ACUTE ABDOMEN IMAGING FINDINGS

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PREFACE

The evaluation of the acute abdomen is one of the most critical areas of medical practice requires a multidisciplinary approach for both diagnosis and treatment. This book was written to offer a comprehensive guide to the imaging findings of acute abdomen cases.

Advancements in imaging techniques within modern medicine have revolutionized the management of the acute abdomen. Plain radiography, ultrasonography, computed tomography and magnetic resonance imaging have all significantly facilitated clinical decision-making and improved patient outcomes. However, effectively using these technologies depends not only on technical expertise but also on the ability to accurately interpret findings in the clinical context.

The primary goal of this book is to bridge theoretical knowledge with practical application, guiding both experienced physicians and junior colleagues. Each chapter provides a detailed examination of the imaging findings associated with the acute abdomen, compiling carefully curated information to support prompt and accurate diagnosis.

I trust that the knowledge you gain throughout this book will empower you to make more confident decisions in your clinical practice and contribute to the scientific understanding in this field. Medicine is a profession that thrives on continuous learning and knowledge-sharing. Through this book, I hope you will expand your expertise in acute abdomen evaluation and make a meaningful impact in the field.

I extend my gratitude to all the colleagues who contributed to this work and to the dear friends who supported me. May this book open new horizons for its readers and help achieve better outcomes in healthcare services.

With love and respect,

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INTRODUCTION

Acute abdomen is a clinical condition frequently encountered in medical emergencies, characterized by the sudden onset of severe abdominal pain arising from various pathological processes involving the abdominal organs or tissues, and necessitating urgent diagnosis and treatment (Stoker, van Randen, Laméris, & Boermeester, 2009). This condition can be caused by pathologies in many internal organs, such as the gastrointestinal system, hepatobiliary system, genitourinary system and vascular structures (Mishra et al., 2003). Early diagnosis and intervention are particularly important to prevent life-threatening complications. In patients presenting with an acute abdomen, a rapid and systematic evaluation to determine the underlying cause forms the basis of patient management. In assessing this condition, along with clinical history and physical examination findings, radiological imaging methods play a critical role (Cartwright & Knudson, 2015).

Although clinical evaluation begins with the patient's history, physical examination findings and laboratory tests, imaging methods emerge as a vital component that completes this process. The imaging modalities used to clarify the causes of an acute abdomen enable the determination of the pathology's location, type and severity. Consequently, decisions regarding surgical or conservative treatment can be made more accurately.

In the evaluation of the acute abdomen, plain radiographs (PR) serve as a fundamental first-line imaging method, particularly for detecting perforations, obstructions and foreign bodies (Gans, Stoker, & Boermeester, 2012). An upright abdominal radiograph can reveal free air and demonstrate gas-fluid levels at sites of obstruction. Supine radiographs are useful for assessing bowel gas distribution and dilation. However, due to their limited sensitivity, PR are often complemented by more advanced imaging methods. Because they are rapid and readily accessible, PR remain valuable, especially in settings with limited resources.

Ultrasonography (US) is among the primary imaging modalities of choice in acute abdomen due to its rapid, non-invasive nature, lack of ionizing radiation and ability to be performed at the bedside. (Mazzei et al., 2013). It is particularly useful for evaluating gallbladder, pancreas, appendix and pelvic organ pathologies. However, factors such as gas accumulation or obesity can affect image quality. In addition, vascular structures and blood flow can be analyzed with the help of Doppler US.

Computed Tomography (CT) is one of the most commonly used imaging modalities in the diagnosis of acute abdomen. Especially with the use of contrast agents, it allows for a more detailed examination of vascular structures and organ damage. CT provides high sensitivity and specificity in confirming perforation, ischemic conditions, acute appendicitis, diverticulitis and intra-abdominal abscesses. Its high-resolution imaging capacity, ability to deliver results in a short time and ability for multiplanar evaluation have established CT as the gold standard in this area (Strömberg, Johansson, & Adolfsson, 2007). Moreover, CT plays a critical role in determining both the location and severity of the disease, as well as assessing its complications. Additionally, by increasing diagnostic accuracy, CT helps prevent unnecessary surgical interventions.

Magnetic Resonance Imaging (MRI) is generally used as a second-line modality in evaluating the acute abdomen. It is particularly advantageous in assessing pelvic pathologies and situations such as pregnancy (Ditkofsky, Singh, Avery, & Novelline, 2014). Thanks to its superior soft-tissue contrast, MRI is highly valuable in diagnosing inflammatory or neoplastic processes.

This book focuses on the etiologies of acute abdomen and their corresponding imaging findings. Common causes including acute cholecystitis, appendicitis, pancreatitis, perforation, diverticulitis, ileus, volvulus, mesenteric ischemia, ovarian torsion, ectopic pregnancy, urinary tract stone disease and trauma-related abdominal pathologies are discussed in detail based on PR, US, CT, and MRI. The goal is to guide clinicians in diagnosing these conditions and to highlight the role of imaging techniques in clinical practice.

1. ACUTE CHOLECYSTITIS

Acute cholecystitis is a clinical condition characterized by acute inflammation of the gallbladder, typically arising from gallstone disease, and is one of the major causes of abdominal pain (Katabathina, Zafar, & Suri, 2015). It may present with typical symptoms and signs such as right upper quadrant pain, fever and leukocytosis. Acute cholecystitis requires early diagnosis and treatment; otherwise, serious complications such as perforation, gangrene or sepsis can develop (Chawla et al., 2015). Imaging plays a critical role in both confirming the diagnosis and evaluating complications.

1.1. US Findings: US is the first-line imaging modality for diagnosing acute cholecystitis (Pinto et al., 2013). Typical US findings include:

- **Gallbladder wall thickening:** A wall thickness of >3 mm is suggestive of pathology.
- **Pericholecystic fluid:** Fluid accumulation around the gallbladder, indicative of inflammation.
- **Positive Murphy's sign:** The patient experiences pain when the ultrasound probe is pressed over the right upper quadrant.
- **Gallstones or sludge:** Hyperechoic stones and layering sludge visible within the gallbladder.

US is rapid and reliable for assessing both the anatomical and pathological status of the gallbladder and bile ducts (Hwang, Marsh, & Doyle, 2014). However, factors such as obesity or bowel gas can limit image quality.

1.2. CT Findings: CT is preferred when US is insufficient or when further evaluation of complications is needed (Shakespear, Shaaban, & Rezvani, 2010). Common CT findings in acute cholecystitis include:

 Marked gallbladder wall thickening (>3 mm) with contrast enhancement.
 Pericholecystic fluid or haziness in the surrounding fat.
 Stones or sludge within the gallbladder lumen.
 Gallbladder distention (greater than 8–10 cm in the longitudinal axis or a transverse diameter >4 cm).
 Reactive hyperemia in the adjacent liver parenchyma, evident during the arterial phase of contrast imaging.
 Findings indicative of complicated acute cholecystitis (empyema, perforation or gangrenous changes) when present.

CT has high sensitivity, especially for detecting complications such as perforation or abscess (Childs et al., 2024).

1.3. MRI Findings: Gallstones are most effectively identified on T2-weighted imaging (T2WI) and MRCP, appearing as signal voids on T1-weighted imaging (T1WI) and T2WI (Tonolini, Ravelli, Villa, & Bianco, 2012). Protein macromolecules within the stones can produce a peripheral hypointensity with central hyperintensity on T1WI and T2WI or a distinctly hyperintense appearance on T1WI (Chawla et al., 2015). Pigment stones, like cholesterol stones, appear hypointense on T2WI. However, depending on their hydration level, they often appear hyperintense on T1WI and exhibit a broader range of signal intensities (Kaura, Haghighi, Matza, Hajdu, & Rosenkrantz, 2013). In vitro studies indicate that metal ions within pigment stones shorten the T1 relaxation time of surrounding protons, resulting in a hyperintense appearance (Altun et al., 2007). MRI findings include:

 Gallbladder wall thickening and edema.
 High signal intensity corresponding to pericholecystic fluid.
 Detection of any biliary obstruction or stones.

MRCP is particularly useful in patients with suspected choledocholithiasis or biliary obstruction (Tonolini et al., 2012). Advantages include the absence of ionizing radiation and superior soft-tissue contrast.

Complications:

- **Gangrenous Cholecystitis:** Characterized by ischemic changes and necrosis in the gallbladder wall (Maddu, Phadke, & Hoff, 2021). On CT, heterogeneous wall enhancement and pericholecystic inflammation may be observed.

- **Perforation:** Results from a full-thickness defect in the gallbladder wall (O'Connor & Maher, 2011). On CT, pericholecystic fluid or free intraperitoneal air supports the diagnosis.

- **Emphysematous Cholecystitis:** Marked by gas formation in the gallbladder wall and lumen, often caused by gas-producing bacteria such as Clostridium species (Narese et al., 2013).

- **Cholecystoenteric Fistula and Gallstone Ileus:** Occur when gallstones pass into intestinal loops through a fistula formed due to inflammation in the gallbladder, leading to luminal obstruction and ileus (Inukai, 2019).

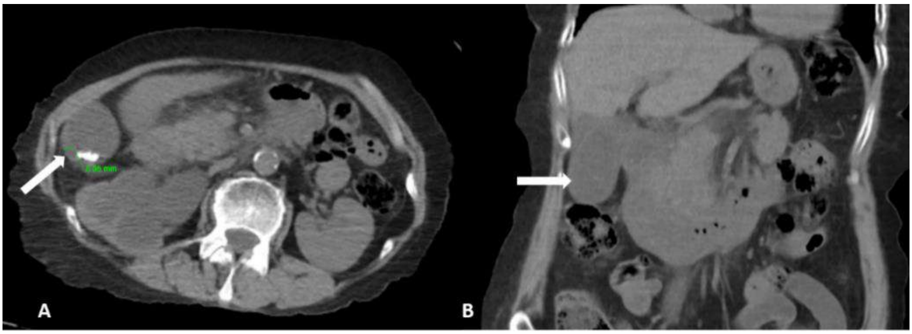

Figure 1. Axial (A) and coronal (B) abdominal CT slices demonstrate diffuse thickening of the gallbladder wall (white arrow in A), multiple millimetric stones within the lumen (A) and a distended gallbladder (white arrow in B). These findings are consistent with acute cholecystitis.

2. ACUTE APPENDICITIS

Acute appendicitis, characterized by inflammation of the vermiform appendix, is one of the most common causes of an acute abdomen that may require urgent surgical intervention (Parks & Schroeppel, 2011). Early in its course, symptoms typically present as vague visceral pain around the periumbilical region, often followed by nausea and vomiting. As the disease progresses, the pain usually localizes in the right lower quadrant due to peritoneal inflammation (Debnath, George, & Ravikumar, 2017). While clinical evaluation is paramount in making a diagnosis, imaging methods are essential when symptoms are atypical or complications are suspected.

2.1. US Findings: US is the first-line imaging modality, particularly in populations where radiation exposure is a concern, such as children and pregnant women (Aspelund et al., 2014). Typical US findings include:

 Appendix diameter: A diameter of ≥7 mm suggests acute appendicitis.
 Wall thickening: Hypoechoic thickening of the appendiceal wall.
 Periappendiceal fluid: Fluid accumulation around the appendix and increased echogenicity, indicating inflammation.
 Non-compressible appendix: Failure of the appendix to collapse when pressure is applied with the US probe is diagnostic.
 Fecalith: Identification of a fecalith causing luminal obstruction reinforces the diagnosis.

US offers bedside application and a high accuracy rate (Mostbeck et al., 2016). However, factors such as bowel gas or obesity may hinder proper visualization of the appendix.

2.2. CT Findings: Contrast-enhanced CT is considered the gold standard for diagnosing acute appendicitis. Common findings on contrast CT include:

- Enlarged appendix with contrast enhancement of the wall.
- Fat stranding and inflammation around the appendix.
- Abscess formation or perforation.
- Obstructive entities such as a fecalith.

CT's high sensitivity is crucial for identifying complications and ruling out other potential diagnoses. In complicated cases, abscess formation, perforation and peritonitis may be observed (Pinto Leite, Pereira, Cunha, Pinto, & Sirlin, 2005). The presence of free fluid or free air in the peritoneal cavity is notable in perforation. CT is also advantageous in diagnosing atypically located appendicitis (e.g., pelvic or retrocecal), especially when clinical findings are unclear (Chin & Lim, 2015).

Another major advantage of CT is its utility in the differential diagnosis. Conditions such as inflammatory bowel diseases, mesenteric lymphadenitis or neoplasms in the right lower quadrant can be easily distinguished on CT. However, exposure to ionizing radiation remains a disadvantage.

2.3. MRI Findings: MRI is increasingly used as an alternative to CT in children and pregnant women (Singh, Desai, & Novelline, 2009). Its absence of ionizing radiation and superior soft-tissue contrast are significant advantages, although the longer scanning time and higher cost are disadvantages.

MRI findings:

- Enlargement of the appendix and edema of the appendiceal wall.
- High signal intensity indicating periappendiceal fluid accumulation.
- Signal changes in surrounding tissues associated with inflammation.

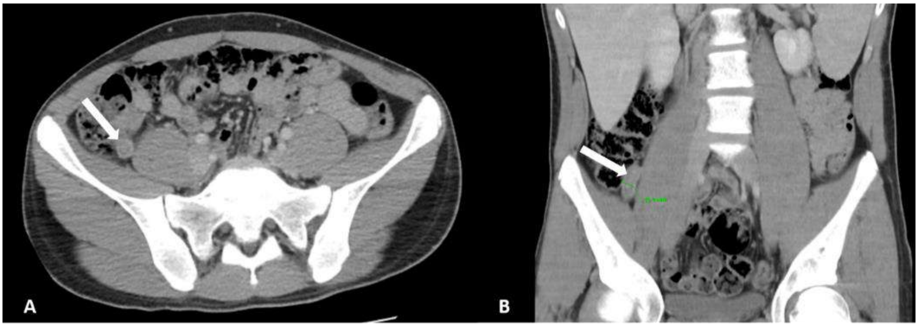

Figure 2. Axial (A) and coronal (B) abdominal CT images show an increased diameter and thickened appendix wall (white arrows), consistent with acute appendicitis.

3. ACUTE PANCREATITIS

Acute pancreatitis is an inflammatory disease characterized by the sudden onset of severe epigastric pain, nausea, vomiting and sometimes a band-like pain radiating to the back (Mederos, Reber, & Girgis, 2021). Although elevated serum amylase and lipase levels (exceeding three times the upper limit of normal) are fundamental for diagnosis, imaging methods are indispensable both for confirming the diagnosis and for assessing disease severity and complications. Imaging also helps identify underlying causes of acute pancreatitis, such as gallstones, pancreatic duct obstructions, or tumors.

3.1. US Findings: US is widely used as an initial imaging modality (Burrowes, Choi, Rodgers, Fetzer, & Kamaya, 2020). However, its utility can be limited by the pancreas's retroperitoneal location and the presence of bowel gas.

Detailed Findings:

1. **Enlargement of the Pancreas**
   - Normally, the pancreas appears iso- or slightly hyperechoic. During inflammation, the pancreas becomes enlarged and its echogenicity becomes heterogeneous.
   - In edematous pancreatitis, the pancreas often appears hypoechoic.
2. **Peripancreatic Fluid Collections**
   - Seen as anechoic or hypoechoic areas.
   - Commonly accumulate in the anterior pararenal space, the mesenteric root or the splenorenal recess.
3. **Gallbladder and Bile Ducts**
   - Gallstones appear as hyperechoic foci with posterior acoustic shadowing.
   - Dilation of the common bile duct (>8 mm) suggests biliary obstruction.
4. **Evaluation of Complications**
   - **Pseudocysts:** Visualized as well-defined fluid collections.
   - **Portal vein thrombosis:** Demonstrated by thrombus formation in the portal vein.

Dynamic Assessment:

- **Color Doppler US:** Aids in diagnosing vascular complications (splenic vein thrombosis or pseudoaneurysms).
- **Increased vascularity** may be observed in the pancreatic parenchyma and surrounding fatty planes secondary to inflammation.

3.2. CT Findings: Contrast-enhanced CT is the most sensitive method for diagnosing acute pancreatitis and evaluating its severity (Balthazar, 2002). CT findings help determine both the stage of the disease and any complications that may be present.

Detailed Findings:

1. **Inflammatory Changes in the Pancreas**
    - **Edematous Pancreatitis:** Uniform swelling of the pancreas with fat stranding in the peripancreatic area.
    - **Necrotizing Pancreatitis:** Hypodense areas that do not enhance with contrast.
2. **Peripancreatic Inflammation**
    - Hazy infiltration in the surrounding fatty tissue is a hallmark of inflammation.
    - Fascial thickening or fluid accumulation is common.
3. **Fluid Collections**
    - **Acute Peripancreatic Fluid Collection:** Fluid without a well-defined wall (<4 weeks).
    - **Thin-Walled Pseudocysts:** Chronic fluid collections that develop after inflammation (>4 weeks).

4. **Vascular Complications**
    - Splenic or portal vein thrombosis.
    - Pseudoaneurysm or intraparenchymal hemorrhage.
5. **Intra-Abdominal Complications**
    - **Infected necrosis:** Indicated by the presence of gas in non-enhancing areas.
    - **Bowel obstruction:** Secondary adynamic ileus or duodenal compression.

CT Scoring Systems:

- **Balthazar Score:** Classifies severity from A (normal) to E (severe) (Balthazar, 2002).

CTSI (Computed Tomography Severity Index):

- Evaluates overall severity by combining pancreatic necrosis and fluid collections (Mikó et al., 2019).

3.3. MRI Findings: MRI serves as an alternative to CT for detailed characterization of acute pancreatitis (Sandrasegaran, Heller, Panda, Shetty, & Menias, 2020). MRCP, in particular, is useful for evaluating the pancreatic duct and biliary tree (Darge & Anupindi, 2009).

Detailed Findings:

1. **Parenchymal Changes**

- In T2WI, the edematous pancreas appears hyperintense.
- Necrotic areas appear hypointense on T1WI and hyperintense on T2WI.

2. **Pancreatic Duct and Bile Ducts**
   - Dilation or obstruction of the main pancreatic duct can be visualized clearly.
   - Choledocholithiasis can be detected without contrast using MRCP.
3. **Peripancreatic Fluid Collections**
   - Appear hypointense on T1WI and hyperintense on T2WI.
   - In pseudocysts, layered or dependent debris seen on T2WI is quite specific; gradual wall enhancement may also be noted.
4. **Vascular Complications**
   - MR angiography can diagnose pseudoaneurysms and vascular thrombosis.
   - Findings of portal hypertension can be evaluated in detail.

Imaging is crucial in acute pancreatitis to determine disease severity and monitor complications (Busireddy et al., 2014). While US provides a rapid initial assessment, CT offers detailed anatomical information and identifies serious complications such as necrosis. MRI is preferred when radiation exposure is contraindicated and for detailed evaluation of the biliary and pancreatic ducts. Overall, imaging is an indispensable tool that supports clinical assessment and guides treatment planning.

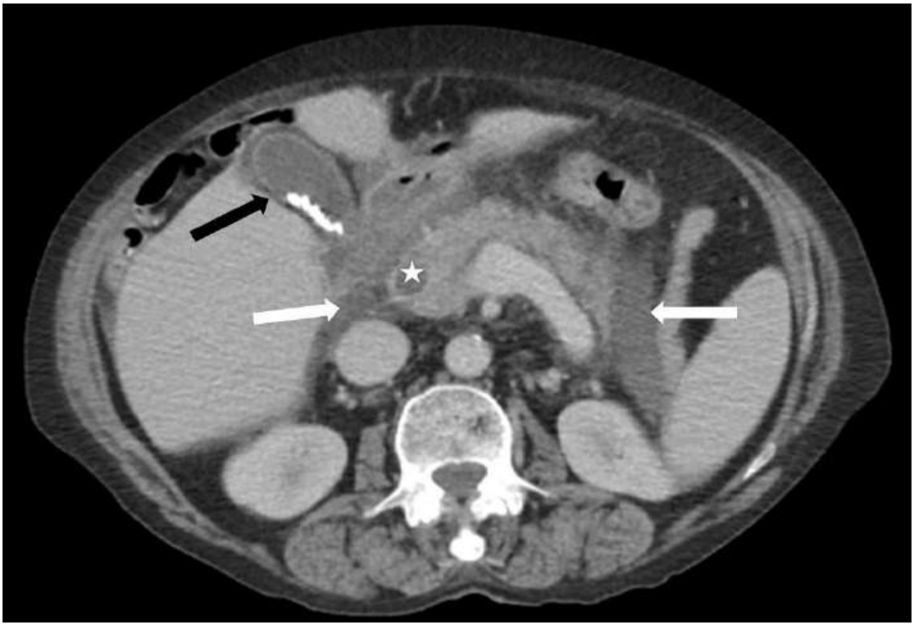

Figure 3. Axial abdominal CT image showing pancreatic enlargement, inflammation in the peripancreatic fat planes, and fluid collections (white arrows), consistent with acute pancreatitis. Multiple millimetric stones in the gallbladder lumen (black arrow) and dilation of the common bile duct (asterisk) are also evident.

4. PERFORATION

Perforation is an acute surgical emergency in which the integrity of a hollow organ is compromised, allowing its contents to leak into the abdominal cavity (Shin et al., 2020). Imaging methods such as US, PR, CT and rarely MRI play a critical role in its diagnosis and management.

4.1. PR Findings: Plain abdominal and chest radiographs are among the first imaging techniques used for the rapid and straightforward evaluation of perforation.

Key Findings:

- **Free Air (Pneumoperitoneum):**
    - **On chest radiograph:** Free air may be seen under the diaphragm.
    - **On abdominal radiograph:** Free air can be visualized along the liver edge in the right upper quadrant.
    - **On left lateral decubitus views:** A thin line of air can be detected along the abdominal wall.
- **Increased Gas in the Stomach or Duodenum:**
    - Localized gas accumulation near the site of perforation.

4.2. US Findings: US can detect indirect signs of perforation, although it may be limited by free air (Coppolino et al., 2013).

Key Findings:

1. **Free Air:**
    - **Peritoneal stripe sign:** Free air appears as a hyperechoic line between the ultrasound probe and the peritoneal surface.
    - **"Comet-tail" artifact:** A characteristic artifact caused by free air.

2. **Free Fluid:**
   - Free fluid may accumulate in the abdominal cavity due to perforation and indicates early inflammation.
   - Often seen as an anechoic collection in the right subhepatic space, pelvic region or perisplenic area.
3. **Peritonitis Indicators:**
   - Thickening of the peritoneum with a heterogeneous appearance owing to inflammation.

4.3. CT Findings: CT is considered the gold standard for diagnosing perforation and clearly demonstrates both the perforation and any associated complications (Søreide et al., 2015).

Key Findings:

1. **Free Air (Pneumoperitoneum):**
   - **Subdiaphragmatic air:** A sharply demarcated hypodense region beneath the diaphragm.
   - **Anterior abdominal cavity:** Free air around the falciform ligament.
   - **Localized air around the stomach:** Particularly in cases of gastric or duodenal perforation, with air seen near the perforation site.
2. **Localization of the Perforation:**
   - Oral contrast leaking from the perforation site on contrast-enhanced CT.

- Disruption of the organ wall integrity at the perforation site.

3. **Peritoneal Reaction:**
   - Peritoneal fluid with heterogeneous density (e.g., mixed with intestinal contents).
   - Fat stranding and inflammatory changes in the mesentery.
4. **Complications:**
   - **Inflammatory pseudomass:** A localized area of inflammation at the site of the perforation.
   - **Abscess formation:** Walled-off fluid collections developing after perforation.

4.4. **MRI Findings:** MRI is typically not the first-choice modality for diagnosing perforation but may be used in patients for whom contrast media are contraindicated or when radiation is undesirable.

Bulgular:

Key Findings:

- **Free Fluid:** Appears hyperintense on T2-weighted images.
- **Signs of Peritonitis:** Peritoneal thickening with hyperintense signal.
- **Localized Inflammation:** Hyperintense signal in the region of the perforation.

Perforation is a life-threatening condition that necessitates prompt diagnosis via imaging. PR serves as a rapid initial tool for detecting free air, while CT is the gold standard, allowing precise localization and assessment of the severity and complications (Baghdanian, Baghdanian, Puppala, Tana, & Ohliger, 2018). US can be a supportive modality but is often limited. MRI may be considered a supplementary option only in selected cases.

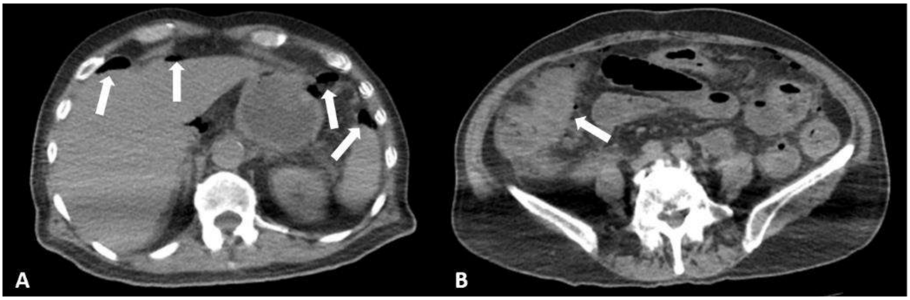

Figure 4. Axial abdominal CT images demonstrating widespread free air densities (white arrows in A) suggestive of perforation and focal inflammatory thickening in the proximal ascending colon (white arrow in B), consistent with a colonic perforation.

5. ACUTE DIVERTICULITIS

Acute diverticulitis is characterized by inflammation and infection of diverticula in the colon (Sugi, Sun, Menias, Prabhu, & Choi, 2020). It most commonly affects the sigmoid colon, and accurate diagnosis and management are critical due to the risk of complications. Imaging studies are essential for confirming the diagnosis, assessing severity, and identifying complications.

5.1. US Findings: US can be used in the diagnosis of acute diverticulitis, especially given its low cost and lack of ionizing radiation (DeStigter & Keating, 2009). However, bowel gas often limits the evaluation.

Findings:

1. **Diverticula**
   - Hyperechoic outpouchings extending beyond the bowel wall, typically containing gas.
   - Often seen in conjunction with bowel wall thickening.
2. **Bowel Wall Thickening**
   - Symmetric or asymmetric thickening (>5 mm) of the involved segment.
   - Heterogeneous echogenicity and edema within the wall.
3. **Pericolic Fat Changes**
   - Increased echogenicity and haziness in the pericolic fat, indicating inflammation.
4. **Signs of Complications**
   - **Abscess:** Anechoic or heterogeneous fluid collections.
   - **Fistula:** Irregular areas of inflammation indicating abnormal connections.

5.2. CT Findings: CT is the gold standard for diagnosing acute diverticulitis and evaluating its complications (Wilkins, Embry, &

George, 2013). It provides detailed information on both the degree of inflammation and any related complications.

Findings:

1. **Diverticulum**
    - Small outpouchings containing air or contrast protruding from the colonic wall.
    - Most prominent in the sigmoid colon.
2. **Bowel Wall Thickening**
    - Focal or circumferential (target sign) thickening of the involved segment.
    - Typically ranging from 4 to 10 mm in thickness.
3. **Pericolic Fat Changes**
    - Hazy attenuation and inflammation in the mesenteric fat (“dirty fat” sign).
    - A key indicator of the severity of inflammation.
4. **Complications**
    - **Abscess:** Fluid collections with thick walls and contrast enhancement.
    - **Perforation:** Presence of extraluminal air (Ames, Federle, & Pealer, 2009).
    - **Fistula:** Abnormal connections containing gas or purulent material between the bowel and bladder or internal genital organs.
    - **Obstruction:** Lumen narrowing in the distal colon with proximal dilatation.

CT Classification (Hinchey Modification) (Bates et al., 2018):

- **Stage I:** Pericolic or mesenteric abscess.
- **Stage II:** Pelvic, intra-abdominal or retroperitoneal abscess.
- **Stage III:** Generalized purulent peritonitis.
- **Stage IV:** Fecal peritonitis.

5.3. MRI Findings: MRI is not typically the first choice for diagnosing acute diverticulitis, but may be used in patients with contrast allergies or when radiation exposure is a concern (Vaughan & Mitchem, 2021).

Findings:

1. **Bowel Wall Thickening**
   - Hyperintense, edematous wall thickening on T2WI.
   - Hypointense appearance on T1WI.
2. **Pericolic Fat and Fluid**
   - Hyperintense pericolic fluid collections and inflammatory changes on T2WI.
3. **Complications**
   - **Abscess:** Hyperintense on T2WI, hypointense on T1WI, with well-defined enhancement of the abscess wall after contrast administration.
   - **Fistula:** Abnormal connections containing both fluid and gas, visible on T2WI.

CT is the most effective modality for diagnosing acute diverticulitis due to its high sensitivity and specificity (Balk et al., 2022). While US provides a dynamic assessment, it is limited in detecting complications. MRI offers a radiation-free alternative in selected cases. Imaging not only confirms the diagnosis but also evaluates the severity and complications, guiding treatment planning.

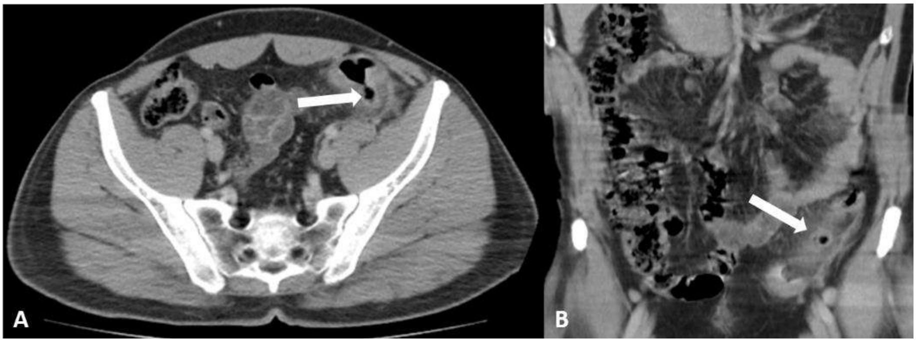

Figure 5. Axial (A) and coronal (B) abdominal CT images show a diverticulum in the sigmoid colon (white arrow in A) and increased inflammatory density in the adjacent mesentery (white arrow in B), consistent with acute diverticulitis.

6. ILEUS

Ileus refers to the cessation of normal bowel passage caused by either a mechanical obstruction or a motility disorder. It is typically categorized into small bowel and large bowel obstructions based on the level of blockage. Each has distinct imaging findings, etiologies, and treatment approaches (Khurana, Ledbetter, McTavish, Wiesner, & Ros, 2002). Imaging is crucial for determining the site, cause and complications of obstruction.

6.1. Small Bowel Obstruction

Small bowel obstructions account for approximately 80% of all mechanical obstructions. The most common cause is fibrous adhesions from previous surgeries, followed by abdominal hernias. Less frequent causes include endometriosis, tumors, strictures from Crohn's disease or radiotherapy, bezoars and gallstone ileus (Brant & Helms, 2012).

6.1.1. PR Findings: PR has a sensitivity of about 50–60% for detecting small bowel obstructions. Findings may include at least three dilated loops of bowel greater than 3 cm in diameter, prominent valvulae conniventes and air-fluid levels (Brant & Helms, 2012).

6.1.2. US Findings

 Dilated Bowel Segments

- Proximal dilated loops (>3 cm).
- Fluid-gas levels within the dilated loops.
- Collapsed distal loops.

 Bowel Wall Motion

- Hyperperistalsis in the early stages or decreased peristalsis in later stages.
- Visualized movement of fluid levels and trapped gas within the lumen.

 Cause of Obstruction

- Hernia sacs, intussusception or masses may be identified via US

6.1.3. CT Findings

1. Dilated Proximal Loops

- Bowel loops >3 cm in diameter proximally and collapsed loops (<2 cm) distally.
- Fluid-gas levels in dilated loops (Boudiaf et al., 2001).

2. Transition Zone

- A marked difference in diameter between proximal and distal segments.
- Commonly due to adhesions, hernias or masses.

3. Bowel Wall

- Wall thickening, edema ("target sign") and contrast enhancement.

4. Complications

- **Strangulation:** Hazy mesenteric fat, trapped gas or gas in the portal vein (Taniguchi et al., 2017).
- **Ischemia:** Loss of contrast enhancement and intramural gas (pneumatosis intestinalis).

6.1.4. MRI Findings

1. **Dilated Loops:** Increased loop diameter and hyperintense fluid on T2WI.
2. **Transition Zone:** Narrowed segment clearly visible.
3. **Complications:**
   - **Ischemia:** Hypointense bowel wall on T1WI and hyperintense on T2WI.

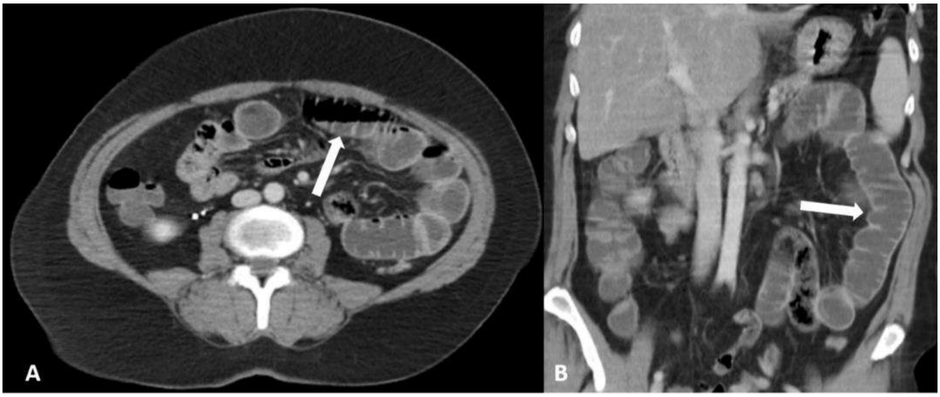

Figure 6. Axial (A) and coronal (B) abdominal CT images demonstrating air-fluid levels within dilated small bowel loops (white arrow in A) and a distended appearance (white arrow in B), findings consistent with ileus.

6.2. Large Bowel Obstruction

Large bowel (colon) obstructions are less frequent than small bowel obstructions (approximately 15–20% of all obstructions) (Brant & Helms, 2012). Clinically, patients present with abdominal pain and distention, as well as lack of gas and stool passage. Although there is no absolute threshold for dilation, a diameter of over 6 cm in the colon or 9 cm in the cecum is suggestive of dilation (Brant & Helms, 2012). Signs of peritonitis raise concern for perforation (Aguirre, Santosa, Casola, & Sirlin, 2005). The two most common causes of colonic obstruction are colorectal cancer and diverticulitis, comprising about 90% of all large bowel obstructions. Other causes include cecal (1–3%) or sigmoid volvulus (3–8%), ischemic strictures, fecal impaction and hernias (Hızal & Akpınar, 2016).

6.2.1. PR Findings:

Marked colonic distention, often with no gas in the distal colon. With prolonged obstruction, the small bowel may also become dilated.

6.2.2. US Findings

 Dilated Colon

- Diameter >6 cm, especially prominent proximally.
- Fluid-gas levels within the dilated segments.

 Cause of Obstruction

- Tumors, volvulus or inflammatory changes may be seen on US.

 Complications

- Evidence of abscess or perforation (heterogeneous fluid collections and free fluid).

6.2.3. CT Findings

Dilated Proximal Segments

- Colonic diameter >6 cm, or >9 cm in the cecum.
- Collapsed distal segments.

Transition Zone

- Often due to adhesions, tumors, or volvulus (Frager, 2002).

Volvulus

- **"Coffee bean" sign** commonly associated with sigmoid volvulus.
- **"Whirl sign"** indicating twisted mesenteric vessels (Khurana, 2003).

Complications

- **Perforation:** Free air and fluid collections.
- **Ischemia:** Loss of wall enhancement and pneumatosis intestinalis (Wiesner, Khurana, Ji, & Ros, 2003).

6.2.4. MRI Findings

- **Dilated Colon:** Hyperintense fluid collection on T2WI.
- **Cause of Obstruction:** Tumor or narrowed segment clearly identified.

 Complications: Signs of ischemia and inflammation.

A closed-loop obstruction occurs when a specific bowel segment has both its proximal and distal ends obstructed often due to adhesions, herniation or mesenteric torsion. Prolonged obstruction elevates venous and lymphatic pressures in the bowel wall, eventually compromising arterial flow, leading to infarction. This life-threatening situation is called “strangulation” and is associated with high mortality. The risk of strangulation is particularly higher in closed-loop obstructions (Boudiaf et al., 2001).

Imaging is essential not only for diagnosis but also for locating the site, determining the cause, and assessing the severity of obstruction. In small bowel obstruction, CT is the gold standard for identifying the transition zone and complications. In large bowel obstruction, CT is highly accurate in identifying causes such as tumors and volvulus. US and MRI can be useful adjuncts in selected cases.

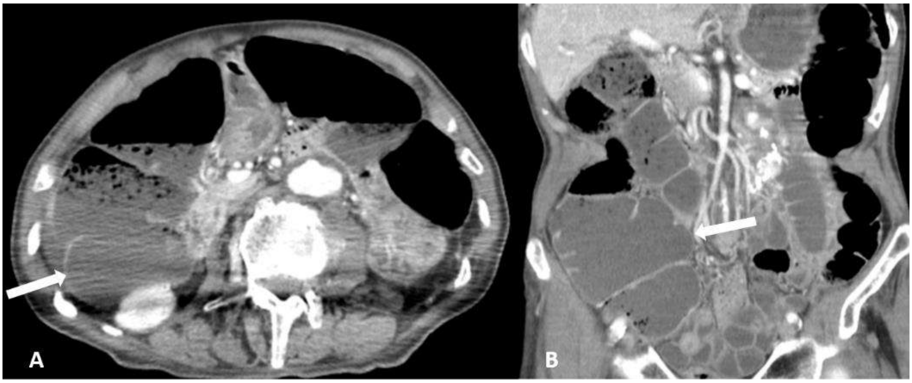

Figure 7. Axial (A) and coronal (B) abdominal CT images show marked dilation and air-fluid levels in the ascending and transverse

colon (white arrow in A) and significantly enlarged bowel loops (white arrow in B), consistent with ileus.

7. VOLVULUS

Volvulus occurs when a segment of the bowel twists around its own mesentery, resulting in luminal obstruction and compression of the mesenteric vessels (Perrot, Fohlen, Alves, & Lubrano, 2016). It most commonly affects the sigmoid colon and cecum, although it can also occur in the small intestine. Imaging plays a vital role in diagnosis and in assessing potential complications.

7.1. Sigmoid Volvulus

Sigmoid volvulus accounts for the majority of volvulus cases (Atamanalp, 2010). It is often seen in older patients and is associated with predisposing factors such as chronic constipation.

7.1.1. US Findings: US has limited utility in sigmoid volvulus but may provide certain clues.

1. **Dilated Bowel Segments**

- Proximal dilation of the sigmoid colon.
- Luminal collapse distally.

2. **“Whirlpool Sign”**

- Twisting of mesenteric vessels seen on color Doppler (Enyuma et al., 2018).
- Blood flow interruptions in mesenteric vessels can be assessed with Doppler US.

3. **Fluid-Gas Levels**

- Fluid accumulation in the proximal portion of the obstructed loop.

7.1.2. CT Findings: CT is considered the gold standard in diagnosing sigmoid volvulus, as it clearly shows both the obstruction and any related complications.

 “**Coffee Bean Sign**”

- The characteristic appearance of markedly dilated loops caused by the twisting of the sigmoid colon (Salati, McNeill, & Torreggiani, 2011).

 “**Whirl Sign**”

- Twisting of mesenteric vessels around the mesentery (Suárez Vega, Martí de Gracia, Verón Sánchez, Alonso Gamarra, & Garzón Moll, 2010).

 Proximal Dilation

- Significant luminal dilation of the proximal sigmoid colon.
- Absence of gas or fluid in the distal colon.

 Complications

- **Ischemia:** Loss of bowel wall enhancement, pneumatosis intestinalis and portal venous gas.

- **Perforation:** Free air and extraluminal fluid collections.

7.1.3. MRI Findings: MRI is not commonly used for diagnosing sigmoid volvulus but may be considered when radiation is contraindicated.

 Dilated Bowel Segments

- Hyperintense fluid on T2-weighted images (T2WI).

 “Whirlpool Sign”

- Twisting of mesenteric vessels, appearing hyperintense on T2WI.

 Complications

- **Ischemia:** Bowel wall hypointense on T1WI and hyperintense on T2WI.

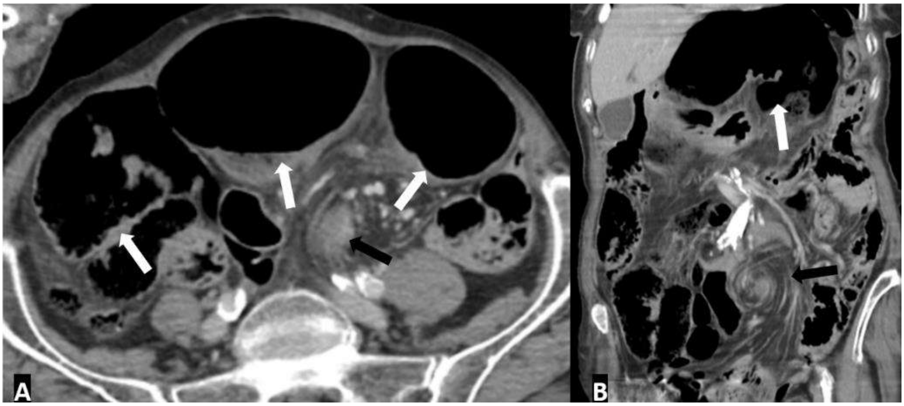

Figure 8. Axial (A) and coronal (B) abdominal CT scans show marked dilation of the ascending and transverse colon (white arrows in A and B) and a "whirl sign" suggestive of volvulus at the sigmoid colon (black arrows in A and B).

7.2. Cecal Volvulus

Cecal volvulus is less common but can lead to severe complications. It typically occurs due to anatomical variations (e.g., a mobile cecum) (Delabrousse, Sarliève, Sailley, Aubry, & Kastler, 2007).

7.2.1. US Findings

 Dilated Cecum

- A large structure with a hyperechoic wall containing fluid and gas.

 Mesenteric Changes

- Doppler US can reveal compromised blood flow in the mesenteric vessels.

7.2.2. CT Findings: CT is the most widely used imaging modality for diagnosing cecal volvulus (Dane, Hindman, Johnson, & Rosenkrantz, 2017).

 Dilated Cecum

- The diameter often exceeds >10 cm.

 Transition Zone

- Difference in caliber between the dilated proximal segment and collapsed distal segment.

 “Whirl Sign”

- Twisting of the mesenteric vessels.

 “Bird Beak Sign”

- İt refers to a tapering obstruction in the lower portion of the right colon.

 Complications

- **Ischemia and Perforation:** Free air, loss of bowel wall enhancement.

7.2.3. MRI Findings: MRI has a limited role in cecal volvulus but may be used in selected patients.

1. **Dilated Cecum**
   - Hyperintense fluid on T2WI with signal voids corresponding to gas.
2. **Complications**
   - Findings of ischemia and inflammation.

Volvulus represents a severe form of bowel obstruction, and delays in diagnosis can significantly increase mortality. CT is the gold standard for diagnosing both sigmoid and cecal volvulus. US and MRI provide supplemental information in selected scenarios. Beyond establishing the diagnosis, imaging is crucial for assessing complications and planning surgical intervention.

8. ACUTE MESENTERIC ISCHEMIA

Acute mesenteric ischemia is a clinical condition that arises when blood flow to the bowel wall is reduced or halted, requiring prompt diagnosis and treatment. It can be caused by arterial or venous events and is typically classified according to four main mechanisms (Harvey, Althans, & Bhama, 2020):

- **Acute arterial embolus**
- **Acute arterial thrombosis**
- **Nonocclusive mesenteric ischemia (NOMI)**
- **Mesenteric venous thrombosis**

Because clinical symptoms are often nonspecific and the diagnosis can be challenging, imaging studies are critical for early detection.

8.1. US Findings: US is generally not the first choice for diagnosing acute mesenteric ischemia but can be useful for bedside evaluation and Doppler assessment.

- **Bowel Wall**

- Thickening (>3 mm) or thinning (<1 mm).
- “Target sign” caused by edematous mucosa and submucosa appearing hyperechoic.

 Doppler US

- **Reduced arterial flow:** Decreased or absent flow velocity in the main mesenteric arteries.
- **Venous thrombosis:** Absent flow or a hyperechoic thrombus in mesenteric veins.

 Peritoneal Fluid

- Free or localized fluid collections suggesting early inflammatory changes.

8.2. Contrast-Enhanced CT Angiography (CTA) Findings: Contrast-enhanced CT angiography (CTA) is the gold standard for evaluating acute mesenteric ischemia (Ofer et al., 2009). Its ability to assess both vascular structures and bowel wall changes is vital for diagnosis.

 Vascular Findings:

Thrombosis or Embolus: Filling defects in the superior mesenteric artery (SMA) or vein (SMV).

Nonocclusive Mesenteric Ischemia (NOMI): Narrowing or irregular filling of mesenteric vessels (Mazzei, 2018).

 Bowel Wall

Thickening or Thinning: Thickening (>3 mm) may indicate edema or inflammation; thinning is more specific for ischemia.

Pneumatosis Intestinalis: Intramural gas, strongly indicative of necrosis due to ischemia.

Decreased Enhancement: Hypodense appearance in segmental or diffuse distributions.

 Mesenteric Changes:

Portal Venous Gas: An advanced sign of bowel necrosis secondary to ischemia (Paran, Epstein, Gutman, Shapiro Feinberg, & Zissin, 2003).

Mesenteric Fat Stranding: Suggestive of inflammation or ischemia.

 Bowel Lumen

Dilation or fluid accumulation.

8.3. MRI Findings: MRI may be used in situations where radiation exposure is a concern or when venous thrombosis is suspected:

1. **Vascular Findings**
   - **Thrombosis:** Hypointense changes on T1WI.
   - **Flow Abnormalities:** Decreased blood flow on phase-contrast MRI.
2. **Bowel Wall**

- Hyperintense edema on T2WI.
- Restricted diffusion on DWI in ischemic segments.

3. **Mesenteric Findings**
   - Edema and inflammation in the mesenteric fat.

8.4. Digital Subtraction Angiography (DSA) Findings: DSA plays an important role in the diagnosis of acute mesenteric ischemia, providing detailed images of the mesenteric vessels (Trompeter, Brazda, Remy, Vestring, & Reimer, 2002). It can precisely localize the area of vascular compromise and guide endovascular treatment (e.g., balloon angioplasty, stenting). DSA can also assess mesenteric venous involvement (van Dijk, van Petersen, & Moelker, 2017).

- **Arterial Occlusion**: Loss of flow in the SMA.
- **Nonocclusive Mesenteric Ischemia**: Vasospasm or narrowing.
- **Collateral Circulation**: Collateral vessels forming in response to obstruction.

Complications

1. **Bowel Necrosis:** Develops if ischemia persists.
2. **Perforation:** Free air or fluid collections.
3. **Sepsis:** Progression of ischemia and necrosis can lead to a septic picture.

Acute mesenteric ischemia progresses rapidly and has a high mortality rate. CTA is the gold standard for diagnosis and assessing complications. While US and MRI can provide additional information in selected cases, DSA remains crucial for both definitive diagnosis and possible therapeutic intervention. Because early recognition and management are directly tied to patient outcomes, imaging methods are of critical importance.

9. OVARIAN TORSION

Ovarian torsion is an emergency condition that occurs when the ovary (and often the fallopian tube) twists around its vascular pedicle, compromising or entirely cutting off the blood supply (Cass, 2005). Rapid diagnosis and surgical intervention are required. This pathology exhibits a bimodal age distribution, typically affecting both younger and postmenopausal women; about 20% of cases occur during pregnancy. Risk factors include adnexal masses or hypermobile ovaries, with dermoid cysts (mature cystic teratomas) being the most common mass associated with torsion (Dähnert, 2011). Imaging plays a major role in diagnosing torsion and ruling out other pelvic pathologies.

9.1. US Findings: Pelvic US, particularly with color Doppler, is the first-line imaging modality for assessing suspected ovarian torsion (Peña, Ufberg, Cooney, & Denis, 2000).

1. **Enlarged and Rotated Ovary**
    - The torsed ovary is typically enlarged (>4 cm) due to edema and venous congestion. Follicles may be displaced toward the periphery, and the ovary itself can shift in position, often moving medially toward the midline.

2. **Ovarian Cystic or Solid Lesions**
    - A predisposing mass (e.g., dermoid cyst, follicular cyst) is often found.
3. **Heterogeneous Ovarian Echotexture**
    - Reduced blood flow can lead to a heterogeneous appearance.
4. **Free Fluid**
    - Free fluid (hemorrhage or exudate) in the pelvis is commonly observed.
5. **"Whirlpool Sign"**
    - A characteristic finding on color Doppler, representing twisting of the ovarian ligaments and vessels.

Note on Doppler Findings:
Venous flow is often diminished or absent, while arterial flow may initially remain intact, its absence is a worse prognostic indicator. Intermittent torsion or dual blood supply from both the ovarian and uterine arteries can lead to preserved flow on Doppler, which does not rule out torsion (Chang, Bhatt, & Dogra, 2008).

9.2. CT Findings: CT is typically a second-line imaging modality in ovarian torsion, used to identify complications or exclude alternative diagnoses (Peña et al., 2000).

1. **Enlarged Ovary**
    - Edematous, enlarged, and heterogeneous appearance.
2. **Mesenteric Fat Changes**

    - Blurring or inflammatory changes due to torsion.
3. **Free Fluid**
    - Hypodense fluid in the pelvic region.
4. **Ovarian Mass**
    - Identification of cystic or solid lesions predisposing to torsion.

9.3. MRI Findings: MRI is generally the third-line modality for ovarian torsion, used when US and CT are inconclusive (Rha et al., 2002).

1. **Enlarged Ovary**
    - Hyperintense on T2WI due to edema.
2. **Hemorrhagic Changes**
    - Hyperintense signals on T1WI if hemorrhage is present.
3. **Associated Masses**
    - Clear visualization of the cystic or solid components causing torsion.

US with color Doppler is the imaging modality of choice for diagnosing ovarian torsion. CT and MRI can provide additional information, particularly regarding complications or in difficult cases. Early diagnosis significantly increases the likelihood of salvaging the ovary.

10. ECTOPIC PREGNANCY

Ectopic pregnancy occurs when a fertilized ovum implants outside the uterine cavity. It accounts for 1–2% of all pregnancies, with an increased incidence in assisted reproductive technologies such as in vitro fertilization (IVF). More than 95% of ectopic pregnancies occur in the fallopian tube, most commonly in the ampulla. Other sites include the interstitial/cornual region, ovary, cervix, cesarean section scar or even the peritoneal cavity (Lin, Bhatt, & Dogra, 2008). Slower than normal rises in serum β-hCG and progesterone levels can indicate ectopic pregnancy. Knowledge of β-hCG levels is crucial before imaging because an intrauterine gestational sac may not be visible on US at levels below about 2,000 IU (Valley, Mateer, Aiman, Tkoma, & Phelan, 1998). Diagnosis typically relies on clinical, laboratory and imaging findings.

10.1. US Findings: Transvaginal ultrasound (TVUS) is the first-line imaging modality for diagnosing an ectopic pregnancy (Chanana et al., 2017).

 Absence of an Intrauterine Gestational Sac

- Even at elevated β-hCG levels, no evidence of an intrauterine sac is seen.

 Adnexal Mass

- A heterogeneous solid-cystic structure within or adjacent to the tube.
- **“Ring of Fire” Sign:** Pronounced peritrophoblastic flow on color Doppler (though it can also be seen in corpus luteum cysts).

□ **Free Fluid**

- Hemoperitoneum in the pelvic cavity or in Morison’s pouch (perihepatic space).

□ **Pseudogestational Sac**

- An intrauterine fluid collection resembling a gestational sac but without an embryo.

10.2. CT Findings: CT is rarely used for ectopic pregnancy but may be utilized to assess complications or rule out other pathologies (Duigenan, Oliva, & Lee, 2012).

□ **Adnexal Mass**

A heterogeneous lesion in or near the fallopian tube or ovary.

□ **Free Fluid**

Evidence of hemoperitoneum.

10.3. MRI Findings: MRI is seldom used for ectopic pregnancy but can be helpful in complex cases requiring detailed pelvic anatomy assessment (Parker III et al., 2012).

 Adnexal Mass

- A cystic lesion that appears hyperintense on T2WI.

 Hemorrhagic Changes

- T1WI hyperintensity indicative of blood.

 Free Fluid

- Fluid collections visible within the pelvic cavity.

TVUS is the gold standard for diagnosing ectopic pregnancy. Color Doppler adds important information regarding vascularity (Bronstein, Pandya, Snyder, Shi, & Muensterer, 2015). CT and MRI can be considered for complex cases or evaluating complications (Lourenco, Swenson, Tubbs, & Lazarus, 2014). Early diagnosis and intervention significantly reduce mortality.

11. TUBO-OVARIAN ABSCESS(TOA)

A tubo-ovarian abscess (TOA) is a serious infectious condition that develops as a complication of pelvic inflammatory disease (PID). It is more frequently seen in sexually active young women. Common symptoms include localized pelvic pain, fever, vaginal discharge, and abdominal tenderness. Rapid diagnosis and treatment are crucial to prevent complications such as sepsis and infertility.

Key Clinical Findings:

- **Pain:** Severe, often unilateral pelvic pain localized in the lower abdomen.
- **Fever and Systemic Symptoms:** Temperature above 38°C, chills and malaise.
- **Vaginal Discharge:** Purulent or mucoid, often foul-smelling.
- **Dyspareunia and Dysmenorrhea:** Pain during sexual intercourse and significant pain during menstruation.
- **Abdominal Tenderness:** Severe tenderness on pelvic examination, often with bilateral adnexal tenderness.

11.1 US Findings

Transabdominal and when necessary, transvaginal US is the first-line imaging modality for TOA. It is fast, free of ionizing radiation, and can reveal the following:

- **Complex Adnexal Mass:** A septated, anechoic or hypoechoic mass.
- **Abscess Content:** Fine internal echoes suggesting purulent material.
- **Free Pelvic Fluid:** Localized or diffuse fluid collection in the pouch of Douglas.

- **Thick Abscess Wall:** Thickening of the infected tissue walls.

11.2. CT Findings

CT plays a significant role in diagnosing TOA and assessing complications. It is particularly useful in differentiating TOA from other urogenital and gastrointestinal pathologies:

- **Adnexal Mass:** A thick-walled, multiloculated mass with heterogeneous contents.
- **Stranding in Surrounding Fat:** Heterogeneous appearance in adipose tissue due to inflammation.
- **Free Fluid Collection:** Fluid accumulation in the retroperitoneal or pelvic area.
- **Air-Fluid Levels:** May be seen in anaerobic infections.

11.3. MRI Findings

MRI is an option for patients who cannot undergo radiation (e.g., pregnancy) or have contrast allergies. Its high soft-tissue contrast offers clear detail:

- **T1WI and T2WI:** Abscess fluid appears hypointense on T1WI and hyperintense on T2WI; marked diffusion restriction on DWI is typical for abscess content.
- **Contrast Enhancement of the Abscess Wall:** Inflamed, infected walls enhance distinctly after contrast administration.
- **Pelvic Inflammation:** Involvement of adjacent tissues.

Complications of Untreated TOA

- **Pelvic Peritonitis:** If the abscess ruptures, widespread peritoneal inflammation may ensue.
- **Sepsis:** Systemic dissemination of infection.
- **Fistula Formation:** The abscess may form abnormal connections with adjacent organs.
- **Chronic Pelvic Pain:** Potentially caused by ongoing inflammation or adhesions.
- **Infertility:** Resulting from fallopian tube damage.

12. URINARY SYSTEM STONE DISEASES

Urolithiasis (urinary system stone disease) is a common worldwide health problem that can significantly reduce quality of life (Abu-Naser & Shaath, 2016). It typically presents with severe colicky pain, hematuria or urinary tract infection symptoms (Sarica et al., 2016).

Stone disease can lead to ureteral obstruction and serious complications such as hydronephrosis, urosepsis, perinephric abscess, retroperitoneal hematoma and urinary extravasation (Ecer et al., 2022; Wollin et al., 2017). Rapid progression of inflammation or infection can result in an acute abdomen. Prompt and accurate diagnosis relies on clinical evaluation alongside imaging studies.

12.1. PR Findings

A direct abdominal x-ray is a simple imaging method with low radiation exposure. Its diagnostic yield varies depending on the stones' composition:

- **Radio-opaque Stones:** Calcium-rich stones are seen as radio-opaque lesions on PR.
- **Stone Localization:** Stones can be identified in the kidney, ureter or bladder.
- **Indirect Signs:** Possible hydronephrosis or secondary gaseous distension of adjacent bowel loops.

PR is useful for diagnosing radio-opaque stones but not for radiolucent stones, such as uric acid stones.

12.2. US Findings

US is frequently chosen for initial evaluation as it is radiation-free and easily performed. In patients with suspected acute abdomen due to urolithiasis, possible US findings include:

- **Echogenic Stone:** Highly echogenic with posterior acoustic shadowing; "twinkling artifact" on color Doppler.
- **Hydronephrosis:** Dilation of the renal collecting system secondary to ureteral obstruction (Davidson, 2022).
- **Perinephric Abscess:** Encapsulated fluid collection in the retroperitoneal space.

- **Retroperitoneal Fluid Accumulation:** May result from stone perforation or urinary extravasation.

Although US is very useful, sensitivity can be limited in detecting small stones or stones located in the ureter.

12.3. CT Findings

CT is considered the gold standard for diagnosing urinary stones, particularly non-contrast CT, which accurately determines the size and location of stones (Rodger, Roditi, & Aboumarzouk, 2018).

 Direct Visualization of the Stone: Hyperdense lesions in the ureter or kidney.

 Hydronephrosis and Ureteral Dilation: Proximal dilation due to back pressure (Leo et al., 2017).

 Perinephric Fat Changes: Stranding or heterogeneity caused by inflammation.

CT also provides valuable information on the severity of complications and aids in surgical planning.

12.4. Dual-Energy CT Findings

Dual-energy CT (DECT) is an advanced imaging technique that can determine the chemical composition of stones. It acquires images at two different energy levels, offering a new perspective in stone assessment:

- **Stone Composition Analysis:** Differentiates between calcium oxalate, uric acid, cystine and other types of stones (Manglaviti et al., 2011).
- **Enhanced Detection of Radiolucent Stones:** Stones that are less visible on conventional CT may be more clearly seen on lower-energy profiles (Ascenti et al., 2010).
- **Hydronephrosis and Surrounding Changes:** As with standard CT, the degree of hydronephrosis and any associated inflammation can be evaluated.

DECT is particularly valuable for treatment planning and is considered a gold standard for analyzing stone composition.

12.5. MRI Findings

Although MRI is not frequently used for assessing urinary stones, it can serve as an alternative for patients where radiation poses a high risk (Silverman, Leyendecker, & Amis Jr, 2009).

- **T2WI Fluid Collections:** Detailed visualization of hydronephrosis, perinephric abscess or retroperitoneal fluid.
- **Tissue Inflammation:** Excellent characterization of soft tissue inflammation.
- **Dynamic Evaluations:** Possible functional assessment of the ureters and kidneys without contrast material.

MRI can be particularly useful in pediatric or pregnant patients who need to avoid ionizing radiation.

12.6. Complications of Urinary System Stones

Urinary stones can lead to acute abdomen by causing various complications (Wollin et al., 2017).

- **Hydronephrosis:** Ureteral obstruction leading to fluid accumulation in the renal collecting system, risking renal function loss.
- **Urosepsis:** A potentially life-threatening systemic infection originating from obstructed, infected urine.
- **Perinephric Abscess:** Localized collection of infected material around the kidney.
- **Retroperitoneal Hematoma:** Bleeding into the retroperitoneum if a stone causes vascular injury.
- **Urinary Extravasation:** Urine leakage into the retroperitoneum through a perforated ureter.
- **Chronic Renal Failure:** Long-term obstructive and inflammatory changes can cause irreversible renal damage.

- **Extrarenal Stone Migration:** Increases in intrarenal pressure during flexible ureterorenoscopy (RIRS) or percutaneous nephrolithotomy (PNL) can cause rupture and displacement of stones beyond the renal capsule (Baytok & Ecer).

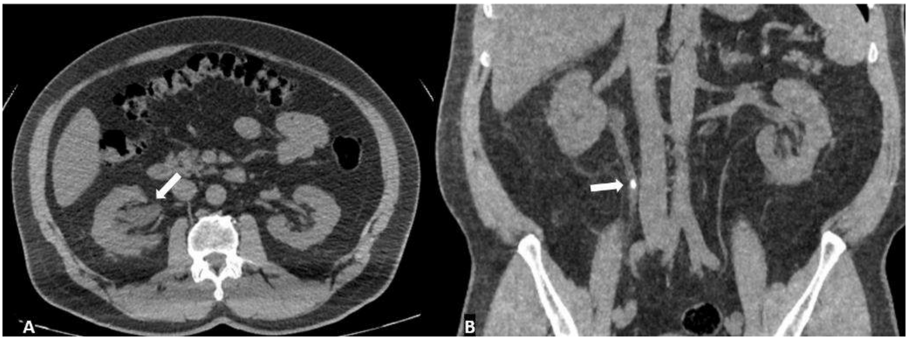

Figure 9. Non-contrast axial (A) and coronal (B) abdominal CT images show mild hydronephrosis in the right renal pelvicalyceal system (white arrow in A) and a small stone in the proximal-mid right ureter (white arrow in B).

13. TRAUMAS CAUSING AN ACUTE ABDOMEN

Traumatic injuries are a major cause of acute abdomen and can occur due to blunt or penetrating mechanisms (Pham, Kemp, & Pruitt, 2020). Solid organs (liver, spleen, kidneys, pancreas) and hollow organs (bowel, bladder) are commonly affected. Along with clinical assessment and laboratory tests, imaging plays a critical role in diagnosing organ injuries, grading them and guiding treatment.

Most organ injury classifications use the AAST (American Association for the Surgery of Trauma) grading system.

13.1. Liver Injuries

Liver injuries are the most frequently encountered solid organ injuries in abdominal trauma (Coccolini et al., 2020). The rate of hepatic injury in polytrauma patients ranges from 1% to 8%. Blunt hepatic trauma is notable for high rates of morbidity and mortality (Yoon et al., 2005). Clinical signs may include right upper quadrant pain, hypotension and hemorrhagic shock (Duron & Stylianos, 2020). Subcapsular hematoma, parenchymal laceration and vascular injuries dictate the diagnostic and therapeutic approach. Lacerations extending to the porta hepatis can involve biliary tract injury and biloma formation. In hemodynamically stable patients, non-operative management is generally preferred. Unstable patients who do not respond to fluid resuscitation or who exhibit peritonitis require surgical intervention (Kaptanoglu, Kurt, & Sikar, 2017). Interventional radiology techniques, such as angiographic embolization for arterial bleeding or percutaneous drainage of bilomas or infected fluid collections, have become increasingly important in managing abdominal trauma.

 US: Heterogeneous echogenicity, subcapsular hematoma or free fluid may be detected. FAST (Focused Assessment with Sonography for Trauma) can easily identify perihepatic fluid.
 CT: Hypodense areas consistent with contusion or laceration, periportal hemorrhage, contrast extravasation, vascular injury and devitalized parenchyma can be visualized. Active bleeding can present as an “arterial blush.” In cases of hypovolemia, the inferior vena cava may appear collapsed. Lacerations extending to the hepatic veins or the inferior vena cava suggest venous injury (Poletti, Mirvis, Shanmuganathan, Killeen, & Coldwell, 2000). A critical situation that generally requires surgery.

- **MRI:** Useful in later stages for evaluating hematoma organization, biliary tract injury and detailed vascular structures.

Table 1. AAST Liver Injury Scale

Grade	Definition
Grade I	Subcapsular hematoma (<10%), parenchymal laceration (<1 cm)
Grade II	Subcapsular hematoma (10–50%), parenchymal laceration (1–3 cm), intraparenchymal hematoma (<10 cm)
Grade III	Subcapsular hematoma (>50%), parenchymal laceration (>3 cm), intraparenchymal hematoma (>10 cm), vascular injury with active bleeding in the hepatic parenchyma
Grade IV	Laceration involving 25–75% of a hepatic lobe or 1–3 Couinaud segments within a single lobe, vascular injuries with active bleeding extending into the peritoneum
Grade V	Laceration involving >75% of a hepatic lobe or >3 segments within a single lobe, juxtahepatic venous injuries involving major hepatic veins or retrohepatic inferior vena cava.

Figure 10. In a trauma patient, axial (A) and coronal (B) contrast-enhanced CT images show hypodense regions in the liver consistent with a Grade III laceration (white arrows in A and B).

13.2. Splenic Injuries

Splenic injuries are the second most common solid organ injuries in abdominal trauma, accounting for up to 40% of intra-abdominal organ injuries (Hildebrand et al., 2014). They are associated with trauma to the lower left thorax or left upper quadrant. Splenic injuries can manifest as lacerations, intrasplenic hematomas, subcapsular hematomas or infarcts (Perrotta, Guerrieri, & Guerrieri, 2021). Rupture of the spleen often causes hemoperitoneum, which may necessitate urgent surgical intervention.

- **US:** Perisplenic fluid and heterogeneous echogenicity may be noted; FAST protocol is used for rapid detection.
- **CT:** Reveals hypodense hematomas, active contrast extravasation, parenchymal damage and devascularized areas (Hassan, Abd Aziz, Ralib, & Saat, 2011). Splenic lacerations typically appear as linear, irregular hypodensities. Intrasplenic hematomas appear as large, non-enhancing, homogeneous or

heterogeneous hypodense collections, which may contain hyperdense clots. Subcapsular hematomas appear as crescentic or oval fluid collections indenting the splenic parenchyma (Shi et al., 2019). Vascular injuries can lead to wedge-shaped infarcts, and active bleeding appears as an "arterial blush."

- **MRI:** Can be used to further characterize chronic hematomas and vascular structures.

Table 2. AAST Spleen Injury Scale

Grade	Definition
Grade I	Subcapsular hematoma (<10%), laceration (<1 cm)
Grade II	Subcapsular hematoma (10–50%), parenchymal laceration (1–3 cm), intraparenchymal hematoma (<5 cm)
Grade III	Subcapsular hematoma (>50%), parenchymal laceration (>3 cm), intraparenchymal hematoma (>5 cm), ruptured subcapsular or intraparenchymal hematoma
Grade IV	Splenic vascular injury or contained active bleeding within the splenic capsule; segmental or hilar vessel involvement causing >25% devascularization
Grade V	Completely shattered spleen or extension of vascular injury beyond the spleen into the peritoneum

Figure 11. In a trauma patient, axial (A) and coronal (B) contrast-enhanced CT images show hypodense areas in the spleen consistent with a Grade III laceration (white arrows in A and B) and extensive free fluid in the pelvis indicating hemorrhage (white arrows in C).

13.3. Renal Injuries

The kidney is the most commonly affected organ in the urinary system following trauma (Santucci et al., 2004). Approximately 8–10% of blunt or penetrating abdominal traumas involve renal injury. Flank pain, hematuria and hypotension are typical clinical signs (Kawashima et al., 2001).

- **US:** Hypoechoic hematomas, parenchymal echogenic changes, and perirenal fluid collections may be visualized. Doppler US can assess vascular injury.
- **BT:** The most sensitive modality for identifying cortical lacerations, perirenal hematomas, active bleeding and injury to vascular structures (Erlich & Kitrey, 2018).
- **MRI:** Rarely used but may help evaluate collecting system injuries and chronic vascular changes.

Table 3. AAST Kidney Injury Scale

Grade	Definition
Grade I	Contusion, hematuria, subcapsular hematoma
Grade II	Cortical laceration (<1 cm)
Grade III	Cortical laceration (>1 cm) not involving the collecting system
Grade IV	Major laceration with collecting system involvement, renal pelvis rupture and/or complete ureteropelvic disruption, segmental renal artery or vein injury, segmental infarctions (due to vascular thrombosis), active hemorrhage extending beyond Gerota's fascia (retroperitoneal or intraperitoneal)
Grade V	Shattered kidney, hilar avulsion, or main renal artery/vein laceration causing devascularization of the kidney

13.4. Pancreatic Injuries

Pancreatic trauma is relatively rare, comprising about 3–12% of all abdominal injuries (Debi et al., 2013). It often occurs in penetrating trauma (gunshot or stab wounds), while blunt trauma can compress the pancreas between the vertebral column and the anterior abdominal wall. Diagnosis is challenging due to variable clinical, laboratory and radiographic findings. Injuries range from minor parenchymal contusions or hematomas to severe lacerations and fractures involving the pancreatic duct (Lahiri & Bhattacharya, 2013). Epigastric pain, peripancreatic fluid and pancreatic duct injury are key indicators.

- **US:** May show peripancreatic fluid, but sensitivity is low.
- **CT:** Reveals parenchymal damage, duct injuries and peripancreatic fluid collections (Wong et al., 2008).
- **MRI:** Allows detailed evaluation of the pancreatic duct (Ragozzino et al., 2003).

Table 4. AAST Pancreas Injury Scale

Grade	Definition
Grade I	Minor contusion, hematoma or superficial laceration without duct injury
Grade II	Major contusion or laceration without duct involvement
Grade III	Distal transection or deep parenchymal injury with duct involvement
Grade IV	Proximal transection or deep parenchymal injury involving the ampulla and/or intrapancreatic common bile duct
Grade V	Massive disruption of the pancreatic head (shattered pancreas)

13.5. Bowel and Mesentery Injuries

Bowel and mesenteric injuries occur in approximately 3–5% of blunt abdominal traumas (Hughes & Elton, 2002). These types of injuries often occur as a result of trauma such as motor vehicle accidents. The mechanism involves compression of bowel segments between the vertebral column and the abdominal wall, causing a sudden increase in intraluminal pressure. The second and third portions of the duodenum are most frequently affected (Degiannis & Boffard, 2000). Peritoneal irritation, free air and mesenteric hematoma support the diagnosis.

- **CT:** Typical findings include extraluminal air due to bowel perforation, leakage of orally administered contrast, free fluid in the abdomen, bowel wall thickening or disruption, and linear areas of high attenuation in the mesenteric fat (Brody et al., 2000). Visible extravasation of oral contrast definitively confirms the diagnosis but is seen in only a small percentage of cases. In the absence of solid organ injury, unexplained free fluid should raise the suspicion of bowel or mesenteric injury.
- **MRI:** May better delineate mesenteric vascular injuries and ischemic areas.

13.6. Bladder Injuries

Bladder injuries often occur in association with pelvic fractures (Mahat, Leong, & Chung, 2019). A distended bladder is more susceptible to injury than an empty one. Bladder rupture presents with hematuria and suprapubic pain. Injuries are classified as extraperitoneal or intraperitoneal (Quagliano, Delair, & Malhotra, 2006), depending on whether urinary extravasation is confined to the extraperitoneal space or extends into the peritoneal cavity. Pelvic fracture, gross hematuria, unexplained pelvic fluid or a perineal hematoma should prompt consideration of lower urinary tract trauma.

- **US:** May show irregular bladder contour and free fluid.
- **CT:** Demonstrates intraperitoneal contrast extravasation and localizes the injury (Vaccaro & Brody, 2000).
- **MRI:** Useful for evaluating soft tissue injuries in the pelvis and chronic changes to the bladder wall.

Table 5. Bladder Injury Scale

Grade*	Definition
Grade I	Contusion, intramural hematoma, partial thickness laceration
Grade II	Extraperitoneal bladder wall laceration
Grade III	Extraperitoneal (>2 cm) or intraperitoneal (<2 cm) bladder wall laceration
Grade IV	Intraperitoneal bladder wall laceration >2 cm
Grade V	Bladder neck or ureteral orifice (trigone) involvement with intraperitoneal or extraperitoneal bladder wall laceration

***:** For multiple lesions up to Grade III, the injury is upgraded by one level.

CONCLUSION

Acute abdomen is a clinical condition arising from a wide range of etiologies, demanding prompt diagnosis and intervention. Accurate diagnosis using appropriate imaging modalities is critical for rapid and effective treatment. While PR is simple, quick, and inexpensive, its diagnostic utility may be limited. Nevertheless, it can be helpful in detecting free air (as in perforation) or certain types of obstruction.

US is often the first-line tool in many cases, offering quick bedside evaluation with no radiation exposure. It is especially valuable for assessing gallbladder disease, appendicitis and gynecological pathologies, providing findings that can guide clinical decisions.

However, CT is considered the gold standard in most acute abdomen scenarios due to its high sensitivity and superior anatomical detail, particularly useful for evaluating conditions like appendicitis, diverticulitis, acute pancreatitis and traumatic injuries.

MRI serves as an important alternative in selected scenarios particularly younger and pregnant patients where radiation is a concern. With or without contrast, MRI can offer high-resolution details of complex cases.

In summary, each imaging modality offers distinct advantages based on the patient's clinical status, the suspected pathology and the resources available. A complementary approach employing different modalities is often necessary to achieve accurate diagnosis and effective management in acute abdomen cases.

REFERENCES

Abu-Naser, S. S., & Shaath, M. Z. (2016). Expert system urination problems diagnosis.

Aguirre, D. A., Santosa, A. C., Casola, G., & Sirlin, C. B. (2005). Abdominal wall hernias: imaging features, complications, and diagnostic pitfalls at multi–detector row CT. *Radiographics, 25*(6), 1501-1520.

Altun, E., Semelka, R. C., Elias Jr, J., Braga, L., Voultsinos, V., Patel, J., . . . Woosley, J. T. (2007). Acute cholecystitis: MR findings and differentiation from chronic cholecystitis. *Radiology, 244*(1), 174-183.

Ames, J. T., Federle, M. P., & Pealer, K. M. (2009). Perforated duodenal diverticulum: clinical and imaging findings in eight patients. *Abdominal imaging, 34*, 135-139.

Ascenti, G., Siragusa, C., Racchiusa, S., Ielo, I., Privitera, G., Midili, F., & Mazziotti, S. (2010). Stone-targeted dual-energy CT: a new diagnostic approach to urinary calculosis. *American Journal of Roentgenology, 195*(4), 953-958.

Aspelund, G., Fingeret, A., Gross, E., Kessler, D., Keung, C., Thirumoorthi, A., . . . Lampl, B. (2014). Ultrasonography/MRI versus CT for diagnosing appendicitis. *Pediatrics, 133*(4), 586-593.

Atamanalp, S. S. (2010). Sigmoid volvulus. *The Eurasian journal of medicine, 42*(3), 142.

Baghdanian, A. H., Baghdanian, A. A., Puppala, S., Tana, M., & Ohliger, M. A. (2018). *Imaging manifestations of peptic ulcer disease on computed tomography.* Paper presented at the Seminars in Ultrasound, CT and MRI.

Balk, E. M., Adam, G. P., Bhuma, M. R., Konnyu, K. J., Saldanha, I. J., Beland, M. D., & Shah, N. (2022). Diagnostic imaging and medical management of acute left-sided colonic diverticulitis: a systematic review. *Annals of internal medicine, 175*(3), 379-387.

Balthazar, E. J. (2002). Acute pancreatitis: assessment of severity with clinical and CT evaluation. *Radiology, 223*(3), 603-613.

Bates, D. D., Fernandez, M. B., Ponchiardi, C., von Plato, M., Teich, J. P., Narsule, C., . . . LeBedis, C. A. (2018). Surgical management in acute diverticulitis and its association with multi-detector CT, modified Hinchey classification, and clinical parameters. *Abdominal Radiology, 43*, 2060-2065.

Baytok, A., & Ecer, G. Extrarenal Stone Migration After PNL and RIRS: Effectiveness of Conservative Follow-up in Light of Literature. *International Journal of Nature and Life Sciences, 8*(2), 204-210.

Boudiaf, M., Soyer, P., Terem, C., Pelage, J. P., Maissiat, E., & Rymer, R. (2001). CT evaluation of small bowel obstruction. *Radiographics, 21*(3), 613-624.

Brant, W. E., & Helms, C. A. (2012). Fundamentals of diagnostic radiology.

Brody, J. M., Leighton, D. B., Murphy, B. L., Abbott, G. F., Vaccaro, J. P., Jagminas, L., & Cioffi, W. G. (2000). CT of blunt trauma bowel and mesenteric injury: typical findings and pitfalls in diagnosis. *Radiographics, 20*(6), 1525-1536.

Bronstein, M. E., Pandya, S., Snyder, C. W., Shi, Q., & Muensterer, O. J. (2015). A meta-analysis of B-mode ultrasound, Doppler ultrasound, and computed tomography to diagnose pediatric ovarian torsion. *European journal of pediatric surgery, 25*(01), 82-86.

Burrowes, D. P., Choi, H. H., Rodgers, S. K., Fetzer, D. T., & Kamaya, A. (2020). Utility of ultrasound in acute pancreatitis. *Abdominal Radiology, 45*, 1253-1264.

Busireddy, K. K., AlObaidy, M., Ramalho, M., Kalubowila, J., Baodong, L., Santagostino, I., & Semelka, R. C. (2014). Pancreatitis-imaging approach. *World journal of gastrointestinal pathophysiology, 5*(3), 252.

Cartwright, S. L., & Knudson, M. P. (2015). Diagnostic imaging of acute abdominal pain in adults. *American family physician, 91*(7), 452-459.

Cass, D. L. (2005). *Ovarian torsion.* Paper presented at the Seminars in pediatric surgery.

Chanana, C., Gupta, N., Bansal, I., Hooda, K., Sharma, P., Gupta, M., . . . Kumar, Y. (2017). Different sonographic faces of ectopic pregnancy. *Journal of clinical imaging science, 7*.

Chang, H. C., Bhatt, S., & Dogra, V. S. (2008). Pearls and pitfalls in diagnosis of ovarian torsion. *Radiographics, 28*(5), 1355-1368.

Chawla, A., Bosco, J. I., Lim, T. C., Srinivasan, S., Teh, H. S., & Shenoy, J. N. (2015). Imaging of acute cholecystitis and cholecystitis-associated complications in the emergency setting. *Singapore medical journal, 56*(8), 438.

Childs, D. D., Lalwani, N., Craven, T., Arif, H., Morgan, M., Anderson, M., & Fulcher, A. (2024). A meta-analysis of the performance of ultrasound, hepatobiliary scintigraphy, CT and MRI in the diagnosis of acute cholecystitis. *Abdominal Radiology, 49*(2), 384-398.

Chin, C. M., & Lim, K. L. (2015). Appendicitis: atypical and challenging CT appearances: resident and fellow education feature. *Radiographics, 35*(1), 123-124.

Coccolini, F., Coimbra, R., Ordonez, C., Kluger, Y., Vega, F., Moore, E. E., . . . Abu-Zidan, F. M. (2020). Liver trauma: WSES 2020 guidelines. *World Journal of Emergency Surgery, 15*, 1-15.

Coppolino, F., Gatta, G., Di Grezia, G., Reginelli, A., Iacobellis, F., Vallone, G., . . . Genovese, E. A. (2013). Gastrointestinal perforation: ultrasonographic diagnosis. *Critical ultrasound journal, 5*, 1-6.

Dähnert, W. (2011). *Radiology review manual*: Lippincott Williams & Wilkins.

Dane, B., Hindman, N., Johnson, E., & Rosenkrantz, A. B. (2017). Utility of CT findings in the diagnosis of cecal volvulus. *American Journal of Roentgenology, 209*(4), 762-766.

Darge, K., & Anupindi, S. (2009). Pancreatitis and the role of US, MRCP and ERCP. *Pediatric radiology, 39*, 153-157.

Davidson, N. J. (2022). Ultrasound of the Renal Tract. *Abdominal Ultrasound E-Book: Abdominal Ultrasound E-Book*, 185.

Debi, U., Kaur, R., Prasad, K. K., Sinha, S. K., Sinha, A., & Singh, K. (2013). Pancreatic trauma: a concise review. *World Journal of Gastroenterology: WJG, 19*(47), 9003.

Debnath, J., George, R., & Ravikumar, R. (2017). Imaging in acute appendicitis: What, when, and why? *Medical Journal Armed Forces India, 73*(1), 74-79.

Degiannis, E., & Boffard, K. (2000). Duodenal injuries. *British journal of surgery, 87*(11), 1473-1479.

Delabrousse, E., Sarlième, P., Sailley, N., Aubry, S., & Kastler, B. A. (2007). Cecal volvulus: CT findings and correlation with pathophysiology. *Emergency radiology, 14*, 411-415.

DeStigter, K. K., & Keating, D. P. (2009). Imaging update: acute colonic diverticulitis. *Clinics in colon and rectal surgery, 22*(03), 147-155.

Ditkofsky, N. G., Singh, A., Avery, L., & Novelline, R. A. (2014). The role of emergency MRI in the setting of acute abdominal pain. *Emergency radiology, 21*, 615-624.

Duigenan, S., Oliva, E., & Lee, S. I. (2012). Ovarian torsion: diagnostic features on CT and MRI with pathologic correlation. *American Journal of Roentgenology, 198*(2), W122-W131.

Duron, V., & Stylianos, S. (2020). *Strategies in liver Trauma.* Paper presented at the Seminars in Pediatric Surgery.

Ecer, G., Sönmez, M. G., Aydın, A., Topçu, C., Alalam, H. N. I., Güven, S., & Balasar, M. (2022). Comparison of retrograde intrarenal stone surgery with and without a ureteral access sheath using kidney injury molecule-1 (KIM-1) levels: a prospective randomized study. *Urolithiasis, 50*(5), 625-633.

Enyuma, C. O., Adam, A., Aigbodion, S. J., McDowall, J., Gerber, L., Buchanan, S., & Laher, A. E. (2018). Role of the ultrasonographic 'whirlpool sign'in intestinal volvulus: a systematic review and meta-analysis. *ANZ journal of surgery, 88*(11), 1108-1116.

Erlich, T., & Kitrey, N. D. (2018). Renal trauma: the current best practice. *Therapeutic advances in urology, 10*(10), 295-303.

Frager, D. (2002). Intestinal obstruction: role of CT. *Gastroenterology Clinics, 31*(3), 777-799.

Gans, S. L., Stoker, J., & Boermeester, M. A. (2012). Plain abdominal radiography in acute abdominal pain; past, present, and future. *International Journal of General Medicine*, 525-533.

Harvey, A. R., Althans, A. R., & Bhama, A. R. (2020). Mesenteric ischemia. *Clinical Decision Making in Colorectal Surgery*, 545-550.

Hassan, R., Abd Aziz, A., Ralib, A. R. M., & Saat, A. (2011). Computed tomography of blunt spleen injury: a pictorial review. *The Malaysian journal of medical sciences: MJMS, 18*(1), 60.

Hildebrand, D., Ben-Sassi, A., Ross, N., Macvicar, R., Frizelle, F., & Watson, A. (2014). Modern management of splenic trauma. *Bmj, 348*.

Hızal, M., & Akpınar, E. (2016). Akut Abdomen. *Trd Sem, 4*, 286-298.

Hughes, T., & Elton, C. (2002). The pathophysiology and management of bowel and mesenteric injuries due to blunt trauma. *Injury, 33*(4), 295-302.

Hwang, H., Marsh, I., & Doyle, J. (2014). Does ultrasonography accurately diagnose acute cholecystitis? Improving diagnostic accuracy based on a review at a regional hospital. *Canadian Journal of Surgery, 57*(3), 162.

Inukai, K. (2019). Gallstone ileus: a review. *BMJ open gastroenterology, 6*(1), e000344.

Kaptanoglu, L., Kurt, N., & Sikar, H. E. (2017). Current approach to liver traumas. *International Journal of Surgery, 39*, 255-259.

Katabathina, V. S., Zafar, A. M., & Suri, R. (2015). Clinical presentation, imaging, and management of acute cholecystitis. *Techniques in vascular and interventional radiology, 18*(4), 256-265.

Kaura, S. H., Haghighi, M., Matza, B. W., Hajdu, C. H., & Rosenkrantz, A. B. (2013). Comparison of CT and MRI findings in the differentiation of acute from chronic cholecystitis. *Clinical Imaging, 37*(4), 687-691.

Kawashima, A., Sandler, C. M., Corl, F. M., West, O. C., Tamm, E. P., Fishman, E. K., & Goldman, S. M. (2001). Imaging of renal trauma: a comprehensive review. *Radiographics, 21*(3), 557-574.

Khurana, B. (2003). The whirl sign. *Radiology, 226*(1), 69-70.

Khurana, B., Ledbetter, S., McTavish, J., Wiesner, W., & Ros, P. R. (2002). Bowel obstruction revealed by multidetector CT. *American Journal of Roentgenology, 178*(5), 1139-1144.

Lahiri, R., & Bhattacharya, S. (2013). Pancreatic trauma. *The Annals of The Royal College of Surgeons of England, 95*(4), 241-245.

Leo, M. M., Langlois, B. K., Pare, J. R., Mitchell, P., Linden, J., Nelson, K. P., . . . Carmody, K. A. (2017). Ultrasound vs. computed tomography for severity of hydronephrosis and its importance in renal colic. *Western Journal of Emergency Medicine, 18*(4), 559.

Lin, E. P., Bhatt, S., & Dogra, V. S. (2008). Diagnostic clues to ectopic pregnancy. *Radiographics, 28*(6), 1661-1671.

Lourenco, A. P., Swenson, D., Tubbs, R. J., & Lazarus, E. (2014). Ovarian and tubal torsion: imaging findings on US, CT, and MRI. *Emergency radiology, 21*, 179-187.

Maddu, K., Phadke, S., & Hoff, C. (2021). Complications of cholecystitis: a comprehensive contemporary imaging review. *Emergency radiology, 28*(5), 1011-1027.

Mahat, Y., Leong, J. Y., & Chung, P. H. (2019). A contemporary review of adult bladder trauma. *Journal of Injury and Violence Research, 11*(2), 101.

Manglaviti, G., Tresoldi, S., Guerrer, C. S., Di Leo, G., Montanari, E., Sardanelli, F., & Cornalba, G. (2011). In vivo evaluation of the chemical composition of urinary stones using dual-energy CT. *American Journal of Roentgenology, 197*(1), W76-W83.

Mazzei, M. A. (2018). Acute mesenteric ischemia: guidelines of the World Society of Emergency Surgery: a brief radiological commentary. *World Journal of Emergency Surgery, 13*, 1-3.

Mazzei, M. A., Guerrini, S., Cioffi Squitieri, N., Cagini, L., Macarini, L., Coppolino, F., . . . Volterrani, L. (2013). The role of US examination in the management of acute abdomen. *Critical ultrasound journal, 5*, 1-9.

Mederos, M. A., Reber, H. A., & Girgis, M. D. (2021). Acute pancreatitis: a review. *Jama, 325*(4), 382-390.

Mikó, A., Vigh, É., Mátrai, P., Soos, A., Garami, A., Balaskó, M., . . . Erőss, B. (2019). Computed tomography severity index vs. other indices in the prediction of severity and mortality in acute pancreatitis: a predictive accuracy meta-analysis. *Frontiers in physiology, 10*, 1002.

Mishra, D. S., Magu, S., Sharma, N., Nain Rattan, K., Tewari, A., & Rohilla, S. (2003). Imaging in acute abdomen. *The Indian Journal of Pediatrics, 70*, 15-19.

Mostbeck, G., Adam, E. J., Nielsen, M. B., Claudon, M., Clevert, D., Nicolau, C., . . . Owens, C. M. (2016). How to diagnose acute appendicitis: ultrasound first. *Insights into Imaging, 7*, 255-263.

Narese, F., Virzì, V., Narese, D., Sciortino, A., Orlando, A., Culmone, G., & Virzì, G. (2013). Emphysematous cholecystitis: Imaging findings. *La Clinica Terapeutica, 164*(6), e519-522.

O'Connor, O. J., & Maher, M. M. (2011). Imaging of cholecystitis. *American Journal of Roentgenology, 196*(4), W367-W374.

Ofer, A., Abadi, S., Nitecki, S., Karram, T., Kogan, I., Leiderman, M., . . . Engel, A. (2009). Multidetector CT angiography in the evaluation of acute mesenteric ischemia. *European Radiology, 19*, 24-30.

Paran, H., Epstein, T., Gutman, M., Shapiro Feinberg, M., & Zissin, R. (2003). Mesenteric and portal vein gas: computerized tomography findings and clinical significance. *Digestive Surgery, 20*(2), 127-132.

Parker III, R. A., Yano, M., Tai, A. W., Friedman, M., Narra, V. R., & Menias, C. O. (2012). MR imaging findings of ectopic pregnancy: a pictorial review. *Radiographics, 32*(5), 1445-1460.

Parks, N. A., & Schroeppel, T. J. (2011). Update on imaging for acute appendicitis. *Surgical Clinics, 91*(1), 141-154.

Peña, J. E., Ufberg, D., Cooney, N., & Denis, A. L. (2000). Usefulness of Doppler sonography in the diagnosis of ovarian torsion. *Fertility and sterility, 73*(5), 1047-1050.

Perrot, L., Fohlen, A., Alves, A., & Lubrano, J. (2016). Management of the colonic volvulus in 2016. *Journal of visceral surgery, 153*(3), 183-192.

Perrotta, G., Guerrieri, E., & Guerrieri, M. (2021). Splenic trauma: Definition, classifications, clinical profiles and best treatments. *Open Journal of Trauma, 5*(1), 019-036.

Pham, J., Kemp, J., & Pruitt, J. (2020). *Acute abdomen in adult trauma.* Paper presented at the Seminars in Roentgenology.

Pinto, A., Reginelli, A., Cagini, L., Coppolino, F., Stabile Ianora, A. A., Bracale, R., . . . Romano, L. (2013). Accuracy of ultrasonography in the diagnosis of acute calculous cholecystitis: review of the literature. *Critical ultrasound journal, 5*, 1-4.

Pinto Leite, N., Pereira, J. M., Cunha, R., Pinto, P., & Sirlin, C. (2005). CT evaluation of appendicitis and its complications: imaging techniques and key diagnostic findings. *American Journal of Roentgenology, 185*(2), 406-417.

Poletti, P. A., Mirvis, S. E., Shanmuganathan, K., Killeen, K. L., & Coldwell, D. (2000). CT criteria for management of blunt liver trauma: correlation with angiographic and surgical findings. *Radiology, 216*(2), 418-427.

Quagliano, P. V., Delair, S. M., & Malhotra, A. K. (2006). Diagnosis of blunt bladder injury: a prospective comparative study of computed tomography cystography and conventional retrograde cystography. *Journal of Trauma and Acute Care Surgery, 61*(2), 410-422.

Ragozzino, A., Manfredi, R., Scaglione, M., De Ritis, R., Romano, S., & Rotondo, A. (2003). The use of MRCP in the detection of pancreatic injuries after blunt trauma. *Emergency radiology, 10*, 14-18.

Rha, S. E., Byun, J. Y., Jung, S. E., Jung, J. I., Choi, B. G., Kim, B. S., . . . Lee, J. M. (2002). CT and MR imaging features of adnexal torsion. *Radiographics, 22*(2), 283-294.

Rodger, F., Roditi, G., & Aboumarzouk, O. M. (2018). Diagnostic accuracy of low and ultra-low dose CT for identification of urinary tract stones: a systematic review. *Urologia internationalis, 100*(4), 375-385.

Salati, U., McNeill, G., & Torreggiani, W. C. (2011). The coffee bean sign in sigmoid volvulus. *Radiology, 258*(2), 651-652.

Sandrasegaran, K., Heller, M. T., Panda, A., Shetty, A., & Menias, C. O. (2020). MRI in acute pancreatitis. *Abdominal Radiology, 45*, 1232-1242.

Santucci, R., Wessells, H., Bartsch, G., Descotes, J., Heyns, C., McAninch, J., . . . Schmidlin, F. (2004). Evaluation and management of renal injuries: consensus statement of the renal trauma subcommittee. *BJU international, 93*(7), 937-954.

Sarica, K., Eryildirim, B., Sahin, C., Türkoğlu, Ö. K., Tuncer, M., Coskun, A., & Akdere, H. (2016). Emergency management of ureteral stones: Evaluation of two different approaches with an emphasis on patients' life quality. *Archivio Italiano di Urologia e Andrologia, 88*(3), 201-205.

Shakespear, J. S., Shaaban, A. M., & Rezvani, M. (2010). CT findings of acute cholecystitis and its complications. *American Journal of Roentgenology, 194*(6), 1523-1529.

Shi, H., Teoh, W., Chin, F., Tirukonda, P., Cheong, S., & Yiin, R. (2019). CT of blunt splenic injuries: what the trauma team wants to know from the radiologist. *Clinical Radiology, 74*(12), 903-911.

Shin, D., Rahimi, H., Haroon, S., Merritt, A., Vemula, A., Noronha, A., & LeBedis, C. A. (2020). Imaging of gastrointestinal tract perforation. *Radiologic Clinics, 58*(1), 19-44.

Silverman, S. G., Leyendecker, J. R., & Amis Jr, E. S. (2009). What is the current role of CT urography and MR urography in the evaluation of the urinary tract? *Radiology, 250*(2), 309-323.

Singh, A. K., Desai, H., & Novelline, R. A. (2009). Emergency MRI of acute pelvic pain: MR protocol with no oral contrast. *Emergency radiology, 16*, 133-141.

Søreide, K., Thorsen, K., Harrison, E. M., Bingener, J., Møller, M. H., Ohene-Yeboah, M., & Søreide, J. A. (2015). Perforated peptic ulcer. *The Lancet, 386*(10000), 1288-1298.

Stoker, J., van Randen, A., Laméris, W., & Boermeester, M. A. (2009). Imaging patients with acute abdominal pain. *Radiology, 253*(1), 31-46.

Strömberg, C., Johansson, G., & Adolfsson, A. (2007). Acute abdominal pain: diagnostic impact of immediate CT scanning. *World journal of surgery, 31*, 2347-2354.

Suárez Vega, V. M., Martí de Gracia, M., Verón Sánchez, A., Alonso Gamarra, E., & Garzón Moll, G. (2010). Trapped on the "whirl": diagnostic sign on emergency CT. *Emergency radiology, 17*, 139-147.

Sugi, M. D., Sun, D. C., Menias, C. O., Prabhu, V., & Choi, H. H. (2020). Acute diverticulitis: Key features for guiding clinical management. *European Journal of Radiology, 128*, 109026.

Taniguchi, K., Iida, R., Watanabe, T., Nitta, M., Tomioka, M., Uchiyama, K., & Takasu, A. (2017). Ileo-ileal knot: a rare case of acute strangulated intestinal obstruction. *Nagoya Journal of Medical Science, 79*(1), 109.

Tonolini, M., Ravelli, A., Villa, C., & Bianco, R. (2012). Urgent MRI with MR cholangiopancreatography (MRCP) of acute cholecystitis and related complications: diagnostic role and spectrum of imaging findings. *Emergency radiology, 19*, 341-348.

Trompeter, M., Brazda, T., Remy, C. T., Vestring, T., & Reimer, P. (2002). Non-occlusive mesenteric ischemia: etiology, diagnosis, and interventional therapy. *European Radiology, 12*, 1179-1187.

Vaccaro, J. P., & Brody, J. M. (2000). CT cystography in the evaluation of major bladder trauma. *Radiographics, 20*(5), 1373-1381.

Valley, V. T., Mateer, J. R., Aiman, E. J., Tkoma, M. E., & Phelan, M. B. (1998). Serum progesterone and endovaginal sonography by emergency physicians in the evaluation of ectopic pregnancy. *Academic emergency medicine, 5*(4), 309-313.

van Dijk, L. J., van Petersen, A. S., & Moelker, A. (2017). Vascular imaging of the mesenteric vasculature. *Best Practice & Research Clinical Gastroenterology, 31*(1), 3-14.

Vaughan, L. A., & Mitchem, J. B. (2021). *Initial evaluation and imaging in acute left-sided diverticulitis.* Paper presented at the Seminars in Colon and Rectal Surgery.

Wiesner, W., Khurana, B., Ji, H., & Ros, P. R. (2003). CT of acute bowel ischemia. *Radiology, 226*(3), 635-650.

Wilkins, T., Embry, K., & George, R. (2013). Diagnosis and management of acute diverticulitis. *American family physician, 87*(9), 612-620.

Wollin, D. A., Joyce, A. D., Gupta, M., Wong, M. Y., Laguna, P., Gravas, S., . . . Preminger, G. M. (2017). Antibiotic use and the prevention and management of infectious complications in stone disease. *World journal of urology, 35*, 1369-1379.

Wong, Y.-C., Wang, L.-J., Fang, J.-F., Lin, B.-C., Ng, C.-J., & Chen, R.-J. (2008). Multidetector-row computed tomography (CT) of blunt pancreatic injuries: can contrast-enhanced multiphasic CT detect pancreatic duct injuries? *Journal of Trauma and Acute Care Surgery, 64*(3), 666-672.

Yoon, W., Jeong, Y. Y., Kim, J. K., Seo, J. J., Lim, H. S., Shin, S. S., . . . Kang, H. K. (2005). CT in blunt liver trauma. *Radiographics, 25*(1), 87-104.

ACUTE ABDOMEN IMAGING FINDINGS

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