Imaging of Acute Gynecologic Disorders

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Introduction

Pelvic pain is one of the most common causes for presentation to the emergency department. A variety of gynecological processes may be the etiology for pelvic pain; hemorrhagic ovarian cysts, pelvic inflammatory disease, ovarian torsion, endometriosis, cystitis, ovarian vein thrombosis, and ovarian hyperstimulation syndrome are a few of the most commonly encountered pathologies. Before medical imaging is performed for evaluation of pelvic pain, it is important to obtain relevant clinical history and review available laboratory information. The patient's age and pregnancy status are of particular importance in the differential diagnosis; therefore, serum beta-hCG laboratory evaluation is performed if there is even a remote possibility of pregnancy.

Transvaginal and transabdominal ultrasound are the workhorse modalities for the evaluation of pelvic pain when a gynecological etiology is suspected. Transvaginal and/or transabdominal ultrasound are both considered equally appropriate when evaluating pelvic pain; this is true whether the serum beta-hCG is positive or negative and whether a gynecologic or nongynecologic etiology is suspected.

Magnetic resonance imaging may be appropriate in the evaluation of pelvic pain in pregnant and nonpregnant women when ultrasound is nondiagnostic. The limitations of MR include limited availability, long imaging time, high cost, and motion artifacts from peristalsing bowel.

CT is not the frontline imaging modality in the evaluation of pelvic pain when a gynecologic etiology is suspected. It is the most appropriate imaging modality for acute pathologies of the gastrointestinal or urinary tract.

Functional Ovarian Cysts

The normal ovary in the preovulation period shows multiple simple follicles including a dominant follicle which usually measures less than 2.5 cm. At ovulation the dominant follicle ruptures, releasing an egg and a small amount of free fluid. Following ovulation, the dominant follicle becomes the corpus luteum cyst which usually measures less than 2.5 cm in maximal diameter and demonstrates a peripheral ring of increased vascularity on Doppler ultrasound. The regressing corpus luteum eventually forms the corpus albicans [1].

During the ovarian cycle, multiple events may occur which would prompt a visit to the emergency department. Many women experience varying degrees of pain during rupture of the dominant follicle at ovulation; the term mittelschmerz ("middle pain") is used to describe this pain accompanying rupture of the normal dominant follicle with release of the egg. A woman may experience pain from peritoneal irritation from the cyst rupture or pain due to hemorrhage into a cyst. Most ruptured ovarian cysts or hemorrhagic ovarian cysts are physiologic [2].

Imaging Findings

Simple ovarian cysts are anechoic without septations on ultrasound. In premenopausal women, if these simple cysts are less than or equal to 5 cm, they are mostly benign. In postmenopausal patients, simple cysts less than 1 cm do not require follow-up. If the features of an ovarian cyst are concerning for malignancy (i.e., thick septations, mural

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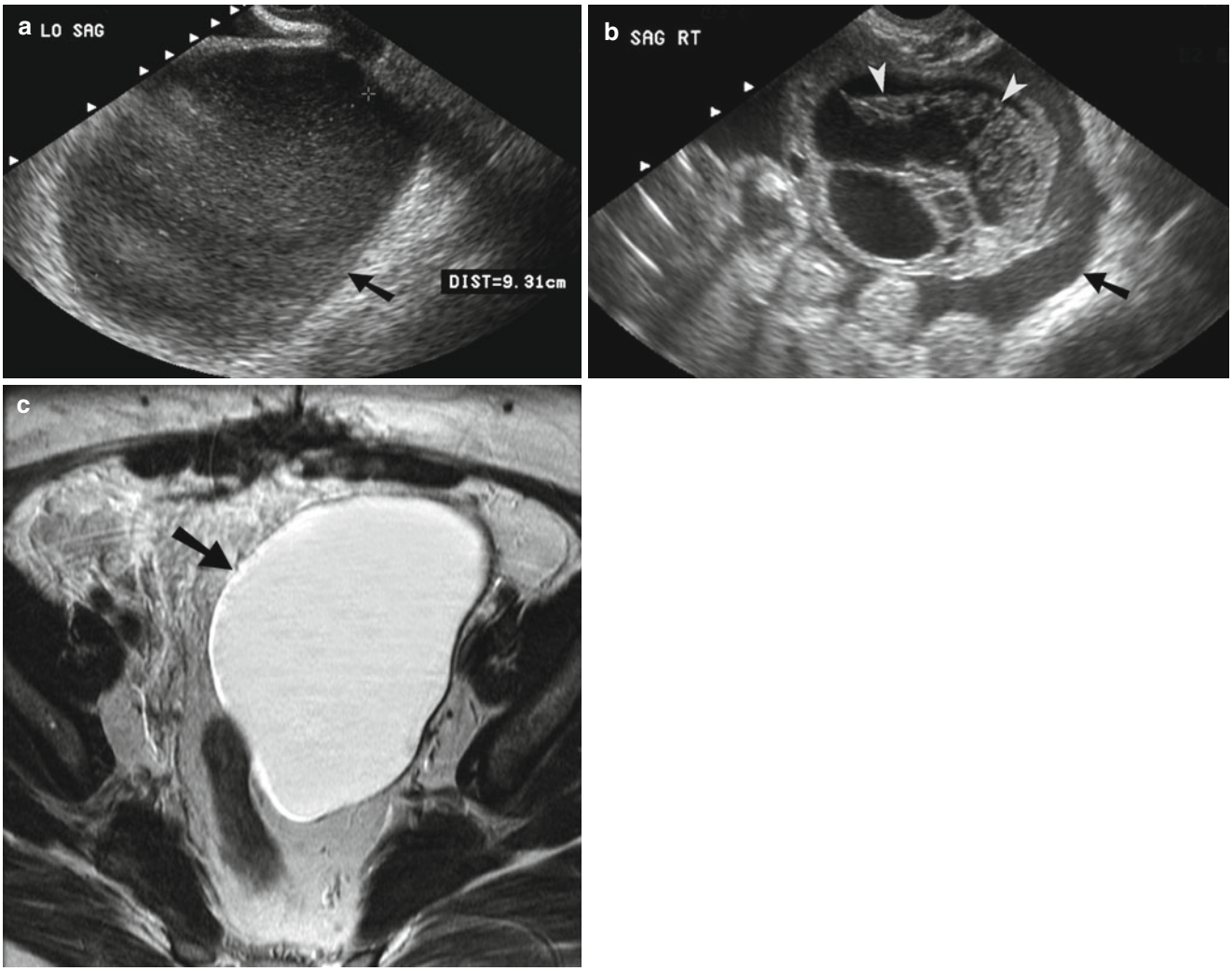


Fig. 13.1 Corpus luteal cyst. (**a**) Sagittal grayscale transabdominal ultrasound image of the pelvis demonstrates a large, cystic lesion (*arrow*) with relatively homogeneous internal echogenicity and posterior acoustic enhancement. (**b**) Ultrasound study demonstrates a hemorrhagic functional ovarian cyst containing a blood clot (*arrowhead*). There is surrounding hemorrhagic fluid (*straight arrow*) that is also seen in the adnexa. (**c**) Axial T2-weighted MR image of the pelvis shows a T2 hyperintense corpus luteal cyst in the left hemipelvis (*arrow*). Note the thin wall and lack of internal septations or nodularity

nodularity, or contrast enhancement), surgical consultation would be recommended regardless of the sonographic appearance.

A ruptured ovarian cyst does not have a specific appearance, and often the only finding is the presence of free fluid in the pelvis. Almost half of women will have some free fluid in the pouch of Douglas on ultrasound during normal ovulation; therefore, correlation with patient symptoms is necessary.

Hemorrhagic ovarian cysts on ultrasound classically have a hypoechoic appearance with a reticular pattern of internal echoes sometimes described as lacelike, spiderweb, or fishnet. Hemorrhagic cysts in premenopausal patients which measure greater than 5 cm should undergo follow-up imaging in 6–12 weeks on days 3–10 of the menstrual cycle (Fig. 13.1). Postmenopausal patients should never have a hemorrhagic cyst [1]. Hemoperitoneum resulting from a ruptured hemorrhagic ovarian cyst may be demonstrated as a large amount of complex fluid in the pelvis on ultrasound. CT reveals hyperdense fluid within the peritoneal space and possible hyperdense sentinel clot adjacent to the hemorrhagic cyst. On MRI, hemorrhagic cyst is most often T2 hyperintense and hemorrhagic ascites is T1 hyperintense (Fig. 13.2) [3].

Pelvic Inflammatory Disease: Tubo-Ovarian Abscess and Pyosalpinx

Pelvic inflammatory disease (PID) is usually caused by bacterial infection with Chlamydia trachomatis or Neisseria gonorrhoeae [4]. Infection begins in the vagina and spreads to the endometrium causing endometritis. The infection then

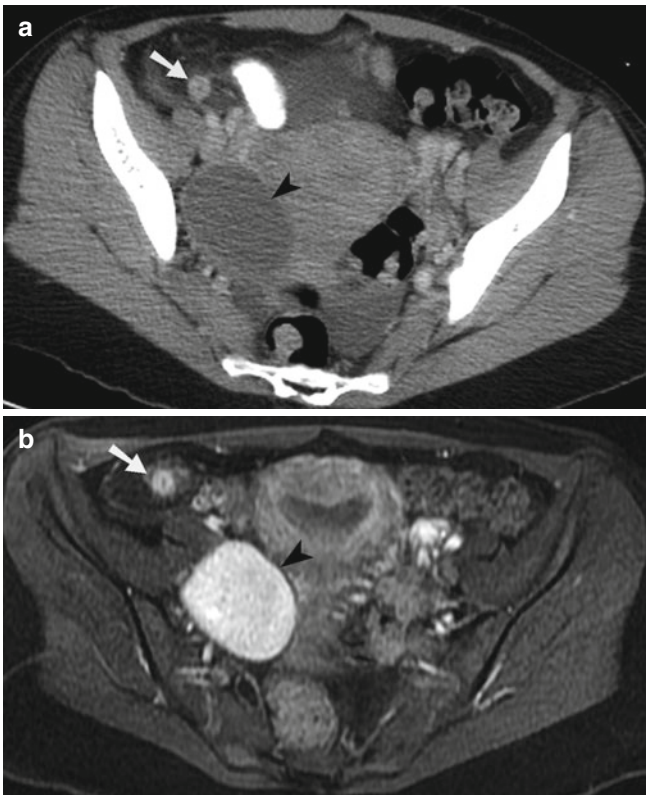


Fig. 13.2 Hemorrhagic ovarian cyst and appendicitis. (**a**) Contrast-enhanced axial CT image through the pelvis demonstrates an enlarged appendix with surrounded inflammatory fat stranding in the right lower quadrant (*arrow*). An oval, rim-enhancing ovarian cyst is identified to the right of the uterus (*arrowhead*), along with small amount of free fluid. (**b**) Axial contrast-enhanced, T1-weighted MR image with fat saturation obtained through the pelvis demonstrates a hyperenhancing, enlarged appendix with surrounding inflammatory changes in the adjacent mesenteric fat (*arrow*). The nonenhancing internal component of the hemorrhagic right ovarian cyst (*arrowhead*) is homogeneously T1 hyperintense, consistent with methemoglobin

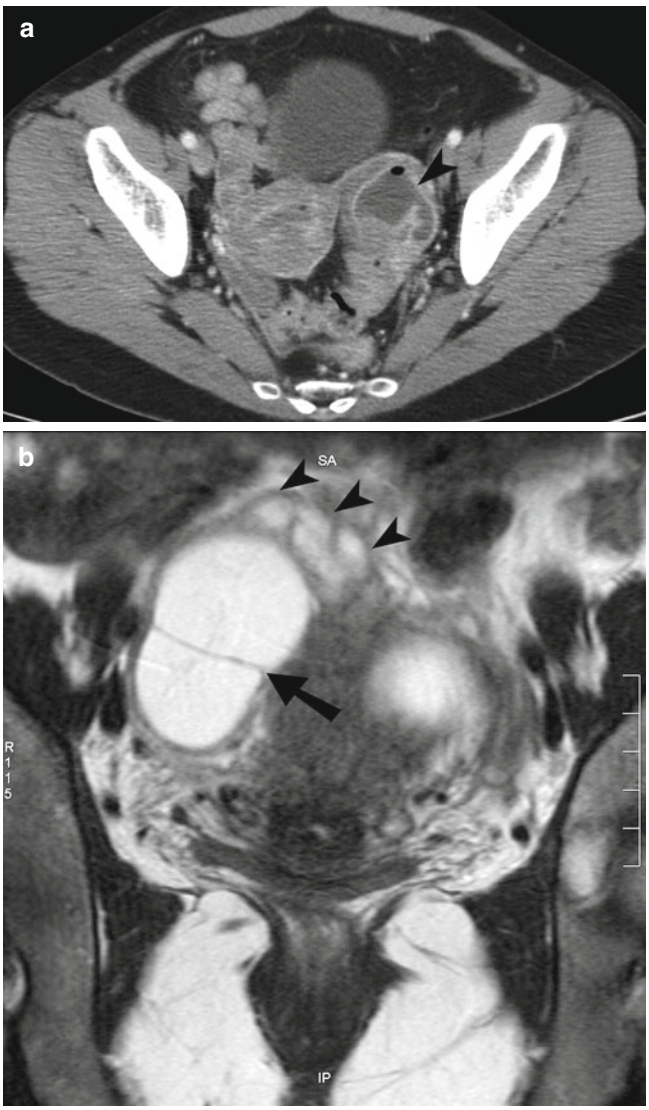


Fig. 13.3 Tubo-ovarian abscess. (**a**) Axial contrast-enhanced CT image through the pelvis shows a left adnexal lesion containing a peripherally enhancing tubo-ovarian abscess (*arrowhead*) with a small focus of nondependent air. The ovary and fallopian tube are not distinguishable as separate structures. (**b**) Coronal noncontrast T2-weighted MR image of the pelvis demonstrates a large T2 hyperintense right adnexal abscess with a thick peripheral capsule and an internal septation (*arrow*). A mildly dilated, serpiginous fallopian tube (*arrowheads*) with a thick wall is seen extending in to the abscess

extends into the fallopian tube. The resulting inflammatory changes, edema, and exudate result in obstruction of the fallopian tube and formation of a pyosalpinx [5]. The infection then extends out along the fimbria and enters the ovary (often via a ruptured corpus luteum), leading to tubo-ovarian abscess [6]. The disease can spread in the peritoneal space to involve various organs including the liver and right paracolic gutter (Fitz-Hugh-Curtis syndrome).

The symptoms are often nonspecific and may include fever, pelvic pain, cervical/adnexal tenderness (chandelier sign), vaginal discharge, dyspareunia, nausea, and vomiting. Up to 35 % of the patients with PID have no symptoms [7].

Imaging

Pelvic ultrasound is the modality of choice when PID is suspected, due to high sensitivity and specificity with relatively low cost. Because the symptoms of PID are nonspecific, CT is often the first study performed, especially when the differential diagnosis is wide and includes other suspected pathologies such as diverticulitis or appendicitis (Fig. 13.3a). Pelvic MRI also has high sensitivity and specificity for pelvic inflammatory disease; however, it is usually not considered a first-line imaging modality (Figs. 13.3b and 13.4) [4].

On ultrasound, the fallopian tubes often become distended with fluid in patients with PID. In acute disease, the fallopian tube walls measure 5 mm or thicker and demonstrate abundant

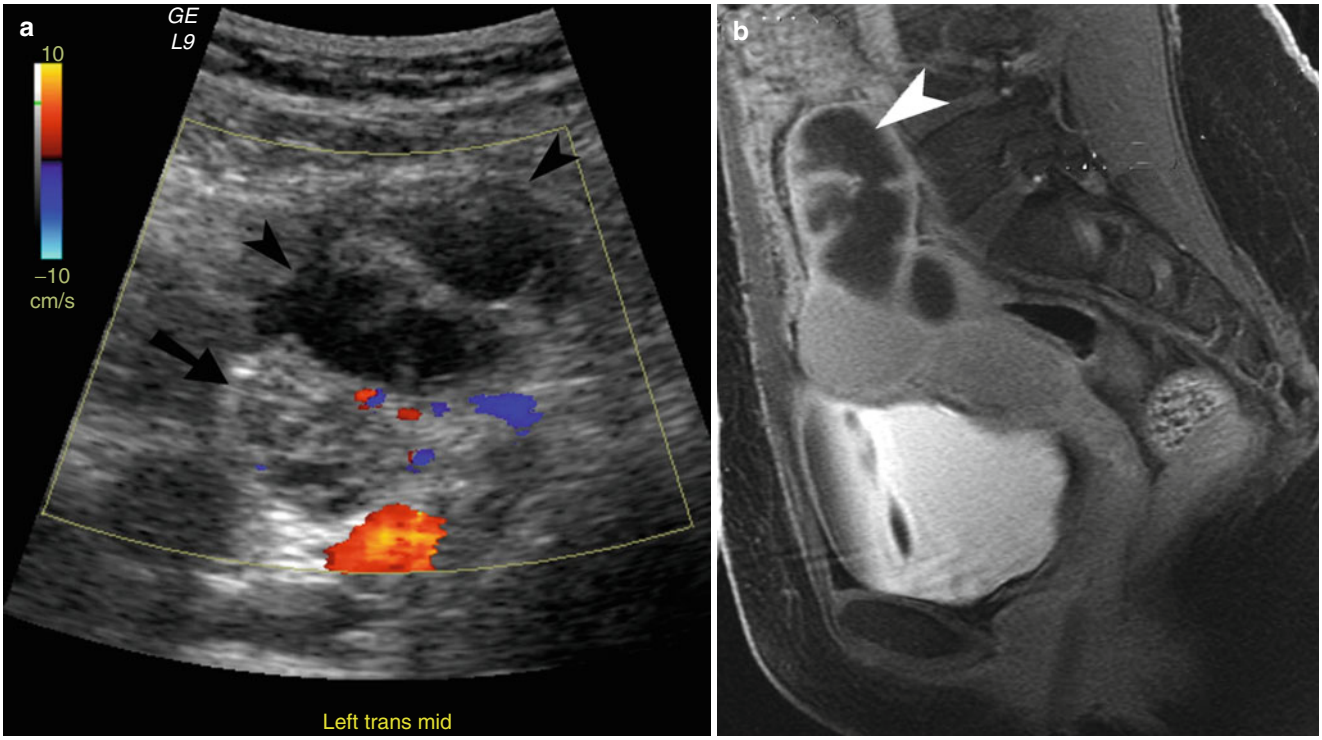


Fig. 13.4 Pyosalpinx (**a**) Transvaginal ultrasound image demonstrates a dilated fallopian tube (*arrowheads*) located adjacent to the ovary (*arrow*). (**b**) Sagittal contrast-enhanced T1-weighted MR image with fat saturation demonstrates a dilated fallopian tube (*arrowhead*) with incomplete internal septations and prominent contrast enhancement of the thickened tube wall

color flow with reduced flow resistance on the Doppler images (resistive index near 0.5). As the fluid-filled fallopian tubes distend, they become tortuous and fold on themselves; these folds have the appearance of incomplete septa. The thickened tube wall, fluid-filled lumen, and thickened mucosal folds can produce the "cogwheel sign" [5]. In pyosalpinx, fluid-debris levels are often visualized in the distended tubes. If the ovary cannot be visualized separate from this inflammatory mass, then the diagnosis of a tubo-ovarian abscess should be suggested rather than pyosalpinx. In chronic tubal disease, the luminal distention increases, the tube wall becomes thin, and mucosal folds are much more spread out resulting in a "beads-on-a-string" sign when visualized in cross section [5].

On CT, the findings of PID include dilated fallopian tubes, enlarged ovaries, inflammatory changes in the adjacent pelvic fat, thickening of the uterosacral ligaments, and peritoneal hyperenhancement [4, 7, 8]. The secondary findings which may include small bowel ileus/obstruction, perihepatitis (Fitz-Hugh-Curtis syndrome), and ureteral obstruction can be better evaluated on CT [4].

Pelvic infection with *Actinomyces israelii* is associated with the use of intrauterine contraceptive device. Tubo-ovarian abscesses with actinomycosis usually appear solid and may contain small rim-enhancing lesions. This infection spreads by direct extension, demonstrating linear, enhancing lesions which often have an appearance resembling carcinomatosis.

On MRI, a tubo-ovarian abscess usually presents as a mass which is T1 hypointense, often with hyperintense hemorrhage or proteinaceous debris. There is often a thin rim of T1 hyperintense signal along the inner portion of the abscess, secondary to hemorrhage within a layer of granulation tissue [8]. The abscess is usually hyperintense on T2-weighted sequence. On the postcontrast images, there is enhancement of the abscess wall and adjacent fat stranding [9]. Tubo-ovarian abscesses are hyperintense on diffusion-weighted images and demonstrate diffusion restriction [10].

Endometriosis

In endometriosis, endometrial tissue develops outside the uterine cavity, possibly due to metastatic implantation of endometrial cells from retrograde menstruation [11]. The most common locations for endometriosis include the ovaries (endometriomas), uterosacral ligament, rectosigmoid colon, vagina, and bladder. The ectopic endometrial tissue in endometriosis infiltrates adjacent structures causing an intense desmoplastic reaction, fibrosis, adhesions, and muscular hyperplasia. These changes can result in dysmenorrhea, dyspareunia, dyschezia, dysuria, back pain with menses, and hematuria [12–14].

Laparoscopy is the gold standard for the diagnosis, staging, and treatment of endometriosis; however, in cases where there is limited mobility of pelvic structures due to extensive fibrosis and adhesions, laparoscopic evaluation may be limited. The goal of imaging is lesion mapping for presurgical

planning and postsurgical response evaluation. Transvaginal ultrasound is the first-line imaging technique for initial evaluation of suspected endometriosis.

Imaging

On ultrasound, deeply infiltrating endometrial implants are hypoechoic compared to myometrium. The endometriomas demonstrate diffuse low-level internal echoes and no internal blood flow.

MRI is probably the most specific imaging modality for diagnosing endometriomas. MRI is best for looking at hemorrhagic content, which is hyperintense on fat-suppressed T1-weighted images and hypointense on T2-weighted images (Fig. 13.5a). The surrounding desmoplastic reaction is hypointense on T1-weighted and T2-weighted sequence [12, 13]. Endometriomas are classically T1 hyperintense and T2 hypointense (described as "T2 shading") (Fig. 13.5b). Endometriosis may rarely be a cause of hemoperitoneum which can result from rupture of an endometrioma or infiltration and subsequent rupture of the uterine artery [14].

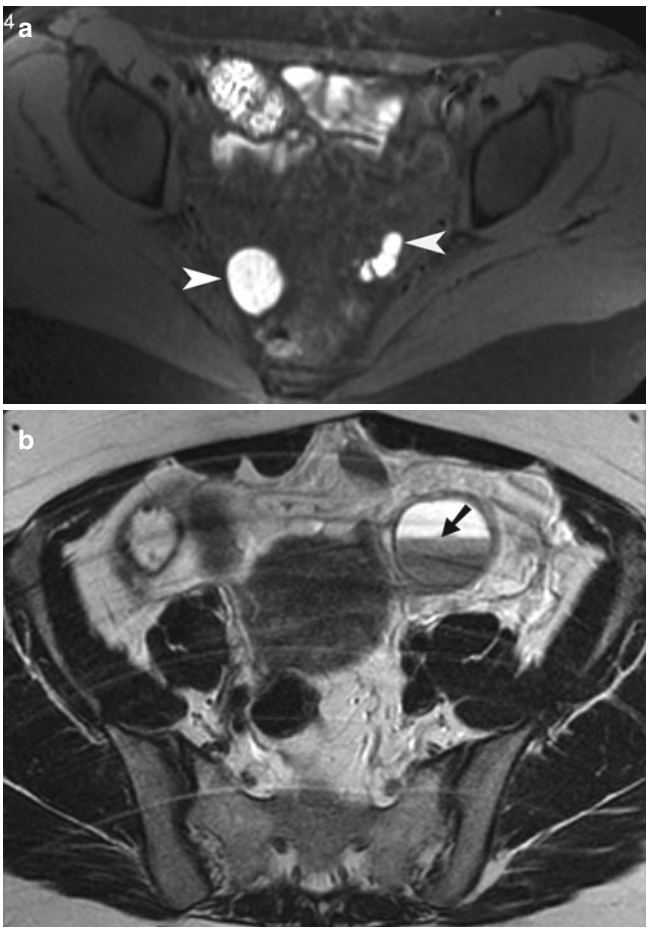


Fig. 13.5 Endometriosis. (**a**) Axial noncontrast T1-weighted MR image with fat saturation obtained through the pelvis showing multiple endometriotic cysts along bilateral pelvic side walls (*arrowheads*). The implants appear T1 hyperintense due to methemoglobin content. (**b**) Axial noncontrast T2-weighted MR image of the pelvis demonstrates a left ovarian endometrioma with a fluid/fluid level (*arrow*). The dependent contents of the endometrioma demonstrated characteristic "T2 shading" (hypointensity)

Ovarian Torsion

Ovarian torsion occurs when the adnexa twists on the vascular pedicle, often resulting in interruption of the venous flow and enlargement of the ovary. As the torsion progresses, the arterial blood flow is interrupted and ovarian ischemia occurs [15]. The ovary has a dual arterial blood supply which includes the ovarian artery and ovarian branches of the uterine artery. Any ovarian mass or large cyst may place the adnexa at risk of torsion [2, 16].

Torsion is most commonly seen in reproductive-age women with an ovarian mass or cyst found in up to 80 % of cases of torsion. Symptoms of torsion are nonspecific and most commonly include acute abnormal pain. Patients may also experience nausea and vomiting with fever occasionally developing several hours late [17]. Because the clinical presentation is nonspecific, correct diagnosis is often delayed [18].

Imaging

Ultrasound is the preferred initial imaging modality when ovarian torsion is suspected. If the ovaries appear normal in size and morphology on ultrasound, then torsion can be excluded [19]. The most common finding is ovarian enlargement of greater than 4 cm. The ovary may have a teardrop configuration with multiple small follicles displaced to the periphery of the ovary.

Although the absent vascular flow on color Doppler imaging is highly suggestive of torsion, normal Doppler flow does not exclude torsion because early torsion is often intermittent or partial [2, 16]. The "whirlpool sign" refers to visualization of twisted or circular vessels in the vascular pedicle; this is highly specific for adnexal torsion [15, 20].

Occasionally on CT and MRI, twisting of the vascular pedicle can be directly visualized; this finding is highly specific for adnexal torsion (Fig. 13.6) [21]. Most other findings are nonspecific and can include an adnexal mass, ipsilateral deviation of the uterus, lack of contrast enhancement, and ascites. On MRI, diffusion-weighted imaging reveals diffusion restriction when ischemia is present. Ovarian enlargement and edema from torsion result in T2 hyperintensity in the central ovarian stroma, which also shows multiple peripheral follicles.

Cystitis

Cystitis can be of multiple etiologies including bacterial infection, mechanical irritation (Foley catheter), medication effects (cyclophosphamide), radiation, or idiopathic

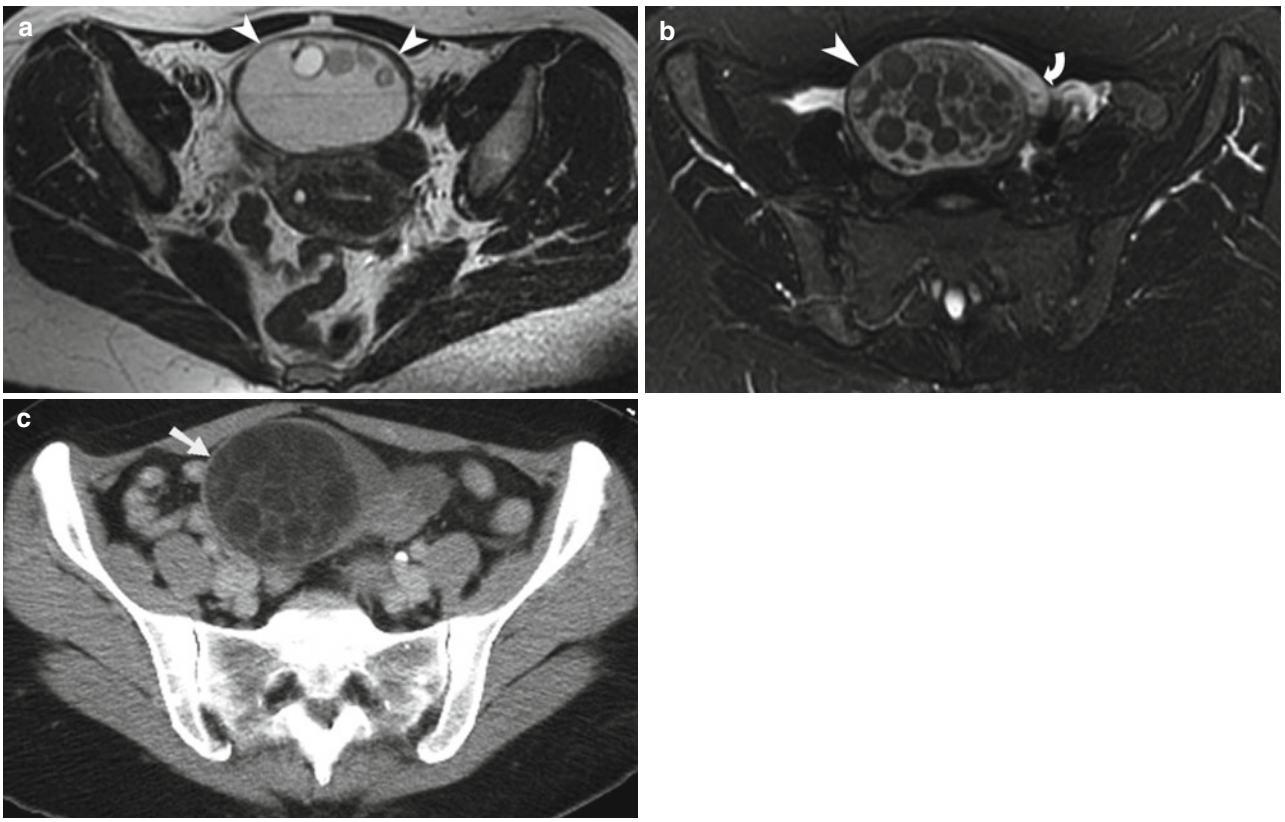
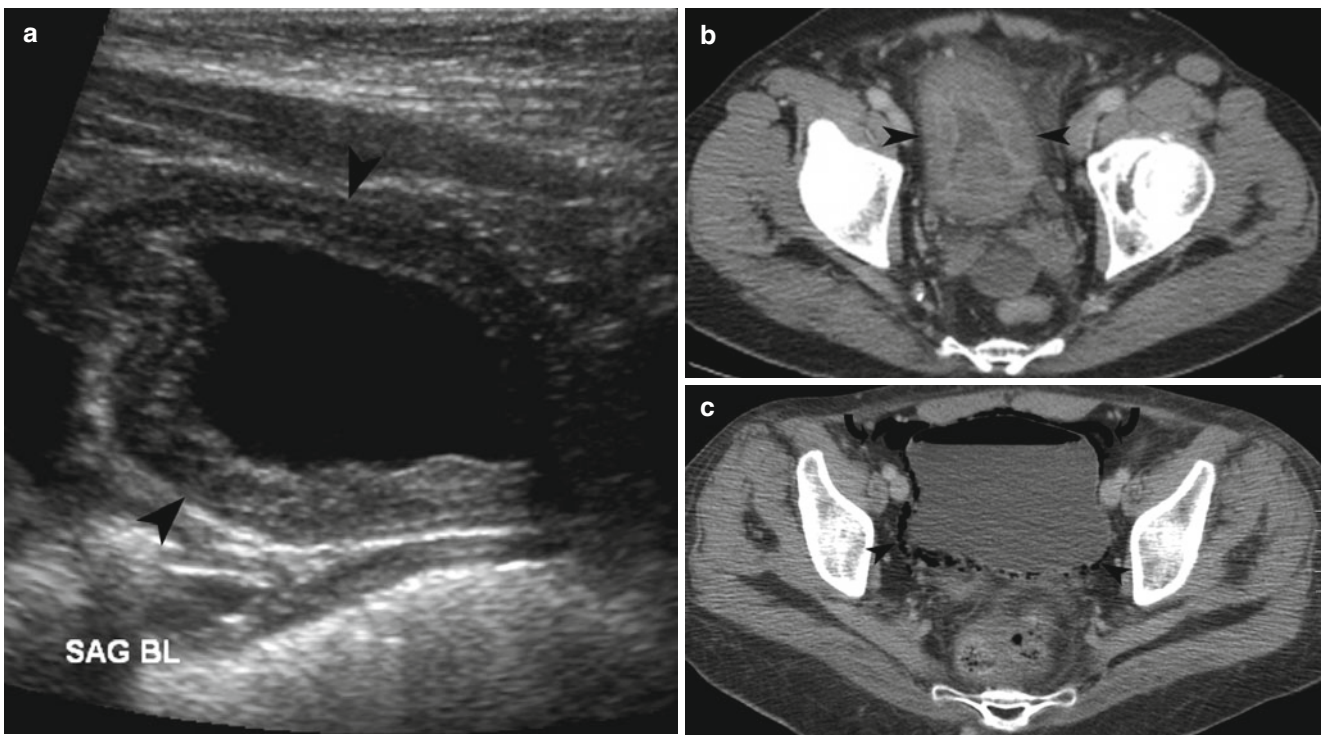


Fig. 13.6 Ovarian dermoid. (**a**) Axial noncontrast T2-weighted MR image of the pelvis demonstrates a well-circumscribed, round lesion (*arrowheads*) located anterior to the uterus. The majority of the contents of this mature teratoma appear T2 hyperintense, but there are multiple round lobules within the lesion. (**b**) Axial noncontrast STIR MR image of the pelvis again demonstrates a round, well-circumscribed ovarian dermoid located midline in the pelvis (*arrowhead*). There are multiple round, internal lobules which demonstrate signal dropout due to the fat content. A rim of edematous ovarian tissue lateral and anterior to the dermoid shows T2 hyperintensity (*curved arrow*). (**c**) Axial contrast-enhanced CT image of the pelvis again shows the immature teratoma with multiple internal fat density lobules demonstrating the characteristic fat attenuation which is diagnostic of an ovarian dermoid (*arrow*)



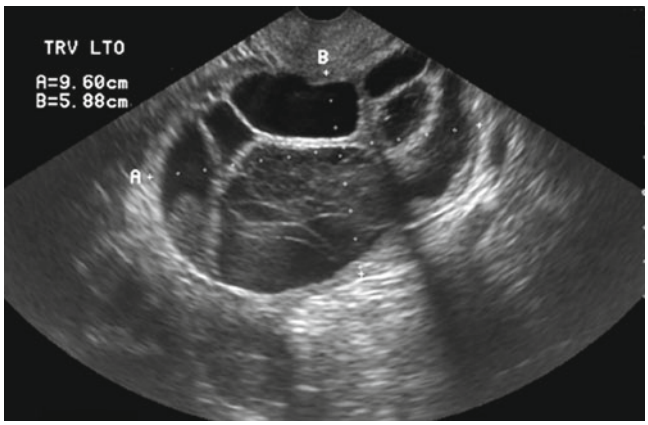


Fig. 13.8 Ovarian hyperstimulation syndrome. Ultrasound study demonstrates a markedly enlarged ovary measuring more than 9 cm in diameter and containing multiple cysts, some of which are hemorrhagic

(interstitial cystitis). When uncomplicated cystitis is suspected, no medical imaging is generally indicated [22]. However, imaging may be indicated if there is concern for malignancy, calculi, or urine flow obstruction.

The imaging findings of uncomplicated cystitis included diffuse bladder wall thickening and pericystic inflammation. The normal bladder wall thickness of the distended (>200 mL) urinary bladder is 1.1–4.5 mm [23]. Although bladder wall thickening can be evaluated with ultrasound, CT, or MRI, pericystic inflammation can only be appreciated on CT or MRI (Fig. 13.7a, b). Immunocompromised patients are at increased risk of emphysematous cystitis, which is best recognized by the presence of air within the urinary bladder wall (Fig. 13.7c) [24].

Ovarian Hyperstimulation Syndrome

Ovarian hyperstimulation syndrome (OHSS) is a rare complication which occurs in women undergoing infertility treatment with gonadotropic hormones. Symptoms include abdominal pain, nausea, vomiting, abdominal distention, and dizziness. The imaging findings include ascites and enlargement of ovaries which contain large peripheral cysts (Fig. 13.8). Pleural effusions may also be present [15, 25].

Ovarian Vein Thrombosis

Ovarian vein thrombosis most often occurs in postpartum or postoperative patients. The symptoms include fever and abdominal pain. Most cases involve the right ovarian vein which appears enlarged with central filling defect and surrounding fat stranding. Contrast-enhanced CT is the most sensitive modality for diagnosis (Fig. 13.9) [25].

Symptomatic Fibroids

Uterine fibroids represent benign masses of uterine smooth muscle and connective tissue proliferation. Fibroids may be the cause for acute pelvic pain in the setting of infarction, torsion (pedunculated subserosal fibroid), or prolapse (pedunculated submucosal fibroid).

On ultrasound, the presence of cystic features within a fibroid indicates internal degeneration. The sensitivity and specificity for the detection of fibroid degeneration is higher with MRI (Figs. 13.10, 13.11, and 13.12). High T2 signal intensity of leiomyomas with poor or no enhancement on contrast-enhanced T1-weighted sequence suggests the presence of ischemia or hemorrhagic necrosis [26].

Red degeneration usually occurs in the setting of pregnancy or in patients on oral contraceptives and is due to obstruction of draining veins. Varying signal intensities are produced within the fibroid due to the presence of hemorrhagic products of different ages. The peripheral obstructed veins may be seen as a peripheral rim of low T2 and high T1 signal intensity. Postcontrast images will demonstrate no enhancement.

Hematometrocolpos and Hydrometrocolpos

While hematometrocolpos represents accumulation of blood within the vagina, hydrometrocolpos represents the presence of fluid within the vagina and uterus. The cause may be congenital imperforate hymen or acquired, such as neoplastic obstruction, postpartum infection, or iatrogenic cervical stenosis. Imaging by sonography, CT, or MRI will most commonly demonstrate cystic distension of the vagina and/or uterine cavity with a possible fluid-debris level posterior to the bladder (Fig. 13.13) [27, 28].

Teaching Points

1. Ultrasound is the primary modality utilized for imaging of acute pelvic disorders.
2. CT is the initial imaging study performed to evaluate for acute diverticulitis and appendicitis.

Fig. 13.7 Cystitis. (**a**) Transabdominal grayscale ultrasound image demonstrates inflammatory thickening of the urinary bladder wall (*arrowheads*). (**b**) Axial contrast-enhanced CT image of the pelvis shows marked thickening and hyperenhancement of the wall of the urinary bladder (*arrowheads*). There is also extensive inflammatory stranding in the adjacent fat. (**c**) Axial contrast-enhanced CT evidence of the pelvis demonstrates extensive emphysema within the urinary bladder wall (*arrowheads*). Extraluminal air is also seen anterior to the urinary bladder (*curved arrows*)

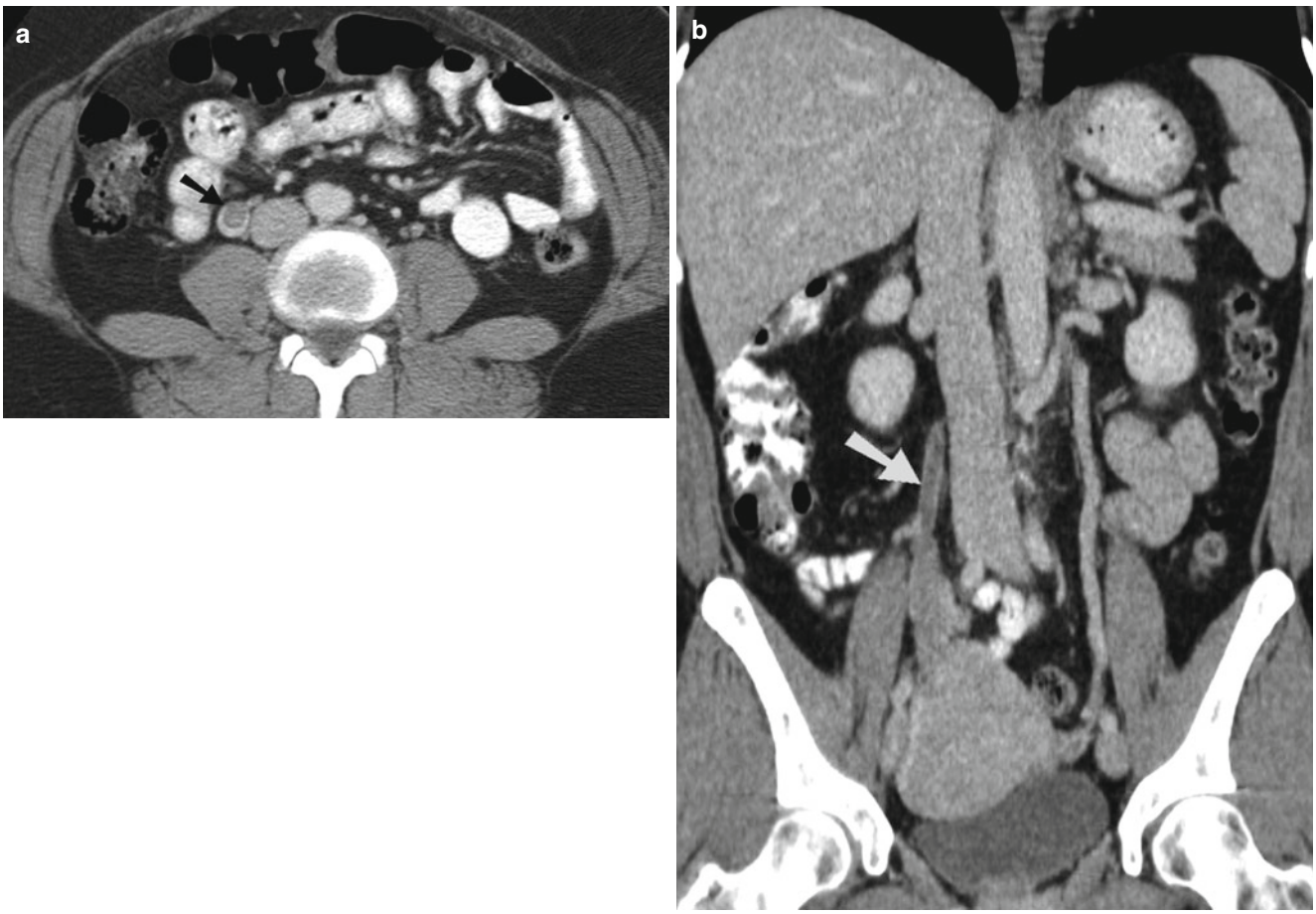


Fig. 13.9 Gonadal vein thrombosis. (**a**) Axial contrast-enhanced CT image of the abdomen demonstrates a low-density intraluminal thrombus within an abnormally expanded right gonadal vein (*arrow*). (**b**) Coronal contrast-enhanced CT image of the abdomen and pelvis shows a tubular intraluminal thrombus in a segment of the right gonadal vein (*arrow*). The vein is abnormally expanded and a small amount of contrast is seen surrounding the thrombus

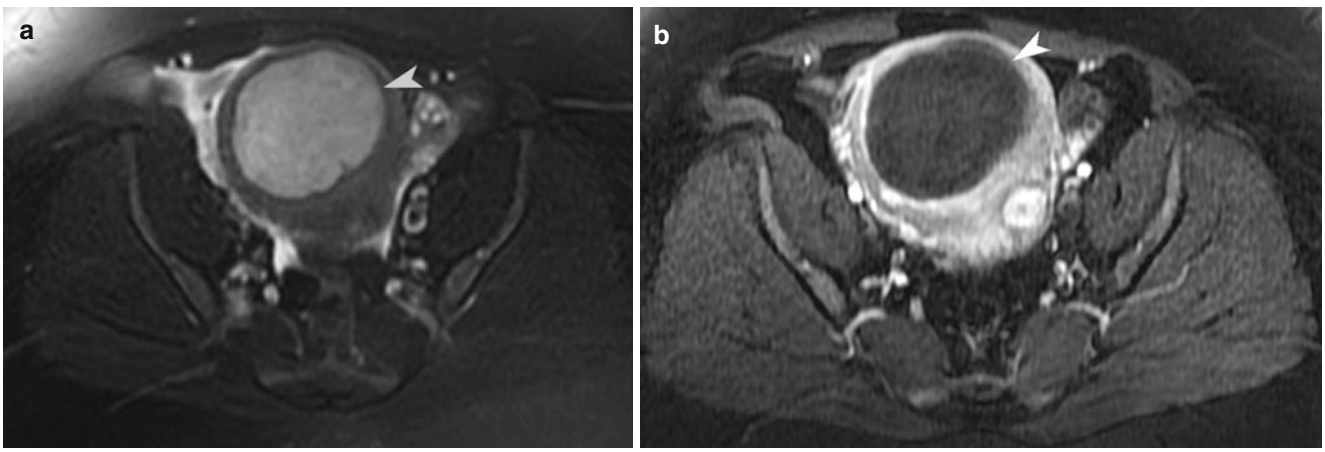


Fig. 13.10 Degenerating uterine fibroid. (**a**) Axial T2-weighted MR image with fat saturation obtained through the pelvis demonstrates a well-circumscribed, T2 hyperintense leiomyoma (*arrowhead*) with cystic degeneration. (**b**) Axial contrast-enhanced T1-weighted MR image with fat saturation shows no enhancement within the round, well-circumscribed leiomyoma (*arrowhead*)

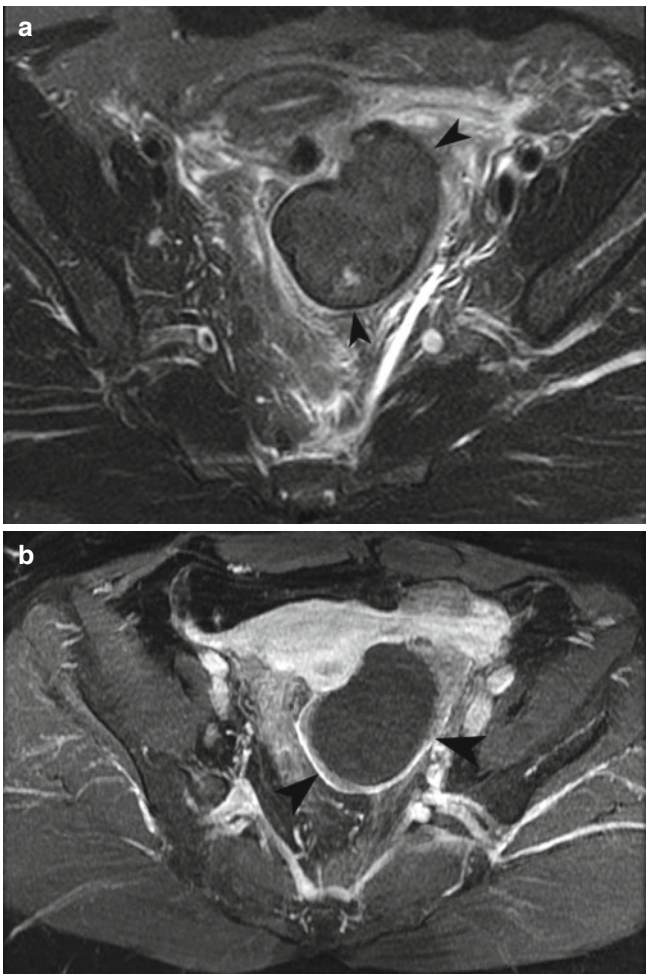


Fig. 13.11 Degenerating uterine fibroid. (**a**) Axial noncontrast T2-weighted MR image with fat saturation obtained in the pelvis demonstrates a hypointense mass with a peripheral rim of low signal intensity which is characteristic of a leiomyoma undergoing red degeneration (*arrowheads*). (**b**) Axial postcontrast T1-weighted MR imaging with fat saturation confirms that there is no contrast enhancement within the subserosal leiomyoma undergoing degeneration (*arrowheads*)

3. Ovarian torsion is most common in women of reproductive age and almost always occurs in the setting of an ovarian abnormality such as a mass or cyst.
4. Although a less convenient and more expensive modality, the sensitivity and specificity for MRI is high with advanced anatomical delineation for most acute pelvic processes.

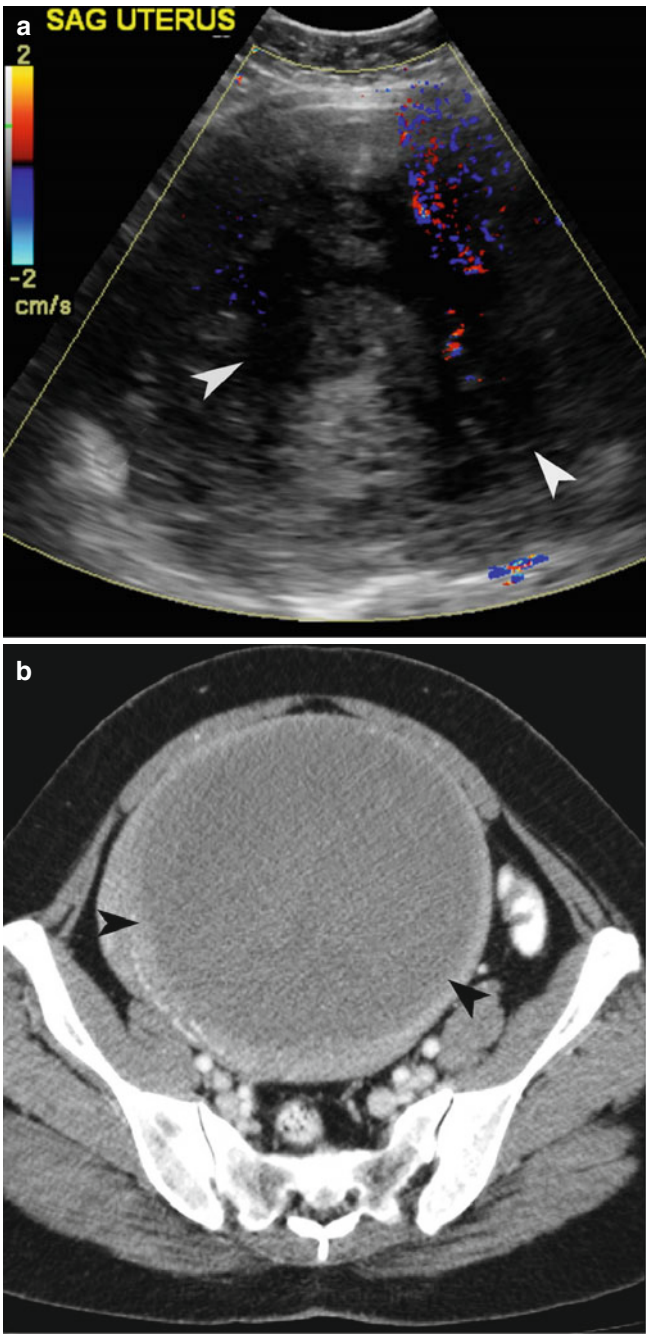


Fig. 13.12 Degenerating fibroid. (**a**) Pelvic ultrasound with color flow demonstrates a large heterogeneous mass with irregular cystic areas (*arrowheads*) within the degenerating fibroid. (**b**) Axial contrast-enhanced CT demonstrates a large, necrotic, well-circumscribed uterine leiomyoma, which does not enhance (*arrowheads*)

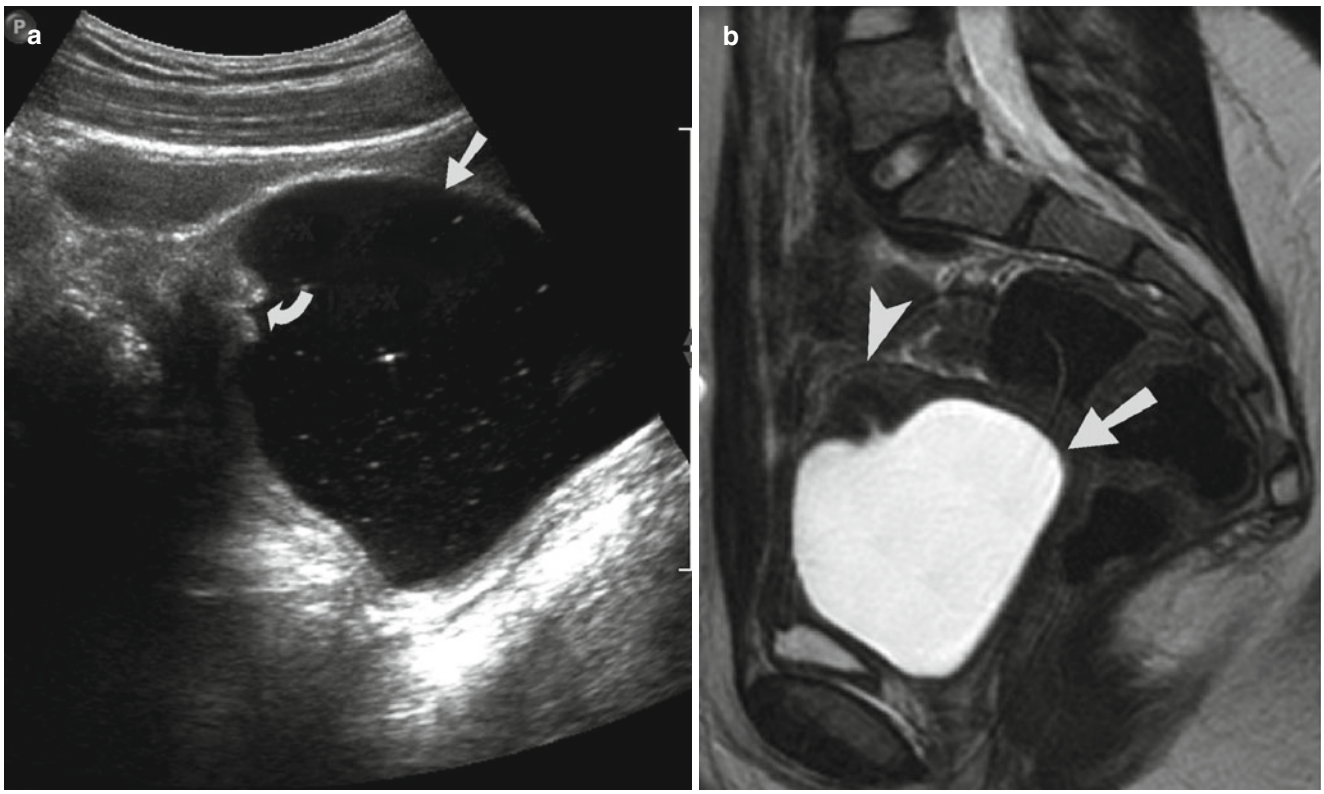


Fig. 13.13 Hematocolpos due to imperforate hymen. (**a**) Transabdominal ultrasound shows a large hypoechoic fluid collection with floating internal echogenic debris within a markedly distended vaginal cavity (*arrow*). The cervix can be seen along the superior aspect of the fluid collection (*curved arrow*). (**b**) Sagittal T2-weighted images of the pelvis demonstrate a large, T2 hyperintense fluid collection within the distended vaginal cavity (*arrow*). The uterus (*arrowhead*) can be seen displaced superiorly by the distended, fluid-filled vagina

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