120 First Trimester Ultrasonography

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KEY POINTS

- Patients with ectopic pregnancy have highly variable and often unhelpful findings on physical examination.
- Ultrasound is the initial imaging modality of choice to locate a pregnancy in the first trimester.
- Emergency physicians proficient in ultrasound are capable of rapidly diagnosing ectopic pregnancy and expediting definitive care.
- Most first trimester pregnancies can be localized within the uterus on initial ultrasound in the emergency department.
- All patients discharged from the emergency department without a confirmed intrauterine pregnancy by ultrasound should thoroughly understand the "ectopic precautions," have close outpatient follow-up arranged with their obstetrician, and have the means to return immediately to the emergency department if complications arise.

INTRODUCTION

All female patients of reproductive age seen in the emergency department (ED) with vaginal bleeding or abdominal or back pain should have a urine or serum pregnancy test performed. Ectopic pregnancy is the number one cause of death in patients in the first trimester.[1] Emergency physicians (EPs) caring for these patients understand that no historical clues or physical findings can effectively affirm or refute an ectopic pregnancy.[2] The rate-limiting step is finding the location of the pregnancy. Ultrasound imaging and interpretation play a crucial role in this decision-making process. The faster this information is available, the quicker management can be implemented. In the late 1980s, a few EP pioneers invested the time and effort to learn the technical and interpretive skills necessary to bring ultrasound to the bedside.[3] The ability to locate a first trimester pregnancy saves valuable time in the search for an ectopic pregnancy.[4] Ultrasound performed at the patient's bedside quickly classifies patients by ultrasound criteria.[5] Based on this ultrasound classification, management strategies can be implemented. The following sections describe the ultrasound techniques and management skills used in symptomatic patients in the first trimester of pregnancy.

EVIDENCE-BASED REVIEW

In most EDs, when "formal" ultrasound is traditionally ordered, it is actually performed in the department of radiology. This requires (1) time to transport the patient out of the ED, (2) a sonographer available to obtain the images, and (3) a radiologist to interpret the study. Ultimately, the combination of these factors postpones the diagnosis, delays definitive care, and increase the patient's length of stay.[4] As an alternative to formal ultrasound, many EPs have learned how to perform and interpret ultrasound images at the patient's bedside. As early as 1989, a number of small studies suggested that EPs were able to perform ultrasound for ectopic pregnancies with high sensitivity.[3] When previous studies from multiple institutions are compiled to increase the sample size ($N = 2057$), it is estimated that EPs have a pooled sensitivity of 99.3% when diagnosing ectopic pregnancies at the bedside. Sensitivity is defined as the proportion of bedside ultrasound images demonstrating a true absence of definitive intrauterine pregnancy (IUP) in patients with ectopic pregnancies.[4]

Multiple retrospective and prospective studies from the late 1990s and early 2000s have reported that when compared with formal imaging, the use of bedside ultrasound to evaluate first trimester bleeding reduced length of stay in the ED by a mean time of 48 to 169 minutes. Time of day, day of the week, and whether ultrasound technicians were in house 24 hours a day were some of the factors that had an impact on the length of stay.[5] Finally, based on two separate studies from the early 2000s, bedside ultrasound performed by EPs saved an estimated $229 to $1244 per ED visit when compared with patients who underwent radiology-performed ultrasound. In some cases this was a 40% savings in billed charges.[5] Literature from the past 20 years has and continues to demonstrate that ultrasound performed by an EP to evaluate for ectopic pregnancies is feasible, fast, and accurate. Bedside ultrasound in symptomatic first trimester pregnant patients has high sensitivity in ruling out ectopic pregnancy, speeds time to diagnosis, and decreases true costs.

HOW TO SCAN

The pelvic organs may be evaluated with one of two different sonographic methods of interrogation: the transabdominal or the endovaginal technique. In the transabdominal approach,

the probe is positioned over the lower portion of the abdomen, just superior to the pubic symphysis, and directed inferiorly into the pelvis because the uterus typically remains a pelvic organ until approximately the 12th week of pregnancy. In the endovaginal approach, the probe is inserted into the vaginal vault, directly in touch with the cervix. These "windows" into the pelvis are illustrated and discussed in the following sections.

TRANSABDOMINAL TECHNIQUE

The transabdominal technique has long been used to evaluate first trimester pregnant patients and is best done with a curvilinear probe. Before the ultrasound examination, a Foley catheter can be inserted to fill the bladder. The practice of filling the bladder accomplishes two things. First, a full bladder displaces bowel out of the anterior cul-de-sac and acts as an acoustic window to the pelvic organs. Second, a full bladder generally aligns the uterus such that its long axis parallels the abdominal wall. This allows the transmitted sound waves to strike the uterus at a nearly perpendicular angle, which produces better reflections when the returning echoes are received by the transducer and plotted on the monitor. Although this optimizes image quality, adequate images can often be achieved without this maneuver.

In the sagittal view, in which the uterus is seen in its long axis, the probe is placed just superior to the pubic symphysis with the indicator pointed toward the patient's head. The anterior-most organ on screen is the fluid-filled, triangular-shaped bladder. Just posterior to the bladder is the pear-shaped uterus. The uterus more commonly lies in an anteverted position, with the fundus pointed toward the anterior abdominal wall, but it may also be seen in a retroverted lie with the fundus pointing posteriorly toward the spine. The endometrial stripe serves as the landmark for identifying the longitudinal uterus in the midline. The endometrial stripe is a result of the endometrial mucosal lining coming together to form a hyperechoic, curvilinear line that continues as the cervical stripe more inferiorly (**Fig. 120.1,** *A* and *B*). After the midline of the longitudinal uterus is identified, the probe is panned from side to side to evaluate the entire width of the uterus. Much of the hyperechoic area surrounding the uterus is the bowel and rectum, which are poorly defined because of their solid and gas contents.

In the transverse view, the probe is rotated 90 degrees counterclockwise so that the indicator is pointed toward the patient's right. With the probe angled inferiorly to visualize into the pelvis, the anterior-most organ is the fluid-filled, rectangular-shaped bladder. Posterior to the bladder is an ovular-shaped cut of the uterus in the transverse view with the hyperechoic endometrial stripe in the center. The rectum and bowel are hyperechoic areas surrounding the bladder and uterus posteriorly and laterally. The uterus should be evaluated from the top of the fundus inferiorly through to the cervix. Though not always visualized, the ovaries may be seen lateral to the fundus of the uterus in either the sagittal or transverse view.

Advantages of the transabdominal technique include (1) an overall view of the true pelvis and (2) a faster examination. The lower-frequency curvilinear probe will penetrate deeper into the pelvis, and although the images might be a little fuzzy, a "full" view of the pelvis is provided. Second, in patients who are farther along in the first trimester or whose bladder is not completely empty, adequate transabdominal views can be obtained without filling the bladder. Less preparation time is needed to scan these patients, and enlisting the assistance of a coworker to chaperone is unnecessary.

The main disadvantage of the transabdominal technique results from the use of a lower-frequency probe. The lower frequency (2- to 5-MHz curvilinear probe) means less resolution and thus the pregnancy must be farther along (usually 7 to 8 weeks' gestational age) to be visualized. The transvaginal probe is a higher-frequency probe (5 to 9 MHz) with increased resolution, which means that pregnancies as early as 5 to 6 weeks can be visualized.

ENDOVAGINAL TECHNIQUE

The arrival of endovaginal transducers in the 1980s significantly improved the quality of ultrasound imaging in female patients. Simplified, the engineering design placed an ultrasound transducer on the end of a stick that could be inserted

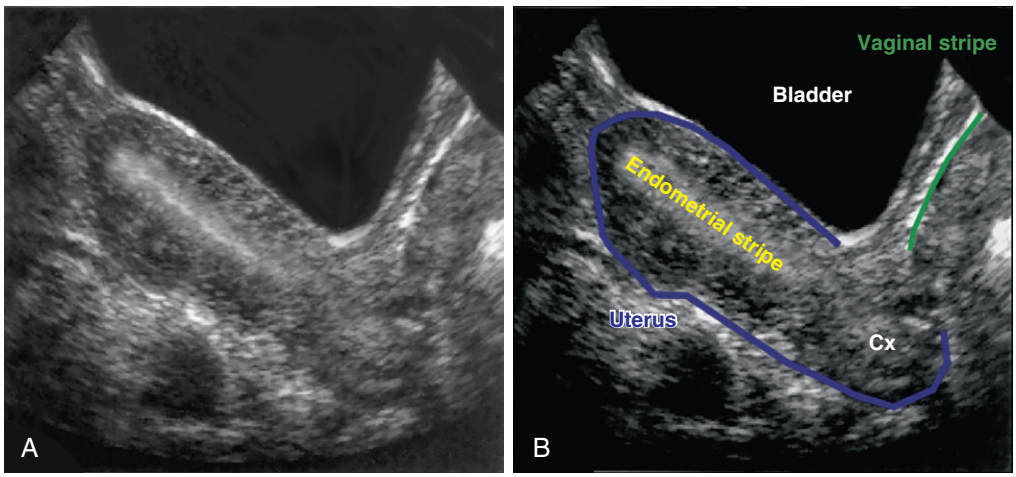

Fig. 120.1 **A** and **B,** Transabdominal views of the sagittal plane of the uterus revealing the typical landmarks of the uterus, endometrial stripe, cervix, bladder, and vaginal stripe.

into the vaginal vault. This permits the transducer scanning head to be in close proximity to the pelvic organs, which has several important implications in ultrasound imaging. First, there is a clearer path to transmit and receive echoes, and second, the shorter distance between the transducer and the pelvic organs allows higher transducer frequencies to be used.[6] In contrast to the transabdominal approach, the quality of images from an endovaginal approach is enhanced with an empty bladder because of less distortion of the pelvic anatomy.

The high-frequency endocavitary probe is prepared by directly placing ultrasound gel on the transducer head, sheathing the probe with a sterile cover, and then adding more sterile gel over the sheathed transducer head. If it is not possible to place the patient in the lithotomy position on a gynecology examination table, it is important to adequately prop up the patient's pelvis for any modified positioning. It is often necessary to manipulate the handle of the probe below the level of the pelvis for better visualization. The covered probe is then inserted into the vaginal vault to begin scanning. Some patients and practitioners have found it more comfortable for patients to insert the probe.

For the sagittal view, the transducer is inserted so that the indicator is straight up and down, with the body sliced into left and right halves. Even after voiding, the bladder usually retains a small amount of fluid, which enables this anechoic structure to be used as a landmark in endovaginal imaging. After initially placing the probe into the vaginal vault, the bladder or uterus (or both) may not initially be visible. To look for these structures, the handle of the probe should be brought down and the footprint of the probe tilted more anteriorly and angled up to get the uterus in its full, longitudinal (sagittal) plane. In this plane, the anterior-most structure is a sliver of bladder, the pear-shaped uterus is posterior to the bladder, and the more hyperechoic bowel and rectum surround the uterus (**Fig. 120.2,** *A* to *C*). As in transabdominal imaging, the endometrial stripe serves as the landmark for identifying the longitudinal uterus in its midline. Once it is identified, the uterus should be interrogated along its entire width by fanning from side to side.

For the coronal view the probe is rotated 90 degrees counterclockwise, with the body cut into anterior and posterior components. As in the sagittal view, the probe is tilted anteriorly by moving the handle of the probe downward to obtain transverse cuts of the uterus. Depending on the depth of probe insertion, some part of the bladder may be seen. Deep to the bladder lies the ovular uterus, which is surrounded by the rectum and bowel.

Advantages of the endovaginal technique include (1) superior resolution and (2) a wider field of view. The shorter pathway from the transducer to the pelvic structures permits the use of higher frequencies. Sound attenuation is limited, and waves reflected from nearby objects are maximized. These higher-frequency probes, with their inherent enhanced resolution, provide the EP with more clinical confidence when interpreting images. In addition, most endovaginal transducers incorporate a beam angle that provides a 120- to 180-degree field of view.

Disadvantages of the endovaginal technique include (1) increased invasiveness, (2) more time to prepare and perform the scan, and (3) decreased depth of view. As the endovaginal probe is inserted into vaginal vault, there is a small risk of transmitting disease through an improperly sanitized probe. Second, the taboo of having an unknown physician insert a probe into the vaginal vault may require greater explanation of the procedure. Optimal examination is performed with a gynecology table, which may be a limited resource. More time commitment is involved in preparation for the endovaginal study and obtaining a chaperone. Third, the higher-frequency probes used for endovaginal scanning limit the range of the transmitted echo. Generally, a full view of the pelvis is not achieved with transvaginal scanning.

IDENTIFICATION AND LOCALIZATION OF THE PREGNANCY

First trimester pregnancies can be categorized into three groups according to location: intrauterine, extrauterine, or indeterminate (**Box 120.1**). Within these three categories, further subdivisions into one of five diagnostic possibilities based on specific criteria (**Box 120.2**) are possible. The significance of this unambiguous classification scheme is that it corresponds with EP management strategies for first trimester symptomatic patients.

INTRAUTERINE PREGNANCY

To define a pregnancy as intrauterine, it is imperative to have a clear understanding of the criteria necessary to support the

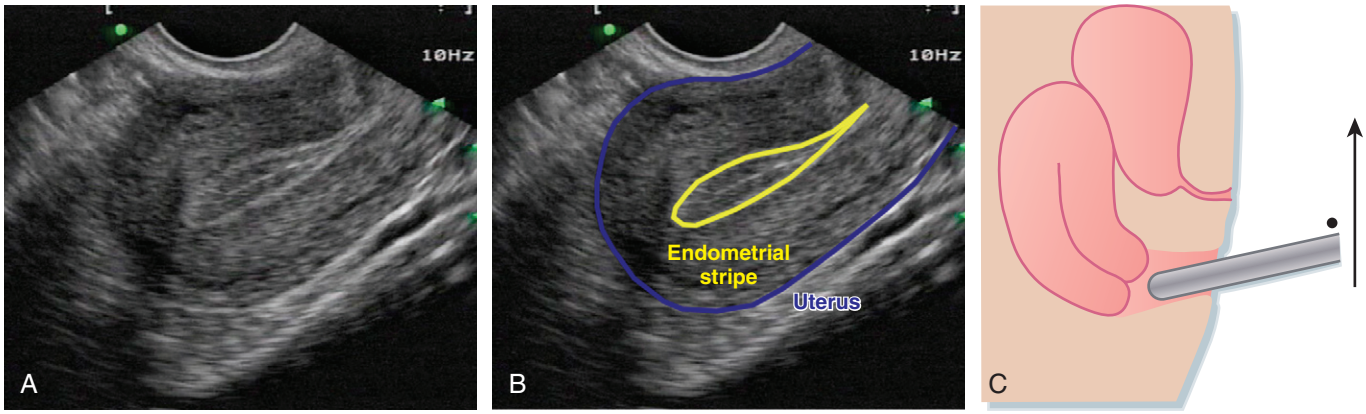

Fig. 120.2 **A** and **B,** Transvaginal views of the sagittal plane of the uterus revealing the typical landmarks of the uterus and endometrial stripe. **C,** Illustration depicting positioning of the probe.

diagnosis by ultrasound (**Box 120.3**). The first component of the criteria is to visualize a gestational sac with a mean sac diameter (height, width, and length) larger than 5 mm and an echogenic ring. Second, this gestational sac must be clearly visualized within the endometrial lining of the uterus and many times may demonstrate a "double decidual sac sign." Finally, this gestational sac, which lies within the endometrial echo of the uterus, must contain a yolk sac or a fetal pole. Although this may be excessive for a radiologist who uses the double decidual sac sign as the earliest criteria for an IUP, it is a conservative safety measure that has served EPs well to avoid confusing the pseudogestational sac of an ectopic pregnancy with a true IUP. Because ectopic pregnancies secrete hormones that stimulate the endometrial lining, occasionally there may be changes in the endometrial lining that can approximate the appearance of a gestational sac. This pseudosac will never have an inner yolk sac or fetal pole. Use of these two additional findings for defining an IUP helps ensure that the EP will not be confused. Whether scanning from a transabdominal or an endovaginal approach, all these criteria should be visualized and documented on every sonogram. The safest way to ensure that these criteria are present is a systematic approach to documenting these landmarks. In the endovaginal approach, documentation is best achieved by obtaining a single sagittal view of the gestational and yolk sacs clearly within the endometrial echo of the uterus, along with the inferiorly positioned endometrial stripe as it passes through the corpus and cervical region of the uterus (**Fig. 120.3,** *A* and *B*). In the transabdominal approach, documentation is best achieved by obtaining a single sagittal view of the gestational and yolk sacs clearly within the endometrial echo of the uterus, along with the anteriorly positioned bladder and the inferiorly positioned vaginal stripe (**Fig. 120.4,** *A* and *B*). By identifying pregnancies as intrauterine, ectopic pregnancy has effectively been excluded with reasonable certainty. There is a theoretic risk for a heterotopic pregnancy of approximately 1 in 30,000 pregnancies.[7] When assisted reproduction is involved, the heterotopic rate is 1 in 7000 overall and as high as 1 in 900 with induction of ovulation.[8] Even when a live IUP is identified in an assisted reproduction patient, close follow-up with the fertility specialist is recommended.

BOX 120.1 Ultrasound Categorization of First Trimester Pregnancies by Location

Intrauterine
Extrauterine
Indeterminate

BOX 120.2 First Trimester Ultrasound Diagnosis

Intrauterine
Intrauterine pregnancy
Live intrauterine pregnancy
Abnormal intrauterine pregnancy

Extrauterine
Extrauterine gestation: ectopic

Indeterminate
No definitive pregnancy

BOX 120.3 Diagnostic Criteria

Intrauterine pregnancy—Gestational sac with a concentric echogenic ring lying within the endometrial echo of the uterus that is greater than 5 mm in mean sac diameter (height, width, and length) and contains a yolk sac with or without a fetal pole

Live intrauterine pregnancy—Gestational sac with a concentric echogenic ring lying within the endometrial echo of the uterus that is greater than 5 mm in mean sac diameter (height, width, and length) and contains a yolk sac plus a fetal pole and cardiac activity

Abnormal intrauterine pregnancy—Gestational sac with a concentric echogenic ring lying within the endometrial echo of the uterus that is greater than 13 mm in mean sac diameter (height, width, and length) without a yolk sac or greater than 18 mm in mean sac diameter (height, width, and length) without a fetal pole or with an obvious fetal pole without cardiac activity

No definitive pregnancy—No definite gestational sac is apparent within the endometrial echo of the uterus, or if a gestational sac is visualized, it is less than 5 mm in mean sac diameter (height, width, and length)

Extrauterine gestation: ectopic—Gestational sac with a concentric echogenic ring lying outside the endometrial echo of the uterus that is greater than 5 mm in mean sac diameter (height, width, and length) and contains a yolk sac with or without a fetal pole and cardiac activity

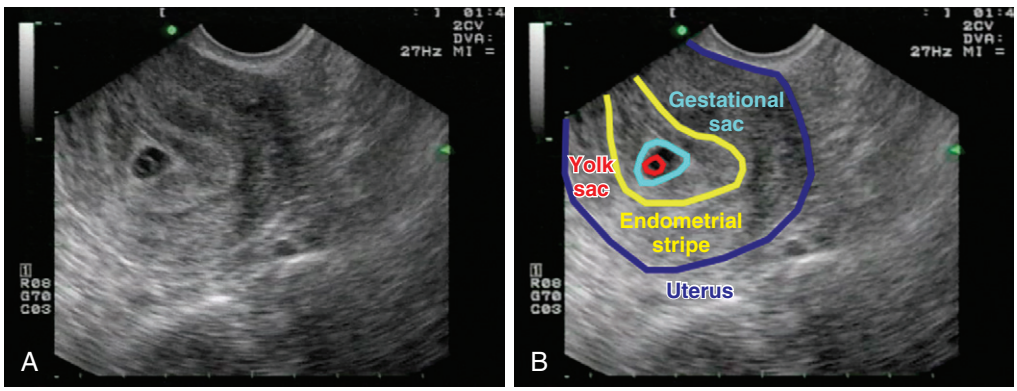

Fig. 120.3 **A** and **B,** Endovaginal views of the sagittal plane showing an intrauterine pregnancy. The gestational sac is located within the endometrial echo of the uterus and contains a yolk sac.

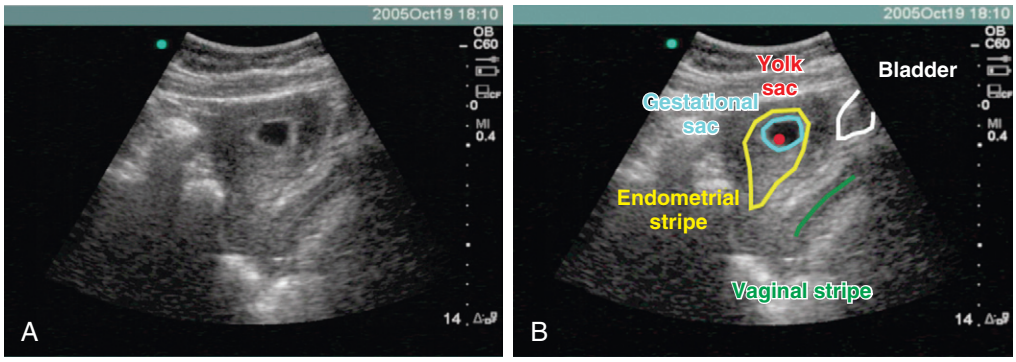

Fig. 120.4 **A** and **B,** Transabdominal view of the sagittal plane showing an intrauterine pregnancy. The gestational sac is located within the endometrial echo of the uterus and contains a yolk sac. The landmarks of the vaginal stripe and bladder help confirm the proper location.

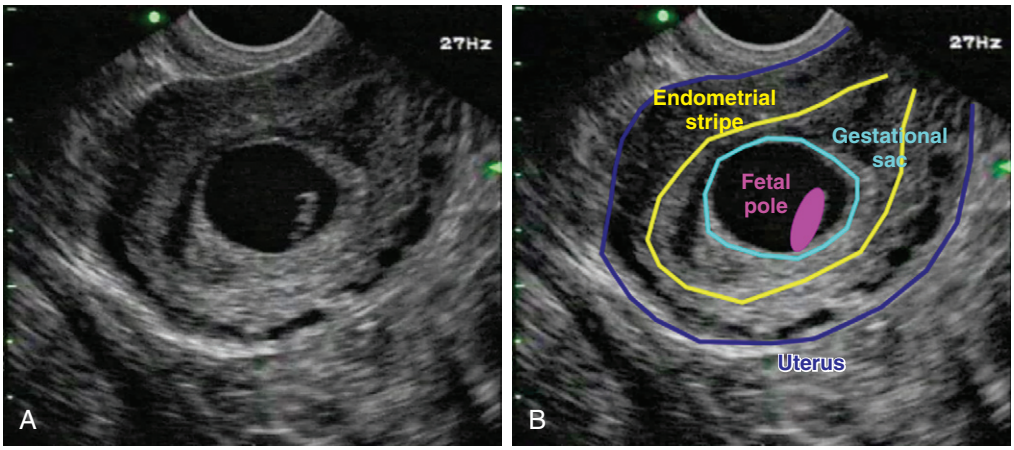

Fig. 120.5 **A** and **B,** Endovaginal views of the sagittal plane showing an intrauterine pregnancy. The gestational sac is located within the endometrial echo of the uterus and contains a fetal pole.

LIVE INTRAUTERINE PREGNANCY

Once the pregnancy is determined to be intrauterine, the next designation is viability. This involves real-time documentation of the cardiac activity normally present at 6 weeks' gestational age when using the endovaginal technique and at 7 to 8 weeks' gestation when using the transabdominal technique. The criteria for documentation of a live IUP is detailed below (see Box 120.3). Simply having a fetal pole within the endometrial echo of the uterus will not suffice (**Fig. 120.5,** *A* and *B*). For our purposes, an IUP is not live until cardiac activity is documented. The flickering of cardiac activity is an unmistakable sign of life that can be identified by the novice sonographer and the patient as well. Documentation can be confirmed by video in B mode or by identifying the fetal heart rate by M mode (**Fig. 120.6**). Pulsed wave Doppler should never be used to document fetal heart rates because of the theoretic risk to the fetus of the increased heat generated by this form of ultrasound. Novice sonographers will occasionally use the zoom feature and record or print an image of a pregnancy without any definite landmarks confirming the pregnancy as intrauterine (**Fig. 120.7**). The problem is that ectopic pregnancies can be indistinguishable with this particular example of a cone-down view, which does not allow visualization of the landmarks that support the criteria for an IUP.

ABNORMAL INTRAUTERINE PREGNANCY

A pregnancy can be categorized as abnormal when the gestational sac is disproportionate to its contents. For example, by the time that a gestational sac measures 13 mm in diameter, a yolk sac should clearly be visualized. Likewise, by 18 mm, all intrauterine gestational sacs containing live embryos should have cardiac activity. When using conservative criteria, it is safe to conclude that any sac larger than 13 mm without a yolk sac or larger than 18 mm without evidence of cardiac activity is termed abnormal (**Fig. 120.8,** *A* and *B*). It has been shown in the obstetric ultrasound literature that gestational sacs reaching 13 mm in size with no yolk sac or fetal pole have virtually no viability and ultimately result in miscarriage. In most cases in which viability is equivocal, there is no rush to make a specific diagnosis (IUP versus abnormal IUP). Because these pregnancies have only a gestational sac visualized on ultrasound, obstetric consultation and close follow-up in 48 hours, repeated ultrasound, and quantitative measurement of β-human chorionic gonadotropin will be required.

EXTRAUTERINE PREGNANCY

Ectopic pregnancies represent approximately 2% of reported pregnancies, and ectopic pregnancy–related deaths account for 9% of all pregnancy-related deaths.[9] The most common

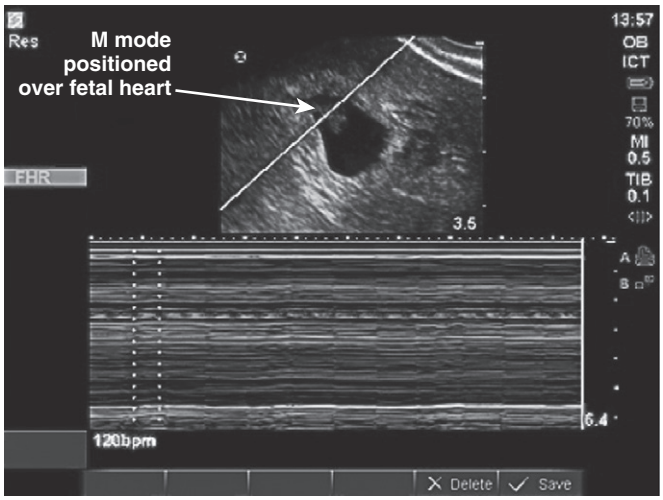

Fig. 120.6 M-mode documentation of the fetal heart rate confirming that an intrauterine pregnancy is a live intrauterine pregnancy.

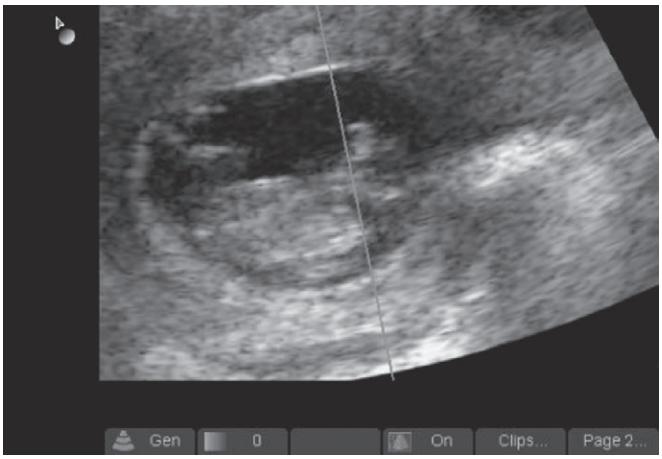

Fig. 120.7 Transabdominal technique in an unknown plane of a live pregnancy. This image demonstrates that with the zoom function, proper identification of landmarks (bladder, vaginal stripe, uterine fundus) is lost such that proper documentation of intrauterine location is not possible.

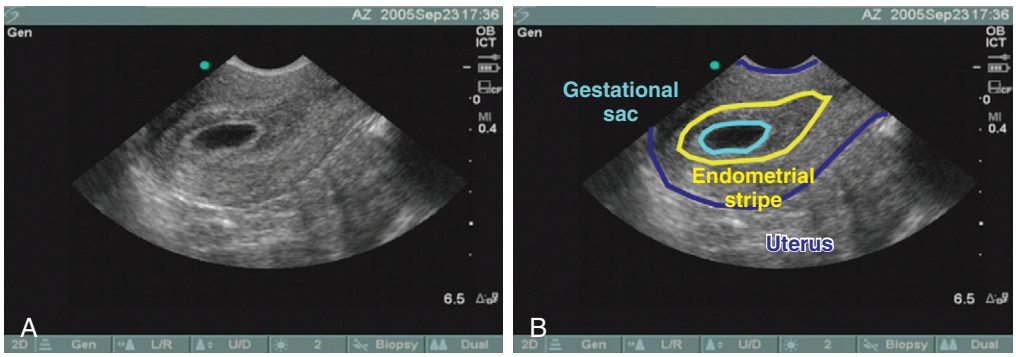

Fig. 120.8 A and **B,** Endovaginal coronal plane views of an abnormal intrauterine pregnancy. The gestational sac is located within the endometrial echo of the uterus but is larger than 10 mm and does not have a fetal pole.

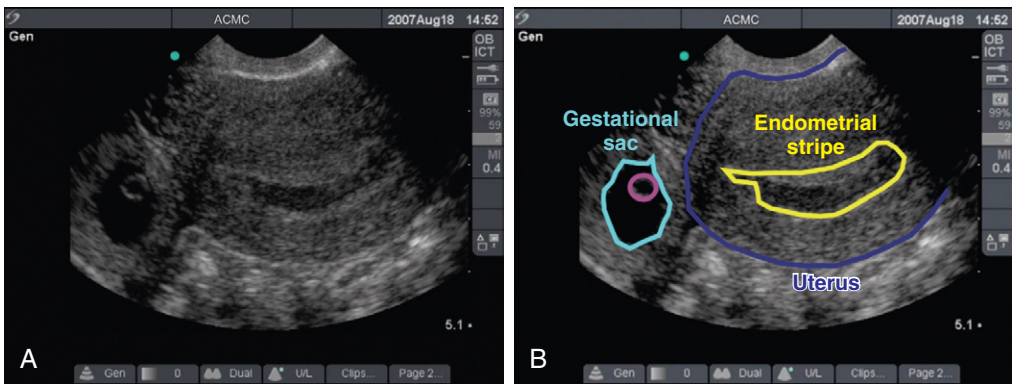

Fig. 120.9 A and **B,** Endovaginal coronal plane views of an extrauterine gestation. The gestational sac is located outside the endometrial echo of the uterus and has a yolk sac.

implantation site is within the fallopian tube (95.5%). Sites of tubal implantation in descending order of frequency are ampullary (73.3%), isthmus (12.5%), fimbrial (11.6%), and interstitial (2.6%). The remaining sites are ovarian (3.2%) and abdominal (1.3%).[10] Visualization of an ectopic pregnancy on ultrasound, even for experienced sonographers, is frequently difficult. As opposed to an IUP, for which ultrasound confirms the diagnosis, an extrauterine pregnancy is often not substantiated by ultrasound and is just presumed because of the absence of an IUP or other findings of a normal pregnancy. The criteria for diagnosis of an extrauterine gestation is a gestational sac outside the endometrial echo of the uterus with evidence of a yolk sac or fetal pole (**Fig. 120.9,** *A* and *B*). In patients who do not have this definitive finding, the diagnosis can be made either intraoperatively or by serial ultrasound in patients who are being monitored very closely. A "ruptured"

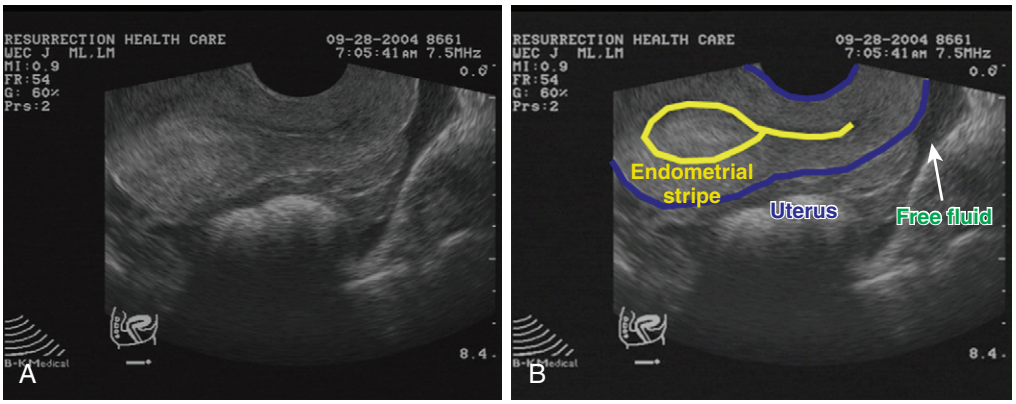

Fig. 120.10 **A** and **B,** Endovaginal sagittal plane views of a uterus with no definitive pregnancy identified. There is no gestational sac in the uterus. In addition, free fluid is seen in the pouch of Douglas.

ectopic pregnancy is frequently suspected on clinical grounds. Supportive sonographic findings of an intraperitoneal fluid collection or an adnexal mass (or both) further strengthen this suspicion.[11] Recent literature suggests that a transabdominal approach in which a large intraperitoneal fluid collection is revealed will decrease the time to diagnosis and treatment.[14] A pregnant female with free fluid visualized in the right upper quadrant should have these findings communicated immediately to obstetric consultants to help facilitate a shorter time to the operating room.

NO DEFINITIVE PREGNANCY

The diagnosis of no definitive pregnancy is established when a technically adept emergency ultrasound examination fails to diagnose an intrauterine or extrauterine gestation (**Fig. 120.10,** *A* and *B*). When this is encountered, three possible diagnoses exist. First, it is possible that an early IUP is present but no definitive signs are visualized within the uterus by ultrasound. Second, the products of conception my have been aborted and the empty uterus is a result of a miscarriage. Finally, a concealed ectopic pregnancy is not identified by emergency ultrasound.

Absence of proof is not proof of absence. It should be borne in mind that patients in whom no definitive pregnancy is diagnosed are at high risk for an ectopic pregnancy. The presence of free fluid in the pouch of Douglas or elsewhere in the pelvis should increase suspicion for an ectopic pregnancy substantially. The literature varies widely in defining ectopic pregnancy rates in patients with indeterminate or no definitive pregnancy. This may be due to variation in the specific criteria used to define this category. Many researchers have added subgroups such as probable ectopic pregnancy and probable IUP.[11,12] The take-home message is that all patients in whom no definitive IUP is diagnosed should be managed closely with our obstetric colleagues regardless of the β-human chorionic gonadotropin level. An interdepartmental policy addressing this issue would clearly be advantageous to each specialty and the patient.

HOW TO INCORPORATE INTO PRACTICE

Use of bedside ultrasound for the evaluation of first trimester pregnancy is a skill that can grow with the experience and practice of the EP. Obtaining the basic skills necessary to safely and consistently identify a live IUP is an excellent foundation. This skill alone will enable EPs to discharge home more than half the pregnant patients seen in the ED by identification of an IUP. The important caveat is to pay attention to detail. Identification of an IUP means finding a gestational sac within the endometrial echo of the uterus *and* a yolk sac or fetal pole within the gestational sac. A systematic approach should be undertaken each and every time to document the location by ultrasound landmarks (uterus, bladder, and endometrial stripe). With time, the ability to recognize abnormal IUPs and adnexal masses will grow, but the goal of EP-performed first trimester ultrasound should be to identify IUPs and refer all others for consultation and further imaging as necessary per local practice standards.

After years of providing ultrasound education, a pattern of learning is so consistent that it is worth printing to help others forgo the same mistakes. First, there is the "puzzled stage" in which everything looks like shades of gray and seems uninterpretable. The second phase is the "eureka phase" in which things start to make sense. The third phase is the most dangerous—also known as the "who's the man (or woman)!" phase in which overconfidence should be closely monitored and the scope of practice closely followed to prevent mistakes. Finally, in the "safe again" phase, limitations are recognized and confident practice is achieved. To achieve the "safe again" phase, a few tips on scanning practice are helpful. Strive to approach every patient systematically. Attempt to define the boundary of each organ that is being evaluated. Document the landmarks pertinent to each ultrasound image obtained. Discipline yourself to systematically save images that provide a clear "story" that other sonographers can follow and interpret. Always obtain confirmatory studies in cases in which the diagnosis is unclear or the images are inadequate. Finally, develop a quality assurance process to share interesting cases, provide technical and interpretative teaching points, and help avoid common errors.

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