

*This guideline did not pass the AGREE II Rigor of Development domain score cutoff, but was included because of its direct relevance to this clinical scenario.

Clinical and imaging notes:

- Chronic pancreatitis is characterized by chronic, progressive pancreatic inflammation and scarring, irreversibly damaging the pancreas, and resulting in loss of exocrine and endocrine function (Conwell et al [*APA*] 2014).
- The clinical manifestations of chronic pancreatitis can include abdominal pain, steatorrhea and diabetes, as well as numerous acute and chronic complications. A subset of chronic pancreatitis patients can develop pancreatic adenocarcinoma, which is generally advanced at the time of diagnosis (Conwell et al [*APA*] 2014).
- The *American College of Gastroenterology* suggests histological examination as the gold standard to diagnose CP in high-risk patients when the clinical and functional evidence of CP is strong, but imaging modalities are inconclusive (Gardner et al [*ACG*] 2020).
- Intraductal pancreatic calcifications are the most specific and reliable sonographic and CT signs of chronic pancreatitis (Conwell et al [*APA*] 2014).
- Ductal abnormalities are very specific and reliable MRI signs of chronic pancreatitis (*American Pancreatic Association* (Conwell et al [*APA*] 2014).
- Signal intensity changes in the pancreas, seen on MRI, may precede ductal abnormalities and suggest early chronic pancreatitis (Conwell et al [*APA*] 2014).
- In patients undergoing MRI for chronic pancreatitis, stimulation of the pancreas using IV secretin may improve the diagnostic accuracy in the detection of ductal and parenchymal abnormalities seen in chronic pancreatitis (Conwell et al [*APA*] 2014).

Evidence update (2014-present):
Low Level of Evidence
Nordaas et al (2022) conducted a cross-sectional study to evaluate whether imaging-based structural pancreatic changes were associated with common clinical complications in a large chronic pancreatitis cohort. A total of 742 patients (mean age of 55 years, 69% with pancreatic exocrine insufficiency, 68% with reported abdominal pain) were included. Main pancreatic duct obstruction severe calcifications, pancreatic atrophy, and parenchymal changes throughout the entire pancreas were positively associated with pancreatic exocrine insufficiency. Severe calcifications were negatively associated with pain, and continuous organ involvement and pseudocysts were positively and negatively associated with diabetes, respectively.

Delhaye et al (2014), in a consensus paper on chronic pancreatitis (CP), issued statements on diagnosis and nutritional, medical, and surgical treatment. MRI/MRCP, if possible with secretin enhancement, is considered the imaging modality of choice for the diagnosis of early-stage disease. MRI is more sensitive than CT for detecting early CP stages, as signal changes can be picked up prior to morphological changes. MRCP allows for excellent visualization of the pancreatic ducts, with secretin enhancement providing an even better visualization of abnormalities of the pancreatic duct and its branches. Endoscopic ultrasound, which is more invasive, is the most sensitive method for detecting minimal structural changes indicative of CP, and may provide add-on value in uncertain cases.

PICO 5: Right lower quadrant pain with suspected acute appendicitis:

- Green – **CT abdomen and pelvis with IV contrast**
- Yellow **– Ultrasound abdomen** and/or **ultrasound pelvis**
- Yellow – **CT abdomen and pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Yellow – **CT abdomen and pelvis without and with IV contrast**
  [patient with known cancer or liver disease]
- Yellow – **MRI abdomen and/or pelvis without and with IV contrast**
- Yellow – **MRI abdomen and/or pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Red – **MRCP**
- Red – **PET** or **PET/CT**
- Red – **SPECT**
- Red – **Scintigraphy**
- Red – **MR or CT enterography; MR or CT enteroclysis**
- Red – **MR or CT angiography**

Level of Evidence: CT: high; MRI: moderate

Notes concerning use of contrast: In patients undergoing CT for suspected acute appendicitis, IV contrast should be used when feasible, while the use of oral or rectal contrast does not improve diagnostic accuracy (Diercks et al [ACEP] 2023: level B recommendation). Contrast-enhanced CT without enteral contrast sensitivities range from 90% to 100% and specificities range from 94.8% to 100%, compared to contrast-enhanced CT with enteral contrast (oral or rectal), for which sensitivities range from 90.4% to 100% and specificities range from 97.67% to 100% (Kambadakone et al [ACR] 2022)

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
In patients with suspected acute appendicitis, clinical findings (i.e., signs and symptoms) can be used to risk-stratify patients and guide decisions about further testing (e.g., no further testing, laboratory tests, and/or imaging studies) and management (e.g., discharge, observation, and/or surgical consultation). Not every patient with possible appendicitis requires abdominal imaging (Diercks et al [ACEP] 2023.). However, there is insufficient data to recommend the use of clinical prediction rules (e.g., the Alvarado score) to identify adult patients for whom advanced imaging is not required (Diercks et al [ACEP] 2023: level C recommendation).

CT abdomen and pelvis
In patients with right lower quadrant (RLQ) pain with fever and leukocytosis, CT abdomen and pelvis with IV contrast is usually appropriate to evaluate for suspected appendicitis (Kambadakone et al [ACR] 2022; Diercks et al [ACEP] 2023). CT has become the primary diagnostic imaging modality for the evaluation of patients with suspected appendicitis because of its high diagnostic yield (Kambadakone et al [ACR] 2022 with a high sensitivity (ranging from 0.96 to 1) and specificity (ranging from 0.91 to 0.99) (Dahabreh et al [*AHRQ*] 2015). In most instances, CT is preferred over MRI because of availability, timeliness, patient compatibility, bowel motion, and patient motion on MRI (PLE expert panel consensus

opinion). While IV contrast is preferred, a noncontrast CT scan may be used for the evaluation of acute appendicitis with minimal reduction in sensitivity (Diercks et al [ACEP] 2023: level C recommendation).

MRI abdomen and/or pelvis
In patients with RLQ, MRI allows accurate diagnosis of appendicitis as well as suggesting alternative diagnosis (Kambadakone et al [ACR] 2022). The advantage of MRI over CT is that no administration of contrast media is necessary and that there is no ionizing radiation exposure (PLE expert panel consensus opinion). However, MRI scanners may not be widely available, and technical quality may also suffer in the acute setting because of patient discomfort with attendant motion artifacts (Kambadakone et al [ACR] 2022; Gans et al 2015;). MRI imaging for appendicitis has been found to have high sensitivity (0.91 to 1.0), but variable specificity (ranging from 0.86 to 1), which may be due to the smaller number of available studies focusing primarily on its use for pregnant women (Dahabreh et al [*AHRQ*] 2015).

Ultrasound
Ultrasound is sometimes used as a triage test for suspected appendicitis to separate patients in whom sonography alone is adequate to establish a diagnosis from those who require further imaging (Dahabreh et al [*AHRQ*] 2015). In adult patients with suspected acute appendicitis, there is mixed findings for ultrasound, with some guidelines noting that an unequivocally positive RLQ ultrasound has comparable accuracy to a positive CT or MRI in ruling in appendicitis (Diercks et al [ACEP] 2023: level C recommendation). Other guidelines point out that the diagnostic performance of US in preoperative evaluation of patients presenting with typical signs and symptoms of appendicitis varies widely (Kambadakone et al [ACR] 2022), with lower reported sensitivity (0.83) and specificity (0.89) than CT and MRI (Dahabreh et al [*AHRQ*] 2015). Using an ultrasound-first approach requires skilled sonographers who can clearly report when the appendix has been fully visualized, and in adult patients, there is a concern for false-negative studies, especially in women, older patients, and those with an elevated BMI (Diercks et al [ACEP] 2023; Dahabreh et al [*AHRQ*] 2015). Ultrasound may be particularly useful as the initial imaging technique in younger patients (PLE expert panel consensus opinion).

<u>Clinical and imaging notes:</u>

- The “classic” clinical presentation of patients with appendicitis consisted of periumbilical abdominal pain migrating to the RLQ, loss of appetite, nausea, or vomiting, with fever, and leukocytosis is present in approximately 50% of patients (Kambadakone et al [ACR] 2022).
- With increasing rates of diagnostic imaging, primarily CT, in patients presenting to emergency departments, the phenomenon of multiple imaging episodes has become of concern. This has led to attempts to develop low-dose CT and limited coverage CT alternatives (Kambadakone et al [ACR] 2022). Dose-reduction strategies in CT should be employed following the *As Low As Reasonably Achievable* principle (e.g., Mayo-Smith et al 2014).

<u>Evidence update (2016-present):</u>

High Level of Evidence
D’Souza et al (2021) in a Cochrane Library systematic review, sought to determine the accuracy of MRI for detecting appendicitis. A total of 58 studies were identified for meta-analysis, including a total of 7,462 participants (1,980 with and 5,482 without acute appendicitis). Study quality was assessed using the QUADAS-2 tool and the bivariate model was used to calculate pooled estimates of sensitivity and specificity. Summary sensitivity was 0.95 (95% confidence interval (CI) 0.94 to 0.97); summary specificity was 0.96 (95% CI 0.95 to 0.97). In a hypothetical cohort of 1000 patients, there would be 12 false-positive results and 30 false-negative results. Methodological quality of the included studies was poor, and the risk of bias was high or unclear in 53% to 83% of the QUADAS-2 domains. The authors conclude

that MRI appears to be highly accurate in confirming and excluding acute appendicitis regardless of protocol. The methodological quality of the included studies was generally low due to incomplete and low standards of follow-up, so summary estimates may be biased.

Rud et al (2019), in a systematic review, evaluated the accuracy of CT for diagnosing appendicitis in adults. The authors included prospective studies comparing results of CT versus outcomes of a reference standard. Two reviewers independently screened/selected studies for inclusion; a total of 64 studies (total n = 10,280) were included. Major methodological problems were poor reference standards and partial verification due to inadequate and incomplete follow-up. Estimates of sensitivity ranged from 0.72 to 1.0 and specificity ranged from 0.5 to 1.0 across studies. Summary sensitivity was 0.95 (95% CI: 0.93 to 0.96), and summary specificity was 0.94 (95% CI: 0.92 to 0.95). At the median prevalence (0.43), the probability of having appendicitis following a positive CT result was 0.92 (95% CI: 0.90 to 0.94), and the probability of having appendicitis following a negative CT result was 0.04 (95% CI: 0.03 to 0.05). In subgroup analyses, summary sensitivity was higher for CT with IV contrast (0.96, 95% CI: 0.92 to 0.98), CT with rectal contrast (0.97, 95% CI: 0.93 to 0.99), and CT with intravenous and oral contrast enhancement (0.96, 95% CI: 0.93 to 0.98) than for unenhanced CT (0.91, 95% CI: 0.87 to 0.93). Summary sensitivity for low-dose CT (0.94, 95% CI: 0.90 to 0.97) was similar to summary sensitivity for standard-dose CT (0.95, 95% CI: 0.93 to 0.96). The authors conclude the sensitivity and specificity of CT for diagnosing appendicitis in adults are high. Unenhanced standard-dose CT appears to have lower sensitivity than standard-dose CT with IV, rectal, or oral contrast enhancement. These results are based primarily on studies of low methodological quality.

Moderate Level of Evidence

Becker et al (2021), in a prospective multicenter study, evaluated the accuracy of point-of-care ultrasound (POCUS) for diagnosing appendicitis in an emergency department (ED) population. A total of 256 subjects were included, with overall appendicitis prevalence of 28.1%. All POCUS exams were compared to surgical pathology in those undergoing appendectomy and advanced imaging in those managed nonoperatively. POCUS demonstrated overall sensitivity of 0.85 (95%CI = 0.74-0.92), specificity of 0.63 (95%CI=0.56-0.70), positive likelihood ratio of 2.29 (95%CI=1.85-2.84), and negative likelihood ratio of 0.24 (95%CI=0.14-0.42). The authors conclude that POCUS is moderately accurate for acute appendicitis but lacks adequate sensitivity and specificity to function as a definitive test in an undifferentiated ED population.

Repplinger et al (2018) prospectively compared the accuracy of MRI to CT for diagnosis of acute appendicitis in 198 ED patients. CT and MR imaging (with non–contrast material–enhanced, diffusion-weighted, and intravenous contrast-enhanced sequences) were performed in tandem, and images were subsequently retrospectively interpreted in random order by three abdominal radiologists who were blinded to clinical outcomes. Likelihood of appendicitis was rated on a five-point scale for both CT and MR imaging. The sensitivity and specificity were 96.9% (95% CI: 88.2%, 99.5%) and 81.3% (95% CI: 73.5%, 87.3%) for MR imaging and 98.4% (95% CI: 90.5%, 99.9%) and 89.6% (95% CI: 82.8%, 94.0%) for CT, respectively, when a cutoff point of $\geq$ 3 was used. The positive and negative likelihood ratios were 5.2 (95% CI: 3.7, 7.7) and 0.04 (95% CI: 0, 0.11) for MR imaging and 9.4 (95% CI: 5.9, 16.4) and 0.02 (95% CI: 0.00, 0.06) for CT, respectively. The authors conclude that the diagnostic accuracy of MRI was similar to that of CT for the diagnosis of acute appendicitis.

Yoon et al (2018), in a 2018 systematic review and meta-analysis, evaluated the diagnostic performance of reduced-dose CT for suspected appendicitis. A total of 14 articles (n = 3,262 patients) were included. For all studies using reduced-dose CT, the summary sensitivity was 96% (95% CI:93-98) with a summary specificity of 94% (95% CI:92-95). For the 11 studies providing a head-to-head comparison between reduced-dose CT and standard-dose CT, reduced-dose CT demonstrated a comparable summary sensitivity of 96 % (95 % CI 91–98) and specificity of 94 % (95 % CI 93–96) without any significant differences (p=.41). The authors conclude that reduced-dose CT shows excellent diagnostic performance for suspected appendicitis.

Kabir et al (2017), in a systematic review of 58 studies, reported and analyzed the latest evidence on the different approaches used in diagnosing appendicitis. The review found that raised Alvarado scores and laboratory markers (WCC, CRP) all contribute to the suspicion of appendicitis. Subsequent surgical intervention should not be based on either alone, however, when used in combination they show greater promise. CT remains the best radiological modality for diagnosing appendicitis, but radiation exposure and long-term cancer risks are a concern. The authors suggest use of low-radiation CT, which has proven to be just as sensitive as normal CT or repeated U/S scanning.

Lietzen et al (2016) examined if preoperative distinction between complicated and uncomplicated acute appendicitis is feasible without imaging. Prospective evaluation of 705 patients who had acute appendicitis on CT was conducted. Patients with uncomplicated acute appendicitis (n = 368) were compared with complicated acute appendicitis patients (n = 337). Subgroup analyses were performed between uncomplicated acute appendicitis and an appendicolith appendicitis (CA1; n = 256), and between uncomplicated acute appendicitis and perforation and/or abscess (CA2; n = 78). The authors concluded that, in clinical decision making, neither clinical findings nor laboratory markers are reliable enough to estimate the severity of the acute appendicitis accurately or to determine the presence of an appendicolith. These results emphasize the role of CT in the differential diagnosis of complicated and uncomplicated acute appendicitis.

Low Level of Evidence

Harringa et al (2019) prospectively compared MR and CT sensitivity among 113 patients ED patients with possible appendicitis. Three radiologists independently interpreted each MR and CT image set separately and blindly. Expert panel chart review and follow-up interviews determined final diagnosis. There were 15 different acute diagnoses identified on the images. The sensitivities of non-contrast enhanced MR (NCE-MR), contrast-enhanced MR (CE-MR), and CT for any acute diagnosis were 77.0% (72.6%−81.4%), 84.2% (80.4%−88.0%), and 88.7% (85.5%−92.1%). Sensitivity of consensus reads was 82.0% (74.9%−88.9%), 87.1% (81.0%−93.2%), 92.2% (87.3%−97.1%), respectively. There was no difference in sensitivities between CE-MR and CT by individual (p=0.096) or consensus interpretations (p=0.281), though NCE-MR was inferior to CT in both modes of analysis (p<0.001, p=0.031, respectively). The authors conclude that the sensitivity of CE-MR was similar to CT, but a statistically significant difference in the sensitivity of CT was found when compared against NCE-MR.

PICO 6: Left lower quadrant pain with suspected acute diverticulitis:

- Green – **CT abdomen and pelvis with IV contrast**
- Yellow – **CT abdomen and pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Yellow - **CT abdomen and pelvis without and with IV contrast**
  [patient with known cancer or liver disease]
- Yellow – **MRI abdomen and/or pelvis without and with IV contrast**
- Yellow - **MRI abdomen and/or pelvis without IV contrast**
- Yellow – **Ultrasound abdomen** and/or **ultrasound pelvis**
- Red – **MRCP**
- Red – **PET** or **PET/CT**
- Red – **SPECT**
- Red – **Scintigraphy**
- Red – **MR or CT enterography; MR or CT enteroclysis**
- Red – **MR or CT angiography**

Level of Evidence: CT: moderate; MRI: low

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
A detailed history, physical examination, and laboratory findings are the first steps in diagnosing acute colonic diverticulitis in most patients with abdominal pain or tenderness primarily in the lower left quadrant (Qaseem et al [ACP] 2022). Imaging may not be required in certain patients with typical symptoms of diverticulitis, a prior history of diverticulitis with similar symptoms, and no evidence of complications (Weinstein et al [ACR] 2023). However, imaging can confirm the diagnosis, evaluate the extent of disease, and detect complications before deciding on appropriate treatment. Additionally, misdiagnosis based on clinical assessment alone is common (Weinstein et al [ACR] 2023).

CT abdomen and pelvis
With superior diagnostic accuracy (98%), accuracy for alternative diagnoses with a similar presentation, and risk-stratification of patients, CT is the most useful exam for patients with suspected diverticulitis, and may also help predict which patients are likely to experience recurrent diverticulitis (Weinstein et al [ACR] 2023; Qaseem et al [ACP] 2022: conditional recommendation, low-certainty evidence; Hall et al [*ASCRS*] 2020: strong recommendation based on moderate-quality evidence, 1B; *NICE* 2019). If a person with suspected complicated acute diverticulitis has raised inflammatory markers, a contrast CT scan can confirm diagnosis and help plan management (*NICE* 2019). In most instances, CT is preferred over MRI because of availability, timeliness, patient compatibility, bowel motion, and patient motion on MRI (PLE expert panel consensus opinion). In people with a CT-confirmed diverticular abscess, if the condition does not improve clinically or there is deterioration, re-imaging can be considered to inform the management strategy (*NICE* 2019). IV contrast is commonly used, while unenhanced CT is more accurate than clinical evaluation alone and can be used in patients with contraindication to IV contrast material (Weinstein et al [ACR} 2023).

MRI abdomen and/or pelvis
There is insufficient published data to support the routine use of MRI for the diagnosis of suspected

diverticulitis, as MRI is less sensitive than CT for small-volume extraluminal gas and MRI is affected by patient motion more than CT (Weinstein et al [ACR] 2023). However, MRI (or ultrasound) can be a useful alternative in the initial evaluation of a patients with suspected acute diverticulitis when CT imaging is not available or is contraindicated (Hall et al [*ASCRS*] 2020: strong recommendation based on low-quality evidence, 1C; *NICE* 2019). MRI can also be considered when ultrasound provides inconclusive results, such as in those with extensive bowel gas (Qaseem et al [ACP] 2022). Therefore, MRI is a second-line imaging exam for suspected complications of diverticulitis and, when performed, contrast-enhanced MRI is likely more accurate than unenhanced MRI (Weinstein et al [ACR] 2023). The advantage of MRI over CT is that no administration of contrast media is necessary and that there is no ionizing radiation exposure. The downside is that MRI scanners may not be widely available and motion may limit image quality in acutely ill patients unable to tolerate lying still for the duration of MRI acquisition (Gans et al 2015).

Ultrasound
While not commonly used for the initial imaging of nongyneclogic left lower quadrant pain, ultrasound can be a useful alternative when CT imaging is not available or is contraindicated (Qaseem et al {ACP] 2022; Hall et al [ASCRS] 2020: strong recommendation, low-quality evidence). In particular, ultrasound may be used to reduce the proportion of CT examinations performed without a deleterious effect on patient care by identifying patients with diverticulitis who do not have a surgical abdomen (Weinstein et al [ACR} 2023). However, ultrasound can miss complicated diverticulitis and should not typically be the only imaging modality utilized if this is suspected (Hall et al [ASCRS] 2020). Ultrasound is also user dependent and its utility in obese patients may be limited (Hall et al [ASCRS] 2020).

<u>Clinical and imaging notes:</u>

- Diverticulitis is suspected in patients with left lower quadrant pain, fever, and leukocytosis; however, this triad is present in only approximately 25% of patients with diverticulitis and misdiagnosis based on clinical assessment alone has been reported to be between 34%-68% (Weinstein et al [ACR] 2023; Hall et al [*ASCRS*] 2020).
- Numerous CT classification systems for diverticulitis have been proposed, but none are widely integrated into clinical practice (Weinstein et al [ACR] 2023).
- Physical examination, complete blood count, urinalysis, and abdominal radiographs can be helpful in refining the differential diagnosis of diverticulitis. Other diagnoses to consider include constipation, irritable bowel syndrome, appendicitis, IBD, neoplasia, kidney stones, urinary tract infection, bowel obstruction, and gynecologic disorders (Hall et al [*ASCRS*] 2020).
- Abdominal radiography is of limited value in evaluating diverticulitis unless complications, such as free perforation or obstruction are suspected (Weinstein et al [ACR] 2023).
- Dose-reduction strategies in CT should be employed following the *As Low As Reasonably Achievable* principle (e.g., Mayo-Smith et al 2014).

<u>Evidence update (2013-present):</u>
Moderate Level of Evidence
Thorisson et al (2016) re-evaluated CT scans of patients in the *antibiotics in uncomplicated diverticulitis* (*AVOD*) study to find out whether there were findings that were missed, and to study whether CT signs in uncomplicated diverticulitis could predict complications or recurrence. The CT scan images from patients included in the *AVOD* study were re-evaluated and graded by two independent reviewers for different signs of diverticulitis, including complications (e.g., extraluminal gas or abscess). Of the 623 patients included, 602 CT scans were re-evaluated. Forty-four (7%) patients were found to have

complications on the admitting CT scan that had been overlooked. Four of these patients deteriorated and required surgery, but the remaining patients improved without complications. Of the 18 patients in the no-antibiotic group in whom signs of complications on CT were overlooked, 15 recovered without antibiotics. No CT findings in patients with uncomplicated diverticulitis could predict complications or recurrence.

Low Level of Evidence

Weinrich et al (2020) retrospectivity examined the prevalence and demographic distribution of colonic diverticulitis (CD) and alternative diagnoses (AD), as well as diagnostic accuracy of CT in 1,069 patients with suspected CD. Final clinical diagnoses derived from the discharge report served as the standard of reference. Prevalence of CD was 52.5% (561/1069) and of AD was 39.9% (427/1069). In the remaining 7.6% (81/1069) no final clinical diagnosis was established. The most frequent AD were appendicitis (12.6%, 54/427), infectious colitis (10.5%, 45/427), infectious gastroenteritis (8.2%, 35/427), urolithiasis (6.1%, 26/427), and pyelonephritis (4.9%, 21/427). CT had a sensitivity and specificity of 99.1% and 99.8% for diagnosing CD and 92.7% and 98.8% for AD, respectively. The authors conclude that CT provides high diagnostic accuracy in the diagnosis of diverticulitis and AD.

PICO 7: Abdominal pain with suspected bowel obstruction:

- Green – **CT abdomen and pelvis with IV contrast**
- Yellow – **CT abdomen and pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Yellow – **CT abdomen and pelvis without and with IV contrast**
  [patient with known cancer or liver disease]
- Yellow – **MRI abdomen and/or pelvis without and with IV contrast**
- Yellow – **MRI abdomen and/or pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Yellow – **CT enterography** or **CT enteroclysis**
  [patient with intermittent, recurrent or low-grade small bowel obstruction]
- Yellow – **MR enterography** or **MR enteroclysis**
  [patient with intermittent, recurrent or low-grade small bowel obstruction]
- Red – **Ultrasound**
- Red – **MRCP**
- Red – **PET** or **PET/CT**
- Red – **SPECT**
- Red – **Scintigraphy**
- Red – **MR or CT angiography**

Level of Evidence: CT: low to moderate; MRI: moderate

Notes concerning applicability and/or patient preferences:
Enteroclysis is generally not useful in the acute situation of suspected obstruction in which the patient is ill, as such patients cannot tolerate the invasive nature of the examination (Chang et al [*ACR*] 2020).

Guideline and PLE expert panel consensus opinion summary:
Small bowel obstruction (SBO) is a common cause of abdominal pain, and imaging plays a key role in diagnosis and management as neither clinical examination nor laboratory testing are sufficiently sensitive or specific enough for these purposes (Chang et al [ACR] 2020). A CT scan in the evaluation of patients with SBO can provide incremental clinically relevant information over plain films that may lead to changes in management (Maung et al [EAST] 2012).

CT abdomen and pelvis
CT abdomen and pelvis with IV contrast is usually appropriate for the initial imaging of a suspected SBO with an acute presentation, or for imaging a suspected intermittent or low-grade SBO with an indolent presentation (Chang et al [*ACR*] 2020). CT of the abdomen and pelvis has been shown to be 83% to 94% accurate at diagnosing obstruction, and can provide incremental information over plain films in differentiating grade, severity, and etiology that may lead to changes in management (Maung et al [*EAST*] 2012: level 1 recommendation).

In hemodynamically stable patients, colonic volvulus is often initially evaluated with plain abdominal radiographs, whereas CT imaging may be used to confirm the diagnosis (Alavi et al [ASCRS] 2021: strong recommendation based on low-quality evidence, 1C). CT with multiplanar reconstruction can diagnose volvulus with near 100% sensitivity and > 90% specificity (Alavi et al [ASCRS] 2021). If the diagnosis remains in question despite imaging, repeat imaging using rectal contrast may better define the anatomy and confirm the diagnosis (Alavi et al [ASCRS] 2021).

MRI abdomen and/or pelvis
MRI has been shown to diagnose SBO with a high reported sensitivity (95%), specificity (100%), and accuracy at determining the level of obstruction (73%) (Maung et al [*EAST*] 2012). Therefore, MRI can be a potential alternative to CT, but may have several logistical limitations. (Maung et al [*EAST*] 2012: level 3 recommendation). MRI examinations may be difficult to interpret related to patient pain and discomfort and associated patient motion in the acute setting (Chang et al [*ACR*] 2020; PLE expert panel consensus opinion). Additionally, MRI may not be available at all centers, has a longer scan time, and may not be as reliable in identifying the cause of obstruction (Maung et al [*EAST*] 2012). Situations in which MRI could be an appropriate alternative to CT include for those who have received multiple prior CT examinations or are expected to get multiple future imaging examinations (Chang et al [*ACR*] 2020).

Enterography / Enteroclysis
As an equivalent alternative to CT abdomen and pelvis, CT enterography is usually appropriate for the imaging of a suspected intermittent or low-grade small bowel obstruction with an indolent presentation (Chang et al [*ACR*] 2020). CT enterography could also be performed as a complementary examination to CT if small bowel distention aids in accentuating small bowel pathology that is not initially evident on CT (Chang et al [*ACR*] 2020). Enteroclysis (CT or MR) offers improved sensitivity and specificity over standard CT examinations in evaluating suspected intermittent or low-grade SBO, and there is evidence that it is highly reliable in revealing sites of low-grade small bowel obstruction (Chang et al [*ACR*] 2020). However, neither MR enteroclysis nor CT enteroclysis are in wide use because patients are often unable to tolerate the degree of small-bowel distension necessary (Chang et al [*ACR*] 2020). MR enterography may be superior to routine MRI examinations for suspected small bowel obstruction and is better accepted by patients than MR enteroclysis (Chang et al [*ACR*] 2020).

<u>Clinical and imaging notes:</u>

- Initial evaluation of colonic volvulus should include a focused history, physical examination, plain radiographs and basic laboratory assessment (Alavi et al [ASCRS] 2021).
- Radiographs have some utility in diagnosing potential bowel obstruction (PLE expert panel consensus opinion). The overall sensitivity of abdominal radiographs for the detection of small bowel obstruction ranges from 59% to 93% but is dependent on the reader's experience. Small-bowel ileus and large-bowel obstruction may also mimic small bowel obstruction findings in traditional planar radiographs. In addition, plain radiographs are nondiagnostic or nonspecific in many cases (Maung et al [*EAST*] 2012).
- Water-soluble contrast study should be considered in patients who fail to improve after 48 hours of nonoperative management because a normal contrast study can rule out operative small bowel obstruction (Maung et al [*EAST*] 2012).
- Abdominal CT (or water-soluble contrast enema) can reliably distinguish acute colonic pseudo-obstruction (ACPO) from a mechanical large-bowel obstruction (Alavi et al [ASCRS] 2021).
- If available, multidetector CT scanner and multiplanar reconstruction should be used because they aid in the diagnosis and localization of small bowel obstructions (Maung et al [*EAST*] 2012).
- MRI should utilize T2 FSE breath holding techniques such as HASTE and breathholding T1-weighted sequences for imaging with IV contrast (PLE expert panel consensus opinion).
- Half-Fourier Acquisition Single-shot Turbo-spin Echo (HASTE) MRI has been shown in Class II and III studies to diagnose SBO with a high reported sensitivity (95%), specificity (100%), and

accuracy at determining the level of obstruction (73%). However, MRI may not be available at all centers (especially at night), has a longer scan time, and may not be as reliable in identifying the cause of the obstruction (Maung et al [*EAST*] 2012).

Evidence update (2012-present):

Moderate Level of Evidence

Taylor et al (2013), in a systematic review and meta-analysis, evaluated the history, physical examination, and imaging modalities associated with the diagnosis of SBO. With respect to imaging, the authors reported that conventional radiography was determined to be the least useful imaging modality for diagnosis of SBO, with a pooled positive likelihood ratio (+LR) of 1.64 (95% CI = 1.07 to 2.52). On the other hand, CT and MRI were both quite accurate in diagnosing SBO with +LRs of 3.6 (5- to 10-mm slices, 95% CI = 2.3 to 5.4) and 6.77 (95% CI = 2.13 to 21.55), respectively. Although limited to a select number of studies, the use of ultrasound was determined to be superior to all other imaging modalities, with a +LR of 14.1 (95% CI = 3.57 to 55.66) and a negative likelihood ratio (–LR) of 0.13 (95% CI = 0.08 to 0.20) for formal scans and a +LR of 9.55 (95% CI = 2.16 to 42.21) and a –LR of 0.04 (95% CI = 0.01 to 0.13) for beside scans.

PICO 8: Abdominal pain with suspected inflammatory bowel disease:

- **Green – MRI abdomen and/or pelvis without and with IV contrast**
  Green – MR enterography
- **Green – CT abdomen and pelvis with IV contrast**
  Green – CT enterography
- **Yellow – MRI abdomen and/or pelvis without IV contrast**
  [patient unable to receive IV contrast]
- **Yellow – CT abdomen and pelvis without IV contrast**
  [patient unable to receive IV contrast and patient unable to undergo MRI]
- **Yellow - CT abdomen and pelvis without and with IV contrast**
  [patient with known cancer or liver disease]
- **Yellow – CT enteroclysis**
  [Patient with a suspected acute exacerbation of known Crohn's disease]
- **Yellow - MR enteroclysis**
  [Patient with a suspected acute exacerbation of known Crohn's disease]
- **Yellow – Ultrasound abdomen and pelvis**
- **Red – MRCP**
- **Red – PET** or **PET/CT**
- **Red – SPECT**
- **Red – Scintigraphy**
- **Red – MR or CT angiography**

Level of Evidence: CT: high; MRI: high

Notes concerning applicability and/or patient preferences:
The decision for which small bowel imaging study to use is in part related to the expertise of the institution and the clinical presentation of the patient (Lichtenstein et al [*ACG*] 2018: summary statement).

In the acute setting, enteroclysis has significant patient tolerance issues and has a higher risk profile related to placement of a nasoduodenal tube and active instillation of contrast (Kim et al [*ACR*] 2020).

Guideline and PLE expert panel consensus opinion summary:
Small bowel imaging should be performed as part of the initial diagnostic workup for patients with suspected Crohn's disease (Lichtenstein et al [*ACG*] 2018: summary statement). For diagnosing Crohn's disease, the *British Society of Gastroenterology* suggests that cross-sectional imaging, specifically MRI, CT, and ultrasound, have largely replaced conventional barium fluoroscopic and nuclear medicine techniques and have the advantage of evaluating both luminal and extraluminal disease (Lamb et al [*BSG*] 2019). The *British Society of Gastroenterology* suggests that, while there is no clear evidence of diagnostic superiority for one cross-sectional imaging modality over another for stricture diagnosis, emphasis should be placed on techniques that do not expose patients to ionizing radiation (Lamb et al [*BSG*] 2019: weak recommendation, very low-quality evidence, agreement: 100%).

Enterography
Either CT enterography or MR enterography is usually appropriate for the initial imaging of suspected Crohn's disease (CD) with no prior Crohn diagnosis (Kim et al [*ACR*] 2020). CT enterography or MR

enterography can also be a complementary procedure to CT abdomen and pelvis for the imaging of known CD with suspected acute exacerbation (Kim et al [*ACR*] 2020). CT enterography and MR enterography are both sensitive for the detection of small bowel disease in patients with Crohn's disease and are comparable to one another (Lichtenstein et al [*ACG*] 2018: summary statement). Either modality allows evaluation of disease proximal to the ileum beyond the reach of the colonoscope as well as detection of transmural disease with overlying normal mucosa that may not be apparent at direct optical inspection (Kim et al [*ACR*] 2020). If possible, emphasis should be placed on MR enterography (or ultrasound) as it does not expose patients to ionizing radiation (Lamb et al [*BSG*] 2019: weak recommendation, moderate-quality evidence, agreement: 97.9%).

MRI abdomen and/or pelvis
Cross-sectional imaging with MRI of the pelvis (and/or endoscopic ultrasound) may be used to further characterize perianal Crohn's disease and perirectal abscesses (Lichtenstein et al [*ACG*] 2018: summary statement). The *British Society of Gastroenterology* recommends that pelvic MRI is used as an important adjunct to clinical assessment and examination in evaluation of fistulizing perianal Crohn's disease (Lamb et al [*BSG*] 2019: strong recommendation, high-quality evidence, agreement: 100%).

CT abdomen and pelvis
As an alternative equivalent to CT enterography or MR enterography, a CT of the abdomen and pelvis with IV contrast is usually appropriate for the initial imaging of suspected Crohn's disease (CD) (Kim et al [*ACR*] 2020). It is also appropriate for the imaging of known CD with suspected acute exacerbation (Kim et al [*ACR*] 2020). Regarding intestinal complications with Crohn's disease, CT can be used to check for the presence and the severity of perianal abscesses, anal fistulas, and intra-abdominal abscesses (Ueno et al 2013).

Enteroclysis
The overall diagnostic performance for CT enteroclysis is excellent (i.e., > 85% sensitivity, > 90% specificity) (Kim et al [*ACR*] 2020). However, it is not typically suitable in the acute setting in which the patient is ill, and it is not uncommon that the patient cannot tolerate the requirements of this somewhat invasive examination (Kim et al [*ACR*] 2020). MR enteroclysis is not a widely utilized examination; however, the overall diagnostic performance for MR enteroclysis is at least equivalent to MR enterography (Kim et al [*ACR*] 2020). Like CT enteroclysis, however, MR enteroclysis is not typically suitable in the acute setting in which the patient is ill, as patients cannot tolerate the necessary requirements (Kim et al [*ACR*] 2020).

Ultrasound
Ultrasound is a potentially effective option in the initial diagnosis of Crohn's disease, with sensitivities for disease detection of 75% to 94% and specificities of 67% to 100% (Kim et al [ACR] 2020). In addition to wall thickening, findings include alteration of the US gut signature, presence of fat wrapping, and vascular changes (Kim et al [ACR] 2020). However, patient factors such as obesity and guarding, especially in the acutely ill scenario, may preclude adequate compression with the US probe, and large amounts of shadowing gas may obscure bowel, preventing an optimal examination (Kim et al [ACR] 2020).

Nuclear Medicine
Leucoscintigraphy or Tc-99m-HMPAO WBC scans have demonstrated good sensitivities and specificities for intestinal inflammation in the 79%-85% and 81%-98% range, respectively (Kim et al [*ACR*] 2020). However, the disadvantages of this examination, such as the decreased ability to depict and therefore

detect alternative diagnoses and the complicated time-consuming technical aspects (Kim et al [ACR] 2020). WBC scans and PET are generally not used for the evaluation of acute abdominal pain (PLE expert panel consensus opinion).

Clinical and imaging notes:

- Ulcerative colitis and Crohn's disease (CD) are the principal forms of inflammatory bowel disease. Both represent chronic inflammation of the gastrointestinal tract, which displays heterogeneity in inflammatory and symptomatic burden between patients and within individuals over time (Lamb et al [*BSG*] 2019).
- CD diagnosis is based on a combination of clinical, laboratory, endoscopic, histological, and imaging findings; no single diagnostic test allows unequivocal diagnosis (Kim et al [*ACR*] 2020).
- Oral contrast plays a key role in assessing CD with cross-sectional imaging, including CT and MR (with or without enterography). Optimal distention of the bowel during CT/MR enterography is obtained by administered large volumes (1300-1800 cc) over a specific time period (30-60 minutes) followed by imaging (Kim et al [*ACR*] 2020).
- Because of the absence of any radiation exposure, MRE should be used preferentially in young patients (<35 years) and in patients in whom it is likely that serial exams will need to be performed (Lichtenstein et al [*ACG*] 2018).

Evidence update (2016-Present):

Moderate Level of Evidence

Ahmed et al (2016), in a systematic review and meta-analysis, evaluated performance of MR enterography with and without IV contrast for imaging the small bowel in patients with Crohn's disease. The authors pooled the results of 19 studies (1,020 patients), with raw data revealing a sensitivity of 0.88 (95% CI 0.86 to 0.91) and specificity of 0.88 (95% CI 0.84 to 0.91). For detecting stenosis, pooled sensitivity was 0.65 (95% CI 0.53 to 0.76) and specificity was 0.93 (95% CI 0.89 to 0.96). The authors concluded that MR imaging provides a reliable alternative in detecting small bowel activity in patients with Crohn's disease. Its advantages include high diagnostic accuracy and no radiation exposure with disadvantages of high cost and limited availability. A subgroup analysis did not find any significant difference in accuracy between MR enterography and MR enteroclysis

Low Level of Evidence

Yu et al (2020) prospectively assessed performance of diffusion-weighted MR enterography (DW-MRE) and contrast enhanced CT enterography (CTE) for detecting different grade lesions in ileocolonic CD among 41 consecutive patients. All patients underwent both exams and also ileocolonoscopy within 2 weeks, and images were independently interpreted by two radiologists. Ileocolonic segments (terminal ileum, right colon, transverse colon, left colon, and rectum) were graded as inactive (0–2), mild (3–6), or moderate–severe (≥ 7). A total of 190 ileocolonic segments were scored as 91 inactive, 68 mild, and 31 moderate–severe CD lesions. The sensitivity of DW-MRE for detecting active from inactive segments was higher than that of CTE, and their specificities had no significant differences. DW-MRE was more sensitive for mild CD lesions than CTE (76.5% vs 60.3%; P = 0.019), while the sensitivities for moderate–severe CD were similar (96.8% for DW-MRE and 93.5% for CTE; P = 1.00). The authors conclude that both DW-MRE and CTE had comparably excellent performances for moderate–severe CD detection, with DW-MRE having better sensitivity in mild lesions.

Saade et al (2019) retrospectively investigated the spectrum of CT enterography (CTE) findings of active Crohn's disease (CD) in comparison to endoscopic, histopathologic, and inflammatory markers among 89 patients. Three-point severity scores for endoscopy, pathology, and hematologic inflammatory markers were recorded. Findings on CTE were identified by three readers and correlated with severity scores. CTE findings significantly correlated with the severity of active disease on endoscopy included bowel wall thickening, mucosal hyperenhancement, bilaminar stratified wall enhancement, transmural wall enhancement, and mesenteric fluid adjacent to diseased bowel ($p < 0.05$). Only bowel wall thickening and bilaminar stratified wall enhancement correlated with pathological severity of active CD. Analyses demonstrated significantly higher areas under the curve ($p < 0.0001$) together with excellent inter-reader agreement ($k = 0.86$). The authors conclude that CTE is a reliable tool for evaluating the severity of active disease and helps in the clinical decision pathway.

PICO 9: Abdominal pain with suspected bowel ischemia or infarction:

- Green – **CT angiography abdomen and pelvis**
- Green – **CT abdomen and pelvis with IV contrast**
- Yellow – **MR angiography abdomen and pelvis**
- Yellow – **CT abdomen and pelvis without and with IV contrast**
  [angiography expertise not available; or patient with known cancer or liver disease]
- Yellow – **CT abdomen and pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Yellow **– Ultrasound abdomen** and/or **ultrasound pelvis**
- Red – **MRCP**
- Red – **PET** or **PET/CT**
- Red – **SPECT**
- Red – **Scintigraphy**
- Red – **MR or CT enterography; MR or CT enteroclysis**

Level of Evidence: CT: moderate; CTA: moderate; MRA: low

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Mesenteric ischemia is an uncommon condition resulting from decreased blood flow to the small or large bowel in an acute or chronic setting (Ginsburg et al [ACR] 2018). There is a need for expedited clinical evaluation and imaging, as these patients have poor outcomes unless diagnosed early (PLE expert panel consensus opinion). While several imaging options exists for the initial evaluation of both acute and chronic mesenteric ischemia, a CTA of the abdomen and pelvis is overall the most appropriate choice for both conditions (Ginsburg et al [ACR] 2018).

CT angiography (CTA) abdomen and pelvis
CTA of the abdomen and pelvis with IV contrast is a fast, accurate, and noninvasive diagnostic tool for evaluating the bowel and assessing intestinal vasculature; it should be the first-step imaging approach in patients with acute bowel ischemia (Ginsburg et al [*ACR*] 2018; Brandt et al [*ACG*] 2015: strong recommendation, moderate level of evidence). Triphasic CTA with 1 mm slices (or thinner) should be used to detect mesenteric arterial occlusion or mesenteric venous thrombosis (Björck et al [*ESVS*] 2017: B level of evidence). CTA is recommended as the preferred definitive imaging test for mesenteric artery occlusive disease unless unusual anatomic features obscure the anatomy such that a catheter-based arteriogram may be required (Huber et al [SVS] 2021: strong recommendation, moderate quality of evidence).

CTA abdomen and pelvis with IV contrast is also recommended as the initial imaging examination in patients with suspected chronic mesenteric ischemia (CMI) (Ginsburg et al [*ACR*] 2018). In these patients, CTA is able to delineate the vascular anatomy before any revascularization (Huber et al [SVS] 2021: strong recommendation, high quality of evidence). In patients with moderate to high suspicion of CMI, CTA can map the occlusive disease, and detect or exclude other intra-abdominal pathology (Björck et al [*ESVS*] 2017: C level of evidence). A CTA is also recommended to confirm any restenosis detected by duplex ultrasound examination in patients with symptoms consistent with CMI (Huber et al [SVS] 2021: strong recommendation, low quality of evidence).

CT abdomen and pelvis
For suspected AMI, CT with IV and oral contrast can be a useful imaging modality (Tilsed et al [*ESTES*] 2016: level III evidence), as data suggests CT is 85%-100% sensitive in the detection of bowel ischemia (Maung et al [*EAST*] 2012). While CT angiography is generally the preferred modality when mesenteric ischemia is suspected, if clinical presentation is less specific, a routine IV contrast-enhanced abdominal CT will screen for findings of ischemia and evaluate for other pathologies (Scheirey et al [*ACR*] 2018). The diagnosis of colon ischemia can be suggested based on CT findings (e.g., bowel wall thickening, edema, thumbprinting) (Brandt et al [*ACG*] 2015: strong recommendation, moderate level of evidence). CT can also be used to assess the distribution and phase of colitis [mucosal ulceration] (Brandt et al [*ACG*] 2015: strong recommendation, moderate level of evidence).

MR angiography abdomen and pelvis
As an alternative to CTA, MRA abdomen and pelvis without and with IV contrast is recommended as the initial imaging examination in patients with suspected CMI (Ginsburg et al [*ACR*] 2018; Björck et al [*ESVS*] 2017: C level of evidence). However, there is some evidence that images obtained with MRA are not as accurate or complete as those obtained with CTA (Björck et al [*ESVS*] 2017).

<u>Ultrasound</u>
Ultrasound can be a useful screening tool for chronic mesenteric ischemia or mesenteric artery occlusive disease (Ginsburg et al [ACR] 2018; Huber et al [SVS] 2021: strong recommendation, moderate quality of evidence) However, the presence of overlying bowel gas, obesity, and vascular calcifications can be challenging for an adequate sonographic evaluation (Ginsburg et al [ACR] 2018). In addition, duplex US has a limited role in detecting distal arterial emboli or in diagnosing nonocclusive mesenteric ischemia (Ginsburg et al [ACR] 2018). Moreover, the length of the examination and the possible pain associated with the applied pressure to the abdomen during imaging may be limiting factors in initial evaluation of patients with suspected acute mesenteric ischemia (Ginsburg et al [ACR] 2018). It is recommended that asymptomatic patients with severe mesenteric artery occlusive disease be closely followed for symptoms consistent with chronic mesenteric ischemia; a possible follow-up schedule includes an annual evaluation with a mesenteric duplex ultrasound examination (Huber et al [SVS] 2021: strong recommendation, low quality of evidence).

<u>Clinical and imaging notes</u>

- Acute mesenteric ischemia should be suspected in patients with acute abdominal pain of sudden onset in whom there is no clear diagnosis, particularly pain that is disproportionate to physical examination findings and in the elderly with a history of cardiovascular comorbidities (Tilsed et al [*ESTES*] 2016).
- The sudden onset of severe pain with spontaneous emptying of the bowel with no significant physical findings in patients with a potential source of emboli are classic signs of embolic acute mesenteric ischemia (EAMI) (Tilsed et al [*ESTES*] 2016).
- In the evaluation of acute mesenteric ischemia, the use of oral contrast will add significant delay to CT and should be avoided. The transit time for oral contrast through the bowel will delay definitive treatment in AMI and the associated vomiting and an adynamic ileus limit the useful passage of oral contrast material (Tilsed et al [*ESTES*] 2016).

- Patients with thrombotic AMI (TAMI) usually report prodromal symptoms of mesenteric angina prior to the acute event. Artherosclerotic disease, a history of prior vascular events and hyperlipidemia are risk factors for TAMI (Tilsed et al [*ESTES*] 2016).
- CT or MRI findings of colonic pneumatosis and porto-mesenteric venous gas can be used to predict the presence of transmural colonic infarction (Brandt et al [*ACG*] 2015).
- The diagnosis of colonic ischemia (CI) is usually established in the presence of symptoms including sudden cramping, mild abdominal pain, an urgent desire to defecate, and passage of bright red or maroon blood (Brandt et al [*ACG*] 2015).
- Chronic mesenteric ischemia (CMI) is caused by the failure to achieve postprandial intestinal blood flow resulting in an imbalance between the supply and demand for oxygen and other metabolites (Huber et al [SVS] 2021).
- Chronic mesenteric ischemia (CMI) is characterized by postprandial abdominal pain, and when severe, by food aversion and weight loss (Björck et al [*ESVS*] 2017).
- The diagnosis of CMI requires the appropriate clinical symptoms, the presence of mesenteric artery occlusive disease, and the exclusion of other potential causes of postprandial abdominal pain (Huber et al [SVS] 2021).

<u>Evidence update (2016-present)</u>:

Low Level of Evidence

Karkkainen et al (2017) authored a clinical review paper on the incidence, etiologies, and how to improve early diagnosis in acute mesenteric ischemia (AMI). The authors note that early diagnosis with contrast-enhanced CT and revascularization has been shown to reduce the overall mortality in AMI by up to 50%. Clinical suspicion is a major factor in the early diagnosis of AMI and correct interpretation of CT findings. If AMI is suspected, contrast-enhanced CT should be performed without fear of contrast-induced nephropathy, preferably in arterial and venous phases. Clinicians should be aware that the clinical presentation of AMI varies a great deal depending on the etiology, and moreover, on the presentation pattern of the arterial obstruction.

PICO 10: Abdominal pain with suspected symptomatic abdominal aortic aneurysm (AAA):

- Green – **CT angiography abdomen and pelvis**
- Green - **MR angiography abdomen and pelvis**
- Green – **CT abdomen and pelvis with IV contrast**
- Green – **Ultrasound aorta abdomen**
- Yellow – **MRI abdomen and/or pelvis without and with IV contrast**
- Yellow – **MRI abdomen and/or pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Yellow – **CT abdomen and pelvis without IV contrast**
  [patient unable to receive IV contrast]
- Yellow – **CT abdomen and pelvis without and with IV contrast**
  [angiography expertise not available; or patient with known cancer or liver disease]
- Red – **MRCP**
- Red – **PET** or **PET/CT**
- Red – **SPECT**
- Red – **Scintigraphy**
- Red – **MR or CT enterography; MR or CT enteroclysis**

Level of Evidence: CT: moderate; CTA: moderate; MRA: low

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Abdominal aortic aneurysm (AAA) is commonly defined as an aneurysmal dilation of the abdominal aorta of at least 3 cm in diameter (Wang et al [ACR] 2023). To mitigate risk of rupture, screening programs have been widely instituted to identify small, developing aneurysms (Wang et al [ACR] 2023). Imaging surveillance can identify interval growth, with rates > 2 mm per year associated with increased adverse events (Wang et al [ACR] 2023). Repair of a AAA requires dedicated preoperative imaging to minimize adverse outcomes (Francois et al [ACR] 2018).

Ultrasound
US of the abdominal aorta is the mainstay imaging procedure for AAA screening and surveillance (Wang et al [ACR] 2023). Transabdominal US of the abdominal aorta poses negligible risk to patients and can reliably detect the presence of an AAA in nearly all patients with sensitivity and specificity approaching 100% (Wang et al [ACR] 2023). An immediate aortic ultrasound can be offered when diagnosis of symptomatic and/or ruptured AAA is being considered (*NICE* 2020). Ultrasound, when feasible and performed by a qualified individual skilled in vascular imaging, is also recommended for the first line diagnosis and surveillance of small abdominal aortic aneurysms (Wanhainen et al [*ESVS*] 2019: class I, level B recommendation; Chaikof et al [*SVS*] 2018: level 1 (strong), quality of evidence A (high)). Image quality using ultrasound is highly dependent on operator experience, patient cooperation, and patient body habitus (Francois et al [*ACR*] 2018). In patients reporting abdominal or back pain with a suspected aneurysm, ultrasound can be useful to determine if an AAA is present and to identify other causes of pain (Chaikof et al [*SVS*] 2009*: strong level of recommendation, moderate quality of evidence).

CT angiography
In patients with abdominal aortic aneurysm (AAA), computed tomography angiography (CTA) is recommended for therapeutic decision making and treatment planning, and for the diagnosis of rupture (Wanhainen et al [*ESVS*] 2019: class I, level C recommendation). CTA is the imaging procedure of choice for preoperative assessment before endovascular or open surgical repair (Wang et al [ACR] 2023). In those with a suspected ruptured AAA who are being evaluated for AAA repair, thin-slice contrast-enhanced arterial-phase CT angiography should be considered (*NICE* 2020; (Francois et al [*ACR*] 2018). Due to its superior spatial resolution and rapid image acquisition, CTA with 3-D volumetric reconstruction and vessel analysis has gained wide acceptance as the gold standard for pre-EVAR evaluation (Francois et al [*ACR*] 2018).

MR angiography
For preoperative AAA repair planning, MRA abdomen and pelvis is an appropriate imaging procedure (Wang et al [ACR] 2023; Francois et al [*ACR*] 2018). The major advantage of MRA relative to CTA is improved soft tissue characterization (Francois et al [*ACR*] 2018). Superior soft-tissue characterization inherent to MRA may assist clinicians in differentiating slow-growing aneurysms from fast-growing aneurysms (Francois et al [*ACR*] 2018). MR imaging also does not require radiation or injection of iodinated contrast agents, and therefore has an advantage over CTA when AAA management requires repeated imaging (Wanhainen et al [*ESVS*] 2019). However, MRI is less widely available than CTA, with contraindications such as claustrophobia and some metal implants (Francois et al [*ACR*] 2018).Other limitations of MRA and MRI in general include longer imaging acquisition times and limited ability to detect and characterize aortic wall calcifications (Wang et al [ACR] 2023).

CT abdomen and pelvis
CT offers excellent spatial resolution, fast image acquisition times, and widespread availability, however, without contrast material administration, its ability to assess vascular structures is limited (Francois et al [*ACR*] 2018). A CT scan can be used to evaluate patients thought to have AAA presenting with recent-onset abdominal or back pain, particularly in the presence of a pulsatile epigastric mass or significant risk factors for AAA (Chaikof et al [*SVS*] 2018, strong level of recommendation/moderate quality of evidence). With modern equipment and imaging techniques, false-positive CT interpretation is low, and radiographic findings of rupture are well characterized (Chaikof et al [*SVS*] 2018).

*This guideline did not pass the AGREE II Rigor of Development domain score cutoff, but was included because of its direct relevance to this clinical scenario.

Clinical and imaging notes

- Symptoms or signs of an intact AAA, if present, are mainly pain or tenderness on palpation, localized to the AAA or radiating to the back or genitals. Symptoms may be related to complications, either by compression of nearby organs (duodenal obstruction, lower limb edema, ureteral obstruction) or distal embolism. For rupture, the signs are usually more dramatic (hemodynamic collapse, pallor, abdominal and/or back pain, abdominal distension, and rarely primary aorto-enteric or arterio-venous fistula) (Wanhainen et al [*ESVS*] 2019).
- For patients who present de novo for treatment of AAA without any prior imaging available, the entire aorta (including the thoracic portion) should be assessed to fully characterize the aneurysm and exclude a concomitant thoracic aortic aneurysm (Francois et al [*ACR*] 2018).
- An abdominal aortic diameter of > 3.0 cm, which usually is more than 2 standard deviations above the mean diameter for men, is considered to be aneurysmal. This definition, based on

external ultrasound diameters had a sensitivity of 67% and a specificity of 97% in predicting the need for AAA repair within 10 years (Wanhainen et al [*ESVS*] 2019).

- Aortic diameter measurement with computed tomography angiography should be considered using dedicated post-processing software analysis in three perpendicular planes with a consistent caliper placement (Wanhainen et al [*ESVS*] 2019).
- The maximum aneurysm diameter derived from CT imaging should be based on an outer wall to outer wall measurement perpendicular to the path of the aorta (Chaikof et al [*SVS*] 2018).

<u>Evidence update (2016-present)</u>:

Moderate Level of Evidence

Fernando et al (2022), in a systematic review and meta-analysis, evaluated the accuracy of presenting symptoms, physical examination signs, CTA, and point-of-care ultrasound (POCUS) for diagnosis of ruptured abdominal aortic aneurysm (rAAA). The authors note that, because POCUS cannot detect rupture, they secondarily assessed its accuracy for the diagnosis of AAA, using the reference standard of intraoperative or CTA diagnosis. A total of 20 studies were included (n = 2,077 patients) with 11 evaluating signs and symptoms, seven evaluating CTA, and five evaluating POCUS. Pooled sensitivities of abdominal pain, back pain, and syncope for rAAA were 61.7%, 53.6%, and 27.8%, respectively (low certainty). Pooled sensitivity of hypotension and pulsatile abdominal mass were 30.9% and 47.1%, respectively (low certainty). CTA had a sensitivity of 91.4% and specificity of 93.6% for diagnosis of rAAA (moderate certainty). In the secondary analysis, PoOUS had a sensitivity of 97.8% and specificity of 97.0% for diagnosing AAA in patients suspected of having rAAA (moderate certainty).

Low Level of Evidence

Baolei et al (2021), in a systematic review, evaluated the role of PET in predicting AAA prognosis. A total of 11 studies were included, with nine using ^{18}F-FDG PET/CT imaging, and the remaining two using ^{18}F-NaF PET/CT and ^{18}F-FDG PET/MRI. Findings from the ^{18}F-FDG PET/CT studies were contradictory, with six finding no significant association or correlation, and two finding a significant negative correlation between ^{18}F-FDG uptake and AAA expansion. One PET/CT study that used ^{18}F-NaF as a tracer showed increased uptake was significantly associated with AAA growth. The ^{18}F-FDG PET/MRI study indicated that ^{18}F-FDG uptake was not significantly correlated with AAA expansion. The authors conclude that a definitive role for ^{18}F-FDG PET imaging for AAA prognosis awaits further investigation.

Hahn et al (2016) sought to retrospectively determine if abdominal aortic aneurysm (AAA) rupture can reliably be excluded in individuals age > 65 with abdominal pain who have had a normal caliber aorta on CT or ultrasound. A total of 606 ED patients (average age 78) were enrolled. All patients received imaging studies of their aorta at two separate visits: (Visit 1) an initial CT or US as an ED patient, inpatient, or outpatient, which identified a normal abdominal aorta and (Visit 2) a second CT or US during an ED visit. Median amount of time between radiographic studies was 392 days. A total of three subjects (0.5%) exhibited an abnormal-sized aorta (average size 3.3 cm) on ED evaluation (Visit 2); none of these subjects had an AAA intervention. The authors conclude that it appears AAA and rupture may reliably be excluded in ED patients > age 65 with abdominal pain who have had a normal caliber aorta on CT or ultrasound [≤ 1 year prior to presentation].

Guideline exclusions:

- Abdominal trauma,
- Chronic liver disease,
- Renal disease, including renal calculus (see Renal, Adrenal & Urinary Tract AUC),
- Pneumonia (see Cough AUC),
- Osseous indications (see Hip Pain AUC),
- Uterine and ovarian disease,
- Prostate cancer and prostatitis,
- Jaundice in the absence of pain,
- GI bleeding in the absence of pain,
- Constipation,
- Follow-up imaging after postendovascular repair (EVAR) or open repair of AAA,
- Staging of primary abdominal cancers,
- Evaluation for abdominal metastatic disease,
- Pregnant patients, and
- Pediatric patients.

AUC Revision History:

Revision Date:	New AUC Clinical Scenario(s):	Approved By:
02/23/2021	n/a	CDI Quality Institute's Multidisciplinary Committee
12/05/2023	n/a	RAYUS Quality Institute's Multidisciplinary Committee

Information on our evidence development process, including our conflicts of interest policy is available on our website at **https://www.rayusradiology.com/ple**

PROVIDER LED ENTITY
Abdominal Pain AUC
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12/05/2023

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