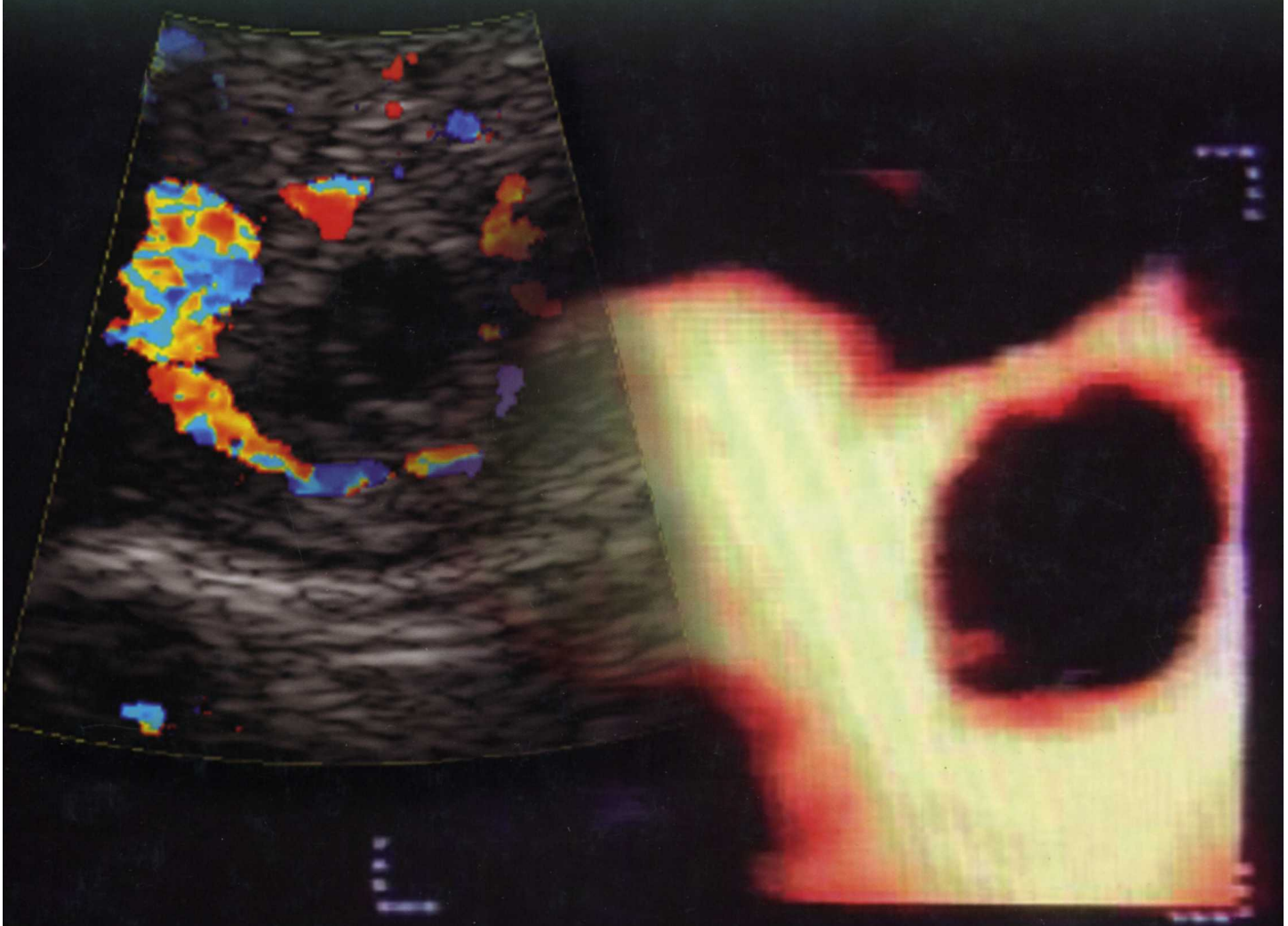
Practical Guide to EMERGENCY ULTRASOUND



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First Trimester Pregnancy

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Introduction

Emergency Department (ED) pelvic ultrasound is an accurate and efficient tool that can facilitate the triage, diagnosis, and management of patients who present to the ED with symptoms or signs related to pregnancy in the first trimester. The primary role of ED ultrasound is to detect ectopic pregnancy in a timely fashion by identifying intrauterine pregnancy (IUP) and thereby excluding ectopic pregnancy in a majority of patients. In addition, emergency physicians can use ultrasound to determine gestational age and establish fetal viability. In the unstable patient, the addition of the Focused Assessment with Sonography for Trauma (FAST) examination for free fluid in the abdomen to the pelvic ED ultrasound can rapidly identify patients requiring emergent surgical intervention for a presumed ectopic pregnancy or other hemorrhagic complication of the first trimester.

The diagnosis of pregnancy can be made at a very early gestational age with remarkable accuracy. The early diagnosis of pregnancy results in an increased ability to recognize complications before they are overtly symptomatic: ectopic pregnancy prior to rupture, an embryonic pregnancy or intrauterine fetal demise before clinical passage of tissue occurs, as well as molar pregnancy and other less common complications of early pregnancy.

Clinical Applications

The primary responsibility of emergency physicians in symptomatic early pregnancy is to recognize ectopic pregnancy before significant morbidity or mortality occurs. History and physical examination are inadequate to this task. Only half of patients with symptomatic ectopic pregnancy have identifiable risk factors, such as a previous ectopic pregnancy, use of an intrauterine device, history of pelvic inflammatory disease, tubal ligation, in vitro fertilization, or infertility (1). The history in early ectopic pregnancy is neither sensitive nor specific. Patients with ectopic pregnancy can initially be pain-free or have midline crampy abdominal pain. They may have passed "tissue"; some even present without a missed menses. Physical examination findings of tenderness, masses, or peritoneal irritation increase the risk of an ectopic pregnancy, but are likewise inadequate to discriminate patients who can be excluded from consideration of an ectopic pregnancy (2). Furthermore even

patients with hemoperitoneum from a ruptured ectopic pregnancy may demonstrate a relative bradycardia, and correlation of vital signs with volume of hemoperitoneum is poor (3). Other ancillary studies are also inaccurate: serum β-hCG levels and progesterone can be helpful over time, or in differentiating a healthy pregnancy from an unhealthy one, but not in locating the pregnancy. Early pregnancy hormonal levels are also frequently in the nondiagnostic range. Ultrasound is the most efficient means of identifying an early IUP and virtually excludes an ectopic pregnancy in the majority of cases (4–6). Pelvic ultrasound markedly decreases the number of patients left with an indeterminate location and viability of pregnancy who must receive close follow-up to make a definitive diagnosis. In a series of 481 consecutive symptomatic ED patients in the first trimester, Kaplan et al showed that transvaginal ultrasound was diagnostic (IUP or ectopic) in 75% of women (4). In other ED studies, 70% of symptomatic first trimester patients were diagnosed with an IUP by pelvic sonography performed by trained ED physicians (7,8).

Secondary roles for early pregnancy pelvic ED ultrasound are diagnosing pregnancy and determining the gestational age and viability of an IUP. A rapid screen during trauma evaluation may detect a new pregnancy and protect against avoidable teratogenic interventions. Early recognition of IUP loss is often not medically necessary. It is still important for patient care to advise a woman of an accurate gestational age when possible, to reassure her of the health of the pregnancy at the time of evaluation, or to prepare her for the high likelihood that the pregnancy is not normal. In addition, urgency and other aspects of follow-up care are clearer when a viable or a nonviable IUP can be suspected based on bedside ultrasound results.

ED ultrasound is well-established as easily repeatable, safe, and nonirradiating for both the mother and the embryo, and it can be accomplished at the bedside rapidly. The emergency physician both performs and interprets the exam, guided by the clinical question, "Is there an IUP present?" Transabdominal ultrasound (Fig. 6.1) successfully identifies IUPs in a majority of women with gestations over 7 to 8 weeks. Transvaginal ultrasound allows definitive diagnosis of a significantly greater number of women, especially in the 5-to-6–week gestational age time period when the risk of ectopic pregnancy is particularly great.

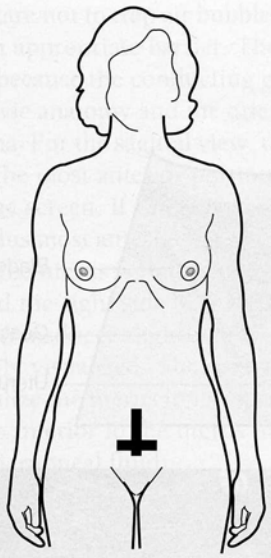
Image Acquisition

Transabdominal Image of the Normal Pregnant Uterus (Figs. 6.1–6.3)

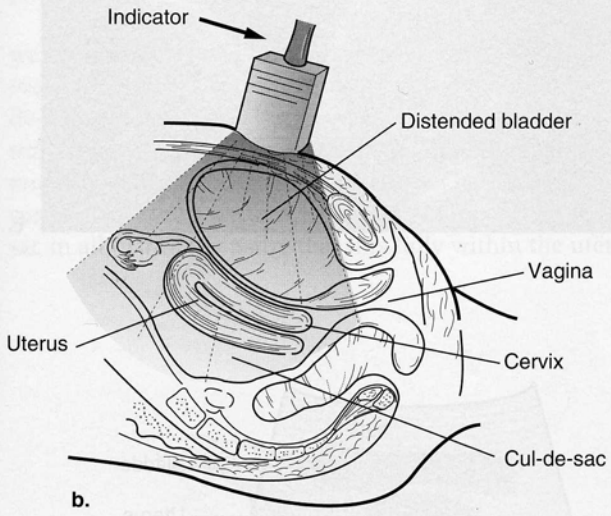
The transabdominal view of the uterus is seen best when the bladder is full and can act as an acoustic window. The full bladder also displaces loops of bowel that scatter ultrasound waves. The uterus should be visualized in the both the sagittal and transverse views.

For the sagittal view of the uterus, a standard curvilinear 3–5 MHz transducer is placed in the midline of the abdomen just above the symphysis pubis (Fig. 6.2). The transducer is held such that the most cephalad point of the transducer (often designated by a marker) is oriented to the left side of the ultrasound screen. This is standard sagittal orientation, which places the most cephalad portion of the image at the left side of the screen. It is important to sweep the transducer cephalad and caudad, as well as from left to right such that the entire uterus and retro-uterine space (the cul-de-sac) is seen. If the uterus is anteverted, the uterus will be seen just left of the anechoic, urine-filled bladder. The bowel contents are seen on the far field (bottom) of the screen.

To visualize the uterus in the transverse plane, the transducer is rotated 90 degrees in the counterclockwise position, which orients the right side of the patient to the left of the screen in the standard convention (Fig. 6.3). As in the longitudinal view, the sonographer should sweep the transducer to both sides to ensure that the entire uterus is visualized.



a.



b.

Figure 6.1. Transabdominal Scan.

- Place the transducer in the midline just above the pubis (A).
- Place the transducer indicator to project the patient's head to the left of the screen to obtain a sagittal view.
- Rotate the transducer 90° counterclockwise to obtain a transverse view.
- In each view, gently rock the transducer to obtain a 3-dimensional view of the uterus and adnexa.
- When possible, scan with a distended bladder to optimize the acoustic window to the pelvis (B).
- The internal landmarks of the transabdominal scan are visualized in B.

(B is redrawn from Simon and Snoey, eds. *Ultrasound in Emergency and Ambulatory Medicine*. St. Louis, MO: Mosby–Year Book, 1997.)

Transvaginal Image of the Normal Pregnant Uterus (Figs. 6.4–6.6)

The transvaginal ultrasound approach to the uterus capitalizes on the shortened distance from the uterus to the transducer, and therefore allows a higher frequency transducer to produce images of improved resolution. However because of the proximity, it is also common to overshoot the target of interest and miss the uterus altogether, imaging only bowel. It is best to ask the patient to empty her bladder, since a large bladder will occupy most of the scan field and make it difficult to visualize the uterus. A small amount of urine in the bladder helps to orient the sonographer.

The examiner should explain this procedure to the patient, obtain the patient's verbal consent, and discuss that this procedure is similar to the gynecologic pelvic examination. In order to prepare the endovaginal transducer, ultrasound gel is applied directly to the transducer and a cover is placed over the transducer to serve as a barrier to infectious dis-

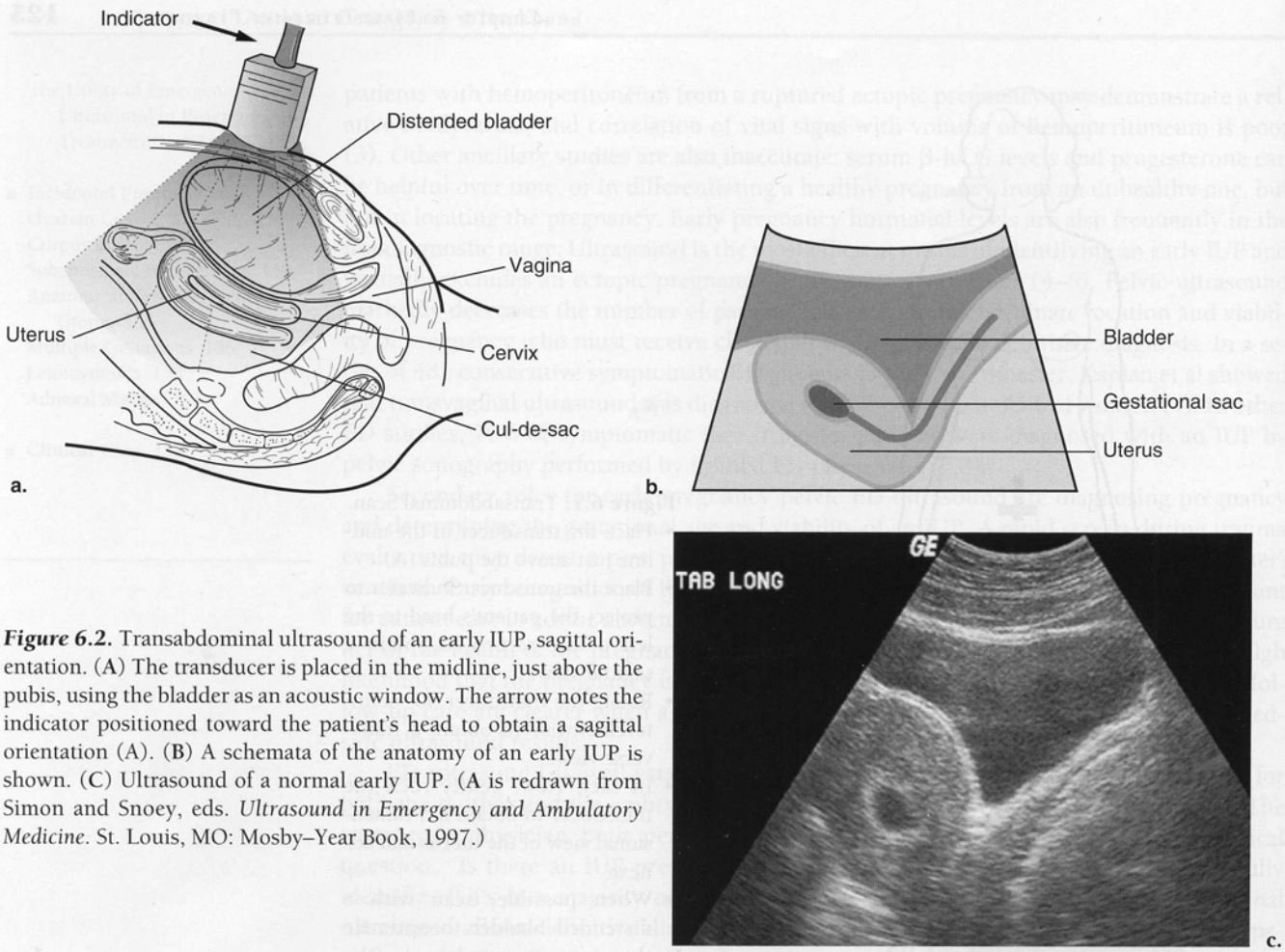


Figure 6.2. Transabdominal ultrasound of an early IUP, sagittal orientation. (**A**) The transducer is placed in the midline, just above the pubis, using the bladder as an acoustic window. The arrow notes the indicator positioned toward the patient's head to obtain a sagittal orientation (A). (**B**) A schemata of the anatomy of an early IUP is shown. (**C**) Ultrasound of a normal early IUP. (**A** is redrawn from Simon and Snoey, eds. *Ultrasound in Emergency and Ambulatory Medicine*. St. Louis, MO: Mosby–Year Book, 1997.)

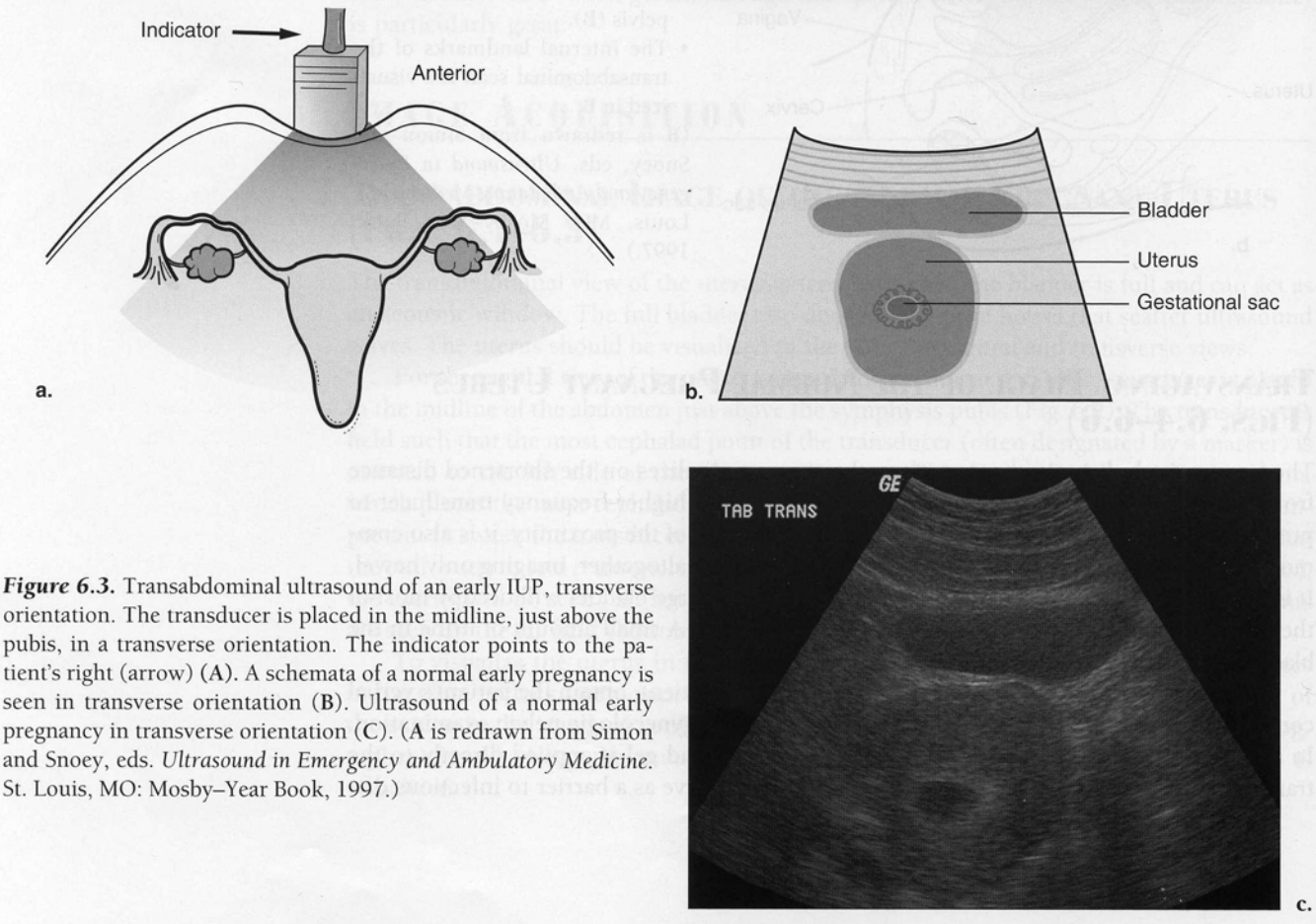


Figure 6.3. Transabdominal ultrasound of an early IUP, transverse orientation. The transducer is placed in the midline, just above the pubis, in a transverse orientation. The indicator points to the patient's right (arrow) (**A**). A schemata of a normal early pregnancy is seen in transverse orientation (**B**). Ultrasound of a normal early pregnancy in transverse orientation (**C**). (**A** is redrawn from Simon and Snoey, eds. *Ultrasound in Emergency and Ambulatory Medicine*. St. Louis, MO: Mosby–Year Book, 1997.)

ease, taking care not to trap air bubbles. A specifically manufactured sheath or condom can be used as an appropriate barrier. Then a water-based lubricant should be applied on top of the cover because the conducting gel can be a vaginal irritant. It is important to understand the pelvic anatomy and the orientation of the endovaginal transducer before placing it in the vagina. For the sagittal view, the superior aspect of the endovaginal transducer corresponds to the most anterior portion of the vaginal vault and projects the bladder on the left side of the screen. If the uterus is anteverted, it will appear as an elongated structure with the fundus most anterior or, by convention, pointing toward the left side of the screen (Fig. 6.5). If the uterus is retroverted, the fundus is directed posteriorly or, by convention, points toward the right side of the screen (Fig. 6.7). The sonographer may need to rotate or move the transducer slightly until the midline of the uterus, noted by the endometrial stripe, is easily visualized. The sonographer then sweeps the transducer laterally to both sides to visualize the uterus in its entirety, because it is often deviated to one side. The cul-de-sac is seen inferior to the uterus in the far field, and it should be assessed for the presence of free peritoneal fluid.

Once the uterus is seen in its long axis, the transducer is rotated 90 degrees to the left (counterclockwise), in order to obtain the coronal view, or short-axis (Fig. 6.6). Although this rotation produces a coronal view through the patient, the image appears as a transverse section through the uterus because the uterus is perpendicular to the transducer. It is not possible to obtain a true transverse image of the uterus because the transducer cannot be placed beside the uterus.

Once the sagittal and coronal planes are identified the transducer is swept laterally, as well as anteriorly and posteriorly, such that the entire uterus and surrounding areas are visualized in all planes, to ensure that the boundaries of the uterus are identified. The cul-de-sac is seen inferior to the uterus, or in the far field, in all images. It is important to determine if there is free fluid present in the cul-de-sac, taking care not to confuse fluid in the rectal lumen with free peritoneal fluid. The endometrial stripe should be identified and visualized in its entirety. At least 5 mm of myometrial mantle should surround a gestational sac in all planes to ensure that it is fully within the uterus.

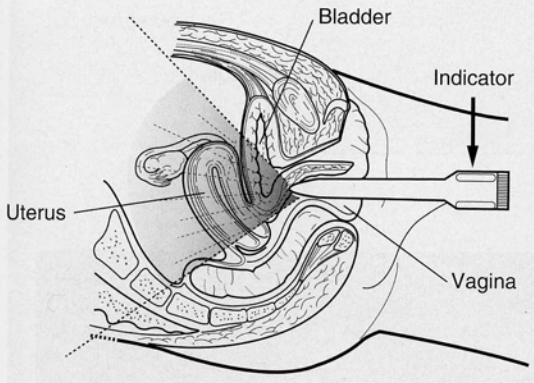


Figure 6.4. The Transvaginal Scan.

- Begin in the sagittal plane with the transducer indicator pointed up (see arrow).
- Advance only as far as necessary to visualize the uterus.
- Find the endometrial stripe to identify the midline of the uterus.
- Rotate the transducer 90° counterclockwise (indicator pointing toward the patient's right side) to obtain a coronal view.
- In each orientation, gently rock the transducer in all planes to obtain a 3-dimensional view of the uterus and adnexa.

(Redrawn from Simon and Snoey, eds. *Ultrasound in Emergency and Ambulatory Medicine*. St. Louis, MO: Mosby–Year Book, 1997.)

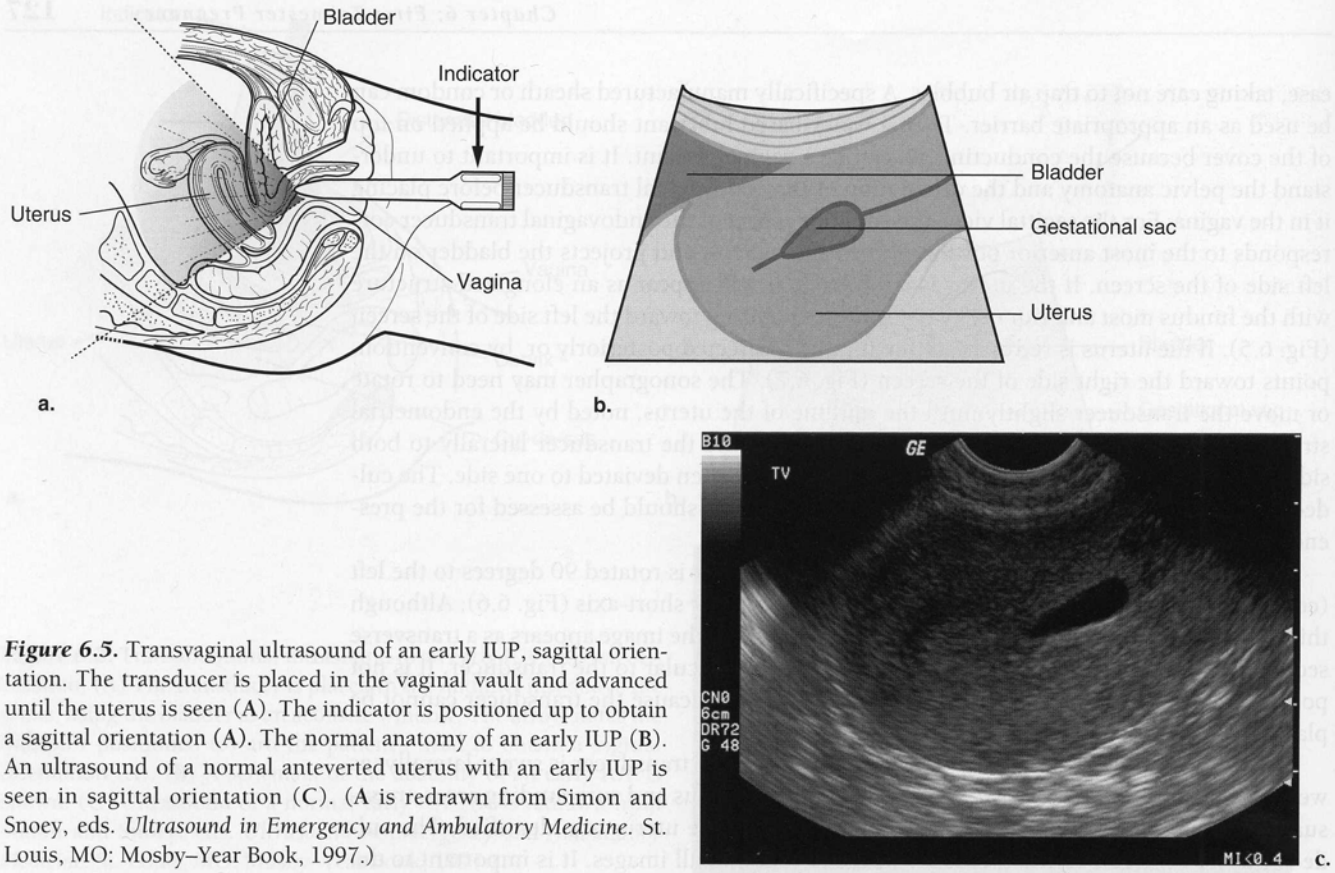


Figure 6.5. Transvaginal ultrasound of an early IUP, sagittal orientation. The transducer is placed in the vaginal vault and advanced until the uterus is seen (**A**). The indicator is positioned up to obtain a sagittal orientation (**A**). The normal anatomy of an early IUP (**B**). An ultrasound of a normal anteverted uterus with an early IUP is seen in sagittal orientation (**C**). (**A** is redrawn from Simon and Snoey, eds. *Ultrasound in Emergency and Ambulatory Medicine*. St. Louis, MO: Mosby–Year Book, 1997.)

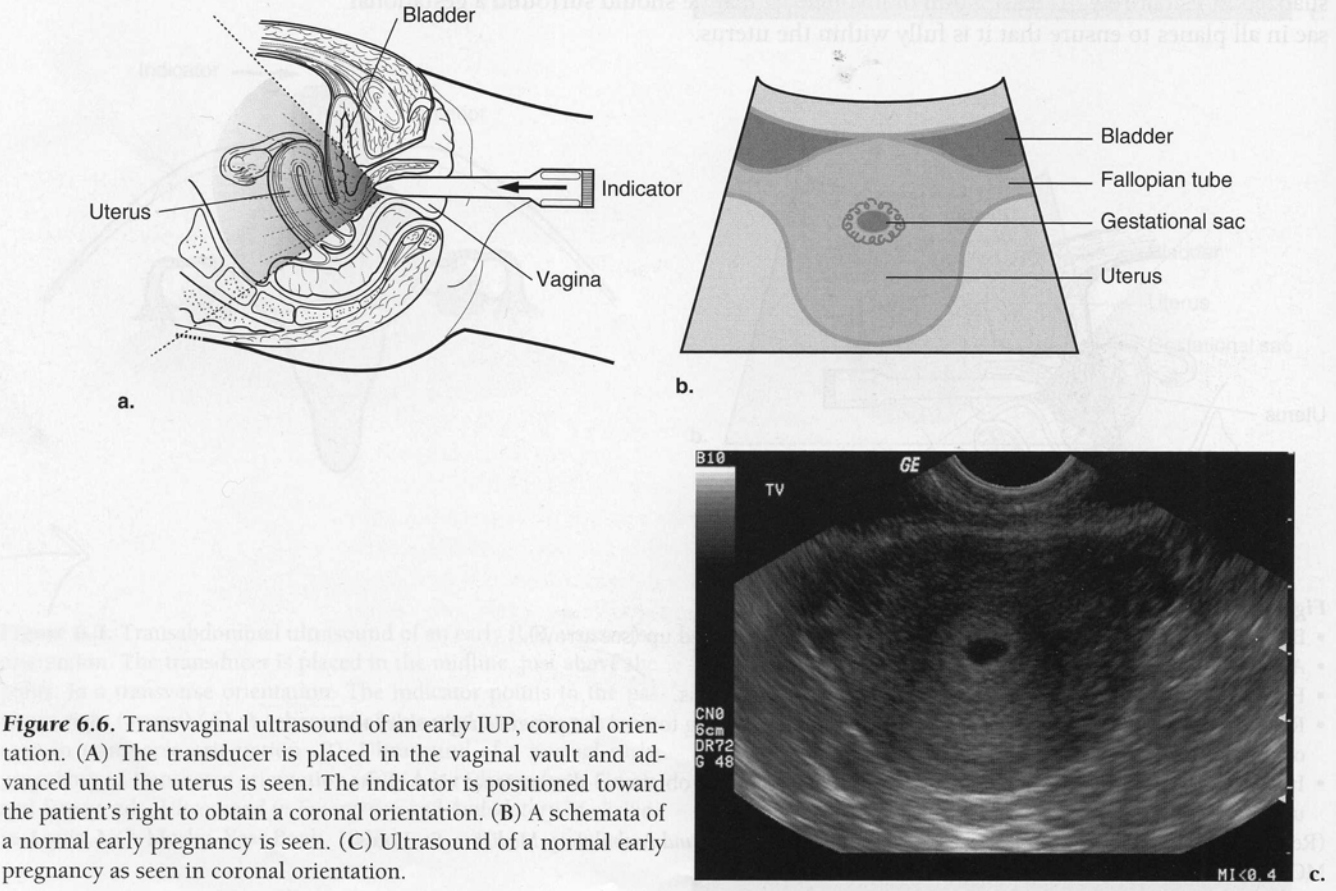


Figure 6.6. Transvaginal ultrasound of an early IUP, coronal orientation. (**A**) The transducer is placed in the vaginal vault and advanced until the uterus is seen. The indicator is positioned toward the patient's right to obtain a coronal orientation. (**B**) A schemata of a normal early pregnancy is seen. (**C**) Ultrasound of a normal early pregnancy as seen in coronal orientation.

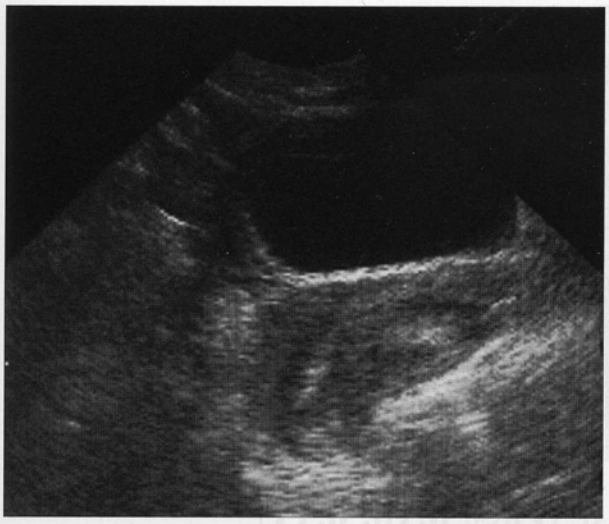


Figure 6.7. Retroverted Uterus. Image courtesy of Mark Deutchman, MD.

Visualization of Ovaries

The ovaries are not the primary focus of emergency ultrasound. However, with experience most sonographers will become competent in visualizing the ovaries and benefit from the information they provide. The ovaries are ovoid structures that have the gray echotexture characteristic of soft tissue punctuated by smooth-walled anechoic cystic structures along their periphery (follicles). The ovaries are lateral to the uterus and usually lie anterior to the internal iliac veins and medial to external iliac vessels (Figs. 6.8, 6.9). If the uterus is retroverted the ovaries may lie more anteriorly.

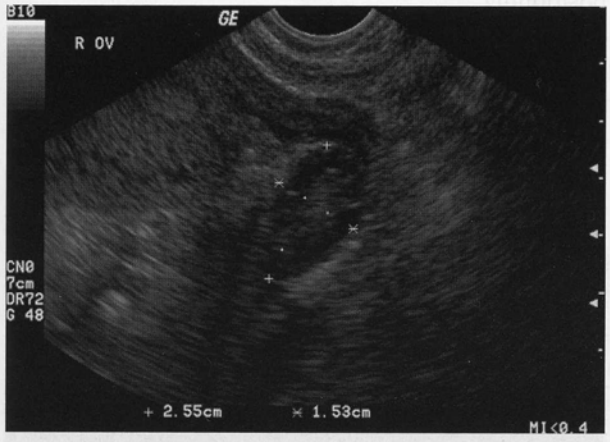


Figure 6.8. Normal Ovary.

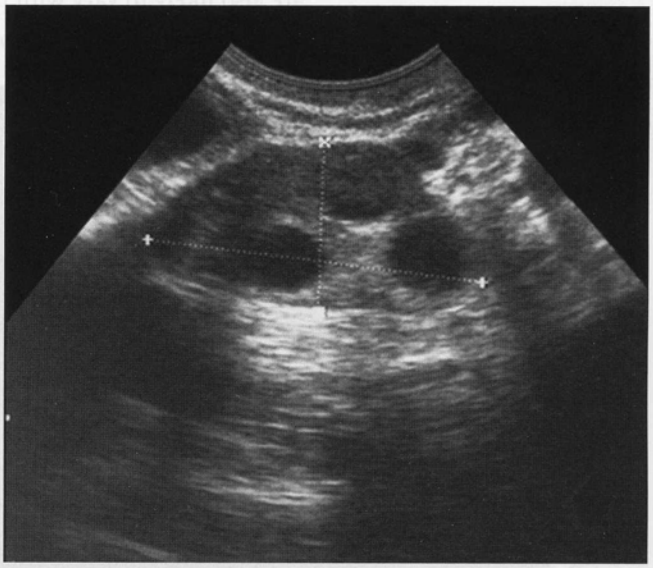


Figure 6.9. Normal Ovary. Reprinted from Kendall JL, Deutchman M. *Ultrasound in Emergency Medicine and Trauma.* Nashville: Healthstream Inc. 2001, with permission.

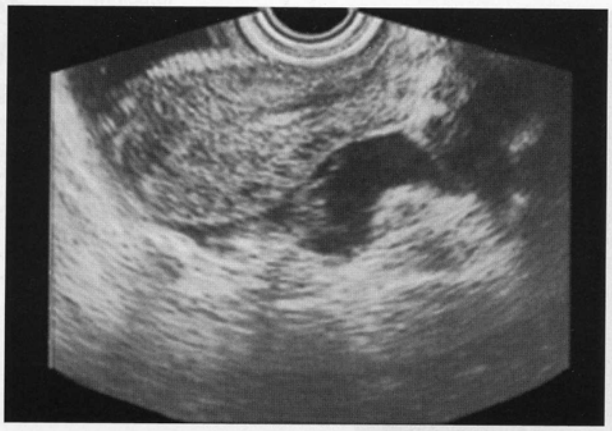


Figure 6.10. Free fluid along the posterior wall of the uterus. Reprinted from Kendall JL, Deutchman M. *Ultrasound in Emergency Medicine and Trauma.* Nashville: Healthstream Inc. 2001, with permission.

Fluid in the Cul-de-sac (Figs. 6.10, 6.11)

A small amount of anechoic (black) or hypoechoic free fluid may be present normally in the pelvis and is more likely to be detected by transvaginal scans than transabdominal. There is no consistent, standardized method for grading the amount of fluid in the cul-de-sac; however, there are generally accepted guidelines. According to conventions established by Dart et al., the amount of fluid is considered "small" if it tracks less than a third of the way up the posterior wall of the uterus. Free fluid is considered "moderate" if it tracks two-thirds up the posterior wall of the uterus but is not free-flowing in the peritoneum. The amount of fluid is considered "large" if it tracks beyond two-thirds of the posterior uterine wall, or if it is free–flowing in the peritoneum or seen in Morison's pouch or the splenic recess (9). In one study, 43 of 68 patients diagnosed with ectopic pregnancy had free intraperitoneal fluid seen by ultrasound in amounts ranging from small (23 patients) or moderate (16 patients) to large (4 patients). However, 30% of nonectopics also had visible free fluid, making this neither a sensitive nor specific sign. Most (88%) ectopic pregnancies with cul-de-sac fluid had echoes within the fluid typical of blood and clot; this additional finding should raise the suspicion of ectopic pregnancy (10). Fluid collections are also likely to vary with patient positioning.

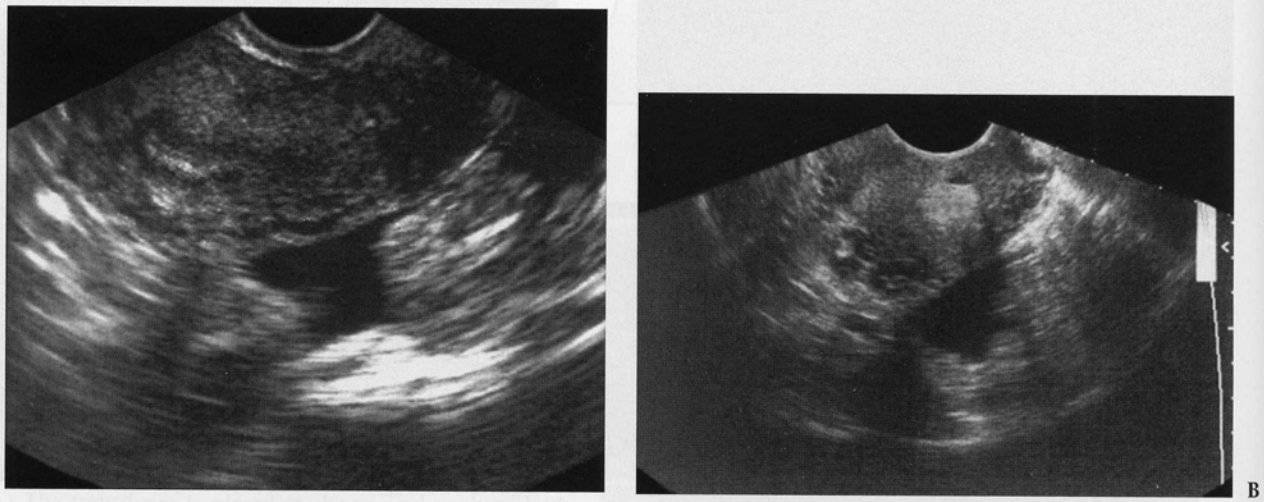


Figure 6.11. Free fluid tracking along the posterior wall of the uterus (A). Fluid seen in the posterior cul-de-sac in a transverse view of the uterus (B). Reprinted from Kendall JL, Deutchman M. *Ultrasound in Emergency Medicine and Trauma.* Nashville: Healthstream Inc. 2001, with permission.

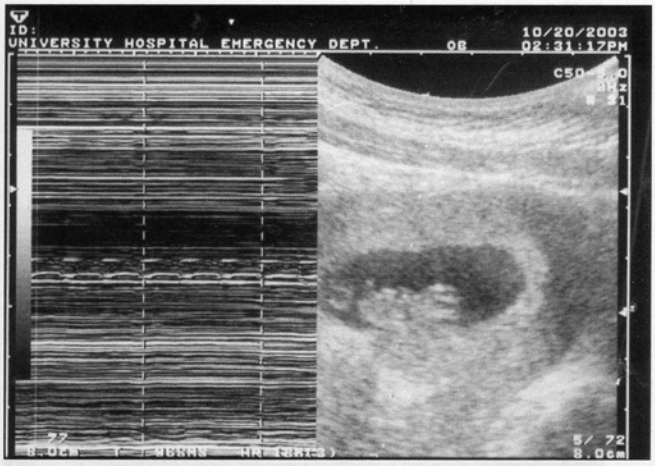


Figure 6.12. M-Mode demonstrates fetal heart activity.

Recognition of Embryonic Heart Rate Using M-mode

If an IUP is visualized, cardiac activity can be documented by using M (motion)-mode imaging (Fig. 6.12). It is necessary to become familiar with the specifics of each ultrasound manufacturer's M-mode function. However, the basic principle is that an M-mode beam is placed through the moving heart, and documents the motion waveform over time. A software calculation will then determine the heart rate and record this on the image. Color Doppler or pulse-wave Doppler techniques of measuring cardiac activity should not be used, because potential adverse effects on the fetus have not been ruled out (11).

Sonographic Findings in Normal First Trimester Pregnancy

Both recognition of the possibility of an ectopic pregnancy and assessment of intrauterine gestational age and viability require an understanding of the ultrasound anatomy and landmarks of normal early pregnancy. A timeline of pertinent landmarks of early pregnancy is depicted in Figure 6.13 (Timeline) and Table 6.1.

Table 6.1: Sonographic Landmarks of Normal Pregnancy

TVS (TAS)			
GA (in weeks)	*US Finding*	*MSD (mm)*	*Embryo/CRL (mm)*
5 (5)	Gestational Sac	5 (5)	—
5.5 (7)	Yolk Sac	8 (20)	—
6 (8)	Cardiac Activity/Embryo	16 (25)	5* (9)

TVS = transvaginal sonography
TAS = transabdominal sonography
MSD = mean sac diameter
CRL = crown rump length
GA = gestational age
Adapted from: Laing FC, Frates MC. "Ultrasound Evaluation During the First Trimester." In: Callen PW, ed. *Ultrasonography in Obstetrics and Gynecology,* 4th ed. Philadelphia: WB Saunders Co, 2000:124.

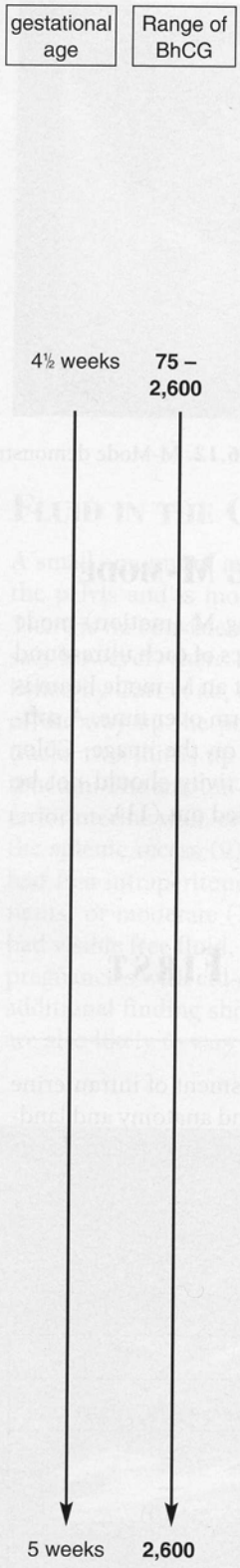
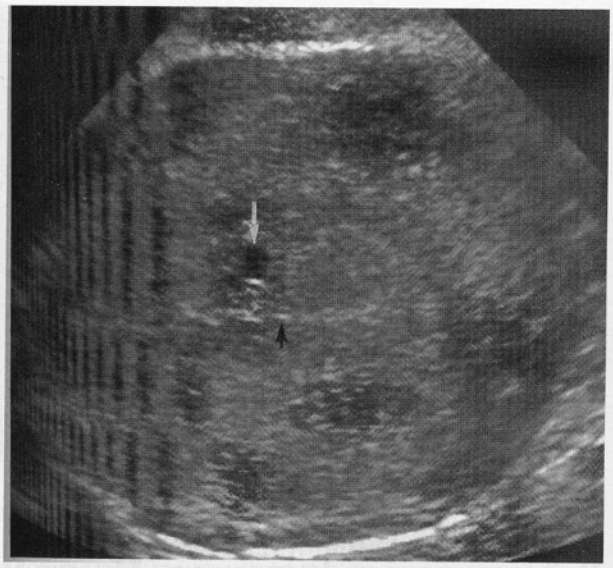
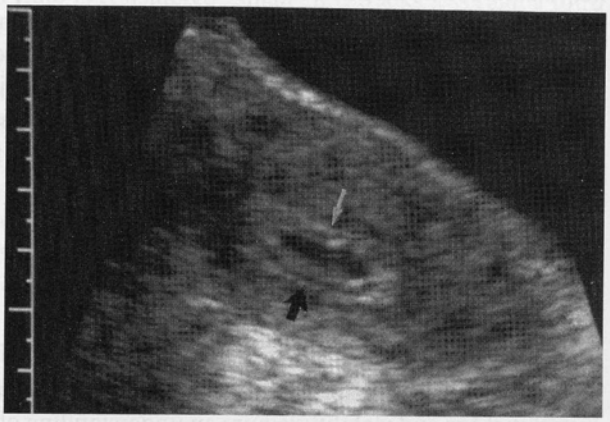


Figure 6.13. Timeline of Normal Pregnancy. Sonographic findings and corresponding range of β-hCG levels are shown.



a. Intradecidual Sign. Reprinted from Brant WE. Ultrasound. The Core Curriculum. Philadelphia: Lippincott Williams & Wilkins 2001:231, with permission.



b. Double Decidual Sign. Reprinted from Brant WE. Ultrasound. The Core Curriculum. Philadelphia: Lippincott Williams & Wilkins 2001:235, with permission

c. Early gestational sac, 5 weeks gestational age, transvaginal scan, sagittal and coronal views.

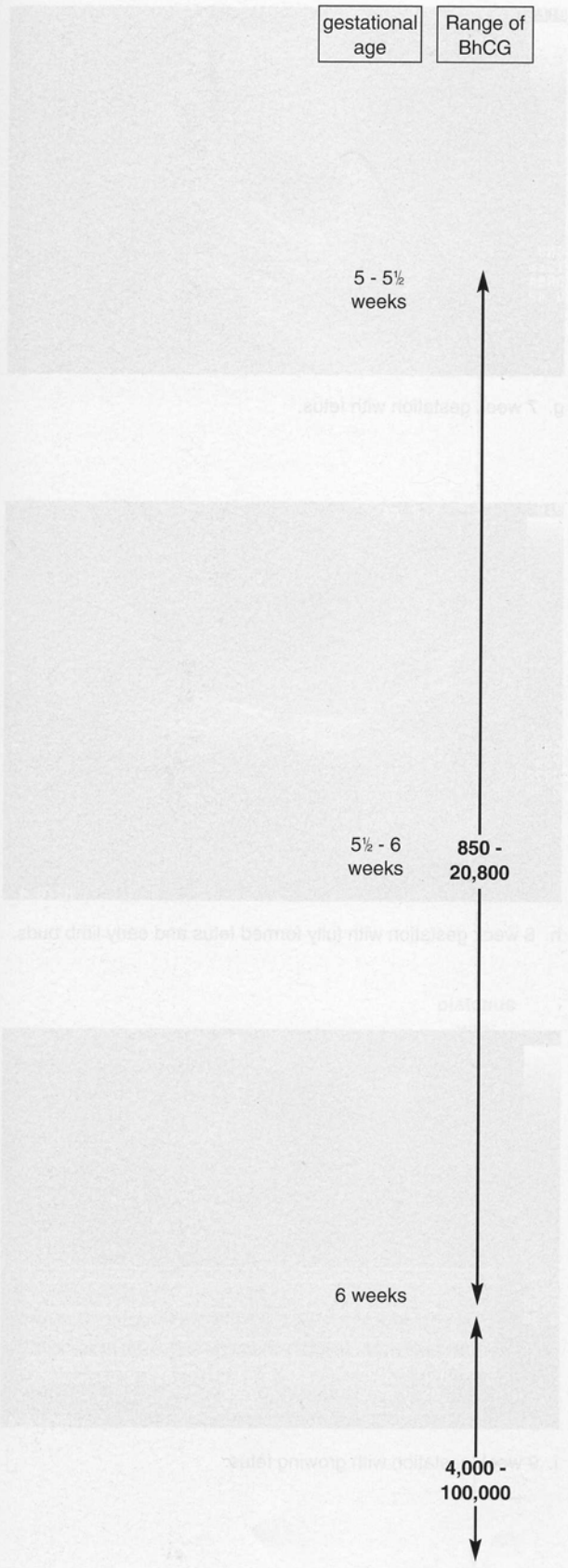
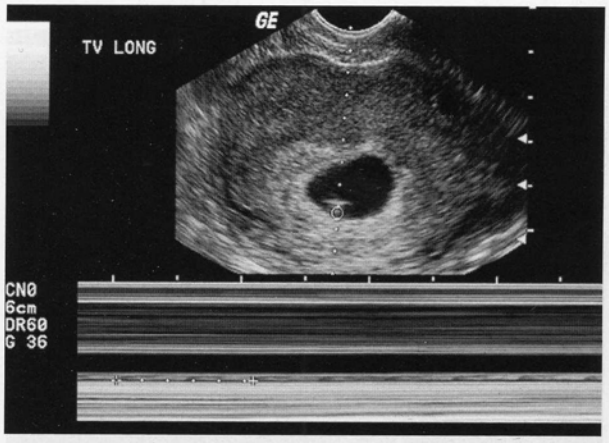


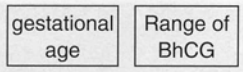
Figure 6.13. *(continued)* Timeline of Normal Pregnancy, 5–6 weeks.

d. 5½ week gestation with yolk sac.



e. 5½ week gestation with embryonic plate. Fetal heart activity is seen in M-mode.

f. 5.5 - 6 week gestation with yolk sac and fetal pole.



4,000 - 100,000

7 weeks

plateaus vary

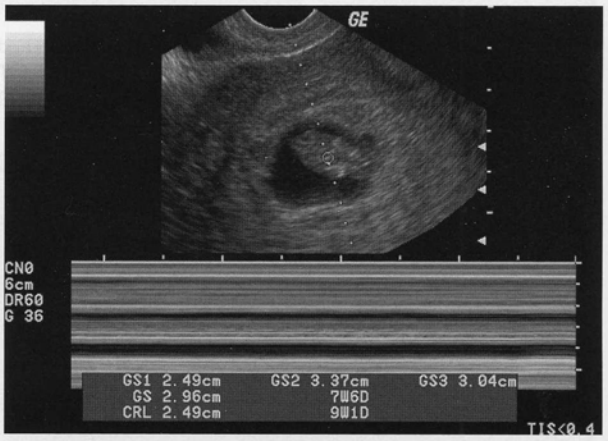
8 weeks

9 weeks

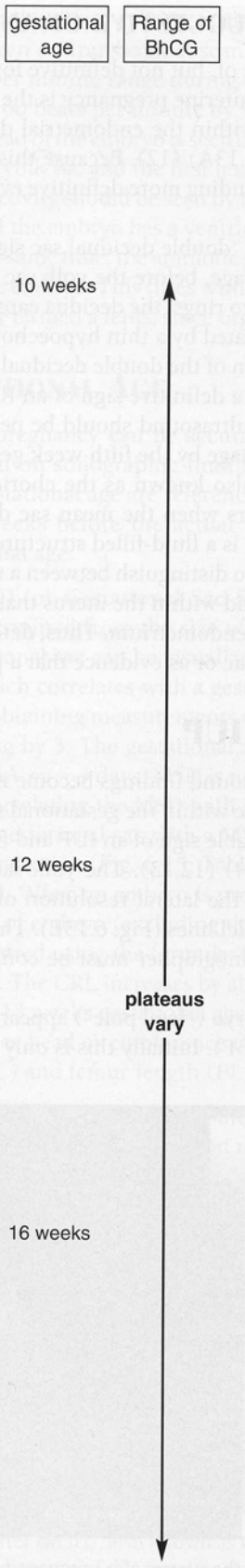
Figure 6.13. *(continued)* Timeline of Normal Pregnancy, 7–9 weeks.

g. 7 week gestation with fetus.

h. 8 week gestation with fully formed fetus and early limb buds.

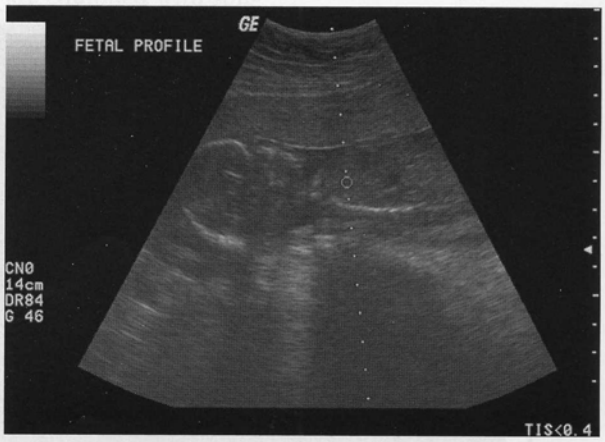


i. 9 week gestation with growing fetus.



j. 10 week gestation.

k. 12 week gestation.



l. 16 week gestation.

Figure 6.13. *(continued)* Timeline of Normal Pregnancy, 10–16 weeks.

Ultrasound Findings Suggestive of an Early IUP

A number of findings are suggestive of, but not definitive for, intrauterine pregnancy. The earliest sonographic sign of an intrauterine pregnancy is the "intradecidual sign," which is an embryo completely embedded within the endometrial decidua, but that does not displace the endometrial stripe (Fig. 6.13A) (12). Because this is technically difficult to recognize, clinicians must depend on finding more definitive evidence of an IUP and the value of this finding is limited clinically.

It is somewhat easier to see the "double decidual sac sign" by transvaginal ultrasound between 5 and 6 weeks gestational age, before the yolk sac can be seen (Fig. 6.13B). The double decidual sac sign refers to two rings: the decidua capsularis (the inner ring) and the decidua vera (the outer ring), separated by a thin hypoechoic layer, all of which surround the gestational sac. Misinterpretation of the double decidual sac sign is common, however, and this should also not be used as a definitive sign of an IUP. When the double decidual sac sign is suspected, transvaginal ultrasound should be performed, because transvaginal imaging offers a more diagnostic image by the fifth week gestation (12,13).

At 5 weeks a gestational sac, also known as the chorionic sac, can be visualized by transvaginal ultrasound. This occurs when the mean sac diameter is 5 mm (Fig. 6.13C, Table 6.1) (13). The gestational sac is a fluid-filled structure that appears "empty." At this stage of development, it is difficult to distinguish between a true gestational sac and a pseudogestational sac, a collection of fluid within the uterus that occurs in ectopic pregnancies due to hormonal stimulation of the endometrium. Thus, detecting a fluid collection should not be interpreted as a gestational sac or as evidence that a pregnancy is intrauterine.

Definitive Findings of IUP

As the pregnancy progresses, ultrasound findings become more definitive. Between 5 and 6 weeks the yolk sac becomes visible within the gestational sac by transvaginal ultrasound; this is considered to be the first reliable sign of an IUP and may be difficult to see on transabdominal scans (Figs. 6.13D, 6.14) (12,13). The yolk sac is a highly echogenic round structure. However, depending on the lateral resolution of the ultrasound transducer, it may initially appear as a set of parallel lines (Fig. 6.13E). These may be very faint and challenging to demonstrate, and the sonographer must be confident of the finding to definitively diagnose IUP at this stage.

Between 5 and 6 weeks an embryo ("fetal pole") appears by transvaginal ultrasound at the border of the yolk sac (Fig. 6.13F). Initially this is only 2 to 3 mm and can be difficult

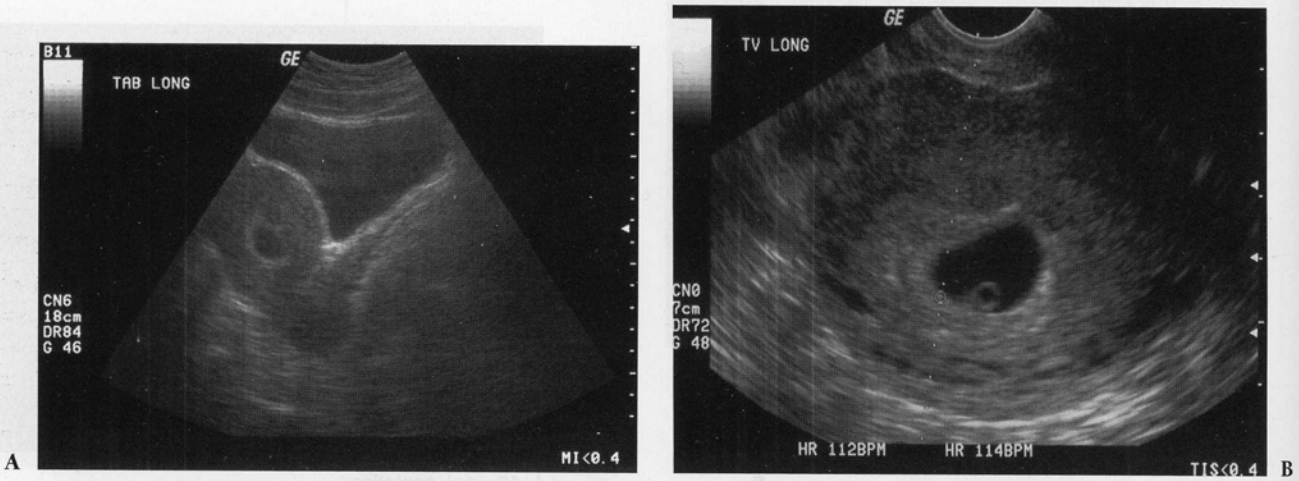


Figure 6.14. Transabdominal view of the uterus of a pregnant patient shows an empty gestational sac that is insufficient to establish an IUP (and exclude ectopic) (**A**). In the same patient, a transvaginal scan demonstrates a gestational sac with a yolk sac, establishing an IUP (**B**).

to visualize. At 6 weeks the embryo is a definite structure that can be measured. In addition, cardiac activity can be seen on transvaginal scans. Normal embryonic heart rate may be as low as 70 to 100 beats per minute range during early gestation, but soon rises to the fetal normal range of 120 to 160 beats per minute by 9 to 10 weeks gestational age (14).

At 7 weeks gestation the head of the embryo is seen on transvaginal scanning (Fig. 6.13G). This is also the time when the yolk sac and the first fetal heart tones can be seen by transabdominal ultrasound. Cardiac activity should be seen by the time the embryo is 5 mm in length (11). After 8 weeks the head of the embryo has a ventricle visible by transvaginal scans, seen as an anechoic structure. At the same time, the amniotic sac can begin to be visualized as a thin echogenic line surrounding the embryo. This fuses with the chorion after 14 weeks gestation. At 10 weeks the embryo is now termed a fetus, since organogenesis is complete.

Determining Gestational Age

The gestational age in early pregnancy can be accurately determined from a number of different measurements, based on sonographic findings at different stages of pregnancy. Standard measurements of gestational age are referenced from the onset of the last normal menstrual period, about 2 weeks before the actual time of conception. The following measurements define gestational age.

1. Mean Sac Diameter (MSD), or Gestational Sac Size (GSS). In early pregnancy the gestational age can be determined from the size of the gestational sac using the MSD. The earliest that the gestational sac can be visualized by transvaginal ultrasound is at a diameter of 2 to 3 mm, which correlates with a gestational age between 4 and 5 weeks. MSD can be calculated by obtaining measurements of the diameter of the gestational sac in three planes and dividing by 3. The gestational age (GA) is calculated from the formula: MSD *(mm)* + 30 = GA +/− 4 days. MSD is normally 5 mm at 5 weeks gestational age. Charts are available correlating the MSD with gestational age (12, 13). An embryo should be visible within a gestational sac with a MSD of 16 mm by transvaginal scans, or 25 mm by transabdominal scans (Fig. 6.15, Table 6.1).
2. Crown Rump Length (CRL). When an embryo is present, the CRL can be measured with calipers defining the length of embryo (excluding the legs and yolk sac) (Fig. 6.16). The gestational age can be measured using the formula: CRL *(in cms)* + 42 = GA (days) between 6 and 9.5 weeks (12). The CRL increases by about 1 mm per day, as does the MSD.
3. Once the fetus has reached 13 weeks gestational age, other methods of determining gestational age are used, such as head circumference (HC), biparietal diameter (BPD), abdominal circumference (AC) and femur length (FL) (Fig. 6.17) (12).

While these guidelines are useful, most ultrasound machines are equipped with software to provide estimates of gestational age based on these measurements.

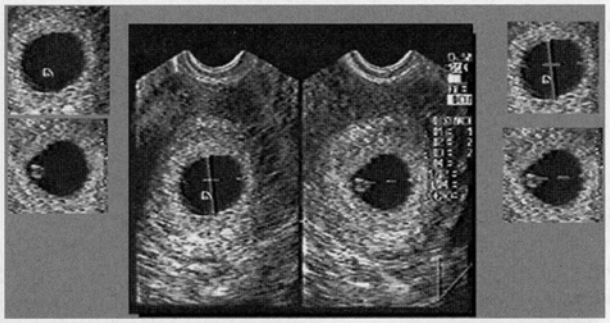


Figure 6.15. The Mean Sac Diameter (MSD), also known as Gestational Sac Size (GSS). Obtained by taking three measurements of the diameter of the gestational sac in three dimensions, as shown here. Reprinted from Kendall JL, Deutchman M. *Ultrasound in Emergency Medicine and Trauma.* Nashville: Healthstream Inc. 2001, with permission.

Figure 6.16. A crown rump length measurement of an 8-week–3-day-old fetus.

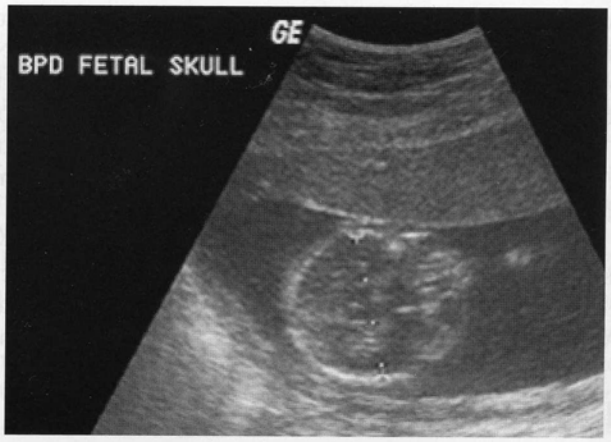


Figure 6.17. Gestational age determined by biparietal diameter (BPD).

PATHOLOGY

ABNORMAL PREGNANCY

If pregnancy does not proceed according to the guidelines in Table 6.1, the pregnancy is probably abnormal. In several series of patients presenting to EDs in the first trimester with vaginal bleeding or pain, only about half of women have normal pregnancies, and 7 to 13% have ectopic pregnancies (4,15,16). Definitive diagnosis of early pregnancy failure usually requires serial examinations or a follow-up consultative ultrasound. Normal pregnancy parameters are shown in Table 6.1, and criteria suggestive for early pregnancy failure are listed in Table 6.2. It is important to remember that either an intra- or extrauterine pregnancy problem may exist if ultrasound findings do not correlate with β-hCG levels described in the timeline of Figure 6.13 and Table 6.1. In addition, women with multiple gestations have elevated β-hCG levels for a given gestational age, and therefore the embryos may not be visible by singleton β-hCG landmarks. Likewise infertility patients with multiple gestations may have an ectopic pregnancy in addition to an IUP (heterotopic pregnancy) and can present a special diagnostic challenge.

SPONTANEOUS ABORTION

Spontaneous abortion occurs in about 20 to 25% of chemically diagnosed pregnancies. About 80% of early fetal loss occurs in the first trimester. Intrauterine fetal loss occurs at several stages. Anembryonic gestation, (blighted ovum or unsuccessful development), in which the embryo never develops within the gestational sac, is defined as the absence of an embryo when the mean gestational sac diameter is 25 mm or more (Fig. 6.18, Table 6.2) (17,18). Abnormal embryonic growth (embryonic demise or failed pregnancy) is in-

Table 6.2: Sonographic Suspicion for Abnormal Pregnancy

No gestational sac at a β-hCG of 3000 mIU/ml or ≥ 38 days since onset last menses
Absent embryo with gestational sac of 25 mm mean diameter (by TAS)
Embryo of 5 mm crown rump length with no heartbeat
No fetal heart tones after 10 to 12 weeks gestational age

Adapted from Dart RG. Role of pelvic ultrasound in evaluation of symptomatic first trimester pregnancy. *Ann Emerg Med.* 1999;33:310.

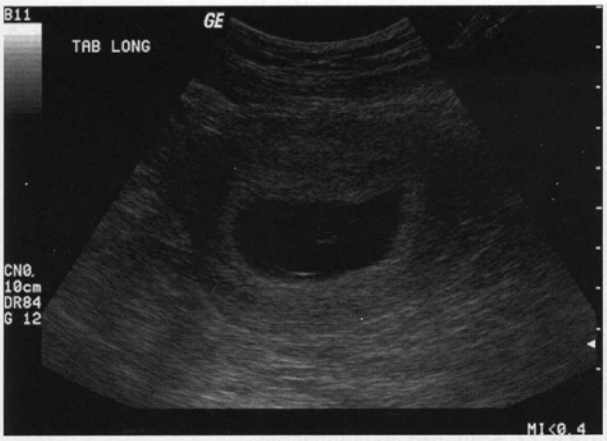


Figure 6.18. Transabdominal scan of a gestational sac without a well-defined fetus, consistent with a blighted ovum.

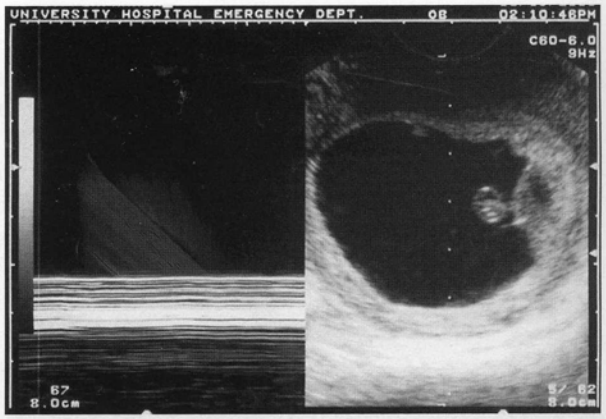
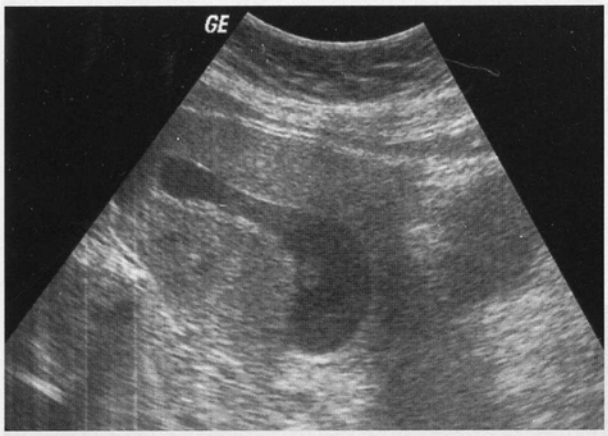


Figure 6.19. Failure of pregnancy to progress and absent fetal heart activity confirm an intrauterine fetal demise.

dicated by the absence of fetal heart activity by transvaginal ultrasound at the normal gestational age of 8 weeks (Fig. 6.19) (7,12). Some intrauterine fetal demise occurs after fetal heart activity develops, secondary to subchorionic hemorrhage, faulty implantation or genetic flaws. Intrauterine fetal demise is often suggested by an abnormal gestational sac (Fig. 6.20). Therefore not only is the gestational sac size not appropriate for dates, but



A

B

C

D

Figure 6.20. Transabdominal (A,B) and Transvaginal (C,D) views show an irregular gestational sac with poorly defined content consistent with an intrauterine fetal demise.

Figure 6.21. Scalloping of the gestational sac in an abnormal pregnancy.

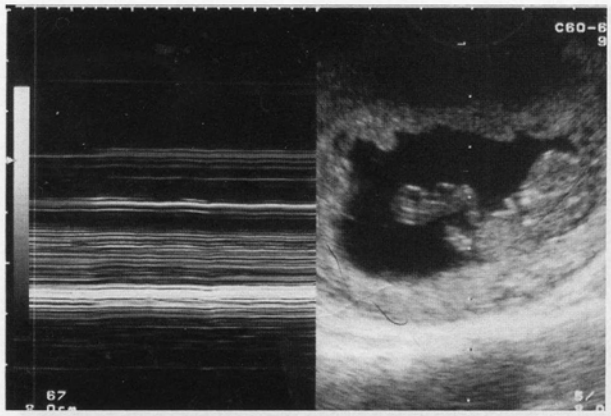
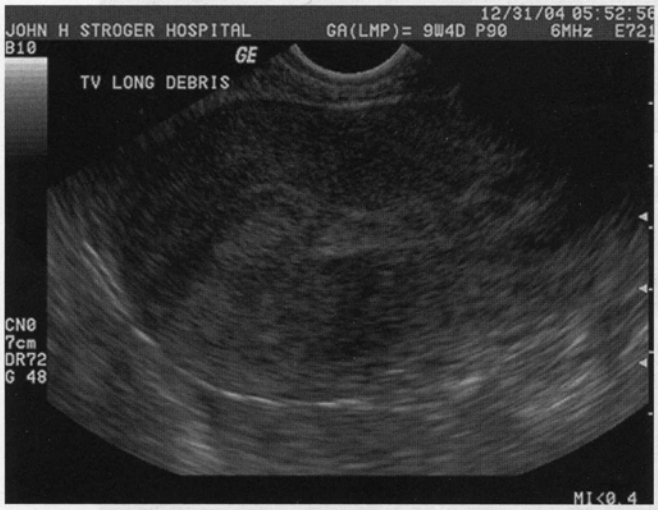
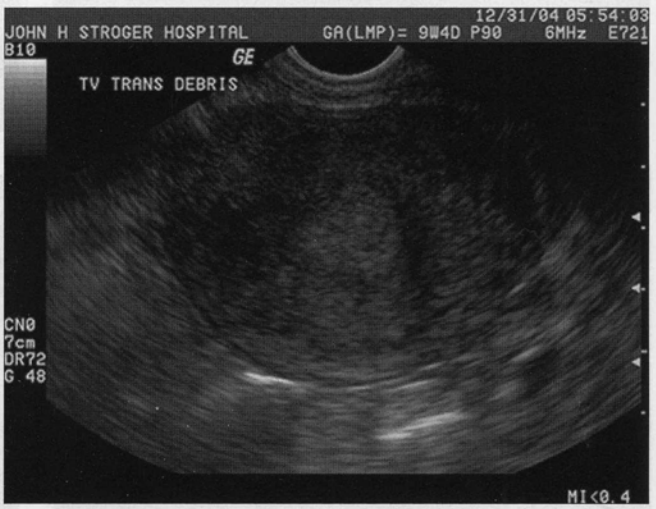


Figure 6.22. Scalloped gestational sac.

the edges are irregular and may be scalloped in appearance (Figs. 6.21, 6.22). Further, a gestational sac positioned near the cervix or low in the uterus is suggestive of demise. Loss of identifiable fetal parts and a thickened, irregular endometrium may reflect debris of a fetal loss (Fig. 6.23). The likelihood of spontaneous loss without symptoms of bleeding or pain has been reported to be only about 5 to 10% after fetal cardiac activity is detected by transabdominal ultrasound (which is almost the same rate as in patients with symptoms). With transvaginal ultrasound the likelihood of pregnancy loss is higher after fetal heart tones are seen, due to the earlier gestational age at which the heartbeat can be detected. While spontaneous abortion rates in younger women (< 36 years) after a heartbeat is identified by transvaginal ultrasound is still in the 5% range, rates of loss after documented fetal heart tones have been reported as high as 30% in patients over 40 years of age (11).



A



B

Figure 6.23. Failed pregnancy with debris. Transvaginal scan, longitudinal orientation (**A**). Transvaginal scan, coronal orientation (**B**).

Ectopic Pregnancy (Figs. 6.24–6.39)

Ectopic pregnancy occurs in about 2% of pregnancies. Ectopic locations for pregnancy implantation vary. Most commonly an ectopic pregnancy is within the fallopian tubes, but interstitial locations (at the edge of the uterus adjacent to the tubes), cornual (in one horn of a bicornuate uterus), cervical, ovarian, and abdominal implantations may occur (Figs. 6.24, 6.25). Interstitial pregnancies are particularly problematic, since the location on the myometrium at the edge of the uterus allows the pregnancy to develop further before rupture occurs (often at 10 to12 weeks gestation), thus accounting for the disproportionate mortality of interstitial ectopics (19,20).

Occasionally an ectopic gestation is directly visualized by ultrasound (Figs. 6.24–6.32). In one series of 45 ectopic pregnancies reported by radiologists, an extrauterine fetal pole (with or without cardiac activity) could be visualized by transvaginal scans in up to one-third of cases; a few were seen by transabdominal scans (21). However, most ectopic pregnancies are not visualized directly by pelvic ultrasound. The emergency sonographer should recognize that even when an ectopic gestation is not seen, the ultrasound may detect other abnormalities that would increase suspicion for an ectopic pregnancy. Indirect evidence suspicious for ectopic pregnancy includes adnexal masses, contained extrauterine fluid collections, or significant free fluid in the cul-de-sac in the setting of failure to detect an intrauterine embryo at any β-hCG level (Figs. 6.33–6.39).

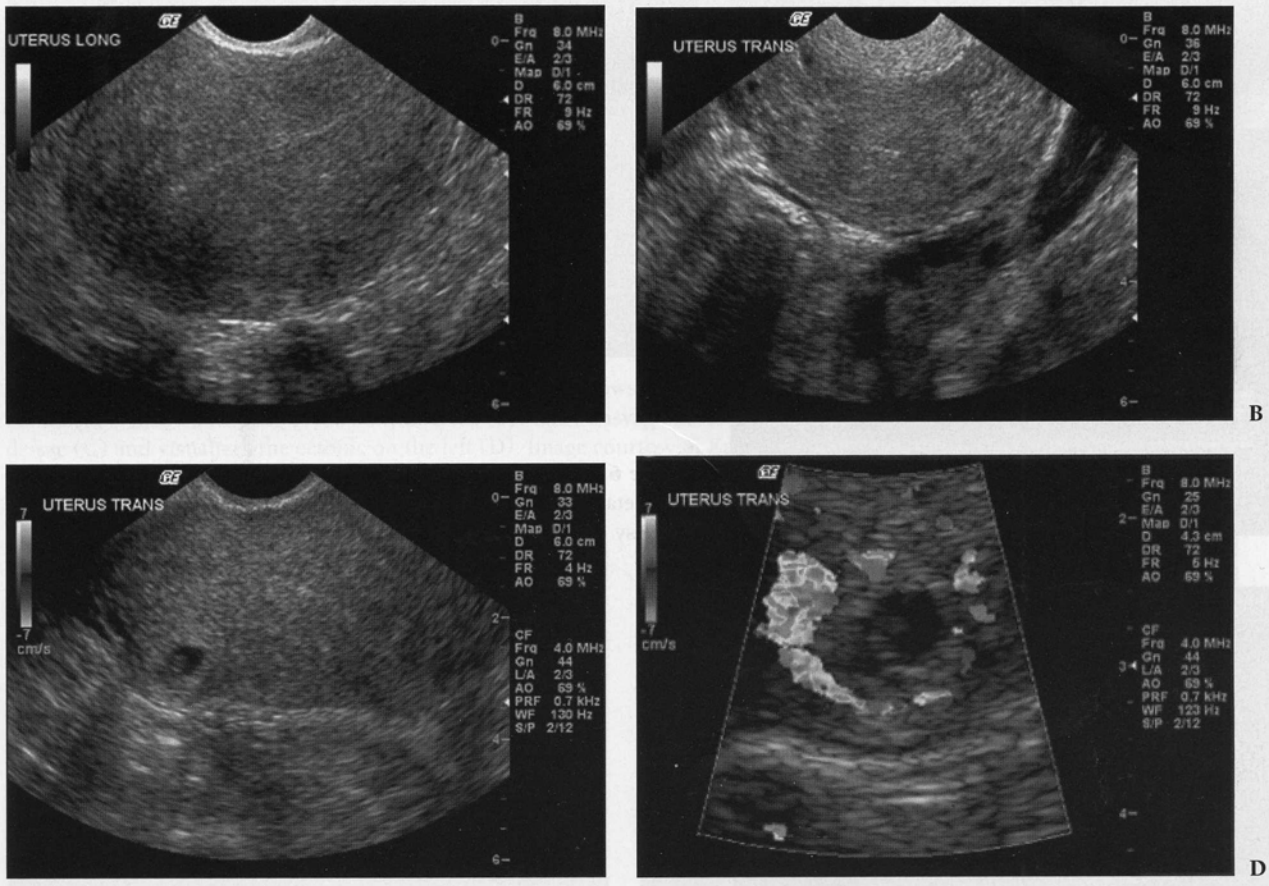
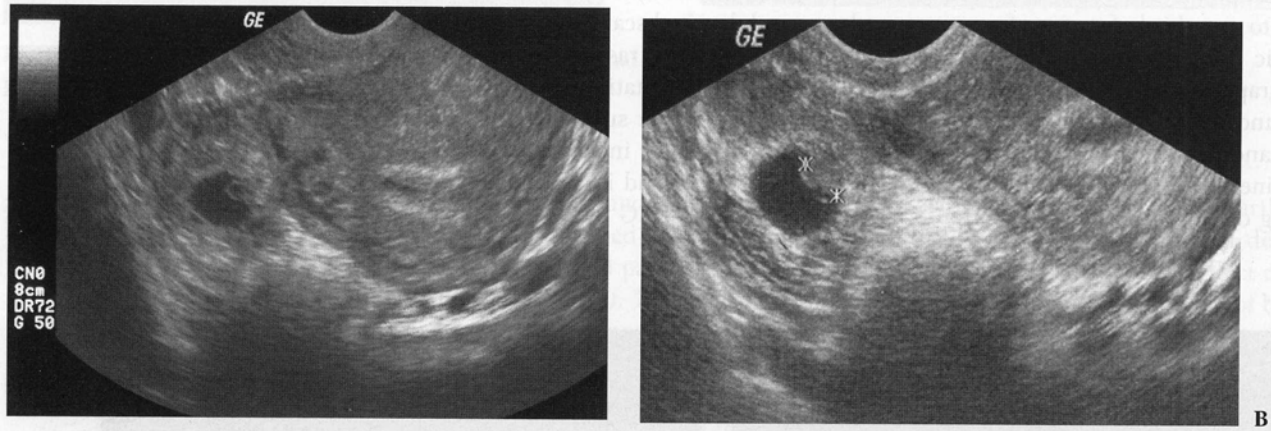
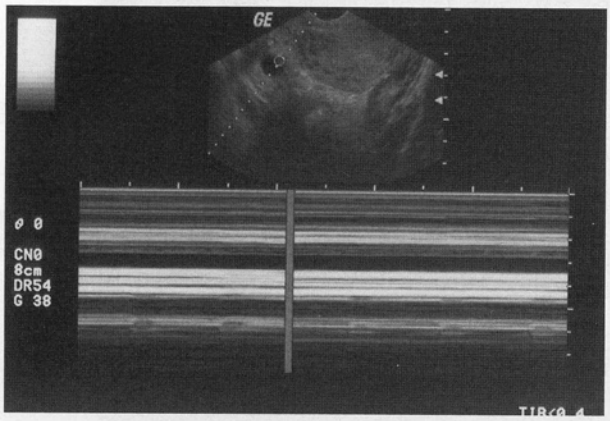


Figure 6.24. Interstitial pregnancy in a pregnant patient with vaginal bleeding. No IUP is seen by transvaginal ultrasound in longitudinal (**A**) and transverse (**B**) views through the midline of the uterus. Further survey of the pelvis reveals an interstitial pregnancy with active fetal heart activity (**C**). A ring of fire is seen by Doppler indicating hypervascularity around the gestational sac (**D**). (See color insert for color image of Part D.) Images courtesy of Cory Cunningham, PA-C, and Karen Cosby, MD.

Figure 6.25. IUP in a Bicornate Uterus. Image courtesy of Kendall JL, Deutchman M. *Ultrasound in Emergency Medicine and Trauma.* Nashville:Healthstream 2001.



A B



C

Figure 6.26. Ectopic Pregnancy. Yolk sac is seen in the right adnexa (A). Fetal pole (B) with fetal heart activity is visualized (C). Image courtesy of Karen Cosby, MD.

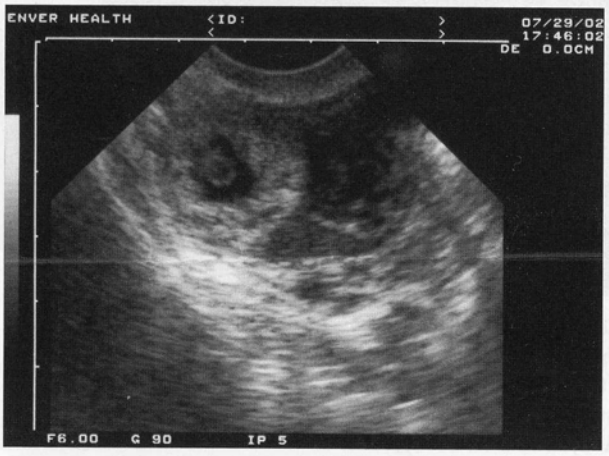
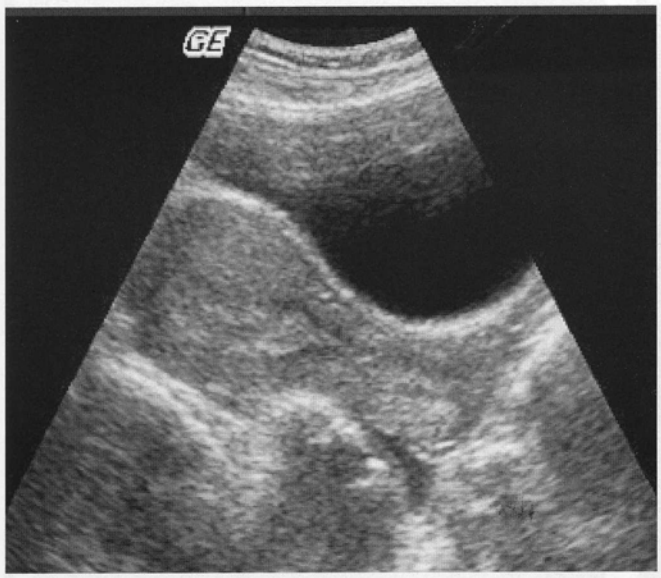
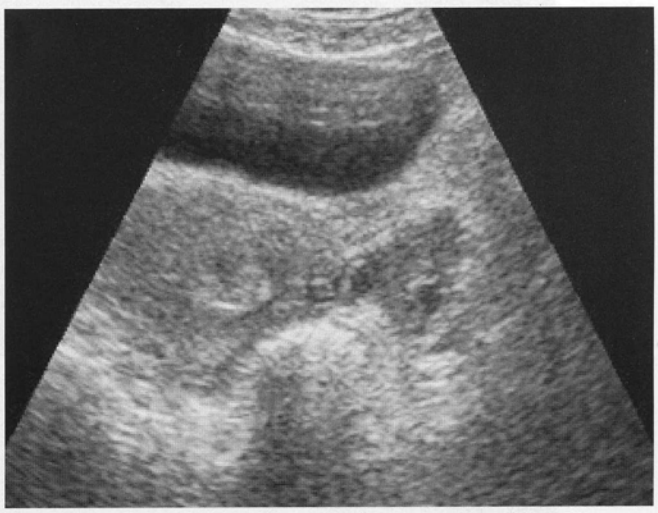


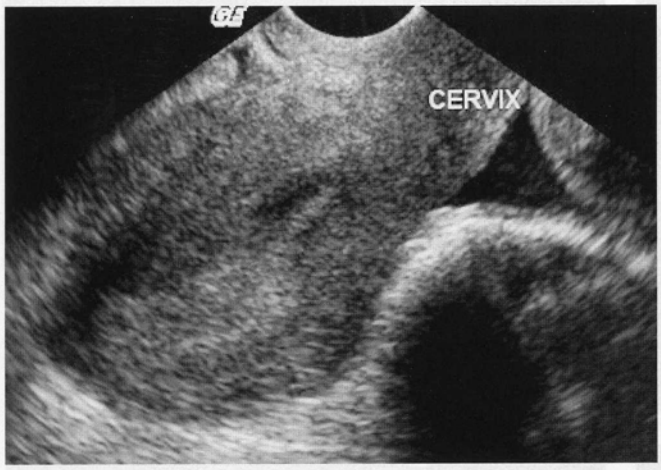
Figure 6.27. An ectopic pregnancy is seen outside the uterus. Image courtesy of John Kendall, MD.



A



B

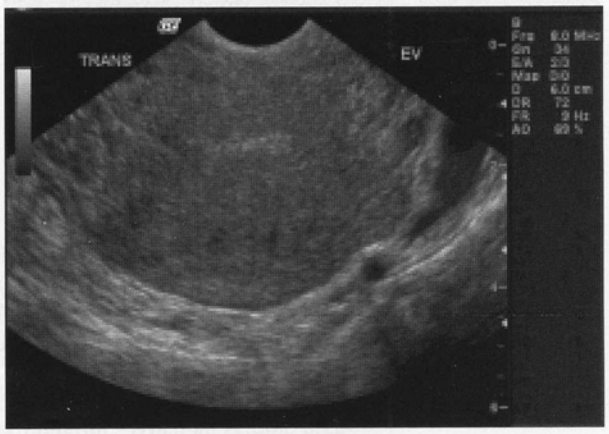


C

D

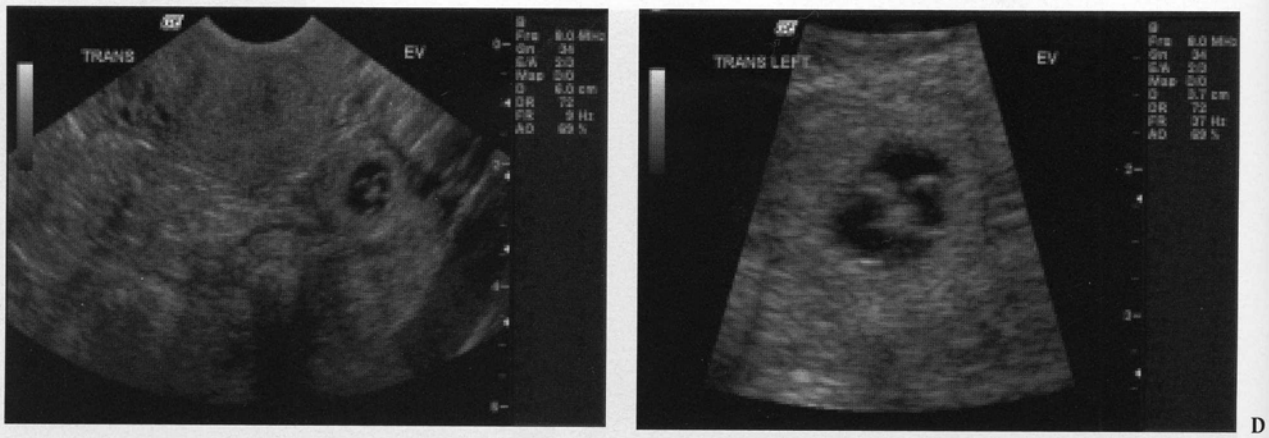
Figure 6.28. Ectopic Pregnancy. A transabdominal scan shows a small amount of free fluid in the cul-de-sac (**A**) and a suspicious left adnexal mass (**B**). The transvaginal scan confirms fluid in the cul-de-sac (**C**) and visualizes the ectopic on the left (**D**). Image courtesy of Karen Cosby, MD.

A



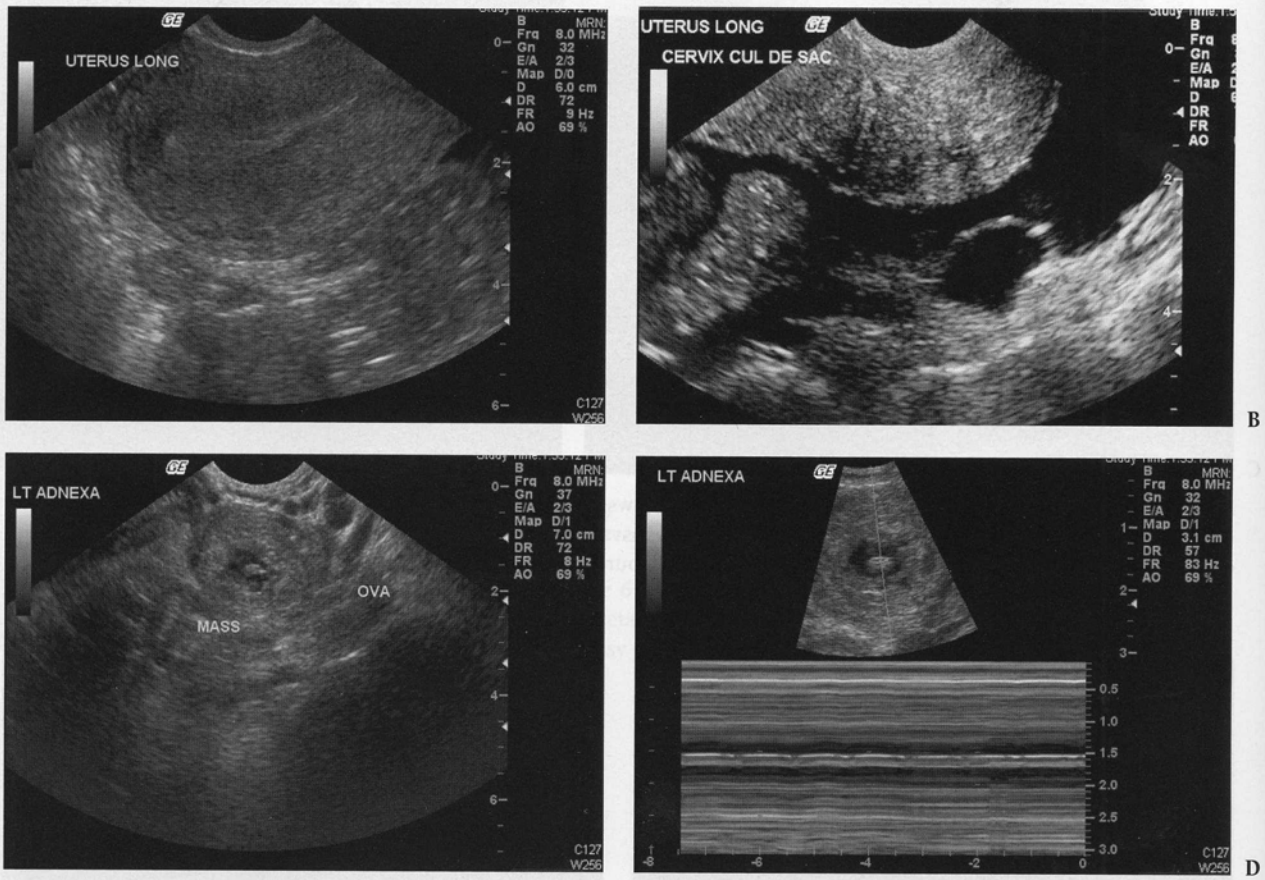
B

Figure 6.29. Ectopic Pregnancy. A transvaginal scan through the midline of the uterus fails to find an IUP in this pregnant patient with a β-hCG of 2,477 (**A** and **B**).



C D

Figure 6.29. *(continued)* On closer inspection an ectopic pregnancy is seen in the adnexa (**C** and **D**). Image courtesy of Karen Cosby, MD.



A B C D

Figure 6.30. Ectopic Pregnancy. This pregnant patient presented with abdominal pain and vaginal bleeding. Her β-hCG was 8,664. A transvaginal scan failed to find an IUP (**A**), but did find a large amount of free fluid in the pelvis (**B**). Closer inspection visualized a complex mass in the left adnexa (**C**) and a fetal pole with active cardiac activity (**D**). Image courtesy of Karen Cosby, MD.

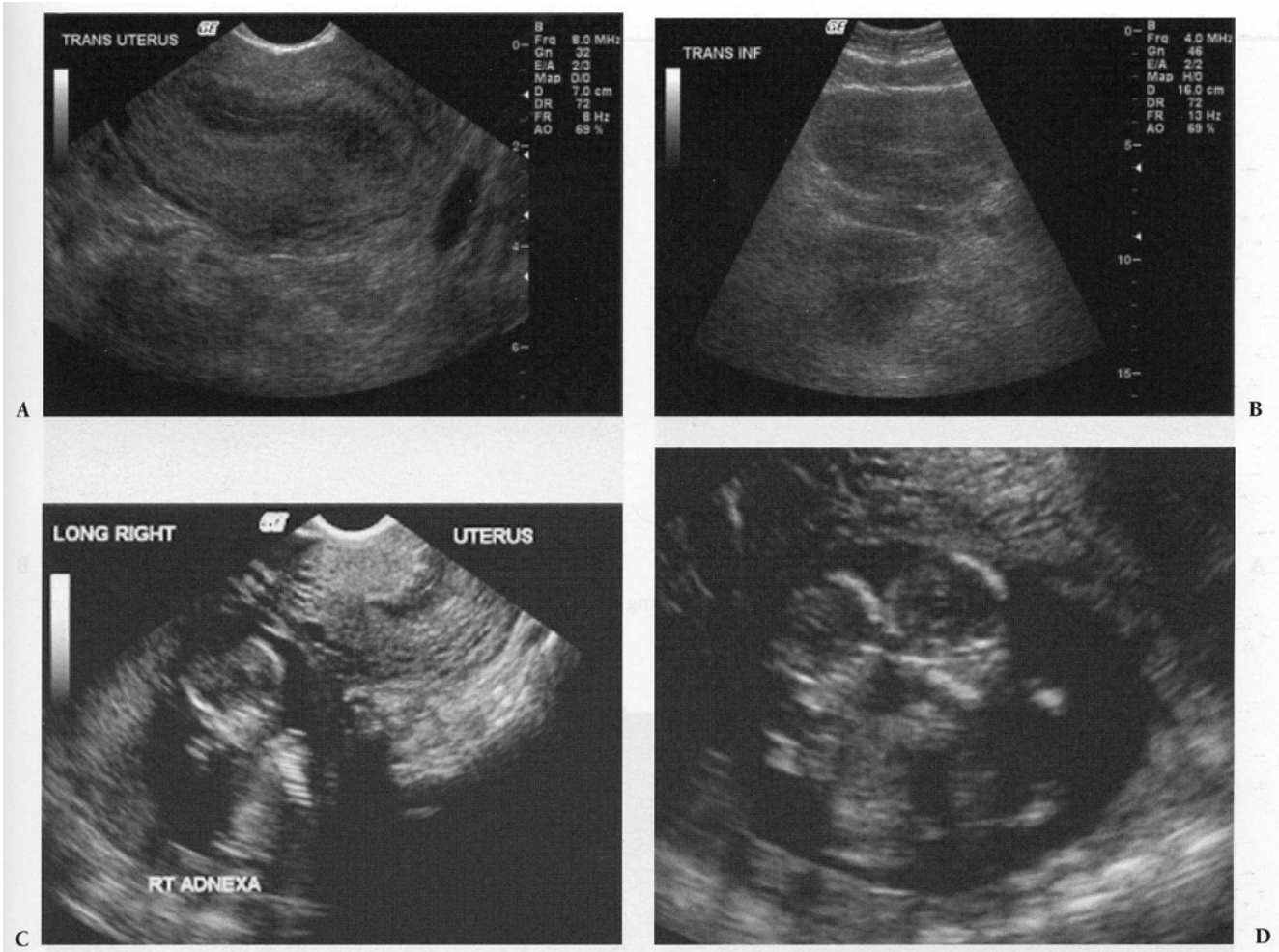


Figure 6.31. An unusual presentation of a twin ectopic pregnancy of advanced gestation. A transvaginal scan fails to demonstrate an IUP in either sagittal (**A**) or coronal (**B**) views. A scan of the right adnexa reveals a well-formed fetus (**C**). On closer inspection, a twin ectopic is seen (**D**). Although interesting, most ectopics fail to reach such an advanced gestational age. Images courtesy of David Greenberg, MD and Karen Cosby, MD.

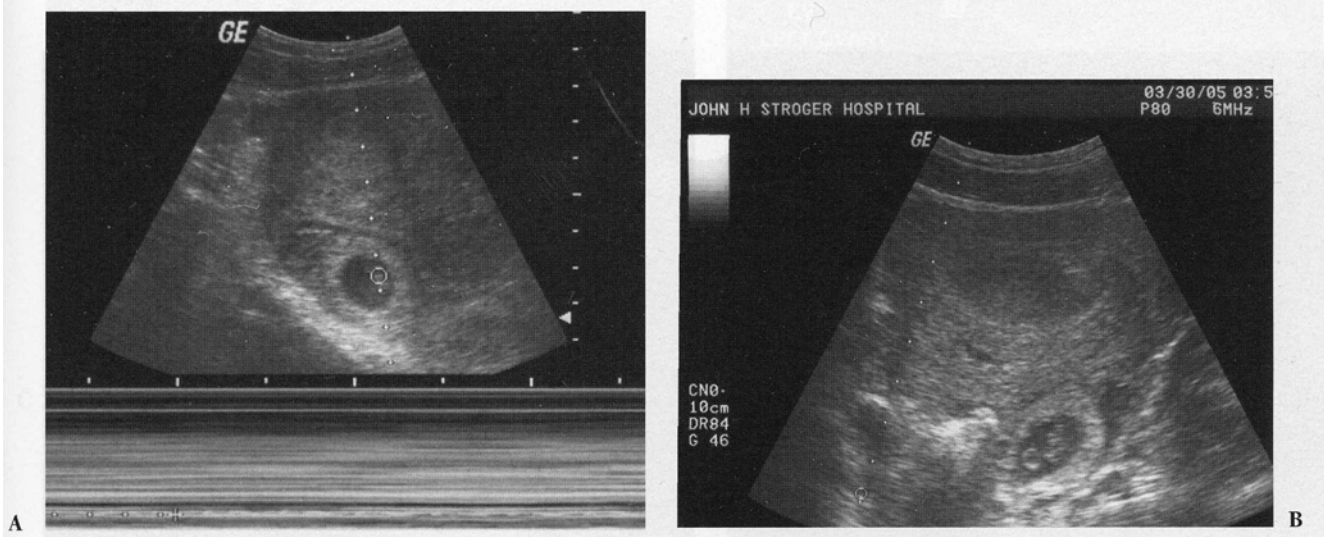
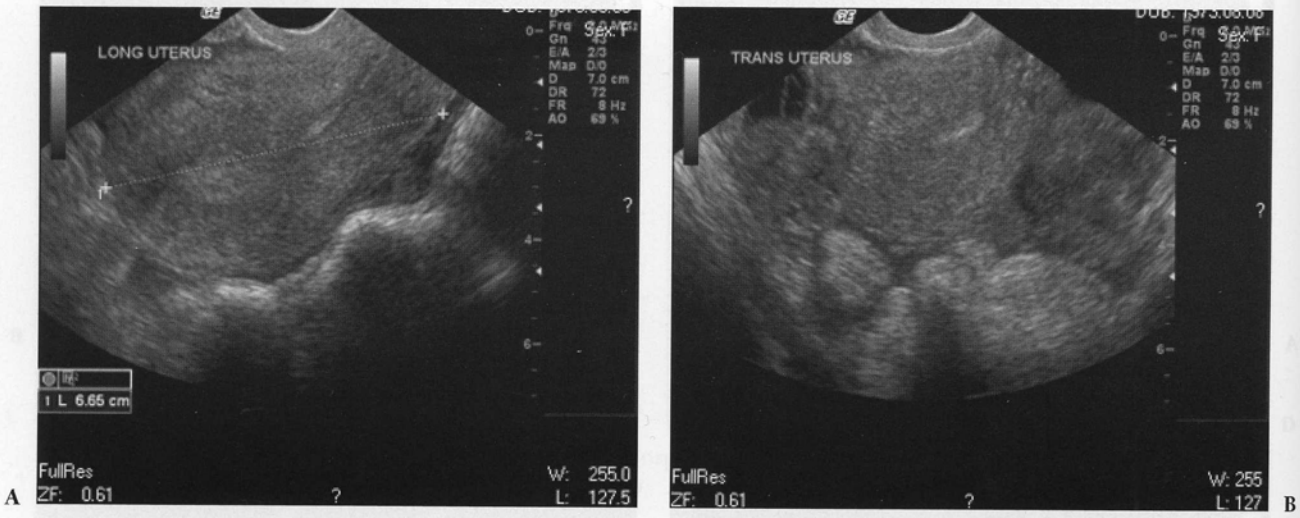


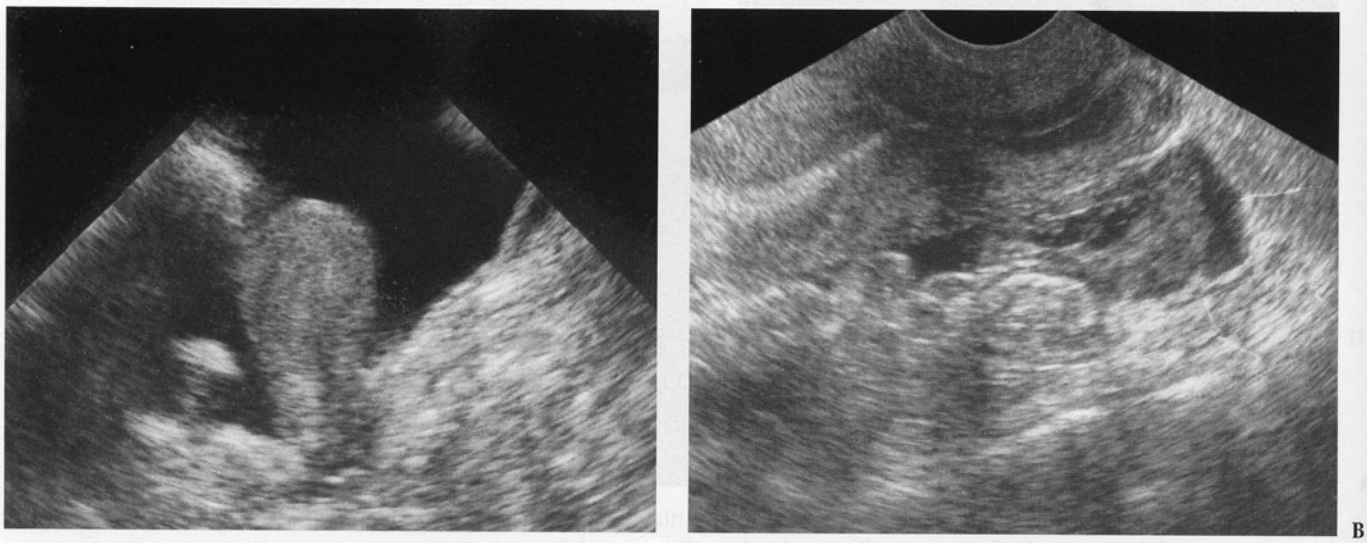
Figure 6.32. Ectopic Pregnancy. A live fetus is visualized in **A**, initially thought to be an IUP. In a transverse view of the uterus, the fetus is actually noted to be extrauterine. When an ectopic pregnancy is adjacent to the uterus it can be mistaken for an IUP. This is a good example of why it is essential to always obtain two views perpendicular to an object of interest to determine its exact location. Image courtesy of Karen Cosby, MD.



A B

Figure 6.33. Free fluid seen outlining the uterus in both sagittal (A) and coronal (B) views in a patient with an ectopic pregnancy.

Figure 6.34. Complex adnexal mass and empty uterus in a pregnant patient found to have an ectopic pregnancy.

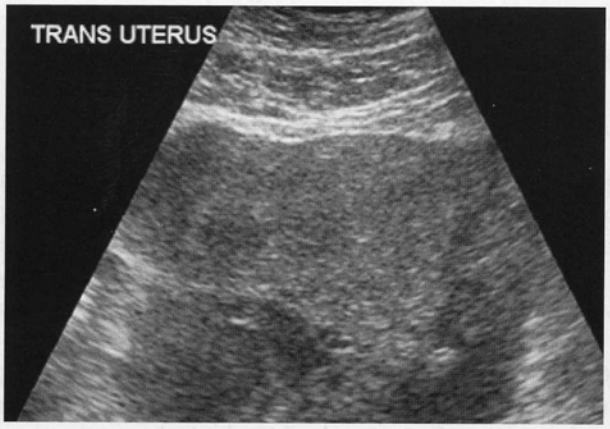


A B

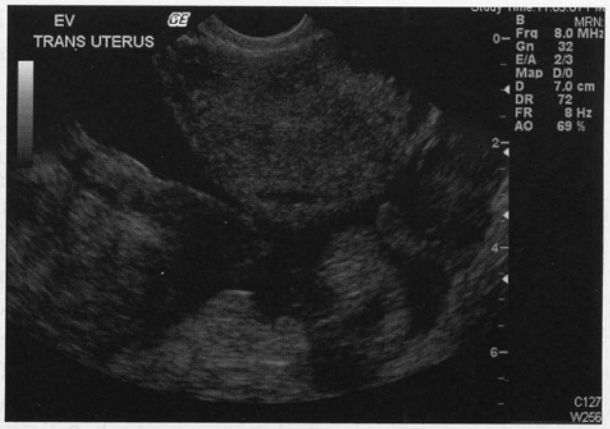
Figure 6.35. Free fluid seen in transabdominal (A) and transvaginal (B) scans of a pregnant patient with an empty uterus found to have an ectopic pregnancy. Image courtesy of John Kendall, MD.

Figure 6.36. Transabdominal Scan. A small amount of free fluid is seen in the cul-de-sac in this patient who was found to have an ectopic pregnancy.

Figure 6.37. Transvaginal Scan. A small amount of free fluid is seen in the cul-de-sac in a patient found to have an ectopic pregnancy.



A



B

C

D

Figure 6.38. Large amount of free-flowing fluid in a patient with a ruptured ectopic pregnancy. Some of the blood has formed clots and appears echogenic. The fluid outlines loops of bowel (**B**, **D**).

Figure 6.39. Large amount of free fluid in a patient with a ruptured ectopic pregnancy.

Patients with an empty uterus are 5 times more likely to have an ectopic pregnancy, compared to those with fluid or debris in the uterus (22). In the emergency medicine and obstetrical literature, detection of a nonovarian adnexal mass by transvaginal ultrasound or detection of free fluid is highly suspicious for ectopic pregnancy (23,24).

Molar Pregnancy

Molar pregnancy is a complication of developing pregnancy in which chorionic villi proliferate in a disordered fashion, usually without the development of a fetus. Bleeding commonly is seen in the late first trimester or early second trimester, and β-hCG levels are markedly elevated. The diagnosis is suspected by the characteristic sonographic appearance of grapelike vesicles or "snowstorm" appearance of the endometrial cavity without an identifiable fetus at β-hCG levels considerably above the β-hCG thresholds to see an intrauterine pregnancy (Figs. 6.40–6.42). In two-thirds of cases, however, the sonographic findings are nonspecific, and include debris in the uterus or absence of a gestational sac and embryo at a high β-hCG level, with confirmation by histological examination. Neoplastic gestational disease develops in about 15% of molar pregnancies after dilatation and curettage (25,26).

Figure 6.40. Molar Gestation.

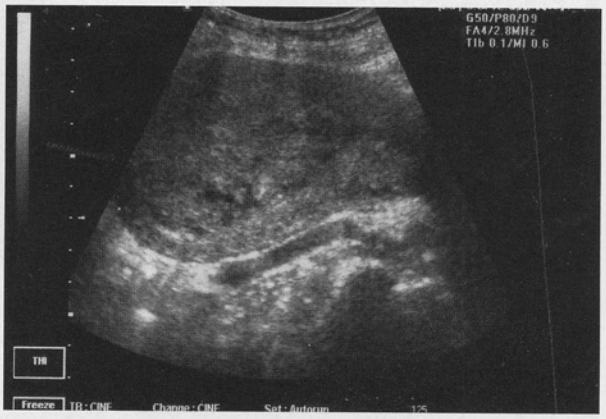


Figure 6.41. Molar Gestation. Image courtesy of John Kendall, MD.

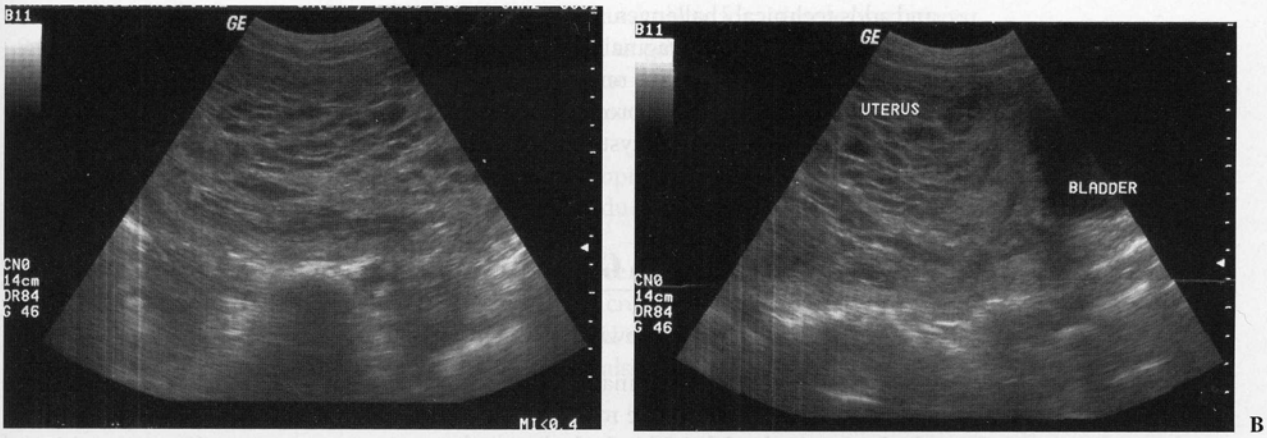


Figure 6.42. Molar Gestation. Image courtesy of Karen Cosby, MD.

Other Pathologic Sonographic Findings

Echogenic material within uterus

Echoes within the uterus must be distinguished from echoes within a gestational sac. Echogenic material in the uterus without a definite gestational sac is almost always abnormal. In a consecutive series over 6 years, Dart found 78 patients with intrauterine echogenic debris and found it to be nonspecific: seen in abnormal pregnancies, ectopic pregnancy, or molar pregnancy (27). Debris can also be seen in patients who have had elective or spontaneous abortions. It may resolve spontaneously, although an ectopic pregnancy must still be considered. Therefore a wide differential diagnosis and a low threshold for a consultative examination are necessary when nonspecific echoes are seen in the uterus (28,29).

Free fluid in the cul-de-sac

Fluid in the pelvic peritoneal cavity can be seen in the normal IUP, IUP with a ruptured corpus luteum cyst, or with a leaking or ruptured ectopic pregnancy. Echogenic fluid is particularly concerning for ectopic pregnancy (Figs. 6.38, 6.39).

Pitfalls and Artifacts of Image Acquisition

Common pitfalls include the following.

1. Failing to have a full urinary bladder in transabdominal pelvic ED ultrasound. This may limit the value of information obtained since the bladder provides an acoustic window and displaces the bowel.
2. Scanning past the uterus with the endovaginal probe. If the transducer is too deep within the vaginal canal, the uterus may not be visualized and only bowel is seen. If this occurs, it may be necessary to pull the transducer back until only a small fraction of the urinary bladder is seen.
3. Utilizing only the transvaginal modality to examine the first trimester uterus. The sonographer may miss cystic or complex ovarian masses, a large uterus, and other important findings if the transabdominal approach is not used first to obtain an overview.
4. Utilizing only the transabdominal modality without transvaginal scanning. Diagnosis of IUP is delayed by a week of gestational age using only the transabdominal approach

and adds technical challenges. In addition, in an obese patient or a patient with a retroverted uterus, the transvaginal scan enhances proximity to the uterus even more.

5. Using inadequate lubricant or having air bubbles at the ultrasound interface. Image quality is significantly compromised by the added acoustic noise.
6. Mistaking a large ovarian cyst or other fluid-filled structure for the urinary bladder may result in misdiagnosis.

Pitfalls of Image Interpretation

Clinicians should avoid the following common pitfalls.

1. Considering history or examination indicating passage of tissue as evidence for a spontaneous abortion. Such tissue may represent sloughing of organized clot or uterine decidual tissue as the β-hCG levels decline with an ectopic pregnancy. (See recognition of chorionic villi below.)
2. Diagnosing an IUP when a gestational sac is seen without embryonic echoes. An early sac is difficult to distinguish from a pseudogestational sac, which is sometimes seen due to endometrial hypertrophy from an adjacent ectopic pregnancy.
3. Mistaking uterine artery or iliac vessel flow for cardiac activity of the embryo. At five weeks gestation, fetal heart rates can be as slow as 70 to 100 beats per minute and mimic the maternal heart rate (14).
4. Not measuring a definite 5 mm rim of myometrium around the entire gestational sac to locate the pregnancy within the body of the uterus. A gestational sac with a thin myometrial mantle can be seen with a cervical or even tubal gestation.
5. Detecting an IUP and completely discarding ectopic pregnancy from the differential when a heterotopic pregnancy (i.e., coexisting IUP and ectopic pregnancy) should still be considered (Fig. 6.43). While the chances of this occurring spontaneously are low (about 1 in 4,000 pregnancies), the incidence in women with multiple gestations from stimulated fertility or implantation procedures can be as high as 1:100 or less (30).
6. Detecting fetal heart tones and assuming that an IUP is present. While traditionally auscultation of fetal heart tones has implied an intrauterine location, newer sonographic techniques detect fetal heart activity in up to 20% of ectopics (20,31). The sonographer must complete the screening ultrasound examination by identifying myometrium with a minimum 5 mm rim surrounding the gestation to assure that the beating embryo is not in an ectopic location.
7. Failing to recognize that a small amount of cul-de-sac fluid can be normal. Echogenic fluid and larger volumes of peritoneal fluid correlate more with ectopic pregnancy than smaller volume and anechoic fluid.

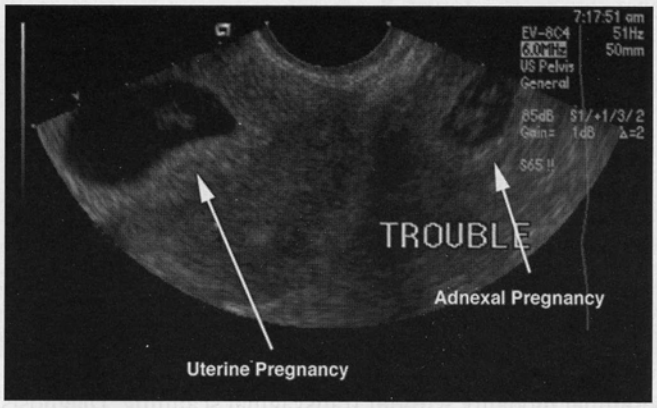


Figure 6.43. A heterotopic pregnancy is seen in the adnexa. Note the normal IUP. Image courtesy of Diku Mandavia, MD.

8. Mistaking an extrauterine gestational sac that lacks an embryo for a simple ovarian cyst.
9. Relying on subtle signs of ectopic pregnancy, such as complex adnexal masses, to diagnose ectopic pregnancy. While this should increase suspicion for ectopic pregnancy, no signs other than a gestational sac with embryonic structures in an extrauterine location are pathognomonic of ectopic pregnancy.
10. Assuming that debris in the uterus excludes an ectopic pregnancy. Heterogeneous debris in the uterus can either represent retained products of conception or endometrial sloughing associated with ectopic pregnancy (32).
11. Failure to recognize that infertility patients may have multiple gestations, and that the likelihood of heterotopic pregnancy is markedly increased in this patient group.
12. Assuming that an empty uterus implies a completed spontaneous abortion. This finding is reported commonly with ectopic pregnancy also (22).

Use of the Image in Clinical Decision Making

The General Approach

The approach to the patient with symptoms of bleeding or pain in early pregnancy should be systematic and aimed at early exclusion or diagnosis of ectopic pregnancy, and diagnosis of early pregnancy failure. Ultrasound has emerged as the best first ancillary study (6). The primary question in a first trimester pregnancy is the location of the pregnancy; thus the primary ED ultrasound question is, "Is there an IUP?" For emergency medicine sites where only transabdominal examinations are performed, a consultative examination including transvaginal ultrasound is probably the most useful next step if an IUP is not seen by transabdominal scans, because about twice as many IUPs can be identified with transvaginal scans (33). Likewise, if no IUP is seen on the ED transvaginal scan, a consultative examination is also a reasonable next step, since ED accuracy has not yet been robustly reported. The radiology or obstetric sonographer may be better able to detect subtle or indirect clues suspicious for ectopic pregnancy, like complex masses, echogenic fluid, etc. If transvaginal ultrasound is not immediately available, a quantitative β-hCG in addition to an obstetrical consultation will help prioritize patients and interpret the eventual ultrasound results. Figure 6.44 describes a recommended approach to evaluation of the first-trimester patient who presents with bleeding or pain to the ED.

The Pregnant Patient with Hemodynamic Instability or an Acute Abdomen

The pregnant patient with hypotension or peritoneal findings requires a FAST examination to detect free fluid in the abdomen. During resuscitation, a transabdominal pelvic ultrasound, followed by a transvaginal scan if not definitive, should be performed to rapidly diagnose intrauterine pregnancy and detect free cul-de-sac fluid. About 20% of ectopic pregnancies present with emergent signs and symptoms (15). When an IUP can be identified at the bedside, the differential leans more towards nongynecologic causes of abdominal catastrophe, though a rare severe hemorrhagic corpus luteum cyst rupture or heterotopic pregnancy cannot be completely excluded.

IUP Detected

In the stable patient, pelvic ultrasound is used to detect an embryo within the gestational sac in the uterus, assuring that there is an IUP. When the pitfalls noted above are avoided and a definitive diagnosis of an IUP can be made, the risk of ectopic pregnancy decreases to the risk of heterotopic pregnancy to about 1 in 4,000. The risk of heterotopic pregnancy

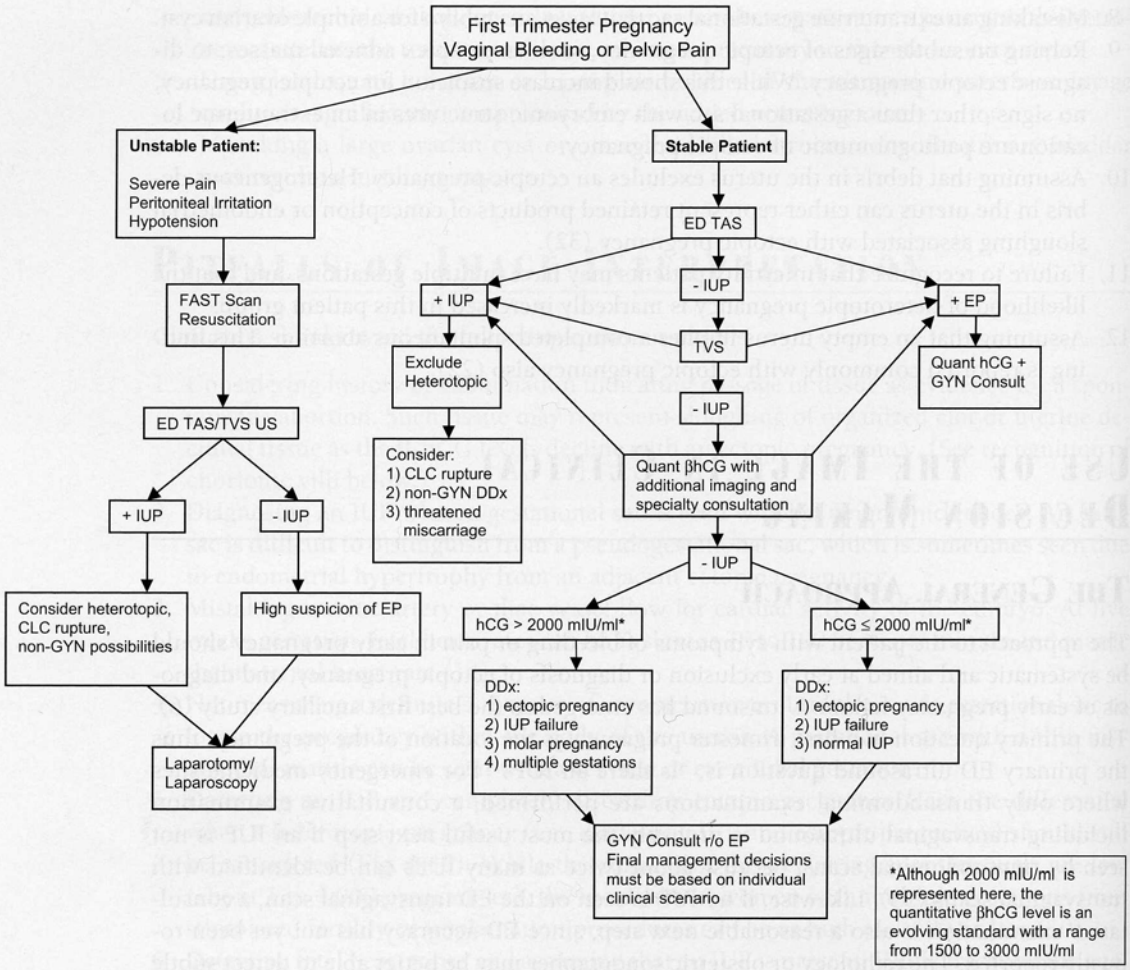


Figure 6.44. Approach to a first trimester pregnancy presenting with vaginal bleeding or pelvic pain.

is strikingly high, however, in patients undergoing pregnancy induction by embryo transfer techniques; in these patients consultative pelvic sonography and close specialty follow-up is required, even after an IUP is diagnosed (30).

For patients in whom an IUP is definitely visualized and in whom examination demonstrates a closed cervical os with bleeding, "threatened abortion" is diagnosed. Patients should be counseled that although an IUP with heartbeat is documented at this time, there is still about a 10 to15% risk of miscarriage. Quantitative serum β-hCG levels are less useful if an embryo is definitively seen on ultrasound, since viability and gestational age are determined by sonographic landmarks and serial studies once an embryo is seen. Serum β-hCG levels plateau after about 8 weeks gestation, rendering them uninterpretable at the gestational age that sonography becomes definitive.

Optimum ED care consists of primary care follow-up, discussion of the risks and symptoms of abortion, and pursuit of an alternative cause of symptoms, particularly if this is a clinical consideration due to significant pain. Alternative diagnoses, including appendicitis, molar pregnancy, ruptured corpus luteum cyst, ovarian torsion, or other intra-abdominal process are important, but are rendered easier by the exclusion of ectopic pregnancy.

Ectopic Pregnancy Detected

Sonographic diagnosis of ectopic pregnancy is definitive if an embryo is seen within a gestational sac outside of the normal endometrial location. The accuracy of bedside

sonography to visualize an ectopic pregnancy is not well-defined, but it is clear that current sonographic hardware detects fetal heart activity or a fetal pole in a significant minority of patients with ectopic pregnancies. Thus it is mandatory that the physician performing bedside sonography be able to recognize the signs that a living early embryo is within the uterus, as well as appreciate secondary findings suggesting an ectopic pregnancy.

No Definite IUP or Ectopic Pregnancy Detected (Indeterminant Scan)

If the ED ultrasound study is "indeterminant," i.e., an IUP is not found, it is most efficient to obtain a quantitative serum β-hCG and specialty consultation with radiology or obstetrics. The risk of an extrauterine pregnancy can be assessed by identifying each individual's ectopic risk factors; correlating gestational age with dates, physical exam, β-hCG, and sonographic findings; and assessing clinical suspicion based on the patient's presentation and physical findings. In a recent large prospective cohort study, 20% of all ED first trimester pelvic ultrasound examinations resulted in an "indeterminate" classification. Of these only 29% were ultimately diagnosed as IUP; the remaining patients either had ultimate diagnoses of embryonic demise (53%), ectopic pregnancy (15%), or "unknown" (3%) (8).

The management of suspected ectopic pregnancy in the face of a nondiagnostic or indeterminant ultrasound is largely based on the quantitative serum β-hCG. The "discriminatory zone" is a term developed to denote the quantitative β-hCG level at which a gestational sac or an embryo can almost always be seen if the pregnancy is developing normally. (This is in contrast to "threshold levels," which are the lowest β-hCG levels at which a finding may be detected.) Early work with transabdominal ultrasound determined that the gestational sac should be visible at β-hCG levels of 6500 mIU/ml (34). Transvaginal ultrasound discriminatory levels are lower (1000 to 2000 mIU/ml), but vary depending on the vaginal probe equipment used, operator skills, and patient population. A clear discriminatory threshold for ED transvaginal ultrasound has not been determined (17). For that reason, ED ultrasound should be used to demonstrate an IUP and to suspect, but not to definitively act on, possible fetal demise. The limited ED ultrasound still significantly narrows the number of women with concern for ectopic pregnancy to those with no sonographic evidence of IUP (Table 6.2).

Indeterminant scan with a β-hCG ≥ 2000

A consultative ultrasound should be used to confirm the pelvic ultrasound in the ED and avoid unnecessary loss of an early normal IUP (35). When the β-hCG is ≥ 2000 mIU/ml and the ultrasound is indeterminant, some obstetricians will consider a dilatation and curettage that can be both diagnostic and therapeutic. If chorionic villi are seen on curettings, a diagnosis of an abnormal IUP is confirmed. If chorionic villi are not seen, a presumptive diagnosis of ectopic pregnancy is strongly supported. The decision to pursue this intervention is highly individualized, based on the practitioner's judgment, the patient's risk of ectopic, and the patient's desire to keep the pregnancy. Some clinicians recommend setting a higher discriminatory zone (β-hCG of 3000 mIU/ml) to avoid unnecessary intervention and possible termination of an early viable IUP (35).

Indeterminant Scan with a β-hCG ≤ 2000

The more difficult situation occurs when an indeterminant scan is obtained in a patient with a β-hCG ≤ 2000 mIU/ml. In the low-risk patient who is stable and relatively asymptomatic, serial β-hCG levels can be followed every 48 hours. The interpretation of the rate of change of β-hCG levels has been evaluated by Barnhart and Dart as a means of risk stratifying patients with an indeterminate ultrasound. Normally β-hCG rises by at least 50% every 2 days for the first 6 weeks of gestation (35,36). In ectopic pregnancy, the expected increase in β-hCG is often less than expected, although in about 25% of ectopic

pregnancies, the β-hCG rises normally for a time. (In such cases the rate of change does not discriminate between early healthy IUP and ectopic pregnancies.) Hormone levels that drop 50% or more over 48 hours are least likely to be ectopic pregnancies, and almost always represent spontaneous abortions (36). Intermediate but abnormal β-hCG changes are seen in both abnormal IUPs and ectopic pregnancy.

Sonography is the primary assessment modality for first trimester pregnancy because it is useful at all quantitative β-hCG levels. The quantitative β-hCG level and size of the embryo do not correlate well with risk of ectopic rupture. In addition, useful findings by ultrasound are not infrequent, even if the β-hCG is below the discriminatory threshold. A majority of ectopic pregnancies present to the ED with a β-hCG less than 3000 mIU/ml, and many never rise above the discriminatory zone where an IUP or gestational sac should be seen (37). At the same time, patients with a β-hCG less than 1000 mIU/ml have a four time relative risk of ectopic pregnancy. (4). In one radiologic study, intrauterine gestational sacs were seen in up to half of women with β-hCG levels less than 1000 mIU/ml (38). In another study, 39% (9 of 23) of women ultimately diagnosed with ectopic pregnancy who had β-hCG levels less than 1000 mIU/ml had diagnostic ultrasounds for ectopic embryo or complex adnexal mass in studies performed by radiology (18).

In addition, clinicians may be misled when women give a history of passing tissue, presumed products of conception. If tissue is seen in the vault or brought to the ED by the patient, it can be rinsed and inspected for the white feathery appearance of villi or visual evidence of a gestational sac with a fetus, thus definitively diagnosing a failed pregnancy. However, nonspecific tissue, by history or examination, may represent organized blood clots, products of conception, or sloughed decidual lining, all compatible with an ectopic pregnancy. Thus, caution should be used in interpreting the passage of tissue.

A woman with an indeterminate bedside ultrasound, regardless of β-hCG level, should receive a consultative study relatively expeditiously. Whether this is done at the time of the initial ED visit or an early follow-up will depend on risk assessment after clinical evaluation and her access to a follow-up visit.

The Utility of Emergency Ultrasound in Reaching Treatment Decisions

About 75% of first trimester symptomatic patients can be determined at the time of the visit to have an intrauterine pregnancy with a consultative pelvic ultrasound that includes both transabdominal and transvaginal imaging (4). The efficiency of sonography by emergency physicians is not as well known, and probably varies considerably depending on machine, operator experience, and whether transabdominal ultrasound is used alone or in combination with transvaginal ultrasound. In one emergency medicine study, an IUP with embryonic structures was seen in 70% of women using transabdominal and transvaginal scanning. There were no false-positives in 87 women in whom emergency physicians detected an IUP, and overall 96% (CI 91–97%) of pelvic ultrasound results were consistent with the radiology department findings (7).

When an IUP can be correctly recognized, efficiency is clearly increased by rapid bedside ultrasound. Two studies have shown that pelvic ultrasound performed by emergency physicians reduces the time of the patient encounter by at least 60 minutes, and decreases the need for consultations in the ED by 85% (39,40). More recently, Blaivas et al showed that when an ED patient has a live IUP diagnosed by an emergency physician the ED length of stay was 21% less than if the diagnosis was made by radiology, and if those patients presented between 6PM and 6AM, they spent about an hour less in the ED (41).

Incidental Findings

In the course of scanning pregnant patients, a number of incidental findings may be encountered. Many of these are not yet considered within the domain of emergency

ultrasound. However, frequent use of bedside ultrasound will probably result in recognition of many of these findings and enhance image interpretation.

Ovarian Cysts

Ovarian cysts are common. There are a wide variety of ovarian cysts and masses with differing sonographic appearances (Figs. 6.45, 6.46). The expertise to distinguish between these is beyond the scope of ED ultrasound, although it is important to recognize ovarian cysts as problems that should eventually be addressed and referred. Ovarian cyst rupture can present with sudden pain and peritoneal irritation in the first trimester, and can result in free fluid in the pelvis. The cyst itself may collapse, making diagnosis less straightforward.

Corpus Luteum

The corpus luteum cyst specifically develops from the ovarian follicle following ovulation and normally involutes after 14 days. In pregnancy the corpus luteum is maintained and supports the pregnancy for the first 6 to 7 weeks. It may become cystic and may rupture or torse. Some corpus luteum cysts fail to involute and continue into the second or third trimester. Rupture of the corpus luteum cyst in the first trimester results in pelvic pain and free fluid in the cul-de-sac and confounds first trimester differential diagnosis.

Subchorionic Hemorrhage

Subchorionic hemorrhage, intrauterine hematomas, or subchorionic blood collections may be seen on ultrasound and are not necessarily poor prognostic signs (42). The association with embryonic loss is strongest with large fluid collections (43). Subchorionic hemorrhage is a common cause of first-trimester vaginal bleeding. It appears as a wedge-shaped or crescent-shaped fluid collection between the chorion and the uterine myometrium (Figs. 6.47, 6.48).

Anatomical Variants: Bicornate Uterus

A bicornate uterus is an anatomic variant of the uterus where a septum divides the uterus into two "horns" to a varying degree. Spontaneous abortion is more common with a bicornate uterus and, rarely, the pregnancy may behave like an ectopic pregnancy, with erosion into the peritoneum. On ultrasound the separate horns can often be visualized, but this can also be a subtle finding (Fig. 6.25).

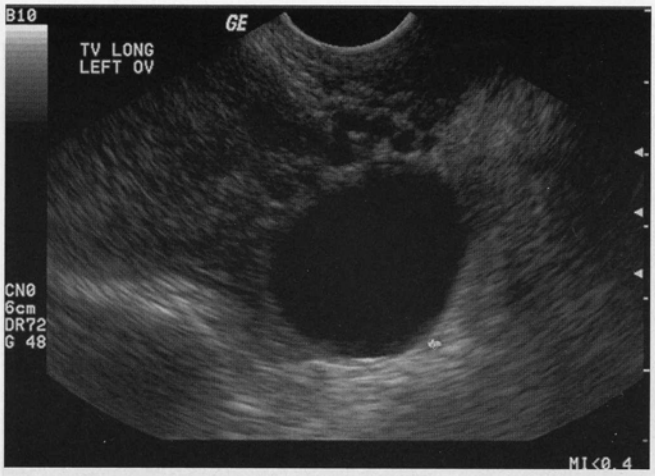


Figure 6.45. Left Ovarian Cyst.

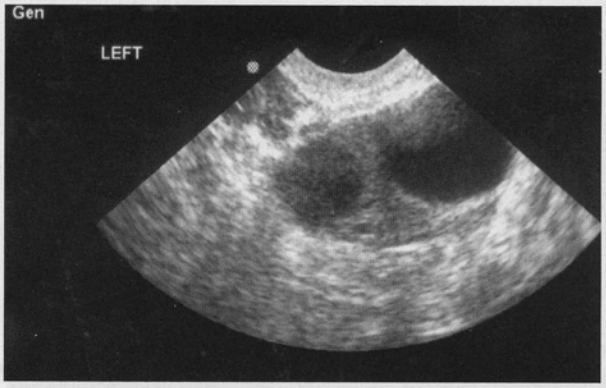


Figure 6.46. Ovarian Cyst. Image courtesy of Mark Deutchman, MD.

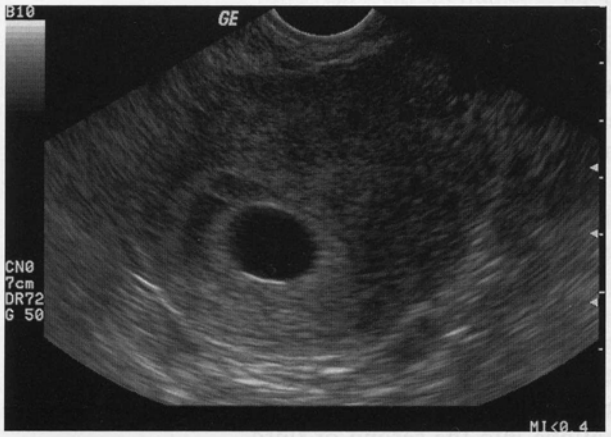


Figure 6.47. Subchorionic Hemorrhage.

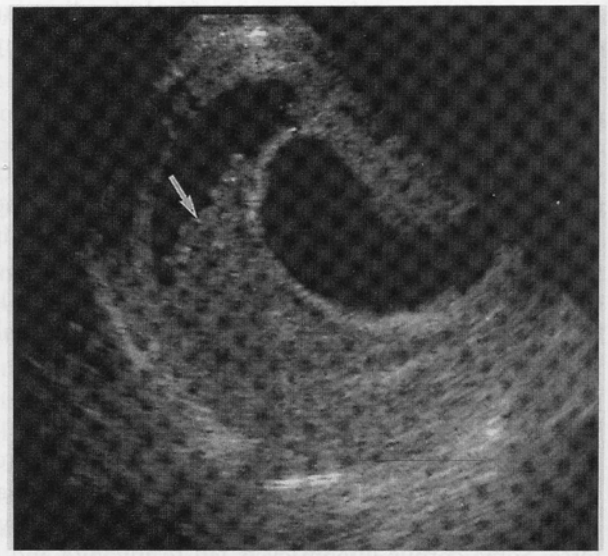


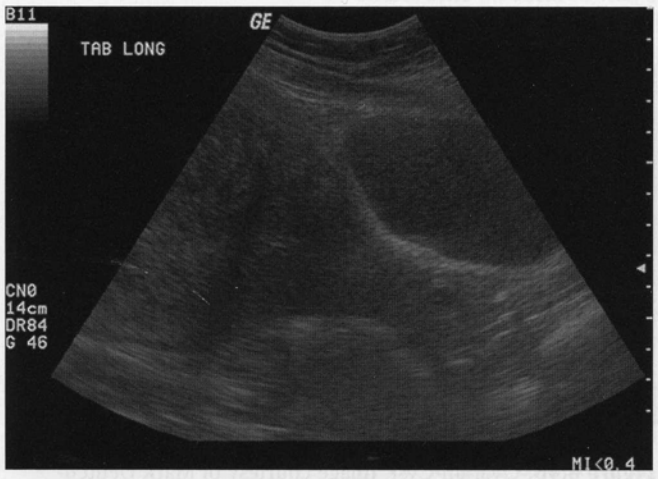
Figure 6.48. Subchorionic Hemorrhage. Reprinted from Brant WE. *Ultrasound. The Core Curriculum.* Philadelphia: Lippincott Williams & Wilkins 2001:240, with permission.

Multiple Gestations

Dichorionic twins will have two chorionic sacs (gestational sacs) and two yolk sacs, whereas monochorionic twins will only have one chorionic sac and either one or two yolk sacs depending on mono- or diamnionicity.

Leiomyomata

Leiomyomata are also known as uterine fibroids. They are benign nodules or tumors that originate in the uterine wall. Myomata frequently grow during pregnancy secondary to the hormonal influences and can distort the normal contours of the uterus. They are common, especially in older women, and can be hyper- or hypoechoic. They occasionally calcify (Figs. 6.49, 6.50).



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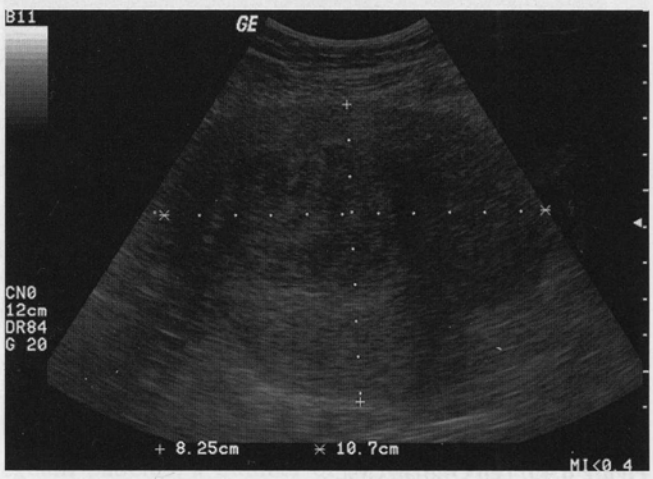

B

Figure 6.49. A large fibroid can be seen to arise from the uterine fundus.

Figure 6.50. Calcified Fibroid.

Adnexal Masses

Complex masses raise the suspicion for ectopic pregnancy, especially when no IUP is seen. Patients should be referred for a consultative ultrasound and specialty consultation. The differential diagnosis includes incidental ovarian pathology (Fig. 6.51).

Clinical Case

A 25-year-old woman presents to the ED with vaginal bleeding beginning the day before her visit. She thinks her last menstrual period was about 28 days earlier, but admits it was an unusually short period, lasting only two days. She denies any pelvic pain or other complaints. Her blood pressure is 100/60 mm Hg, pulse is 77 beats per minute, respirations are 18 per minute, and temperature is 37.4°C. Pelvic exam reveals bleeding coming from an otherwise normal cervical os and slight tenderness and fullness in the left adnexa, but is otherwise normal.

A rapid urine pregnancy test is positive. A transabdominal ultrasound is performed by the ED physician, and the uterus is visualized and appears to have within it a discrete fluid collection in addition to a small amount of free fluid in the cul-de-sac (Fig. 6.52). An ED transvaginal ultrasound is then performed. An empty sac is visualized within the uterus, and a moderate amount of free fluid of mixed echogenicity is noted in the cul-de-sac, measuring up to half of the length of the posterior uterine wall. A quantitative β-hCG is 3500 mIU/ml.

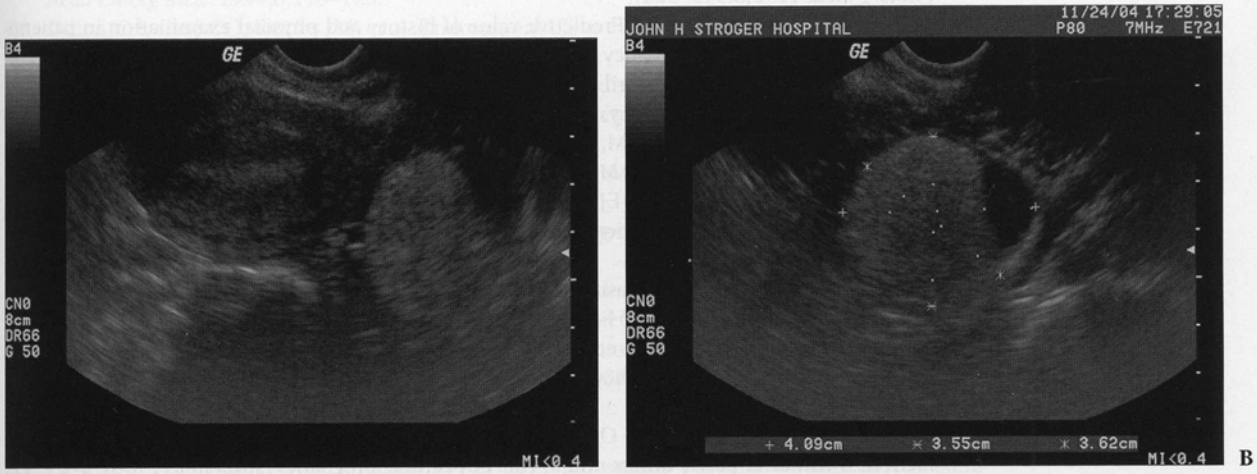

Figure 6.51. A complex left adnexal mass, found to be a dermoid tumor. Image courtesy of Karen Cosby, MD.

9. Dart RG. Role of pelvic ultrasonography in evaluation of symptomatic first-trimester pregnancy. *Ann Emerg Med.* 1999;33:310–320.
10. Nyberg DA, Hughes MP, Mack LA, et al. Extrauterine findings of ectopic pregnancy of transvaginal US: importance of echogenic fluid. *Radiology*. 1991;178:823–826.
11. Ball RH. The sonography of pregnancy loss. *Semin Reprod Med.* 2000;18:351–355.
12. Laing FC, Frates MC. Ultrasound Evaluation During the First Trimester. In: Callen PW, ed. *Ultrasonography in Obstetrics and Gynecology, 4th ed.* Philadelphia: WB Saunders; 2000: 105–145.
13. Filly RA, Hadlock FP. Sonographic Determination of Menstrual Age. In: Callen PW, ed. *Ultrasonography in Obstetrics and Gynecology, 4th ed.* Philadelphia: W. B. Saunders; 2000:146–153.
14. Merchiers EH, Dhont M, De Sutter PA, et al. Predictive value of early embryonic cardiac activity for pregnancy outcome. Am J Obstet Gynecol. 1991;165:11–14.
15. Barnhart K, Mennuti MT, Benjamin I, et al. Prompt diagnosis of ectopic pregnancy in an emergency department setting. *Obstet Gynecol.* 1994;84:1010–1015.
16. Kohn MA, Kerr K, Malkevich D, et al. Beta-human chorionic gonadotropin levels and the likelihood of ectopic pregnancy in emergency department patients with abdominal pain or vaginal bleeding. *Acad Emerg Med.* 2003;10:119–126.
17. Goldstein SR. Early detection of pathologic pregnancy by transvaginal sonography. *J Clin Ultrasound.* 1990;18:262–273.
18. Dart RG, Kaplan B, Cox C. Transvaginal ultrasound in patients with low beta-human chorionic gonadotropin values: how often is the study diagnostic? *Ann Emerg Med.* 1997;30:135–140.
19. DeWitt C, Abbott J. Interstitial pregnancy: a potential for misdiagnosis of ectopic pregnancy with emergency department ultrasonography. *Ann Emerg Med.* 2002;40:106–109.
20. Athey PA, Lamki N, Matyas MA, et al. Comparison of transvaginal and transabdominal ultrasonography in ectopic pregnancy. *Can Assoc Radiol J.* 1991;42:349–352.
21. Dashefsky SM, Lyons EA, Levi CS, et al. Suspected ectopic pregnancy: endovaginal and transvesical US. *Radiology*. 1988;169:181–184.
22. Dart RG, Burke G, Dart L. Subclassification of indeterminate pelvic ultrasonography: prospective evaluation of the risk of ectopic pregnancy. *Ann Emerg Med.* 2002;39:382–388.
23. Cacciatore B, Stenman UH, Ylostalo P. Diagnosis of ectopic pregnancy by vaginal ultrasonography in combination with a discriminatory serum hCG level of 1000 IU/l (IRP). *Br J Obstet Gynaecol.* 1990;97:904–908.
24. Sadek AL, Schiotz HA. Transvaginal sonography in the management of ectopic pregnancy. *Acta Obstet Gynecol Scand.* 1995;74:293–296.
25. Mungan T, Kuscu E, Dabakoglu T, et al. Hydatidiform mole: clinical analysis of 310 patients. *Int J Gynaecol Obstet.* 1996;52:233–236.
26. Sebire NJ, Rees H, Paradinas F, et al. The diagnostic implications of routine ultrasound examination in histologically confirmed early molar pregnancies. *Ultrasound Obstet Gynecol.* 2001; 18:662–665.
27. Dart R, Dart L, Mitchell P. Normal intrauterine pregnancy is unlikely in patients who have echogenic material identified within the endometrial cavity at transvaginal ultrasonography. *Acad Emerg Med.* 1999;6:116–120.
28. Dillon EH, Case CQ, Ramos IM, et al. Endovaginal US and Doppler findings after first-trimester abortion. *Radiology*. 1993;186:87–91.
29. Rulin MC, Bornstein SB, Campbell JD. The reliability of ultrasonography in the management of spontaneous abortion, clinically thought to be complete: a prospective study. *Am J Obstet Gynecol.* 1993;168:12–15.
30. Braude P, Rowell P. Assisted conception. III–problems with assisted conception. *BMJ.* 2003; 327:920–923.
31. Fleischer AC, Pennell RG, McKee MS, et al. Ectopic pregnancy: features at transvaginal sonography. *Radiology*. 1990;174:375–378.
32. Yip SK, Sahota D, Cheung LP, et al. Accuracy of clinical diagnostic methods of threatened abortion. *Gynecol Obstet Invest.* 2003;56:38–42. Epub 2003 Jul 22.
33. Thorsen MK, Lawson TL, Aiman EJ, et al. Diagnosis of ectopic pregnancy: endovaginal vs transabdominal sonography. *AJR Am J Roentgenol.* 1990;155:307–310.
34. Kadar N, DeVore G, Romero R. Discriminatory hCG zone: its use in the sonographic evaluation for ectopic pregnancy. *Obstet Gynecol.* 1981;58:156–161.
35. Barnhart KT, Sammel MD, Rinaudo PF, et al. Symptomatic patients with an early viable intrauterine pregnancy: HCG curves redefined. *Obstet Gynecol.* 2004;104:50–55.