

Provider Led Entity

CDI Quality Institute PLE Nontraumatic Abdominal Pain AUC 2021 Update

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

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 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, and also for foreign bodies or free air.
- **Ultrasound**, while not considered an advanced imaging modality, 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. 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 a number of pathologic entities. CT is accurate in the detection and evaluation of abscess, appendicitis, diverticulitis, bowel obstruction, perforation, abscess, and aneurysms of the abdominal aorta.
- **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 inflammatory bowel disease.
- **Cholescintigraphy** may be used in patients presenting with right upper quadrant pain suggestive of cholecystitis, particularly when ultrasound is inconclusive. In some instances, scintigraphy may be useful to evaluate patients with inflammatory bowel disease.

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

- **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]
- **Red** – PET; PET/CT; SPECT; scintigraphy; MR enterography; MR enteroclysis; CT enterography
CT enteroclysis; MR angiography; 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:

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). Abdominal CT scanning may be considered for select patients with suspected ventral hernia to confirm the diagnosis or to aid with preoperative planning (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). 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).

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).

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). A preoperative abdominal ultrasound may be considered (as an alternative to CT) for selected patients with suspected ventral hernia to confirm the diagnosis or to aid with preoperative planning (Earle et al (2013); moderate quality, strong recommendation). It can also be used in the patient with obscure pain and/or swelling and suspicion for inguinal hernia (Simons et al 2009; grade C). In patients with epigastric pain, consideration should be given to a right upper quadrant (RUQ) ultrasound (US) to exclude hepatobiliary disease (PLE expert panel consensus opinion).

Clinical and imaging notes:

- 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).
- 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).
- Suspected abdominal abscess may present in a number of ways: with fever, with diffuse or localized abdominal pain, or with a history of a condition that may predispose to abdominal abscess (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 scans accurately assess the relationship of a hernia to structures such as the bladder, pubic symphysis, anterior superior iliac spine, and the ribs, in addition to defining the integrity and nature of the muscles of the abdominal wall and the size of the defect (Earle et al 2016).
- Clinical signs may be understated and less specific in paraplegic patients, and early CT imaging should therefore be considered (PLE expert panel consensus opinion).
- CT should use the “as low as reasonably achievable” radiation dose (e.g., Mayo-Smith et al 2014).

Evidence update (2010-present):

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

unenanced, then unenanced 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 unenanced 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 unenanced ($\kappa = 0.745—0.789$) and combined CT ($\kappa = 0.745—0.799$). The authors conclude that unenanced CT alone is accurate and associated with a high inter-reader agreement of acute abdominal pain, and can be a valuable tool for triaging (low level of evidence).

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 (low level of evidence).

Millet et al (2017) prospectively assessed the added-value of unenanced abdominal CT on ED diagnosis and management accuracy, compared to current practice, in 401 elderly patients with nontraumatic acute symptoms. Consecutive patients ≥ 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 unenanced abdominal CT improves ED diagnosis accuracy and appropriate management in elderly patients presenting with acute symptoms compared to current practice (moderate level of evidence).

Juvonen et al (2014), in a prospective randomized study, assessed the need for surgical treatment in 203 patients with acute abdominal pain. Patients were randomized to either routine abdominal CT (rCT; $n = 118$; mean age 52 – contrast-enhanced CT within 24 hours of admission) or selective abdominal CT (sCT; $n = 85$; mean age 55 – contrast-enhanced CT performed if considered necessary) over a period of 16 months. Of these, 93 of the randomized patients (45.8%) underwent the study design and were reached for follow-up at 3 months. Diagnostic accuracy improved significantly in the rCT group, and the surgeon's assessment of need for surgery changed more in the rCT group (78.7%) than the sCT group (46.9%). The confidence to treat operatively increased significantly in the rCT vs. the sCT group (65.6% vs. 40.6%, $p = 0.028$). The authors conclude that routine CT allows for more confidence in decision making for the surgical treatment of patients with acute abdominal pain (moderate level of evidence).

Priola et al (2013) prospectively assessed the accuracy of CT in the differential diagnosis of acute abdomen. 181 ED patients (mean age 58.7 years) with surgically treated acute abdomen were included. IV contrast was used in 81% of cases. In 158 (87.3%) cases, CT was totally concordant with surgical findings. Partial concordance was found in 15 cases, bringing overall sensitivity to 95.6%. The authors conclude that CT shows high reliability in the differential diagnosis of surgically treated acute abdomen, although associated conditions can sometimes be missed (moderate level of evidence).

Right upper quadrant pain with suspected hepatobiliary disease; initial ultrasound is nondiagnostic or ultrasound expertise is not available*:

- **Green** - Cholescintigraphy
- **Green** - MRI abdomen without and with contrast with MRCP
- **Green** – MRI abdomen without contrast with MRCP
- **Green** - 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; PET/CT; SPECT; MR enterography; MR enteroclysis; CT enterography; CT enteroclysis; MR angiography; CT angiography; WBC scintigraphy

*In patients with suspected gallstone-related disease, the recommended initial test is ultrasonography (*EASL* 2016, high quality evidence/strong recommendation; *NICE* 2014; PLE expert panel consensus opinion).

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:

Ultrasound

While not considered to be an advanced imaging modality, ultrasound, when expertise is available, is the first choice for investigation of biliary symptoms or right upper quadrant abdominal pain (Peterson et al [ACR] 2019; PLE expert panel consensus opinion). Ultrasound has an accuracy for detecting gallbladder stones in excess of 95% (*EASL* 2016: high quality evidence, strong recommendation; Peterson et al [ACR] 2019) 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 or acute cholangitis is suspected (Yokoe et al [JSHBPS] 2013: recommendation 1, level A; *EASL* 2016: moderate quality evidence, strong recommendation). Ultrasonography shows 50-88% sensitivity and 80-88% specificity for acute cholecystitis (Yokoe et al [JSHBPS] 2013). In the initial presentation of a patient with jaundice, abdominal ultrasound can detect both cirrhosis and the presence of dilated intrahepatic/extrahepatic bile ducts (Hindman et al [ACR] 2019). In general, normal ultrasound results do not preclude further investigation if clinical suspicion remains high (Williams et al 2017: low quality evidence, strong recommendation).

Cholescintigraphy

Nuclear medicine scanning is usually appropriate, following a negative or equivocal ultrasound, in the imaging of patients with right upper abdominal pain if there is concern regarding gallbladder or other hepatobiliary disease (Scheirey et al [ACR] 2018; Dillehay et al [SNMMI] 2017; Peterson et al [ACR] 2019). 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 the patient (Dillehay et al [SNMMI] 2017). HIDA scintigraphy with cholecystokinine (CCK)

is appropriate in patients with abnormal ultrasound results, and may also be appropriate in patients with normal ultrasound results if suspicion remains high (Dillehay et al [SNMMI] 2017: moderate level evidence). 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 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 HIDA imaging in 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 (with or without fever or high WBC count) following a negative or equivocal ultrasound, MRI without and with contrast with MRCP (or MRI without contrast with MRCP) is usually appropriate (Peterson et al [ACR] 2019; *EASL* 2016: low quality evidence, weak recommendation). These modalities can also be useful for imaging jaundice patients with suspected mechanical obstruction, such as CBD stones (Hindman et al [ACR] 2019). 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). While contrast-enhanced examinations are preferred, MRI of the abdomen without IV contrast can provide improved characterization of incidental sonographic liver findings when compared to noncontrast CT, and is helpful in the follow-up of known hepatobiliary stone disease (Peterson et al [ACR] 2019). Patients at intermediate risk of CBD stones (age > 55, dilated CBD on US, or elevated liver enzymes or bilirubin <4mg/dl) following ultrasound generally undergo MRCP or endoscopic ultrasound (EUS) (Williams et al 2017). MRCP is often preferred over EUS, with choice between the two modalities determined by individual suitability, availability, local expertise, and patient acceptability (Williams et al 2017: moderate quality evidence, strong recommendation). 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 (Kiryama et al [*JSHBPS*] 2013: recommendation 2, level D; *EASL* 2016: moderate quality evidence, strong recommendation).

CT abdomen

In the setting of right upper quadrant pain with suspected biliary disease and a negative or equivocal ultrasound, CT of the abdomen with IV contrast is usually appropriate and considered to be an equivalent alternative to MRI with MRCP, with a negative predictive value near 90% (Peterson et al [ACR] 2019). 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). Reported sensitivity for gallstone detection by CT is approximately 75% (Peterson et al [ACR] 2019). CT is suggested as the most effective imaging method for the diagnosis and complications of acute cholangitis (Kiryama et al [*JSHBPS*] 2013: recommendation

2, level D). There is limited data on the utility and value of noncontrast CT for biliary obstruction (Peterson et al [ACR] 2019; Hindman et al [ACR] 2019). While CT without IV contrast can detect certain features and complications of acalculous cholecystitis (e.g., gallbladder wall thickening, pericholecystic inflammation, gas formation, hemorrhage), other important features (such as wall enhancement and adjacent liver parenchymal hyperemia) cannot be detected, and so IV contrast is preferred (Peterson et al [ACR] 2019). CT without and with IV contrast is not often viewed as necessary in the assessment of patients with right upper quadrant abdominal pain, except possibly for those with prior chronic disease or neoplasia (Peterson et al [ACR] 2019; Hindman et al [ACR] 2019).

Clinical and imaging notes:

- 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, and tenderness on palpation (Murphy's sign) (EASL 2016; Peterson et al [ACR] 2019).
- 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).

Evidence update (2015-present):

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 ≥ 200 IU, elevated bilirubin levels, alanine transaminase of ≥ 220 IU, and male age of ≥ 50 years were significantly associated with choledocholithiasis and included in the scoring system. 96 patients (35%) had scores of ≥ 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 (low level of evidence).

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 (low level of evidence).

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 with IV contrast
 - **Green** – MRI abdomen without and with IV contrast with MRCP
 - **Yellow** - MRI abdomen without IV contrast with MRCP
[patient unable to receive 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; PET/CT; SPECT; MR enterography; MR enteroclysis; CT enterography; CT enteroclysis; scintigraphy; CT angiography; MR 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: Consulting and reporting requirements are not required for orders for applicable imaging services made by ordering professionals under the following circumstances (42 C.F.R. § 414.94. 2015):

- Emergency services when provided to individuals with emergency medical conditions.
- For an inpatient and for which payment is made under Medicare Part A.

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). 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

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). 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

While not considered an advanced imaging modality, 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; Greenberg et al 2016*: strong recommendation, low quality of evidence; PLE expert panel consensus opinion). Ultrasonography advantages include its availability and lack of associated radiation exposure (Greenberg et al 2016*). At baseline, ultrasonography should be performed 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.

Clinical and imaging notes:

- The most common causes of acute pancreatitis are gallstone and binge alcohol consumption (Greenberg et al 2016).
- 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*).

Evidence update (2014-present):

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 \leq 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 \geq 8 points (\geq 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).

Zhang et al (2016) assessed the value of early abdominal non-enhanced computed tomography (NECT) in developing strategies for treating acute gallstone pancreatitis (AGP). A total of 102 patients were enrolled and underwent NECT within 48 hours after symptom onset to determine presence of peripancreatic fluid collection, gallstones, and common bile duct stones. NECT was 89.2% and 87.8% accurate in detecting gallbladder stones and CBD stones, respectively. Patients were then assigned to either early laparoscopic cholecystomy (ELC; n = 49) or late laparoscopic cholecystomy (LLC; n = 53). All patients in both groups were cured, no LC-related complications occurred, and no case of AGP increased in severity following LC. The authors conclude that NECT can accurately detect peripancreatic fluid collection and biliary obstructions, and that early abdominal NECT is valuable when developing strategies for treating AGP (moderate level of evidence).

Signoretti et al (2014) aimed to evaluate the diagnostic accuracy of repeated ultrasound (U/S) for biliary acute pancreatitis (AP). The accuracy of U/S and magnetic resonance cholangiopancreatography (MRCP) for diagnosis of biliary AP was evaluated according to final diagnosis. Among 155 patients with AP, the etiology was biliary in 52% and alcoholic in 20%. The accuracy of first U/S alone and of the two combined exams for a biliary etiology were 66% and 83%, respectively. Comparison of receiver operating characteristic curves showed a better performance of repeated U/S. MRCP had high specificity (93%), low sensitivity (62%), and an accuracy of 76%. The accuracy of the combination of the two U/S examinations and of elevated alanine transferase was 87%. The authors conclude that repeated U/S is effective for biliary AP diagnosis, while MRCP might be restricted to selected cases (low level of evidence).

Abdominal pain with suspected chronic pancreatitis*:

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

CT abdomen

In general, the radiologic and endoscopic evaluation of a patient with suspected chronic pancreatitis (CP) should progress from a least invasive to more invasive approach to establish a diagnosis; this makes a CT scan of the pancreas 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 can be 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/secretin-enhanced MRCP, or endoscopic procedures (Conwell et al [APA] 2014*: conditional recommendation, low level 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.

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).
- Endoscopic ultrasonography (EUS), because of its invasiveness and lack of specificity, should be used only if the diagnosis is in question after cross-sectional imaging is performed (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):

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 (low level of evidence).

Right lower quadrant pain with suspected acute appendicitis:

- **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]
- **Red** – PET; PET/CT; SPECT; scintigraphy; MRCP; MR enterography; MR enteroclysis; CT enterography; CT enteroclysis; MR angiography; CT angiography

Level of Evidence: CT: high; MRI: moderate

Notes concerning use of contrast: The addition of IV and oral contrast may increase the sensitivity of CT for the diagnosis of appendicitis (Howell et al [ACEP] 2010, Level B recommendation).

Notes concerning applicability and/or patient preferences: Consulting and reporting requirements are not required for orders for applicable imaging services made by ordering professionals under the following circumstances (42 C.F.R. § 414.94. 2015):

- Emergency services when provided to individuals with emergency medical conditions.
- For an inpatient and for which payment is made under Medicare Part A.

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 (Howell et al [ACEP] 2010: level B 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 (Garcia et al [ACR] 2018; Howell et al [ACEP] 2010). 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). CT has become the primary diagnostic imaging modality for the evaluation of patients with suspected appendicitis because of its high diagnostic yield (Garcia et al [ACR] 2018); for the diagnosis of appendicitis, CT has reported high sensitivity (ranging from 0.96 to 1) and specificity (ranging from 0.91 to 0.99) (Dahabreh et al [AHRQ] 2015). 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% (Garcia et al [ACR] 2018).

MRI abdomen and/or pelvis

Recent studies have demonstrated that MRI is sufficiently accurate to diagnose appendicitis. The advantage of MRI over CT is that no administration of contrast media is necessary and that there is no

ionizing radiation exposure. However, MRI scanners may not be widely available, and technical quality may suffer in the acute setting due to patient discomfort with attendant motion artifacts (Gans et al 2015; Garcia et al [ACR] 2018). 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). This may be due to the smaller number of available studies, which focus 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). It may be particularly useful as the initial imaging technique in younger patients (PLE expert panel consensus opinion). Diagnostic performance of ultrasound in preoperative evaluation of patients presenting with typical signs and symptoms of appendicitis varies widely (Garcia et al [ACR] 2018). In adult populations, ultrasound had lower reported sensitivity (0.83) and specificity (0.89) than CT and MRI, and produced more non-diagnostic scans (Dahabreh et al [AHRQ] 2015). Examination is also considered to be highly operator dependent, and may be technically challenging in obese patients or women in late pregnancy (Dahabreh et al [AHRQ] 2015).

Clinical and imaging notes:

- The “classic” clinical presentation of appendicitis consists of periumbilical abdominal pain migrating to the RLQ, loss of appetite, nausea or vomiting, with fever and leukocytosis. This is present in about 50% of patients (Garcia et al [ACR] 2018).
- Clinical decision tools, such as the Alvarado score (AS), have not improved the outright diagnostic accuracy of the clinical examination, and demonstrate mixed results as an adjunct to help guide CT use (Garcia et al [ACR] 2018).
- Enteric and IV contrast may be more helpful in thin patients with low body mass index who lack sufficient mesenteric fat to demonstrate periappendiceal fat stranding that is associated with appendicitis (Howell et al [ACEP] 2010). Enteric and IV contrast can also help identify conditions other than acute appendicitis (e.g., diverticulitis, inflammatory bowel disease, cancer) (Howell et al [ACEP] 2010).
- 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 (Garcia et al [ACR] 2018). Dose-reduction strategies in CT should be employed following the *As Low As Reasonably Achievable* principle (e.g., Mayo-Smith et al 2014).

Evidence update (2014-present):

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 (high 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 (low level of evidence).

Replinger 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 ≥ 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 (moderate level of evidence).

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 (moderate level of evidence).

Lietzen et al (2018) conducted a prospective study of 1,065 patients to assess the accuracy of CT in diagnosing acute appendicitis with special reference to radiologist experience. All patients underwent CT for suspected appendicitis; the on-call radiologist preoperatively analyzed these images. Radiologists were divided into experienced (consultants) and inexperienced (residents), and comparisons were made. Of the 1,065 patients, 714 (67%) had acute appendicitis on CT. Sensitivity and specificity of CT were 96.7% (95% CI, 95.1–97.8) and 95.9% (95% CI, 93.2–97.5), respectively. The rate of false CT diagnosis was 4.2% for consultants and 2.2% for residents ($p = 0.071$). Thus, the experience of the radiologist had no effect on the accuracy of CT diagnosis. The results emphasize the role of CT as an accurate modality in daily routine diagnostics for acute appendicitis (moderate level of evidence).

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 (moderate level of evidence).

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 (moderate level of evidence).

Lietzen et al (2016) conducted a retrospective analysis of prospectively collected data in a randomized multicenter trial comparing surgery and antibiotic treatment for acute uncomplicated appendicitis. A total of 1,321 patients with clinical suspicion of acute appendicitis who underwent CT were evaluated. CT confirmed diagnosis of acute appendicitis in 73% (n = 970; median age 35.0), while in 27% (n = 351; median age 31) it revealed no appendicitis or another diagnosis. Acute appendicitis patients had significantly higher WBC levels than patients without appendicitis, whereas CRP levels did not differ between the two groups. The authors concluded that clinical findings and laboratory tests are unable to reliably distinguish between patients with acute appendicitis and those without. If both WBC count and CRP are normal, acute appendicitis is very unlikely. These results emphasize the role of CT imaging in patients with suspected acute appendicitis (low level of evidence).

Lahaye et al (2015) retrospectively evaluated whether mandatory imaging is an effective strategy in 1,556 patients (mean age of 31.6 years) with clinically suspected appendicitis for reducing unnecessary surgery and costs. The study included 756 patients prior to development of Dutch Guidelines recommending mandatory use of preoperative imaging and 800 patients after implementation of the guidelines. After clinical examination by a surgeon, 509 patients in group I and 540 patients in group II were still suspected of having appendicitis. In group I, 58.5% received preoperative imaging (42% U/S / 12.8% CT / 3.7% both), compared with 98.7% after the guidelines (61.6% U/S / 4.4% CT / 32.6% both). The percentage of unnecessary surgeries decreased from 22.9% before the guidelines to 6.2% after implementation. The surgical complication rate also dropped from 19.9% to 14.2%. The authors conclude that increased use of imaging in diagnostic work-up of patients with suspected appendicitis reduced rate of negative appendectomies and surgical complications (low level of evidence).

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
- **Red** – PET; PET/CT; SPECT; scintigraphy; MRCP; MR enterography; MR enteroclysis; CT enterography; CT enteroclysis; MR angiography; CT angiography

Level of Evidence: CT: moderate; MRI: low

Notes concerning applicability and/or patient preferences: Consulting and reporting requirements are not required for orders for applicable imaging services made by ordering professionals under the following circumstances (42 C.F.R. § 414.94. 2015):

- Emergency services when provided to individuals with emergency medical conditions.
- For an inpatient and for which payment is made under Medicare Part A.

Guideline and PLE expert panel consensus opinion summary:

CT abdomen and pelvis

CT scan of the abdomen and pelvis with IV contrast is usually the most appropriate imaging modality of left lower quadrant pain with suspected diverticulitis or suspected complications of diverticulitis (Galgano et al [ACR] 2019; 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).

MRI abdomen and/or pelvis

Preliminary data suggest that MRI may have diagnostic potential in patients with suspected diverticulitis, with reported sensitivity of 86%-94% and specificity of 88%-92% (Galgano et al [ACR] 2019). Therefore, 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). 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; Galgano et al [ACR] 2019).

Clinical and imaging notes:

- The most common cause of left lower quadrant pain in adults is acute sigmoid or descending colonic diverticulitis (Galgano et al [ACR] 2019).
- Classis findings related to sigmoid diverticulitis include left lower quadrant pain, fever, and

leukocytosis (Hall et al [ASCRS] 2020).

- 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 (Galgano et al [ACR] 2019).
- Dose-reduction strategies in CT should be employed following the *As Low As Reasonably Achievable* principle (e.g., Mayo-Smith et al 2014).

Evidence update (2013-present):

Weinrich et al (2020) retrospectively 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 (low 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 (moderate level of evidence).

Fung et al (2015) retrospectively validated a CT grading system for acute complicated diverticulitis in predicting operative or percutaneous intervention. Hospital and radiology records identified patients with acute complicated diverticulitis confirmed by CT. A gastrointestinal radiologist, blinded to clinical outcomes, assigned a score according to the CT grading system. Of the 1,060 patients, 367 patients (34.6%) had CT performed for acute diverticulitis during the study period. Forty-four patients (12%; mean age 59 years; age range 19-92) had acute complicated diverticulitis (e.g., abscess and/or free intraperitoneal air) confirmed on CT. According to CT findings, there was one case with grade 1, eighteen with grade 2, four with grade 3, and twenty-one with grade 4 diverticulitis. Three patients with grade 2, three patients with grade 3, and ten patients with grade 4 disease underwent acute radiological or surgical intervention. The authors conclude that use of a CT grading system for acute complicated diverticulitis did not predict the need for acute radiological or operative intervention. Decision making guided by patient clinical condition still retains a primary role in the management of this disease (low level of evidence).

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** – PET; PET/CT; SPECT; scintigraphy; MRCP; MR angiography; CT angiography

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

Notes concerning applicability and/or patient preferences: Consulting and reporting requirements are not required for orders for applicable imaging services made by ordering professionals under the following circumstances (42 C.F.R. § 414.94. 2015):

- Emergency services when provided to individuals with emergency medical conditions.
- For an inpatient and for which payment is made under Medicare Part A.

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:

CT abdomen and pelvis

CT abdomen and pelvis with IV contrast is usually appropriate for the initial imaging of a suspected small bowel obstruction (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). CT should also be considered to aid in the diagnosis of small-bowel volvulus; findings include multiple transition points, posterior location, and the “whirl” sign (Maung et al [EAST] 2012: level 3 recommendation; Vogel et al [ASCRS] 2016: strong recommendation, based on low- or very-low-quality evidence).

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).

Clinical and imaging notes:

- Initial evaluation of acute colonic pseudo-obstruction should include a focused history and physical examination, complete blood count, serum electrolytes, renal function assessment, and diagnostic imaging (Vogel et al [ASCRS] 2016).
- 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).
- Contrast enhanced CT is the preferred confirmatory diagnostic study for both cecal and sigmoid volvulus and has the advantage of identification of incidental pathology that may be missed with plain radiographs or fluoroscopic contrast studies (Vogel et al [ASCRS] 2016).
- Abdominal CT (or water-soluble contrast enema) can reliably distinguish acute colonic pseudo-obstruction (ACPO) from a mechanical large-bowel obstruction (Vogel et al [ASCRS] 2016).
- 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).
- 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).
- 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).

Evidence update (2012-present):

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 bedside scans (moderate level of evidence).

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]
- **Red** – Scintigraphy; MR angiography; CT angiography; PET; PET/CT; SPECT

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).

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). Proponents contend that leucoscintigraphy is useful in the diagnosis and evaluation of activity and extent of disease, however, it is limited in its ability to detect and characterize alternative diagnoses (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 (no date limit):

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 (low level of evidence).

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 (low level of evidence).

Kopylov et al (2017), in a systematic review and meta-analysis, compared the diagnostic yield of capsule endoscopy (CE) to magnetic resonance enterography (MRE) and small bowel intestinal contrast ultrasound (SICUS) in detection and monitoring of small bowel CD. A total of 13 studies were included. The diagnostic yield of CE for detection of active SB CD was similar to that of MRE (10 studies, 400 patients, OR 1.17; 95% CI: 0.83–1.67) and SICUS (5 studies, 142 patients, OR 0.88; 95% CI: 0.51–1.53), with similar outcomes for subgroups of suspected vs. established CD. CE was superior to MRE for proximal SB CD (7 studies, 251 patients, OR 2.79; 95% CI 1.2–6.48); the difference vs SICUS was not significant. The authors conclude that CE, MRE and SICUS have similar diagnostic yield for detection of small bowel CD (low 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). In regard to 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 (moderate level of evidence).

Wu et al (2013), in a systematic review, evaluated the overall diagnostic accuracy of MRI in assessing the activity of Crohn's disease (CD) in the small bowel. Two reviewers identified studies in which MRI imaging was evaluated for assessing activity of CD in the small bowel. MRI was found to have a pooled sensitivity of 0.87 (95% CI: 0.77-0.93) and a pooled specificity of 0.91 (95% CI: 0.81-0.96). Overall, likelihood ratio (LR)+ was 9.5 (95% CI: 4.4-20.6) and LR- was 0.14 (95% CI: 0.08-0.26). In patients with high pretest probabilities, MRI enabled confirmation of active CD; in patients with low pretest probabilities, MRI enabled exclusion of active CD. The authors conclude that a limited number of small studies suggest that MRI has high sensitivity and specificity for diagnosis of active CD in the small bowel, and that MRI will likely also prove to be suitable as the primary modality for active CD imaging surveillance (moderate level of evidence).

Jensen et al (2011) conducted a prospective, blinded, multi-center study to determine and compare the sensitivities and specificities of MR enterography (MRE) and CT enterography (CTE) for detection of small bowel lesions. A total of 50 patients (median age of 39 years; age range 18-76) with symptomatic preexisting Crohn's disease (CD) and a demand for small bowel imaging to support changes in treatment strategy were included. MRE and CTE were performed on same day in alternating order and subsequently compared with the gold standard: pre-defined lesions at ileoscopy (n = 30) or surgery with (n = 12) or without (n = 3) intra-operative enteroscopy. 35 patients had active small bowel CD and 20 had small bowel stenosis. Sensitivity and specificity of MRE for detection of small bowel CD were 74% and 80%, compared to 83% and 70% with CTE. MRE and CTE detected small bowel stenosis with 55% and 70% sensitivities, respectively and 92% specificities. The authors conclude that MRE and CTE have comparable diagnostic accuracies for detection of small bowel CD and stenosis (high level of evidence).

Abdominal pain with suspected bowel ischemia or infarction:

- **Green** – CT angiography abdomen and pelvis
- **Green** – CT abdomen and pelvis with IV contrast
- **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** – MR angiography abdomen and pelvis
- **Red** – Scintigraphy; PET; PET/CT; SPECT; MRCP; MR enterography; MR enteroclysis; CT enterography; CT enteroclysis

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

Notes concerning applicability and/or patient preferences: Consulting and reporting requirements are not required for orders for applicable imaging services made by ordering professionals under the following circumstances (42 C.F.R. § 414.94. 2015):

- Emergency services when provided to individuals with emergency medical conditions.
- For an inpatient and for which payment is made under Medicare Part A.

Guideline and PLE expert panel consensus opinion summary:

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 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 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). In those where presentation of colon ischemia (CI) may be a heralding sign of acute mesenteric ischemia (AMI) (e.g., IRCI, severe pain without bleeding, atrial fibrillation), and multiphasic CT is negative for vascular occlusive disease, traditional splanchnic angiography should be considered for further assessment (Brandt et al [ACG] 2015: conditional recommendation, low level 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).

Clinical and imaging notes

- 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 or bloody diarrhea (Brandt et al [ACG] 2015).
 - A diagnosis of non-isolated right colon ischemia should be considered when patients present with hematochezia (Brandt et al [ACG] 2015).
- Chronic mesenteric ischemia (CMI) is characterized by postprandial abdominal pain, and when severe, by food aversion and weight loss (Björck et al [ESVS] 2017).
 - Patients with CMI should preferably be investigated and treated at specialized centers that can offer a multidisciplinary assessment, as well as both open and endovascular treatment (Björck et al [ESVS] 2017).

Evidence update (2016-present):

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 (low level of evidence).

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
- **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** – PET; PET/CT; SPECT; scintigraphy; MR enterography; MR enteroclysis; CT enterography; CT enteroclysis

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

Notes concerning applicability and/or patient preferences: Consulting and reporting requirements are not required for orders for applicable imaging services made by ordering professionals under the following circumstances (42 C.F.R. § 414.94. 2015):

- Emergency services when provided to individuals with emergency medical conditions.
- For an inpatient and for which payment is made under Medicare Part A.

Guideline and PLE expert panel consensus opinion summary:

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). In people 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] 2017). 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] 2017).

MR angiography

For preoperative AAA repair planning, MRA abdomen and pelvis is an appropriate imaging procedure (Francois et al [ACR] 2017). The major advantage of MRA relative to CTA is improved soft tissue characterization (Francois et al [ACR] 2017). Superior soft-tissue characterization inherent to MRA may assist clinicians in differentiating slow-growing aneurysms from fast-growing aneurysms (Francois et al [ACR] 2017). 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] 2017).

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] 2017). 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).

Ultrasound

While not considered an advanced imaging modality, an immediate aortic ultrasound can be offered to people in whom a 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] 2017). 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).

*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] 2017).
- 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).

Evidence update (2016-present):

Forsythe et al (2018) prospectively assessed whether ¹⁸F-NaF positron emission tomography and CT (PET-CT) predicts AAA growth and clinical outcomes. Consecutive patients > 50 years old were enrolled: 72 patients with AAA (aortic diameter > 40 mm) and 20 control subjects (aortic diameter < 30 mm). All underwent abdominal ultrasound, PET-CT, CT angiography, and calcium scoring. Clinical endpoints were aneurysm expansion and the composite of AAA repair/rupture. Fluorine-18-NaF uptake was increased in AAA compared with nonaneurysmal regions within the same aorta (p = 0.004) and aortas of control

subjects ($p = 0.023$). Histology and micro-PET-CT demonstrated that ^{18}F -NaF uptake localized to areas of aneurysm disease and active calcification. Aneurysms in the highest tertile of ^{18}F -NaF uptake expanded 2.5x more rapidly than those in the lowest tertile (3.10 [interquartile range (IQR): 2.34 to 5.92 mm/year] vs. 1.24 [IQR: 0.52 to 2.92 mm/year]; $p = 0.008$) and were nearly 3x as likely to experience AAA repair or rupture (15.3% vs. 5.6%; log-rank $p = 0.043$). The authors conclude that PET-CT is a novel and promising approach for identification of disease activity in patients with AAA and an additive predictor of aneurysm growth and future clinical events (low level of evidence).

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 $> \text{age } 65$ with abdominal pain who have had a normal caliber aorta on CT or ultrasound [≤ 1 year prior to presentation] (low level of evidence).

Guideline exclusions:

- Cases meeting the definition of a suspected or confirmed emergency medical condition,
- 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:

<u>Revision Date:</u>	<u>New AUC Clinical Scenario(s):</u>	<u>Posting Date:</u>	<u>Approved By:</u>
02/23/2021	n/a	03/02/2021	CDI 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.mycdi.com/ple>

Provider Led Entity

Appropriateness of Advanced Imaging in Patients with Abdominal Pain: Bibliography

02/23/2021

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