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Recognizing the CT Manifestations of Gynecologic Conditions Encountered in the Emergency Department

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A B S T R A C T

Women commonly present to the emergency room with subacute or acute symptoms of gynecologic origin. Although a pelvic exam and ultrasound (US) are the preferred initial diagnostic tools for gynecologic entities, a CT is often the first line imaging modality in the emergency department. We will provide a review of normal uterine enhancement and normal pregnancy related findings, and then familiarize radiologists with the CT appearances of gynecologic entities classically described on ultrasound that may present to the emergency department.

Introduction

Pelvic pain is a common reason for women to present to the emergency department. Detailed menstrual, sexual, and surgical history, and screening beta-human chorionic gonadotropin (hCG), are essential to differentiate gynecologic pain from other etiologies. Ultrasonography is the preferred modality for imaging of gynecologic disease, but in a busy emergency room setting, computed tomography (CT), may be the initial imaging modality used for women with incomplete history and nonspecific complaints. Furthermore, CT is widely available, fast, and efficient and can rule out other causes of pain. Although most radiologists are familiar with common gynecologic entities with ultrasonographic imaging, recognizing the CT appearance of gynecologic pathology is important. Unfortunately, in a very busy emergency department, it is often easy to overlook subtle abnormality in the female pelvis on CT, even though, it can often reveal the source of pain or pathology when the rest of the study is normal.

The Wide Spectrum of Normal

Patterns of Uterine Enhancement

The appearances of the normal uterus vary greatly, especially after intravenous contrast. Familiarity with the spectrum of normal imaging patterns is important to avoid describing a variant of normal as pathologic.

On noncontrast CT, the myometrium appears homogenous and isodense to skeletal muscle. The normal endometrial canal exhibits lower attenuation than myometrium, its thickness varies with the menstrual cycle, and it should not be mistakenly described as blood or fluid in the canal (Fig 1 A/B open arrowhead). During the menstrual cycle, the endometrium can measure anywhere from 1 mm during menstruation and up to 7-16 mm during the secretory phase.[1]

Four subtypes of myometrial enhancement have been described.[2,3] Type 1 is a subendometrial band of enhancement that may be thin or thick (Fig 1 A/B), with or without outer myometrial enhancement (Fig 1 C), 30-120 seconds after contrast injection.[3] The type 1 pattern is seen mainly in premenopausal women.[3] Type 2 is diffuse enhancement throughout the entire myometrium or enhancement that progresses from the outer myometrium to the entire myometrium (Fig 1 D/E), without distinct subendometrial enhancement. The type 2 pattern of enhancement is observed equally in pre and postmenopausal women.[3] Type 3 is no or minimal enhancement throughout the myometrium (Fig 1 F). This type is seen in postmenopausal women.[3] Type 4 is a patchy, heterogeneous enhancement of the entire myometrium (Fig 1 G/H) and is less well described and less common than the other types.[2]

The physiology underlying the wide range of normal enhancement patterns is not well understood. Menstrual status, patient age, and contrast timing are the most important factors.[3] Given the variability of myometrial enhancement, recognizing focal mass-like enhancement, parametrial stranding, and uterine contour abnormality are the key to diagnosing gynecologic infection or neoplasm. When the uterus has an abnormal appearance on CT, an MRI or ultrasound is indicated for further characterization.

The vascular structures within the pelvis can also exhibit variability. Dilated uterine vessels (Fig 1 H) may be encountered incidentally and are often seen in multiparous reproductive age women. The increase vascularity associated with pregnancy may cause dilation of venous structures in the pelvis and over time lead to incompetent venous valves. Dilated uterine veins have been associated with a condition called pelvic venous congestion syndrome, and while the

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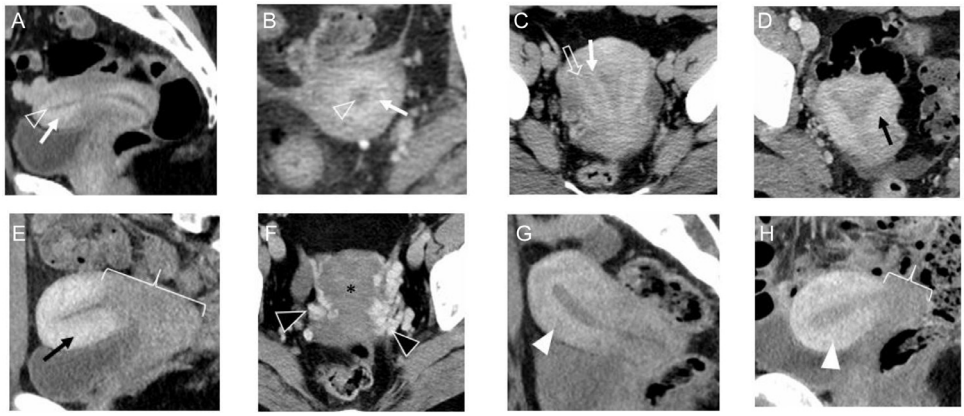

FIG 1. Wide range of normal uterine enhancement patterns are observed on contrast enhanced CT. (a) and (b) sagittal and axial CT images of different patients show normal thin (A) and thick (B) subendometrial enhancement (arrow). Also note the variable thickening of the normal hypoattenuating endometrial tissue (open arrowheads), not to be confused with fluid in the endometrial canal. (C) Axial CT image shows a normal retroverted uterus with both subendometrial enhancement (arrow) and outer myometrial (open arrow) enhancement. (D) and (E) axial and sagittal CT images of a normal uterus with diffuse myometrial enhancement (black arrows), (F) axial CT image shows minimal diffuse enhancement (asterisk) and dilated pelvic varices (black arrowheads). (G) and (H) Sagittal CT images of different patients show normal patchy heterogeneous enhancement of the myometrium (arrowheads). Note the relative hypoenhancement of the cervix compared to the uterus (brackets) on e and h.

majority of women with dilated pelvic vessels are asymptomatic, it may be helpful to raise the possibility of pelvic venous congestion syndrome in ED patients presenting with engorged pelvic veins.[4] The diagnostic criteria for CT consists of at least 4 ipsilateral parauterine veins of varying caliber, with at least 1 measuring more than 4 mm in diameter, or an ovarian vein diameter greater than 8 mm.[4]

Variability of the Cervix and Upper Vagina

The normal cervix measures on average 3 cm and the width of the internal cervical os measures 3 mm.[5] Cervical zonal enhancement is seen in patients with a type 1 or type 2 uterine enhancement pattern (Fig 1 A).[3] A target-like appearance of the cervix results from relative hyper-enhancement of the central glandular mucosa and relative hypo-enhancement of the outer fibromuscular stroma.[3] The cervical fibromuscular stroma demonstrates gradual enhancement that often lags behind uterine myometrium (Fig 1 E/H).[6]

Nabothian cysts are benign retention cysts resulting from chronic inflammation on endocervical glands that should not be mistaken for pathology. Nabothin cysts can vary in size, ranging from a few millimeters in diameter but may reach 4 cm or more.[7] On CT, they solitary, scattered or clustered cysts, with a thin nonenhancing wall, and central fluid attenuation.[2]

On CT, the vaginal mucosa of reproductive age women enhances. The vaginal wall is may be inseparable from the urethra and rectal wall and is hypoattenuating relative to the mucosa. In postmenopausal women, the vaginal mucosa appears similar to the vaginal wall and is hypoenhancing.[8]

Foreign Bodies

Foreign bodies related to menstruation, pelvic floor laxity, and contraception are often seen incidentally on CT in the emergency room setting. The most common vaginal foreign body is a tampon, which typically has the attenuation of air, secondary to gas trapped between the tampon fibers (Fig 2 A). Occasionally patients will forget to remove a tampon, and it can serve a source of infection. A pessary is a device placed into the vagina to prevent pelvic organ prolapse. They have variable appearance but most commonly appear as a thick ring of uniform high attenuation in the vagina. (Fig 2 B/C) A

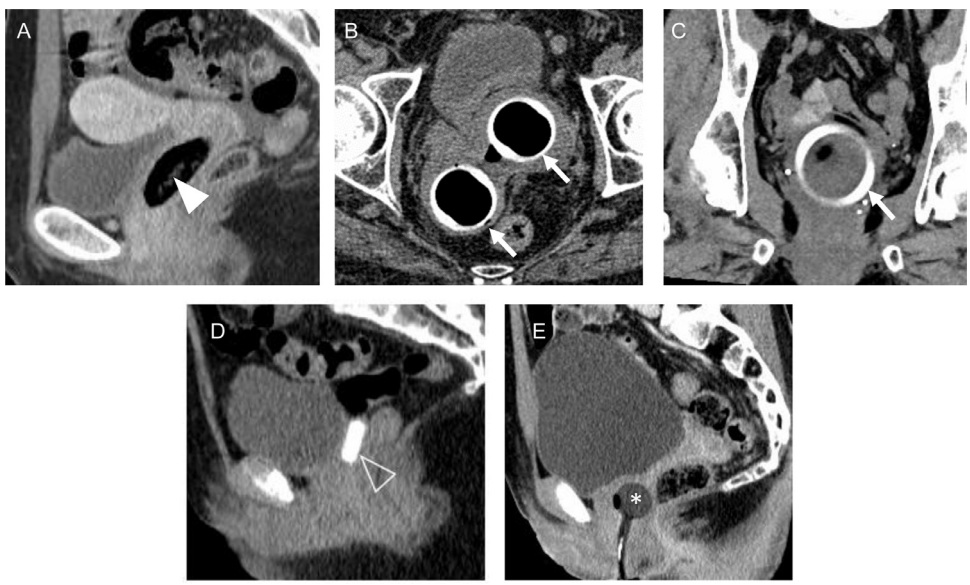

FIG 2. Foreign bodies are commonly encounter in the vagina. (A) sagittal CT image shows a mixed attenuation tubular tampon predominately composed of gas in the vagina (arrowhead). (B) and (C) axial and coronal CT images of different patients with pessary devices in the vagina (arrows). (D) sagittal CT image shows a rectangular hyperdense foreign body in the vagina which on physical exam was a piece of candy (open arrowhead). (E) sagittal CT image shows a urinary catheter inadvertently placed in the vagina (asterisk).

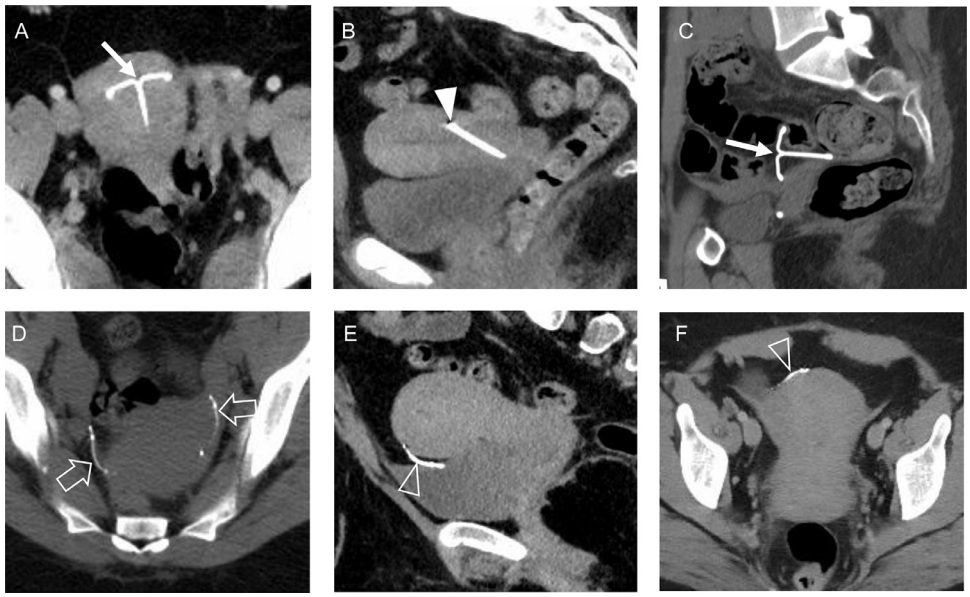

FIG 3. Intrauterine devices (IUD) and tubal occlusion devices (TOD) are frequently encountered on CT. (A) axial CT image of the pelvis shows a T-shaped IUD (arrow) in expected position with the 2 limbs extending toward the uterine cornua and the stem within the endometrial canal. (B) sagittal CT image of the pelvis shows an IUD extending from the cervix into the posterior myometrium (arrowhead) of the low uterine segment. (C) oblique sagittal CT image shows an IUD (arrow) which has migrated out of the uterus into the peritoneal cavity. (D) axial CT image shows TOD (open arrow) extending from the cornua of the uterus along the expected course of the fallopian tubes. (E) sagittal CT image shows a TOD which has migrated out of the fallopian tube to an intraperitoneal location inferior to the uterus (open arrowhead). (F) axial CT image shows a TOD which has migrated anterior to the uterus (open arrowhead).

contraceptive ring appears similar to a pessary, but is found in reproductive age women and has low attenuation.[9,10] Children and patients with certain psychiatric conditions may place foreign bodies in the vaginal canal (Fig 2 D). Metallic piercings may be present and are typically located just above the introitus. Sometimes a urinary bladder catheter may be mistakenly placed in the vagina (Fig 2 E).

Long-term or permanent contraceptive devices are becoming more common. Modern intrauterine devices (IUDs) have a T-shaped configuration and appear metallic (Fig 3 A). The limbs of the "T" should conform to the uterine cornua with the stem centered in the endometrial canal. IUDs may be improperly inserted or migrate out of the endometrial canal, becoming embedded in the myometrium (Fig 3 B), and can even perforate the myometrium and enter the peritoneal cavity[11] (Fig 3 C). Tubal occlusion devices provide a permanent form of contraception by inducing fibrosis and eventual tubal occlusion. Tubal occlusion devices appear as linear metallic foreign bodies within the fallopian tubes (Fig 3 D), but are also subject to misplacement and migration (Fig 3 E/F).[11]

Postpartum Findings

Postpartum women may present to the ED for complaints such as acute abdominal pain, suspicion for retained products of conception (RPOC), or postpartum fever, and undergo CT. Immediately postpartum, blood products or debris may be observed within the endometrial canal and increased vascularity may be seen within the myometrium.[2] In the absence of signs or symptoms of infection, intrauterine air can be a normal finding for up to 3 weeks[2] (Fig 4 A).

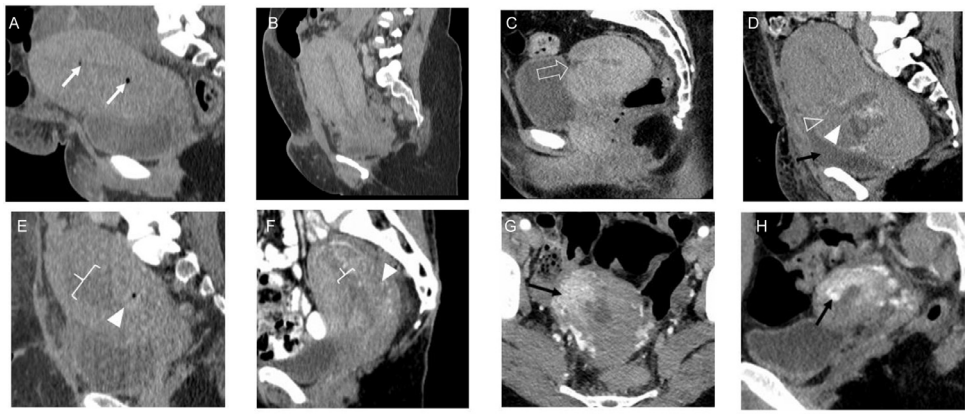

FIG 4. Postpartum imaging of the pelvis can identify complication of pregnancies. (A) sagittal CT image during postpartum hemorrhage evaluation shows small flecks of gas (arrows), a normal finding. (B) sagittal CT image of the pelvis shows a normally enlarged postpartum uterus with a thin endometrial canal. (C) sagittal CT image shows thinning of the lower uterine segment (open arrow) at the site of prior cesarean section which can place the patient at risk for uterine rupture with subsequent pregnancies. (D) sagittal CT image shows a heterogeneous fluid collection (open arrowhead) at the site of cesarean section, with fluid (black arrow) anterior to the uterus in the setting of acute postoperative hemorrhage after cesarean section. (E) sagittal CT image shows a fluid filled endometrial canal (bracket) with a discrete soft tissue nodule and gas (arrowhead), in the setting of retained products of conception and endometritis. (F) sagittal CT image shows a fluid filled endometrial canal (bracket) with a focal area of high attenuation (arrowhead) which was clotted blood in the setting of postpartum hemorrhage. (G) and (H) coronal and sagittal CT images of arteriovenous fistula (black arrows) in the uterus after elective abortion.

The postpartum uterus will be enlarged (Fig 4 B) with a distended endometrial canal for up to 8 weeks. A cesarean section scar (Fig 4 C) appears as a low attenuation irregular line at the lower uterine segment, and can be the site of postoperative hemorrhage (Fig 4 D) or infection. Thinning of the lower uterine segment after cesarean can also place the patient at risk for placenta accreta or uterine rupture with subsequent pregnancies. Intraperitoneal air can be seen after a cesarean section, although usually small in volume.

Ultrasound (US) imaging is generally adequate when retained products of conception are suspected. On CT, retained products of conception often manifest as hyperenhancing soft tissue within the endometrial canal, but may also be nonenhancing (Fig 4 E).[12] Clotted blood from postpartum hemorrhage can mimic retained products of conceptions (Fig 4 F).[12] Without precontrast images, enhancement can be difficult to distinguish from high-attenuation clot at CT and enhancement may even be partial or delayed.[12] Arteriovenous fistula is important differential consideration for a hyperenhancing endometrial or myometrial nodule demonstrating marked vascularity if the patient underwent dilatation and curettage. (Fig 4 G/H).[12] On CT, RPOC may be distinguished from arteriovenous malformations based on the vascular component involving the endometrium in RPOC, whereas uterine AVMs primarily involve only the myometrium.[12]

CT imaging may be performed for problem solving or when the presentation is nonspecific. Multidetector CT with contrast is the initial imaging modality of choice to rule out postpartum bleeding and postsurgical or intraabdominal complications. Contrast-enhanced CT can give information about the anatomic location of arterial bleeding sites and hematomas and provide vascular mapping for endovascular embolization.[13]

Neoplasm and Malignancy

Fibroids

Fibroids or leiomyomas are the most common uterine neoplasms, and are reported in over 20% of women over 30 years of age.[14] They are benign smooth muscle tumors with variable fibrous connective tissue.[15] Uterine fibroids are classified as submucosal, intramural, or subserosal (Fig 5 A-D). Submucosal fibroids project into the endometrial canal, and may cause vaginal bleeding or infertility.[15] Patients with fibroids may present secondary to pelvic pain, fibroid torsion, acute degeneration, submucosal fibroid prolapse, or vaginal bleeding.[14]

On noncontrast CT, fibroids may cause uterine enlargement with focal contour deformation. Contrast enhancement is usually heterogeneous (Fig 5 D).[14] Fibroids that undergo hyaline degeneration and necrosis may be heterogeneously hypoenhancing with areas of fluid attenuation (Fig 5 B).[14] Dystrophic calcifications in a uterine mass are specific for fibroids.[14] Differentiation of leiomyosarcoma from leiomyoma is difficult or impossible with standard imaging techniques, but larger size, rapid growth, early contrast enhacement, and metastatic disease in the absence of other primary malignancy should raise suspicion of malignancy.[16] In addition, marginal irregularity has been suggested as a differentiating characteristic but the sensitivity, which was 56% in one series, is variable.[14]

A torsed fibroid may have rim enhancement from obstructed peripheral veins.[15] Torsion may lead to infarction, degeneration, necrosis, and possible infection.[14] Subserosal fibroids may be confused with ovarian masses or endometrial disease, and can be further characterized with MR.

Endometrial/Cervical Neoplasm

The variable orientation and enhancement of the cervix in relation to the uterus can simulate a mass. The cervix tends to be hypoenhancing compared to the uterus. Assessing the continuity of the endometrial canal with the endocervical canal may help differentiate a normal cervix from a mass.[2] An obliterated endocervical canal (Fig 6 A) with a distended endometrial canal may signify an obstructing mass.[2] Other signs that should alert the radiologist to neoplasm include irregularity of the subendometrium, tissue invading the myometrium or parametrial fat, or over-dilation of the endometrial canal.

CT can depict gross endometrial thickening but has a low sensitivity (53.1% regardless of age or menopausal status) for showing mildly thickened endometrium.[17] Grossman et al. demonstrated that at an endometrial thickness of 3 mm or below, endometrium was interpreted as normal on CT but found to be thickened on sonography. In contrast, when the endometrium was interpreted as thickened on both techniques, the mean difference between the measured endometrial thickness and accepted top normal sonographic value was larger (7 mm; $P < 0.002$).[16]

Measurement may require reformatted images in sagittal relative to the uterus, as thickness can be overestimated if the endometrium is imaged obliquely. Blood products, fluid, and endometrial tissue may all appear as endometrial thickening on CT. In the cases of suspected endometrial thickening (Fig 6 B/C) or endometrial canal fluid in the emergency room setting, transvaginal ultrasound is the preferred modality for additional characterization. An MRI may provide addition information when characterizing known uterine or cervical malignancy.

Malignant mixed müllerian tumors (MMMTs) are rare uterine malignancies also known as carcinosarcomas.[18] The CT appearance of MMMT is highly variable, but MMMT often appears as a heterogeneous, ill-defined mass within the endometrial canal (Fig 6 D/E). Tissue sampling is required for diagnosis.

Ovarian Neoplasm

Benign and malignant ovarian neoplasms are commonly encountered on CT in the emergency department setting and often require US or MR for additional characterization. Simple cysts greater than 7 cm in a reproductive age women and greater than 5 cm in a postmenopausal woman should be further characterized (Fig 7 A/B).[19] Any solid mass or partially solid partially cystic mass should be further characterized with US or MR (Fig 7 C/D).

Benign cystic ovarian teratomas (dermoids) account for 10%-25% of ovarian neoplasms, and can be diagnosed by their CT appearance (Fig 7 E-H).[20] They may be detected at any age and are bilateral in 8%-15% of cases.[20] Dermoids are composed of well differentiated derivatives of all 3 germ cell layers.[21] Patients may rarely present with acute

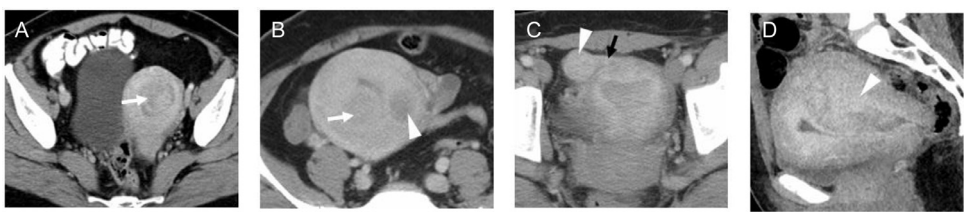

FIG 5. Fibroids are the most common neoplasm of the uterus, with varying appearances. (A) and (B) axial CT images of different patients with a submucosal fibroid (white arrows). (B) also shows a cystic intramural fibroid (arrowhead). (C) axial CT image shows a pedunculated subserosal fibroid (arrowhead) with a well-defined stalk (black arrow) which is at risk for torsion. (D) sagittal CT image with large heterogeneous intramural fibroid (arrowhead) deforming the endometrium.

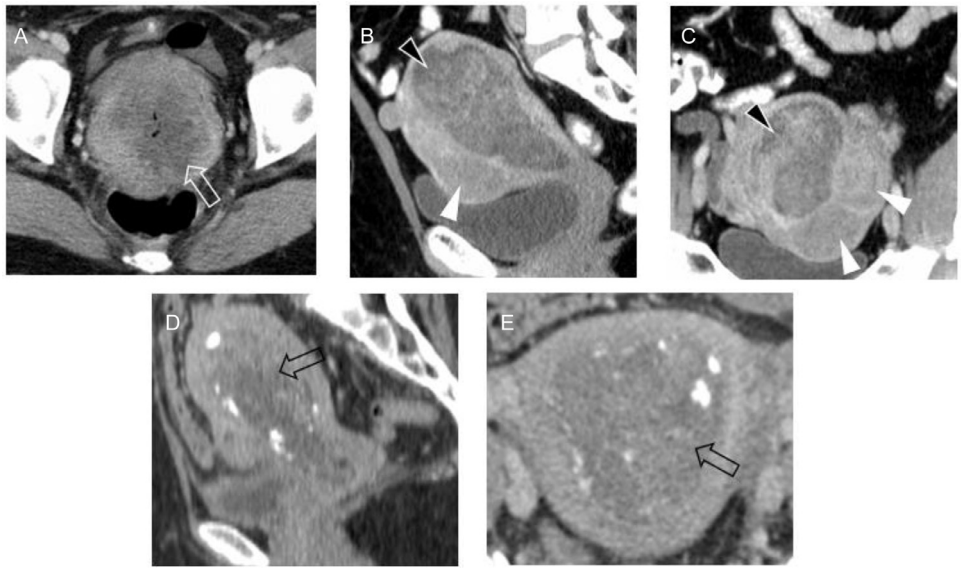

FIG 6. Neoplasm of the cervix and endometrium can have a wide range of appearances. (A) axial CT image show a heterogeneous cervical squamous cell carcinoma with central gas and necrosis (open arrow). (B) and (C) sagittal and axial CT images show a heterogeneous endometrial mass biopsy proven to be endometrial adenocarcinoma (black arrowhead). (D) and (E) coronal and axial CT images show an enlarging heterogeneous endometrial mass mistaken for a fibroid with calcifications, but show to be a mixed malignant mullerian tumor, aka carcinosarcoma, with osteosarcoma elements (black open arrow).

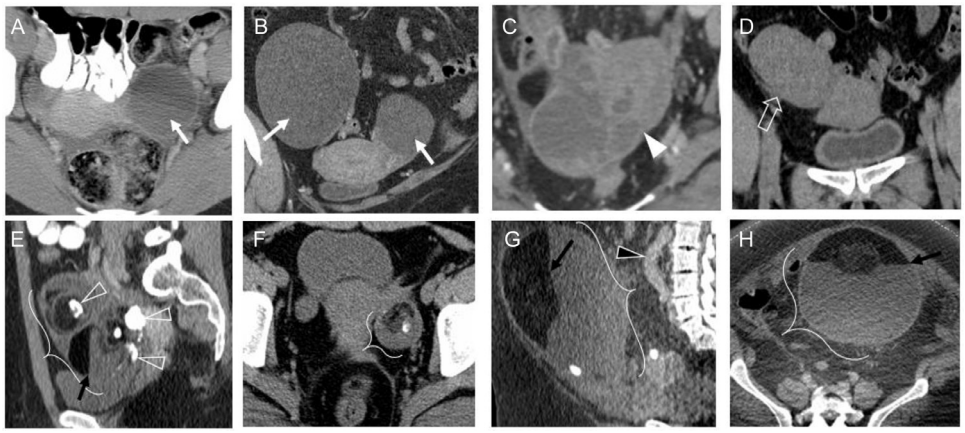

FIG 7. Cystic and solid ovarian neoplasms are often first detected incidentally with CT as benign and malignant ovarian masses are often asymptomatic. (A) axial CT image shows a simple 5 cm cyst (arrow) in a 24-year-old woman which requires no follow-up imaging. (B) coronal CT image shows 12 and 7 cm simple ovarian cysts (arrows) in a 50-year-old woman which require additional characterization with US. (C) coronal CT image shows an enhancing cystic and sold ovarian mass consistent with ovarian cystadenocarcinoma (arrowhead). (D) coronal CT image shows a solid right ovarian mass determined to be a granulosa cell tumor (open arrow) at surgical pathology. (E) sagittal CT image shows a complex solid and cystic mass with course calcifications and fat fluid levels consistent with a mature cystic teratoma (bracket). (F) axial CT image shows a small left ovarian mass with fat, soft tissue, and calcification compatible with mature cystic teratoma (bracket). (G) and (H) sagittal and axial CT images show a large ovarian mass with a fat fluid level (bracket) in a women presenting with acute right lower quadrant pain. The appendix was dilated and inflamed at laparotomy found a ruptured cystic teratoma with secondary appendicitis (black arrowhead).

symptoms of super-infection, torsion, autoimmune hemolytic anemia, or rupture.[20,22]

The most common appearance of an ovarian teratoma is a cystic mass with intratumoral fat (Fig 7 E/F).[22] Diagnosis of benign ovarian teratomas on CT and MR is fairly straightforward as these modalities are quite sensitive in detection of characteristic intratumoral fat.[22] On CT, there may be a fat fluid level. Calcifications are also a frequent finding in cystic teratomas.[22]

Rupture occurs in 1%-4% of ovarian teratomas, and is a rare due to the thick capsule that is usually present.[20] Rupture can lead to secondary inflammation of other intra-abdominal organs such as the appendix (Fig 7 G/H). Rarely, dermoid rupture can cause acute peritonitis, shock, or hemorrhage.[20] More commonly, rupture results in chronic granulomatous peritonitis with dense adhesions, peritoneal implants, and ascites which mimics peritoneal carcinomatosis.[20,22] Visualization of fatty implants within the peritoneal cavity can aid in diagnosis.[20]

Pelvic Infection

Pelvic Inflammatory Disease

Pelvic infection typically affects reproductive age women. Pelvic inflammatory disease is inflammation of the endometrium, fallopian tubes, and the pelvis. It is common for patients to have abnormal vaginal discharge, fever, and leukocytosis.

Imaging may be normal in the early phases of pelvic inflammatory disease (PID).[23] Subclinical PID may manifest as simple hydrosalpinx (Fig 8 A). Acute PID may be subtle on CT with mild parametrial soft tissue fat stranding, free pelvic fluid, and thickened ligaments (Fig 8 B).[23] Cervicitis may be seen on CT as cervical enlargement,

surrounding soft tissue stranding or thickening, and increased enhancement.[2] Nathobian cysts may develop during acute cervicitis or be the long-term sequelae of prior infection. The typical CT findings of pyosalpinx include an enlarged or tortuous fallopian tube, with or without adjacent tubo-ovarian abscess. The fallopian tubes can be mistaken for small bowel on CT, as the wall thickening, dilated tube and intraluminal fluid or debris create the appearance of obstructed bowel (Fig 8 C/D). The uterus may be enlarged or have thickened endometrium. The adnexa may be hyperenhancing with thick walls and septations.[23] Tubo-ovarian abscesses (Fig 8 E/F) may displace other pelvic structures such as the uterus or cause anterior displacement of the broad ligament.[23] Tubo-ovarian abscesses usually manifest in the adnexa as a multilocular septated cystic mass with a thick enhancing wall. Other imaging findings include loss of fat planes between the mass and adjacent organs, thickening of the uterosacral ligaments, and fluid within the cul-de-sac.[24] When there is ascites, it can be difficult to differentiate a TOA from a cystic ovarian neoplasm. However, key imaging finding suggestive of malignancy include a lobulated solid or complex mass larger than 4 cm, enhancing papillary projections, and walls or septa that measure more than 3 mm in thickness.[24] Significant surrounding inflammatory reaction associated with tubo-ovarian abscess can mimic other inflammatory disease processes such as ruptured appendicitis or vice versa. Key imaging features suggestive of appendicitis over a TOA include the presence of an appendicolith, cecal or rectosigmoid wall thickening, or cecal origin of a tubular structure.[24] In general, abscesses related to a perforated diverticulitis tend to have thicker walls, extraluminal air, and fistula formation.[24]

Management for early pelvic inflammatory disease includes 14 days of empiric broad spectrum antibiotics.[25] Surgical drainage or percutaneous intervention is typically reserved for patients that are septic or after failure of medical management,[25] unless the tubo-ovarian abscess exceeds 8-10 cm at presentation, and then primary drainage may be beneficial.

Actinomycosis

Actinomycosis is a rare chronic infection by the bacteria Actinomyces israelii. It is invasive due to proteolytic enzymes, spreading by direct extension across tissue planes with the formation of multiple abscesses and possibly tracts and sinuses.[26]

Intrauterine device-related actinomycosis is uncommon, but is the second most common presentation for actinomycosis.[27] IUD-related actinomycosis may be mistaken for invasive neoplasm and is characterized by a heterogeneous pelvic mass that does not respect tissue planes, in a patient with an IUD or recently removed IUD. The heterogeneous pelvic mass may be associated with adjacent cysts, surrounding inflammation and tubo-ovarian abscesses (Fig 8 G/H).[27] Actinomycosis can spread through the abdominal wall. A chronic indwelling IUD may cause endometrial erosion facilitating actinomycosis colonization and infection. Management of IUD related actinomycosis includes prompt removal of the device, 2-6 months of IV and oral antimicrobial therapy, and surgical resection of the infection.[27]

Acute Ovarian Pathology

Hemorrhagic Cyst or Follicle

Women commonly present to the ED due to pain associated with hemorrhage into corpus luteal or follicular cysts, or rupture of corpus luteal cysts. Due to the acute, but nonspecific, low-grade pain associated with hemorrhagic or ruptured cysts, a CT may be performed.

A hemorrhagic ovarian cyst on CT may appear as a smooth walled heterogeneous adnexal mass with a hyperdense component (45-100 HU).[14,28] Unfortunately, the hyperdense components may simulate enhancing soft tissue, and an ultrasound may be required to differentiate hemorrhagic cyst from ovarian neoplasm. Clot may adhere to the cyst wall mimicking nodularity. Fluid and debris levels may be observed. Cysts with a typical hemorrhagic appearance in a premenopausal or early menopausal patient can have a short interval follow-up US of 6-12 weeks to ensure resolution.[19] Any complex cyst in postmenopausal women should be considered neoplastic and a surgery consultation should be sought.[19]

Corpus Luteal Cyst Rupture

A ruptured corpus luteal cyst presenting to the emergency room as abdominal pain is referred to as Mittelschermz Syndrome. On CT, a collapsed ovarian cyst with wavy discontinuous peripheral enhancement is pathognomonic for a ruptured corpus luteal cyst (Fig 9 A/B). High-density fluid in the rectouterine pouch is characteristic of an associated small volume of hemoperitoneum. Corpus luteal cyst rupture occurs midmenstrual cycle, and it is unclear whether the

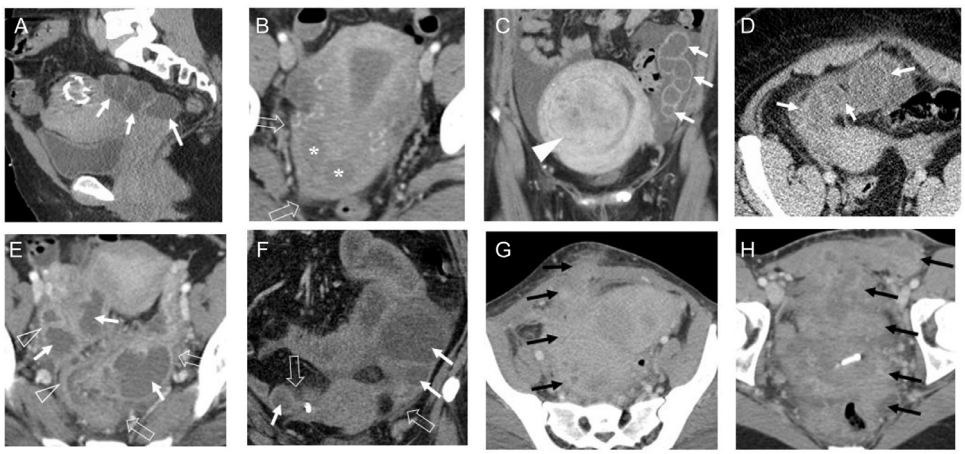

FIG 8. Pelvic inflammatory disease (PID) can present with a spectrum of findings. (A) sagittal CT image shows dilated tubular structures extending from the uterus with surrounding inflammatory change consistent with simple hydrosalpinx (arrows) in the setting of subclinical PID. (B) axial CT image shows a patient with cervicitis evident by mild parametrial fat stranding (open arrow), cervical enlargement and large endocervial cysts (asterix). (C) coronal CT images hyperemic dilated tubular structures with surrounding free fluid compatible with pyosalpinx (arrows) which were initially mistaken for obstructed small bowel. Additional, large submucosal fibroid (arrowhead). (D) Axial CT images shows pyosalpinx (arrows) with a dilated tubular structure with surround fluid that requires a narrow window to detect the fallopian tube. (E) and (F) coronal CT images from different patients show tubo-ovarian abscesses evident by fallopian tube wall thickening (open arrowhead), parametrial stranding (open arrows) and loculated collections (arrows). (G) and (H) axial CT images in different patients show IUD-related pelvic actinomycoses infection evident by an inflammatory mass not conforming to anatomic planes, invading the pelvic organs, and extending through the abdominal wall (black arrows).

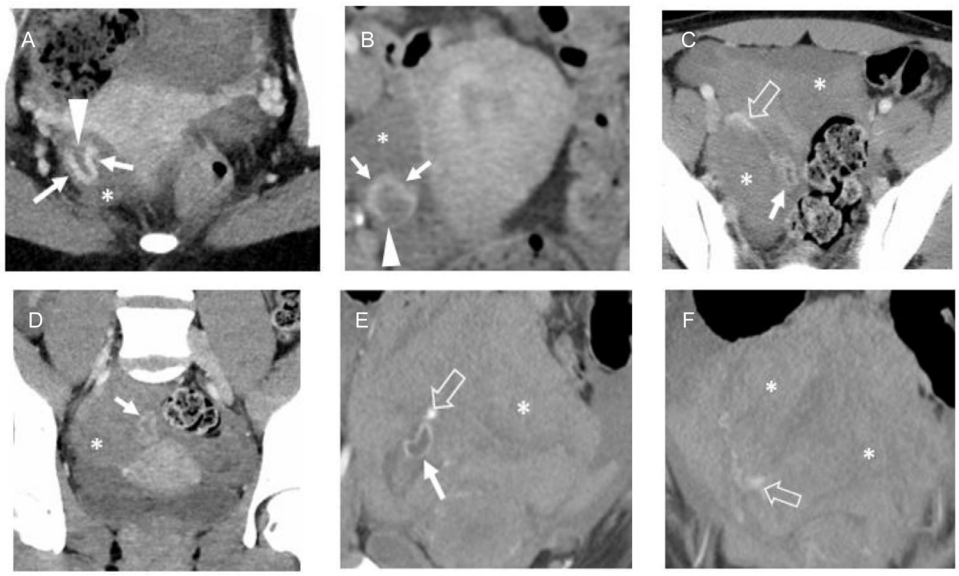

FIG 9. Women with Mittelschermz syndrome present midmenstral cycles with acute pelvic pain and imaging findings of rupture corpus luteal cyst and free fluid (asterisk). (A) and (B) axial CT images show the classic wavy (arrows) discontinuous enhancement (arrowhead) of a ruptured corpus luteal cyst with adjacent free fluid in reproductive age women presenting with midmenstrual cycle pelvic pain. (C) and (D) axial and coronal CT images shows a ruptured corpus luteal cyst (arrow), hemoperitoneum (asterisk), and active extravasation (open arrow) in a patient who required emergent oophorectomy due to hemorrhagic shock. (E) and (F) axial and coronal CT images show a different patient requiring emergent oophorectomy for hemorrhagic shock due to a ruptured corpus luteal cyst (arrow) with active extravasation (open arrow) and hemoperitoneum (asterisk).

associate pain comes from capsular stretch prior to rupture, cyst rupture, or peritoneal irritation from hemoperitoneum.

Cystic rupture uncommonly results in large volume hemoperitoneum and hemodynamic instability (Fig 9 C-F). On CT, hemoperitoneum will have higher attenuation than simple free fluid and pooling of contrast on delayed imaging indicates active extravasation.[23] Unfortunately, with CT, it can be difficult to delineate the ovary from other adnexal or intra-abdominal structures in the presence of large volume hemoperitoneum.

Conservative management with reassurance is sufficient for most patients presenting with midcycle pelvic pain from a ruptured corpus luteal cyst, and follow-up imaging is not necessary. Hemodynamic instability could indicate ongoing hemorrhage and may require repeat cross sectional imaging. Active extravasation should be managed emergently with an exploratory laparoscopy and cauterization, cystectomy or oophorectomy.

Ovarian Torsion

Ovarian torsion occurs when the ovary or fallopian tube rotate around the vascular pedicle occluding the ovarian artery or vein. Patients usually present with lower abdominal or pelvic pain. Large or enlarging ovarian cysts may predispose patients for torsion.[23] Ovarian tumors are also another important predisposing factor for torsion. Delayed diagnosis of torsion can lead to loss of the ovary and infertility.

Diagnosing ovarian torsion on imaging can be difficult. Bar-on et al. found that preoperative diagnosis of ovarian torsion was confirmed in only 46% of patients.[29] Ultrasound is usually the initial imaging technique used when women present for suspected ovarian torsion. The ovary may be enlarged and edematous. However, it has been found that between 9% -and 26% of torsions occur in normal appearing and normal sized ovaries.[30,31] Ovarian torsion can also be intermittent.

CT may show a vascular pedicle that is twisted, demonstrate an underlying mass, or enlarged, edematous ovary (Fig 10 A). The torsed ovary is often asymmetrically enlarged (Fig 10 B). Free pelvic free fluid and uterine deviation are common.[32] The torsed ovary may show midline positioning anterior or posterior to the uterus (Fig 10 C). The fallopian tube may be thickened, engorged with heterogeneous fluid and debris, tortuous, or have a "knuckle" (Fig 10 D). The fallopian tube may appear twisted with a triangular shape. CT reveals a predisposing mass, commonly a hemorrhagic cyst or cystic teratoma.[33] Management includes an exploratory laparoscopy with detorsion possible cystectomy or oophorectomy.

Intervention for ovarian torsion should be prompt to preserve ovarian function. Laparoscopic de-torsion is the treatment of choice in

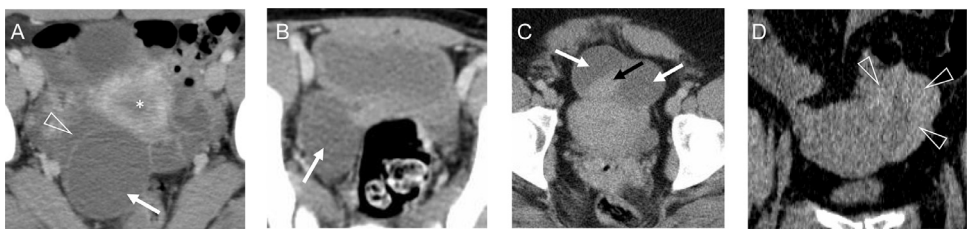

FIG 10. Ovarian torsion can present with an array of nonspecific imaging findings on CT and US. (A) axial CT image shows a large right ovarian cyst (arrow), the adjacent dilated fallopian tube (arrowhead), and uterine deviation (asterisk), in a patient with acute ovarian torsion. (B) axial CT image in 5-year-old with acute pelvic pain shows an enlarged ovarian cyst (arrow) and asymmetric right ovary in a patient with ovarian torsion. (C) axial CT image showing an ovary positioned anterior to the uterus with 2 cysts (arrows), one which contains layering hemorrhage (black arrow) in a patient with subacute or chronically torsed ovary. (D) coronal CT image show a patient with hematosalpinx evident by a dilated fallopian tube (arrowheads) with hyperdense fluid; hematosalpinx may be seen with ovarian torsion. Note that lack of ovarian blood flow is a specific finding for torsion but is not sensitive, and patients presenting with acute pain, an asymmetrically enlarged ovary, abnormally positioned ovary, uterine deviation, and a hemorrhagic cyst or cystic teratoma, should be clinically evaluated by GYN to assess for torsion.

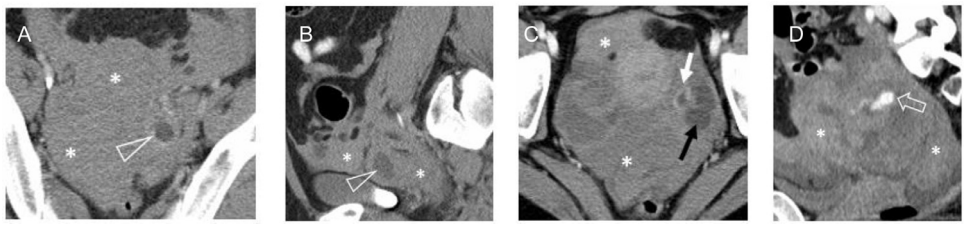

FIG 11. Although it can be difficult to diagnose on CT, familiarity with CT signs of ectopic pregnancy is important. (A) and (B) axial and sagittal CT images show an extrauterine gestational sac with mild peripheral enhancement (open arrowhead) and large volume hemoperitoneum (asterisk) in a patient with ruptured ectopic pregnancy. (C) and (D) axial and sagittal CT image show active extravasation (open arrow) from the right adnexa and large volume hemoperitoneum (asterisk) in a patient with ruptured ectopic pregnancy. Note the contralateral left sided hydrosalpinx (black arrow) and a corpus luteal cyst (arrow).

women of reproductive age. In women no longer desiring fertility, an oophorectomy may reduce the risk of retorsion. A cystectomy may be performed in case of a nonfunctional ovarian cyst in younger women.[34]

Miscellaneous GYN Conditions

Ectopic Pregnancy

An ectopic pregnancy is defined as implantation of an embryo outside of the endometrium and is diagnosed with a combination of beta-hcG and imaging findings.[35] Symptoms of an ectopic pregnancy on presentation to the emergency department may be nonspecific. Complaints of pelvic pain with bleeding and positive beta-human chorionic gonadotropin should raise the possibility of ectopic pregnancy.[35] Ectopic pregnancy most commonly occurs in the fallopian tube and resembles an adnexal mass on CT.[36] Other uncommon locations for ectopic pregnancies include caesarean section scars, uterine cornua, ovary, cervix, and peritoneum.[36]

CT is often inadequate for the diagnosis of ectopic pregnancy, but familiarity with CT signs of ectopic pregnancy is important. A tubal ectopic pregnancy on CT may look like a heterogeneous cystic adnexal mass. The cystic mass may show enhancement around the periphery (Fig 11 A), called the "ring of fire" sign.[37] The endometrium may contain a decidual cyst or a pseudogetational sac.[37] The distinction between an ectopic pregnancy and a corpus luteal cyst is more difficult on CT relative to ultrasound,[37] but ectopic pregnancy rarely occurs in or on the ovary, and are commonly adjacent or distinct from the ovarian tissue. The CT features of a cornual or interstitial pregnancy include a rounded ring-enhancing mass seen adjacent to the cornual region of the uterine fundus.[37] If the surrounding myometrium is $<$5mm there is a high risk for rupture.[35] Abdominal ectopic pregnancy presents as a sac-like structure with an enhancing rim distinct from the uterus fallopian tube or ovary. Abdominal ectopic pregnancies may have delayed presentations compared to tubal ectopic pregnancies and may even result in an advanced gestation or a lithopedion, in which a fetus dies and undergoes calcification.[37]

Patients with a ruptured ectopic pregnancy may present in shock,[37] and patients with hemodynamic instability are more commonly imaged with CT. A complex adnexal mass with free pelvic fluid should raise concern for a ruptured ectopic pregnancy with hemoperitoneum (Fig 11 A-D).[37] An acute hemorrhage may have attenuation of 30-45 HU on unenhanced images while clotted blood appears even more hyperdense ($>$60 HU).[37] A hyperdense clot, "the sentinel clot sign," within the adnexa helps to identify the source of bleed while high attenuating foci isodense to vessels on contrast enhanced CT is a sign of active hemorrhage (Fig 11 D).[37] Rupture ectopic pregnancy and ruptured corpus luteal cyst with ongoing hemorrhage will have a similar appearance on CT, and are both managed with emergent laparotomy. A positive bHCG may help differentiate between the 2 but in patient with hemodynamic instability surgery may be required prior to laboratory results.

Treatment for ectopic pregnancies vary, with medical treatment now preferred to surgery in unruptured cases. Medical treatments include single dose methotrexate, multidose methotrexate, and percutaneous injection of potassium chloride.[36]

Fistulas

Fistulas are abnormal communications between 2 hollow or tubular organs or between 2 epithelial lined surfaces. Causes of fistula involving female reproductive organs include: obstetric trauma, radiation, Crohn Disease, diverticulitis, and gynecologic surgery. CT can demonstrate fistula and surrounding complications such as infection or abscesses. Gastrointestinal fistulas may connect to any reproductive organ, most commonly the vagina.[38] Fistulas involving the fallopian tubes or uterus are rare and

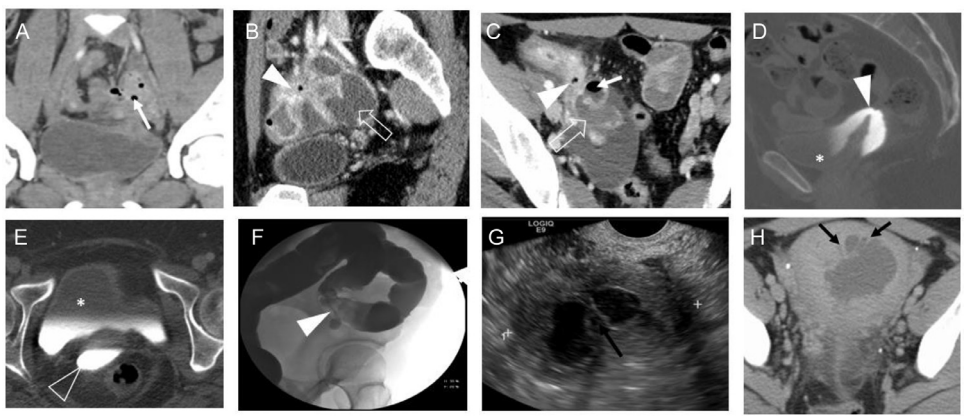

FIG 12. A range of atypical GYN pathology may first be detected in the emergency department and require appropriate imaging recommendations to definitively characterize. (A) axial CT image show gas (arrow) in the left ovary with surrounding inflammation. (B) and (C) sagittal and axial images in a patient with penetrating Crohn disease shows a fistula (arrowhead) from the terminal ileum to the dilated right fallopian tube (open arrow) which contains gas (arrow). (D) and (E) sagittal and axial CT urography images show a fistula (arrowhead) between the bladder (asterisk) and vagina (open arrowhead) in a patient presenting with watery vaginal discharge after hysterectomy. (F) fluoroscopic image in the same patient demonstrates a fistula (arrowhead) from the sigmoid colon to the ovarian, likely the sequela of perforated diverticulitis. (G) ultrasound image in a patient showing post ablation synechiae (black arrows) with loculated functioning endometrium after endometrial ablation. (H) axial CT image in a different patient show a dilated endometrial canal (with multiple septations [black arrows]) in a patient presenting with pain after endometrial ablation.

usually involve the left colon.[38] Indirect signs of a fistula include gas within the reproductive organ, surrounding inflammation, or intervening gas (Fig 12 A-C). Enteric contrast or contrast extending from the bladder into another organ may better reveal a communication between organs (Fig D/E). Lower GI fluoroscopy may be necessary for confirmation of a fistula (Fig 12 F).

Treatment includes excision of the fistula tract, multilayer closure, and at times diverting ostomy when involving the bowel. Although surgery is the definitive treatment for enteric fistulas, conservative management has been described.[39]

Complications of Endometrial Ablation

Endometrial ablation used for treatment of abnormal uterine bleeding. After the procedure, thermal damage may cause necrosis and inflammation. Scarring ensues between the collapsed myometrial walls leading to uterine cavity adhesions.[40] Viable endometrium may become trapped within the scar tissue and may expand over time. Bleeding from the viable, obstructed endometrium can cause a central hematometra, a collection of blood within the endometrial canal, which in turn can prompt retrograde bleeding into an occluded fallopian tube leading to a hematosalpinx, or post ablation tubal sterilization syndrome (PATSS).[40] Blood can also become trapped in the scarred cornu leading to a cornual hematometra. Entrapped endometrium can lead to cyclical pelvic pain prompting women to seek treatment in the emergency room. A delayed diagnosis of endometrial cancer may also result, as sentinel uterine/vaginal bleeding may not occur.[40]

On ultrasonography, postablation images may show persistent islands of endometrial tissue or hematometra (Fig 12 G).[40] Other times, the ultrasound can be normal. CT may show hypo or hyperdense hematometra and variable thickness septations throughout the endometrial canal (Fig 12 H). CT is less helpful for diagnosing a cornual hematometra or PATSS, with MR better delineating blood trapped in the endometrial canal, cornu, or the proximal oviduct.[40] The MR should be performed around the time of patient menstruation as the hematometra or hematosalpinx may be resorbed at other times of the menstrual cycle.

Management of a central hematometra can be as simple as a cervical dilatation or may involve a hysteroscopic surgical perforation of the scarred intrauterine walls and drainage of the hematometra.[40] If there is recurrence of hematometra, a hysterectomy is required for definitive treatment. Laparoscopic surgery for PATSS usually results in short term pain alleviation but the definitive treatment for PATSS is a hysterectomy with proximal salpingectomy.

Conclusions

In cases of suspected acute gynecological disease, the findings on imaging must be interpreted in association with the clinical presentation. The pregnancy status of the patient must always be established, in order to exclude ectopic pregnancy and to avoid using imaging modalities, which pose a risk to the fetus. Clinical signs of sepsis can make the clinicians more suspicious of PID.

Ultrasonography is often the modality of choice for initial imaging of gynecologic disease and many radiologists are very familiar with the gynecologic findings on ultrasound. However, in a busy emergency department setting, CT may be the default imaging and the recognition of common features of gynecologic entities on CT images is essential for prompt diagnosis and expeditious treatment.

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