

# Chapter 2

## Emergency Department Ultrasound in Pregnancy

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### Introduction

Pregnant patients often present to the emergency department (ED) with complaints of abdominal pain and vaginal bleeding, particularly in the first trimester. Point-of-care ultrasound is a useful tool for rapid assessment of the pregnant ED patient, allowing emergency physicians to quickly diagnose unstable conditions like ectopic pregnancy (pregnancy outside of the uterus) at the bedside. While obstetricians employ comprehensive ultrasound imaging for a variety of purposes, such as dating or detection of fetal anomalies, the goals of point-of-care ultrasound are limited by design. These studies seek to quickly, but accurately, answer very focused questions and, by necessity, must be narrow in scope. Point-of-care ultrasound can be used for identifying early pregnancy location (intrauterine vs. ectopic vs. indeterminate), gestational dating, and limited fetal biometry.

### Image Acquisition

Ultrasound images in early pregnancy can be acquired in two ways, transabdominally and transvaginally. Transvaginal ultrasound (TVUS) is more sensitive due to the probe's proximity to the uterus, but it requires placement of a sterile probe cover, emptying of the bladder, and appropriate positioning of the patient. Transabdominal

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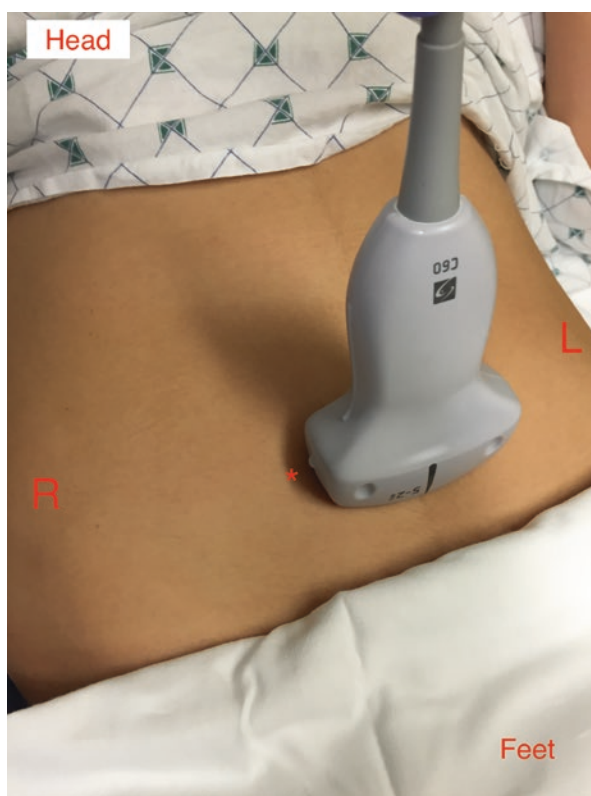
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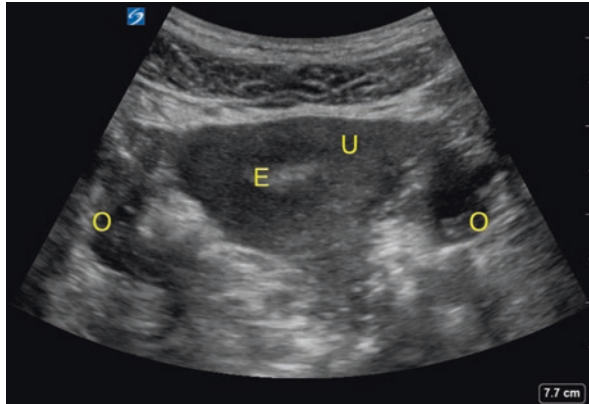
ultrasound (TAUS), by comparison, is faster and easier but provides lower-resolution images, so very early intrauterine gestations may not be detectable by this method. The authors recommend using TAUS as the initial imaging modality in all pregnant patients because it is less invasive, but inconclusive TAUS should be followed by TVUS.

### *Transabdominal Technique*

TAUS is best performed with a low-frequency (2–5 MHz) curvilinear probe because of the wide footprint and deep tissue penetration. Because the probe is distant from the tissues of interest, imaging improves with a full bladder because this fluid provides a good acoustic medium for ultrasound wave propagation. With any point-of-care ultrasound, the authors adhere to the convention of orienting the probe with the indicator either toward the patient's right side or toward the patient's head. For transverse (axial/coronal) TAUS views, the probe should be oriented to the patient's right and placed in the suprapubic region of the abdomen at midline as shown in Fig. 2.1. The probe should then fan superiorly and inferiorly to obtain a complete view of the uterus (Fig. 2.2).



**Fig. 2.1** Transabdominal ultrasound, transverse view. Note probe orientation with dot indicator (\*) to patient's right side



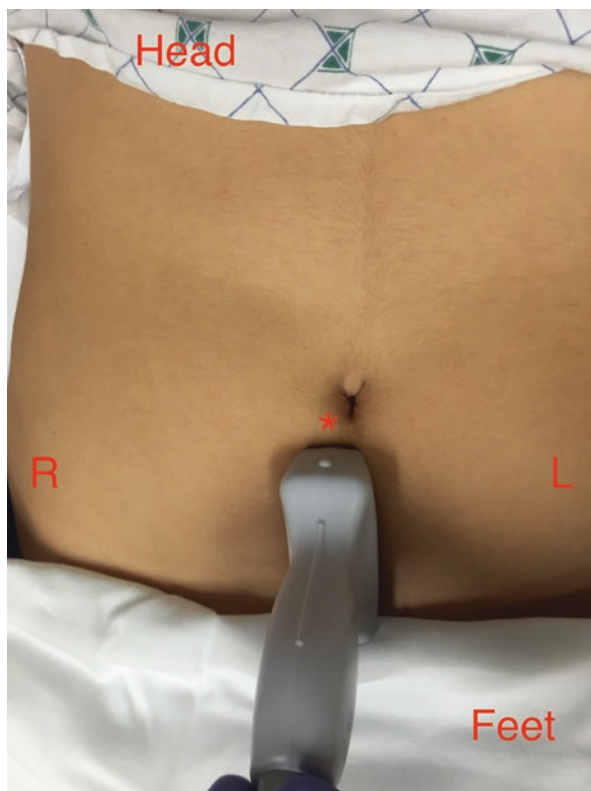
**Fig. 2.2** TAUS transverse view. The uterus (U) is seen in the center of the image with its hyper-echoic endometrial stripe (E). The ovaries (O) are seen laterally

Incomplete imaging of the uterus may miss important findings, such as twin gestations or free fluid. A longitudinal (sagittal) view of the uterus should also be obtained by orienting the probe vertically and fanning side to side (Fig. 2.3). This view is best for evaluating the cervix and endometrial stripe and may allow easier detection of free fluid in the cul-de-sac (Fig. 2.4).

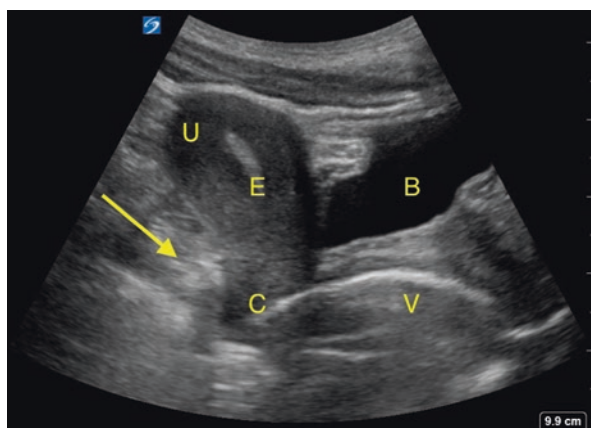
Bilateral adnexal imaging in the transverse plane is also critical in early pregnancy, because the vast majority of ectopic pregnancies are located in the adnexa [1]. An adequate adnexal view should contain the uterus medially and the pelvic brim laterally, with the iliac vessels visualized between these structures (Fig. 2.5). The ovary and, if fluid filled, the fallopian tube may be seen in this area but are not always visible with TAUS due to the lower overall image resolution. If an intrauterine pregnancy (IUP) is detected, calculations of gestational age and fetal heart rate should also be performed. These techniques will be discussed later in more detail in the sections on dating and fetal biometry.

### ***Transvaginal Technique***

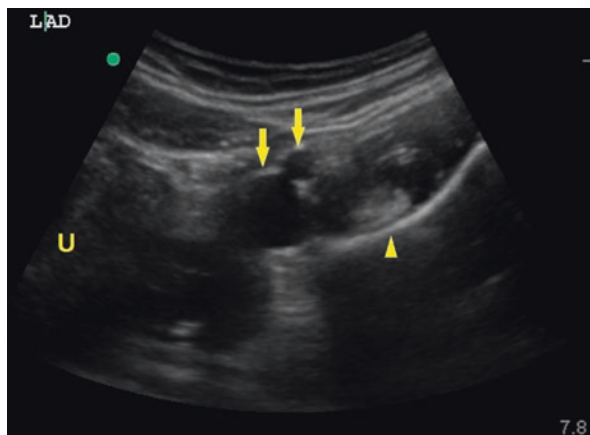
TVUS imaging provides greater detail than TAUS because the endocavitary probe has a higher frequency (5–8 MHz), allowing better imaging of more superficial structures, and is placed directly against the cervix by insertion into the vaginal canal. As mentioned earlier, TVUS requires the use of a sterile probe cover and sterile gel to protect the patient from contamination by the inserted probe. Because the probe lies against the cervix, a full bladder confers no benefit and can actually impair imaging by deflecting the uterus superiorly/posteriorly and away from the probe. For this reason, patients should empty their bladder immediately before TVUS. When inserting the probe, a common error is to advance too deeply and lodge the probe in the posterior fornix, preventing any view of a typical anteverted uterus. To avoid this, look to the screen immediately after probe insertion and



**Fig. 2.3** Transabdominal ultrasound, longitudinal view. Note probe orientation with dot indicator (\*) to patient's head

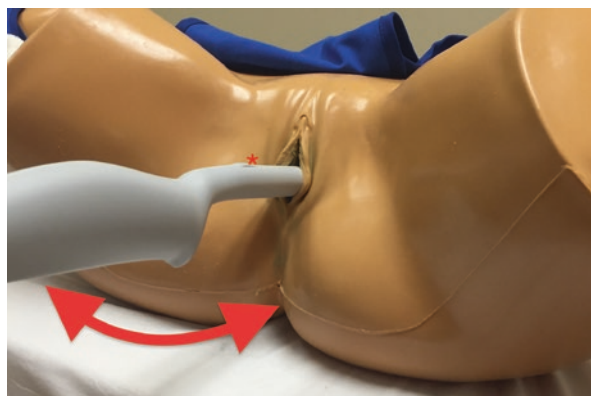


**Fig. 2.4** TAUS longitudinal view. The uterus (U) is seen in the center of view with the hyper-echoic endometrial stripe (E) and cervix (C) deep to the fundus. The anechoic bladder (B) is seen anteriorly to the vaginal vault (V). Note the potential space of the cul-de-sac (arrow), which can be replaced with free fluid



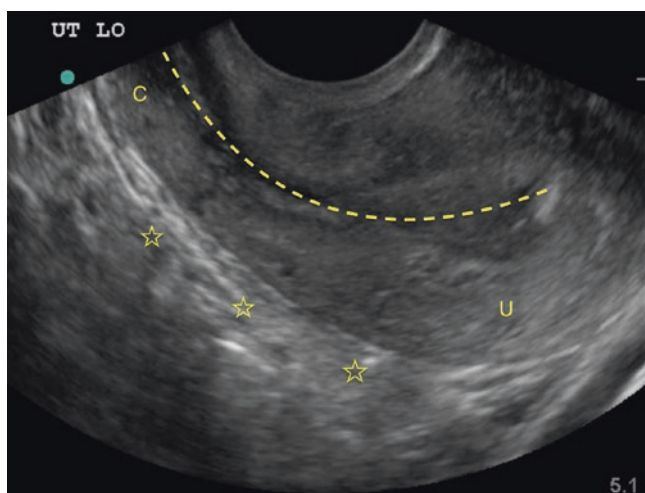
**Fig. 2.5** TAUS adnexal view in the transverse plane. The region of interest is bordered by the uterus (U) medially and the pelvic brim (*arrowhead*) laterally, with the iliac vessels (*arrows*) located in between

**Fig. 2.6** Endocavitary probe orientation, sagittal view. Note the probe dot indicator (\*) is pointed superiorly to acquire sagittal views of the pelvis. The probe is swept horizontally left and right to image the pelvic organs



continue to watch the screen as you advance the probe. If there is difficulty locating the uterus after insertion, slowly pull back and/or adjust the angle of the probe. Positioning of the endocavitary probe is similar to the mechanics of a speculum exam and should be adjusted the same way. When in position, the probe indicator should be pointed either toward the ceiling (Fig. 2.6) or the patient's right by turning the probe in a counterclockwise direction (Fig. 2.7). For longitudinal, or sagittal, views, the indicator will be toward the ceiling and the probe will fan from side to side to visualize the entire uterus (Fig. 2.8). For transverse, or coronal, views, the probe indicator will be oriented to the patient's right and should fan anteriorly and posteriorly through the uterus (Fig. 2.9). Adnexal views are best obtained in the transverse orientation and are analogous to the TAUS adnexal views with the uterus located medially, the pelvic brim laterally, and the ovary and iliac vessels in between (Fig. 2.10).

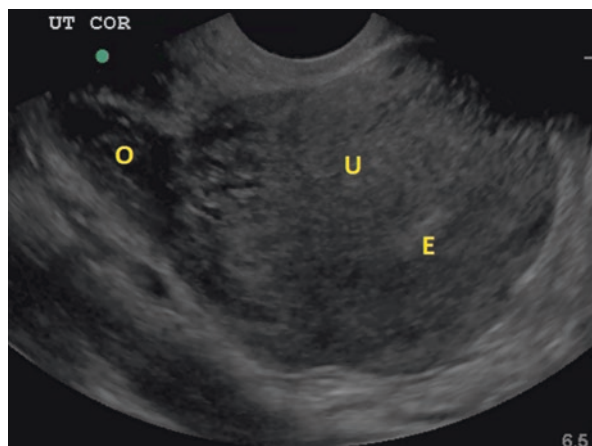
**Fig. 2.7** Endocavitary probe orientation, coronal view. Note the probe dot indicator (\*) is pointed to the patient's right to acquire coronal views of the pelvis. The probe is swept superiorly and inferiorly to investigate the pelvic organs in the coronal view



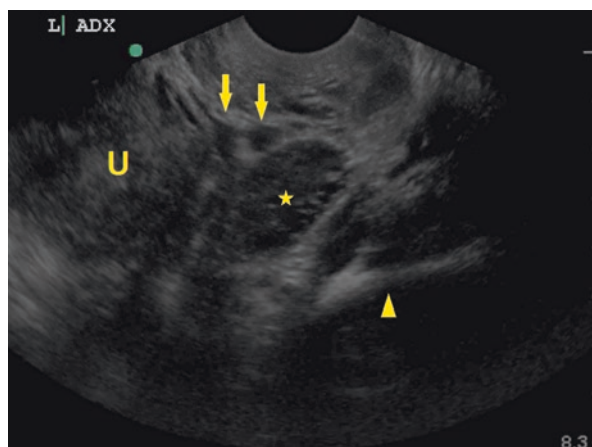
**Fig. 2.8** TVUS longitudinal/sagittal view. The uterus (U) is seen closest to the endocavitary probe foot print. The cervix (C) is seen at the left of the image and the endometrial stripe (*dotted line*) traverses the uterus. Deep to the uterus is the cul-de-sac (*stars*), which should be investigated for anechoic free fluid



**Fig. 2.9** TVUS transverse view. The right ovary (O) is visualized adjacent to the uterus (U). In this orientation, a limited view of the hyperechoic endometrial stripe (E) is also obtained



**Fig. 2.10** TVUS adnexal view in the transverse plane. The left ovary (*star*) lies in its usual position lateral to the uterus (U) between the iliac vessels (*arrows*) and the pelvic brim (*arrowhead*)



## Application of Point-of-Care Ultrasound to the Pregnant Emergency Department Patient

Numerous studies have shown that with sufficient training, emergency physicians can use point-of-care ultrasound as a clinical tool for the rapid, bedside assessment of pregnant patients with the primary goal of determining pregnancy location—*intrauterine, ectopic, or indeterminate (pregnancy of unknown location)* [2–5].

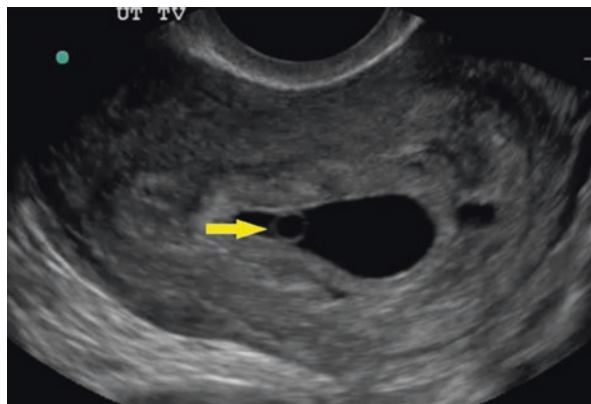
Patients without demonstrated intrauterine gestations are at high risk for ectopic pregnancy, so early identification of these patients is crucial to providing timely, and sometimes lifesaving, care. On the other hand, detection of an intrauterine pregnancy can reassure, in the case of a stable patient, or direct efforts toward the diagnosis and management of a different condition in the unstable patient.

### *Intrauterine Pregnancy*

The ultrasound finding easiest to interpret in early pregnancy is a normal intrauterine pregnancy (IUP). The authors define an IUP as a gestational sac containing, at a minimum, a yolk sac with or without the presence of an identifiable fetal pole. Historically, the presence of a double decidual sign (concentric hyperechoic and hypoechoic rings surrounding a fluid-filled sac) was considered the earliest sign of an IUP, but studies have shown this to be potentially deceptive, as this finding correlates poorly with actual presence of an IUP [6]. Therefore, the authors consider an empty sac within the uterus to be nondiagnostic, as discussed in more detail in the section on indeterminate location.

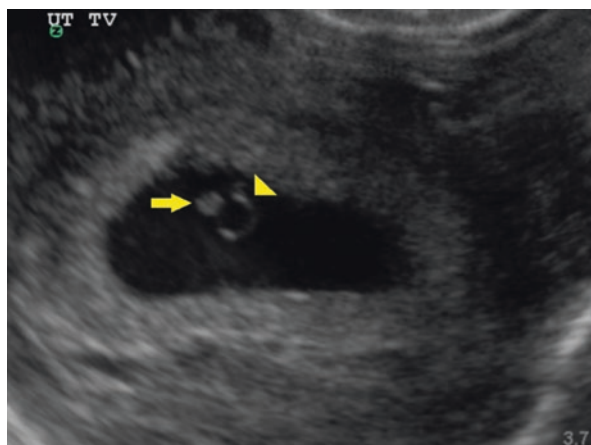
A yolk sac is the earliest sign of an IUP, detectable as early as the fifth week of gestation by TVUS, and appears as a circular structure within a fluid-filled sac, sometimes casually referred to as a “sac within a sac” or a “cheerio” due to its similarity to the breakfast cereal (Fig. 2.11) [7, 8]. Three to 4 days after the development of the yolk sac, a fetal pole can first be detected, with cardiac activity visible starting at 6 weeks [9]. At this early stage of pregnancy, a normal fetal pole will be immediately adjacent to the yolk sac, sometimes appearing contiguous with the sac’s wall (Fig. 2.12). Of note, special consideration is necessary with patients using assisted reproductive technology because they are at much higher risk for heterotopic pregnancy (simultaneous IUP and ectopic pregnancy) than the general population (approximately 1 in 100 vs. 1 in 4000–30,000). These patients require comprehensive radiology imaging, even when an IUP is seen at the bedside [10–14].

**Fig. 2.11** TVUS view with yolk sac (arrow)

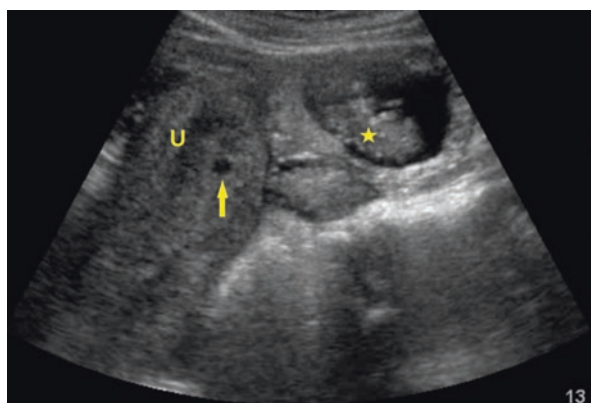




**Fig. 2.12** TVUS view with yolk sac (arrowhead) and small adjacent fetal pole (arrow)



**Fig. 2.13** TAUS view in the transverse plane with large ectopic pregnancy (star) visible in the left adnexa. A small pseudogestational sac (arrow) is seen within the uterus (U)



## ***Ectopic Pregnancy***

Although ectopic pregnancy should always be considered whenever an IUP is not detected, in some cases, the ectopic can be directly visualized using point-of-care ultrasound. For this reason, careful inspection of the adnexa is a vital component of any bedside exam. As discussed in the previous section, a fluid-filled sac within the uterus is not sufficient for diagnosis of an IUP because the hormonal changes that accompany pregnancy of any location may cause the development of intrauterine fluid collections, known as “pseudosacs,” in up to 20% of ectopic pregnancies [15, 16]. Figure 2.13 shows an example of a large fetus in the left adnexa with a small pseudosac in the otherwise empty uterus that could have been mistaken for an IUP.

When an ectopic is detected (or suspected), additional focused assessment with sonography in trauma (FAST) views (right upper quadrant, left upper quadrant) of the abdomen should also be obtained to evaluate for free fluid (Fig. 2.14). Although a small amount of pelvic free fluid is common in normal pregnancies, the presence

**Fig. 2.14** Right upper quadrant FAST view from a patient with a ruptured ectopic demonstrating free fluid (*star*) in Morison's pouch between the liver (L) and kidney (K)



of free fluid in an unstable patient or patient with suspected ectopic should prompt immediate OB/GYN consultation. The characteristics of the fluid are also important, as studies have shown that the presence of echogenic fluid is very sensitive for the presence of hemoperitoneum [17, 18].

### ***Pregnancy of Unknown Location***

When no IUP is identified and a clear ectopic pregnancy is not detected, this is defined as a pregnancy of unknown location (PUL). These patients may have normal pregnancies that have not yet developed to a stage that is visible by TVUS, may be experiencing a spontaneous miscarriage, or they may have an ectopic pregnancy that is not yet detectable by imaging. For emergency physicians, the greatest concern is an ectopic pregnancy; however, hasty designation of an abnormal pregnancy without definitive proof may lead to the unnecessary disruption of an otherwise viable pregnancy.

A great deal of study and debate has recently emerged surrounding the concept of the discriminatory zone, and its utility has been called into question [19]. The discriminatory zone is the level of beta-hCG at which an IUP, if present, should be seen consistently. For TVUS, the discriminatory zone is generally accepted as between 1000–2000 IU/mL. Previous practice was to use  $\beta$ -HCG levels to determine the utility of ultrasonography—i.e., levels below the discriminatory zone did not warrant imaging because, presumably, no IUP was likely to be detected. Recent studies have found fault with this practice. In one study, deferring imaging due to  $\beta$ -HCG levels below the discriminatory threshold delayed diagnosis of ectopic pregnancy by more than 5 days [20]. In another study, ectopic pregnancies were present in as many as 40% of patients with  $\beta$ -HCG levels below the discriminatory zone [21].

Using a discriminatory threshold to exclude a viable pregnancy is also problematic. Wang et al. [22] were unable to identify any  $\beta$ -HCG level above which 100% of IUPs could be visualized. Other studies have shown that normal intrauterine pregnancy is subsequently possible above the discriminatory zone, even if an IUP is not yet visualized on TVUS [23, 24]. Therefore, caution should be used when interpreting a single beta-hCG measurement. The current American College of Emergency Physicians (ACEP) clinical policy is to obtain or perform a pelvic ultrasound on all patients presenting in early pregnancy with abdominal pain or vaginal bleeding regardless of the  $\beta$ -HCG levels, which should not be used to defer imaging or rule out ectopic pregnancy [25]. There is no beta-hCG level in which an ectopic pregnancy can be completely ruled out. If the patient is hemodynamically stable, it is appropriate to repeat beta-hCG measurements and consider repeating TVUS in 48 hours instead of initiating treatment for possible ectopic pregnancy based on the discriminatory zone alone.

## **Secondary Applications of Point-of-Care Ultrasound in Early Pregnancy**

Although the main objective of bedside ultrasonography in early pregnancy is the determination of pregnancy location, other useful information can be obtained with little additional effort. Comprehensive fetal assessment is beyond the scope of a point-of-care scan, but dating and measurement of cardiac activity are appropriate extensions of a limited bedside exam.

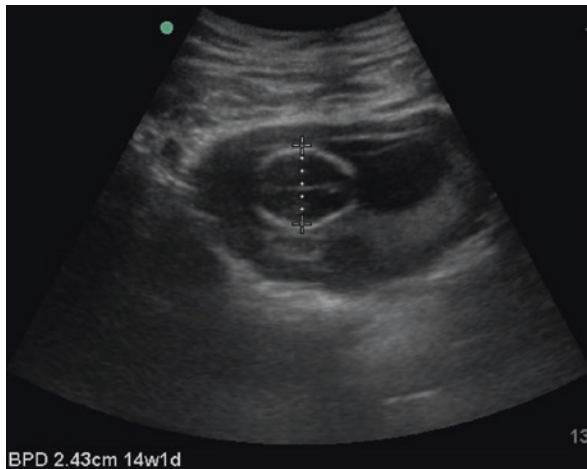
### ***Fetal Gestational Dating***

Because calculations of gestational age are more accurate early in pregnancy, these measurements are useful to patients and their obstetricians and should be obtained when possible. The crown-rump length (CRL) is the best method for dating within the first trimester and is accurate up to 14 weeks gestation [26–32]. As shown in Fig. 2.15, an appropriate CRL measurement is a straight line drawn from the crown of the head to the rump, taking care not to include limb buds or the yolk sac. For the most accurate measurement, adjust the probe to obtain a view of the fetus in its longest orientation.

When the patient has reached her second trimester, biparietal diameter (BPD) is the preferred dating measurement. This method is most accurate between 14 and 20 weeks gestation ( $\pm 7$  days within this window) but declines in accuracy as the pregnancy progresses beyond these dates [32–35]. An accurate BPD should be measured in the axial orientation in plane with the third ventricle and bilateral thalami by drawing a line from the innermost edge of the posterior calvarium to the outermost edge of the anterior calvarium (Fig. 2.16). This convention prevents exaggeration of



**Fig. 2.15** Crown-rump length, TAUS image (zoomed in)



**Fig. 2.16** Biparietal diameter, TAUS image

the measurement by acoustic enhancement of the posterior calvarium, an artifact that makes the calvarium's thickness appear greater and artificially increases the BPD.

Other methods can also be used for gestational dating in the second and third trimester, but are not as accurate as the BPD [36]. Examples include femur, tibia, or humerus length, in which the bone is captured in its longest orientation and the full length of the cortex is measured, or head or abdominal circumference, in which an appropriate axial view of the structure is outlined for calculation of the circumference.

On occasion, the BPD may be difficult to obtain due to fetal positioning, and femur length is an acceptable alternative, though this measurement may be off by as much as 1–3 weeks [29].

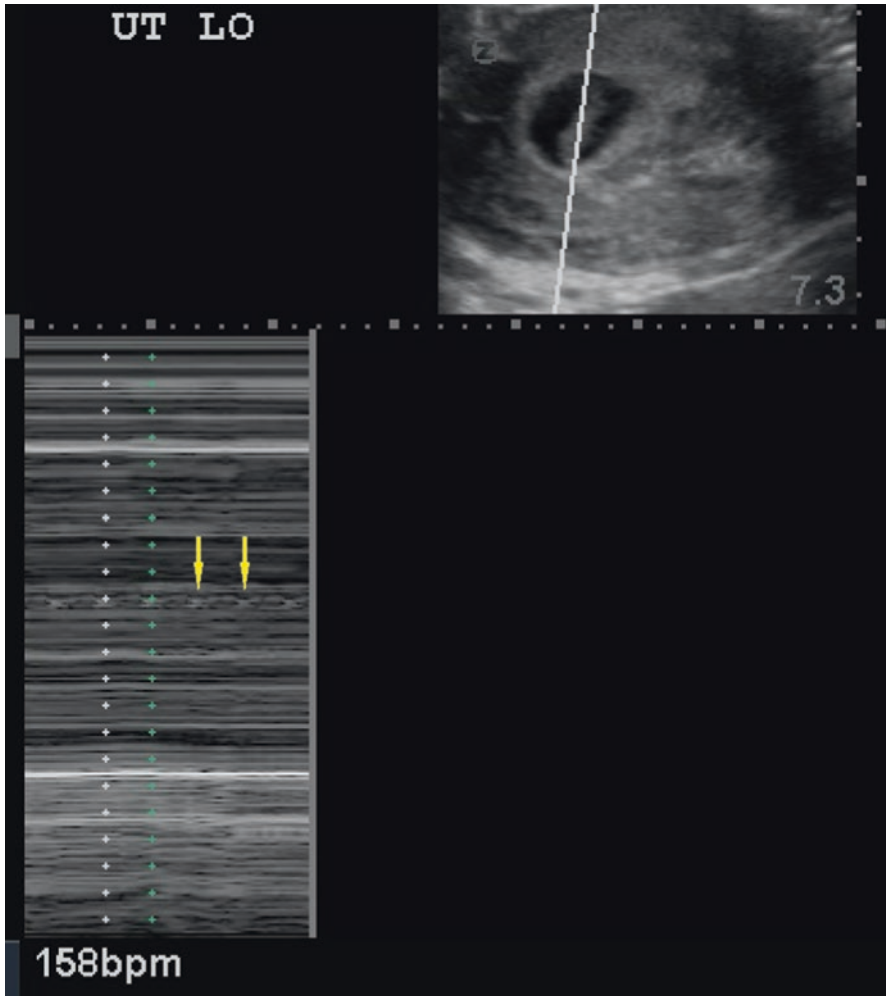
## ***Fetal Biometry***

In addition to dating, ultrasound is also useful for the detection and measurement of fetal cardiac activity. The first step is to look for the presence of cardiac movement, which may be detectable by TVUS as early as 6 weeks. Cardiac activity appears as a rhythmic flicker within the fetal pole in early gestations or varying degrees of cardiac anatomy in more advanced pregnancies. When this activity is detected, the next step is to measure the rate of activity, which can have prognostic value when abnormal. Normal fetal heart rates should be >100 beats per minute before 6.3 weeks or >120 bpm after 6.3 weeks; fetal bradycardia is associated with poor outcomes, including fetal loss [37]. Fetal tachycardia is typically defined as rates >160–180 bpm. The prognosis for fetal tachycardia is good, often resolving spontaneously without intervention [38].

To measure fetal heart rate, M-mode is used, which follows the changes in position of one portion of the image over time. The area of interest is first identified in the standard 2D B-mode. When M-mode is applied, a line appears on the screen and should be placed directly across the fetal heart. Activating M-mode measurement plots out the changes in position of the selected area over time, which looks like a series of horizontal lines and waves. Because the heart is moving, its position will change rhythmically and can be detected as a wavelike pattern. The rate can then be measured by placing the calipers at the same place on two consecutive waves, which represent cardiac cycles (Fig. 2.17). Due to concerns about the higher thermal energy used for spectral Doppler, the authors do not employ this method for measuring cardiac activity and recommend against its use [39, 40].

## **Summary**

Point-of-care ultrasound is a useful tool for rapid assessment of the pregnant emergency department patient. Two methods can be used for image acquisition, transabdominal and transvaginal imaging, and must be employed whenever the location of the pregnancy is in doubt. The primary goal of bedside ultrasound in the pregnant patient is to identify an intrauterine pregnancy and an ectopic pregnancy or, when neither can be visualized, to designate a pregnancy of unknown location. In patients



**Fig. 2.17** Fetal heart rate measurement using M-mode. The 2D view is shown in the upper portion of the screen, while the M-mode output is below. The *dotted lines* are placed at two consecutive cycles (cycles emphasized by *arrows*) to calculate a rate of 158 bpm (*lower left*)

with hemodynamic compromise and in whom pretest probability for ectopic pregnancy is high, further evaluation for free fluid and prompt OB/GYN consultation should occur. There is no beta-hCG level at which an ectopic pregnancy can be completely ruled out, and ultrasound should be obtained in all patients presenting in early pregnancy with abdominal pain or vaginal bleeding. When possible, gestational dating and measurement of fetal heart rate should be performed to guide obstetric management.



## Key Points

- Perform transabdominal imaging before proceeding to transvaginal imaging to prevent unnecessary TVUS.
- Intrauterine pregnancy is defined as a gestational sac containing, at a minimum, a yolk sac with or without the presence of an identifiable fetal pole. A gestational sac without a yolk sac and/or fetal pole may be a pseudosac and cannot exclude the presence of an ectopic pregnancy.
- Do not use  $\beta$ -HCG levels to rule in *or* rule out ectopic pregnancy—always get an ultrasound when pregnancy location is in doubt.
- Patients using assisted reproductive technology are at higher risk of heterotopic pregnancy and should undergo comprehensive radiology ultrasound if stable.
- Crown-rump length is measured for dating in the first trimester. Biparietal diameter is the preferred measurement in the second trimester and beyond.
- Measure fetal heart rate using M-mode—spectral Doppler confers a theoretical risk of thermal injury to the fetus.

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