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Imaging of Pelvic Pain in the First Trimester of Pregnancy

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The noninvasive nature, safety, and reliability of ultrasonography make it the diagnostic method of choice for pregnant patients who have pelvic pain. Sonography provides information that allows for diagnosis of both pregnancy-related pain, such as a ruptured ectopic pregnancy, miscarriage, or threatened abortion; and may be useful in the diagnosis of pain unrelated to pregnancy, such as that seen in appendicitis and nephrolithiasis.

Normal pregnancy

Because of hormonal changes, rapid growth of the uterus, and increased blood flow, "crampy" pelvic pain is common in early pregnancy. For the primapara, this pain can be quite worrisome. It is common for pregnant patients to present with pain in the first trimester and have normal findings on sonography. The first sonographic demonstration of early pregnancy is the intradecidual sign [Fig. 1] [1–3]. This is visualized as a discrete hypoechoic fluid collection with an echogenic rim that is eccentrically located in the endometrial cavity, and deviates the endometrial stripe. This is seen at 4.5 to 5 weeks of gestation [3]. Because small endometrial fluid collections can simulate the intradecidual sign, care should be taken to ensure that the collection has a well-defined echogenic rim, is just

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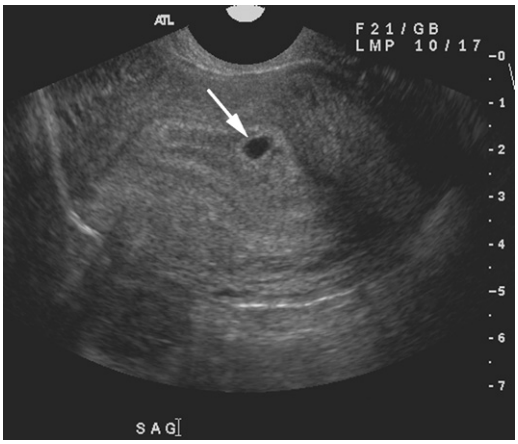

Fig. 1. Normal early pregnancy. Sagittal view of the uterus at 4 1/2 weeks gestational age shows an intradecidual sign with a small sac (*arrow*) eccentrically located in the endometrium.

beneath the central endometrial echo, and has an unchanging appearance [1]. It is prudent to obtain follow-up in patients at high risk for ectopic pregnancy or patients who have symptoms in order to ensure that an intrauterine pregnancy is present.

Slightly later the decidua capsularis and decidua vera are seen as two distinct hyperechoic layers surrounding the early gestational sac; this is known as the double decidual sac sign [4]. The yolk sac is the next structure to be visualized. It appears as a small hyperechoic ring within the gestational sac, and is present at 5.5 weeks [Fig. 2]. Finally, the embryo can be seen adjacent to the yolk sac. Cardiac activity can usually be observed whenever an embryonic pole is seen, but should be visualized by the time the embryonic pole is 5 mm [5,6].

Fig. 2. Normal early pregnancy. Sagittal view of the uterus at 5 1/2 weeks gestational age shows a yolk sac (*arrow*) within the intrauterine gestational sac.

Subchorionic hemorrhage

Subchorionic hemorrhage is seen on ultrasound in 4% to 22% of patients who have symptoms of pain and bleeding in early pregnancy [7]. It is caused by a partial detachment of the trophoblast from the uterine wall. On ultrasound the placental margin is displaced by anechoic or heterogeneous hypoechoic material [8]. Small echogenic structures can be found in such areas, likely due to blood clots. Because the hematoma can dissect in the potential space between the chorion and endometrial cavity, it may be visualized separate from the placenta. Because it typically conforms to the shape of the uterus, it usually has a falciform shape [Fig. 3]. A small collection likely has no clinical significance, whereas moderate or large subchorionic hematomas have a poorer prognosis [9]. Seventy percent of subchorionic hematomas resolve spontaneously by the end of the second trimester [10]. As in all early pregnancy assessments, demonstration of cardiac activity is crucial in determining prognosis.

Spontaneous abortion

First-trimester spontaneous abortion occurs in 10% to 12% of clinically recognized pregnancies [11]. Pain may be constant or intermittent and crampy over the uterus or lower back. Most women with spontaneous abortion experience vaginal bleeding. Up to 25% of all pregnant women bleed some time during pregnancy, with about half of them eventually undergoing miscarriage. The term "threatened abortion" is used to define bleeding in the first 20 weeks of pregnancy with a closed internal os. Ultrasound in the case of a threatened abortion is used to detect an intrauterine pregnancy and to determine if a live embryo or fetus is present. The landmarks for normal pregnancy help to distinguish between a normal early intrauterine pregnancy and a miscarriage. To ensure high specificity in our diagnosis of spontaneous abortion, the authors use generous thresholds: visualization of a yolk sac by the time the gestational sac has a mean sac diameter of 13 mm, visualization of an embryo by the time the mean sac diameter is 18 mm, and visualization of cardiac activity by the time the embryonic pole is 5 mm [12]. Between 6.5 to 10 weeks of gestation, the length of the amniotic cavity is similar to that of the embryo. At times a failed early pregnancy will present as an "empty amnion sign" [13] [Fig. 4].

In addition to the absolute criteria mentioned above, sonographic findings in spontaneous abortion include a thin decidual reaction (less than 2 mm), weak decidual amplitude, irregular contour of the sac, absent double decidual sac sign, and low position of the sac.

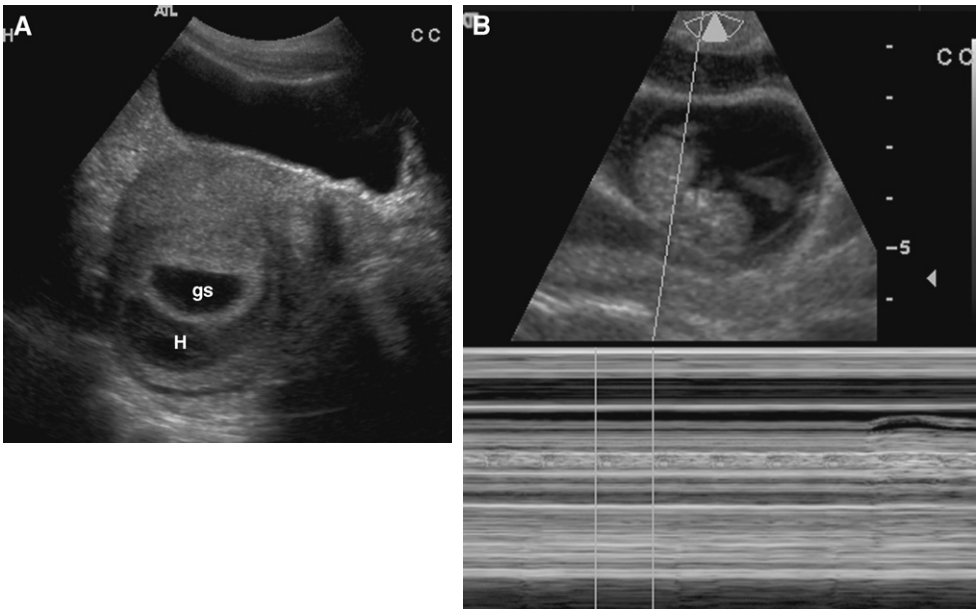

Fig. 3. Subchorionic hematoma at 10 weeks gestational age. (*A*) Transabdominal sagittal image shows an intrauterine gestational sac (*gs*) with a subchorionic hematoma (*H*). (*B*) Transvaginal view with m-mode shows fetal pole with normal cardiac activity.

Molar pregnancy

Molar pregnancy can be associated with pelvic pain because of either the rapid change in size of the uterus, the size of the associated theca lutein cysts, or torsion of the ovaries caused by the theca lutein cysts [Fig. 5]. The classic sonographic appearance of a complete mole has multiple cystic spaces representing hydropic villi; however, the size of the villi is directly proportional to gestational age [14], and early molar pregnancies frequently do not have the typical sonographic appearance [15]. Other appearances that can be seen in the first trimester include an intrauterine anechoic fluid collection similar to a gestational sac, a fluid collection with a complex echogenic mass similar to an edematous placenta, a heterogeneously thickened endometrium, and echogenic fluid-fluid levels within the endometrium [15].

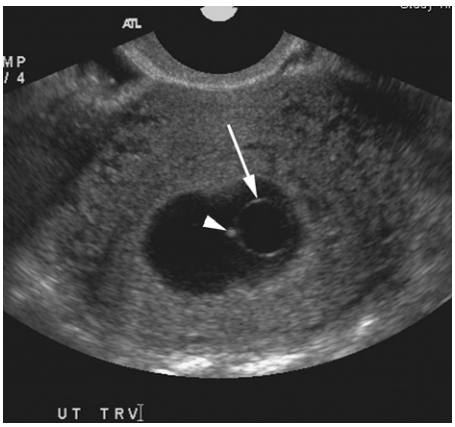

Fig. 4. Incomplete miscarriage at 8 weeks by menstrual dates. A prior sonogram had shown a live embryo. Transvaginal image of the uterus shows an intrauterine gestational sac with mean sac diameter of 22 mm. An amnion (*arrow*) is present that measures 10 mm. A residual 1 mm embryonic pole is present (*arrowhead*). No yolk sac was visualized. Even without the history of a prior sonogram demonstrating a live pregnancy, a miscarriage can be diagnosed because the amnion is much larger than the residual embryonic pole.

Corpus luteum

The corpus luteum is the most common adnexal mass in pregnancy, and is a common cause of pelvic pain. The pain is lateralized to the side of the cyst. Pain can be due to the size of the cyst, bleeding within the cyst, torsion, or rupture. The cyst is typically less than 6 cm in diameter, but may be larger. There is typically posterior through transmission because of the cystic composition. The internal echotexture varies, depending on the stage of hemorrhage and the amount of fluid within the cyst. This is best appreciated with transvaginal scanning. The diagnosis of a hemorrhagic cyst can be made with the presence of fibrin strands, a retracting clot, septations, and wall irregularity [16,17]. The

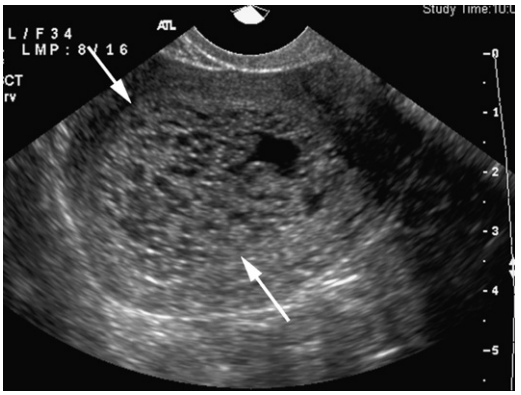

Fig. 5. Molar pregnancy at 10 weeks gestational age in patient with pelvic pain. Sagittal transvaginal image shows the endometrial cavity (*arrows*) to be distended with echogenic material with multiple small cysts compatible with a molar pregnancy. Human chorionic gonadotropin level was 42,000.

wall of the cyst may appear thick or thin, ranging from 2 to 22 mm [Fig. 6]. The corpus luteum is a very vascular structure, and typically a ring of color flow can be demonstrated [Fig. 7] [18]. It is important to recognize that this flow is a normal finding, so as not to mistake a corpus luteum for an ectopic pregnancy.

If a hemorrhagic corpus luteum cyst is the cause of the patient's pain, it should be tender to direct pressure using the transvaginal probe. If it is pain-free, another source for the patient's pelvic pain should be sought.

Hemoperitoneum

Echogenic fluid suggests hemoperitoneum. When echogenic fluid is visualized in a patient who has

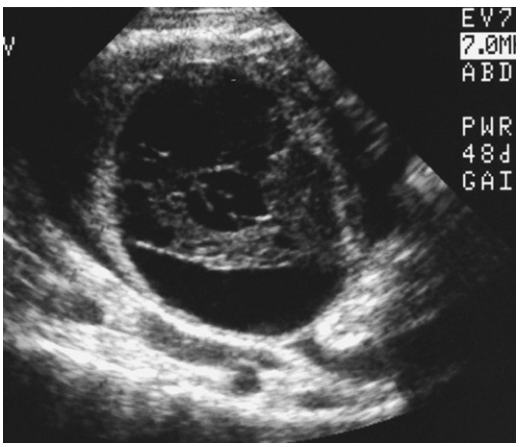

Fig. 6. Transverse transvaginal image of a hemorrhagic cyst. Note the strands of internal density that have a "cobweb" appearance.

positive β-hCG results, this has a positive predictive value (86%–93%) in the diagnosis of ectopic pregnancy [19], and may be the only endovaginal sonographic finding [20]; however, a ruptured hemorrhagic corpus luteum cyst can also result in hemoperitoneum [Fig. 8]. If the patient is clinically unstable, differentiating between a ruptured ectopic and a ruptured hemorrhagic corpus luteum is unimportant, because in either case a laparotomy is indicated. In unstable patients who have demonstration of hemoperitoneum, the sonographic examination may not demonstrate an ectopic pregnancy. In the clinically stable patient it is more important to carefully examine the adnexa to determine if an ectopic pregnancy is present. When free fluid is documented in the pelvis, it is helpful to obtain images of the kidneys to assess whether a large amount of hemoperitoneum is present [Fig. 9].

Ectopic pregnancy

Symptoms of an ectopic pregnancy are pelvic and abdominal pain and amenorrhea. Vaginal spotting or bleeding may be present. In a 5-year review of 98 cases who underwent surgery for ectopic, Aboud [21] showed that the most common presenting symptoms were pain (in 97%), followed by vaginal bleeding (in 79%), with the most frequent physical findings being abdominal tenderness (in 91%) and adnexal tenderness (in 54%). The combination of ultrasound and hCG level is the best way to diagnose an ectopic pregnancy. More than 1 in every 100 pregnancies in the United States is ectopic [22]. The incidence has increased fourfold from 1970 to 1992 [22]. Some causes include a higher incidence of salpingitis and an increased use of assisted reproductive techniques [23].

Patients typically present at about 5 to 6 weeks gestational age. Because menstrual dates are often inaccurate, however, an early gestational age by dates should not influence the diligence taken to diagnose an ectopic pregnancy.

The possibility of an ectopic pregnancy is low if a gestational sac is clearly documented within the uterine cavity. The incidence of heterotopic pregnancy (the occurrence of intrauterine and extrauterine pregnancy) ranges from 1/2,100 to 1/30,000 [24,25]. Of importance, the incidence is as high as 2.9% in the assisted fertilization population [26,27]. Therefore, although visualization of an intrauterine gestation is crucial, careful attention to the adnexa is always important.

Ectopic pregnancy should be suspected in patients who present with a positive pregnancy test with absence of an intrauterine pregnancy on ultrasound. In general, an intrauterine gestational sac

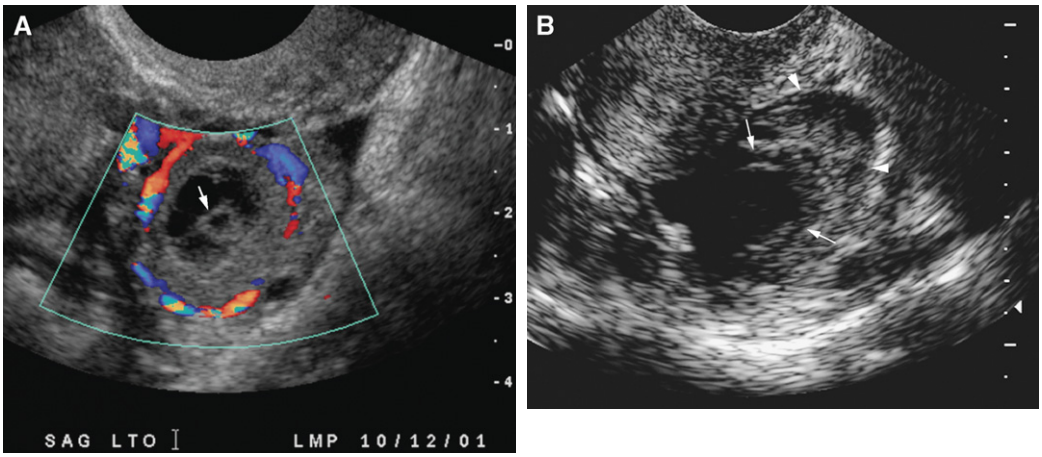

Fig. 7. Ring of flow on hemorrhagic cyst. (*A*) Sagittal transvaginal color Doppler image of 2 cm thick-walled hemorrhagic cyst in a pregnant patient. Note the central fibrin stand mimicking a yolk sac (*arrow*). Note the ring-of-fire appearance to the cyst. (*B*) Transverse, transvaginal image of the same patient in (*A*), showing that the mass (*arrows*) is located within the ovary (*arrowheads*). Additional images (not shown) demonstrated an intrauterine gestational sac with yolk sac. (*From* Swire MN, Castro-Aragon I, Levine D. Various sonographic appearances of the hemorrhagic corpus luteum cyst. Ultrasound Q 2004;20:49; with permission.)

is expected to be visualized when β-hCG is 1000 mIU/ml (Second International Standard,) or 2000 mIU/ml international reference preparation (IRP) [28,29]. It should be emphasized that the majority of studies of b-hCG in early pregnancy evaluated normal early pregnancy, and described an intrauterine gestational sac as any collection of fluid in the endometrial cavity. Small fluid collections of 2 mm without a decidual reaction were considered sufficient to describe an early gestational sac. It should be noted that this type of fluid collection can be caused by a decidual cyst or even a pseudosac, and therefore may not represent a normal intrauterine pregnancy; however, these values are helpful in triaging patients. When β-hCG is below the discriminatory zone (2000 mIU/mL, IRP) and no intrauterine gestation is present, the diagnosis could be an early intrauterine pregnancy, a miscarriage, or an ectopic pregnancy, and therefore close follow-up is indicated [30]. When the β-hCG value is above the discriminatory zone, one can expect to

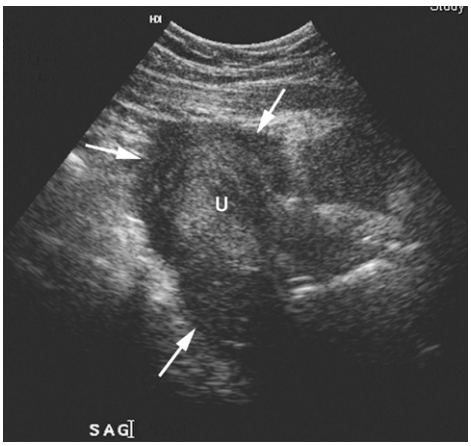

Fig. 8. Ruptured hemorrhagic cyst in patient 4 weeks pregnant with pelvic pain. Sagittal view of the uterus shows hemorrhage (*arrows*) around the uterus (U). No intrauterine gestational sac was seen. Because of continued pain and bleeding, the patient underwent laparotomy. A ruptured hemorrhagic cyst was found. Follow-up sonogram demonstrated a live intrauterine pregnancy.

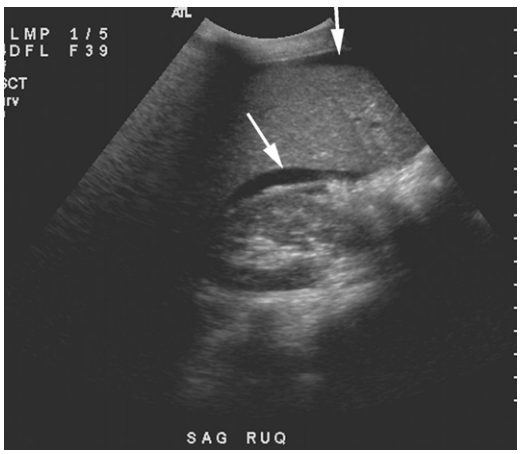

Fig. 9. Hemoperitoneum in patient with ectopic pregnancy. Oblique sagittal view of right upper quadrant in patient with pelvic pain in the first trimester shows fluid (*arrows*) around the liver and kidneys, consistent with a large amount of hemoperitoneum.

see an intrauterine gestational sac; however, even without visualization of a sac there could still be a very early normal intrauterine pregnancy. Technical quality of the examination, presence of fibroids, intrauterine contraceptive devices, large hemorrhage, and multiple gestation may contribute to nonvisualization of an early sac [30–32]; however, none of these factors may be present, and follow-up may still reveal a normal early pregnancy [30]. Because of this, and because stable patients can be watched rather than treated [33–35], it is reasonable to follow stable patients who have a nonvisualized gestational sac with serial β-hCG and ultrasound rather than immediately treating with methotrexate or laparotomy.

A normal pregnancy shows a doubling time of the β-hCG value of 2 days (range 1.2–2.2 days) [36]. This doubling time is increased in ectopic pregnancy. If the β-hCG values rise abnormally (<60% increase over 48 hours and not steadily declining), the patient is presumed to have an ectopic pregnancy.

The most common location for ectopic pregnancy is in the fallopian tubes, occurring in up to 97% of the cases. Of these, 75% to 80% are located in the ampullary region, 10% in the isthmic portion, 5% in the fimbrial portion, and 2% to 4% in the interstitial portion. Uncommon locations include the ovary, abdomen, cervix, and uterine scars [37,38]. Because most ectopic pregnancies are located within the tubes, it is important to scan above and below the ovaries and between the uterus and ovaries.

Sonographic diagnosis of ectopic pregnancy

Endometrial findings

Small fluid collections without an echogenic rim can be present. These decidual cysts are typically located at the junction of the endometrium with the myometrium, and were originally reported as being highly specific for ectopic pregnancy [39], but are now known to be neither specific nor sensitive [40,41]. When fluid is seen centrally in the endometrial cavity, this is termed a "pseudosac" [Fig. 10]. This fluid collection represents blood in the endometrial cavity, which can be present in both intrauterine and ectopic pregnancies. The pseudosac has only one layer corresponding to the endometrial decidual reaction, compared with the double decidual sac sign seen in early intrauterine pregnancy [4].

Adnexal findings

The most specific finding for ectopic pregnancy is the presence of a live extrauterine pregnancy [Fig. 11]; however, this pathognomonic sign is present only in only 8% to 26% of ectopic pregnancies on transvaginal sonogram [42]. The next most specific sign is an extrauterine gestational sac containing a yolk sac, with or without an embryo [see Fig. 10] [19]; however, care should be taken not to confuse a hemorrhagic cyst with debris mimicking a yolk sac or embryo [see Fig. 7].

An extra-ovarian tubal ring is 40% to 68% sensitive for ectopic pregnancy [see Fig. 10] [43,44]. Slightly less specific but most common is a complex adnexal mass separate from the ovary [19,20,31,43–55]. These should be distinguished from a hemorrhagic corpus luteum cyst arising from the ovary. The transvaginal transducer can be used "real-time" to determine if the echogenic ring moves with or is independent of, the ovary. Another sonographic finding that can help distinguish the corpus luteum from the adnexal ring of an ectopic pregnancy is the relative echogenicity of the wall of the corpus luteum compared with that of a tubal ectopic and of the endometrium. The wall of a corpus luteum is less echogenic when compared with the wall of the tubal ring associated with an ectopic pregnancy, and is less echogenic compared with the endometrium [56,57]. If the diagnosis of an adherent ectopic pregnancy or an exophytic ovarian cyst cannot be confirmed and the patient is stable, a follow-up examination is reasonable, because an intrauterine pregnancy may be seen on follow-up, and a hemorrhagic cyst is expected to undergo evolution.

The least specific finding of ectopic pregnancy is the presence of any adnexal mass other than a simple cyst. Even a complex cyst in the ovary is more likely to be the corpus luteum than an ectopic pregnancy.

Use of color Doppler in diagnosis of ectopic pregnancy

Using color Doppler flow, uterine or extrauterine sites of vascular color can be identified in a characteristic placental shape, the so-called "ring-of-fire" pattern, and a high-velocity, low-impedance flow pattern may also be identified that is compatible with placental perfusion [58]. A ring of fire has been described as characterizing the appearance of flow around an ectopic pregnancy; however, the corpus luteum is also very vascular and can have a similar appearance [see Fig. 7] [59,60]. Color Doppler is most helpful when an extra ovarian mass has not yet been found, because use of Doppler may allow for detection of an ectopic surrounded by loops of bowel. Luteal flow can be helpful in identifying an ectopic, because about 90% of ectopic pregnancies occur on the same side as luteal flow [61].

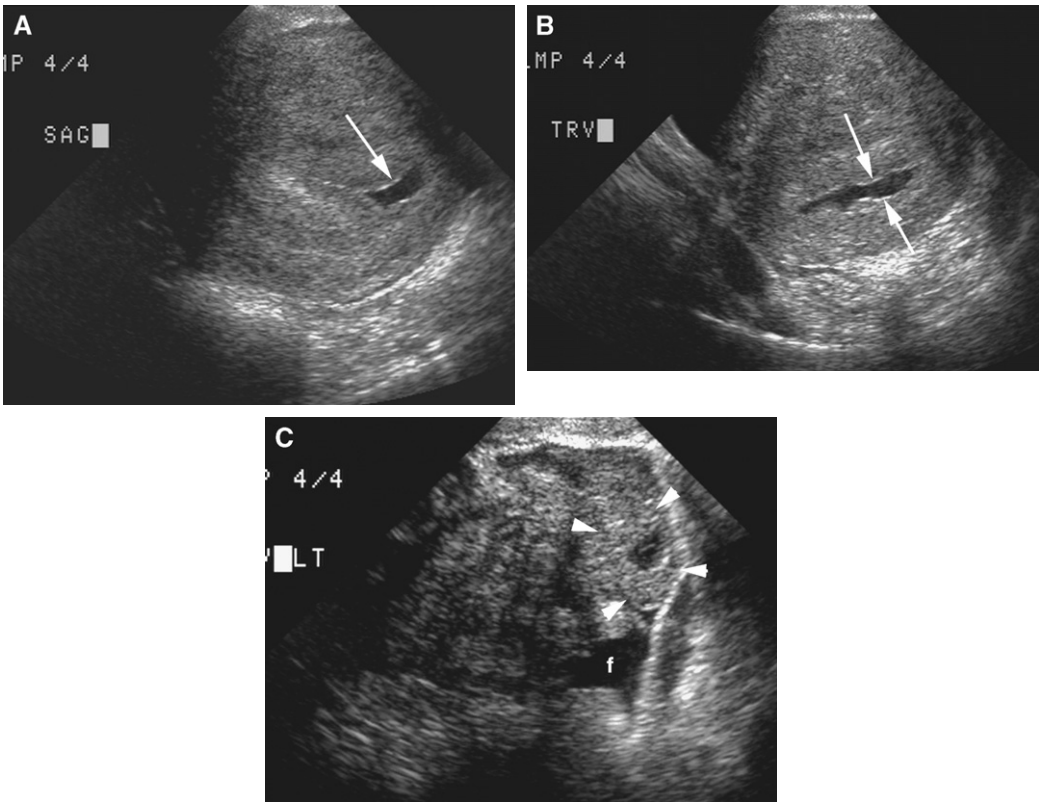

Fig. 10. Pseudosac in patient with ectopic pregnancy at 5 weeks gestational age. Transvaginal sagittal (*A*) and transverse (*B*) images show fluid (*arrows*) centrally located within the endometrial cavity. Oblique image in the left adnexa (*C*) shows a ringlike mass (*arrowheads*) with a faint yolk sac and some free fluid (*f*). The mass was separate from the left ovary (not shown). A left-sided ectopic pregnancy was confirmed at laparotomy.

Interstitial pregnancy

Interstitial pregnancies represent 2% to 4% of ectopic pregnancies [62]. These pregnancies are associated with a higher morbidity and mortality than other tubal pregnancies [63]. Although some term these "cornual pregnancies," this term is best used if pregnancy occurs in a bicornuate uterus. The high morbidity from these pregnancies is caused by the fact that the interstitial portion of the tube dilates more freely and painlessly than the rest of the tube, leading to later clinical presentation than the typical ectopic pregnancy, and the potential for massive hemorrhage. Rupture occurs later in interstitial ectopics, usually between 8 and 16 weeks. Because the implantation site may be located between the ovarian and uterine arteries, rupture in this area may prove fatal [64].

The diagnosis is suggested when what appears to be an intrauterine pregnancy is visualized high in the fundus and is not surrounded in all planes by 5 mm of myometrium [**Fig. 12**] [44,65]. These can be treated with laparotomy, systemic methotrexate [66], or transvaginal, sonographically guided injection of potassium chloride [67].

Cervical ectopic pregnancy

Cervical ectopic pregnancy occurs in fewer than 1% of all ectopics [68,69]. The sonographic diagnosis is made when a gestational sac with peritrophoblastic flow or a live embryo is identified within the cervix. When a gestational sac with a yolk sac or embryo is seen within the cervix without a heartbeat, the differential diagnosis includes spontaneous abortion and cervical ectopic. Follow-up scanning allows for differentiation; in cases of ectopic pregnancy the sac does not change in position, whereas in spontaneous abortion, the sac shape and position will change. Patients who have cervical ectopics tend to bleed profusely because the cervix does not have contractile tissue. Therefore treatment by dilatation and curettage is more risky than treatment of an intrauterine pregnancy. Because of these risks, in the past cervical ectopics were often treated with hysterectomy. Newer conservative therapies include sonographically guided local potassium chloride injection [67,70,71], systemic or local methotrexate [71–74], or preoperative uterine artery embolization before dilatation and evacuation [71,75].

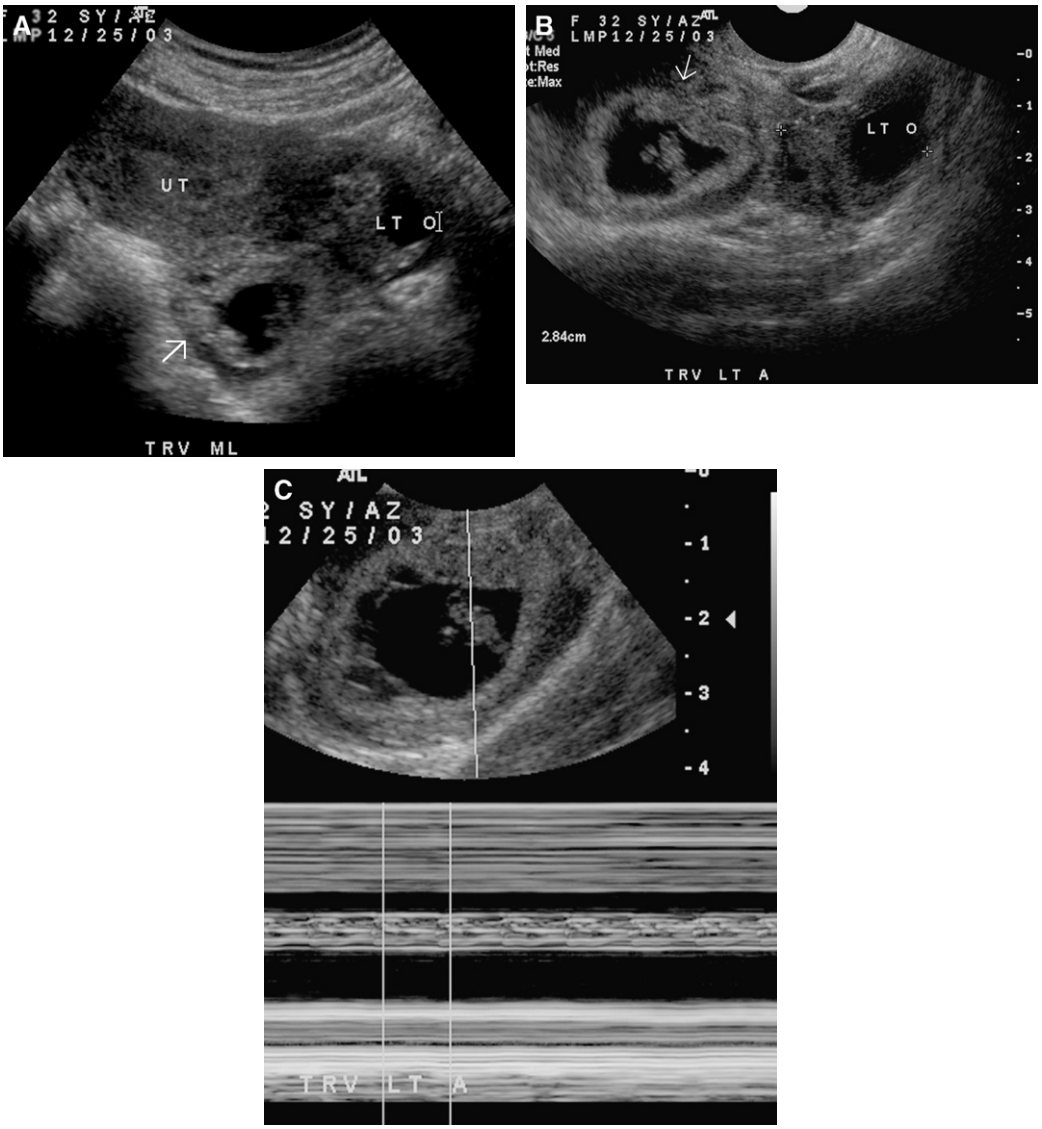

Fig. 11. Live ectopic pregnancy. (*A*) Transverse transabdominal image shows a left- sided gestational sac (*arrow*) adjacent to the uterus (*UT*), clearly separate from the left ovary (*LT O*). (*B*) Transverse transvaginal image shows the ectopic pregnancy adjacent to the left ovary. (*C*) M-Mode demonstrates cardiac activity.

Scar pregnancy

Scars in the uterus can be sites for implantation of pregnancy. Cesarean section scar pregnancy is being increasingly reported [76]. There is complete embedding of the gestational sac in the myometrium. The myometrium between the bladder and the sac becomes thinner or disappears because of distension of the sac. Only the thin, serosal layer is apparent. Criteria used for diagnosis are an empty uterus, empty cervical canal, and development of the sac in the anterior part of the lower uterine segment [Fig. 13] [77]. Current non- and minimally invasive treatments include sonographically guided methotrexate or potassium chloride injection [67,78], or intramuscular methotrexate [79]. Definitive treatment of a cesarean scar pregnancy is by laparotomy and hysterotomy, with repair of the accompanying uterine scar dehiscence [80]. Other procedures that scar the uterus put the patient at increased risk for scar pregnancy. For example, a pregnancy can implant in a myomectomy scar [60].

Ovarian and abdominal ectopic pregnancy

Ovarian pregnancies usually appear as an ovarian cyst with a wide, echogenic outside ring. A yolk

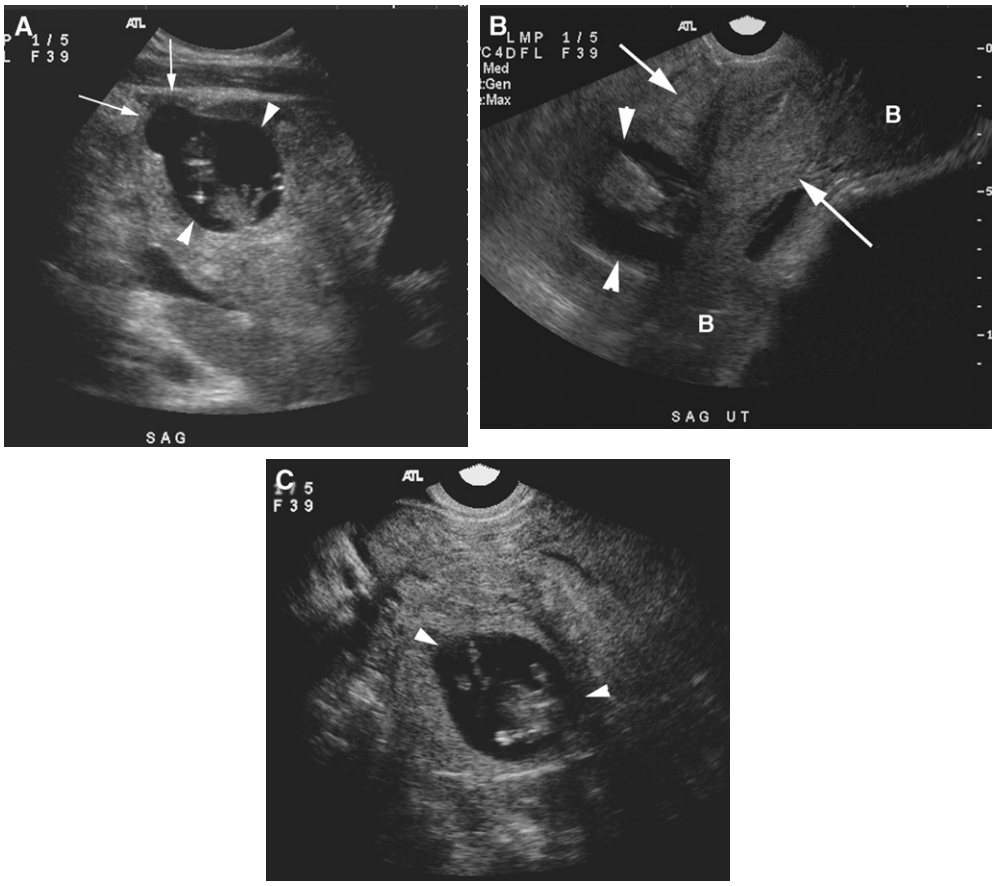

Fig. 12. Ruptured isthmic pregnancy at 11 weeks gestational age. (*A*) Sagittal transabdominal image shows a gestational sac (*arrowheads*) located high in the uterus, with the superior portion of the sac (*thin arrows*) bulging beyond the confines of the uterus. (*B,C*) Sagittal transvaginal images show blood (*B*) surrounding the uterus (*arrows*). The gestational sac (*arrowheads*) is again noted to be high in the uterus, without myometrium around the superior portion of the sac. At surgery a ruptured isthmic pregnancy was found.

sac or embryo is less commonly seen, with the appearance of the contents lagging in comparison with the gestational age. Abdominal pain before 7 weeks gestational age is typically present [81].

Abdominal pregnancies are rare. The pregnancy typically develops in the ligaments of the ovary, usually the broad ligament. It can then obtain blood supply from the omentum and abdominal organs. Sonographically, the pregnancy is seen separate from the uterus, adnexa, and ovaries. Treatment is by laparotomy or laparoscopy [82]. Abdominal pregnancy can result in a life-threatening emergency. However, if diagnosed late in gestation, a viable pregnancy can result.

Ovarian hyperstimulation

Ovarian hyperstimulation is diagnosed by the presence of abdominal pain, enlargement of the ovary greater than 5 cm, and ascites or hydrothorax [83]. In addition, one of the following criteria has to be met: hematocrit 45% or more, white blood cells greater than 15,000/ml, oliguria, elevated liver enzymes, dyspnea, anasarca, or acute renal failure [83]. These patients may benefit by sonographically guided drainage of hyperstimulated ovaries to relieve the abdominal pain and distension they experience. One problem in the diagnosis of ovarian hyperstimulation is that if the patient is pregnant, ectopic pregnancy is still a possibility. If the pain is severe, torsion may also be present [Fig. 14].

Ovarian torsion

Ovarian torsion is the most frequent and most serious complication of benign ovarian cysts during pregnancy. Torsion is most common in the first trimester, and may result in cyst rupture into the peritoneal cavity. Symptoms include abdominal pain and tenderness that are usually sudden in onset,

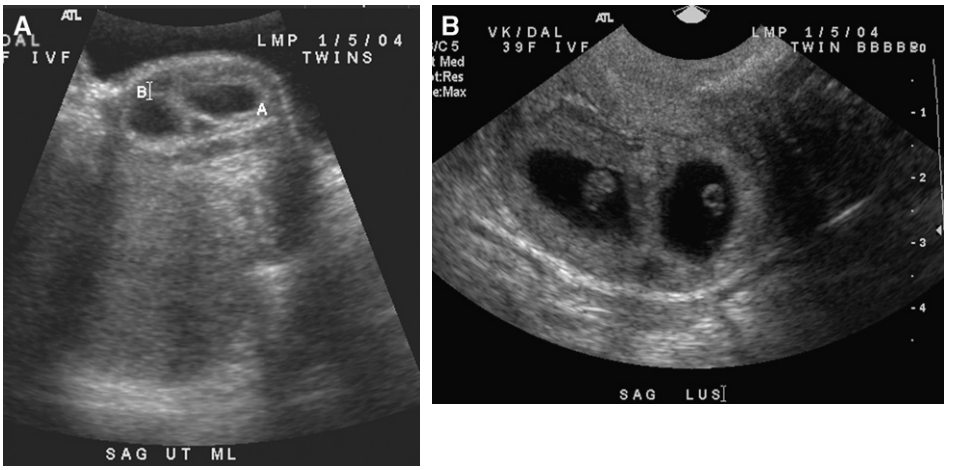

Fig. 13. Twin gestation in cesarean section scar. (*A*) Transabdominal view of a retroflexed uterus shows two gestational sacs (*A,B*) in the region of a prior cesarean section scar. (*B*) Transvaginal image shows embryos within the gestational sacs. These are in the anterior myometrium, separate from the endometrial cavity. The patient was given systemic methotrexate and the embryos were injected with potassium chloride.

and localized to the torsed ovary. Ultrasound frequently demonstrates an adnexal mass, and may show altered blood flow on Doppler studies. Doppler of ovarian torsion can be difficult because the ovaries have a dual blood supply, from the ovarian artery laterally and from the ovarian branch of the uterine artery medially. Presence of venous flow is predictive of ovarian viability [84]. In difficult cases, the authors have found MRI to be helpful in confirming the diagnosis of torsion [Fig. 15] [85].

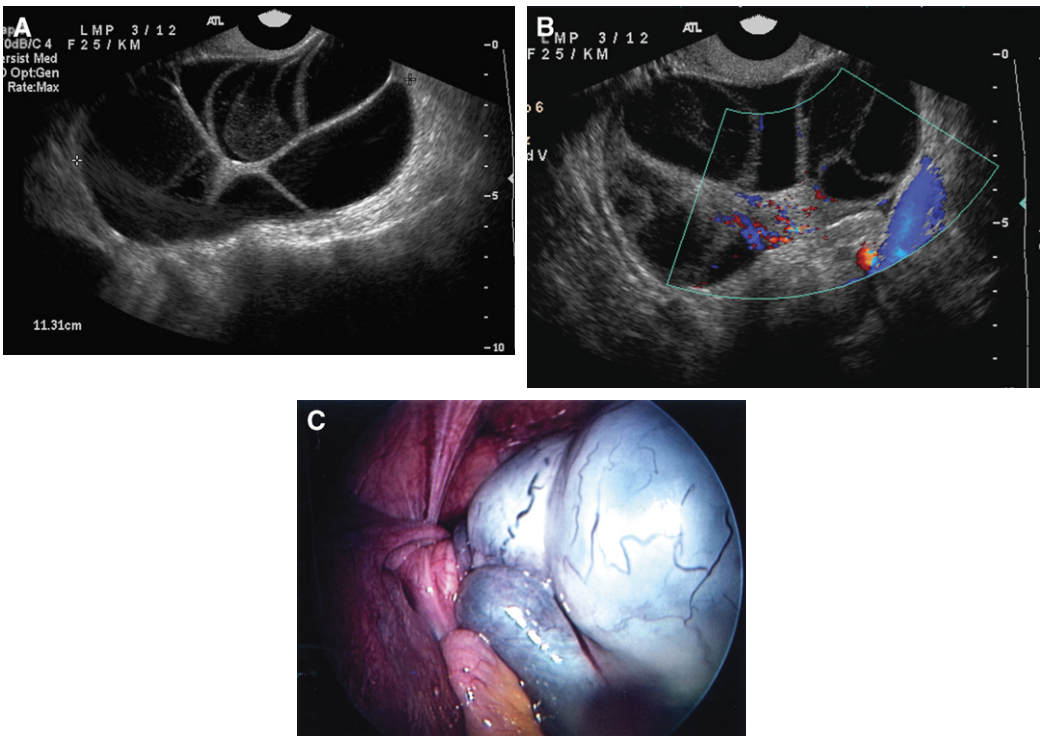

Fig. 14. Hyperstimulated torsed ovary in patient 7 weeks pregnant with severe pain. (*A*) Transverse sonogram demonstrates an enlarged left ovary measuring 11 cm with multiple cysts consistent with the patient's history of hyperstimulation. (*B*) Color Doppler shows flow in the ovary. Pulsed Doppler (not shown) demonstrated both arterial and venous flow. (*C*) Image at surgery shows torsion of the hyperstimulated ovary.

Fibroids

Uterine fibroids are commonly found during pregnancy. One in 500 pregnant women is admitted for a complication related to a fibroid [86]. Inconsistency of uterine size and gestational dates in a pregnant patient who has acute abdominal pain may be the first sign of leiomyoma. Fibroids during pregnancy occasionally undergo red degeneration that is caused by hemorrhagic infarction. The symptoms and signs are focal pain, with tenderness on palpation and sometimes low-grade fever. Moderate leukocytosis is common. The greatest increase in volume of myomas occurs before the 10th week of gestation. Fibroids either remain unchanged or increase in size in the first trimester as a response to increased estrogen [87]. The sonographic diagnosis of a degenerating fibroid is made when the patient experiences pain when the probe is placed over the fibroid. At times a lucent center will be visualized [Fig. 16].

Urinary tract

The urinary system undergoes many changes during pregnancy. The enlarging uterus puts pressure on the ureters, which can partially obstruct the normal downward flow of urine. Pregnancy also increases the risk of reflux of urine by causing the ureters to dilate and reducing the muscle contractions that propel urine downwards into the bladder. These changes make urinary tract infections very common. Many women who have bacteriuria will develop pyelonephritis during pregnancy. Both cystitis and pyelonephritis can be a cause of pelvic pain.

Although hydronephrosis of pregnancy can cause flank pain, is not a typical cause of pelvic pain. The appearance of dilated tracts can be confusing in pregnancy, however, because hydronephrosis can be caused by physiologic dilation of pregnancy, nephrolithiasis, or structural abnormalities.

Nephrolithiasis is an uncommon but important condition in pregnant women. The most common presenting complaint is flank pain.; however, when the stone is at the ureterovescicle junction, the patient may present with pelvic pain [Fig. 17]. The incidence of nephrolithiasis in pregnancy is about 1 per 2000 pregnancies [88]. If the ureter is dilated and a stone is not visualized, it can be helpful to assess for urinary jets in the bladder; however, these jets can be absent in cases without stones, and present with nonobstructing stones [89,90].

Gastrointestinal causes of pelvic pain

Acute appendicitis is the most common nonobstetrical surgical condition of the abdomen complicating pregnancy. Although the incidence of appendicitis occurring in pregnant women is considered to be the same as in nonpregnant women, the signs and symptoms and the laboratory findings usually associated with appendicitis in the nonpregnant condition are frequently unreliable during pregnancy [91]. On ultrasound, the abnormal

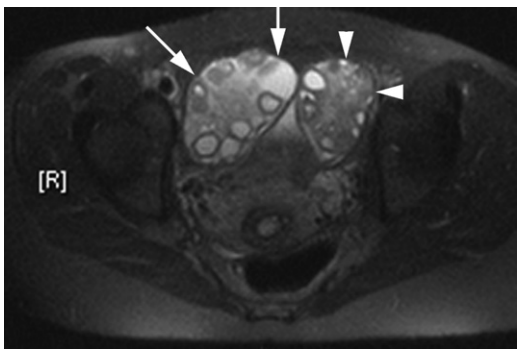

Fig. 15. Ovarian torsion in patient with twins after in vitro fertilization with severe intermittent right lower quadrant pain (11 weeks pregnant). Sonogram (not shown) had demonstrated enlarged ovaries with flow. Due to severe pain, an MR was performed. Axial fat saturated, T_2-weighted, single-shot, fast-spin echo image shows large ovaries, right (*arrows*) greater than left (*arrowheads*), with multiple follicles, consistent with history of hyperstimulation. The stroma of the right ovary is brighter than the left, consistent with edema caused by torsion. At surgery the ovary was edematous with 360° of torsion. (*From* Levine D, Pedrosa I. MR imaging of the maternal abdomen and pelvis in pregnancy. In: Levine D, editor. Atlas of fetal MRI. Boca Raton (FL): Taylor & Francis Group; 2005. p. 216; © 2005. Reproduced by permission of Routledge/Taylor & Francis Group, LLC.)

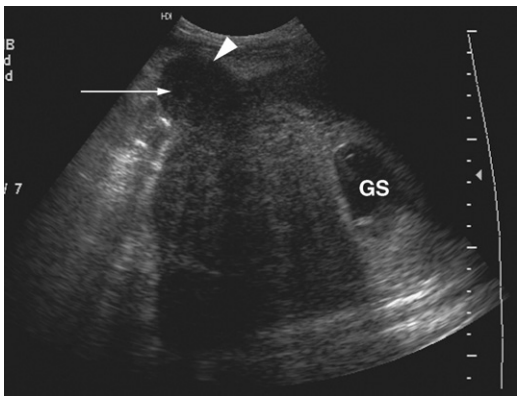

Fig. 16. Degenerating fibroid in patient 10 weeks pregnant. Transabdominal view of the uterus shows a gestational sac (*GS*) and an anterior fibroid (*arrowhead*) with a small lucency centrally (*thin arrow*). The patient was focally tender over the fibroid.

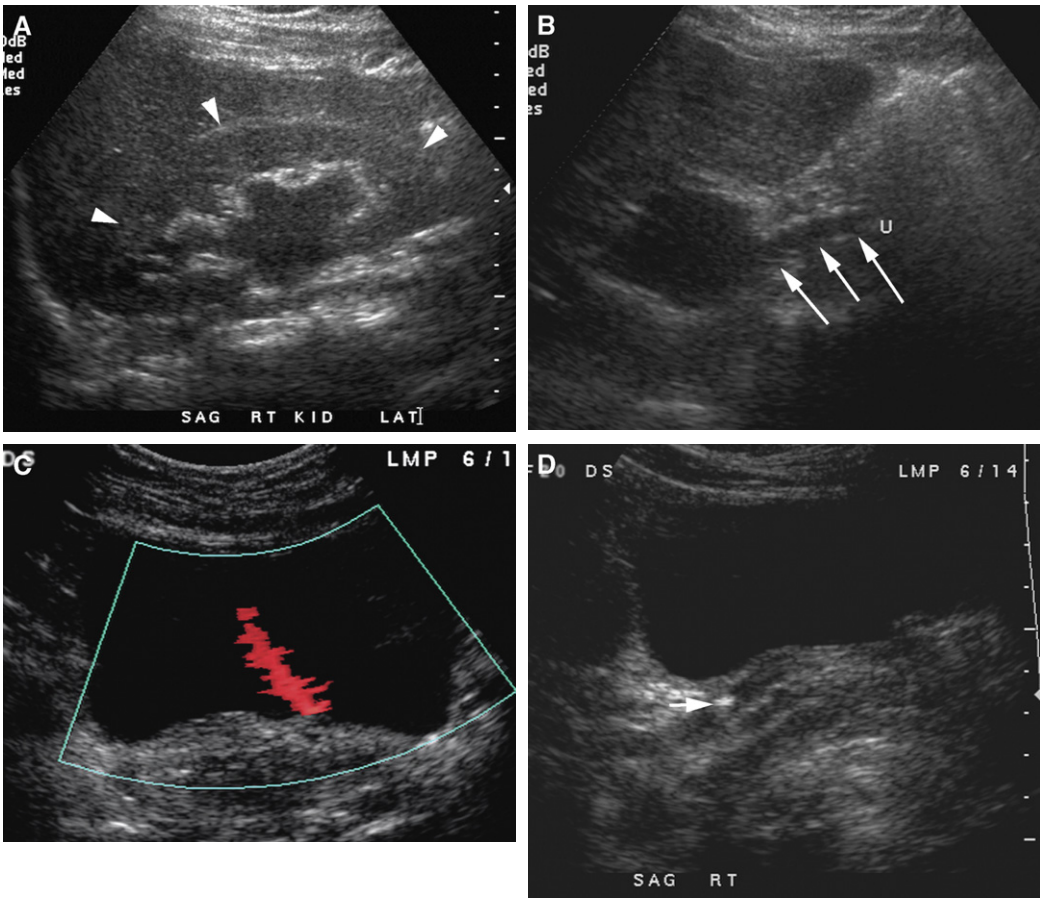

Fig. 17. Obstructing stone at 13 weeks gestational age. (*A*) Sagittal view of the right kidney (*arrowheads*) demonstrates hydronephrosis. (*B*) Sagittal view of the uteropelvic junction demonstrates dilation of the proximal right ureter (*U*, *long arrows*). (*C*) Transverse view of the bladder with color shows a left ureteral jet but no right jet was demonstrated. (*D*) View of the right ureterovescicle junction demonstrates a small stone (*small arrow*) without a shadow.

appendix is visualized as a noncompressible tubular structure measuring 6 mm or greater in the region of the patient's pain [Fig. 18]. An appendicolith or periappendiceal fluid may be visualized. If ultrasound diagnosis is inadequate, MRI can be helpful in assessing the etiology of right-sided pain in pregnancy [92,93].

Crohn's disease can also be a cause of pelvic pain in pregnancy. Most pregnant women who have a history of inflammatory bowel disease have uneventful pregnancies, and exacerbations of disease can be controlled with medical therapy. Although it is rare for the new onset of inflammatory bowel disease to be diagnosed during pregnancy [94], when a relapse of Crohn's disease occurs during pregnancy, it typically will occur during the first trimester [95]. Imaging can start with ultrasound, but frequently another modality is needed, such as MRI or CT.

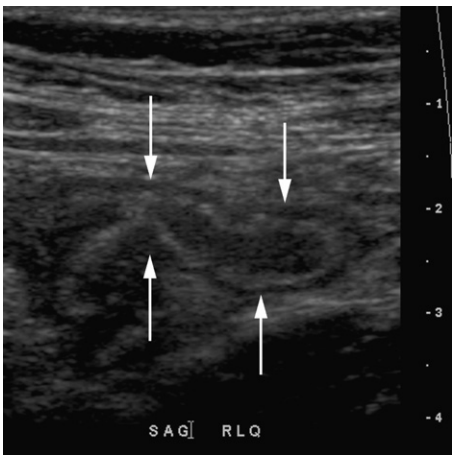

Fig. 18. Appendicitis in pregnancy. Oblique view in the right lower quadrant demonstrates the dilated appendix (*arrows*).

Summary

Pelvic pain during the first trimester of pregnancy can pose a challenge to the clinician. Ultrasound is a very important imaging modality in evaluating these patients.

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