



Imaging of Acute Pelvic Pain

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Abstract: Determining the cause of acute pelvic pain in the female patient is often a clinical challenge. Diagnostic imaging can be invaluable in this situation. Ectopic pregnancy, pelvic inflammatory disease, and hemorrhagic ovarian cysts are the most commonly diagnosed gynecologic conditions presenting with acute pelvic pain. Ovarian torsion and degenerating fibroids occur less frequently. Other causes to consider include endometriosis, and postpartum causes such as endometritis, or ovarian vein thrombosis. Finally, nongynecologic conditions may overlap in their presentation of acute pelvic pain and should also be considered. The most important of these is acute appendicitis.

Key words: ectopic, PID, torsion, endometriosis, endometritis

Introduction

Acute pelvic pain in a woman can be secondary to a variety of disorders, which may be difficult to differentiate on clinical grounds. This clinical conundrum is often solved by diagnostic imaging. Ultrasound (US) is the primary imaging modality for the evaluation of suspected acute gynecologic disease but is distinctly operator dependent and suffers from technical lim-

itations due to patient body habitus. Computed tomography (CT) serves an important role in patients with nonlocalizing symptoms, an indeterminate US evaluation, or in patients who require a wider search beyond the field of view available with US. In addition, the widespread availability of and familiarity with CT have helped to expand its role in the emergency evaluation of the female patient with acute pelvic pain. Magnetic resonance imaging (MRI) is an extremely useful second-line modality for problem solving after US or CT has been performed.

Clinicians should be knowledgeable about available imaging modalities and the findings of common and less common causes of pelvic pain to meet this challenge. This paper will review the various potential gynecologic sources for acute pelvic pain and their manifestations at US, CT, and MRI. The relative utility and diagnostic accuracy of imaging findings will be discussed.

Ectopic Pregnancy

Ectopic pregnancy (EP) should be suspected in the patient presenting with acute

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pelvic pain and a positive pregnancy test. With an incidence of approximately 1 out of every 200 diagnosed pregnancies, EP remains the leading cause of maternal death in the first trimester and the second leading cause of maternal mortality overall.^{1,2} US is the most important tool in the evaluation of suspected EP and should be combined with measurement of quantitative β -human chorionic gonadotropin (β -HCG) for appropriate interpretation.

The first goal of US evaluation is to determine whether an intrauterine pregnancy is present. If an intrauterine pregnancy can be demonstrated, an EP can be reasonably excluded, as synchronous intrauterine and EPs are exceedingly rare in the general population (1:7000 pregnancies).³ However, it is important to note that the risk is much higher in patients who have undergone assisted reproduction (1:100 pregnancies).^{3,4} An intrauterine gestational sac should be seen on endovaginal US when the β -HCG level is greater than 2000 mIU/mL by the third International Reference Preparation. It first manifests as the “intradecidual sac sign,” a small, round, well-defined fluid collection completely surrounded by echogenic decidual tissue. It is eccentrically located adjacent to the hyperechoic line representing the opposing walls of the endometrium (Fig. 1). This sign, however, has limited utility with a sensitivity of only 34% to 66% and a specificity of 55% to 73%.⁴ The “double-decidual sac sign” is usually easier to identify and forms as the round fluid collection embedded in the decidua enlarges and develops the appearance of an echogenic double layer of decidua along its border with the endometrial cavity. The 2 decidual layers, the decidua capsularis and the decidua parietalis, are separated by the hypoechoic endometrial cavity (Fig. 2). Color Doppler evidence of trophoblastic blood flow around the fluid collection further supports the diagnosis of an intrauterine pregnancy. Pulsed Doppler should be

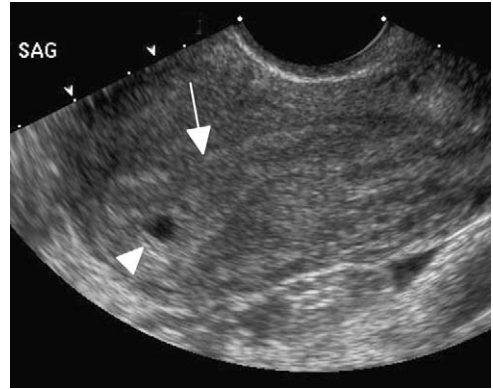


FIGURE 1. Intradecidual sac sign. Transvaginal ultrasound of the uterus shows a small, round anechoic fluid collection (arrowhead), eccentrically implanted within the echogenic endometrium (arrow), consistent with a very early intrauterine pregnancy.

avoided because of concerns regarding heat deposition in the developing embryo.

The double-decidual sac sign must be distinguished from a pseudosac, an intrauterine fluid collection, which forms in response to the hormonal influences on the endometrium in the presence of

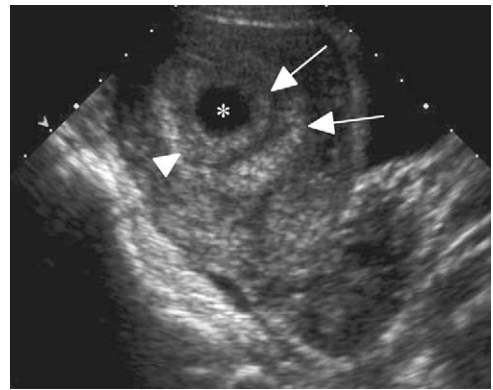


FIGURE 2. Double decidual sac sign. Transabdominal ultrasound of the uterus with an intrauterine gestational sac (*) shows a double layer of echogenic decidua (arrows) separated by the hypoechoic endometrial cavity (arrowhead).

an EP. In contrast to the double decidual sac of an intrauterine pregnancy, the pseudosac has a single echogenic layer of endometrium surrounding an ovoid, elongated, centrally located collection of endometrial fluid (Fig. 3). Only 5% to 10% of patients with EP will demonstrate a pseudosac on US.³ More commonly the uterus will show neither a true nor a pseudosac. Correlation with the clinical presentation, specifically with respect to pain and amount of bleeding, quantitative β -HCG, and a meticulous sonographic search of the adnexae is necessary to determine if the findings represent an intrauterine pregnancy which is too small to be seen sonographically, a recent spontaneous abortion or an EP.

The ovary provides a landmark for evaluation of the adnexa, as it is usually located near the ampullary portion of the fallopian tube, which is the most frequent site of ectopic implantation. The area surrounding the ovary should be evaluated thoroughly for any extraovarian abnormality. Although the sonographic appearance of EP can be quite varied, it

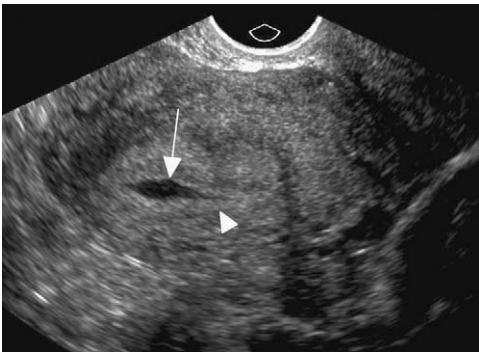


FIGURE 3. Pseudosac in the setting of ectopic pregnancy. Sagittal transvaginal ultrasound of the uterus shows an elongated fluid collection (arrow) located centrally within the cavity. It is surrounded by a single, echogenic layer (arrowhead) of endometrium. An ectopic pregnancy (not shown) was identified in the right adnexa.

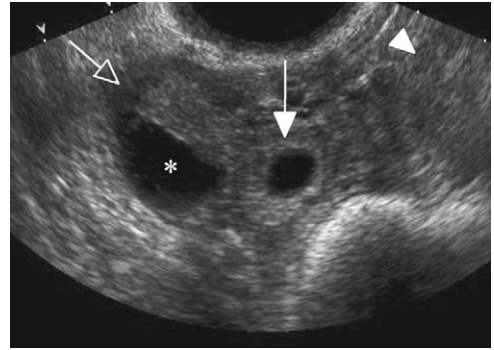


FIGURE 4. Tubal ring sign of ectopic pregnancy. Transverse ultrasound of the right adnexa shows a cystic structure with a thick echogenic rim (closed arrow), consistent with an ectopic gestational sac, located between the uterus (arrowhead) and the right ovary (open arrow), which contains a corpus luteum cyst (*).

most commonly manifests as a ring-shaped structure with an anechoic center and a thick echogenic periphery, the “tubal ring sign” (Fig. 4). A yolk sac and fetal pole may be present, with or without cardiac activity, providing the most specific sonographic finding of an EP (specificity of 100%) (Fig. 5). However, this appearance is the least sensitive finding in EP (15% to 20%).³ More commonly an EP is identified as a complex adnexal mass in a patient with a positive pregnancy test and no intrauterine pregnancy. Although most EPs are located between the ovary and the uterus, they may implant anywhere in the pelvis and it is necessary to carefully search the regions adjacent to the uterine fundus, cul-de-sac and lateral margins of the pelvis.

An uncommon but important type of EP is an interstitial pregnancy, which occurs in 2% to 3% of EPs.⁵ An interstitial pregnancy results from implantation within the interstitial or intramyometrial portion of the fallopian tube. In this location, the EP can grow larger before becoming symptomatic.

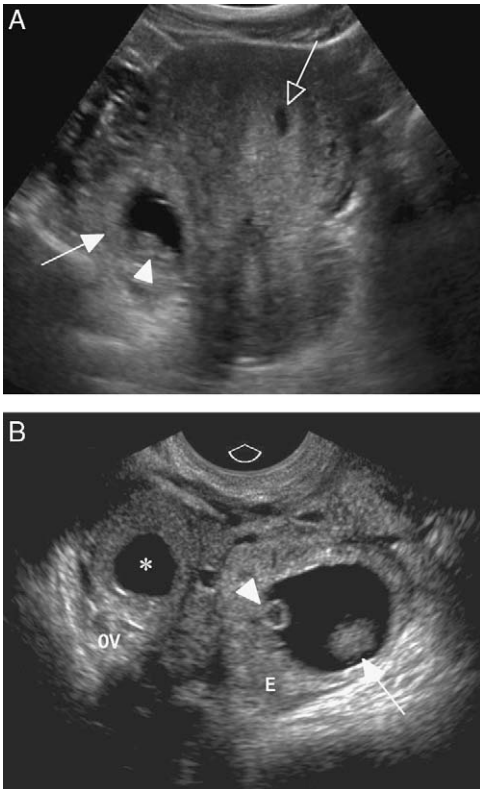


FIGURE 5. Ectopic pregnancy with a yolk sac and fetal pole. (A) Sagittal transabdominal ultrasound of the uterus shows a small central fluid collection (open arrow), consistent with a pseudosac. A ring-shaped structure (closed arrow) adjacent to the uterus contains a fetal pole (arrowhead), confirming an ectopic pregnancy. (B) Transvaginal ultrasound of the right adnexa in the same patient better demonstrates the ectopic pregnancy (E), with a yolk sac (arrowhead) and fetal pole (arrow), separate from the right ovary (OV), which contains a corpus luteum (*).

Significantly higher morbidity and mortality due to uterine rupture and massive hemorrhage are seen than with a tubal EP. The classic transvaginal sonographic finding of an interstitial pregnancy is the “interstitial line sign” (Fig. 6). The sign refers to a thin, straight, echogenic line extending from the endometrial cavity to

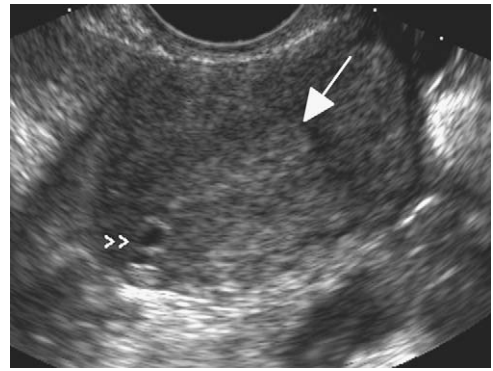


FIGURE 6. Interstitial line sign. Transvaginal ultrasound of the uterus shows no evidence of a normal intrauterine pregnancy. The 2 layers of the echogenic endometrium are coapted (arrow) and extend to the center of a small round fluid collection (arrowheads) eccentrically located in the myometrium.

the eccentrically located gestational sac in the uterine fundus. The line represents the 2 opposing layers of coapted endometrium when the sac is large or the intramural portion of the tube when the sac is small. The sac is incompletely surrounded by myometrium that may become progressively thinned or absent laterally as the sac grows.

Other sites of extratubal EP are even rarer; intraovarian EPs account for less than 1% and cervical EPs, approximately 0.15%.³ A simple or complex intraovarian lesion should not raise concern for an EP, as it is statistically much more likely to represent the corpus luteum (Figs. 4, 5B). Differentiating between an extraovarian EP and an exophytic or intraovarian corpus luteum can be aided by gently pushing on the area with the endovaginal probe. Independent movement of the lesion and the ovary, separate from each other, confirms the extraovarian location of the adnexal ring seen with an EP, whereas a corpus luteum will move with the ovary. The corpus luteum usually has a less echogenic wall than an ovarian

ectopic and may contain hemorrhagic debris, although this is variable and non-specific.

Cervical pregnancies have a worse prognosis than tubal pregnancies because of their potential for uncontrollable hemorrhage. Sonographic features are those of an early pregnancy embedded within the cervical stroma. It should not be confused with an abortion in progress that appears as a flattened sac within the endocervical canal and changes appearance on follow-up imaging.

The presence of free fluid, especially echogenic free fluid, is an important finding in the hunt for an EP. Although isolated free fluid is the least specific criterion for diagnosing EP, it often accompanies other findings that suggest the diagnosis. Echogenic free fluid is particularly concerning because it suggests hemoperitoneum and a moderate to large amount carries a high positive predictive value (86% to 93%) for EP.⁶ Occasionally an amorphous echogenic mass may be seen, representing a mass of clotted blood indicating a ruptured ectopic. However, other causes of intraperitoneal bleeding include leakage of blood from the fimbriated end of the fallopian tube, tubal abortion and even rupture of a corpus luteum cyst.

Pelvic Inflammatory Disease

Pelvic inflammatory disease (PID) is one of the most common causes of acute pelvic pain in sexually active women, affecting 1 million women and resulting in 275,000 hospitalizations each year.⁷ PID should be suspected in all patients presenting with pelvic pain/cervical motion tenderness, fever, and leukocytosis. Infection usually ascends from a cervicitis to involve the uterus, and then progresses to salpingitis. If treatment is delayed, the infection can ultimately result in pyosalpinx, tuboovarian complex, and abscess potentially necessitating radiologic or

surgical drainage. The resulting tubal damage and scarring increase the risk for long-term complications of infertility, EP, and chronic pelvic pain.

Diagnosis is usually made based on the clinical and laboratory findings. However, this can be challenging because of the potentially vague and nonspecific nature of the symptoms, and the diagnosis may be incorrect in approximately 35% of women with clinically suspected PID.⁸ Imaging can play a crucial role in diagnosis and management. It is usually reserved for patients with an uncertain clinical diagnosis, and those who are severely ill or unresponsive to initial therapy. The demonstration of pyosalpinx or tuboovarian abscess (TOA) will alter medical management and can result in hospitalization, surgery, or follow-up imaging to evaluate nonoperative management.

The imaging findings vary depending on disease severity. Findings are often bilateral but may be asymmetric. Pelvic US is the primary imaging modality of choice in cases of suspected PID but is frequently normal in the early stages or in uncomplicated cases of the disease. The use of transvaginal sonography with color or power Doppler can improve detection of the subtle abnormalities of endometritis, salpingitis, and oophoritis. These include uterine enlargement and indistinctness, endometrial thickening with or without endometrial fluid, larger than normal ovarian volumes due to thickening of the ovarian stroma and reactive polycystic change, and complex free fluid with internal echoes.⁸ Endometrial fluid or a fluid/debris level may also be seen on CT (Fig. 7).

As infection progresses, the sonographic findings of tubal inflammation become more striking. The normal fallopian tubes (which are rarely visualized), thicken from inflammation and become visible with US and tender to pressure. Pyosalpinx results from luminal

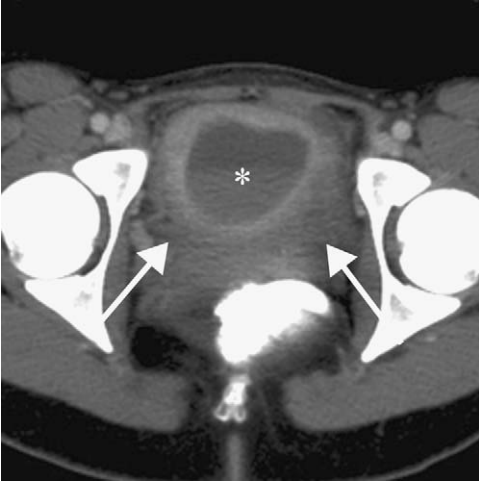


FIGURE 7. Endometritis from pelvic inflammatory disease. Axial-enhanced computed tomography shows a fluid/debris level within the endometrial cavity (*). Note the ill-defined borders of the uterus and the free pelvic fluid (small arrows).

adhesions that cause the tube to dilate as it fills with fluid. US shows a tubular, ovoid, or pear-shaped configuration with wall thickening (>5 mm) and anechoic or layering echogenic fluid with debris. Incomplete septae may be apparent as the tube folds over itself. In cross section a “cogwheel” appearance may be seen due to thickened endosalpingeal folds (Fig. 8). Color and power Doppler will show hyperemia of the thickened walls and folds. The sonographic findings of a thick-walled, tubular adnexal mass with or without intrapelvic free fluid have been reported to have a sensitivity of 85% and a specificity of 100% for the diagnosis.⁹

Ovarian involvement may manifest on imaging as a tuboovarian complex, in which the ovary is adherent to the inflamed tube but maintains its architecture and is still visible as a separate structure. With further disease progression, there is complete destruction of the ovarian architecture and a separate ovary cannot be distinguished from the resulting complex,



FIGURE 8. Salpingitis. Longitudinal transvaginal ultrasound shows a dilated fallopian tube with endosalpingeal fold thickening (arrow) representing the “cogwheel sign.”

solid, and cystic adnexal mass termed as TOA (Fig. 9). This complication occurs in approximately 33% in patients hospitalized for PID.¹⁰

The role of CT in imaging PID continues to expand due to its ready availability and the often vague and nonspecific nature of the disease symptomatology. It is often performed in patients with diffuse pelvic pain, peritonitis or a difficult or equivocal US. CT should be performed with both oral and intravenous contrast, as unopacified bowel may be confused for an abscess.

Early or mild inflammatory changes may be better appreciated on CT than on US. These include haziness of the pelvic fat, obscuration of the pelvic fascial planes, thickening of the uterosacral ligaments, abnormal endometrial enhancement with fluid in the endometrial cavity, enhancement and thickening of the fallopian tubes, and abnormal enhancement, enlargement, and reactive polycystic change of the ovaries.⁷ As the disease progresses and a pyosalpinx develops, CT shows fluid-filled tubular lesions, with thick enhancing walls and mural nodules corresponding to thickened endosalpingeal folds (Fig. 10). Mildly

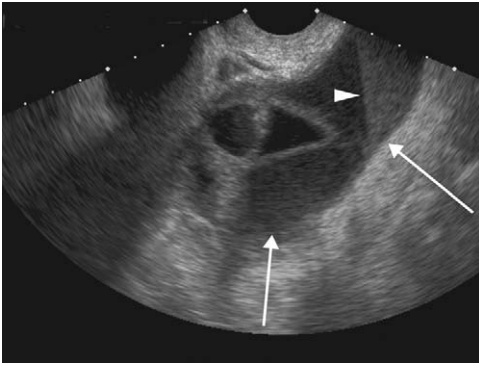


FIGURE 9. Tuboovarian abscess. Transvaginal image shows a dilated fallopian tube (arrows) with layering pus (arrowhead).

dilated tubes may go unrecognized by CT and are much better seen on US.

The characteristic CT appearance of a TOA is that of a low-attenuation, multilocular, thick-walled adnexal mass with an associated serpiginous structure corresponding to the dilated, pus-filled fallopian tube (Fig. 11). The tubular component may be better appreciated on reformatted images in the coronal or sagittal planes, which help to distinguish

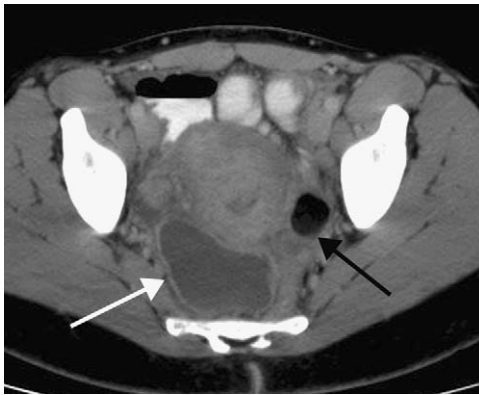


FIGURE 10. Pyosalpinx. Enhanced computed tomography shows a pyosalpinx (white arrow) with indistinctness of the adjacent pelvic fat and soft tissues. An incidental fat-containing mature teratoma (black arrow) is seen on the left side.



FIGURE 11. Tuboovarian abscess with gas. Enhanced computed tomography shows bilateral, gas-containing, tuboovarian abscesses (arrows).

a TOA from other complex cystic adnexal masses. Internal gas bubbles are a highly specific sign of TOA, but are rarely seen.¹¹

Although MRI is rarely used in the diagnosis of PID, fat-suppressed T2-weighted images are very sensitive for the detection of inflammation, which appears as ill-defined hyperintense areas. Inflammation also shows intense enhancement on contrast-enhanced fat-suppressed T1-weighted images. The fluid-filled, tortuous appearance of pyosalpinx is readily apparent on T2-weighted images and multiplanar images can help distinguish it from fluid-filled loops of bowel. TOA characteristically manifests on MRI as a multilocular, round adnexal mass, which is predominantly dark on T1-weighted images and heterogeneously bright on T2-weighted images with intense enhancement of the thick irregular surrounding wall and adjacent soft tissue inflammation.

MRI has been shown to be superior to US at diagnosing PID when any of the following are present: TOA, pyosalpinx, fluid-filled tube, or enlarged, polycystic ovaries with free intrapelvic fluid.¹²

However, both US and CT are more cost-effective than MRI and more readily available. MRI, therefore, continues to play a complementary, problem-solving role in the imaging evaluation of PID.

Hemorrhagic Ovarian Cyst

Functional (follicular and corpus luteal) ovarian cysts are a common cause of acute pelvic pain when they are associated with acute intracystic hemorrhage or intraperitoneal rupture. The abrupt onset of pain can be severe and localized, or more diffuse and nonspecific. Cyst rupture may be associated with abdominal distension from associated hemoperitoneum and hypotension, possibly leading to shock, especially in patients receiving anticoagulation. A ruptured EP can have a similar clinical presentation and correlation with β -HCG levels is essential in excluding this possibility.

US should be the first study of choice; however, the nonspecific nature of the pain may prompt CT study as an alternative. A follicular cyst shows an anechoic appearance with a thin wall and posterior acoustic enhancement, seen as an area of increased echogenicity posterior to the cyst (Fig. 12). After ovulation a corpus luteum forms which has a thicker wall with increased vascularity (Fig. 13). This appearance changes in the presence of hemorrhage and can be quite varied depending on the age of the bleed. Acute intracystic hemorrhage is isoechoic to the ovarian stroma and can mimic an enlarged ovary. As clot forms over time, a more characteristic lace-like, reticular or "fish-net" pattern of internal echoes develops (Fig. 14) or a fluid-debris level may be present. As the clot begins to retract, it may appear as an echogenic mass, either mobile or adherent to the cyst wall, potentially being confused with wall thickening (Fig. 15). Color Doppler imaging should demonstrate an absence of vascu-

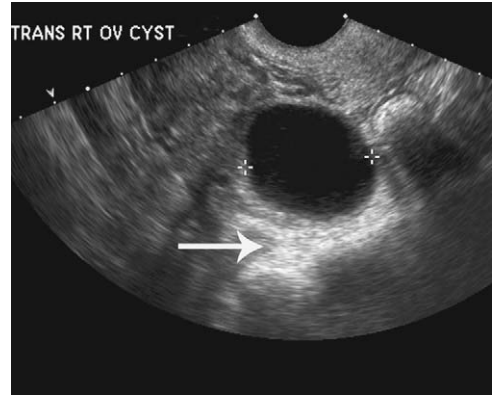


FIGURE 12. Follicular cyst. Transvaginal ultrasound of a follicular cyst (calipers), which resolved on follow-up 2 months later. The cyst is anechoic, thin-walled, and shows posterior acoustic enhancement (arrow).

larity in the complex components of the cyst.

In the appropriate context of an ovulating woman with acute pelvic pain, a cyst with a reticular appearance can be classified as a hemorrhagic cyst. If the

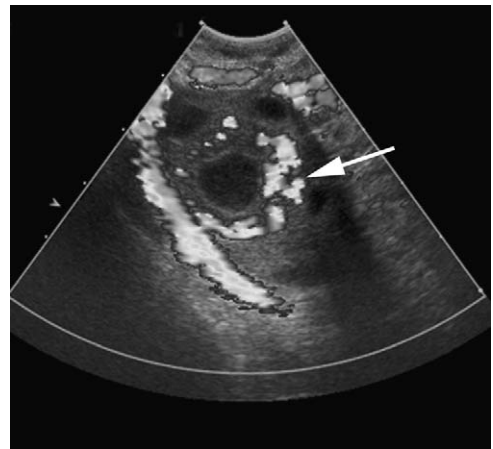


FIGURE 13. Corpus luteum cyst. Color Doppler image (shown in black and white) shows peripheral blood flow in the thick cyst wall (arrow). A corpus luteum cyst has a thicker, more echogenic, and vascular wall compared with a follicular cyst.

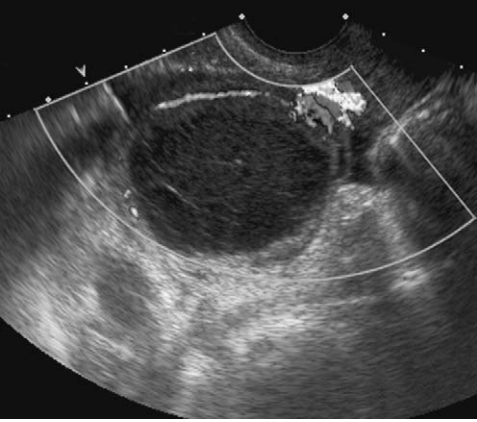


FIGURE 14. Hemorrhagic cyst. Transvaginal ultrasound of a hemorrhagic cyst shows the characteristic mesh of fine linear echoes referred to as a “lacy” or “fish net” appearance. Color Doppler shows absence of blood flow in the fine septations.

sonographic or clinical features are not classic, follow-up US or further assessment with MRI can be performed to exclude the possibility of an ovarian neoplasm. Follow-up US can readily show the rapid evolution and/or cyst resolution

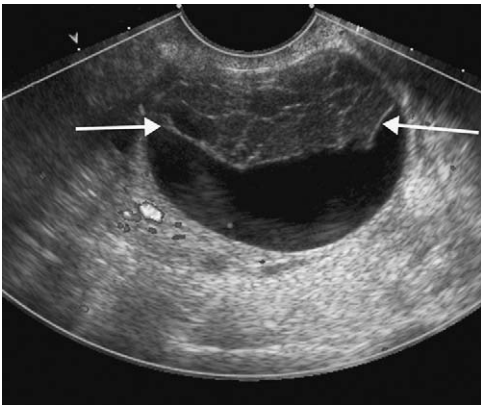


FIGURE 15. Hemorrhagic cyst with retracting clot. Transvaginal ultrasound shows an eccentric retracting clot (arrows) adherent to the cyst wall. Fibrin strands within the clot give it a “lacy” appearance.

of hemorrhagic cysts, whereas MRI is particularly useful in the further assessment and characterization of lesions that are more indeterminate.¹³

It is important to also search for free intrapelvic fluid during the sonographic examination; this will be present with rupture or leakage from a hemorrhagic ovarian cyst. The cyst itself may have an angular or crenated appearance and the free fluid typically contains low-level echoes or echogenic frank clot in the cul-de-sac or adjacent to the ovary² (Fig. 16).

On CT, hemorrhagic ovarian cysts typically manifest as a mixed-attenuation adnexal mass with a hyperdense component (45 to 100 HU), and possibly a fluid-hematocrit level (Fig. 17). With rupture, hemoperitoneum will be evident as high attenuation fluid in the pelvis and possibly even the abdomen, if the volume is large. The administration of intravenous contrast allows the enhancing cyst wall of a corpus luteal cyst to be better seen. Delayed CT images can demonstrate active extravasation, which manifests as pooling of contrast-enhanced blood in the pelvis. CT has the added advantage of excluding other intra-abdominal causes

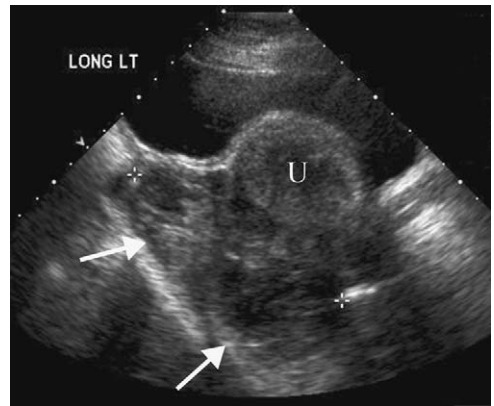


FIGURE 16. Acute bleed from a left hemorrhagic cyst. There is a clot (arrows) posterior to the uterus (U) on transabdominal ultrasound.



FIGURE 17. Computed tomography scan shows a hyperdense clot (arrow) in the cul-de-sac, surrounding a corpus luteum cyst (arrowhead), which contains a high-density hematocrit level, indicating acute hemorrhage.

of acute hemorrhage in the young female patient (eg, ruptured hepatic adenoma).

MRI is reserved for equivocal cases in which the US or CT study is indeterminate, or in cases of a complex cystic mass warranting further study to exclude an ovarian neoplasm. Simple ovarian cysts (nonhemorrhagic follicular or corpus luteal cysts) typically show low signal on T1-weighted MR images and very high-signal intensity on fluid-sensitive T2-weighted MR images. Hemorrhagic cysts will show relatively high-signal intensity on T1-weighted images and intermediate to high-signal intensity on T2-weighted MR images. Hemoperitoneum, seen in the setting of cyst rupture, will be bright on T2-weighted images and slightly hyperintense on T1-weighted images. A layering low-signal fluid-fluid level may be seen on the T2-weighted images, due to the presence of clot and debris.

Ovarian Torsion

Torsion of the ovary or, more frequently, the adnexa (ovary and fallopian tube) accounts for approximately 3% of emergency gynecologic surgeries.¹⁴ It is a

diagnosis which requires prompt identification and treatment, especially in young women, to prevent infarction and preserve ovarian function. Torsion can occur at any age, however, is rare in the postmenopausal patient. In adults, it is often associated with an ovarian cyst or benign neoplasm, which serves as a fulcrum for the twisting (50% to 81% of cases).¹⁵ In children and adolescents, torsion more often occurs in the absence of an associated adnexal mass and is felt to be due to increased mobility of the vascular pedicle.¹⁵ There is an increased risk of torsion in pregnancy; 25% of cases occur in pregnant patients, most commonly between 6 and 14 weeks and in the immediate postpartum period.² The pain of torsion can be quite severe and unilateral, however, it can be difficult to diagnose clinically because the presenting symptoms of pain, nausea, and vomiting are nonspecific.

If ovarian torsion is suspected, US with duplex Doppler imaging is the study of choice. The twisting of the ovarian vascular pedicle compromises lymphatic, venous, and then arterial flow, resulting in a variety of imaging appearances on US. Classically, with gray-scale US, the ovary will appear enlarged, amorphous, and hypoechoic due to edema from obstruction of lymphatic and venous drainage (Fig. 18). Numerous follicles may be seen peripherally. The ovarian stroma becomes more heterogeneous over time, with areas of increased echogenicity representing hemorrhage and hypoechoic areas reflecting edema. Free fluid may be present in the pelvis resulting from lymphatic and venous congestion or infarction with intraperitoneal hemorrhage.¹⁶

Duplex Doppler interrogation should be performed in every case of suspected torsion, with the most specific finding being absence of venous and arterial flow. The demonstration of intraovarian arterial flow, however, does not exclude torsion. This may be due to early or partial torsion, in which only the venous

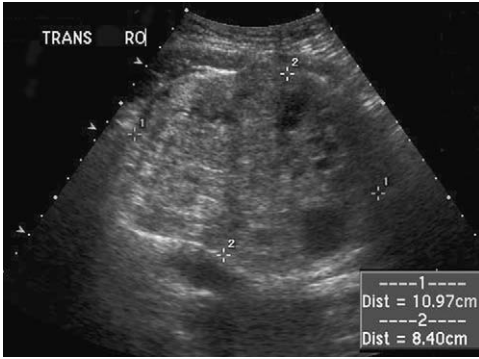


FIGURE 18. Ovarian torsion in a patient with acute pelvic pain 2 weeks postpartum. Sonography showed a markedly enlarged right ovary with no flow on color Doppler (not shown).

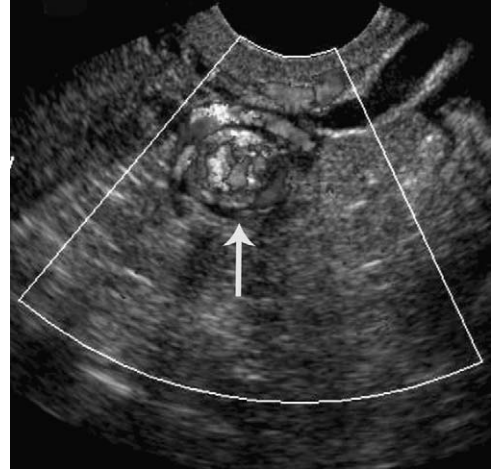


FIGURE 19. “Whirlpool sign” of ovarian torsion. Transvaginal ultrasound with color Doppler (shown in black and white) shows the corkscrew appearance of the twisted vascular pedicle (arrow).

channels are occluded, or to the dual arterial supply to the ovary with occlusion of only one of the supply channels. Alternatively, the arterial flow that is present may be decreased, and the relative difference is difficult to appreciate unless comparison with the contralateral side is made.¹⁷ For these reasons, in the appropriate clinical setting with an ovary that demonstrates gray-scale findings consistent with torsion, the diagnosis should be suggested even in the presence of documented arterial flow. Color Doppler sonography of the adnexa may reveal the twisted vascular pedicle, termed “the whirlpool sign”; if flow is seen within it, this is a useful marker of ovarian viability (Fig. 19).¹⁸

A CT scan may be performed initially if the diagnosis is unsuspected or the patient is being evaluated for alternative diagnoses. Both CT and MRI are more useful in evaluating patients with suspected subacute or chronic torsion and those with a suspected pelvic mass. Findings of ovarian torsion on CT and MRI include an enlarged ovary displaced from its normal location in the adnexa with or without an associated mass, deviation of the uterus to the twisted side, obliteration of the fat

planes, thickening of the fallopian tube, and ascites. Contrast-enhanced CT may show engorged enhancing adnexal vessels, due to congestion, possibly with a beaked configuration at the periphery of the ovary. In the setting of hemorrhagic infarction, there may be lack of ovarian enhancement, with hematoma or gas present. Contrast-enhanced dynamic subtraction MRI has better contrast resolution than CT and can readily demonstrate nonenhancement of the ovary. Bright ovarian signal on fat-suppressed T1-weighted images indicates the presence of hemorrhage or vascular congestion. The combination of these findings with a thickened tube or a twisted vascular pedicle, which is often easier to see on multiplanar CT or MRI, is very suggestive of hemorrhagic infarction after ovarian torsion.¹⁵

Fibroid Degeneration

Leiomyomata (fibroids) are the most common gynecologic neoplasm, occurring in 20% to 40% of all women during

their reproductive years.¹⁹ They are associated with a variety of symptoms including menorrhagia, dysmenorrhea, urinary frequency, pain, pressure, and infertility. Acute pain is usually due to acute fibroid degeneration that occurs when a leiomyoma enlarges and outgrows its blood supply.²⁰ Degeneration can be of various types including hyaline or myxoid, calcific, cystic, and hemorrhagic. Local pain may be accompanied by systemic symptoms such as low-grade fever and leukocytosis. Fibroids are hormonally responsive and can increase rapidly in size during pregnancy predisposing them to hemorrhagic or “red degeneration.”²¹ US is usually diagnostic in detecting fibroids, with MRI used for further characterization if clinically necessary. Although fibroids are often incidentally seen, CT is not useful for diagnosis or characterization of fibroids.

The most common sonographic appearance of a fibroid is a well-defined, hypoechoic mass. They can, however, be heterogeneous, hyperechoic, or calcified with acoustic shadowing. Anechoic, irregular spaces may be seen in necrotic fibroids that have undergone degeneration (Fig. 20). Occasionally, it may be difficult to distinguish a pedunculated fibroid from a solid ovarian neoplasm and MRI can be useful in further characterization.

CT will demonstrate lobular uterine enlargement due to distortion of the uterine contour by the focal intrauterine masses, and there will be a heterogeneous pattern of contrast enhancement. Coarse dystrophic calcification in a uterine mass is the most specific CT sign for a leiomyoma; however, this is seen in only 10% of cases.²² Fibroid degeneration results in varying degrees of liquefaction, which correspond to a more cystic appearance and diminished contrast enhancement with areas of low attenuation (Figs. 21, 22).²² With extensive degeneration, the leiomyoma may be quite large and pre-



FIGURE 20. Large degenerating fibroid. Transabdominal ultrasound of the uterus shows the very heterogeneous appearance of a degenerating fibroid (arrows), which contains irregular hypoechoic components.

dominantly cystic, and may be confused with a cystic ovarian mass (Fig. 22). Further evaluation with MRI may be needed to exclude a lesion of adnexal origin.

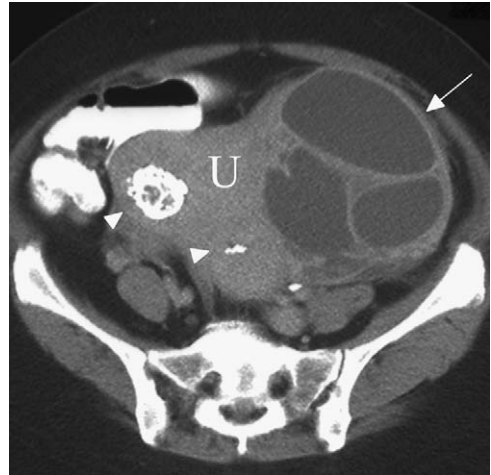


FIGURE 21. Fibroids, computed tomography (CT). Axial unenhanced CT shows the lobular contour of a myomatous uterus (U), which contains 2 calcified fibroids (arrowheads) and a large, degenerating, cystic-appearing fibroid (arrow).

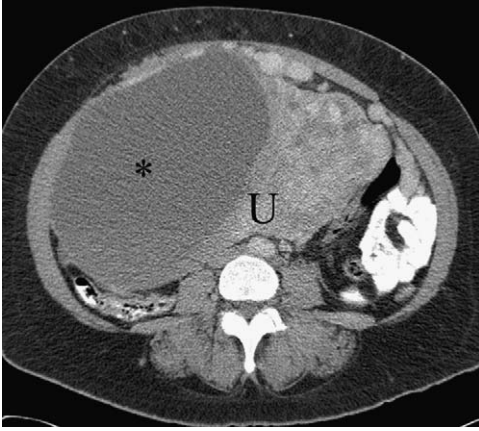


FIGURE 22. Degenerating fibroid. The uterus (U) shows a very heterogeneous pattern of enhancement and there is a large, liquefied fibroid (*).

MRI offers the most accurate imaging technique for detection and characterization of uterine leiomyomata.²⁰ Nondegenerated fibroids typically appear as well-circumscribed intrauterine masses with homogeneously decreased signal on T2-weighted images and enhancement after gadolinium administration. Degenerated fibroids have a more variable appearance on both unenhanced and enhanced MRI. The multiplanar capability of MRI enables better localization of masses that protrude into the adnexa, and can differentiate a leiomyoma from an ovarian mass. Recognition of separate normal ovaries and/or continuity of the adnexal mass with the myometrium, make the diagnosis of a pedunculated fibroid.

Endometriosis

Endometriosis is defined as the presence of extrauterine endometrial mucosa, and is most commonly found, in descending order, in the ovaries, uterine ligaments, pouch of Douglas, serosal surface of the uterus, fallopian tubes, rectosigmoid co-

lon, and bladder. The ectopic mucosa is hormone responsive and bleeds cyclically resulting in hemorrhage-filled cysts and hemorrhagic ascites. Endometriosis occurs almost exclusively in women of reproductive age, with an estimated prevalence of 10%, however, the prevalence in women with infertility is approximately 25%.²³ The classic clinical symptoms include pelvic pain, dysmenorrhea, dyspareunia, and infertility. Laparoscopy remains the gold standard for diagnosis and staging, and best demonstrates small peritoneal implants and adhesions. Larger implants, however, can be identified with radiologic imaging allowing noninvasive diagnosis in the patient presenting with pelvic pain.

Eighty percent of all pelvic endometriosis occurs in the ovary.¹³ Endometriotic cysts in the ovaries, also called endometriomas, have a variety of appearances on US, ranging from an anechoic cyst to a complex cystic mass with septations and heterogeneous echogenicity. The most typical appearance on an endometrioma is that of a homogeneously hypoechoic, cystic mass with diffuse, low-level internal echoes and posterior acoustic enhancement. This homogeneous appearance has been termed the “ground glass” pattern. The additional presence of punctate, peripheral, echogenic foci within the cyst wall is a very specific sign for an endometrioma (Fig. 23).²⁴ Endometriomas can also have a more complex multiloculated appearance, with fluid-debris levels, or less commonly, thick internal septa.¹³ The sonographic appearance may be similar to that of a hemorrhagic cyst, especially an acute or subacute hemorrhagic cyst, however, the internal echoes seen with a hemorrhagic cyst are classically more lace-like, as opposed to the homogeneously hypoechoic appearance characteristic of an endometrioma. Endometriomas also are more commonly multiple and their appearance is stable over time, compared with the changing appearance of a hemorrhagic cyst.²

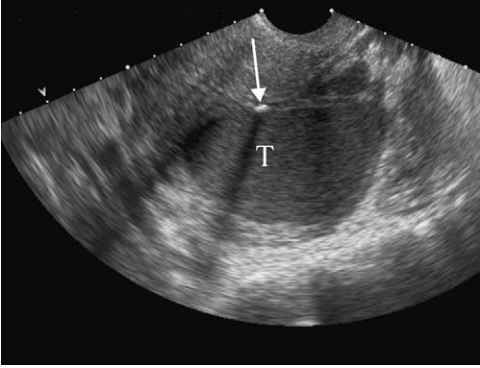


FIGURE 23. Tubal Endometrioma. Ultrasound shows the classic “ground glass” appearance in an endometrioma (T). A mural reflector (arrow) is seen within the cyst wall. This is a highly specific sign for an endometrioma.

CT is generally not very useful in evaluating patients with endometriosis, because the findings tend to be nonspecific. Although CT may show hyperattenuation indicative of blood products, this is more conclusively demonstrated with MRI. The CT appearance of a focal hyperdense clot in a cystic mass has been described as a finding suggestive of endometrioma, however, it is not commonly seen (15% of cases) and can also be seen with other hemorrhagic masses, such as a hemorrhagic ovarian cyst.²² The demonstration of multiple lesions and bilaterality increase the specificity for the diagnosis. CT may be more useful in demonstrating unusual sites of endometrial implantation, such as the anterior abdominal wall.²²

MRI allows for more definitive characterization of suspected endometrial implants and endometriomas because of the presence of blood within these lesions. Most typically endometriomas on MRI are seen as cystic masses, often multiple, with hyperintense signal on T1-weighted images, unlike cysts or abscesses which show low T1 signal. Owing to the concentrated blood products, endometriomas

will appear hypointense on T2-weighted images, again unlike cysts or abscesses that are hyperintense on T2-weighted images. The characteristic hypointense T2 signal of an endometrioma is referred to as “T2 shading,” which is quite variable and includes complete loss of signal, heterogeneous signal loss or a fluid/fluid level of dark and bright signal (Fig. 24).²⁵

MRI has a sensitivity of 90% to 92% and a specificity of 91% to 98% for the diagnosis of endometriomas if the following criteria are met: multiple cystic masses, hyperintense signal on T1 images, shading (loss of signal) on T2 images.¹³ Less typically, an endometrioma may show high-signal intensity on T1-weighted and T2-weighted images, possibly with a thickened, low-signal intensity wall. Adhesions to other organs may be seen. Small, noncystic implants may be difficult to detect, even with MRI. The use of fat-suppressed contrast-enhanced T1-weighted images may be helpful in their detection.

Postpartum Causes of Pelvic Pain

The normal postpartum uterus is initially quite enlarged and “boggy.” Involution occurs over the course of the next 6 to 7 weeks until the uterus returns to its baseline size. Imaging in this period is only performed if the patient has symptoms such as unexplained fever or pelvic pain. The primary concern in this setting is for endometritis or retained products of conception. Ovarian vein thrombosis (OVT) is another important cause of pelvic pain and fever in the postpartum setting.

ENDOMETRITIS

Endometritis is the most common cause of postpartum fever, with a reported prevalence of 3.8%.¹⁴ The diagnosis is usually based on the clinical findings of fever and an enlarged tender uterus. Imaging is

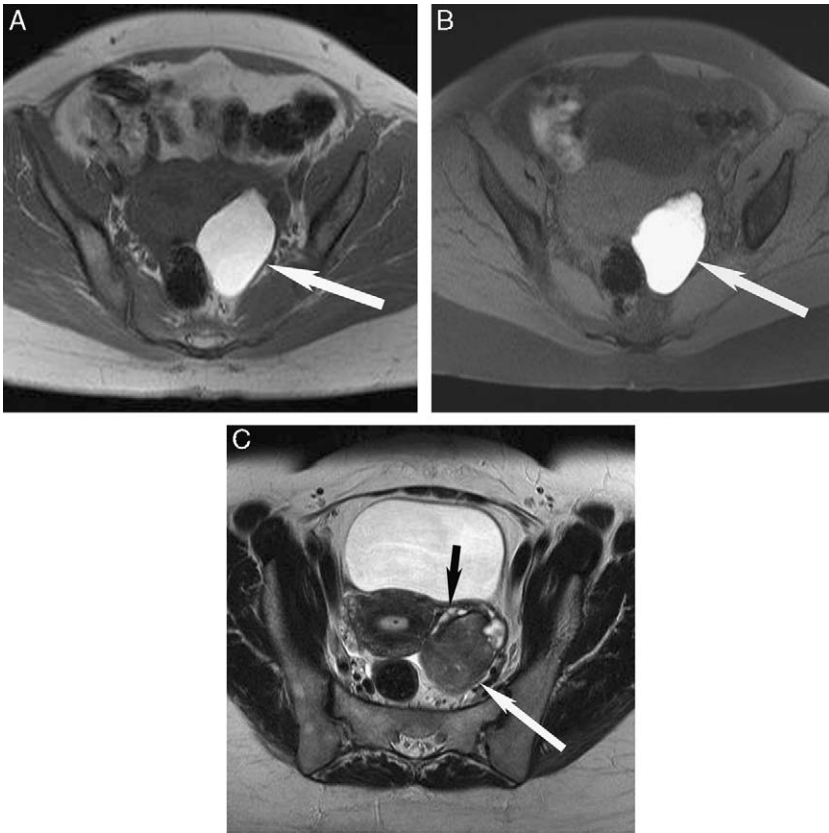


FIGURE 24. Endometrioma, magnetic resonance imaging. (A) Axial, nonfat suppressed T1-weighted MR shows a large, unilocular, high-signal lesion (arrow), which remains bright (B), with fat suppression. (C) The T2-weighted image shows classic loss of signal intensity “shading” (white arrow), which is from the concentrated blood products within an endometrioma. Small peripheral ovarian follicles are also noted (black arrow).

often not helpful in establishing the diagnosis because of the overlap in finding between endometritis and the normal postpartum state. Both may appear as enlarged uterus with a small amount of blood or fluid. The presence of gas is not diagnostic either, because a small amount of gas may be seen by US and CT in the endometrial cavity in up to 21% of healthy postpartum women several weeks after delivery.²⁶ Imaging, therefore, is usually reserved for patients who are non-responsive to treatment with refractory

pain or fever, to exclude an additional abnormality.¹⁴

There are no classic sonographic findings of endometritis. The uterus may appear normal or may show nonspecific findings that overlap with retained products of conception including: a thickened heterogeneous endometrium and intrauterine fluid with or without internal echoes representing blood, retained products of conception, or gas. Similar findings are seen on CT (Figs. 7, 25). CT has the added advantages over US of

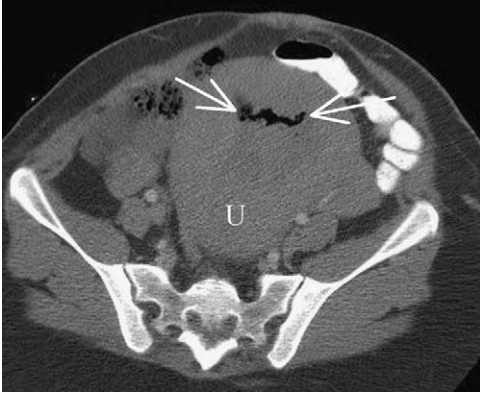


FIGURE 25. Postpartum endometritis. Axial-enhanced computed tomography image shows an enlarged uterus (U) with low-density fluid and gas (arrows) in the endometrial cavity.

better demonstrating associated inflammation of the parametrial soft tissues and identifying potential extrauterine abscesses.²²

OVT

OVT is an uncommon, yet potentially fatal disorder because of the risk for pulmonary embolism. Although OVT may occur after pelvic surgery or in association with malignancy and inflammatory conditions, it occurs most often in the early postpartum period, possibly due to the retrograde propagation of thrombosed myometrial veins draining an infected placenta.¹⁶ Doppler US has been used to diagnose this condition and may demonstrate an enlarged ovary with a dilated, noncompressible ovarian vein showing little or no flow. In 80% to 90% of cases, the right ovarian vein is involved.²⁶ The vein should be followed cephalad to look for extension into the inferior vena cava.

Contrast-enhanced CT and MRI have shown greater sensitivity and specificity than Doppler US in the detection of

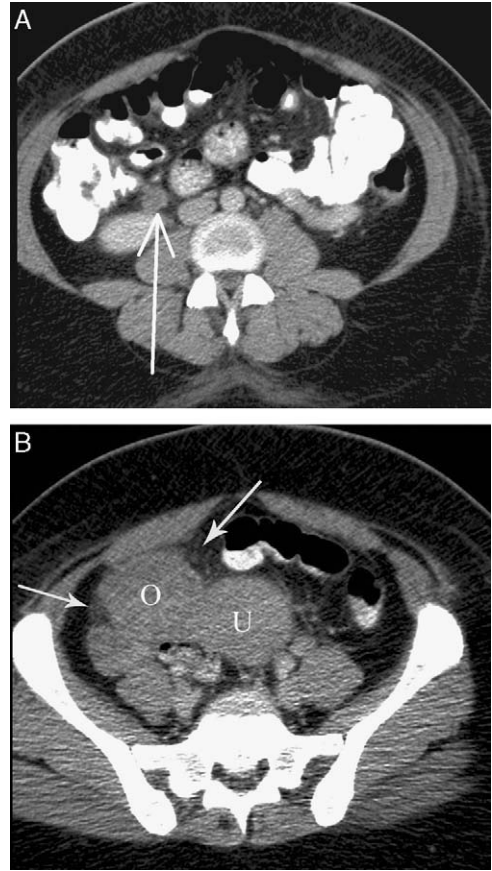


FIGURE 26. Ovarian vein thrombosis, computed tomography (CT). (A) Axial-enhanced CT image demonstrates expansion and poor enhancement of the right ovarian vein (arrow). (B) Axial CT image through the uterine fundus (U) and right adnexa shows the secondary signs of ovarian vein thrombosis including an enlarged right ovary (O) and mild edema of the surrounding pelvic fat (arrows).

OVT, and are the imaging modalities of choice for when this condition is suspected.^{14,26} Contrast-enhanced CT shows an enlarged vein, distended with a low-density, intraluminal-filling defect representing the thrombus. The pelvic fat may show inflammatory change, and ascites may be present (Fig. 26). Similar findings

are seen with MRI. Multiplanar imaging can help in distinguishing the inflamed tubular vessel from the ureter, an inflamed appendix, or other loop of bowel.

Appendicitis

Appendicitis is the most common nongynecologic cause of acute pelvic pain in women and the most frequent indication for emergency surgery in pregnancy.² Although the incidence of acute appendicitis is not increased in pregnancy, appendiceal rupture occurs 2 to 3 times more frequently because of the delay in diagnosis and treatment.² The symptoms of acute appendicitis in pregnant patients tend to be nonspecific because of the displacement of the appendix by the gravid uterus and leukocytosis may be overlooked, as it is commonly seen physiologically in pregnancy. Even in nonpregnant females the presentation of appendicitis can overlap with other gynecologic causes of acute pelvic pain and result in delay in diagnosis. The incidence of misdiagnosed appendicitis in women of reproductive age has been shown to be in the range of 23.6% to 26.6%.²⁷ A discrepancy between the false-negative appendectomy rate in men and women has been documented as well (9% vs. 19%, respectively).²⁸

The use of imaging, particularly CT, which is the test of choice for suspected appendicitis in adults, has been shown to improve diagnostic accuracy. CT decreases the false-negative rate to 4% overall and 8.3% in females of childbearing age.²⁹ Findings on CT are overall swelling (>6 mm), wall thickening, and enhancement of the appendix. Secondary signs include periappendiceal fat stranding, pericolic fluid, and focal thickening of the cecum. The appendix may be difficult to visualize in cases of appendiceal rupture, which may be suspected if there is a focal defect in the wall of the inflamed appendix, an appendicolith outside the appendix, a

periappendiceal fluid collection, or extraluminal gas near the appendix.

US with graded compression is a proven useful test for diagnosing appendicitis. Although the sensitivity of US examination (75% to 90%) is not as high as with CT (87% to 98%), the advantages of a lack of ionizing radiation and a high

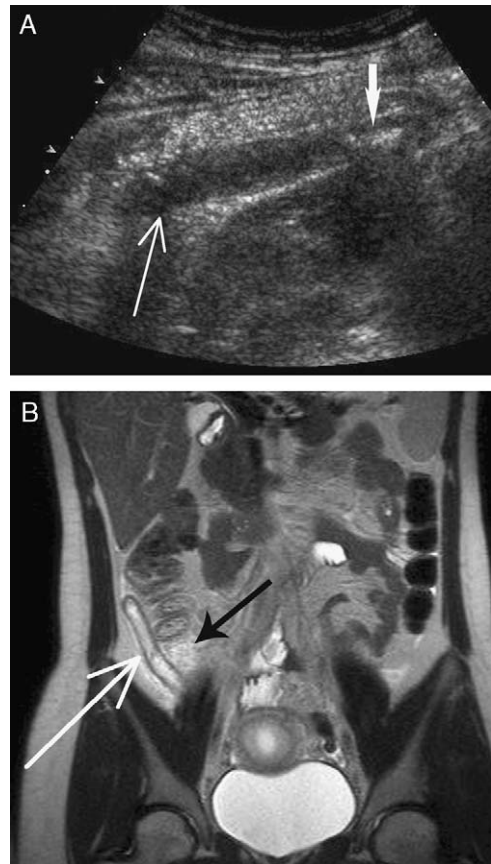


FIGURE 27. Acute appendicitis in a pregnant patient. (A) Ultrasound shows a blind-ending, tubular structure (long arrow) measuring greater than 6 mm in diameter. A shadowing appendicolith (short arrow) is also seen. (B) Coronal T2-weighted magnetic resonance imaging better demonstrates the dilated, fluid-filled bright appendix (white arrow). The periappendiceal fat is also hyperintense (black arrow) from edema and inflammation.

positive predictive value (95%) make it the recommended first-line investigation in pregnant patients and children.²⁹ The normal appendix is rarely seen by US. The diagnosis of acute appendicitis, however, can be made by demonstration of a non-compressible, aperistaltic, blind-ending tubular structure measuring greater than 6 mm in diameter (Fig. 27A). The periappendiceal fat may be echogenic due to the inflammation. Color Doppler US may be helpful, in showing hyperemia within the thickened wall.

MRI is used predominantly to diagnose acute appendicitis in pregnant patients, often after a nondiagnostic US study. The inflammation will be depicted best on the fluid-sensitive T2-weighted images; fat saturation allows the signal abnormality to be more readily apparent. Appendiceal wall thickening (>2 mm) will show hypointense signal on T1-weighted images and hyperintensity on T2-weighted images, with the caliber of the appendix measuring greater than 6 mm. Periappendiceal fat inflammation will manifest as hyperintense T2 signal, consistent with edema (Fig. 27B). In the nonpregnant patient, gadolinium contrast administration increases the sensitivity of MRI in diagnosing acute appendicitis where intense appendiceal wall enhancement is seen on the fat-suppressed postcontrast T1 images.^{24,30} Gadolinium is, however, contraindicated in pregnancy, especially in the first trimester.

Conclusions

Determining the cause of acute pelvic pain can be clinically challenging in the female patient. Diagnostic imaging can be invaluable in this situation. Although pelvic US is often the primary imaging test of choice for suspected gynecologic pathology, CT and MRI are extremely useful tests when properly applied. Clinicians who are armed with an understanding of

the utility of the various imaging options, and the manifestations of potential disorders will be best prepared to meet this challenge.

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