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Acute Pelvic Pain in Premenapausal Women, Children and Infants: Evidence-Based Emergency Imaging

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Key Points

- Ultrasound (US) is the recommended initial imaging tool for pregnant and nonpregnant women and girls presenting with acute pelvic pain and in which a gynecological etiology is suspected (strong evidence).
- Transvaginal ultrasound is the single best diagnostic modality for the detection of ectopic pregnancy (strong evidence).
- In menstruating women and adolescents, pregnancy (orthotopic or ectopic) should always be considered as a cause of abdominopelvic discomfort/pain (moderate evidence).
- Doppler US is useful in the diagnosis of ovarian torsion but cannot rule out or rule in this diagnosis (moderate evidence).
- If US is nondiagnostic and the clinical picture remains uncertain, magnetic resonance imaging (MRI) can be performed as the next imaging test and problem-solving tool, particularly in pregnant patients (moderate evidence).
- If US is indeterminate and the clinical picture remains uncertain, and MRI not available, CT can be considered as an alternative imaging test in nonpregnant women (moderate evidence).

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Definitions and Pathophysiology

Acute lower abdominal and pelvic pain in premenopausal women has a wide range of etiologies including gastrointestinal, urological, obstetrical, and gynecological causes. In girls and female adolescents, acute pelvic or lower abdominal pain is mainly associated with gastrointestinal disorders, but may be secondary to a wide range of gynecological disorders [1, 2]. In adolescents, a gynecological process is more commonly the cause for acute pain than appendicitis. Klein et al. diagnosed pelvic inflammation or a gynecological process (including pregnancy) in 20% of girls over 12 years of age with acute pain, whereas appendicitis was only found in 4% [3]. Gynecological disease (adnexitis or ovarian cysts) was identified in 12% of children, adolescents, and young adults following negative appendectomy for a preoperative diagnosis of appendicitis in the study by Puig et al. [4]. Specifically, in younger patients, it is difficult to localize the pain during both history and physical examination, making it a diagnostic challenge.

Acute pelvic pain is defined as that lasting less than 3 months [5]. Gynecological or obstetric symptoms are often nonspecific, and the clinical presentations of the various conditions overlap and can vary. In adolescents and premenopausal women, a gynecological or obstetrical etiology should always be considered, and it is crucial before diagnostic workup to determine whether the patient is pregnant or not as this will influence the imaging workup [6, 7]. Many of the potential conditions (such as gastroenteritis, appendicitis, diverticulitis, ureteric colic, etc.) are discussed in other chapters of this book. In this chapter, we focus on five common gynecological conditions [ovarian torsion, hemorrhagic or ruptured ovarian cysts, ectopic pregnancy, endometriosis, and pelvic inflammatory disease (PID)], which can present as acute pelvic pain, some of which may be potentially life-threatening and potentially impact fertility.

Ectopic pregnancy should be suspected in any pregnant woman presenting with acute pelvic pain [8]. The classic triad for ectopic pregnancy after the confirmation of pregnancy at a specific β-hCG discriminatory level is pelvic pain, vaginal bleeding, and an adnexal mass. Most ectopic pregnancies are located in the fallopian tube, and of these, 75–80% are ampullary, 10% are isthmic, 5% are fimbrial, and 2–4% are found in the interstitial portion [9]. The most common underlying cause of ectopic pregnancy is salpingitis due to previous pelvic infections, and in one surgical study, almost 50% of patients had clinical history or histological findings of acute salpingitis [10]. Other causes include altered ciliary motility in the oviduct due to hormonal imbalances or tobacco abuse, altered tubal architecture from pelvic masses, adhesions from prior tubal surgeries, and abnormal embryonic development. These processes result in fallopian tubes having decreased luminal diameters or altered architecture resulting in the fertilized oocyte, or embryo, having difficulty navigating the length of the tube to the intrauterine cavity. The comparatively smaller spermatozoa can travel distally resulting in fertilization, and if the delay in passage of the fertilized oocyte or embryo exceeds 7 days of gestational age, then implantation occurs in the fallopian tube rather than in the uterus.

Pelvic inflammatory disease (PID) is often associated with *Chlamydia trachomatis* and/or *Neisseria gonorrhoeae* infections [11, 12]. The hallmark of diagnosis is pelvic tenderness combined with inflammation of the lower genital tract, from the cervix to the peritoneal cavity [11, 13]. Recently, Lis et al. presented a meta-analysis including ten studies published between 1987 and 2012, showing that *Mycoplasma genitalium* infections are associated with an increased risk of PID (pooled OR 2.14, 95% CI, 1.31–3.49) [14]. Other microorganisms of the vaginal flora including anaerobes, streptococci, staphylococci, *Escherichia coli*, and *Haemophilus influenzae* may also be involved in the etiology of PID [11, 15, 16]. The infection spreads from the vagina to the fallopian tubes and leads to pelvic pain, vaginal discharge or dyspareunia, endometritis, salpingitis, parametritis, oophoritis, tubo-ovarian abscess, and/or pelvic peritonitis [12]. The clinical diagnosis of PID is based on the finding of pelvic organ tenderness, as indicated by cervical motion tenderness, adnexal tenderness,

or uterine compression tenderness on bimanual examination, in conjunction with signs of lower genital tract inflammation [11]. A palpable adnexal mass may be seen in PID complicated by tubo-ovarian abscess.

Ovarian cysts are generally benign and naturally resolve without treatment. These cysts cause little, if any, symptoms, especially if they are small. Functional (follicular and corpus luteal) ovarian cysts can be complicated by acute intracystic hemorrhage or intraperitoneal rupture and lead to acute pelvic pain [8]. The ovary becomes increasingly vascular about 2–4 days after ovulation, and with neovascularization, blood from the vascular theca zone can fill the cavity of the cyst. The cyst usually reabsorbs the blood, but, if the extent of bleeding is large or the cyst ruptures, hemoperitoneum can result [17]. Enlarging ovarian follicles can produce a colicky pain or dull unilateral tenderness in the lower abdomen or pelvis. Ruptured cysts may manifest as hypovolemia and hemodynamic instability.

Adnexal torsion is defined as a complete or partial rotation of the ovary and/or fallopian tube including the vascular pedicle [18]. Torsion may occur throughout life, from prenatally to postmenopause, with a peak occurrence during the reproductive years [18]. In women, the normal ovarian size varies, but some suggest an upper length limit of 4 cm and a volume of 20 mL [17]. For children over age 1 year, this is less well established, but some suggest a length of 5 cm for torsion [18]. While ovarian torsion is the twisting of an ovary on its ligamentous supports, which may result in a compromised blood supply, the term adnexal torsion describes a twisting of either the ovary or fallopian tube, or both. Concomitant torsion of an ovary and the ipsilateral fallopian tube occurs in up to 67% of patients with adnexal torsion [17, 19, 20]. It may lead to initial compromise of lymphatic and venous drainage, later to arterial occlusion and thrombosis, resulting in a hemorrhagic infarction. Adnexal torsion may be misdiagnosed as appendicitis [21]. Adnexal torsion presents with intermittent acute abdominal pain and is almost always associated with an enlarged ovary or a mass, with the greatest risk when the mass measures between 8 and 12 cm [22]. There is an increased incidence for adnexal torsion in patients undergoing in vitro fertilization as the ovarian follicles become hyperstimulated and enlarged. Pregnancy may also predispose a patient to adnexal torsion with the enlarging uterus extending out of the pelvis (around 10–12 weeks) into the abdominal cavity, displacing the ovaries anteriorly. Ovarian tumors account for 50–60% of torsion cases, with mature cystic teratomas (dermoid tumors) most frequently involved.

Endometriosis is defined as the presence of functional endometrium-like tissue outside the uterine cavity [23]. It may be associated with infertility and dysmenorrhea, dyspareunia, dysuria, or dyschezia. Although it is a chronic disease, it may lead to acute symptoms, when the ectopic endometrial tissue responds to hormonal changes during the menstrual cycle [24]. The appearance of endometriosis ranges from small peritoneal lesions to large ovarian endometriotic cysts and extensive fibrosis and adhesions leading to significant distortion of pelvic anatomy. The three primary types of endometriosis are superficial peritoneal lesions, ovarian endometriomas, and deep infiltrating endometriosis [25]. About 3–12 years may pass between symptom onset and a definitive diagnosis [26–28]. The spectrum of symptom severity in endometriosis is wide and includes severe abdominal or pelvic pain or an acute abdomen.

Epidemiology

According to the US National Center of Health Statistics, the number of patients presenting with acute abdominal pain (including lower abdominal and/or pelvic pain) increased by 31.8%, from 5.3 million in 1999–2000 to 7.0 million in 2007–2008 [29]. In women, acute pelvic pain is the main cause of emergency consultations for gynecological conditions [30].

Ectopic pregnancy occurs in 1–2 out of 200 pregnancies and is the leading cause of maternal death in the first trimester [8, 31]. If an intrauterine pregnancy is present, the likelihood of an ectopic pregnancy is dramatically decreased, noting

that heterotopic pregnancies (concurrent intrauterine and extrauterine pregnancies) are extremely rare, occurring in 1:2100 to 1:30,000 of spontaneous pregnancies [9]. In adolescents and young women, the incidence is 0.5% of pregnancies. However, the incidence of heterotopic pregnancy can be as high as 2.9% in the assisted reproduction population [9, 32]. In the study by Menon et al. of symptomatic women, the incidence of ectopic pregnancies was significantly lower in women under 20 years of age (9.7%) compared with those aged 20 years and older (21.7%) [33]. Zane et al. estimated a total number of 10,221–77,129 ectopic pregnancy cases per year in the USA [34]. In the UK, nearly 32,000 ectopic pregnancies are diagnosed every year, resulting in an incidence of about 11 per 1000 pregnancies [31].

Pelvic inflammatory disease is one of the most common causes of acute pelvic pain in sexually active women and is the most frequent gynecologic cause of emergency department (ED) visits, with the number of visits approaching 350,000 per year in the USA [35]. As many as 70% of adolescents with PID are diagnosed in the ED, and nearly 1 million patients with PID are diagnosed annually in the USA, resulting in 275,000 hospitalizations [5, 8, 36]. Factors associated with PID are related to sexual behavior (young age, multiple partners, recent new partners in the previous 3 months, and past history of sexually transmitted disease) and interruption of the cervical barrier (e.g., termination of pregnancy, insertion of an intrauterine device within the past 6 weeks, hysterosalpingography, and intrauterine insemination) [12]. Multiple studies have shown that 19–55% of women who present with pelvic pain have PID [1, 5, 8, 11, 14, 17, 30, 37–45].

Adnexal torsion may occur at any age, even prenatally, but most commonly happens in the first two decades of life [28]. Some authors reported a peak incidence after menarche, others in pregnant women [17, 46, 47]. Adnexal torsion is reported to account for up to 2.7% of all cases of acute abdominal pain in children and is the fifth most common gynecologic emergency with a reported incidence of 3% in one series [20, 48, 49]. At large institutions, 3–5 cases of adnexal torsion are seen per year [20, 50, 51]. It represents a real medical and surgical emergency. Concomitant fallopian tube torsion has been shown to occur in up to 67% of cases of ovarian torsion [18]. Adnexal torsion has even been described in the neonatal and antenatal period [51]. There is a predisposing factor found for torsion in women 64–82% of the time, and this is similar in children [52]. The most frequently encountered ovarian lesions causing torsion in both adults and children are typically benign, with cystic teratomas (31%) and hemorrhagic or follicular cysts (23–33%) being the most common [52].

Functional (follicular and corpus luteal) ovarian cysts are thought to be a common cause of acute pelvic pain when associated with acute intracystic hemorrhage or intraperitoneal rupture. The exact incidence of hemorrhagic or ruptured ovarian cysts in premenopausal females is uncertain.

Endometriosis is a relatively common disease affecting 0.5–15% of women, in general, and 25–80% of women with pelvic pain and/or infertility. The true prevalence of endometriosis remains unclear [53]. For adolescents, a prevalence of 25–38% of those with acute pelvic pain is reported. If the pain is persistent, the prevalence increases to 70–79% [54–56].

Overall Cost to Society

Trent and colleagues calculated the costs per episode of medical care for PID in adolescents in the emergency department to be an average of $1382 in 2009 [57]. In a study from the early 1990s, using insurance data, Washington and colleagues estimated that direct costs of PID, PID-associated ectopic pregnancy, and infertility amount to $2.73 billion in 1990, with hospitalization costs amounting for 75% of this total [58]. These authors made an assumption of a ratio of 2:1 for physician offices compared to hospital outpatient and emergency department visits. Direct costs of hospitalization were estimated at $1850.40 in this study, but no specific figures are available for emergency department visits [58]. Later in the 1990s, Rein and colleagues used insurance claims data to estimate the lifetime cost ($1167) of a case of PID with

the majority ($843) of these costs for acute PID care [59]. The same authors estimated that nearly three quarters of cases (73%) would not accrue costs beyond those of treatment of the acute episode of PID.

An estimated 96 million *C. trachomatis* and *N. gonorrhoeae* infections occur globally among women each year, and about 15% of untreated infections lead to PID, the global burden of PID and the cost to society are substantial [11]. Yeh et al. calculated the costs of major complications of PID based on a cohort of 100,000 women aged 20–24 years, in which 8550 ectopic pregnancies, 16,800 cases of infertility, and 18,600 cases of chronic pelvic pain were projected to occur [60]. They found an average per-person lifetime cost of US$2150. The incidence of PID is thought to be decreasing, but it will remain a significant cause for acute and chronic pelvic pain and reproductive sequelae [61].

With the prevalence of endometriosis estimated at 6–10% of women in the reproductive age group, direct healthcare costs for managing endometriosis, as well as indirect costs to patients, employers, and society due to loss of employment and productivity, are substantial [62]. In this systematic review from 2016, total direct costs in the USA were estimated to be $12,118 per patient per year, compared to other countries, which ranged from $1109 per patient per year in Canada to $8820 per patient per year in Austria [62]. These figures are in agreement with previous systematic reviews reporting on the economic consequences of endometriosis and related symptoms [28, 63]. Assuming a prevalence of 10% (the rate most frequently reported in the literature), direct healthcare costs for endometriosis were estimated at more than $17 million and indirect costs of lost productivity at nearly $5 million in the USA. [28, 63]. A major contributor to those costs is delays in reaching the correct diagnoses. Cost estimates for acute episodes are not currently available.

Estimated direct costs for treatment of ectopic pregnancy were summarized in a recent literature review by Ebner et al. [64]. Total direct costs for cases managed surgically ranged between $2695 in France to $6840 in the USA, while for medically managed (methotrexate) cases, total direct costs ranged from $818 in the USA to $4066 in the Netherlands [64].

For other specific causes of acute pelvic pain in women, a reduction of costs is suggested if diagnosis occurs earlier [65, 66], although no evidence was found for this assumption nor an estimation of the amount of healthcare costs raised by these problems.

Goals of Imaging

In cases of acute lower abdominal or pelvic pain, confirmation or exclusion of gonadal causes in girls and adolescents is mandatory, since it may constitute a surgical emergency. Clinical presentation is often nonspecific and may overlap with symptoms of other abdominal pathologies such as appendicitis. In adolescents and premenopausal women, diagnosis of extrauterine pregnancy is critical to avoid catastrophic complications. Many of the diagnoses considered for acute pelvic pain require confirmatory testing. History, physical examination, and laboratory testing narrow the differential diagnosis and guide the physician to choose the proper imaging test. Life- and/or fertility-threatening conditions are the first to be considered until they can be confidentially excluded. Regardless of what testing is performed, limiting radiation exposure is paramount, particularly for infants and children, radiosensitive tissues, and for the developing fetus in potentially pregnant patients.

Methodology

The diagnostic performance of radiographic examinations in patients with pelvic pain caused by gynecological pathologies was evaluated based on a systematic literature review using PubMed, Scopus, the Cochrane Library, and the Appropriateness Criteria® of the American College of Radiology. All searches were performed in July 2015 without any time restrictions. The search strategy used the following statements: *lower abdominal OR pelvic pain*, *women*, *clinical examination*, *epidemiology*,

imaging (including *MRI*, *ultrasound*, *computed tomography*, *scintigraphy*, and acronyms of these terms), *diagnosis*, as well as combinations of these search strings. Animal studies and publications of languages other than English or German were excluded.

Discussion of Issues

What Initial Imaging Tests Are Appropriate in Infants, Girls, Adolescent Girls, and Premenopausal Women Presenting with Acute Pelvic Pain?

Summary of Evidence When a menstruating patient presents with symptoms of acute pelvic pain, knowledge of pregnancy status is of utmost importance. In order to locate the pregnancy, ultrasound (US) is the imaging tool of choice (strong evidence). Because of its wide availability, low cost, and diagnostic versatility, US is also recommended for the (initial) assessment of other disorders of obstetrical and gynecological etiology (moderate evidence). When US is indeterminate, magnetic resonance imaging (MRI) or computed tomography (CT) [if MRI is not available] should be considered (moderate evidence).

Supporting Evidence The American College of Radiology Appropriateness Criteria (ACRAC)® 2015 update for the clinical condition "Acute pelvic pain in the reproductive age group" recommends both transvaginal and transabdominal US as first choice imaging modality in all women in which a gynecological etiology is suspected (variant 1, serum β-hCG positive, and variant 2, serum β-hCG negative) as well as in pregnant women in which other causes are presumed (variant 4) [7]. The appropriateness rating applied for all of these variants was 9/9 (usually appropriate). In women and sexually active adolescents and girls, transvaginal US allows detailed visualization of the uterus, adnexa, ovaries, and thickened fallopian tubes. Transabdominal US is complementary to the endovaginal examination because it provides a more global view of the pelvic contents. Transabdominal US also evaluates the pelvis and lower abdomen and can detect appendicitis, in some cases, nephrolithiasis, ovarian cysts, tumors, and tubo-ovarian abscess. In addition, duplex and color or power Doppler imaging can be used to assess vascularity of the ovaries and the adnexal structures, providing information that can be helpful in narrowing the field of differential considerations. While the ACRAC rating for pulsed Doppler US ranges between 7 and 9/9 (usually appropriate) to evaluate for gynecological and non-gynecological etiology, the ACRAC advises that Doppler imaging should be avoided in the setting of developing intrauterine pregnancy and be performed in pregnant patients only when absolutely necessary [7].

A systematic review of 14 studies including more than 12,000 pregnant patients computed a positive likelihood ratio of 111 for ectopic pregnancy if an adnexal mass was present in the absence of intrauterine pregnancy on transvaginal US [67]. A number of studies show that US examinations are also very useful for the detection of other gynecological conditions in the ED setting [7] (see Issue II) and even the initial study in symptoms of gastrointestinal or urological disorders [68–71] (see relevant chapters in this book).

In serum β-hCG-positive patients with suspected gynecological etiologies and a negative or inconclusive US, the ACRAC guidelines recommend MRI as the next imaging test, giving it an appropriateness rating of 6/9 (may be appropriate). When available, MRI is preferable to CT because it lacks ionizing radiation. The MRI is usually performed without contrast material, as a problem-solving tool, particularly in pregnant patients. Gadolinium can cross the placenta, and while no studies have demonstrated adverse effects to fetuses at clinically recommended doses have been used, the ACRAC advise caution with contrast-enhanced MRI, using it only when necessary to critically change a diagnosis. In pregnant patients, the ACRAC recommend against the use of CT as the next line test for gynecological etiologies, giving it a rating of 1/9

(usually not appropriate). Contrast-enhanced MRI is also not recommended, with a score of 1/9 (usually not appropriate).

For serum β-hCG-positive patients, with suspected non-gynecological etiologies, the ACRAC guidelines recommend non-contrast MRI as the next imaging test, giving it an appropriateness rating of 8/9 (usually appropriate). For serum β-hCG-positive patients, with suspected non-gynecological etiologies, when MRI is not available, the ACRAC give CT with contrast material a rating of 4/9 (may be appropriate) and CT without contrast material a rating of 3/9 (usually not appropriate). Some have suggested low-dose non-contrast CT in these pregnant patients to reduce radiation exposure, but CT is best avoided during pregnancy when possible. In these patients, contrast-enhanced MRI receives a low recommendation, with an appropriateness rating of 2/9 (usually not appropriate).

In serum β-hCG-negative patients with suspected gynecological etiologies and a negative or inconclusive US, the ACRAC guidelines recommend MRI with and without contrast as the next imaging test, giving it an appropriateness rating of 6/9 (may be appropriate). For nonpregnant patients with suspected gynecological disease, and a negative or inconclusive US, non-contrast MRI and CT are indicated as the next most appropriate tests, both receiving lower ratings of 4/9 (may be appropriate).

For serum β-hCG-negative patients with suspected non-gynecological pathology, the ACRAC guidelines recommend a contrast-enhanced CT of the abdomen and pelvis as the first-line test, with an appropriateness rating of 8/9 (usually appropriate). Similarly, a large study of more than 1000 adult patients with nontraumatic acute abdominal pain presenting at different EDs concludes that in the imaging evaluation of adults, a conditional strategy with CT after negative or inconclusive US results shows the highest overall sensitivity, with only 6% missed urgent conditions, and the lowest overall exposure to radiation [72]. Transabdominal US with Doppler receives an appropriateness rating of 7/9 (usually appropriate). Non-contrast CT may also be appropriate (rated as 6/9), as is contrast-enhanced MRI in the evaluation of nonpregnant women with suspected non-gynecological disease. Transvaginal US receives a lower rating for the evaluation of these non-gynecological disorders at 4/9 (may be appropriate).

Special Case: Infants, Children, and Adolescents

There are a few considerations in the pediatric population that require different imaging decision-making from women. First, ionizing radiation protection culture often results in substitution of MRI for CT in the ED setting and in follow-up imaging. The adolescent may have similar pathology to the adult women, but the use of radiation optimization protocols such as the Image Gently or Image Wisely sites is recommended (www.imagegently.org; www.imagewisely.org). Second, the premenarchal children typically do not undergo transvaginal US. Yet, they will have similar diagnoses with the exception of pregnancy and unlikely PID that include ovarian torsion (15% of all cases occur in children), ovarian cysts with or without hemorrhage, and tumors. Further, there are unique indications in the ED setting that the pediatric population may present with that include foreign body, child abuse, and congenital Mullerian anomalies (vaginal obstruction). The Mullerian anomalies will be discussed in a separate section.

In the pediatric emergency setting, MRI is increasingly used as the second-line emergency diagnostic imaging test after an inconclusive or negative transabdominal US. Contrast-enhanced MRI of the pelvis provides excellent tissue contrast without radiation exposure in the evaluation of suspected ovarian torsion in children and pregnant patients [18, 73]. Magnetic resonance imaging may also demonstrate the early stages of ovarian edema and hemorrhagic infarction in cases where US is inconclusive [74]. Contrast-enhanced MRI may also help characterize tubo-ovarian abscess and differentiate it from malignancy and endometriosis [75].

What Are the Best Imaging Techniques for the Diagnosis of Acute Pelvic Pain in the Emergency Department?

Summary of Evidence CT is the preferred imaging technique for identifying causes of acute pelvic pain in the gastrointestinal and urinary tract showing high sensitivity and specificity (strong evidence). CT is suggested as second-line imaging tool in female, serum β-hCG-negative patients with equivocal US findings and symptoms suggestive of gynecological etiologies, although MRI may also be used, specifically if an infectious etiology is suspected (moderate evidence). In the pregnant patient, MRI is preferred to CT if US findings are indeterminate (limited evidence). Apart from that, the decision whether to use CT or MRI after inconclusive US findings should be based on the suspected etiology of acute pelvic pain.

Supporting Evidence The recently updated ACR Appropriateness Criteria® 2015 for the clinical condition "Acute pelvic pain in the reproductive age group" recommend CT with an appropriateness rating of 9/9 (usually appropriate) for the evaluation of the gastrointestinal and urinary tract in nonpregnant women presenting with acute pelvic pain (variant 4) [7].

Ectopic Pregnancy

As ectopic pregnancy is a life-threatening condition, a rapid diagnosis is crucial. It is suspected if transabdominal US does not show an intrauterine gestational sac and the patient's β-hCG level is greater than 6500 IU/L or if transvaginal US does not show an intrauterine gestational sac and the patient's β-hCG level is 1500 IU/L or greater [76].

Summary of Evidence Combined transvaginal US and serial quantitative β-hCG testing are very sensitive and specific in the evaluation of ectopic pregnancy (strong evidence). Pregnancy and ectopic pregnancy are both best imaged by sonography (strong evidence). Abdominal ultrasound is performed initially, and if this is nondiagnostic for pregnancy or ectopic pregnancy, transvaginal sonography improves diagnostic accuracy (moderate evidence). In cases where US is nondiagnostic or equivocal, MRI is the next indicated imaging test (moderate evidence).

Supporting Evidence Combined transvaginal US and serial quantitative β-hCG are 96–99% sensitive and 84–97% specific for diagnosing ectopic pregnancy [77–80]. The systematic review by Crochet et al. computed a positive likelihood ratio of 111 for ectopic pregnancy if an adnexal mass was present in the absence of intrauterine pregnancy on transvaginal US [67]. In the same meta-analysis, they found that existing studies do not establish a single serum hCG level to be diagnostic of ectopic pregnancy; therefore transvaginal US is considered the single best diagnostic modality in this regard. Clinical factors affecting the accuracy of US include low hCG levels, significant bleeding, and lacking evidence of a yolk or embryo [81].

Ultrasound findings most predictive of ectopic pregnancy are extrauterine cardiac activity, a gestational sac, a mass, and fluid in the pouch of Douglas, although these signs are only seen in 8–26% of cases [9, 80]. An extrauterine gestational sac containing a yolk sac, with or without an embryonic pole, is also a relatively specific finding. More commonly, an echogenic tubal ring and complex adnexal mass separate from the ovary are found with ectopic pregnancy and need to be distinguished from a corpus luteum cyst in the ovary, which is more common than an ectopic pregnancy. On color Doppler imaging, flow surrounding an adnexal mass, or the "ring of fire," can be present with an ectopic pregnancy or corpus luteum. Color Doppler imaging may be helpful to detect an ectopic pregnancy that is surrounded by loops of bowel [9]. The visualization of an intrauterine sac is the strongest evidence against ectopic pregnancy, although concomitant intrauterine and ectopic pregnancy can occur, especially in women with assisted reproduction, but they are extremely rare [76].

Magnetic resonance imaging has been utilized in the evaluation of suspected ectopic pregnancy in very early gestational age cases or where the US was inconclusive. Direct signs of ectopic pregnancy (a gestational sac) had a sensitivity of 91%, a specificity of 100%, and a pos-

itive predictive value of 100% in a small retrospective study by Takahashi et al. [82]. In the same study, the diagnostic accuracy increased from 92% to 100% when the diagnostic criteria required at least two indirect signs or the direct sign [83]. The characteristic feature of a gestation saclike structure with a "three-ring" appearance on T2-weighted images with marked enhancement in the tubal wall was described in 80% of cases in a more recent small retrospective study in 24 patients [84].

When the combination of serum beta-hCG level and US findings is nondiagnostic, another option to be considered, depending on the presenting patient's individual risk, is repeated beta-hCG level testing or surgical consultation [78].

Pelvic Inflammatory Disease

Historically, PID is diagnosed clinically with imaging findings (US or MRI) used to confirm clinical suspicions [75]. Despite its relative frequency, PID is a diagnostic dilemma with mild nonspecific symptoms that overlap those of other abdominal and pelvic processes, which may not direct the clinician toward the correct diagnosis. As a consequence, CT of the abdomen and pelvis may inadvertently be performed as the initial diagnostic imaging examination. US should be the first diagnostic imaging examination to be performed in cases of suspected PID [7]. However, acute uncomplicated PID may be difficult to detect with US only [83]. Therefore, reported sensitivity rates have a relatively wide range (Table 27.1).

Summary of Evidence Early manifestations of or uncomplicated PID may be difficult to detect with US only (moderate evidence). US is moderately sensitive and highly specific in the diagnosis of tubo-ovarian abscess (strong evidence). Transvaginal US is more sensitive than transabdominal US in the evaluation of PID and tubo-ovarian abscess (limited evidence). For the depiction and management planning of pelvic abscesses, advanced cross-sectional imaging with contrast-enhanced CT or MRI is often required (moderate evidence). Comparison studies between US, CT, and MRI are not available (limited evidence).

Table 27.1 Sensitivity and specificity of ultrasound in the evaluation of obstetrical/gynecological conditions in women and children presenting with acute pelvic pain

	Sensitivity (%)	Specificity (%)
Ectopic pregnancy	96–99	84–97
Pelvic inflammatory disease (PID)	56–100	78–80
Hemorrhagic/ruptured ovarian cyst	80–90	98
Adnexal/ovarian torsion	75–100	93
Endometriosis	75–95	83–100
Tubo-ovarian abscess	56–93	86–98
Torsion		
Tissue edema	21	100
Absent flow	52	91
Absent arterial flow	76	99
Absent/abnormal venous flow	93–100	97

For ectopic pregnancy diagnosis, the US performance is by transvaginal and reported in conjunction with the appropriate hCG levels
Data from references [7, 77–79, 89, 102, 105, 109, 114–117]

Supporting Evidence Ultrasound features in hydrosalpinx include dilated fluid-filled fallopian tubes, with folds and incomplete septations [9]. On transverse section, short linear projections protruding into the lumen can cause a cogwheel appearance. Small echogenic foci may be seen in the tubal wall, representing flattened endosalpingeal folds secondary to distension of the tube giving a "beads-on-a-string" appearance. Indentations present on opposite sides in the longitudinal scanning plane have been described as the "waist sign." Color or power Doppler transvaginal US can be used to detect more subtle abnormalities of PID, which include uterine enlargement and indistinctness, endometrial thickening with our 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 [85]. Transrectal US may also be used to demonstrate rectal involvement in endometriosis, but it has not been shown to be superior to transvaginal US [86].

Bulas et al. studied the diagnostic performance of transabdominal and transvaginal sonography prospectively in 84 patients aged 12–21 years with

the clinical diagnosis of acute PID [87]. Transvaginal sonography demonstrated superior resolution of 25 dilated fallopian tubes. However, 31 transabdominal and transvaginal US studies were normal despite patients fulfilling strict clinical criteria for PID. The severity level of PID, as diagnosed by transabdominal sonography, was changed in 28 cases, with medical therapy altered in 23 cases because of additional transvaginal sonographic findings. Transvaginal sonography provided superior anatomic information in patients with PID, demonstrating abnormalities not seen at transabdominal sonography in 71% of cases [87].

US is also indicated to evaluate for complications of PID. A tubo-ovarian abscess, a potentially life-threatening complication of PID, can be detected by means of transvaginal US with a sensitivity of 56–93% and a specificity of 86–98% [7]. Transvaginal US is superior to transabdominal ultrasound in identifying thickened, fluid-filled fallopian tubes. Since the sonographic findings for a tubo-ovarian abscess are nonspecific, the presence of a mass in the expected location of the ovaries or in the cul-de-sac together with an elevated white cell count and erythrocyte sedimentation helps to establish the diagnosis [88]. In a recent small prospective study including 17 patients with laparoscopically confirmed salpingitis, all 13 cases with moderate or severe salpingitis were diagnosed with US, compared with one of four cases of mild salpingitis [83].

On MRI, fat-suppressed T2-weighted images are very sensitive for the detection of inflammation [8, 89, 90]. On MRI, both hydrosalpinx and pyosalpinx appear as dilated, fluid-filled tubular structures, and cannot be reliably differentiated from each other, although a pyosalpinx usually has thicker walls and may have layering T1 signal secondary to proteinaceous debris. A tubo-ovarian abscess appears as a multilocular cystic structure or a heterogeneous mass with solid and cystic components. The abscess wall and adjacent inflammatory changes enhance avidly with gadolinium-based contrast. Contrast-enhanced MRI may also help characterize tubo-ovarian abscess and differentiate it from malignancy and endometriosis [75].

CT plays also an expanding role in the evaluation of PID due to its wide availability and often vague and nonspecific nature of disease symptomatology. It is performed mainly in patients with equivocal US findings [7]. CT should be performed with oral and intravenous (IV) contrast, as unopacified bowel loops may be confused with abscesses [8]. In addition, early manifestations of PID can be better appreciated on CT than on US [91]. The most common general CT findings of PID described in the literature are thickening of the uterosacral ligaments, obliteration of fascial planes, free fluid in the cul-de-sac, loss of definition of the uterine border, pelvic fat infiltration or haziness and pelvic edema, reactive lymph node enlargement, and signs of peritonitis [75]. On CT, enhancing, thickened fallopian tubes containing complex fluid and debris are characteristic of pyosalpinx. A tubo-ovarian abscess appears as a thick-walled, complex fluid collection with septations, a fluid-debris level, and occasionally gas [9]. Pelvic fat haziness is one of the most sensitive findings of acute PID and is seen in as many as 65% of patients, but it has very low specificity [75]. The combination of the two findings of hepatic capsular enhancement on the late arterial phase images and fallopian tube thickening of more than 5 mm has a sensitivity of 71.9%, a specificity of 81.3%, and an accuracy of 76.6% [92]. The specificity of the tubal thickening sign alone has been reported to be as high as 95% [93].

Hemorrhagic or Ruptured Ovarian Cysts

Hemorrhagic cysts usually result from hemorrhage within a corpus luteum or other functional cyst and often present as an acute abdomen in females of childbearing age. Hemorrhagic cysts typically resolve within 8 weeks. Relevant history should include when the patient's last menstrual period occurred. Abdominal pain can occur with ovulation of a follicular cyst mid menstrual cycle, known as mittelschmerz, "mid (cycle) pain." Enlarging ovarian follicles often produce a colicky or dull unilateral tenderness in the lower abdomen or pelvic region. Rarely, patients with hemorrhagic cysts present with hypovolemia and hemodynamic instability. The triad of symptoms includes a delay in menses, followed by spotting, unilateral pelvic pain, and a small, tender, adnexal mass [22]. On physical examination, corpus luteal cysts can mimic ectopic pregnancy.

Summary of Evidence US of the pelvis (a combination of transabdominal and transvaginal approaches to visualize the cyst) is recommended as the first-line imaging test to evaluate large cysts in the pelvis of nonpregnant females of reproductive age (strong evidence). The US findings of fibrin strands and a retracting clot in ovarian cysts have a high diagnostic accuracy for hemorrhage (moderate evidence). Clinically detected simple cysts less than 5 cm in size in females of reproductive age don't require follow-up (strong evidence). Clinically detected simple cysts greater than 5 and ≤7 cm in size in females of reproductive age will require annual follow-up (strong evidence).

Supporting Evidence The characteristic appearance of a hemorrhagic cyst on US is a complex cystic mass with lacelike reticular echoes (also known as fishnet, cobweb, or spiderweb) due to fibrin strands or a solid-appearing component with concave margins representing clot [9, 94]. Classic features on US include no internal vascularity by color Doppler, but there may be circumferential flow in the cyst wall. These features allow a confident diagnosis of a hemorrhagic ovarian cyst [94].

A study assessing the likelihood ratio of US findings for the diagnosis of a hemorrhagic ovarian cyst found that in at least 90% of cysts, one or both of the following features are present: fibrin strands and a retracting clot [95]. The authors concluded that these are the paramount observations in allowing high confidence in the diagnosis of hemorrhagic ovarian cysts. Free fluid in the pelvis can be an indicator of cyst rupture but is nonspecific [8]. Generally, the diagnostic accuracy of US for the detection of hemorrhagic or ruptured ovarian cysts is high [7] (Table 27.1). In cases of cyst rupture, the ovary may be normal in size if rupture has decompressed any cysts. In these cases, a large amount of pelvic fluid is usually noted.

For nonpregnant females of childbearing age, the ACR appropriateness criteria for clinically suspected adnexal masses (variant 1, initial evaluation) recommend US (using a combination of transabdominal and transvaginal to visualize the lesion) of the pelvis with Doppler, giving an appropriateness rating of 9/9 (usually appropriate) [96]. The next most appropriate test during the initial encounter in females of childbearing age with clinically suspected adnexal mass is MRI with and without IV contrast, which is given a rating of 6/9 (may be appropriate), or MRI without contrast which has a rating of 5/9 (may be appropriate) [96]. Computed tomography with or without contrast material is not indicated in the initial evaluation, with a rating of 2/9 (usually not appropriate).

For nonpregnant females of childbearing age, the ACR appropriateness criteria for clinically suspected adnexal masses (variant 5, large simple cysts, greater than 5 cm diameter) recommend US (using a combination of transabdominal and transvaginal to visualize the lesion) of the pelvis with Doppler, giving an appropriateness rating of 9/9 (usually appropriate) [97]. If the hemorrhagic cyst is less than 3 cm in a woman of reproductive age, it is probably physiological and does not require follow-up according to the Society of Radiologists in Ultrasound (SRU) Consensus Conference Statement [94]. Hemorrhagic cysts less than 5 cm in women of reproductive age don't require any follow-up [94]. These recommendations also align with the advice from the Choosing Wisely initiative of the American Board of Internal Medicine foundation and the ACR (www.chosingwisely.org). If the cyst is greater than 5 cm, it should be described in the report, and short-term follow-up with US is recommended at 6–12 weeks to ensure resolution [94]. While short-term follow-up imaging in the follicular phase, on days 3–10 of the menstrual cycle, is optimal, this is sometimes difficult to coordinate in clinical practice, with annual follow-up recommended for persistent cysts according to the SRU Consensus Conference Statement [94]. For cysts greater than 7 cm in size in nonpregnant reproductive age females, which may be difficult to evaluate with US, the SRU recommends further imaging with MRI or surgical consultation be considered [94]. The next diagnostic testing option in females of childbearing age with large simple cysts is MRI with contrast material, which receives a rating of 4/9 (may be appropriate). Non-contrast MRI and CT have ratings of 3/9 and 2/9 (usually not appropriate) [97].

Since women in early postmenopause occasionally ovulate and, therefore can develop complex cysts with the appearance of a classic hemorrhagic cyst, these cysts should be described in the imaging report with short-interval follow-up (6–12 weeks) with US recommended to ensure resolution [94].

For indeterminate or probably benign cysts (such as a single thin septation <3 mm or a small calcification in the wall), follow-up can be similar to that for simple cysts. For indeterminate cysts (without classic appearances for hemorrhagic cysts, dermoids, or endometriomas) in women of reproductive age or women in early postmenopause, follow-up US should be performed in 6–12 weeks. Resolution of the lesion confirms a hemorrhagic cyst. If the lesion persists and is unchanged, then a hemorrhagic cyst is unlikely, and continued follow-up with either US or MR imaging should then be considered. If these studies do not confirm an endometrioma or a dermoid, then consider surgical evaluation at this stage [94].

For indeterminate cysts with features suggestive of benign neoplasms (multiple thin septations or a solid nodule without detectable flow at Doppler US), or with cyst wall irregularity or tiny areas of focal thickening, more comprehensive evaluation is required, and for women of reproductive age, this entails a short-interval follow-up (6–12 weeks) with US or occasionally further characterization with MRI [94]. MRI may be particularly helpful to confirm the absence of MR contrast enhancement in sonographically solid-appearing areas that do not have demonstrable flow at Doppler US. A short-interval follow-up of 6–12 weeks with US should allow enough time for a physiologic cyst to resolve and should be performed during a different phase of the menstrual cycle, ideally between days 3 and 10 of the menstrual cycle, so that new cyst development does not complicate things. Larger cysts take more time to resolve. If the lesion persists, and continues to have indeterminate findings at US or MRI, surgical evaluation should then be considered. Although size cannot reliably distinguish between benign and malignant etiologies, once the cyst exceeds 10 cm in size, it has a 13% chance of being malignant [94].

For adnexal cysts with frankly malignant features, such as thick septations (>3 mm), solid elements with flow at Doppler US, and focal areas of wall thickening (>3 mm), particularly when seen in association with omental or peritoneal masses or a moderate or large amount of ascitic fluid in the pelvis [94], a cyst with a nodule that has internal blood flow has the highest likelihood of being malignant, and rather than follow-up imaging, they require surgical evaluation [98].

Adnexal/Ovarian Torsion

Adnexal torsion is a medical or surgical emergency and can occur with normal ovaries, particularly in adolescents. Postulated causes of normal adnexal torsion include mobile fallopian tubes or mesosalpinx, elongated pelvic ligaments, fallopian tube spasm, strenuous exercise, or abrupt changes in intra-abdominal pressure [17, 20, 51, 99]. Ovaries with any type of mass are predisposed to torsion, and benign lesions are most frequently implicated in both adults and children, with cystic teratomas (31%) and hemorrhagic or follicular cysts (23–33%) being the most common [52].

Summary of Evidence Ultrasound is the first-line modality in children and adolescents with abdominal and/or pelvic pain suspected to be of gynecological origin (limited evidence). In adult women, sonography is indicated as first imaging with acute pelvic pain, due to its excellent diagnostic accuracy in the evaluation of pregnancy (intrauterine or ectopic), ovarian cysts, and torsion (limited evidence). The most US common finding in ovarian torsion is an enlarged heterogeneous ovary (limited evidence). Ovarian enlargement and a lack of Doppler flow are the most sensitive and specific US signs in adnexal or ovarian torsion (moderate evidence). However, the presence of Doppler flow cannot be used to exclude ovarian/adnexal torsion as flow can be seen in up to a third of surgically proven cases (limited evidence). Therefore, close clinical correlation is mandatory, and if suspected, laparoscopy confirmation and treatment may be indicated.

Supporting Evidence Adnexal torsion is generally characterized by an enlarged, edematous ovary or ovarian complex consisting of an ovary and an associated adnexal mass. Common imaging findings are an adnexal mass, a displaced adnexal mass/enlarged ovary, and ascites—detectable with US nearly as reliably as with CT or MRI [96].

Chiou et al. reviewed surgically proven cases of adnexal torsion between 1990 and 2006 [96]. A correct preoperative diagnosis was made in 15 (71%) of 21 with initial sonography versus 5 (38%) of 13 cases with initial CT. A correct imaging diagnosis was made more frequently in premenopausal than in menopausal patients (p = 0.02). Common imaging findings were an adnexal mass (65% on sonography, 87% on CT, and 75% on MRI), a displaced adnexal mass/enlarged ovary (53% on sonography, 87% on CT, and 75% on MRI), and ascites (53% on sonography, 73% on CT, and 50% on MRI) [96].

The degree of ovarian volume asymmetry is important and should typically be at least 2:1 [7]. A retrospective study with surgically and pathologically proven ovarian torsions found in 100% of the patients an enlarged torsed ovary, with the median volume 12 times (range 4.4–27.3) that of the normal contralateral side [100].

The use of Doppler in this diagnosis is helpful, but its interpretation is controversial due to conflicting literature [7]. Findings on Doppler vary, including absent, decreased, or reversed ovarian artery flow, and may depend on the degree of obstruction and the chronicity [25]. Lack of Doppler flow enables fairly confident diagnosis, but the presence of arterial and venous Doppler signal has been documented in one-third of cases with surgically proven torsion [26, 27]. Arterial flow has been described in one-third of surgical cases of torsion [7, 96, 101]. Venous or arterial flow was present in the torsed ovary in 62% of a pediatric sonographic study [100]. Therefore the sensitivity of absent arterial flow is low at 40–73% [52]. More recently, a study has appeared in the literature demonstrating an abnormal flow pattern within the ovarian vein as the only Doppler finding in patients with early torsion, lending support for Doppler findings associated with the diagnosis [28, 29]. In summary, indeterminate US Doppler results should not determine whether or not a patient undergoes laparoscopic examination if the clinical suspicion is high.

A twisted vascular pedicle (whirlpool sign) was found in up to 88% of twisted ovaries in earlier US studies [102, 103]. The sensitivity of sonography was 100%, and specificity was 93% in a small study of 28 girls, using an enlarged ovary as the criterion for abnormal (limited evidence). The volume of the enlarged ovaries ranged from 34 to 365 cm^3 (mean 130 ± 99 cm^3) [104].

Another feature suggestive of torsion is peripherally placed follicles in an enlarged ovary (in 74% of cases due to ovarian edema) with a small amount of pelvic free fluid; however this finding is not common and can also be seen in a polycystic ovary [7]. Other US signs include free fluid in the cul-de-sac (nonspecific) and a more medial position of the torsed ovary toward the uterus from twisting around the broad ligament [105].

Because adnexal/ovarian torsion often mimics the clinical presentation of appendicitis, diverticulitis, or renal colic, CT, rather than US, is often the first modality in which patients are imaged [106]. Alternatively, MRI can be used in inconclusive US findings, and many MRI features of adnexal torsion overlap with CT such as mal-location of the ovary, uterine deviation, adnexal fat infiltration, and the presence of free fluid. One advantage of MRI over CT in the diagnosis of adnexal torsion is its sensitivity in demonstrating blood products within the lesion [106].

Endometriosis

Endometriosis does not usually require emergent management, but women in whom the diagnosis has not yet been established can present with acute pelvic pain to the ED. Laparoscopy remains the gold standard for the evaluation of endometriosis, but it is invasive and it carries surgical risks. Therefore, diagnostic imaging tends to be performed, with its main purpose in the emergency setting being to exclude surgical or acute medical causes of acute pelvic pain, such as adnexal/ovarian torsion, ectopic pregnancy, or

PID/tubo-ovarian abscess, and for these reasons, US remains the first-line test.

Summary of Evidence Transvaginal US is the best initial imaging method for the evaluation of endometriosis (limited evidence). Outside the emergency setting, and for some less common imaging findings, MRI has higher sensitivity and diagnostic likelihood ratios for uterosacral ligament and vaginal endometriosis (limited evidence).

Supporting Evidence Serum biomarkers have been evaluated but have been found not to be clinically useful in the diagnosis of endometriosis [107]. Laparoscopy is the gold standard for the evaluation of endometriosis, but it is invasive and carries surgical risks. In a recent Cochrane systematic review, none of the evaluated imaging modalities (US, MRI, or CT) were able to detect overall pelvic endometriosis with enough accuracy that they would be suggested to replace surgery [108]. Therefore, imaging tends to be performed, with the goals of diagnosing other acute causes of pelvic pain.

Transvaginal US is the best initial imaging method for the evaluation of endometriosis [7]. This enables the diagnosis or exclusion of etiologies that require surgical or urgent medical management, such as adnexal torsion, ectopic pregnancy, and PID/tubo-ovarian abscess. A comparison between physical examination, transvaginal US, rectal endoscopic US, and MRI for the diagnosis of endometriosis in adult patients prior to surgery revealed that US and MRI perform similarly for the diagnosis of intestinal endometriosis; MRI, however, shows higher sensitivity for uterosacral ligament and vaginal endometriosis [109].

If endometriosis is suspected and US results are inconclusive, a workup using MRI may be recommended because MRI allows for more definitive characterization of suspected endometrial implants and endometriomas compared with CT [8]. MRI may help guide surgical approaches, especially for deep infiltrating endometriosis and other unusual sites of presentation [25]. It is superior to US in diagnosing rectosigmoid lesions and endometriosis of the bladder. Endometriosis is uncommon in children.

Special Case: Congenital Uterovaginal Abnormalities Including Congenital Vaginal Obstruction (Mayer-Rokitansky-Kuster-Hauser Syndrome)

The Mullerian fetal system forms two merging ducts that regress in the male and develop into the normal uterus, fallopian tubes, and upper two-thirds of the vagina. Mullerian ductal anomalies (MDA) are estimated to occur in 0.1–1.5% of women in the general population, and approximately 90% of these anomalies involve the uterus [110, 111], so vaginal obstruction is very rare. The etiology is not well known although there are associated congenital anomalies that include the skeletal and renal system.

The classification of MDA ranges from vaginal agenesis, the easiest to surgically repair (class 1), through various levels of uterine abnormalities as follows: class 2, unicornuate uterus; class 3, uterine didelphys; class 4, bicornuate uterus; class 5, septate uterus; class 6, arcuate uterus; and a group of unclassified defects. When there is vaginal agenesis with a Mullerian anomaly, this is referred to as the Mayer-Rokitansky-Kuster-Hauser (MRKH) syndrome.

Adolescent girls with MDA may present with acute pelvic pain and occasionally with an abdominal/pelvic mass due to vaginal obstruction. Because of the complexity of the embryology, obstruction may occur at different levels and in various degrees, including imperforate hymen, complete vaginal membrane, or atresia of the vagina and/or uterus [2, 110]. These conditions are usually encountered either in the neonatal period or in adolescence at the time of menarche [2].

Transabdominal US is the initial modality of choice for pediatric gynecologic patients. In teenagers with obstructive uterovaginal anomalies presenting to the ED with acute abdominopelvic pain, US is valuable in differentiating the frequent case of hemato(metro)colpos due to imperforate hymen or transverse vaginal septum from the rare case of hematometra due to cervical dysgenesis [112]. In indeterminate or complex cases, MRI provides more precise demonstration of

anatomic features in multiple planes and does not involve ionizing radiation [112, 113].

The neonate may also have vaginal obstruction and typically presents with a palpable abdominal mass. The maternal hormonal stimulation produce mucous and blood products, together with vaginal agenesis or obstruction to create this condition. Neonates may present with either hydrocolpos or hydrometrocolpos and should be evaluated for associated renal anomalies with US.

Because these presentations are uncommon, they are sometimes confused with ovarian cystic masses, the normal bladder, and perforated appendicitis at ultrasound and, sometimes, CT imaging.

There is a lack of diagnostic accuracy studies supporting these recommendations.

Take-Home Tables and Figure

Table 27.1 presents sensitivity and specificity of ultrasound in evaluating obstetrical/gynecological conditions in women and children with acute pelvic pain. Table 27.2 gives the differential diagnoses for acute pelvic pain in adolescent girls and premenopausal women. Figure 27.1 presents an algorithm to be used for the evaluation of acute pelvic pain in women.

Table 27.2 Differential considerations of acute pelvic pain in adolescent girls and premenopausal women

Gynecological: Adenomyosis, uterine fibroid, hemorrhagic or ruptured ovarian cyst, adnexal torsion, pelvic inflammatory disease (PID), spontaneous abortion, ectopic pregnancy, endometriosis, tubo-ovarian abscess, teratomas, cystadenomas In *adolescent girls* additionally: congenital anomalies such as imperforated hymen, transvaginal septum
Pregnant women: Ectopic pregnancy, spontaneous abortion, corpus luteum hematoma, adnexal torsion, placental abruption (postpartum), ovarian vein thrombosis, endometritis (postpartum), uterine impaction
Gastrointestinal: Appendicitis, bowel obstruction, diverticulitis, gastritis, infectious enteritis, inflammatory bowel disease, inguinal hernia, irritable bowel syndrome, pelvic thrombophlebitis, perirectal abscess
Urological: Urinary tract calculi, pyelonephritis, cystitis

These diagnostic considerations also apply in the pediatric population except for pregnancy issues and uterine pathologies that tend to occur later in life (endometriosis, adenomyosis, and fibroids)
Data from references [5, 8, 118]

Imaging Case Studies

Case 1

Figure 27.2a, b presents a 10-year-old girl with acute abdominal pain and urinary retention

Case 2

Figure 27.3 presents ovarian torsion in a 32-year-old female with acute pelvic pain

Case 3

In Fig. 27.4, a 27-year-old female with acute pelvic pain and a hemorrhagic ovarian cyst is presented

Suggested Imaging Protocols

Ultrasound

Ultrasound with Doppler—first transabdominal followed by transvaginal scanning—is the key screening tool and often the only examination needed. For adolescents and adults, a curved multifrequency probe is required. To evaluate the female reproductive tract, a full urinary bladder is essential. If the bladder is not adequately full, it may be useful to repeat the examination every 15 min or to place a Foley catheter and fill the bladder. Further evaluation with CT or MRI depends on the results of the sonograms, the clinical examination, and the acuity of the problem. For children, transabdominal US with Doppler is the key screening tool.

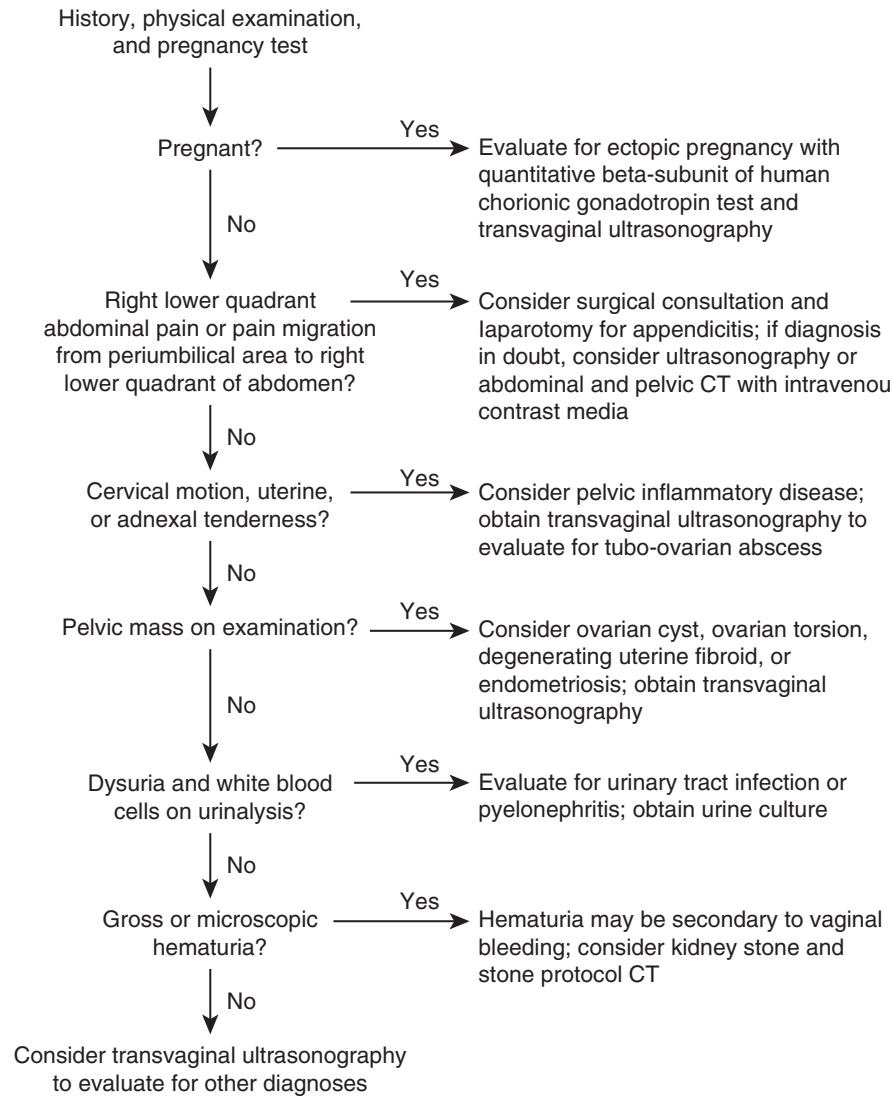

Fig. 27.1 Algorithm for the evaluation of acute pelvic pain in women (Used with permission of AAFP from Kruszka PS, Kruszka SJ. Evaluation of acute pelvic pain in women. Am Fam Physician 2010;82:141–7. © American Academy of Family Physicians)

Multi-detector Computed Tomography

Intravenous contrast is essential to visualize infection or inflammation and abscess. Oral or rectal contrast may help to distinguish fluid-filled bowel loops in the pelvis.

Magnetic Resonance Imaging

Axial and coronal T1-spin echo, axial and sagittal T2 Fast Spin Echo (FSE) with fat saturation, coronal Short Tau Inversion Recovery (STIR) or Half-fourier Acquired Single shot Turbo spin Echo (HASTE), and axial and coronal T1 2D

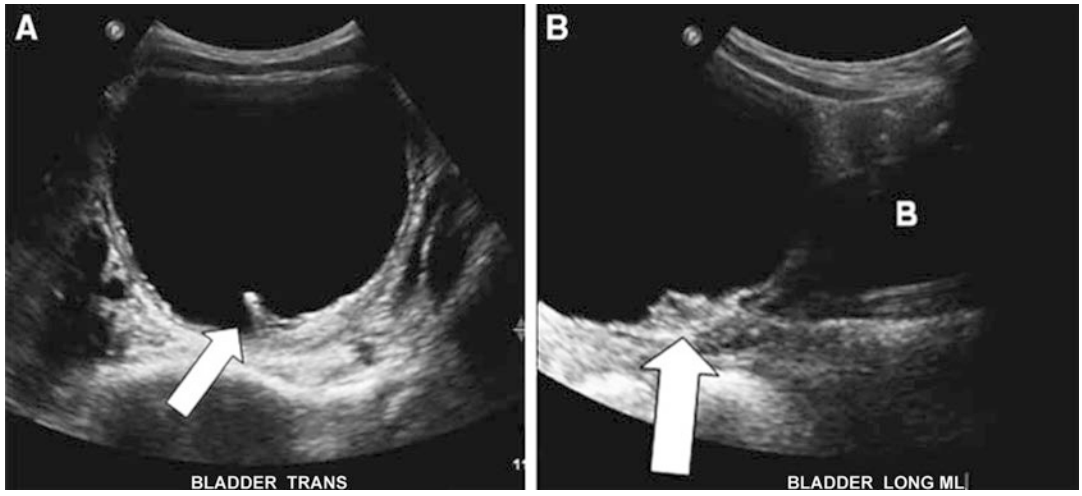

Fig. 27.2 (**a**) and (**b**). A 10-year-old girl presented with acute abdominal pain and urinary retention. At US, a very large simple cyst measuring up to 11 cm in transverse (**a**) and in long axis (**b**) could be seen. Note the wall of the cyst had a few focal thickened strands (*white arrows*). The bladder is visualized inferior to the cyst in **b** (bladder). At surgery, the ovary had torsed, was necrotic, and was removed (Used with permission from Puig S. Imaging of Female Children and Adolescents with Abdominopelvic Pain Caused by Gynecological Pathologies. Medina LS et al., eds: Evidence-Based Imaging: Improving the Quality of Imaging in Patient Care. New York: Springer Science; 2011)

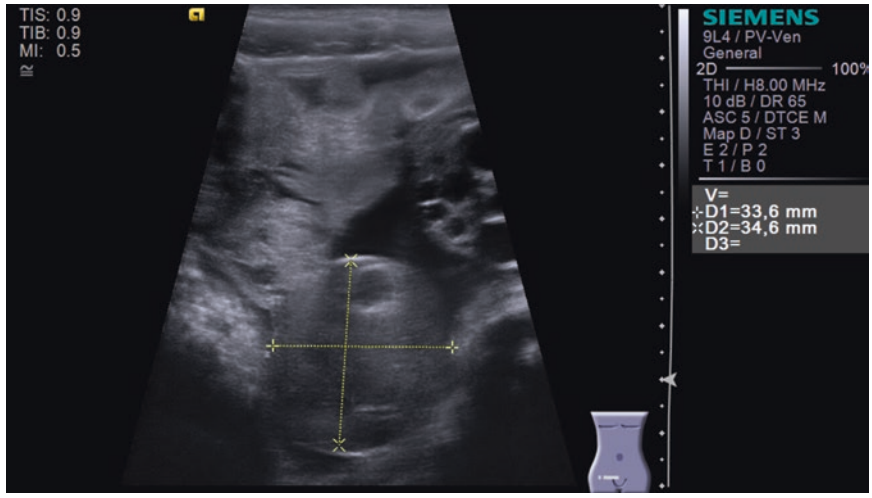

Fig. 27.3 Ovarian torsion in a 32-year-old female with acute pelvic pain. US in the axial plane shows an enlarged inhomogenous ovary without blood flow on color Doppler (not shown)

SPoiled Gradient Recalled echo (SPGR) with fat saturation before and after intravenous gadolinium (in patients with acceptable renal function). MRI can be used as an alternative to imaging with CT. It is not as sensitive for calcification but can provide functional data.

Future Research

- More and larger clinical follow-up studies are needed to better define the role and utility of imaging in the treatment of women and children presenting with acute pelvic pain in the ED.

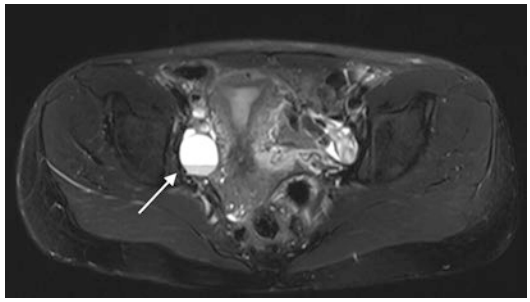

Fig. 27.4 Hemorrhagic ovarian cyst on the right (*white arrow*) in a 27-year-old female with acute pelvic pain. Axial MRI T2-fat-sat sequence depicts the hematocrit level within the cyst, indicating acute hemorrhage

- The use of limited, fast MR protocols should be investigated for their cost-effectiveness.
- The development of MR tables with continuous table movement similar to CT in conjunction with focused, fast MRI protocols will allow for increased use of MRI in infants and children without sedation.

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