BJR

https://doi.org/10.1259/bjr.20210281

Received: 28 February 2021 | Revised: 04 July 2021 | Accepted: 16 August 2021

Cite this article as:
Basta Nikolic M, Spasic A, Hadnadjev Simonji D, Stojanović S, Nikolic O, Nikolic D. Imaging of acute pelvic pain. *Br J Radiol* 2021; **94**: 20210281.

REVIEW ARTICLE

Imaging of acute pelvic pain

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ABSTRACT

Acute pelvic pain (APP) requires urgent medical evaluation and treatment. Differential diagnosis of APP is broad, including a variety of gynecologic and non-gynecologic/ urinary, gastrointestinal, vascular and other entities. Close anatomical and physiological relations of pelvic structures, together with similar clinical presentation of different disorders and overlapping of symptoms, especially in the emergency background, make the proper diagnosis of APP challenging. Imaging plays a crucial role in the fast and precise diagnosis of APP. Ultrasonography is the first-line imaging modality, often accompanied by CT, while MRI is utilized in specific cases, using short, tailored protocols. Recognizing the cause of APP in females is a challenging task, due to the wide spectrum of possible origin and overlap of their imaging features. Therefore, the radiologist has to be familiar with the possible causes of APP, and, relying on clinical presentation, together with laboratory findings, choose the best imaging strategy in order to establish a fast and accurate diagnosis.

INTRODUCTION

Pelvic pain is a common condition affecting patients of all age groups and is defined as acute when it lasts for less than 3 months. Acute pelvic pain (APP) requires urgent medical evaluation and treatment. Differential diagnosis of APP is broad, including a variety of gynecologic and non-gynecologic entities. Close anatomical and physiological relations of pelvic structures, together with a similar clinical presentation of different disorders and overlapping of symptoms, especially in the emergency background, make the proper diagnosis of APP challenging.

The diagnosis of APP is based on anamnesis, clinical and laboratory findings, together with diagnostic imaging, which significantly increases the speed and accuracy, as well as confidence in the patient management.[1,2] In an emergency setting, both transvaginal and transabdominal ultrasound is the first-line imaging modality for initial evaluation of the patients presenting with APP, with rather high sensitivity and specificity for detection of pelvic pathology. It is a low-cost diagnostic modality, widely available, and lacks ionizing radiation.[3,4] Nevertheless, many urgent conditions require further diagnostic imaging.

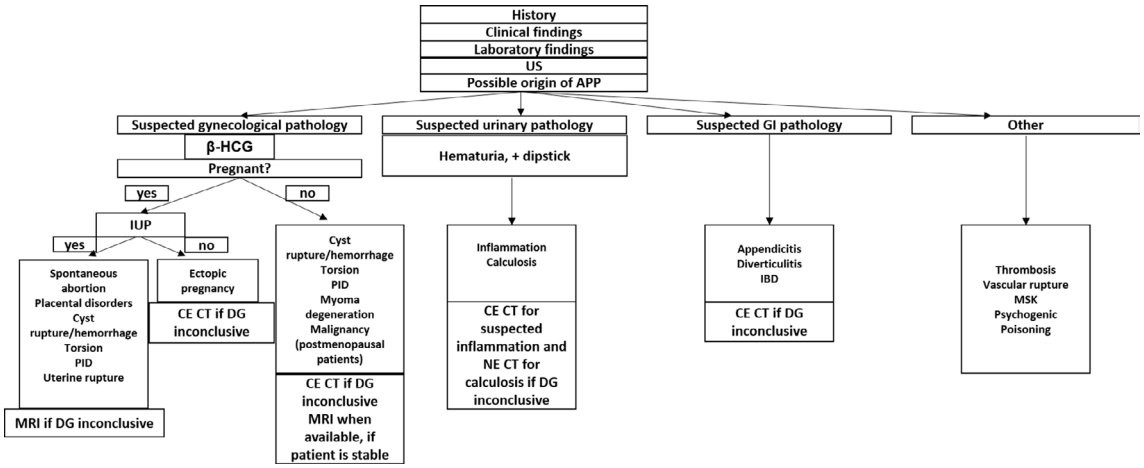
CT is a powerful diagnostic tool, widely utilized in patients with APP, especially in cases when ultrasound findings are inconclusive or urinary and gastrointestinal pathology is suspected. According to the American College of Radiology appropriateness criteria, a contrast-enhanced CT scan is the preferred imaging given the high diagnostic performances, widespread availability, and fast acquisition.[5] It has been proven that CT findings changed the referring diagnosis in more than half of all patients administered at ED and significantly influenced the treatment planning.[6] However, due to the potential harmful effects of ionizing radiation, MRI is the method of choice for young and pregnant patients, whenever available, using shorter, tailored protocols depending on the suspected diagnosis.[5,7]

The list of the most common causes of APP is summarized in Figure 1, whereas the most common radiological findings and suggested differential diagnosis were listed in Table 1.

Gynecological causes

Gynecological emergencies are among the most common conditions causing APP.–[8,9] The underlying pathological conditions leading to the onset of pain are rather diverse—[10]and can be didactically divided according to the age group, pregnancy status, and organ of origin.[11]

Figure 1. Diagnostic approach to the most common causes of APP -ultrasonography. APP, acute pelvic pain; CECT, contrast-enhanced computed tomography; DG, diagnosis; GI, Gastrointestinal; IUP, Intrauterine pregnancy; NECT, non-enhanced computed tomography.



The most common causes in non-pregnant females of reproductive age are rupture or hemorrhage of ovarian cysts, inflammation, ovarian torsion, and myoma degeneration or torsion.

Ovarian cysts are a common finding in pre-menopausal females and usually are not related to intensive pain unless they undergo hemorrhage or rupture.[12] They are easily identified with ultrasonography and CT as a thin-walled serous follicular cyst, with a diameter of 3 cm or larger, or corpus luteum cysts, which have a thick irregular wall of increased peripheral vascularity, presented as a "ring of fire" on Color Doppler ultrasound or peripheral enhancement on CT.[13]

Physiological changes during the menstrual cycle lead to increased ovarian vascularity during the luteal phase, which may lead to hemorrhage or rupture.[14] Ultrasonographicaly, hemorrhagic cyst can have a diverse presentation, depending on the evolutional stage of blood products, however, lace-like internal echoes with peripheral vascularization on CD and no internal signal, with possible fluid–fluid levels are typical. On CT, high-density content and thick, enhancing walls are observed.

In cases of rupture, hematoperitoneum (high density peritoneal free fluid) is observed, sometimes accompanied by active extravasation of contrast agent in the proximity of the cyst (Figure 2).

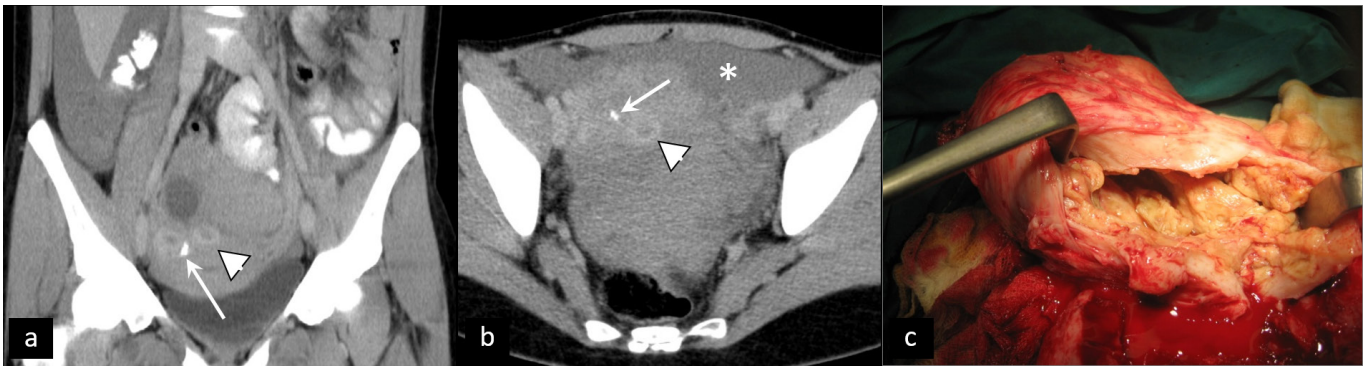
MRI is not a method of choice for the evaluation of ovarian cysts in the acute background due to the fact that it is not widely available and fast. However, hemorrhagic cysts are easily identified by MRI as T_1W hyperintense lesions without a drop of the signal on T_1W fat saturation sequences, shading sign (which is characteristic for endometrioma), and contrast enhancement.[15,16]

Table 1. Common radiological findings in APP and suggested differential diagnosis

Radiological finding		Differential diagnosis
Peritoneal fluid		Ovarian cyst rupture, ovarian torsion, ovarian hyperstimulating syndrome, ruptured ectopic pregnancy, mittelschmerz, PID, appendicitis, colonic diverticulitis, ovarian carcinoma
Fat stranding	Ileocoecal	Appendicitis, Crohn`s disease
	Pericolic	Colonic diverticulitis, epiplioc appendagitis, omental infarction
	Periileal	Crohn`s disease, regional enteritis, omental infarction
	Pelvic	PID, endometriosis, iliac aneurysm rupture
	Perirenal	Pyelonephritis
Bowel distension		Volvulus, incarcerated hernia, intususception
Pneumoperitoneum		Intestinal perforation, colonic diverticulitis, appendicitis
Retropneumoperitoneum		Emphysematous pyelonephritis, perinephric abscess
Pelviceal mass		Gynecological malignancy, degenerated myoma, endometrioma, extrauterine pregnancy, periappendicular abscess, peridiverticular abscess, iliac aneurysm
Kidney enlargement		Perinephritic abscess, pyelonephritis
Retroperitoneal heamathoma		Aortic/iliac aneurysm rupture, perirenal haemathoma

APP, acute pelvic pain; PID, pelvic inflammatory disease.

Figure 2. Rupture of corpus luteum cyst. Contrast-enhanced CT (a, b) shows multiple cysts with thick, enhancing walls (arrowhead), corresponding to the "ring of fire" sign on ultrasound, and active extravasation of contrast agent (arrow), accompanied by hematoperitoneum (asterisk). (c) Intraoperative specimen.



Some females may experience APP of different intensity at the moment of ovulation, caused by the rupture of the follicle, called "Mittelschmerz".[17] Such pain is physiological and does not require significant medical attention. It is presented as unilateral discomfort or pain of the lower abdomen, usually spontaneously resolved within several hours, sometimes accompanied by a small amount of free pelvic fluid.

Pelvic inflammatory disease (PID) is defined as an acute clinical syndrome associated with ascending spread of microorganisms unrelated to pregnancy or surgery, typically arising in sexually active pre-menopausal females.[18] It has a broad spectrum of presentation, depending on the extent of the inflammation and affected genital structures. Ultrasound findings may be inconclusive, comprising thickening and hypervascularity of genital organs, especially Fallopian tubes, accompanied by ascites and presence of cogwheel sign and beads on a string sign,[19] and should therefore always be interpreted with clinical and laboratory correlation. CT findings indicating PID include thickening and enhancement of Fallopian tube wall exceeding 5 mm, thickening of the uterosacral ligaments, obliteration of fascial planes, free fluid in the cul-de-sac, loss of definition of the uterine border, pelvic fat infiltration and pelvic edema, reactive lymphadenopathy, and signs of peritonitis–[20] (Figure 3).

Ovarian torsion is defined as torsion of the ovary and part of the tube around the vascular pedicle, leading to partial or complete vascular compromisation. It is most commonly caused by ovarian lesions but can occur in females with no underlying ovarian pathology, probably due to ovarian hypermobility.[21] Ultrasonography is the first-line imaging modality, showing enlarged ovary with engorged central ovarian parenchyma and peripherally displaced follicles, sometimes accompanied by "whirlpool sign" presenting twisted vascular pedicle and free fluid. A complete absence of Doppler signal is not mandatory due to the dual arterial supply of ovaries. Ovarian torsion has a similar presentation on CT and MRI, with MRI being preferable due to the absence of ionizing radiation and higher specificity whenever available (Figure 4). Since it most commonly affects young females, a fast and precise diagnosis is essential for the preservation of ovaries and the prevention of complications, which may include abscess formation and peritonitis.[22]

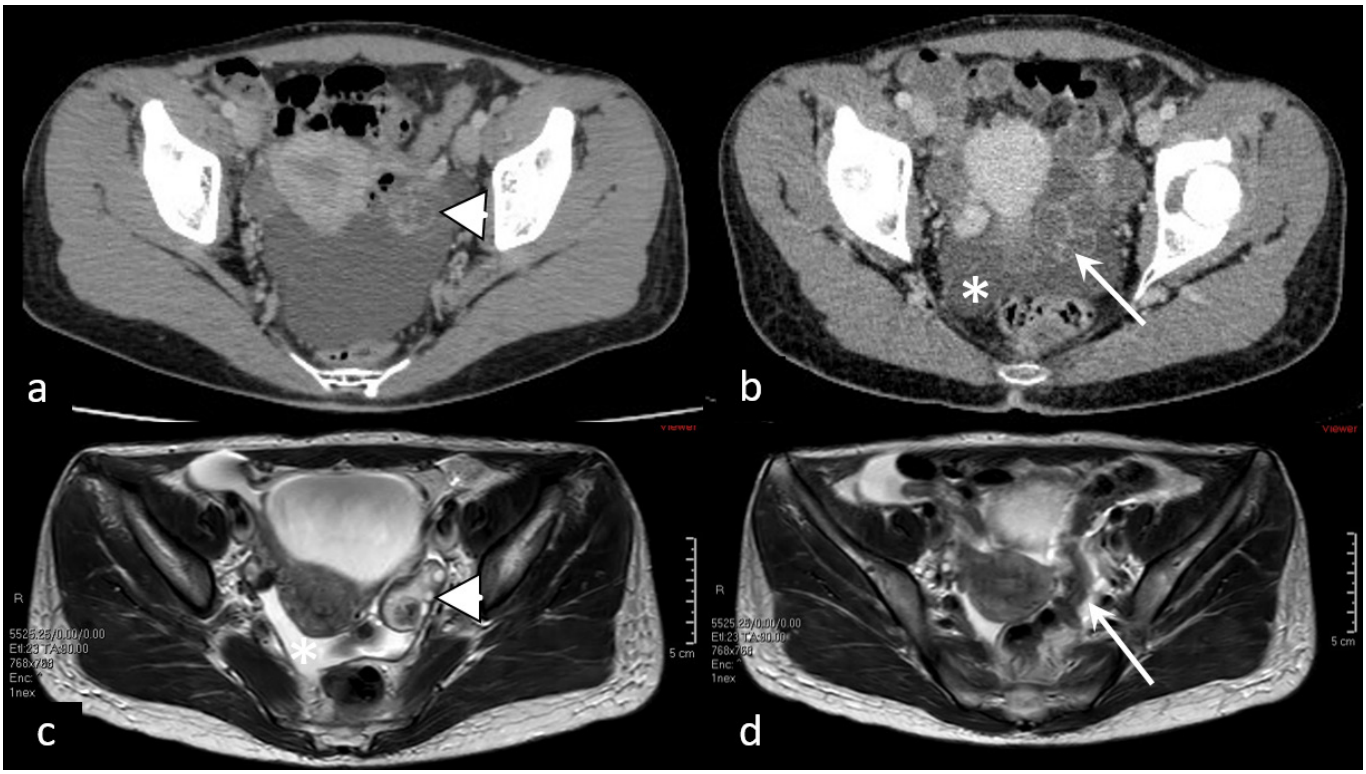
Most myomas are asymptomatic or with mild symptoms. However, in about one-third of patients, myomas can cause pain either due to degeneration or torsion. Degeneration occurs when myoma outgrows its vascular supply and can be hyaline, myxoid, red, cystic, and hemorrhagic.[23] Although hyaline is the most common, the hemorrhagic one is most likely to cause APP and is frequently related to pregnancy or contraceptive intake. Depending on the type of degeneration, ultrasonography can demonstrate inhomogeneous uterine mass, with possible cystic areas and partial absence of Doppler signal in infarction areas.[24] CT and MRI show a similar presentation of degenerated myomas, which are inhomogeneous, with cystic appearance and areas of low post-contrast attenuation due to necrosis and infarction[25] (Figure 5). Areas of high attenuation on CT and high signal intensity on MRI may suggest hemorrhage. Rapid growth and irregular pattern may pose a diagnostic challenge towards myosarcoma.[26]

Torsion of pedunculated myoma, which is a rare cause of APP, is ultrasonographically presented as heterogeneous pedunculated parauterine mass, with twisted pedicle and no or diminished blood flow within the mass on CD. CT findings include enlarged, heterogenous parauterine mass, while twisted pedicle is best depicted using MRI[27] (Figure 6).

Endometriosis, defined as as the presence of functional endometrial glands and stroma outside the uterus, is relatively common cause of acute and chronic pelvic pain, which is usually cyclic, related to secretory phase of menstrual cycle.[28] Both ultrasound and MRI are excellent diagnostic tools for depicting ovarian endometriomas—unilocular "ground glass" cystic lesions without vascularization on ultrasound and with typical "shading sign" on T_2W images, whereas MRI has shown better sensitivity for deep pelvic form.[29]

APP during pregnancy can have obstetric etiology which comprises ectopic pregnancy, spontaneous abortion, preterm or normal labour, placental disorders, predominantly placental abruption or inflammation, either pre- or post-partum. However, other disorders, such as ovarian cyst rupture or torsion, myoma degeneration, or torsion, occurring in young females can concur with pregnancy and cause acute onset of pain[30] (Figure 7). Due to the harmful effect of ionizing radiation on the fetus, especially

Figure 3. Pelvic inflammatory disease. Contrast-enhanced CT (a, b) shows slightly enlarged, inhomogenous left ovary (arrowhead), together with left parauterine tubular structure with enhancing walls (arrow), resembling inflamed fallopian tube, accompanied by ascites (asterisk). MRI (c, d) performed 3 days later confirmed oophoritis (arrowhead), however, parauterine mass was confirmed to be sigmoid colon loop (arrow).



in early pregnancy, ultrasonography, both pelvic and vaginal, is the method of choice, accompanied by MRI whenever strongly needed and available.[31]

The important diagnostic step of patients in early pregnancy with pelvic pain or vaginal bleeding is the exclusion of ectopic pregnancy (EP).[32] Transabdominal and transvaginal ultrasound in most cases show empty cavum and extrauterine mass, usually separate from an ovary, since the vast majority of EPs have tubal localization.[33] CT is not a preferable imaging modality due to radiation. However, it is occasionally utilized due to the inaccessibility of MRI and inconclusiveness of ultrasound.[34,35] In cases of rupture, hematoperitoneum is observed, clinically accompanied by signs of hemorrhagic shock (Figure 8).

Figure 4. Ovarian torsion. Inhomogenous retrouterine pelvic mass (arrowhead) presenting edematous, displaced ovary due to ovarian torsion, accompanied by ascites (arrow).

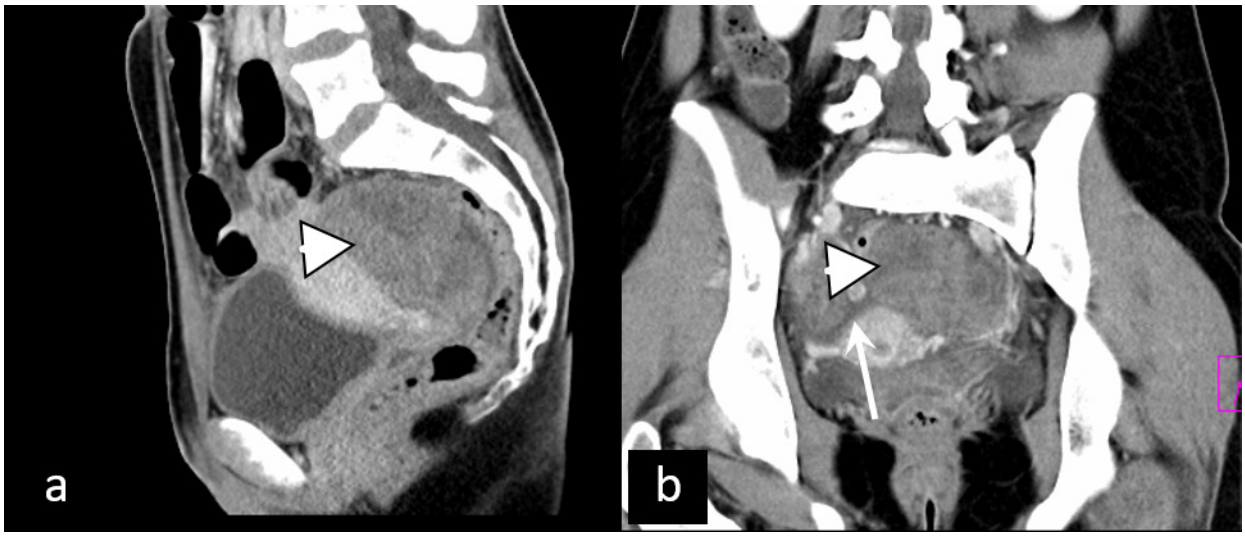
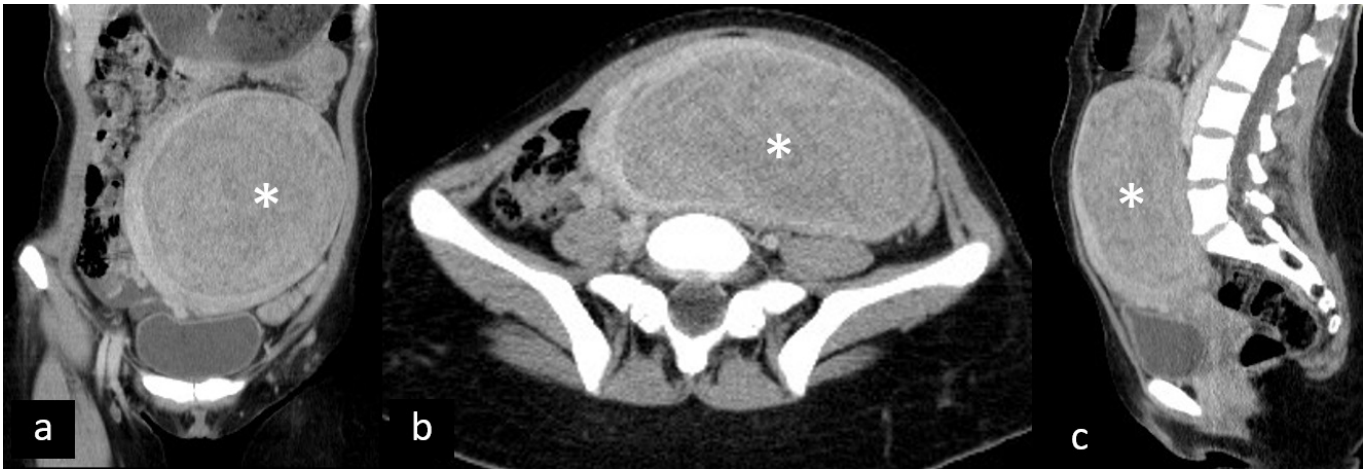


Figure 5. Degenerated myoma. Coronal (a), axial (b), and sagittal (c) contrast-enhanced CT shows large myoma (asterisk) with signs of extensive degeneration.



Placental disorders comprise placental abruption and placental adhesive disorders. The sensitivity of ultrasonography for placental abruption is low, while MRI is superior to ultrasound in the evaluation of placental hemorrhage due to better resolution and larger field of view. Three types of placental adhesive disorders (PAD), placenta accreta, placenta increta and placenta percreta show different degrees of chorionic invasion into the myometrium. The initial diagnostic tool is ultrasonography, with

Figure 6. Torsion of pedunculated myoma. (a) Coronal contrast-enhanced CT of torsion of pedunculated subserous myoma (arrowhead). Differential diagnosis towards torsion of an ovarian lesion can be challenging. Intraoperative specimen (b) and T_2W MRI (c, d) of partly necrotic solid ovarian tumor (asterisk), due to torsion, with typical "whirlpool" sign (arrow).

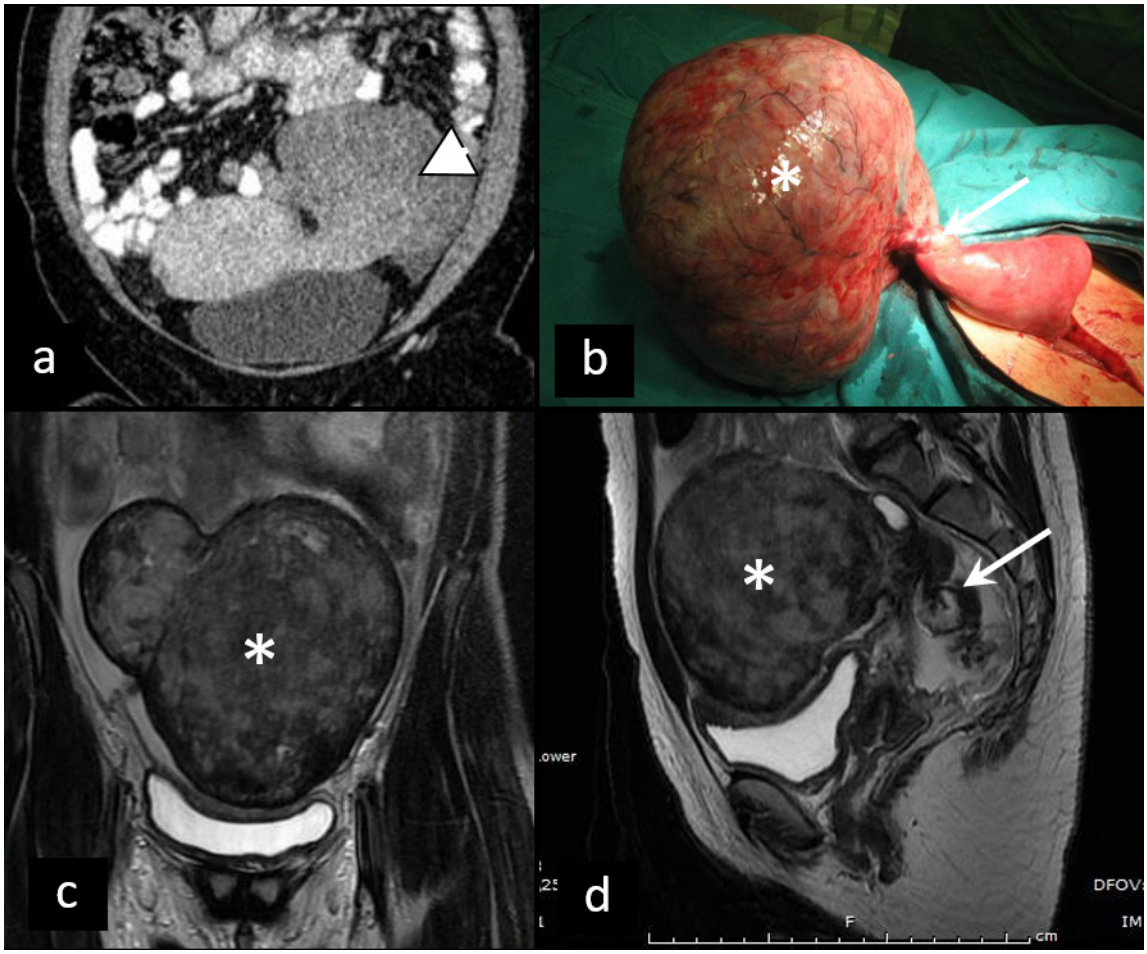
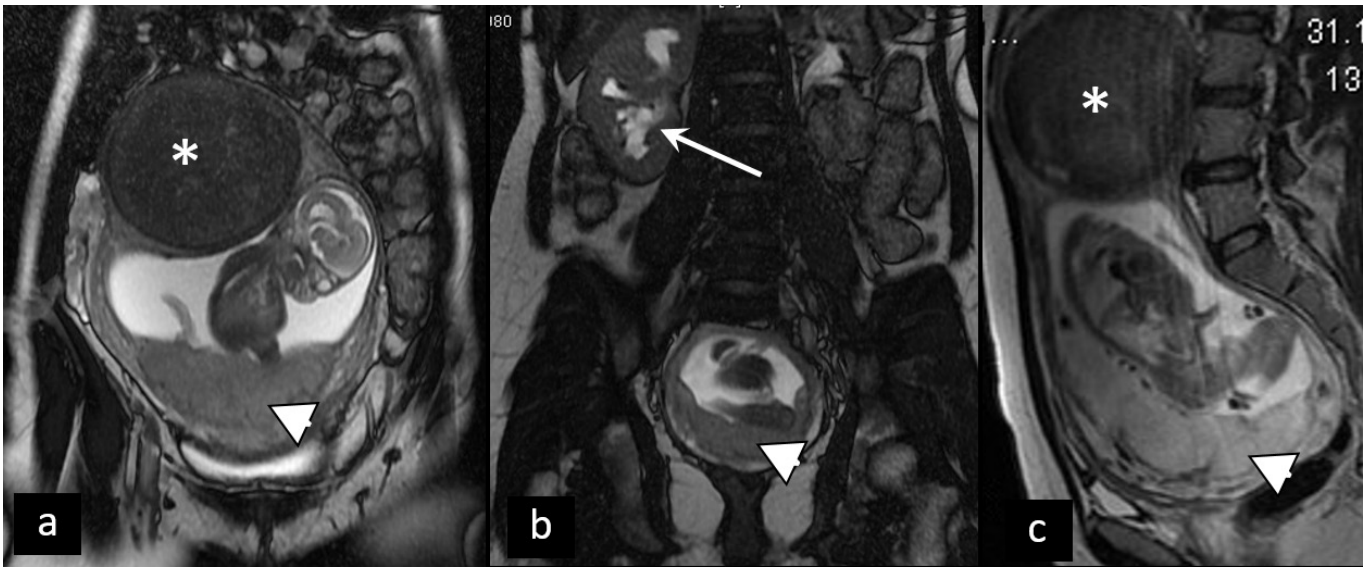


Figure 7. Patient in the second trimester of pregnancy presenting with acute abdominopelvic pain. Coronal (a, b) and sagittal (c) T_2W MRI show partly degenerated intramural myoma (asterisk), placenta previa (arrowhead), and right hydronephrosis (arrow), caused by compression of the right ureter by the enlarged uterus. Acute pain in this patient is caused by hydronephrosis.



the typical presence of lacunae in the placenta, while MRI shows dark T_2W placental bands.[30]

In females undergoing fertility treatment, ovarian hyperstimulation syndrome, a possible life-threathening iatrogenic condition, should be considered. It is characterized by enlarged ovaries with multiple follicular cysts arranged in a spoke-wheel pattern and acute fluid shift out of the intravascular space, leading to ascites, pleural od pericardial effusions[36] (Figure 9).

In post-menopausal females presenting with APP, malignancy has to be ruled out. Pelvic malignancies, most commonly ovarian or uterine cancers, can induce pain of different intensity and duration, which tends to have sudden onset in cases of complications such as perforation, venous thrombosis or inflammation (Figure 10).

Urinary causes

The origin of APP can be related to urinary system pathology, among other sites. Pain resulting from renal and ureteral stones is a common cause for patients presenting in the acute setting.[37] According to current guidelines, low dose CT is the preferred first-line imaging modality for nephrolithiasis in adults, while ultrasound is reserved for children and pregnant females[30,38] (Figure 11).

Acute pyelonephritis may well be demonstrated on non-contrast CT as unilateral perinephric stranding or renal enlargement—mild to severe grade.[39] It is mainly a clinical diagnosis with symptoms such as flank or suprapubic pain, high temperature, dysuria, or vomiting.[40] If there are no calculi, one should think of more severe complications, and intravenous iodinated contrast media must be applied. Typically, acute pyelonephritis on contrast-enhanced CT may be demonstrated as focal or wedge-shaped areas of hypoattenuation of the renal parenchyma, or it may show striated nephrogram pattern[41] (Figure 12). More serious complications of acute pyelonephritis such as a renal or perinephric abscess (Figure 13) or even vascular complications may also be seen.[42]

MRI appearance of acute pyelonephritis is similar to CT signs of the affected kidney: renal enlargement, striated nephrogram, and perinephric fluid reaction. Areas of focal pyelonephritis have lower signal intensity on T_2 weighted and show restricted proton diffusion. Calculi or air bubbles in the urinary tract may be depicted as MRI signal void.[40,43]

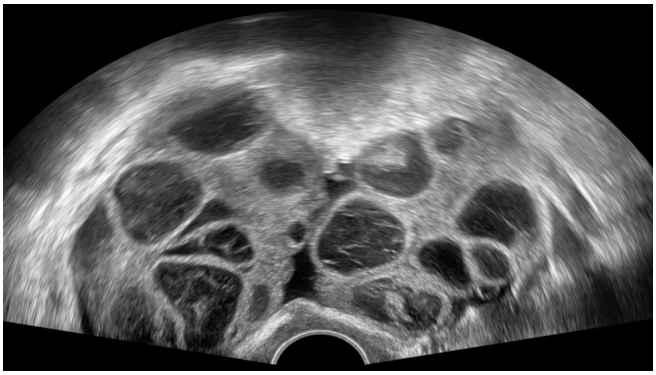
The renal ultrasound is also the first-line imaging modality in symptomatic pregnant females. The transabdominal ultrasound can visualize calculi in the renal pelvis and proximal and distal parts of the ureter (the ureteropelvic and the ureterovesical junction).[44] The transvaginal ultrasound may be useful for visualizing stones in the distal part of the ureter and at the ureterovesical junction.[45] If the ultrasound is negative for urolithiasis, a non-contrast MRI may be performed. MRI resolution tends to be less than optimal, and small stones can be missed. In unresolved cases, ultra-low-dose CT is suggested for depicting obstructing urinary tract calculi in pregnant females. Comparing to standard non-contrast CT of the abdomen and pelvis, which delivers an estimated effective radiation dose of 8–10 mSv, ultra-low-dose CT of the same region reduces radiation dose below teratogenic threshold levels significantly.[43,44]

Unsuspected urinary tract infections (UTI) may be detected on CT performed for other clinical reasons. Complicated UTI occurs in patients with structural or functional risk factors. The key aims of imaging are confirmation of urological cause, detection of obstruction and abscesses requiring interventional or surgical treatment, and detection of urolithiasis and retained foreign bodies such as catheters.[46]

Figure 8. Ectopic pregnancy. (a, b) Ruptured right tubal ectopic pregnancy (arrowhead) with massive hematoperitoneum (asterisk). (c, d) Unperforated left tubal ectopic pregnancy (arrow)—CT shows gestational sac with no signs of rupture.

Diagnosis of acute infective cystitis (AIC) is suggested when inflammatory changes are present in the bladder. Diffuse mural bladder thickening is significant if the circumferential wall is over 1 cm in thickness. On CT, the muscular layer shows poor enhancement from intramural edema. There is also "hazy "increased attenuation of the extraperitoneal perivesical fat planes.[47,48]

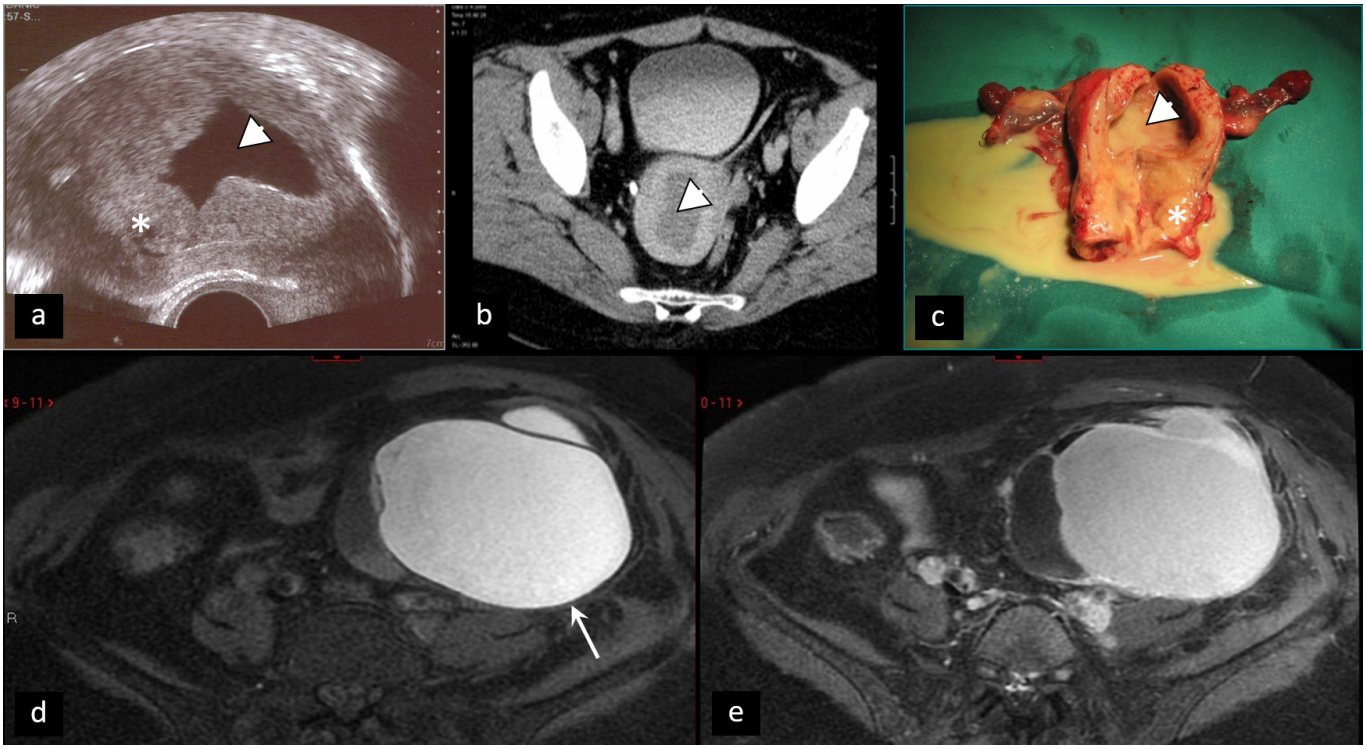
Figure 9. Ovarian hypertimulation syndrome. Ultrasonography depicts enlarged ovaries with multiple follicular cysts arranged in a spoke-wheel pattern.



Emphysematous cystitis as well as emphysematous pyelonephritis, particularly seen in diabetic patients, are a form of complicated life-threatening UTI, in which gas-forming microorganisms lead to the formation of characteristic air-attenuation linear changes within the bladder wall, air bubbles in the renal parenchyma, collecting system, bladder lumen and sometimes in the perirenal and perivesical tissue[46] (Figure 13).

At MRI, AIC can be depicted as focal or diffuse mural oedema and as inflammatory T2 hyper signal of the perivesical fat, which is most appreciated with fat suppression techniques.[49] When a soft-tissue irregularity is visualized at the interface between mural thickening and perivesical fat, the differential diagnosis of AIC must include bladder carcinoma and certain non-neoplastic disorders. Because of better tissue characterization and diffusion-weighted sequences, MRI is superior to CT in detecting tumor tissue.[46]

Figure 10. Gynecological malignancies presenting as APP. (a, b and c) Cervical cancer. (a) Ultrasound of cervical cancer (asterisk) causing cervical stenosis and consequent pyometra (arrowhead). (b) CT shows a distended uterine cavum filled with hypodense thick fluid (arrowhead). (c) Intraoperative specimen confirms the diagnosis of pyometra caused by tumor inducing cervical stenosis. (d) and (e) hemorrhagic ovarian metastasis presenting as T1FS hyperintense ovarian mass (arrow). Pre- (d) and post-contrast (e) T1FS tomograms.



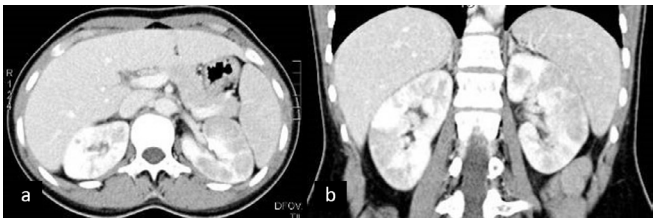
Post-treatment bladder aspect due to chemotherapy (particularly with cyclophosphamide) and irradiation, as well as rare inflammatory diseases of the bladder such as cystitis cystica, cystitis glandularis, eosinophilic cystitis, can be confused with AIC or bladder neoplasm.[50–52].

If a patient is middle-aged or elderly, with symptoms of flank pain and hematuria, one should always consider renal neoplasms. On unenhanced images, one could easily overlook urinary tract cancers as they could have discrete non-specific presentations such as subtle, focal contour abnormalities of the kidney or focal ureteral or bladder wall thickening. Close attention should be paid to an isolated subcapsular or perinephric hemorrhage because there can be underlying neoplasm.[39,53]

As for acute urethritis, imaging is preferred to exclude complications such as a periurethral abscess. A periurethral abscess can be visualized by ultrasound, but because of inflammatory swelling and tenderness of the penile and perineal structures, MRI is more often used. MRI appearance of acute urethritis is demonstrated as diffuse thickening of the urethra and periurethral tissues, with intermediate to high signal intensity on T_2 weighted images

Figure 11. Calculus (arrowhead) in the distant segment of the right ureter, causing obstruction and proximal dilatation of ureter and hydronephrosis. Pelvic ureterolithiasis can easily be misdiagnosed as phleboliths (arrow).

Figure 12. Pyelonephritis. Contrast-enhanced CT appreciation of bilateral hypodense wedge-shaped areas within thickened renal parenchyma.



and intense contrast enhancement. A urethral diverticulum can mimic the urethral abscess. It is most commonly located in the distal urethra. Other complications of acute urethritis can be visualized on CT and MRI, such as urethroperineal fistula, Fournier gangrene, and fasciitis.[54]

Gastrointestinal causes

Many intestinal pathological conditions are causes of APP. The localization of the coecum, sigmoid colon, and rectum inside the pelvis and proximity of the intestine with the utero-ovarian complex in females can lead to challenging differential diagnosis in the acute setting.

Acute appendicitis is a common cause of predominantly lower-right quadrant pain. After initial ultrasound evaluation as

Figure 13. Non-contrast CT in evaluation of urinary emergencies. (a) Patient with emphysematous pyelonephritis presenting with gas collections in pyelon (asterisk) and upper calyx (arrow). (b) The same patient with gas collections in the wall of the gallbladder and urinary bladder (arrowheads)—simultaneous emphysematous cholecystitis and cystitis. (c, d) Perinephric abscess—thick perirenal collection (asterisk) with gas particles (arrowhead).

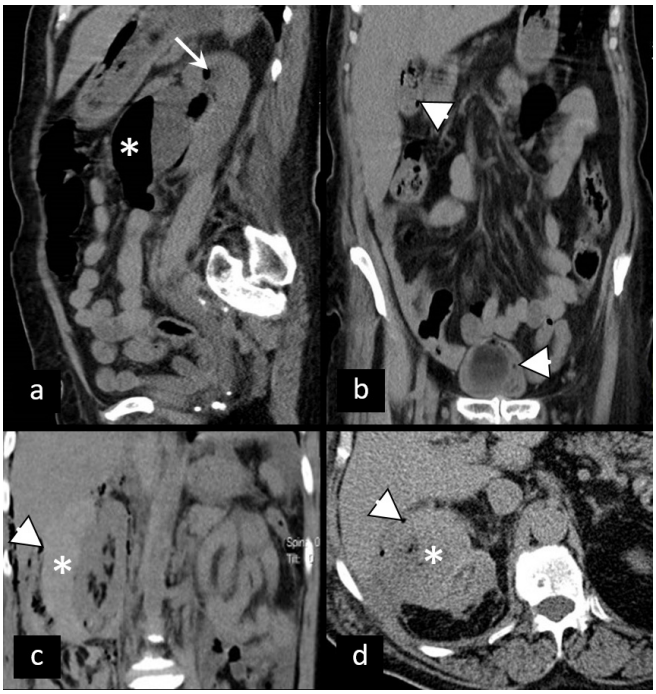
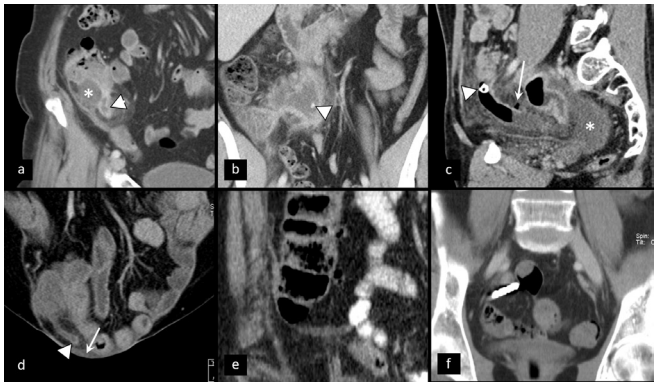


Figure 14. Appendicitis—a spectrum of appearances. (a) Enhancement of appendiceal wall (arrowhead) with periappendicular fat stranding and abscess collection (asterisk) below the insertion of appendix to the coecum. (b) Extraluminal appendicolith (arrowhead) inside periappendicular abscess. (c) Intraluminal appendicolith (arrowhead) at the insertion of the appendix—note the intraluminal air in the proximal appendix, extraluminal air bubble (arrow), contrast enhancement defect of the appendiceal wall just posterior to the air bubble, and intraperitoneal liquid (asterisk). (d) Appendicitis in a large ventral hernia—contrast enhancement of appendiceal wall (arrowhead), periappendicular fat stranding and intraperitoneal free fluid (arrow). (e) The same patient as in (d) 7 years before with horizontally positioned appendix with no signs of inflammation. (f) Imaging pitfalls—dense appendicoliths or contrast from previous imaging causing artifacts which make evaluation of the appendiceal wall and adjacent fat difficult with no evident signs of appendicitis (operative findings indicated acute gangrenous appendicitis).



second-line imaging test ultrasound, CT, and MRI evaluation have comparable and high sensitivity and specificity in children and adults, including pregnant females.[55] The concept of appendectomy as the only therapeutical measure for therapy of acute appendicitis has been challenged, thus making us regard uncomplicated and complicated appendicitis as two discrete entities where conservative therapy can be sufficient for the former.[56] Hallmarks of complicated appendicitis include contrast enhancement defect in the appendiceal wall, abscess, extraluminal air, intraluminal air, extraluminal appendicolith, intraluminal appendicolith, periappendiceal fat stranding, periappendiceal fluid, ileus, and ascites[57] (Figure 14). Although all imaging modalities have difficulties in discriminating complicated from uncomplicated appendicitis CT was reported to have a high negative predictive value for complicated appendicitis.[58] With the increased number of patients primarily treated conservatively, the role of interventional radiology in drainage of periappendicular abscesses is emerging with the reported clinical and technical success of 90%.[59] The contemporary state of knowledge on acute appendicitis places radiology in a central position in its diagnostics with proper classification of complications. Also, interventional radiology has an important role in minimally invasive treatment in selected cases.

Acute colonic diverticulitis is another cause of pelvic pain which can be classified into complicated and uncomplicated type. Uncomplicated diverticulitis is characterized by the thickening

Figure 15. Acute diverticulitis of sigmoid colon—a spectrum of appearances. (a) Non-complicated inflamed diverticulum of the sigmoid colon (arrowhead) with stranding of adjacent fat and edema of the sigmoid wall. (b) Two simultaneous diverticula with signs of non-complicated inflammation (arrowheads). (c) Liquid–fluid collection contained within mesosigmoid fat not bigger than 4 cm (arrowhead).

of the colonic wall and the edematous reaction of surrounding fat. CT is a leading imaging modality in imaging of acute colonic diverticulitis and evaluation of its complications which include perforation, abscess, bleeding, fistula, peritonitis, and stenosis,[60] with different grading systems based on CT findings. Signs of complicated disease with an increasing gravity have been proposed: pericolic air bubbles or little pericolic fluid, presence of peridiverticular abscess collection smaller and than larger than 4 cm, gas further than 5 cm from an inflamed diverticulum, and at the end of spectrum diffuse fluid collection with distant

Figure 16. Epiploic appendagitis. Ovoid fatty formation with fat stranding as a sign of edema next to the sigmoid wall. Demarcation of a hyperattenuating ring of visceral peritoneum (arrowhead). Note the lack of edema of the sigmoid wall contrary to the findings of acute diverticulitis.

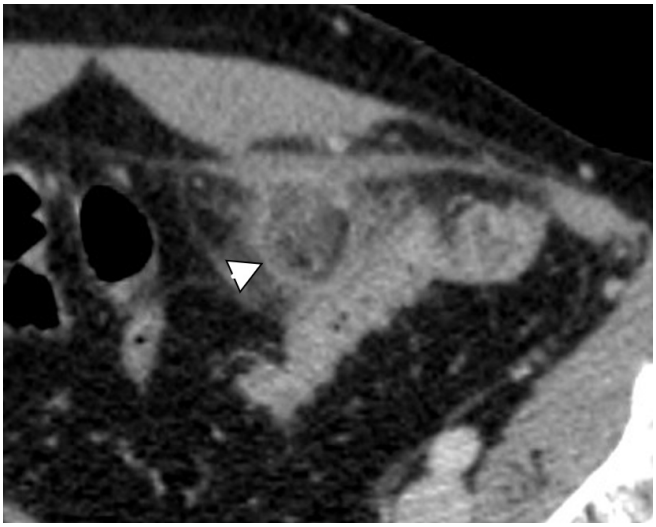


Figure 17. Necrosis of terminal ileum. (a, b) Submucous fat deposition and edema (arrow) of terminal ileum and colon with mucosal hyperemia (arrowhead); air collection in terminal ileum wall as a sign of necrosis (asterisk) and free air bubbles next to the ileal and cecal wall.

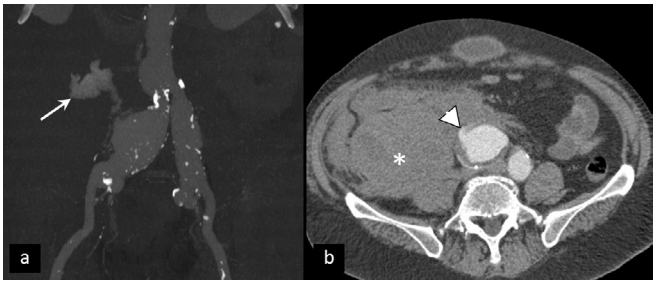
free air, as a sign of a persistent hole in the colon[61] (Figure 15). Ultrasound is usually performed as a first-line imaging modality, but its limitation in the evaluation of free gas along with difficulties in evaluation of deep abscesses and potential differential diagnosis concerning vascular and ovarian pathology stay its main limitations in characterization and grading of acute diverticulitis.[62]

Acute epiploic appendagitis is often a forgotten differential diagnosis concerning APP of intestinal origin. Torsion of cecal appendages with consequent edema and potential ischemic necrosis and aseptic inflammation leads to characteristic radiological signs on all modalities. The most specific sign on CT imaging is a fatty ovoid pericolic mass with a hyperdense ring which depicts the inflammation of the peritoneal covering of the appendage[63] (Figure 16). Secondary acute epiploic appendagitis represents inflammation of the appendage located in the proximity of another inflammatory process such as colonic diverticulitis, appendicitis, or cholecystitis.[64] If not complicated epiploic appendagitis is a self-limiting condition that resolves within 3–14 days without the need for antibiotics and surgery.[65]

Crohn's disease follow-up is a domain of MR enterography in comparison to CT imaging largely due to ionizing radiation issues. However, in an urgent setting, no significant difference between the two modalities was noted concerning acute findings in Crohn's disease.[66] APP can be caused by terminal ileitis and colitis and its complications such as fistula, abscess formation, or necrosis (Figure 17). Due to the ability of MRI to give functional information on diffusion-weighted imaging, it can be used in patients where ionization or contrast administration should be avoided.[67] New fast protocols for MR enterography evaluation have been developed with balanced steady-state free precession imaging offering excellent overall visualization of the small bowel wall, vascular structures, mesentery, and lymph nodes without contrast administration,[68] but patient preparation for MR enterography evaluation still stays as a time-consuming obstacle in the urgent setting.

Some other differentials in lower abdominal acute pain of intestinal origin are intestinal obstruction, including volvulus, intestinal perforation, regional enteritis, incarcerated hernia perirectal

Figure 18. Rupture of the right common iliac artery fusiform aneurysm. (a) VRT MIP - active extravasation of contrast material (arrow). (b) Place of the rupture of the arterial wall (arrowhead) and massive retroperitoneal hematoma (asterisk).



abscess, intussusception, Meckel diverticulitis, mesenteric arterial or venous thrombosis, omental infarction, and various rare entities such as ileal tumor torsion etc.[69–71]

Vascular causes

Acute pain in the pelvis in patients with known or newly diagnosed arterial aneurysms prompts urgent evaluation of arterial status and search of signs of potential rupture. CT is a modality of choice for evaluation of aortic and iliac artery rupture based on its speed, availability, ability to depict signs of contained or impending ruptures along with its excellent depiction of arterial anatomy (Figure 18), while bedside ultrasound examination may be helpful for patients whose condition is too unstable to allow their transfer to the CT scanner.[72] When periarterial hematoma is depicted on non-contrast CT examination in non-traumatic patients with the arterial aneurysm, an aneurysmatic rupture is highly suspicious, and after that, planning of interventional or surgical treatment is mandatory. Performing CT angiography gives further details concerning the anatomy of arterial tree and depicts possible active extravasation of contrast which is a direct sign of rupture.

Isolated iliac artery dissection is a relatively rare phenomenon, with only 3 out of 11 patients reported pain as a symptom.[73] In patients with such finding, the "satisfaction of search error" could be an issue with the real cause of pain being unidentified. On the side of the venous system, thrombosis of the iliac, mesenteric, or ovarian veins could cause APP,[74] and care must be taken to include these structures in the evaluation checklist.

Other miscellaneous conditions that can lead to APP include lead poisoning, porphyria, sickle cell crisis, somatization disorder, malingering, and narcotic seeking.[69]

CONCLUSION

Recognizing the cause of APP in females is a challenging task due to the wide spectrum of possible origin and overlap of their imaging features. Therefore, the radiologist has to be familiar with the possible causes of APP and, relying on clinical presentation, together with laboratory findings, choose the best imaging strategy in order to establish a prompt and accurate diagnosis.

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