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CDI Quality Institute PLE Nontraumatic Abdominal Pain AUC 2019 Update

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

02/05/2019

*Including MRI, MRCP, MR enterography/enteroclysis, CT, CT enterography/enteroclysis, MRA, CTA, scintigraphy, PET, and PET/CT

Abbreviation list:

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

Diffuse or poorly localized acute abdominal pain with or without fever (including clinical suspicion for perforated peptic ulcer disease, bowel perforation, abscess, incarcerated hernia, post-surgical complication, and symptomatic abdominal aortic aneurysm):

- **Green** – CT abdomen and pelvis with IV contrast
- **Yellow** – CT abdomen and pelvis without IV contrast for patients with allergy to CT contrast, poor or difficult IV access, or poor renal function
- **Yellow** – MRI abdomen and/or pelvis with and without IV contrast; MRI abdomen and/or pelvis without IV contrast
- **Yellow** – CT abdomen and pelvis with IV contrast and/or CTA for suspected symptomatic AAA in patients with nondiagnostic, inconclusive or positive ultrasound exam
- **Yellow** – MRA for suspected symptomatic AAA in patients with nondiagnostic, inconclusive, or positive ultrasound exam and with allergy to CT contrast, poor or difficult IV access, or poor renal function
- **Orange** – CT abdomen and pelvis with and without IV contrast except in patients with a known or suspected cancer or liver disease
- **Red** – PET; PET/CT; scintigraphy; MR or CT enterography/enteroclysis

Level of Evidence: CT (for acute nonspecific): low to high; CT (for AAA): moderate; CTA (for AAA): moderate; MRA (for AAA): low; MRI (for hernia): low

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Most commonly, in the setting of nonlocalized, nontraumatic abdominal pain, a routine CT of the abdomen and pelvis is performed with IV contrast and a single postcontrast phase (Scheirey et al. [*ACR*] 2018).

In patients with *acute nonlocalized abdominal pain and fever, no recent surgery, initial imaging* the *American College of Radiology* recommends CT abdomen and pelvis with IV contrast (*usually appropriate*). Additionally, the *ACR* recommends that MRI abdomen and pelvis without and with IV contrast, US abdomen, CT abdomen and pelvis without IV contrast, MRI abdomen and pelvis without IV contrast, CT abdomen and pelvis without and with IV contrast, or radiography abdomen *may be appropriate* (Scheirey et al. [*ACR*] 2018).

In patients with *acute nonlocalized abdominal pain and fever, postoperative patient, initial imaging*, the *American College of Radiology* recommends CT abdomen and pelvis with IV contrast (*usually appropriate*). Additionally, the *ACR* recommends that MRI abdomen and pelvis without and with IV contrast, US abdomen, CT abdomen and pelvis without IV contrast, MRI abdomen and pelvis without IV contrast, CT abdomen and pelvis without and with IV contrast, radiography abdomen, fluoroscopy contrast enema or fluoroscopy upper GI series with small bowel follow-through *may be appropriate* (Scheirey et al. [*ACR*] 2018).

In patients with *acute nonlocalized abdominal pain, neutropenic patient, initial imaging*, the *American*

College of Radiology recommends CT abdomen and pelvis with IV contrast or CT abdomen and pelvis without IV contrast (*usually appropriate*). Additionally, the *ACR* recommends that MRI abdomen and pelvis without and with IV contrast, US abdomen, MRI abdomen and pelvis without IV contrast, or CT abdomen and pelvis without and with IV contrast *may be appropriate* (Scheirey et al. [*ACR*] 2018).

In patients with *acute nonlocalized abdominal pain, not otherwise specified, initial imaging*, the *American College of Radiology* recommends CT abdomen and pelvis with IV contrast, CT abdomen and pelvis without IV contrast, or MRI abdomen and pelvis without and with IV contrast (*usually appropriate*). Additionally, the *ACR* recommends that US abdomen, MRI abdomen and pelvis without IV contrast, CT abdomen and pelvis without and with IV contrast, or radiography abdomen *may be appropriate* (Scheirey et al. [*ACR*] 2018).

A CT scan is recommended 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).

Computed tomography leads to the highest sensitivity and specificity in patients with acute abdominal pain. Due to the downsides of computed tomography, an ultrasound is preferred as the first imaging modality. Only in critically ill patients a computed tomography should be performed without a prior ultrasound. When the ultrasound is negative or inconclusive, a computed tomography scan can be performed (Gans et al. 2015).

When optimized for the acute setting, MRI can be an accurate examination for detecting abdominal and pelvic abscesses (Scheirey et al. [*ACR*] 2018).

Based on the lack of current literature, there is no place yet for MRI in the diagnostic pathway [of patients with acute abdominal pain] (Gans et al. 2015).

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).

<u>Clinical notes:</u>

- 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 the elderly with acute abdominal pain and fever (Scheirey et al. [*ACR*] 2018).
- Patients suspected of having abdominal abscesses 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 abscesses (Scheirey et al. [*ACR*] 2018).
- In neutropenic patients, abdominal pain remains a diagnostic challenge due to the lack of classic clinical and laboratory signs. CT with IV contrast is extremely useful in the evaluation of the neutropenic patient with abdominal pain secondary to its high spatial resolution and ability to display key imaging features (Scheirey et al. [*ACR*] 2018).

- Clinical signs may be understated and less specific in paraplegic patients and early CT imaging should be considered in these patients (PLE expert panel consensus opinion).

Imaging notes:

- Conventional radiography may be performed in the setting of acute abdominal pain. Conventional radiography, however, has a limited role in the evaluation of nontraumatic abdominal pain in adults. Although the use of radiographs has shown high sensitivity (90%) for detecting intra-abdominal foreign bodies and moderate sensitivity for detecting bowel obstruction (49%), its low sensitivity for sources of abdominal pain and fever or abscess limits its role in this setting (Scheirey et al. [*ACR*] 2018).
- In patients with epigastric pain and suspected peptic ulcer disease (PUD) without fever or suspected perforation, consideration should be given to a right upper quadrant (RUQ) ultrasound (US) to exclude gallbladder disease, and a gastric cocktail to test for PUD (PLE expert panel consensus opinion).
- Ultrasound can be used to screen the abdomen for sources of abdominal pain, but in general is less sensitive and specific than CT. Although ultrasound may be able to depict portions of an abscess or malignancy, it is not optimized to view many areas of the abdomen, particularly in the presence of increased bowel gas or free intraperitoneal air. In spite of these shortcomings, ultrasound may be useful in this setting in the initial imaging of younger patients (Scheirey et al. [*ACR*] 2018).
- In patients with abdominal or back pain with a suspected aneurysm, an ultrasound is recommended to determine if an AAA is present and to identify other causes of pain. If an AAA rupture is suspected, CT is the preferred initial test (Chaikof et al. [*SVS*] 2009, strong level of recommendation/moderate quality of evidence).
- The diagnosis based on clinical assessment and ultrasound corresponds with the final diagnosis in 53-83% of patients (Gans et al. 2015).
- In female patients with acute pelvic pain, consideration might be given to pelvic ultrasound with arterial Doppler evaluation of the ovaries to evaluate for torsion of the ovaries (PLE expert panel consensus opinion).
- Although sensitivity and specificity ranges are not routinely reported because of the wide spectrum of pathology encountered, there are sufficient data to suggest that CT with IV contrast adds diagnostic value and helps direct management [of nontraumatic abdominal pain] (Scheirey et al. [*ACR*] 2018).
- Clinical assessment and conventional radiography combined with CT corresponded with the final diagnosis in 61.6-96% of patients. They correctly identified an urgent cause in 89% of patients (Gans et al. 2015).
- Multiplanar reformations [on CT] have been shown to improve diagnostic confidence in patients with abdominal pain (Scheirey et al. [*ACR*] 2018).
- The use of IV contrast increases the spectrum of detectable pathology and is recommended in preference to other methods of contrast administration (Scheirey et al. [*ACR*] 2018; Gans et al. 2015).
- CT should use the “as low as reasonably achievable” [radiation] dose (e.g., Mayo-Smith et al. 2014).
- We suggest that 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).
- 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).

Evidence update (2010-present):
Rubano et al, in a 2013 systematic review of seven studies (n = 655), evaluated the operating characteristics of emergency department (ED) ultrasonography for abdominal aortic aneurysm (AAA). Studies included bedside ultrasound performed by emergency physicians in adult patients with symptoms/signs suggestive of AAA. The weighted average prevalence of AAA in symptomatic patients > age 50 was 23%. The authors note that, on history, 50% of AAA patients will lack the classic triad of hypotension, back pain, and pulsatile abdominal mass. The pooled operating characteristics of ED ultrasound for detection of AAA were sensitivity 99% (95% CI = 96-100%) and specificity 98% (95% CI = 97-99%). The authors conclude that emergency bedside ultrasound showed excellent diagnostic performance in detecting the presence of AAA in symptomatic patients (high level of evidence).

Millet et al (2017) prospectively assessed the added-value of systematic unenhanced abdominal CT on emergency department (ED) diagnosis and management accuracy, compared to current practice, in elderly patients with nontraumatic acute abdominal symptoms. The study included 401 consecutive patients ≥ 75 years (median age 85) admitted to the ED with acute symptoms and investigated by CT scan. CT was found to significantly improve diagnosis (85% vs. 76.8%) and management (95.8% vs. 88.5%) rates compared to current practice. In the group for which CT was not requested, CT led to diagnosis of acute unsuspected disorders in 30.3% of cases, and to a change in scheduled management in 37.1% of cases. The authors conclude that unenhanced abdominal CT improves ED diagnosis accuracy and appropriate management in elderly patients presenting with acute abdominal 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 64-row computed tomography (CT) in the differential diagnosis of acute abdomen in the ED. A total of 181 patients (mean age 58.7 years; range 17-88 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% when these were also included. The authors conclude that CT showed high reliability in the differential diagnosis of surgically treated acute abdomen, although associated conditions can sometimes be missed (moderate 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 > 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).

Right upper quadrant pain with suspected hepatobiliary disease with or without jaundice, with or without known gallbladder calculi, after initial evaluation with ultrasound (if available):

- **Green** - †
- **Yellow** – Cholescintigraphy in patients with suspected acute or chronic cholecystitis and a nondiagnostic or discordant ultrasound
- **Yellow** – MRI abdomen [with MRCP] in patients with suspected acute cholecystitis and a nondiagnostic or discordant ultrasound
- **Yellow** – CT abdomen with or without IV contrast in patients when other intra-abdominal processes are suspected, or when common bile duct obstruction is suspected
- **Yellow** – CT abdomen with and without IV contrast or CT abdomen with IV contrast in patients with suspected acute cholangitis
- **Yellow** – MRI abdomen [with MRCP] in patients with suspected acute cholangitis or gallstone pancreatitis, or in patients at intermediate risk for CBDS
- **Yellow** – CT abdomen without IV contrast in patients with suspected acute cholangitis and allergy to CT contrast, poor or difficult IV access, or poor renal function
- **Orange** - MRI abdomen in patients with a low probability of common duct bile stones (CBDS) and negative ultrasound
- **Orange** - MRI abdomen or CT abdomen as the initial imaging modality, except when ultrasound is not available
- **Red** – PET; PET/CT; MR or CT enterography/enteroclysis; MRA; CTA; WBC scintigraphy

† In patients with suspected gallstone-related disease, the recommended initial test is ultrasonography (Alam et al. [*UMHS*] 2014; *EASL* 2016, high quality evidence/strong recommendation; *NICE* 2014).

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

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Upper abdominal pain with suspected gallstone-related disease:
In patients with suspected gallstone-related disease, cholescintigraphy scanning should be reserved for situations in which the initial sonogram is inconclusive or is discordant with the clinical evaluation (Alam et al. [*UMHS*] 2014).

Cholescintigraphy may have a role if there is specific concern regarding gallbladder or other hepatobiliary disease (Scheirey et al. [*ACR*] 2018).

In patients with upper abdominal pain, hepatobiliary iminodiacetic acid (HIDA) scintigraphy is usually indicated when a gallbladder or biliary cause is suspected (score: 7 – appropriate). However, it may not be the first study ordered. If there is a history of gallstones documented by either ultrasound or CT and the clinical setting indicated acute cholecystitis, then HIDA can play a pivotal role in the management of the patient. (Dillehay et al. [*SNMMI*] 2017).

Computed tomography (CT) and magnetic resonance imaging (MRI) may provide additional diagnostic value, but are not recommended as initial imaging tests for gallstone-related diseases (Alam et al. [*UMHS*] 2014).

CT detection of gallstones is poor when compared to ultrasound, as more than 60% of gallstones are not radiopaque and therefore difficult to detect or undetectable. However, when CT demonstrates acute cholecystitis or choledocholithiasis, no further imaging is needed. In patients with right upper quadrant pain, CT is generally reserved for use when other intra-abdominal processes are suspected (Alam et al. [*UMHS*] 2014).

In case of strong clinical suspicion of gallbladder stone and negative abdominal ultrasound, endoscopic ultrasound or MRI may be performed (*EASL* 2016, low quality evidence/weak recommendation).

Acute cholecystitis:
Ultrasonography should be performed at the initial consultation for all cases for which acute cholecystitis is suspected (Yokoe et al. [*JSHBPS*] 2013, recommendation 1/level A).

In patients with suspected acute cholecystitis, cholescintigraphy scanning should be reserved for situations in which the initial sonogram is inconclusive or is discordant with the clinical evaluation (Alam et al. [*UMHS*] 2014).

HIDA scintigraphy is considered appropriate in patients with suspected acute cholecystitis or acute cystic duct obstruction (score: 9 – appropriate) (Dillehay et al. [*SNMMI*] 2017).

CT or MRI should be considered adjunctive radiographic modalities for diagnosis of acute cholecystitis. If ultrasound confirms the diagnosis then there is no need to obtain these studies. MRI [with MRCP] may be a useful alternative test for acute cholecystitis for patients in whom the US is technically degraded. (Alam et al. [*UMHS*] 2014).

Acute cholangitis:
In patients with suspected acute cholangitis, white blood cells, C-reactive protein and liver biochemical tests should be determined and abdominal ultrasound should be performed as the initial investigations (*EASL* 2016, moderate quality evidence/strong recommendation).

Contrast-enhanced dynamic CT is recommended for making a prompt diagnosis of clinically suspected acute cholangitis. CT is suggested as the most effective imaging method for the diagnosis of etiology and complication of acute cholangitis (recommendation 2, level D) (Kiriyama et al. [*JSHBPS*] 2013, recommendation 2/level D).

MRI/MRCP is suggested for the etiologic diagnosis of acute cholangitis (Kiriyama et al. [*JSHBPS*] 2013, recommendation 2/level D).

Common bile duct stones (CBDS):
Trans-abdominal ultrasound scanning and liver function tests are recommended for patients with suspected CBDS. Normal results do not preclude further investigation if clinical suspicion remains high (Williams et al. 2017, low quality evidence/strong recommendation).

Abdominal ultrasound should be the first imaging method when CBD stones are suspected (*EASL* 2016,

low quality evidence/weak recommendation). Stones in the gallbladder, a dilated CBD, acute cholangitis and hyperbilirubinemia are strong predictors for CBD stones (*EASL* 2016, high quality evidence/strong recommendation).

In patients identified as having an intermediate risk of choledocholithiasis, magnetic resonance cholangiopancreatography (MRCP) or endoscopic ultrasound (EUS) [can] be used to confirm the presence of common bile duct stones (CBDS) (Alam et al. [*UMHS*] 2014; *EASL* 2016, moderate quality evidence/strong recommendation).

MRCP and EUS are both recommended as highly accurate tests for identifying CBDS among patients with an intermediate probability of disease. MRCP predominates in this role, with choice between the two modalities determined by individual suitability, availability of the relevant test, local expertise, and patient acceptability (Williams et al. 2017, moderate quality evidence/strong recommendation).

Consider MRCP if ultrasound has not detected CBDS but the bile duct is dilated, and/or liver function test results are abnormal. Consider EUS if MRCP does not allow a diagnosis to be made (*NICE* 2014).

Chronic cholecystitis:
On the basis of moderate-level evidence demonstrating the utility of cholescintigraphy in the evaluation of chronic cholecystitis, HIDA with CCK is appropriate in patients with abnormal results and may be appropriate in patients with normal ultrasound results (Dillehay et al. [*SNMMI*] 2017).

Cholecystokinin (CCK) cholescintigraphy is presently considered to be a valuable time-proven test (score: 7 – appropriate) for HIDA imaging in chronic acalculous gallbladder disease (CAGBD) (Dillehay et al. [*SNMMI*] 2017).

<u>Clinical/Imaging notes:</u>
Upper abdominal pain with suspected gallstone related disease/biliary colic:

- The 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, very low quality evidence/weak recommendation).
- Ultrasound is useful to evaluate biliary pain. Its accuracy for detecting gallbladder stones is in excess of 95% (*EASL* 2016, high quality evidence/strong recommendation).
- U/S is useful to evaluate for bile duct obstruction with a sensitivity of 55-95% and a specificity of 71-96% (Lalani et al. [*ACR*] 2012).
- The evidence for the accuracy of hepatobiliary iminodiacetic acid (HIDA) in the setting of painful acute biliary obstruction is limited with a sensitivity of 67-93% and a specificity of 64-67% (Dillehay et al. [*SNMMI*] 2017).
- CT is slightly more sensitive (74%-96%) and specific (90%-94%) than ultrasound for the detection of biliary obstruction (Lalani et al. [*ACR*] 2012).
- MRI/MRCP can demonstrate both the site and cause of biliary obstruction, and is the most sensitive noninvasive test for ductal calculi (Lalani et al. [*ACR*] 2012).
- MRCP is useful in identifying CBD stones and delineating pancreatic and biliary tract anatomy. The sensitivity and specificity of MRCP to diagnose biliary obstruction has been reported to be 95% and 97% respectively. Sensitivity was slightly lower at 92% for the detection of biliary stones (Greenberg et al. [*Best Practice in General Surgery Group: University of Toronto*] 2016).

Acute cholecystitis:

- Acute cholecystitis should be suspected in a patient with fever, severe pain located in the right upper abdominal quadrant lasting for several hours… and tenderness on palpation (Murphy's sign) (*EASL* 2016, moderate quality evidence/strong recommendation).
- Ultrasonography shows 50-88% sensitivity and 80-88% specificity for acute cholecystitis (Yokoe et al. [*JSHBPS*] 2013; Alam et al. [*UMHS*] 2014).
- 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; Alam et al. [*UMHS*] 2014).
- The accuracy of HIDA scintigraphy for the detection of acute acalculous cholecystitis is more limited, with the reported sensitivity 67% to 100% and specificity from 58% to 88%, based on 4 studies of critically ill patients (Dillehay et al. [*SNMMI*] 2017).
- With MRI, the summary estimate of sensitivity for acute cholecystitis is 85% with a specificity of 81%, with no significant difference between MRI and U/S (Alam et al. [*UMHS*] 2014).

Acute cholangitis:

- 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 (*EASL* 2016, high quality evidence/ strong recommendation).

Common bile duct stones:

- Patients with jaundice, acute cholangitis or acute pancreatitis should be evaluated for common bile duct stones (*EASL* 2016, high quality evidence/strong recommendation).
- Patients with a high probability for CBDS after ultrasound (CBD stone on US, clinical ascending cholangitis, bilirubin > 4mg/dl, or dilated CBD on U/S with an elevated bilirubin) need further evaluation of the bile duct and generally proceed directly to ERCP or IOC (*ASGE Standards of Practice Committee* 2010).
- Patients at intermediate risk after ultrasound (age over 55, clinical gallstone pancreatitis, dilated CBD on US, or elevated liver enzymes or bilirubin <4mg/dl) generally undergo MRCP or EUS for the identification of CBDS (Williams et al. 2017; *ASGE Standards of Practice Committee* 2010).
- MRCP is a noninvasive method for detecting common bile duct stones with a negative predictive value of 100%. In the context of gallstone pancreatitis, MRCP may be inadequately sensitive to exclude choledocholithiasis, with a sensitivity of 62% and specificity of 98%. (Alam et al. [*UMHS*] 2014).

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

Al-Jiffry et al (2016) conducted a prospective cohort study to develop and validate a clinical scoring system for predicting choledocholithiasis. A total of 155 consecutive patients (mean age 51 years) with symptomatic gallstones, biliary pancreatitis, obstructive jaundice, or cholangitis, who subsequently underwent biochemical testing and U/S, were enrolled. A predictive model was developed with imaging and laboratory data using endoscopic retrograde cholangiopancreatography (ERCP) or intraoperative cholangiography for confirmatory diagnosis. CBD acoustic shadowing on U/S, CBD dilatation on US, alkaline phosphatase of $\geq$ 200 IU, elevated bilirubin levels, alanine transaminase of $\geq$ 220 IU, and male age of $\geq$ 50 years were significantly associated with choledocholithiasis and included in the scoring system. Ninety-six patients (35%) had scores of $\geq$ 8 (high risk) and 88 (91.7%) had a CBD stone. 62 had a score of 4-7 (intermediate risk); these patients underwent MRCP and only underwent ERCP if MRCP was

positive. 43.5% of patients with intermediate risk were found to a CBD stone. Seven patients with a normal CBD via U/S were subsequently found to have CBD stones via MRCP, and 16 with a dilated CBD via U/S had normal MRCP findings. The authors concluded that their grading system was useful for predicting the need for therapeutic ERCP (low level of evidence).

Ginsburg et al (2016) aimed to establish factors affecting total number of imaging studies performed for acute cholecystitis (AC) prior to surgery. The study included subjects with cholecystectomy and pathologic diagnosis of AC, and imaging studies (CT, U/S and/or cholescintigraphy) within 7 days of surgery. There were 219, 339, and 38 subjects in CT, U/S, and cholescintigraphy group, respectively. Prior to surgery, only one study was performed in 21.9% of CT group, 70.2% of U/S group, and 71.1% of cholescintigraphy group ($p < 0.0001$). Compared to the U/S group, the odds of undergoing additional study were 11.8x higher in the CT group and 1.7x higher in the cholescintigraphy group. The authors concluded that patients with AC and CT as the first study are more likely to undergo additional imaging studies prior to surgery, as compared to U/S or cholescintigraphy (low level of evidence).

Abdominal pain with suspected or known acute pancreatitis:

- **Green** - †
- **Yellow** – CT abdomen with IV contrast for severe or atypical abdominal pain and/or when amylase and lipase levels are equivocal
- **Yellow** – CT abdomen with IV contrast after 48 hours to assess the severity of disease, to guide management, or for follow-up
- **Yellow** – CT abdomen with IV contrast when there is a significant deterioration in the patient's clinical condition
- **Yellow** – MRI abdomen with and without IV contrast [with MRCP] for initial evaluation of acute pancreatitis if pain is atypical and/or when amylase and lipase are equivocal
- **Yellow** - MRI abdomen without IV contrast [with MRCP] for initial evaluation of acute pancreatitis in patients who are unable to receive or who refuse IV contrast if pain is atypical and/or when amylase and lipase are equivocal
- **Yellow** – CT abdomen without IV contrast if the patient has impending renal failure, allergy to CT contrast, or poor/difficult IV access after 48 hours, for severe or atypical pain, when amylase and lipase levels are equivocal, or when there is significant deterioration in the patient's clinical condition
- **Orange** – CT abdomen with or without IV contrast within 48 hours in patients with a typical clinical presentation and elevated amylase and lipase
- **Orange** – CT abdomen with and without IV contrast except in patients with a known or suspected cancer or liver disease
- **Red** – PET; PET/CT; MR or CT enterography/enteroclysis; scintigraphy; CTA; MRA

†In patients with a suspected diagnosis of acute pancreatitis ultrasonography should be performed at baseline to evaluate the biliary tract to determine if the patient has gallstones and/or a stone in the common bile duct (Greenberg et al. [*Best Practice in General Surgery Group: University of Toronto*] 2016, high strength of evidence/strong guideline recommendation; Tenner et al. [*ASG*] 2013, strong recommendation/low quality of evidence).

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

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Ultrasound of the abdomen is recommended for the initial evaluation of acute pancreatitis for first time presentation, typical abdominal pain, and increased amylase and lipase with high clinical suspicion of diagnosis within < 48-72 hours after onset of symptoms (Baker et al. [*ACR*] 2013; PLE expert panel consensus opinion).

CT is not indicated in the first 48-72 hours after the onset of symptoms in patients with an unequivocal clinical presentation and appropriately elevated amylase and lipase; it could lead to inappropriate conclusions and does not alter patient management (Baker et al. [*ACR*] 2013).

Routine early CT in acute pancreatitis is 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; (3) there is evidence to suggest that an early (inappropriate) CT may increase the duration of hospital stay, has low yield without direct management implications, does not improve clinical outcomes, and poses risks of contrast allergy and nephrotoxicity (*IAP*/*APA* 2013).

The indication for initial CT assessment in acute pancreatitis can be: (1) diagnostic uncertainty, (2) confirmation of severity based on clinical predictors of severe acute pancreatitis, or (3) failure to respond to conservative treatment or in the setting of clinical deterioration. Optimal timing for initial CT assessment is at least 72-96 h after onset of symptoms (*Working Group International Association of Pancreatology* [*IAP*] / *American Pancreatic Association* [*APA*] *Acute Pancreatitis Guidelines* 2013, GRADE 1C/strong agreement).

MDCT is the primary imaging technique used to determine the extent of disease in patients suspected of having acute pancreatitis. It can demonstrate morphological changes in the pancreas, confirm pancreatitis, and assess the severity of the disease, and is the only imaging modality that has consistently shown clinical value in predicting the severity of the disease as well as clinical outcomes (Baker et al. [*ACR*] 2013).

Follow-up CT or MR 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).

In patients with suspected biliary pancreatitis without cholangitis, endoscopic ultrasound (or MRCP) may [eliminate the need for] ERCP and prevent its risks if no stones are detected (*EASL* 2016, low quality evidence/weak recommendation).

The *American College of Radiology* recommends CT abdomen with IV contrast (8), CT abdomen without IV contrast (7), MRI abdomen without and with IV contrast with MRCP (6), CT abdomen without and with IV contrast (5), MRI abdomen without IV contrast with MRCP (5), and ultrasound abdomen (5) for the evaluation of *acute pancreatitis – initial presentation with atypical signs and symptoms, including equivocal amylase and lipase values (possibly confounded by AKI or chronic kidney disease) and when diagnoses other than pancreatitis may be possible (bowel perforation, bowel ischemia, etc)* (Baker et al. [*ACR*] 2013).

The *American College of Radiology* recommends CT abdomen with IV contrast (9), CT abdomen without and with IV contrast (7), MRI abdomen without and with IV contrast with MRCP (7), CT abdomen without IV contrast (6), MRI abdomen without IV contrast with MRCP (6), and ultrasound abdomen (5) for the evaluation of *acute pancreatitis – continued SIRS, severe clinical scores, leukocytosis, and fever; > 7-21 days after onset of symptoms* (Baker et al. [*ACR*] 2013).

<u>Clinical notes:</u>

- The diagnosis of acute pancreatitis is established by 2 of the 3 criteria: (i) abdominal pain consistent with the disease, (ii) serum amylase and/or lipase > 3 times the upper limit of normal, and/or (iii) characteristic findings on abdominal imaging (Tenner et al. [*ACG*] 2013, strong recommendation/moderate quality of evidence).

<u>Imaging notes:</u>

- Right upper quadrant ultrasonography is the primary imaging modality for suspected acute biliary pancreatitis owing to its low cost, availability and lack of associated radiation exposure

(Greenberg et al. [*Best Practice in General Surgery Group: University of Toronto*] 2016, strong recommendation/low quality of evidence).

- Early CT may be useful to rule out bowel ischemia or intra-abdominal perforations in patients presenting with both acute pancreatitis and acute abdomen (*IAP*/*APA* 2013).
- In patients undergoing CT to assess for local complications of acute pancreatitis, intravenous contrast should be given unless contraindicated (Greenberg et al. [*Best Practice in General Surgery Group: University of Toronto*] 2016, high strength of evidence/strong guideline recommendation).
- 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, GRADE 1C/strong agreement).
- MRI offers similar diagnostic capabilities to MDCT with better depiction of stones and the pancreatico-biliary system, and does not use ionizing radiation. MRI, however, is typically not readily available in the acute setting, is more difficult to perform on acutely ill patients, and has longer acquisition times (Baker et al. [*ACR*] 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, GRADE 1C/strong agreement).

Evidence update (2014-present):

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 cholesystomy (ELC; n = 49) or late laparoscopic cholesystomy (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 the 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 examinations 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).

Cho et al (2017) retrospectively investigated the prognostic usefulness of several existing scoring systems in predicting the severity of acute pancreatitis (AP). A prospectively collected clinical database of consecutive patients with AP was analyzed; Ranson, Acute Physiology and Chronic Health Evaluation (APACHE)-II scores, bedside index for severity in acute pancreatitis (BISAP) scores, and computed tomography severity index (CTSI) of all patients were calculated. SCRP levels were measured at

admission and after 24 hours. Severe AP was defined as persistent organ failure for > 48 hours. Of 161 patients (mean age 62.3 years), 21 (13%) were classified as severe AP, and 3 (1.9%) died. APACHE-II demonstrated the highest accuracy for prediction of severe AP (AUC of 0.78), however, no statistically significant differences were observed between APACHE-II and the other scoring systems, including CRP after 24 hours. The authors conclude that the various scoring systems showed similar predictive accuracy for severity of AP (low level of evidence).

Abdominal pain with suspected chronic pancreatitis:

- **Green** – CT abdomen with and/or without IV contrast for initial diagnosis of chronic pancreatitis
- **Green** – MRI abdomen with and without IV contrast [with MRCP] for initial diagnosis of chronic pancreatitis
- **Yellow** - MRI abdomen without IV contrast [with MRCP] in patients who cannot receive or refuse IV contrast for initial diagnosis of chronic pancreatitis
- **Orange** – Repeat CT or MRI in patients with recurrent pain and known chronic pancreatitis, except in patients with atypical presentation or complications
- **Red** – PET; PET/CT; scintigraphy; MR or CT enterography/enteroclysis; MRA; CTA

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

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
In general, the radiologic and endoscopic evaluation of a patient with suspected chronic pancreatitis should progress from a least invasive to more invasive approach to establish a diagnosis. A CT scan of the pancreas is usually the initial imaging modality of choice (Conwell et al. [*APA*] 2014).

Ultrasound and CT are best for the late findings of chronic pancreatitis, but are limited in the diagnosis of early or mild pancreatitis (conditional recommendation; moderate level of evidence). CT is helpful for the diagnosis of complications of chronic pancreatitis (strong recommendation; moderate level of evidence) and for diagnosis of other conditions that can mimic chronic pancreatitis (conditional recommendation; low level of evidence) (Conwell et al. [*APA*] 2014).

Compared to ultrasound and CT, MRI is a more sensitive imaging tool for the diagnosis of chronic pancreatitis (Conwell et al. [*APA*] 2014, conditional recommendation/moderate level of evidence).

Clinical 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 develop pancreatic adenocarcinoma, which is generally advanced at the time of diagnosis (Conwell et al. [*APA*] 2014).

Imaging notes:

- Intraductal pancreatic calcifications are the most specific and reliable sonographic and CT signs of chronic pancreatitis (Conwell et al. [*APA*] 2014, strong recommendation/moderate level of evidence).
- Ductal abnormalities are very specific and reliable MRI signs of chronic pancreatitis (*American Pancreatic Association* (Conwell et al. [*APA*] 2014, conditional recommendation/low level of evidence).

- Signal intensity changes in the pancreas, seen on MRI, may precede ductal abnormalities and suggest early chronic pancreatitis (Conwell et al. [*APA*] 2014, conditional recommendation/low level of evidence).
- Patients with equivocal or mild CT imaging findings or refractory symptoms may be referred to specialized centers for additional studies such as magnetic resonance imaging (MRI)/secretin-enhanced magnetic resonance cholangiopancreatography (sMRCP) or endoscopic procedures such as endoscopic ultrasound, endoscopic retrograde cholangiopancreatography, and pancreas function testing (Conwell et al. [*APA*] 2014, conditional recommendation/low level of evidence).
- 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. The authors state that clinicians should attempt to classify patients into one of the six etiologic groups according to the TIGARO classification system. 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).

Acute right lower quadrant pain with suspected appendicitis:

- **Green** – CT abdomen and pelvis with IV contrast
- **Yellow** – CT abdomen and pelvis without IV contrast for patients with allergy to CT contrast, poor or difficult IV access, or poor renal function
- **Yellow** – MRI abdomen and/or pelvis with and without IV contrast
- **Yellow** – MRI abdomen and/or pelvis without IV contrast
- **Orange** – CT abdomen and pelvis with and without IV contrast except in patients with a known or suspected cancer or liver disease
- **Red** – PET; PET/CT; scintigraphy; MRCP; MR or CT enterography/enteroclysis; MRA; CTA

Level of Evidence: CT: high; MRI: moderate

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
In patients with suspected acute appendicitis, use clinical findings (i.e., signs and symptoms) 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) (Level B recommendation). Not every patient with possible appendicitis needs abdominal imaging (Howell et al. [*ACEP*] 2010).

In adult patients undergoing a CT scan for suspected appendicitis, perform abdominal and pelvic CT scan with or without contrast (intravenous [IV], oral, or rectal). The addition of IV and oral contrast may increase the sensitivity of the CT scan for the diagnosis of appendicitis (Howell et al. [*ACEP*] 2010, Level B recommendation).

Recent studies have demonstrated that MRI is sufficiently accurate to diagnose appendicitis and diverticulitis. The advantage of MRI over computed tomography 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 that the assessment of MRI images needs specific training (Gans et al. 2015).

In most instances, CT would be preferred over MRI because of availability, timeliness, patient compatibility, bowel motion and patient motion on MRI (PLE expert panel consensus opinion).

In patients with *right lower quadrant pain, fever, leukocytosis, suspected appendicitis, initial imaging*, the *American College of Radiology* recommends CT abdomen and pelvis with IV contrast (*usually appropriate*). Additionally, the *ACR* recommends that CT abdomen and pelvis without IV contrast, US abdomen, MRI abdomen and pelvis without and with IV contrast, US pelvis, or MRI abdomen and pelvis without IV contrast *may be appropriate* (Garcia et al. [*ACR*] 2018).

In patients with *right lower quadrant pain, fever, leukocytosis, possible appendicitis, atypical presentation, initial imaging*, the *American College of Radiology* recommends CT abdomen and pelvis with IV contrast (*usually appropriate*). Additionally, the *ACR* recommends that CT abdomen and pelvis

without IV contrast, US abdomen, US pelvis, MRI abdomen and pelvis without and with IV contrast, or MRI abdomen and pelvis without IV contrast *may be appropriate* (Garcia et al. [*ACR*] 2018).

Clinical notes:

- The "classic" clinical presentation of patients with appendicitis consists of periumbilical abdominal pain migrating to the RLQ, loss of appetite, nausea or vomiting, with fever, and leukocytosis, and 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).

Imaging notes:

- Diagnostic performance of U/S in preoperative evaluation of patients presenting with typical signs and symptoms of appendicitis vary widely (Garcia et al. [*ACR*] 2018).
- In adult populations, ultrasound had lower sensitivity (0.83) and specificity (0.89) than CT and MRI, and produced more non-diagnostic scans (Dahabreh et al. [*AHRQ*] 2015).
- [For the diagnosis of acute appendicitis] computed tomography (CT) had high sensitivity (summary estimates ranging from 0.96 to 1) and specificity (ranging from 0.91 to 0.99) in all populations of interest to this report (Dahabreh et al. [*AHRQ*] 2015).
- CECT without enteral contrast sensitivities range from 90% to 100%, and specificities range from 94.8% to 100% compared to CECT with enteral contrast (oral or rectal) for which sensitivities range from 90.4% to 100% and specificities that range from 97.67% to 100% (Garcia et al. [*ACR*] 2018).
- Abdominal CT has been shown to have an excellent interobserver agreement for specific urgent diagnoses, such as appendicitis (kappa value of 0.84) (Yaghmai et al. [*ACR*] 2012).
- 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 also help identify conditions other than acute appendicitis (e.g., diverticulitis, inflammatory bowel disease, cancer) (Howell et al. [*ACEP*] 2010).
- Increased sensitivity of newer-generation multislice CT scanners may improve diagnostic accuracy, obviating the need for contrast (Howell et al. [*ACEP*] 2010).
- Multiplanar reformations have been shown to improve diagnostic confidence in patients with abdominal pain (Yaghmai et al. [*ACR*] 2012).
- Dose-reduction strategies in CT should be employed following the *As Low As Reasonably Achievable* principle (e.g., Mayo-Smith et al. 2014).
- MRI had high sensitivity (ranging from 0.91 to 1) but appeared to have variable specificity (ranging from 0.86 to 1), mainly due to the smaller number of available studies, which focused on its use for pregnant women (Dahabreh et al. [*AHRQ*] 2015).

Evidence update (2014-present):

Yoon et al., 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).

Kabir et al, in a 2017 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).

Andersson et al (2017) conducted a prospective interventional study and nested randomized trial to analyze the impact of implementing a risk stratification algorithm based on the Appendicitis Inflammatory Response (AIR) score and compare routine imaging with selective imaging after clinical reassessment. The baseline period included 1,152 patients and intervention period 2,639 patients of whom 1,068 intermediate-risk patients were randomized to either routine imaging (n = 485; mean age 27.6) or selective imaging (n = 1,383; mean age 27.5). In low-risk patients, use of the AIR score-based algorithm resulted in less imaging (19.2 vs. 34.5%; P < 0.001), fewer admissions (29.5 vs. 42.8%; P < 0.001), and fewer negative explorations (1.6 vs. 3.2%; P = 0.030) and operations for non-perforated appendicitis (6.8 vs. 9.7%; P = 0.034). Intermediate-risk patients randomized to the imaging and observation groups had the same proportion of negative appendectomies (6.4 vs. 6.7%, respectively; P = 0.884), number of admissions, number of perforations and length of hospital stay, but routine imaging was associated with increased proportion of patients treated for appendicitis (53.4 vs. 46.3%; P = 0.020). The authors conclude that AIR score-based risk classification can safely reduce the use of diagnostic imaging and hospital admissions in patients with suspicion of appendicitis (moderate level of evidence).

Hernandez et al (2017) aimed to validate an anatomic severity grading system (proposed by the Association for the Surgery of Trauma - AAST) in patients with appendicitis and determine if cross-sectional imaging correlates with disease severity at operation. Patients undergoing treatment for acute appendicitis over a two-year period were identified, with 344 patients (mean age of 39.3 years) included. All patients had cross-sectional imaging, and 299 (86.9%) underwent appendectomy (85% laparoscopic). Analyses comparing AAST grade and cross-sectional imaging demonstrated no difference. The authors conclude that the AAST grading system is valid in this patient population, and that the AAST emergency general surgery grade determined by preoperative imaging strongly correlated to operative findings (moderate level of evidence).

Lietzen et al (2016) attempted to determine 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; mean age 36.8) were compared with complicated acute appendicitis patients (n = 337; mean age 37.6). Subgroup analyses were performed between uncomplicated acute appendicitis and an appendicolith appendicitis (CA1; n = 256; mean age 36.4), and between uncomplicated acute appendicitis and perforation and/or abscess (CA2; n = 78; mean age 41.7). 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 (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 CT 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. The sensitivity and the specificity of CT were 96.7% (95% confidence interval, 95.1–97.8) and 95.9% (95% confidence interval, 93.2–97.5), respectively. The rate of false CT diagnosis was 4.2% for consultant radiologists and 2.2% for resident radiologists (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).

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 clinically suspected appendicitis reduced rate of negative appendectomies and surgical complications (low level of evidence).

Boonstra et al (2015) evaluated the implementation of a Dutch Guideline stating that, in every patient with clinically suspected appendicitis, an ultrasonography or CT scan is advised to confirm the diagnosis before surgery. The authors selected all consecutive patients with acute appendicitis in their hospital over a one year period before guideline implementation (n = 228; mean age 32.8; imaging performed in 43%), and over a one year period after guideline implementation (n = 238; mean age 33; imaging performed in 99%). A decrease in patients with negative appendectomy was seen from 19% before guidelines to 5% after guidelines. Financial analysis also showed reduction in costs from before guideline implementation to after. The authors conclude that the increased use of preoperative imaging in patients with suspected acute appendicitis resulted in a cost-effective way to decrease the number of patients with negative appendectomies (low level of evidence).

Hendricks et al (2015) evaluated the effect of the implementation of the Dutch Guideline suggesting that, with the standardized use of imaging (U/S or CT), the percentage of negative appendectomies can

be reduced. A total of 1,102 patients were included, spanning a period of 5.5 years. 35.2% of patients underwent U/S and 16.2% underwent CT; 54.8% of patients had no U/S or CT performed (n = 580; median age of 23 years) prior to implementation of the guideline, and 84.5%, 32.2%, and 9.0% (n = 522; median age of 27 years) after implementation of the guideline. The percentage of negative appendectomies decreased from 18% prior to guideline implementation to 9.2% after implementation ($p < 0.001$). The percentage of patients with appendicitis in which the appendix perforated remained similar (20.9% before vs. 19.2% after). The authors conclude that their data show a significant decline in negative appendectomies without an increase of perforation rate after introduction of the new diagnostic guideline for acute appendicitis (low level of evidence).

Acute left lower quadrant pain with suspected diverticulitis:

- **Green** – CT abdomen and pelvis with IV contrast
- **Yellow** – CT abdomen and pelvis without IV contrast for patients with allergy to CT contrast, poor or difficult IV access, or poor renal function
- **Yellow** – MRI abdomen and/or pelvis with and without IV contrast
- **Yellow** - MRI abdomen and/or pelvis without IV contrast
- **Orange** – CT abdomen and pelvis with and without IV contrast, except in patients with a known or suspected cancer or liver disease
- **Red** – PET; PET/CT; scintigraphy; MRCP; MR or CT enterography/enteroclysis; MRA; CTA

Level of Evidence: CT: moderate; MRI: low

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
CT is now nearly universally used as the imaging examination of choice for evaluating patients with suspected descending or sigmoid colon diverticulitis because of its high sensitivity and specificity, and its ability to demonstrate other causes of left lower quadrant pain that mimic diverticulitis (McNamara et al. [*ACR*] 2014).

The role of magnetic resonance imaging (MRI) has not been adequately evaluated, but preliminary data suggest that it may have diagnostic potential in patients with suspected diverticulitis (McNamara et al. [*ACR*] 2014).

Recent studies have demonstrated that MRI is sufficiently accurate to diagnose appendicitis and diverticulitis. The advantage of MRI over computed tomography 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 that the assessment of MRI images needs specific training (Gans et al. 2015).

In most instances, CT would be preferred over MRI because of availability, timeliness, patient compatibility, bowel motion and patient motion on MRI (PLE expert panel consensus opinion).

Nuclear medicine imaging has no role in the evaluation of left lower quadrant pain (McNamara et al. [*ACR*] 2014).

The *American College of Radiology* recommends CT abdomen and pelvis with IV contrast (9), CT abdomen and pelvis without IV contrast (6), CT abdomen and pelvis without and with IV contrast (5), MRI abdomen and pelvis without IV contrast (5), and MRI abdomen and pelvis without and with IV contrast (5) for the evaluation of *left lower quadrant pain, suspected diverticulitis – typical clinical presentation for diverticulitis, suspected complications or atypical presentations* (McNamara et al. [*ACR*] 2014).

Clinical notes:

- Patients with diverticulitis may require surgery or interventional radiology procedures because of associated complications, including abscesses, fistulas, obstruction, or perforation. As a

result, there has been a trend toward greater use of medical imaging to confirm the diagnosis of diverticulitis, evaluate the extent of disease and detect complications before deciding on appropriate treatment (McNamara et al. [*ACR*] 2014).

Imaging notes:

- Abdominal radiography is of limited value in evaluating diverticulitis unless complications such as free perforation or obstruction are suspected (McNamara et al. [*ACR*] 2014).
- CT is widely available, reproducible, and has a reported overall accuracy of 99%. CT has a major role for depicting extracolonic disease extent; this assessment is rarely possible with a contrast enema. By revealing the presence and extent of abscess formation, CT facilitates selection of patients for medical rather than surgical therapy, and determination if hospitalization is required (McNamara et al. [*ACR*] 2014).
- Abdominal CT has been shown to have an excellent interobserver agreement for specific urgent diagnoses, such as diverticulitis (kappa value of 0.90) (Yaghmai et al. [*ACR*] 2012).
- Multiplanar reformations have been shown to improve diagnostic confidence in patients with abdominal pain (Yaghmai et al. [*ACR*] 2012).
- Dose-reduction strategies in CT should be employed following the *As Low As Reasonably Achievable* principle (e.g., Mayo-Smith et al. 2014).
- The role of MRI in the setting of left lower quadrant pain has been evaluated, and preliminary data suggest that it may have diagnostic potential in patients with suspected diverticulitis, with reported sensitivity of 86%–94% and specificity of 88%–92% (McNamara et al. [*ACR*] 2014).

Evidence update (2013-present):

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 presence of an abscess). Of the 623 patients included in the AVOD study, 602 CT scans were obtained and 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).

Kiewiet et al (2014) aimed to externally validate and compare diagnostic accuracy of two predictive tools in diagnosing acute diverticulitis: the emergency department (ED) triad and the clinical scoring (CS) tool. The ED triad cohort used prospective inclusion of patients with acute abdominal pain for > 2 hours and less than 5 days, warranting additional radiological examination. Diverticulitis was present in 80 patients (mean age 58; 56% female) and absent in 46 patients (mean age 54; 67% female). The CS tool cohort used retrospective inclusion of patients admitted to the hospital with acute abdominal pain and clinical suspicion of acute diverticulitis based on the CT application form. Diverticulitis was present in 124 patients (mean age 59) and absent in 163 patients (mean age 53). Both tools were then validated in a third independent cohort, which used prospective inclusion of patients with acute abdominal pain for < 7 days. Diverticulitis was present in 58 patients (mean age 62) and absent in 45 patients (mean age 67). Performance was compared by calculating positive predictive values of the ED triad in the validation cohorts. The positive predictive value of the ED triad was 97% for the ED cohort, 81% for the CS tool

cohort and 100% for the independent cohort. The positive predictive value of the CS tool was 92% for the ED cohort, 89% for the CS tool cohort and 89% for the independent cohort. The authors concluded that the ED triad and CS tool have significant predictive value in external cohorts of patients suspected of diverticulitis. These tools can be used to select patients in whom additional imaging to diagnose acute diverticulitis may be omitted (moderate level of evidence).

Fung et al (2015) retrospectively validated a CT grading system for acute complicated diverticulitis in the prediction of need for operative or percutaneous intervention. Hospital and radiology records were reviewed to identify patients with acute complicated diverticulitis confirmed by CT. A consultant gastrointestinal radiologist, blinded to clinical outcomes, assigned a score according to the CT grading system. Of the 1,060 patients (median age 59 years), 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 the 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 nausea, obstipation, vomiting, and/or distention with suspected bowel obstruction:

- **Green** – CT abdomen and pelvis with IV contrast
- **Yellow** – CT abdomen and pelvis without IV contrast for patients with allergy to CT contrast, poor or difficult IV access, or poor renal function
- **Yellow** – MRI abdomen and/or pelvis with and without IV contrast
- **Yellow** – MRI abdomen and/or pelvis without IV contrast if the patient is unable to receive or refuses IV contrast
- **Yellow** – CT or MR enterography/enteroclysis for intermittent, recurrent or low-grade small bowel obstruction (SBO)
- **Orange** – CT/MR enteroclysis or CT/MR enterography in the acute setting
- **Orange** – CT abdomen and pelvis with and without IV contrast, except in patients with a known or suspected cancer or liver disease
- **Red** – PET; PET/CT; scintigraphy; MRCP; MRA; CTA

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

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
CT scan of abdomen and pelvis should be considered in all patients with small bowel obstruction because it can provide incremental information over plain films in differentiating grade, severity, and etiology of small bowel obstructions that may lead to changes in management (Maung et al. [*EAST*] 2012, Level 1 recommendation).

Magnetic resonance imaging (MRI) and ultrasound are potential alternatives to computed tomography [for imaging small bowel obstruction] but may have several logistical limitations (Maung et al. [*EAST*] 2012, Level 3 recommendation).

Diagnostic imaging for colonic volvulus is initially based on plain abdominal radiographs and often includes confirmatory imaging with a contrast enema or CT imaging (Vogel et al. [*ASCRS*] 2016, strong recommendation/based on low- or very-low-quality evidence).

CT scan should 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).

Initial evaluation [of acute colonic pseudo-obstruction (ACPO)] should include a focused history and physical examination, complete blood count, serum electrolytes, renal function assessment, and diagnostic imaging (strong recommendation, based on low- or very-low-quality evidence). Abdominal CT or water-soluble contrast enema can reliably distinguish ACPO from a mechanical large-bowel obstruction (Vogel et al. [*ASCRS*] 2016).

The *American College of Radiology* recommends CT abdomen and pelvis with IV contrast (9), CT abdomen and pelvis without IV contrast (7), MRI abdomen and pelvis without and with IV contrast (6),

and x-ray abdomen and pelvis (5) for the evaluation of *suspected small-bowel obstruction – suspected high-grade small-bowel obstruction (SBO), based on clinical evaluation or initial radiography (if performed)* (Katz et al. [*ACR*] 2013).

The *American College of Radiology* recommends CT abdomen and pelvis with IV contrast (8), CT enteroclysis (8), MR enteroclysis (8), x-ray small bowel enteroclysis (7), CT abdomen and pelvis without IV contrast (6), CT enterography (5), MR enterography (5), and x-ray small bowel follow-through (5) for the evaluation of *suspected small-bowel obstruction – suspected intermittent or low-grade SBO* (Katz et al. [*ACR*] 2013).

Imaging notes:

- The overall sensitivity of abdominal radiographs for the detection of small bowel obstruction ranges from 59% to 93% but is dependent on the radiologist'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, Level 2 recommendation).
- Abdominal CT has been shown to have an excellent interobserver agreement for specific urgent diagnoses, such as bowel obstruction (kappa value of 0.81) (Yaghmai et al. [*ACR*] 2012).
- CT scans have been shown in Class II and III studies to be superior to plain film radiography in the overall diagnosis of small bowel obstruction. They can also provide additional information that alters patient management. CT scans have been shown to be 83% to 94% accurate at diagnosing obstruction (Maung et al. [*EAST*] 2012).
- CT scans can determine not only the level of obstruction (93%) but also the cause (80%-91%) in most patients. There are also Class II data to suggest that CT is 85% to 100% sensitive in detection of bowel ischemia (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).
- 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, Level 3 recommendation).
- 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., in a 2013 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 X-ray 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 (U/S) was determined to be superior to all other imaging modalities, with a +LR of 14.1 (95% CI = 3.57 to 55.66) and a negative likelihood ratio (–LR) of 0.13 (95% CI = 0.08 to 0.20) for formal scans and a +LR of 9.55 (95% CI = 2.16 to 42.21) and a –LR of 0.04 (95% CI = 0.01 to 0.13) for beside scans (moderate level of evidence).

Scrima et al (2017) assessed the value of a large panel of clinical and MDCT variables in patients with suspected SBO for predicting urgent surgical intervention (< 72 hours), bowel ischemia, and bowel resection. MDCT studies performed at admission for 179 nonconsecutive adults (mean age 55.8 years) with suspected SBO were retrospectively reviewed by three radiologists. Each radiologist also scored the overall likelihood of each main outcome measure using a 5-point scale. Among all 179 patients, a total of 56 (31.3%) underwent surgical intervention within 27 hours, 10 (5.6) had ischemia at surgery, and nine (5%) required small-bowel resection. On univariate analysis, multiple CT findings were highly significant ($p < 0.01$) for predicting the main surgical outcomes, including degree of obstruction, 5-point radiology likelihood scores, and the presence of a transition point, closed loop, and mesenteric congestion. None of the objective clinical or laboratory variables reached this level of significance. The authors conclude that a number of findings on abdominal MDCT are associated with the need for surgery and other important surgical outcomes in patients with suspected SBO, and that overall radiologist impression of need for surgical intervention was a better predictor than any clinical or laboratory parameter (low level of evidence).

Abdominal pain with distention, diarrhea, nausea, and/or vomiting with suspected inflammatory bowel disease†:

- **Green** – MRI abdomen and/or pelvis or MR enterography (MRE) with and without IV contrast
- **Green** – CT or CT enterography with IV contrast
- **Yellow** – MRI abdomen and/or pelvis or MR enterography without IV contrast for patients with allergy to MRI contrast, poor or difficult IV access, or who refuse IV contrast
- **Yellow** - CT/CT enterography without IV contrast for patients with allergy to CT contrast, poor or difficult IV access, or poor renal function, and MRI/MRE is not available
- **Orange** – CT enteroclysis or MR enteroclysis, except in patients with more indolent or chronic presentations
- **Orange** – WBC scintigraphy; PET or PET/CT, except in patients with more chronic presentations, when colonoscopy is incomplete, or when other diagnostic modalities are negative
- **Orange** – CT abdomen and pelvis with and without IV contrast, except in patients with a known or suspected cancer or liver disease
- **Red** – Cholescintigraphy; MRA; CTA

† This scenario refers to the management of patients with suspected inflammatory bowel disease rather than to the management of patients with known or established Crohn's disease or ulcerative colitis.

Level of Evidence: CT (for inflammatory bowel disease): high

Notes concerning applicability and/or patient preferences:
In the acute setting, CT enteroclysis and MR enteroclysis has significant patient tolerance issues and has a higher risk profile (i.e., related to placement of a nasoduodenal tube and active instillation of contrast) (Kim et al. [*ACR*] 2014*).

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 imaging the small bowel, MRI is the preferred technique where available. MRI technique is ideally suited to the Crohn's disease population given their age demographic and need for repeat imaging (Mowat et al. [*BSG*] 2011).

CT imaging of the bowel (either CT enteroclysis or CT enterography) provides similar information to MRI [in the assessment of IBD], although tissue characterization capability is less. It is traditionally the 'gold standard' for the detection of extraluminal complications, notably abscess formation (Mowat et al. [*BSG*] 2011).

Regarding intestinal complications [with Crohn's disease], use computed tomography (CT) and/or magnetic resonance imaging (MRI) to check for the presence and the severity of perianal abscesses, anal fistulas, and intra-abdominal abscesses (Ueno et al. 2013).

For patients presenting for evaluation of indolent abdominal pain and more chronic abdominal symptoms and with suspected CD, CT enterography or CT enteroclysis is preferable. CT enterography

and CT enteroclysis each have shown increased sensitivity for subtle CD changes in comparison to standard CT (Kim et al. [*ACR*] 2014*).

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).

Technetium-99m labelling of white blood cells remain a widely acceptable scintigraphic method for the evaluation of disease extension and severity. Positron emission tomography alone or with CT using fluorine-18 fluorodeoxyglucose appears to be a promising method of measuring inflammation in patients with IBD. These techniques might be considered when colonoscopy is not completed successfully or other imaging modalities are negative (Mowat et al., *BSG* 2011). *The PLE expert panel noted that WBC scans and PET were generally not used for the evaluation of acute abdominal pain* (PLE expert panel consensus opinion).

The *American College of Radiology* recommends CT abdomen and pelvis with IV contrast (8), CT enterography (8), MR enterography (6), MRI abdomen and pelvis without and with IV contrast (5), x-ray abdomen (5), CT abdomen and pelvis without IV contrast (5), ultrasound abdomen and pelvis (5) and MR/CT enteroclysis (3) for the evaluation of *Crohn disease – adult; acute initial presentation; fever, severe abdominal pain, vomiting, leukocytosis; suspected Crohn disease* (Kim et al. [*ACR*] 2014*).

The *American College of Radiology* recommends CT enterography (9), MR enterography (9), CT abdomen and pelvis with IV contrast (6), CT enteroclysis (6), MRI abdomen and pelvis without and with IV contrast (routine) (6), CT abdomen and pelvis without IV contrast (5), MR enteroclysis (5), x-ray small-bowel follow-through (5), and ultrasound abdomen and pelvis (5) for the evaluation of *Crohn disease – adult; nonacute or indolent initial presentation; mild to moderate abdominal pain or cramping; suspected Crohn disease* (Kim et al. [*ACR*] 2014*).

* The *ACR* guideline by Kim et al (2014) did not pass the AGREE II rigor of development scaled domain score cutoff. It was included, however, because of its direct relevance to this clinical scenario.

<u>Imaging notes:</u>

- Computed tomography enterography (CTE) is sensitive for the detection of small bowel disease in patients with Crohn's disease and is comparable to magnetic resonance enterography (MRE) (Lichtenstein et al. [*ACG*] 2018, summary statement).
- CT enterography/enteroclysis has a sensitivity for CD of 75-90% and a specificity of > 90% compared to endoscopy (Kim et al. [*ACR*] 2014).
- The performance of MR enterography for CD is very good and is similar to CT enterography. The sensitivity and specificity are 77%–82% and 80%–100%, respectively for active inflammation and complications. Overall, MR is more prone to respiratory and bowel-motion artifact despite the use of glucagon leading to suboptimal examinations and more difficult interpretations (Kim et al. [*ACR*] 2014).
- Tc-99m HMPAO white-cell-labeled scanning has a high sensitivity for IBD (91-98%) (Yaghmai et al. [*ACR*] 2012).
- Ultrasound is the first-line test for gallstones and kidney stones, which should not be forgotten as complications of Crohn's disease. In expert hands, it has a high sensitivity for detecting disease, particularly in the terminal ileum. However, such expertise is not widely available (Mowat et al. [*BSG*] 2011).

- 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, summary statement).
- 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 general, attempts should be made to minimize exposure to ionizing radiation (Mowat et al. [*BSG*] 2011).

Evidence update (no date limit):
Kopylov et al., in a 2017 systematic review and meta-analysis, compared the diagnostic yield (DY) 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 DY 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 DY for detection of small bowel CD (low level of evidence).

Ahmed et al., in a 2016 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).

Puylaert et al., in a 2015 meta-analysis of 19 studies, assessed the accuracy of CT, MRI, U/S and scintigraphy for the grading of Crohn's disease. The authors found that CT and MRI showed comparable high accurate grading estimates (86% and 84% respectively) in the per-patient analysis. Results for U/S and scintigraphy were inconsistent and limited with reported per-patient accuracies of 44% and 40% (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; 74% female) 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. The sensitivity and specificity of MRE for detection of small bowel CD was 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).

Wu et al (2013) evaluated the overall diagnostic accuracy of MRI in assessing the activity of Crohn's disease (CD) in the small bowel. Two reviewers searched electronic databases (over a 10 year period) to identify 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).

Abdominal pain with suspected mesenteric ischemia/infarct, or ischemic colitis:

- **Green** – CTA for acute or chronic mesenteric ischemia
- **Green** – CT abdomen and pelvis with IV [and oral] contrast for ischemic colitis
- **Yellow** – CT abdomen and pelvis with and without IV contrast for acute or chronic mesenteric ischemia if CTA expertise is not available
- **Yellow** – CT abdomen and pelvis with IV contrast with CTA to supplement recent CT without IV contrast for acute or chronic mesenteric ischemia
- **Yellow** – MRI abdomen and pelvis with and without IV contrast with MRA for acute or chronic mesenteric ischemia in patients with a moderate or severe allergy to iodinated (CT) contrast
- **Orange** – CTA for ischemic colitis, except when there is suspected involvement of the right side of the colon (e.g., suggestive of superior mesenteric artery occlusion)
- **Orange** – CT abdomen and pelvis without IV contrast, except in patients who cannot undergo contrast-enhanced CT or MRI
- **Red** – scintigraphy; PET; PET/CT; MRCP; MR or CT enterography/enteroclysis

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

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
For suspected acute mesenteric ischemia (AMI), multidetector computerized tomography scanning (MDCT) with intravenous contrast should be performed immediately (Tilsed et al. [*ESTES*] 2016, level of Evidence: III).

For suspected AMI, 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).

For suspected isolated right colon ischemia (IRCI) or… AMI, multiphasic CTA should be performed (Brandt et al. [*ACG*] 2015, strong recommendation/moderate level of evidence).

For suspected AMI in patients with elevated creatinine values, CTA might be considered, accepting the risk of contrast induced renal failure, to save life (Björck et al. [*ESVS*] 2017, C level of evidence).

CTA of the abdomen and pelvis is a fast, accurate, and noninvasive diagnostic tool for evaluating the bowel and assessing intestinal vasculature and should be the first-step imaging approach in patients with acute bowel ischemia (Ginsburg et al. [*ACR*] 2018).

In patients with *suspected acute mesenteric ischemia, initial imaging*, the *American College of Radiology* recommends CTA abdomen and pelvis with IV contrast (*usually appropriate*). Additionally, the *ACR* recommends that CT abdomen and pelvis with IV contrast, arteriography abdomen, MRA abdomen and pelvis without and with IV contrast, radiography abdomen, or US duplex Doppler abdomen *may be appropriate* (Ginsburg et al. [*ACR*] 2018).

For suspected colonic ischemia (CI), CT with intravenous and oral contrast should be the first imaging modality of choice for patients … to assess the distribution and phase of colitis [mucosal ulceration] (Brandt et al. [*ACG*] 2015, strong recommendation/moderate level of evidence).

For a moderate to high suspicion of CMI, CTA is recommended to map the occlusive disease, and to detect or exclude other intra-abdominal pathology (Björck et al. [*ESVS*] 2017, C level of evidence).

For suspected CMI, MRA may be considered an alternative to CTA, although 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, C level of evidence).

In patients with *suspected chronic mesenteric ischemia, initial imaging*, the *American College of Radiology* recommends CTA abdomen and pelvis with IV contrast or MRA abdomen and pelvis without and with IV contrast (*usually appropriate*). Additionally, the *ACR* recommends that arteriography abdomen, CT abdomen and pelvis with IV contrast, MRA abdomen and pelvis without IV contrast, or US duplex Doppler abdomen *may be appropriate* (Ginsburg et al. [*ACR*] 2018).

In patients with intestinal ischemia, CT can detect vessel thrombosis, intramural or portal gas, and lack of bowel wall enhancement. CT angiography is the preferred modality when mesenteric ischemia is suspected; however, 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).

<u>Clinical/Imaging notes</u>

Acute mesenteric ischemia:

- Acute mesenteric ischemia should be suspected in patients with acute abdominal pain of sudden onset in whom there is no clear diagnosis, particularly when the pain is disproportionate to the physical examination findings and in the elderly with a history of cardiovascular comorbidities (Tilsed et al. [*ESTES*] 2016, level of Evidence: III).
- The sudden onset of severe pain with spontaneous emptying of the bowel (vomiting and diarrhea) 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).
- 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).
- Patients with AMI secondary to venous thrombosis (VAMI), while occasionally idiopathic, most commonly report a history of venous thrombosis or pulmonary embolism, of a hypercoagulability state such as Leiden factor V mutation (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, strong recommendation/moderate level of evidence).
- MDCT should be performed with and without intravenous contrast and with arterial and venous phase imaging in the contrast-enhanced segment of the examination (triphasic protocol). Arterial and venous phase images should be performed with a slice thickness of 1 mm or thinner, and with sagittal and coronal reformations (Björck et al. [*ESVS*] 2017).Biphasic multidetector computed tomography (MDCT) is the most sensitive and specific tool for the detection of acute mesenteric ischemia with a meta-analysis of six primary studies on 619 cases

reporting a pooled sensitivity of 93.3 % (95 % confidence interval 82.8, 97.6 %) and a pooled specificity of 95.9 % (95 % confidence interval 91.2, 98.2 %) (Tilsed et al. [*ESTES*] 2016).
- In the evaluation of acute mesenteric ischemia, the use of oral contrast will add significant delay to the MDCT 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).

Colonic ischemia:

- 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 within 24 h of bright red or maroon blood or bloody diarrhea (Brandt et al. [*ACG*] 2015, strong recommendation/very low level of evidence).
- 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).
- A diagnosis of non-isolated right colon ischemia (non-IRCI) should be considered when patients present with hematochezia (Brandt et al. [*ACG*] 2015).
- In a patient in whom the presentation of CI may be a heralding sign of AMI (e.g., IRCI, severe pain without bleeding, atrial fibrillation), and the 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).

Chronic mesenteric ischemia:

- 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, C level of evidence).

Ischemic colitis:

- In the evaluation of ischemic colitis, oral contrast should be used and is useful to evaluate for mucosal ulceration (PLE expert panel consensus opinion).

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

Guideline exclusions:

- Abdominal trauma,
- Chronic liver disease,
- Renal disease, including renal calculus,
- Uterine and ovarian disease, including pelvic inflammatory disease,
- Prostate cancer and prostatitis,
- Painless jaundice,
- GI bleeding,
- Constipation,
- Irritable bowel syndrome,
- Inguinal and hiatal hernias,
- Abdominal pain following abdominal aortic aneurysm repair,
- Staging of primary abdominal cancers,
- Evaluation for abdominal metastatic disease,
- Pregnant patients, and
- Pediatric patients.

AUC Revision History:

Revision Date:	New AUC Clinical Scenario(s):	Posting Date:	Approved By:
02/05/2019	n/a	02/13/2019	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/about_us/cdi_quality_institute/provider_led_entity/**