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Quadrant Specific Diagnostic Evaluation of Acute Abdomen

Behar Toçilla

Department of Advanced Imaging
American Hospital of Tirana, Albania

Abstract

Facing with a patient with acute abdominal pain is really challenging not only because these cases are so common, but also the presentation of patient conditions range from benign to life-threatening. So it is very important to note a careful history, to make a good physical examination, to require the appropriate laboratory testing and to choose the proper diagnostic imaging in order to create a differential diagnosis. The sensitivity and specificity of diagnostic imaging procedures is different in different diagnosis. The American College of Radiology has developed clinical guidelines, based on the location of the abdominal pain to choose the most appropriate imaging study. This paper will be focused on diagnostic approach in quadrant specific abdominal pain. Ultrasonography is the initial imaging test of choice for patients presenting with right upper quadrant pain. The same for children, gynecological pathologies and pregnant patients. While magnetic resonance imaging that avoids ionizing radiation is especially useful in pregnant patients. Computed tomography (CT) is recommended for evaluating almost all other suspected diagnosis. Conventional radiography has limited diagnostic value in the assessment of most patients with abdominal pain. Using CT (computed tomography) scans should concern doctors about patient exposure to ionizing radiation.

Keywords: Acute abdomen, CT, diagnostic approach.

Address for correspondence: Behar Toçilla, American Hospital of Tirana, Albania. Email: behartocilla@yahoo.it

INTRODUCTION

The term *acute abdomen* defines a clinical syndrome characterized by the sudden onset of severe abdominal pain requiring emergency medical or surgical treatment (1).

Acute abdominal pain can represent conditions ranging from benign to life-threatening.

The differential diagnosis includes a large spectrum of diagnosis like: inflammatory, infectious, obstructive, and oncological pathologies varying from benign self-limited diseases to situations that require emergency surgery.

Imaging plays an important role in the treatment and management of patients as clinical evaluation results can be inaccurate.

An approach for narrowing the diagnosis is based mainly on clinical history, physical examination, and labo¬ratory testing. In addition, diagnostic imaging role, is evaluated in this article.The location of pain is often a helpful start¬ing point.

The American College of Radiol¬ogy (ACR) has developed evidence-based guidelines, the ACR Appropriateness Criteria, to help physicians make the most appropriate imaging decisions for specific clinical condi¬tions. The acute abdominal pain is a common complaint in patients presenting in the emergency department (ED) and can be related to a large number of diagnoses.

Obtaining a careful medical history and performing a good physical examination are the initial diagnostic steps to correct diagnosis. Before the widespread use of diagnostic imaging techniques, these patients were candidates for urgent surgery. Actually, with the accessible role of imaging, some of this patients will not undergo surgery.

DIFFERENTIAL DIAGNOSIS

While evaluating patients with acute abdominal pain, the clinicians should be focused on most common causes that provoke abdominal pain as well as on more serious conditions. The location of pain is crucial in performing the evaluation (Table 1)

The approach of the upper quadrant pain

The list of differential diagnosis in this quadrant is shown in table 1.

Acute cholecystitis is the first diagnostic consideration in patients presenting with acute onset right upper quadrant pain. Cholecystolithiasis is the main cause of acute cholecystitis, for which an estimated 120 000 cholecystectomies are performed annually in the United States (2).

The ACR Appropriateness Criteria recommend ultrasonography as the initial imaging test for patients presenting with right upper quadrant pain (3), (Table 2) either if a patient presents fever and elevated WBC or not and if the patient is pregnant.

Table 1. Selected Differential Diagnosis of Abdominal Pain

Pain location	*Possible diagnoses*	*Pain location*	*Possible diagnoses*
Right upper quadrant		**Epigastric**	
Biliary:	cholecystitis, cholelithiasis, cholangitis	Biliary:	cholecystitis, cholelithiasis, cholangitis
Colonic:	colitis, diverticulitis	Cardiac:	myocardial infarction, pericarditis
Hepatic:	abscess, hepatitis, mass	Gastric:	esophagitis, gastritis, peptic ulcer
Pulmonary:	pneumonia, embolus	Pancreatic	mass, pancreatitis
Renal:	nephrolithiasis, pyelonephritis	Vascular:	aortic dissection, mesenteric ischemia
Left upper quadrant		**Right lower quadrant**	
Cardiac:	angina, myocardial infarction, pericarditis	Colonic:	appendicitis, colitis, diverticulitis, IBD (inflammatory bowel disease), IBS (inflammatory bowel syndrome),
Gastric:	esophagitis, gastritis, peptic ulcer	Gynecologic:	ectopic pregnancy, fibroids, ovarian mass, torsion, PID (pelvic inflammatory disease)
Pancreatic:	mass, pancreatitis	Renal:	nephrolithiasis, pyelonephritis
Renal:	nephrolithiasis, pyelonephritis	**Suprapubic**	
Vascular:	aortic dissection, mesenteric ischemia	Colonic:	appendicitis, colitis, diverticulitis, IBD (inflammatory bowel disease), IBS (inflammatory bowel syndrome),
		Gynecologic:	ectopic pregnancy, fibroids, ovarian mass, torsion, PID (pelvic inflammatory disease)
		Renal:	cystitis, nephrolithiasis, pyelonephritis
Periumbilical		**Left lower quadrant**	
Colonic:	early appendicitis	Colonic:	colitis, diverticulitis, IBD (inflammatory bowel disease), IBS (inflammatory bowel syndrome),
Gastric:	esophagitis, gastritis, peptic ulcer, small bowel mass or obstruction	Gynecologic:	ectopic pregnancy, fibroids, ovarian mass, torsion, PID (pelvic inflammatory disease)
Vascular:	aortic dissection, mesenteric ischemia	Renal:	nephrolithiasis, pyelonephritis
Any location			
Abdominal wall:	herpes zoster, muscle strain, hernia		
Other:	bowel obstruction, mesenteric ischemia, peritonitis, narcotic withdrawal, sickle cell crisis, porphyria, IBD, heavy metal poisoning		

Table 2. Right upper quadrant pain. Suspected biliary disease. Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
US abdomen	Usually Appropriate	O
CT abdomen with IV contrast	May Be Appropriate	☢☢☢
MRI abdomen without and with IV contrast with MRCP	May Be Appropriate	O
MRI abdomen without IV contrast with MRCP	May Be Appropriate	O
Nuclear medicine scan gallbladder	May Be Appropriate	☢☢
CT abdomen without IV contrast	May Be Appropriate	☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Clinical indications for MRCP

Identification of congenital anomalies of the cystic and hepatic ducts, Post-surgical biliary anatomy and complications, Pancreas divisum, Anomalous pancreaticobiliary junction, Choledocholithiasis, Benign biliary strictures, Malignant biliary strictures, Chronic pancreatitis, Cystic pancreatic tumours, Biliary injuries. It remains the investigation of choice for the non-invasive diagnosis of many pancreatico-biliary disorders (8).

Diagnostic approach in left upper quadrant pain

Left upper quadrant pains are caused by different clinical conditions; so, diagnostic imaging recommendations are not clear-cut. If the clinical history and physical examination of the patient is suggestive of gastroesophageal pathology, endoscopy (or an upper gastrointestinal series) is recommended. In other clinical conditions with left upper quadrant pain patients, CT is useful because it provides imaging of the pancreas, spleen, kidneys, intestines, and vasculature.

The main clinical diagnosis that affect this quadrant include: splenomegalia, splenic trauma, splenic infarct, splenic hemorrhage, left lower pneumonia, renal colics and peptic ulcers.

Splenic trauma is the main issue to be considered in localized pain in this quadrant. Spleen is the most fragile organ in the abdomen especially in splenomegalia. In non-stabilized patients the initial examination might be ultrasound and thoracic X-Ray but the specific imaging for trauma is the abdominal CT. ACR recommendation for these cases are listed in table 3 (9).

Table 3. Major blunt trauma. Hemodynamically stable. Not otherwise specified. Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
CT whole body with IV contrast	Usually Appropriate	☢☢☢☢
Radiography trauma series	Usually Appropriate	☢☢☢
US FAST scan chest abdomen pelvis	Usually Appropriate	O
CT whole body without IV contrast	May Be Appropriate	☢☢☢☢
Fluoroscopy retrograde urethrography	Usually Not Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O

Sensitivity and specificity of ultrasound is low for blunt abdominal trauma. Ultrasound may miss up to 25 % of hepatic and splenic trauma. The most of renal traumas are missed with ultrasound. Almost all of mesenteric, pancreatic and intestinal traumas are missed with ultrasound. So ultrasound is not considered suitable (10).

Sensitivity and specificity of CT for blunt trauma are respectively 97 % and 95 % (11).

For splenic infarcts CT is considered the “gold standard“ with a sensitivity at about 100 % , while ultrasound has a sensitivity at about 50% (12).

Right Lower Quadrant Pain

Acute appendicitis is the most common cause of right lower quadrant pain in patients presenting in emergency department and should be considered for best imaging evaluation in this location (13).

Differential diagnosis in this quadrant includes: diverculitis, mesenterial adenitis, Chron disease, urolithiasis and gynecological pathologies.

CT is the initial imag¬ing test of choice for patients presenting with right lower quadrant pain according to ACR recommendation (table 4 and table 5). CT has better sensitivity and specificity than ultraso¬nography for detecting acute appendicitis. CT also provides more consis¬tent results than ultrasonography, because ultrasonogra¬phy is a highly operator-dependent technique (13).

Table 4. Right lower quadrant pain, fever, leukocytosis. Suspected appendicitis. Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
US abdomen	May Be Appropriate	O
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	O
US pelvis	May Be Appropriate	O
MRI abdomen and pelvis without IV contrast	May Be Appropriate	O
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
Radiography abdomen	Usually Not Appropriate	☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢
WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢

Table 5. Pregnant woman. Right lower quadrant pain, fever, leukocytosis. Suspected appendicitis. Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
US abdomen	Usually Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Appropriate	O
US pelvis	May Be Appropriate	O
CT abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
WBC scan abdomen and pelvis	Usually Not Appropriate	☢☢☢☢
Radiography abdomen	Usually Not Appropriate	☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢

CT will be the imaging modality of choice for patients with lower quadrant pain expect children for which initial examination will be ultrasound, and if it is unremarkable CT should be done with low dose. Also in pregnant patients the first line examination is ultrasound and second line MRI.

Sensitivity and specificity of ultrasound depending on several publications is respectively: 21- 95.7 % and 71- 97.9 % (14). CT with iv contrast has sensitivity and specificity respectively: 90- 100 % and 94.8- 100 % (15) while the use of oral contrast doesn't show any increase in sensibility (16).

In MRI sensitivity and specificity respectively is: 89.6- 99.6 % (97%) and 97.9-99.9% (99.4%) (17)

The diagnosis of acute appendicitis is rather difficult for different population groups such as: infants, young children, elderly patients, and women of reproductive age. In the past, without using computed tomography, an average negative laparotomy rate of 20% was acceptable. Nowadays widespread use of MDCT (multi detector computed tomography) for patients with right lower quadrant pain suspected for acute appendicitis positively affected patient outcomes and decreased the number of negative laparotomies (18).

In ultrasound, appendix appears as a slightly distended (6-15 mm in diameter), fluid-filled structure that shows circumferential symmetric mural thickening. On sonographic examination, periappendiceal inflammation may be seen, and pain on compression may occur during examination. The inflamed appendix is often hypervascular on color Doppler ultrasound (7).

CT findings might be dense contrast enhancement of the wall, but a target sign may be seen. Periappendiceal inflammation is manifested as slight haziness of the mesoappendix fat. A calcified appendicolith is reliably CT sign. A phlegmon or abscess may be seen. Associated mural thickening of the adjacent distal ileum and cecum may also occur (19).

The MR features are quite similar to those seen on computed tomography. The appendix is distended with a diameter greater than 6 to 7 mm with surrounding inflammatory modifications.

Mesenterial adenitis

This clinical diagnosis is sometimes challenging as clinically can mimic appendicitis. It's a pathology of ileal or ileocecal lymphnodes with higher incidence in children. It is among the most cases with acute abdomen where the normal appendectomy is done. Using CT the negative appendectomy rate has decreased from 15-20 % to 4 %.

Urolithiasis

According to ACR (American College of Radiology) CT is the best choice if clinically suspected for urolithiasis, table 6 (20).

Clinical Condition: Acute Onset Flank Pain—Suspicion of Stone Disease (Urolithiasis)

Table 6. Suspicion of stone disease

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis without IV contrast	8	Reduced-dose techniques are preferred.	☢☢☢
CT abdomen and pelvis without and with IV contrast	6	This procedure is indicated if CT without contrast does not explain pain or reveals an abnormality that should be further assessed with contrast (eg, stone versus phleboliths).	☢☢☢☢
US color Doppler kidneys and bladder retroperitoneal	6		O
Radiography intravenous urography	4		☢☢☢
MRI abdomen and pelvis without IV contrast	4	MR urography.	O
MRI abdomen and pelvis without and with IV contrast	4	MR urography.	O
X-ray abdomen and pelvis (KUB)	3	This procedure can be performed with US as an alternative to NCCT.	☢☢
CT abdomen and pelvis with IV contrast	2		☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

In most European countries US is the first choice. It is true that has no radiation effect but has also lower sensitivity comparing with CT in stone detecting and differentiation between obstruction and dilatation.

The American Urological Association recommends the algorithm as shown in figure 1.

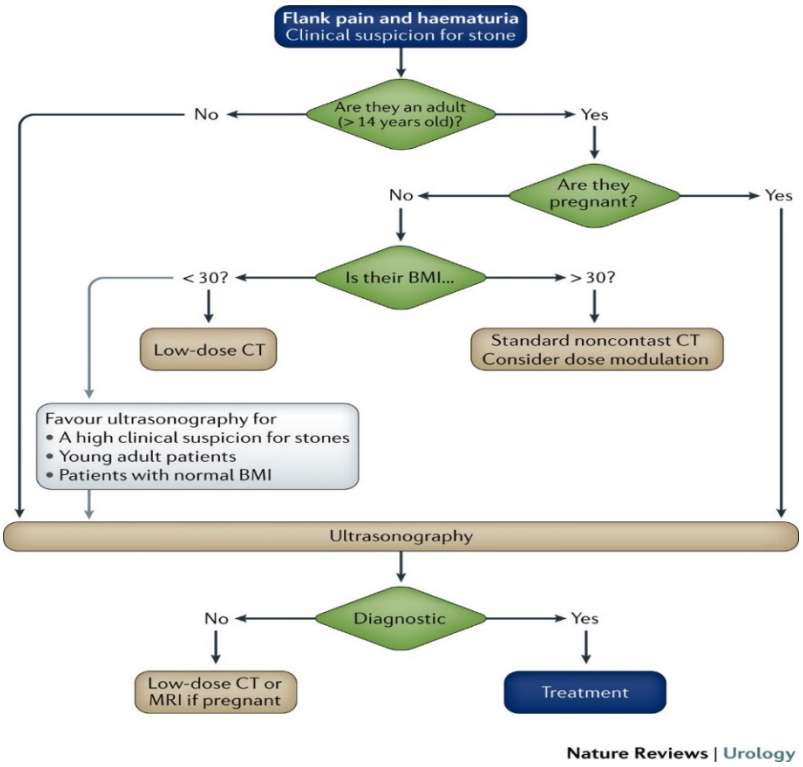

Figure 1. Algorithm of American Urological Association recommendation about clinically suspicion for stone.

In plane abdominal X ray the stone might be opaque but with a sensitivity of 29 % (21).

In ultrasound stones are hiperechoic foci with posterior shadowing with /without hydronephrosis with 61-90% sensitivity when they cause hydronephrosis and 24-57 % sensitivity in general for stones (22).

In CT we can evaluate the hydronephrosis and the hydrourether. Also the exact location of stone, Unilateral renal edema, periuretheral edema and hiperdense perinephritic stranding (23).

The sensitivity and specificity is more than 95 % (23).

Pyelonephritis

Urinary tract infections (UTIs) are among the most common infections affecting humans. UTIs diagnosis is established by clinical or laboratory studies and imaging studies are not required. When the kidney itself is involved or when there is difficulty in differentiating lower urinary tract infection (LUTI) from renal parenchymal involvement, imaging studies are often requested, both for diagnosis and to plan the further management. Conditions that are thought to predispose a patient with (LUTI) to renal involvement include: vesicoureteral reflux, altered bladder function, congenital urinary tract anomalies, and the presence of renal calculi. Patients with underlying diabetes are of particular concern as they are more vulnerable to complications from acute pyelonephritis, including renal abscesses and emphysematous pyelonephritis.

According to ACR the appropriate diagnostic image choosing depends on several factors and it gives two variants table 7 and table 8 (24).

CT remains the best choice for pyelonephritis especially in complicated patients with sensitivity at about 90-92 % (24).

Left Lower Quadrant Pain

Acute sigmoid diverticulitis is the most common cause of left lower quadrant pain in adults. Imaging should be considered if the diagnosis is unclear or if complications (e.g., abscess, fistula, obstruction, perforation) are suspected. CT has a sensitivity of more than 95% for detecting diverticulitis (25), and it can provide information about the extent of the disease and the presence of abscess formation (26). In addition, CT can reveal disease processes other than diverticulitis that have a similar clinical presentation. Differential diagnosis in this quadrant include: perforated colon cancer, nephrolithiasis and uretherolithiasis, epiploic appendagitis and gynecological pathologies.

ACR appropriateness criteria are listed in table 9.

Table 7. Acute pyelonephritis. Uncomplicated patient (eg, no history of diabetes or immune compromise or history of stones or obstruction or prior renal surgery or lack of response to therapy). Initial imaging

Procedure	Appropriateness Category	Radiation Level Relative
Radiography intravenous urography	Usually Not Appropriate	☢☢☢
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢☢
Radiography abdomen and pelvis (KUB)	Usually Not Appropriate	☢☢
Fluoroscopy antegrade pyelography	Usually Not Appropriate	☢☢☢
US color Doppler kidneys and bladder retroperitoneal	Usually Not Appropriate	O
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢
Tc-99m DMSA scan kidney	Usually Not Appropriate	☢☢☢

Table 8. Acute pyelonephritis. Complicated patient (eg, diabetes or immunocompromised or history of stones or prior renal surgery or not responding to therapy). Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Appropriate	☢☢☢☢
MRI abdomen without and with IV contrast	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate (Disagreement	O
OMRI abdomen and pelvis without IV contrast	May Be Appropriate	O
MRI abdomen without IV contrast	May Be Appropriate	O
US color Doppler kidneys and bladder retroperitoneal	May Be Appropriate	O
Tc-99m DMSA scan kidney	May Be Appropriate	☢☢☢
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢ ☢
Radiography abdomen and pelvis (KUB)	Usually Not Appropriate	☢☢☢
Fluoroscopy antegrade pyelography	Usually Not Appropriate	☢☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢

Table 9. Left lower quadrant pain. Suspected diverticulitis. Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV Contrast	May Be Appropriate	O
MRI abdomen and pelvis without IV contrast	May Be Appropriate	O
US abdomen transabdominal	May Be Appropriate	O
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
Fluoroscopy contrast enema	Usually Not Appropriate	☢☢☢
Radiography abdomen and pelvis	Usually Not Appropriate	☢☢☢
US pelvis transvaginal	Usually Not Appropriate	O

CT presents sensitivity of about 99 % compared with ultrasound 60-77 % or MRI 86-94 %.

CT has greatest sensitivity in differential diagnosis with other pathologies mimicking diverticulitis. Also CT can evaluate extracolonic spread of diverticulitis (27).

These patients typically present with left lower quadrant pain, fever, and leukocytosis. The role of CT for these patients is to confirm the diagnosis, to establish the presence of complications. The CT hallmark of diverticulitis is inflammatory change in the pericolic fat, which is observed in 98% of patients (27). Minimal haziness of adjacent fat occurs in mild cases. Small fluid collections, fine linear strands, and extraluminal gas bubbles may also occur. In more severe cases, phlegmon or frank abscess formation can occur (19). Diverticula are seen in patients at about 80% of cases. Symmetric parietal thickening of more than 4 mm is seen in about 70% of patients. Other features are engorgement of the vasa recta and the presence of fluid in the inferior portion of the combined interfascial plane. Complications of acute diverticulitis include abscess formation, obstruction of the large and small bowel, secondary inflammation of the appendix, fistula, sinus tracks, and frank intraperitoneal perforation.

Appendagitis epiploica

Epiploic appendagitis is a rare self-limiting inflammatory/ischemic process involving an appendix epiploica of the colon and may either be primary or secondary to adjacent pathology. Epiploic appendagitis merely denotes

inflammation of the one or more appendages epiploicae, which number 50-100 and are distributed along the large bowel. The pathogenesis is thought to be due to torsion of a large and pedunculated appendage epiploicae, or spontaneous thrombosis of the venous outflow, resulting in ischemia and necrosis. Clinically, patients present with abdominal pain and guarding. It is essentially indistinguishable from diverticulitis and acute appendicitis (depending on location) and, although an uncommon condition, it accounts for up to 7% of cases of suspected diverticulitis (28). CT is the modality of choice. CT appearances are usually characteristic consisting of: a fat-density ovoid structure with thin high-density rim, known as the hyperattenuating ring sign, central hyperdense dot (representing the thrombosed vascular pedicle) and adjacent colonic wall thickening .

Pelvic pain/gynecological causes

In females of reproductive age, gynecologic and obstet¬ric causes of abdominal pain (e.g., ectopic pregnancy, ovarian cyst, ovarian torsion, pelvic inflammatory dis¬ease) are important considerations in addition to the diagnoses commonly made in the general population. Transvaginal or transabdominal ultrasonography of the pelvis is the recommended imaging study for reproductive-aged females in whom a gynecologic etiol¬ogy is suspected or a β-hCG test result is positive. For pregnant patients with acute abdominal pain, ultra¬sonography and MRI are typically the imaging studies of choice because they lack ionizing radiation (29).

ACR appropriateness criteria suggestions are shown in table 10.

Clinical Condition: Acute Pelvic Pain in the Reproductive Age Group

Table 10. Gynecological etiology suspected, serum β-hCG positive

Radiologic Procedure	Rating	Comments	RRL
US pelvis transvaginal	9	Both transvaginal and transabdominal US should be performed if possible.	O
US pelvis transabdominal	9	Both transvaginal and transabdominal US should be performed if possible.	O
US duplex Doppler adnexa	8		O
MRI pelvis without IV contrast	8	This procedure can be performed if US is inconclusive or nondiagnostic	O
MRI abdomen and pelvis without IV contrast	6	This procedure can be performed if US is inconclusive or nondiagnostic.	O

Pelvic inflammatory disease

US is the modality of choice with sensitivity of 56-93 % and specificity of 86-98 %. CT also can detect signs of PID (pelvic inflammatory disease) with a sensitivity of 84 % and especially in differentiating it with intestinal pathologies. MRI has greater sensitivity compared with CT especially in pregnant patients or in patients with abdominal pain and inconclusive or unremarkable ultrasound (30).

Ultrasound features of PID demonstrates ascitic fluid in the peritoneal cavity or non-specific thickening and increased vascularity of the endometrium. In the most severe cases, ultrasound may show adnexal masses with a heterogeneous echo-pattern. Other sonographic signs associated with tubal inflammation include: thickened/dilated fallopian tubes, incomplete septa in the tube, increased vascularity around the tube and echogenic fluid in the tube (pyosalpinx) (31).

CT features of PID include: thickening of the uterosacral ligaments, complex free fluid in the pouch of Douglas (cul-de-sac), pelvic fat stranding or haziness, indistinct uterine border and fallopian tube thickening of >5 mm with enhancing wall (30).

Epigastric and back pain (Acute pancreatitis)

Acute pancreatitis (AP) is an inflammatory process affecting the pancreas. The clinical diagnosis of AP requires 2 of the following features: 1) abdominal pain consistent with AP (acute onset of persistent, severe, epigastric pain often radiating to the back); 2) serum lipase or amylase levels at least 3 times the upper limits of normal; and 3) characteristic findings of AP on contrast-enhanced CT, MRI, or transabdominal ultrasound (US).

Differential diagnosis include Abdominal aortic rupture, mesenterial ischemia, ileus and peptic ulcer. (Table 11)

Table 11. Suspected acute pancreatitis. Initial examination should be abdominal CT with contrast according to ACR

Procedure	**Appropriateness Category**	**Relative Radiation Level**
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
MRI abdomen without and with IV contrast with MRCP	Usually Appropriate	O
MRI abdomen without IV contrast with MRCP	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
US duplex Doppler abdomen	May Be Appropriate	O
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢

In acute cases (<48–72 hours from onset of symptoms), CT is not recommended if clinical presentation is clear with amylase and lipase elevation (more than three times the normal value). CT is recommended in acute cases when the clinical presentation and laboratory data are unremarkable. In the first 72 hours the CT data can underestimate the severity (32).

CT with contrast enhancement after 48–72 hours evaluate pancreatic necrosis and peripancreatic fluid/collection.

Late CT (>7–21 days) is very effective in assessing the severity and the probability of drainage /aspiration (33).

CT with contrast enhancement should be done where there is a severe clinical condition like hypotension, hemoglobin decrease or leukocytosis.

CT with contrast enhancement can evaluate better the complications.

US is done in patients that come for the first time to asses if there is cholelithiasis or not.

MRI with contrast enhancement /MRCP is limited in acute conditions (34).

CT features of acute pancreatitis findings include: Focal or diffuse parenchymal enlargement, changes in density because of edema, indistinct pancreatic margins owing to inflammation and surrounding retroperitoneal fat stranding.

The role of ultrasound is to identify gallstones as a possible cause of pancreatitis. Ultrasound also is used for the diagnosis of vascular complications, (e.g. thrombosis), identifying areas of necrosis (which appear as hypoechoic regions) and assessment of clinically similar etiologies of an acute abdomen.

Ultrasound features of acute pancreatitis include: Increased pancreatic volume with a marked decrease in echogenicity, displacement of the adjacent transverse colon and/or stomach secondary to pancreatic volume expansion.

Complications include necrosis which has high mortality, collections, pseudoaneurisms, peripancreatic thrombosis, overinfection which also increases the mortality rate and pseudocysts after 4- 6 weeks.

Abdominal aortic aneurisms

Abdominal aortic aneurysms (AAA) are focal dilatations of the abdominal aorta measuring 50% greater than the proximal normal segment, or >3 cm in maximum diameter. Large aneurysms may present as a pulsatile abdominal mass. Asymptomatic unless they leak or rupture, they are commonly diagnosed incidentally. The classical triad of pain, hypotension and pulsatile abdominal mass due to rupture into the retro peritoneum is only seen in 25-50% of patients. The two/third of patients die before hospital arrival.

Ruptured risk in 5-year period varies from dimensions, 3-3.9 cm: 2 %, 4-4.9 cm: 3-12 %, 5-5.9 cm: 25 %, 6-6.9 cm: 35% and 7 + cm: 75% (35).

CT angiography is the modality of choice in symptomatic patients and also does a good perioperative assessment (36) (Table 12). Ultrasound presents limitations because of meteorism and patient body mass index.

Table 13. Suspected aortic aneurism. Initial examination should be abdominal CT with contrast according to ACR

Procedure	Appropriateness Category	Relative Radiation Level
CTA abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢☢☢
MRA abdomen and pelvis without and with IV contrast	Usually Appropriate	○

Table 13. Suspected acute mesenteric ischemia. Initial imaging

Procedure	Appropriateness Category	Relative Radiation Level
CTA abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢

CT findings of ruptured AAA: Retroperitoneal hemorrhage adjacent the aneurysm is the most common finding. The peri-aortic blood may be seen into perirenal or pararenal spaces, or adjacent the psoas muscles. Intraperitoneal extension of the hemorrhage may be seen as other finding (37).

Another important feature seen in a rupture of an aortic aneurysm is the draped aorta sign - in which the posterior wall of the aorta is not seen distinctly from adjacent structures, and the contour of the aorta follows that of adjacent vertebrae.

A hyperattenuating crescent sign, which is an area of increased attenuation within the aortic aneurysmal mural thrombus, can be demonstrated on plain CT images. This is caused by the insinuation of fresh blood into the mural thrombus and aortic wall (37).

Mesenterial thrombosis

Even though bowel ischemia as a cause of acute abdominal pain is a life-threatening condition, it is present in only about 1% of patients, but mortality rate is very high accounting 30-90 %.

The causes of bowel ischemia might be arterial or venous.

Acute arterial occlusion occurs in 60%–70% of cases, meanwhile veins in 5%–10% of cases.

Ultrasound has a low sensitivity.

CT angiography remain the modality of choice having over 93 % of sensitivity and specificity at about 100 % (38).

The most sensitive sign of mesenteric ischemia is the visualization of occluded mesenteric arteries or venous thrombus. Secondary signs are: bowel wall thickening (>3 mm) because of mural edema, congestion, hemorrhage, or superinfection. Thickening wall with such changes is a frequent finding of venous obstruction. Abnormal bowel wall enhancement (target sign), bowel wall hyperattenuation (hemorrhage), absence of bowel wall enhancement or bowel wall hypoattenuation (edema), are features of bowel ischemia. Another sign which is highly specific but often missed is the absence of bowel wall enhancement.

Bowel Obstruction

Obstruction of the small intestine and colon are not rare, they account approximately 20% of all acute abdomen in surgical conditions. Multidetector Computed Tomography (MDCT) nowadays has replaced conventional contrast studies because it is capable to do small slices and reconstructions and is more reliable to answer several questions by the surgeon (Is obstruction present? If yes, where is the level of obstruction? What is the cause of obstruction? Is a simple obstruction or a closed loop? What is the severity of obstruction? Is any strangulation or ischemia present?).

CT is the modality of choice for bowel obstruction. It can prescribe the cause of obstruction and evaluate also any complications with a sensitivity of about 90% (39). Abdominal X-RAy is the starting point for the imaging evaluation of suspected SB with a sensitivity of 30-70 %, which doesn't find the cause of obstruction, but detects the hydroaeric levels (40). Ultrasound can detect the ileus, but not the cause and has its value in pediatric especially intussusception (41). (Table 14)

For patients with bowel obstruction, CT scans are recommended to be performed without oral contrast material. First of all, the patient can't tolerate it, maybe from nausea and vomiting and also because intraluminal fluid and gas serve as natural contrast agents. Intravenous contrast material is very important in assessing intestinal perfusion and ischemia evaluating mesenteric vessels. The CT hallmark of bowel obstruction is the delineation of a transition zone between dilated and decompressed bowel. CT can evaluate better than all other modalities, internal and external hernias, neoplasms, gallstone ileus, various forms of enteroenteric intussusception. If no mass, hernia, intussusception, abscess, or inflammatory thickening is present, adhesion is the most likely diagnosis. An adhesion has a

Table 14. Suspected small-bowel obstruction. Acute presentation. Initial imaging

Procedure	**Appropriateness Category**	**Relative RadiationLevel**
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	O
Radiography abdomen and pelvis	May Be Appropriate (Disagreement)	☢☢☢
Fluoroscopy small bowel follow-through	May Be Appropriate	☢☢☢
MRI abdomen and pelvis without IV contrast	May Be Appropriate	O

Table 15. Acute non localized abdominal pain and fever. No recent surgery. Initial imaging

Procedure	Appropriateness Category	Relative Radiation level
CT abdomen and pelvis with IV contrast	Usually Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	O
US abdomen	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
MRI abdomen and pelvis without IV contrast	May Be Appropriate	O
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	☢☢☢☢
Radiography abdomen	May Be Appropriate	☢☢

beaklike narrowing, sometimes the affected gut difficult to view. The small bowel feces sign is another specific sign often seen just proximal to the obstruction.

In patients with high-grade obstruction of the small bowel, CT has a reported sensitivity of 90% to 99%.

Acute Non localized Abdominal Pain

Although disease processes such as cholecysti¬tis, appendicitis, and diverticulitis commonly present with a localized pain to a specific abdominal quadrant, non-localized abdominal pain is also a common clinical presentation. The differential diagnosis of acute non ¬localized abdominal pain is so broad. CT is typically the imaging modality of choice if there is significant concern for serious pathology or if the diagnosis is unclear from history, physical examination, and laboratory testing (42) Table 15.

CONCLUSIONS

Plain X ray of the abdomen in an acute abdomen is the first choice only in patients with high suspect of ileus and perforation.

Ultrasound remains the examination of choice in patients with biliary colic and in every acute abdomen in pediatric patients. In pregnant patients and in gynecological pathologies ultrasound is the modality of choice.

CT (computed tomography) angiography of the abdomen is the best choice in patients with abdominal aortic aneurisms and bowel ischemia.

MRI is used in pregnant patients when ultrasound is unremarkable, and it should be done without contrast media.

In all other cases of abdominal colic, contrast enhancement CT (computed tomography) is the best modality.

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Conflicts of Interest statement:

The authors declare no conflict of interest.

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