Ultrasound examination in obstetrics and gynecology

Author: Thomas D Shipp, MD, RDMS
Section Editors: Susan M Ramin, MD, Deborah Levine, MD
Deputy Editor: Vanessa A Barss, MD, FACOG

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INTRODUCTION — The term "ultrasound" refers to sound waves of a frequency greater than that which the human ear can appreciate, namely frequencies greater than 20,000 cycles per second or Hertz (Hz). To obtain images of the pregnant or nonpregnant pelvis, frequencies of 2 to 10 million Hertz (2 to 10 megahertz [MHz]) are typically required.

Real-time imaging is the most common sonographic technique used in obstetrics and gynecology. Multiple individual B-mode gray-scale images are obtained and rapidly displayed in succession, thereby creating a video of the area of interest over time that can be used to evaluate its structure and some aspects of its function. Real-time ultrasound is especially useful for imaging mobile subjects, such as the fetus or heart, and for quickly viewing an organ from different orientations.

The physical principles of ultrasound imaging are discussed separately. (See "Basic principles and safety of diagnostic ultrasound in obstetrics and gynecology".)

BASIC PROCEDURE AND EQUIPMENT — Sonography, like surgery, is an operator-dependent technology. A high level of competence can only be achieved by supervised experience with a large variety of normal and abnormal examinations.

Preprocedure issues — The sonographer should know the reason for the ultrasound examination and results of other evaluations related to the patient's problem. All of this information is critical for targeting specific structures, choosing whether to use a transvaginal and/or transabdominal technique, and deciding whether additional studies may be helpful (eg, saline infusion sonohysterography, Doppler velocimetry).

In the past, patients were routinely asked to fill their bladders prior to the ultrasound examination. With improvements in ultrasound technology and use of the vaginal probe, this has become unnecessary [1]. There is little benefit to having a full bladder for obstetrical exams and it is often very uncomfortable for the patient. Furthermore, a full bladder can distort anatomy (eg, false diagnosis of placenta previa or falsely elongated cervix). The cervix can usually be seen transabdominally without a full bladder. If it cannot be seen transabdominally, transvaginal sonography almost always provides satisfactory images. Similarly, if transabdominal visualization of the pregnancy is inadequate in the first trimester, transvaginal sonography will almost always show more detail. In most cases it is optimally performed with an empty bladder; however, when the lower uterine segment or related structures are the area of interest, urine in the bladder can provide a helpful window for the evaluation.

In gynecologic patients, not allowing the patient to empty whatever urine is in her bladder just prior to a transabdominal ultrasound examination generally permits sufficient initial visualization of the pelvis. Transvaginal sonography is usually performed with an empty bladder.

Obesity — Abdominal obesity limits the technical quality of the ultrasound examination. Imaging may be improved by having the patient lie on her side and placing the transducer at the side of the maternal abdomen rather than in the midline where there is greater thickness of abdominal adipose tissue and/or by use of transvaginal ultrasound. Although fetal anatomic surveys for malformations are typically performed at 18 to 20 weeks, performing transabdominal examination later in gestation (20 to 22 weeks) in the obese gravida may improve visualization of anatomy [2]. However, transvaginal ultrasound of fetal anatomy may be more effective earlier.

Patient position — In obstetrics and gynecology, most exams are performed with the woman in a semi-recumbent position. A padded table and pillows provide reasonable comfort. It is desirable to be able to elevate the head of the bed because many pregnant women are unable to lie flat, especially later in pregnancy. Others will require pillows underneath their knees or behind their back to achieve a comfortable position.

Transvaginal ultrasound examinations are done with the woman in a lithotomy position. Alternatively, a cushion can be placed under the buttocks to raise the pelvis, while the lower extremities are frog-legged.

Gel — Ultrasound waves pass very poorly through air; therefore, coupling gel is necessary. The gel, which is placed on the patient's skin for transabdominal scans and on the covered probe for transvaginal scans, prevents air from coming between the transducer and the patient. The gel also permits the ultrasound probe to gently slide over the abdomen or along the vagina. Warming the gel in a commercial warming device improves patient comfort.

Transducers and probes — The transducer is located inside the ultrasound probe. The most common transducers used for transabdominal scanning are sector or curvilinear transducers that have frequencies up to 7.0 or 8.0 MHz [3]. Transducers used for transvaginal scanning typically have frequencies up to 9.0 MHz. It is important to keep in mind that higher frequency transducers provide superior resolution, but have less tissue penetration. This trade-off is important for achieving images of diagnostic quality.

Standard orientation when performing an ultrasound examination allows a consistent optimal interpretation of the ultrasound findings. The transabdominal ultrasound probe is held in the right hand with the mark (ie, a groove or ridge on one side of the ultrasound transducer) on the thumb side. With this orientation, the right side of the patient is displayed on the left side of the ultrasound imaging screen. The top of the image (the small angled portion) represents structures that are closer to the transabdominal ultrasound transducer, and the bottom of the image (the wide pie shaped perimeter) represents structures further away from the transducer. Because the ultrasound probe can be maneuvered from many different vantage points, the image orientation is only limited by the flexibility of the hand holding the ultrasound probe.

Transvaginal ultrasound probes differ from transabdominal probes. With a transvaginal probe, the ultrasound beam can project at an angle from the axis of the probe. The mark on the probe represents the left side of the screen. Therefore, if the probe is inserted into the vagina and the mark is held at 12:00, the left side of the image display represents the anterior aspect of the pelvis, and the right side represents the posterior aspect of the pelvis. The top of the image (the small angled portion) represents structures that are closer to the transvaginal ultrasound transducer, and the bottom of the image (the wide pie shaped perimeter) represents pelvic structures further away from the transducer. When the probe is rotated with the mark at 9:00, the orientation is quite different. The inferior and superior portions are unchanged, but the left and right sides of the screen now represent the right and left aspects of the pelvis, respectively. The transvaginal probe can be both rotated and angled to both sides of the pelvis. This maneuvering can be disorienting to inexperienced examiners, yet is essential for a complete examination of the female pelvis.

It may be more comfortable for the patient if she inserts the transvaginal probe into her vagina herself. A disposable probe cover (eg, male condom) is used to keep the transvaginal probe clean during examinations [4]. After each use, transvaginal probes are cleaned and disinfected according to the manufacturer recommendations. The goal of preparing transvaginal ultrasound transducers for patient use is to achieve a high-level of disinfection. This is accomplished by removing the disposable probe cover and using running water to remove any debris. A cloth or similar pad can be used to clean and dry the transvaginal probe. The probe is then disinfected with a high-level disinfectant to provide maximum safety for reuse in the next patient. There are many such disinfectants, including 2.4 to 3.2 percent glutaraldehyde products, such as "Cidex," "Metricide," and "Procide," non-glutaraldehyde products, such as "Cidex OPA" and "Cidex PA," and 7.5 percent hydrogen peroxide solution [4].

Manual settings — Several parameters require manual adjustment to obtain optimal images because patients differ in body shape and in the area targeted for examination (eg, cul-de-sac, upper abdomen, kidney).

- The size of the image field should be adjusted to obtain the best visualization. The area of interest should be enlarged to allow for critical evaluation.
- The depth of penetration should be adjusted for thorough assessment of the structure of interest and its environment. If set high, a broad anatomic area can be seen, but individual structures will be small, indistinct, and 'far away,' while at low settings, the image will be seen 'close up' and detailed, but surrounding structures will not be visualized. Depending on the area of interest, the depth of penetration will typically be adjusted many times during an ultrasound examination to both obtain a broad view and to hone in on specific structures.
- The focal zone should be electronically adjusted to enhance visualization of structures at the depth being evaluated. The transmit zone focus should be manually placed at, or just below, the level of the structure of interest.
- The gain should be adjusted to achieve an appropriate level of brightness. Turning the gain up too high will make the image too bright, and turning it down too low will make the image too dark. There is progressive loss of amplitude and intensity of returning sound waves when imaging structures that are at greater distances from the probe. This loss varies with the particular tissue being insonated. Echoes from deeper structures can be amplified or enhanced to improve visualization. Similarly, excessive reverberant echoes can be decreased by turning down the gain, thus raising the threshold for echo detection at a particular level. This is accomplished by using the time-gain-compensation (TGC) knobs, which are adjusted to change the brightness at various levels of the image [3,5]. Some newer ultrasound machines have an automatically adjusting gain feature. This may be especially helpful for those with less experience, and for those patients who are more difficult to insonate, such as obese women or those with prior abdominal surgery.

- Tissue harmonic imaging is an ultrasound technique that enhances visualization of structures that may not have been visualized clearly with standard gray-scale imaging [6]. Standard two-dimensional gray-scale ultrasound uses a certain fundamental frequency, specific to the transducer. The returning echoes are detected at this frequency. Harmonic frequencies occur as the sound wave moves through tissues and are formed in multiples of the fundamental frequency. The first harmonic, which is twice the fundamental frequency, is used for tissue harmonic imaging. These harmonic frequencies increase with more penetration of the ultrasound beam, and they are at lower amplitude than the fundamental frequency. The inclusion of these harmonic frequencies results in an image with better contrast. Tissue harmonic imaging is especially helpful in obstetrics and gynecology in the obese patient when visualization is limited [5,7].

Scanning and documentation — The patient's name, medical record number, date of exam, referring clinician, and reason for referral should be documented. It is best to start the examination by getting an overall view of the uterus in an obstetrical ultrasound examination or the pelvis in a gynecologic examination. After this global view, the exam can focus on specific aspects of anatomy. To accomplish this overall view, the depth of penetration should be great enough to allow for a broad view of the uterus and pelvis. Without this global view, important aspects of the examination could be missed (eg, large pedunculated fibroids or large ovarian dermoids).

Almost all obstetrical and gynecologic sonography is done in real-time, freely moving the probe to view each structure from multiple orientations and then freezing and storing the desired images. Most ultrasound systems can reevaluate the last few seconds of images by scrolling through them as slow as frame-by-frame in a cine loop. Short clips of mobile structures, such as the fetal heart, are also commonly kept as part of the patient's record. Images of both normal and abnormal anatomy, including size measurements where appropriate, should be stored. Biometric measurements are typically performed on the display monitor from a frozen image. (See "Prenatal assessment of gestational age and estimated date of delivery".) The ultrasound images should be retained as long as clinically useful and consistent with local legal requirements.

A written ultrasound report should be included in the patient's medical record, and sent to the referring clinician in a timely fashion [8-10]. Clinically significant findings should be called to the referring clinician to ensure and facilitate appropriate follow-up. Emergent findings should be called to the referring clinician while the patient is still in the ultrasound facility or en route to the physician's office or hospital.

ADVANCED TECHNIQUES — Additional clinical techniques are used selectively to provide further evaluation of uncertain findings on real time grey scale two dimensional sonography [6].

Three-dimensional sonography — Three-dimensional sonography refers to a two-dimensional static display of three-dimensional data. Special probes and software are needed to acquire and render the images. Although not a new technique, the indications for its use have not been well-defined [5]. The use of three-dimensional technology can reduce scanning time while maintaining adequate visualization of the fetus in obstetrical ultrasound and the pelvis in gynecologic ultrasound [11-13]. Surface rendering of the fetus with three-dimensional sonography can better demonstrate abnormalities previously detected with two-dimensional sonography, especially facial abnormalities and neural tube defects. Fetal central nervous system three-dimensional data sets can be examined remotely to diagnose fetal brain malformations [14].

In gynecology, the coronal plane of the uterus is easily obtained with three-dimensional but not two-dimensional sonography, thus enhancing visualization of the uterus, especially the uterine cavity. This has improved the capabilities for the sonographic diagnosis of uterine anomalies [15].

Three-dimensional sonography has been used to identify malposition of an intrauterine device (IUD), especially among symptomatic patients [16].

Four-dimensional sonography — Four-dimensional sonography refers to three-dimensional images that can be viewed in real-time. It is also called dynamic three-dimensional sonography. It has been used to study the fetal heart, fetal movement, and fetal behavioral states.

Sonohysterography — Saline infusion sonohysterography refers to a procedure in which fluid is instilled into the uterine cavity transcervically to provide enhanced endometrial visualization during transvaginal ultrasound examination. (See "Saline infusion sonohysterography".)

Doppler ultrasound — Real-time ultrasound is primarily used to evaluate morphology, and is especially useful for studying the anatomy of moving objects, such as the fetus. By comparison, Doppler ultrasound is used to study blood flow and is particularly helpful in evaluating the functional state of the fetal cardiovascular system, fetoplacental and uteroplacental blood flow, and pelvic tumors. Specific uses of Doppler sonography are for evaluation of fetal anemia by assessing peak systolic flow in the middle cerebral artery, for evaluation of uteroplacental insufficiency in fetuses with growth restriction, and for assessing blood flow to suspected ovarian tumors among menopausal women. Doppler color flow mapping uses different colors to depict the direction of flow on a real-time ultrasound image. Power Doppler enables visualization of slower flow in small vessels without differentiating the direction of blood flow.

Doppler ultrasound and specific uses of Doppler ultrasound are discussed in detail separately:

- (See "Doppler ultrasound of the umbilical artery for fetal surveillance".)
- (See "Ultrasound differentiation of benign versus malignant adnexal masses".)
- (See "Management of pregnancy complicated by Rhesus (D) alloimmunization", section on 'Assess for severe anemia in fetuses at risk'.)

TELEMEDICINE — Both two-dimensional ultrasound images and three-dimensional data sets can be sent electronically for evaluation by experts [11-13] or to facilitate consultation between a patient or referring physician and a specialist [17]. The transmission and sharing of ultrasound images and volumes can be easily accomplished using the Digital Imaging and Communications in Medicine (DICOM) protocol [17]. The provision of such consultative services to resource-poor or remote areas allows patient care to occur that may not have happened, except under more difficult circumstances.

OBSTETRICAL SONOGRAPHY — The benefits and limitations of ultrasonography should be discussed with all patients. Obstetrical ultrasound provides information about the pregnancy that is essential for providing optimal prenatal care: accurate determination of gestational age, fetal number, cardiac activity, placental localization, and diagnosis of major fetal anomalies. In the second trimester, fetal anomaly detection rates range from 16 to 44 percent, with detection rates up to 84 percent for lethal anomalies [18]. Ultrasound examination also improves the detection of fetal growth disturbances and abnormalities in amniotic fluid volume; however, a beneficial impact on pregnancy outcome has not been proven.

The American College of Obstetricians and Gynecologists has recommended ultrasound examination for all pregnant patients [19].

Indications — Specific obstetrical indications for ultrasound examination by trimester are listed in the table (table 1) [19]. More than one examination is indicated for patients with ongoing risk factors for adverse pregnancy outcome.

Aneuploidy screening examinations can be performed in the first and/or second trimester. A fetal structure screening examination is typically performed in the second trimester. If a single screening examination is performed, the optimal time is at 18 to 20 weeks of gestation [18]. This represents a balance between accurate dating of gestational age and detection of fetal anomalies. (See "Routine prenatal ultrasonography as a screening tool".)

Basic examination — A basic obstetrical ultrasound examination provides the following information [19-21]:

- Fetal number (chorionicity if multiple gestation)
- Fetal biometry
- Fetal presentation
- Documentation of fetal cardiac activity
- Placental appearance and location
- Assessment of amniotic fluid volume
- Survey of fetal anatomy (lateral ventricles, choroid plexus, falx, cavum septi pellucidi, cerebellum, cisterna magna, upper lip, four chamber cardiac view and ventricular outflow tracks, stomach, kidneys, bladder, cord insertion site at abdomen and number of cord vessels, spine, limbs, genitalia in multiple gestations [when medically indicated])
- Maternal anatomy (cervix, uterus, adnexa)

Fetal biometry is used to estimate gestational age and fetal weight, as appropriate for the stage of pregnancy. (See "Prenatal assessment of gestational age and estimated date of delivery" and "Prenatal sonographic assessment of fetal weight".)

ACOG recommends examining the uterus, cervix, and adnexa when technically feasible [19]. The American Institute of Ultrasound in Medicine (AIUM) and the American College of Radiology (ACR) affirm this position, and further state that "a transperineal or transvaginal scan may be considered when evaluation of the cervix is needed" [9,22]. (See "Second-trimester evaluation of cervical length for prediction of spontaneous preterm birth in singleton gestations".)

Fetal movement should be assessed, although temporary absence or reduction of fetal movement during an examination is not necessarily worrisome as it can be due to a normal fetal sleep cycle. (See "Decreased fetal movement: Diagnosis, evaluation, and management", section on 'Normal fetal movement'.) Abnormal positioning or unusually restricted or persistently absent fetal movements may suggest an abnormality, such as arthrogryposis.

The specific components of first versus second and third trimester examinations are listed in the tables (table 2 and table 3). If a component is not visualized adequately, a panel of experts opined that a follow-up examination in two to four weeks may be reasonable, depending on the limitations and findings of the initial examination [18].

In-depth discussions of sonographic examination of congenital anomalies, the placenta, amniotic fluid, and fetal growth abnormalities can be found separately:

- (See "Clinical features, diagnosis, and course of placenta previa".)
- (See "Clinical features and diagnosis of the morbidly adherent placenta (placenta accreta, increta, and percreta)".)
- (See "Assessment of amniotic fluid volume".)
- (See "Fetal growth restriction: Diagnosis".)
- (See "Fetal macrosomia".)
- (See "Sonographic findings associated with fetal aneuploidy".)
- (See "Second-trimester evaluation of cervical length for prediction of spontaneous preterm birth in singleton gestations".)
- See individual topic reviews on specific congenital anomalies

Limited examination — Limited ultrasound examinations can be performed to address specific focused questions, ideally in patients who have been previously evaluated by a complete examination. Examples of appropriate use of limited studies include confirmation of the presence or absence of fetal cardiac activity, checking fetal presentation, measuring cervical length, and assessment of amniotic fluid volume in conjunction with nonstress testing [9,19].

Detailed examination — A detailed (specialized) fetal structural survey should only be undertaken by those with the necessary training and skills required for these advanced examinations. Indications for a detailed fetal examination include, but are not limited to, a previous pregnancy affected by a fetal anatomic or genetic/chromosomal abnormality, suspected or known fetal anatomic or genetic/chromosomal abnormality in the current pregnancy, known fetal growth disorder, and current pregnancy complications possibly affecting the fetus (eg, congenital infection, abnormal amniotic fluid volume, alloimmunization) [21]. Fetal evaluation in these settings requires a more detailed examination of fetal anatomy than a basic fetal survey and requires more advanced skills and knowledge. In 2013, a task force composed of participants from several major national obstetrical and radiological organizations in the United States developed a consensus report with guidelines for performance of this examination [21]. The detailed examination includes all of the elements of the basic examination and also may include:

- Evaluation of the brain, including all ventricles, parenchyma, vermis, cisterna magna, cerebellum, and corpus callosum
- Neck including nuchal thickness
- Inner and outer facial structures (eg, palate, orbits, lens, lips, nose/nasal bone, jaw)
- Ears
- Detailed examination of cardiopulmonary anatomy
- Diaphragm
- Ribs
- Small and large bowel
- Adrenal glands
- Gall bladder, liver
- Spleen
- Renal arteries
- Abdominal wall
- Spine
- Limbs, including hands, feet, digits (number and position), humerus, femur, ulna, radius, tibia, fibula

- Sex
- Umbilical cord (vessels, placental insertion, structure)
- Placenta (lobes)
- Neoplasms

Transabdominal examination — The patient's abdomen is exposed from the pubic bone to the umbilicus or xiphoid (depending upon stage of pregnancy) and draped to prevent gel from soiling clothing. It is prudent to document fetal cardiac activity as the initial step, as a diagnosis of fetal demise determines the context for the remainder of the examination. Using real-time scanning, the transabdominal ultrasound probe is maneuvered into different positions to allow visualization of multiple structures, to view a single structure from many different vantage points, and to avoid interference from impediments such as bone and intestinal air. Other maneuvers that may improve the quality of the image include:

- Adjusting the frequency of the ultrasound wave: higher frequencies result in lower penetration and improved resolution. Multiple transducers of different frequencies may be necessary during an examination to balance resolution and need for tissue penetration. As an example, if one of the areas to be examined is close to the ultrasound probe, a higher frequency probe would give the best resolution, but may not give an adequate image of another structure deep in the pelvis.

- Using the probe to apply pressure. This can be particularly helpful when assessing the relationship between two or more contiguous structures.

- Having the patient roll from side to side. Scanning from the side of the maternal abdomen can sometimes greatly improve visualization of the fetus in pregnant women with truncal obesity.

- If the fetal presenting part is low in the pelvis, elevating the maternal hips may help move the presenting part cephalad, making it easier to visualize.

Transvaginal examination — A transvaginal ultrasound examination is indicated for evaluating an early pregnancy, assessing the cervix to evaluate bleeding (eg, length, proximity to placenta), or improving visualization of fetal parts low in the pelvis. (See "Prenatal assessment of gestational age and estimated date of delivery" and "Second-trimester evaluation of cervical length for prediction of spontaneous preterm birth in singleton gestations".)

Transvaginal probes are manipulated both by rotation and angling from the midline. Proper orientation is essential as the field of view is much smaller with the transvaginal probe as compared to transabdominal probes (see 'Transducers and probes' above).

Nonmedical use — (See "Basic principles and safety of diagnostic ultrasound in obstetrics and gynecology", section on 'Nonmedical use'.)

GYNECOLOGIC SONOGRAPHY

Indications — Gynecologic ultrasound examination has multiple uses, including but not limited to [23]:

- Evaluation of the menstrual cycle (endometrial thickness, follicular development)
- Monitoring natural or stimulated follicular development during infertility therapy
- Localization of an intrauterine device
- Evaluation of abnormal uterine bleeding

- Assessment of a pelvic mass (eg, adenomyosis, fibroid, cancer, cysts)
- Evaluation for sequelae of pelvic infection (eg, abscess, hydrosalpinx)
- Evaluation of congenital uterine anomalies
- Screening for malignancy

Components — The components of a typical gynecologic sonographic examination include [23]:

- Uterine size, shape, and orientation
- Evaluation of endometrium, myometrium, and cervix
- Identification and morphology of ovaries, if possible
- Assessment of the uterus and adnexa for masses, cysts, hydrosalpinges, fluid collections
- Evaluation of the cul-de-sac for free fluid or masses

Normal fallopian tubes usually cannot be seen during pelvic sonography.

Examination — The ultrasound examination is usually initiated transabdominally. The bladder does not have to be full; however, if the pelvis cannot be seen well, it may be necessary to have the patient fill her bladder to a comfortable capacity. This may be especially important for those women who are unable to tolerate placement of a transvaginal ultrasound probe. Often in these cases, the entire examination can be performed transabdominally. If a specific question remains unanswered, or if an abnormality is suspected, other approaches, such as a transrectal examination or even a transperineal examination, may be considered. Other techniques for improving visualization are described above (see 'Transabdominal examination' above). Transabdominal scanning is important for evaluating the upper pelvis and abdomen, such as with large fibroids, ovarian neoplasms that extend into the upper abdomen, or ovaries lying high in the pelvis. Images only obtained by transvaginal scanning may not be adequate, or may miss pathology, as distance between the area under investigation and the vagina increases.

After evaluation of the pelvis transabdominally, the patient is asked to void because transvaginal sonography is best performed with an empty bladder. Guiding the probe toward the area of interest, such as an ovary, and watching how this area moves in relation to the other pelvic organs is helpful for evaluation of complicated or unclear pelvic anatomy, especially in the setting of abnormalities. As an example, a pelvic mass (pedunculated fibroid or solid ovarian mass) may lie between the uterus and normal appearing ovarian tissue. On a still image, the uterus, mass, and normal ovary may appear contiguous. With movement of the probe, the specific origin of the mass can usually be determined.

Visualization of pelvic structures with the transvaginal probe is limited by the relative positions of the pelvic organs and the presence of any pelvic masses. The resolution of high-frequency vaginal probes is good up to a depth of 6 to 8 cm. Transvaginal sonography can be performed concurrently with an abdominal examination to better define normal and abnormal anatomy [24]. As an example, by applying pressure abdominally, the uterus with any associated fibroids, and even the intestines, can be moved away from the ovaries, allowing better visualization.

Uterine weight correlates with uterine volume, which can be calculated using the prolate ellipsoid method where volume = 4/3 (pi)(uterine length/2)(anteroposterior diameter/2)(transverse diameter/2) [25,26]. Uterine measurements are most accurately obtained by transvaginal sonography [27]. The mean outer dimensions of the uterus among 263 premenopausal women (nulliparas, primiparas, multiparas) and menopausal women (less than or equal to five years of menopause, and greater than five years of menopause) with no uterine or ovarian pathological findings are shown in the table (table 4). The average transverse width of the endometrial cavity (ie, inside dimension of the uterus) is 2.7 cm among nulliparas, 3.0 cm among primiparas, and 3.2 cm among multiparas [28].

The typical measurement of endometrial thickness includes both the anterior and posterior endometrial walls. If fluid is present within the endometrial cavity, the anterior and posterior endometrial echoes can be measured independently and summed. Immediately after menses, the endometrium is 1 to 4 mm thick; as the estrogen concentration rises, the thickness increases to 7 to 10 mm. After ovulation, echogenicity increases starting in the basal area; by the luteal phase, the entire endometrium is hyperechogenic with a thickness of 8 to 16 mm. In postmenopausal women, a thick endometrial lining (defined as >4 mm) can be a marker of endometrial hyperplasia or malignancy [29].

Multiple 2 to 5 mm follicles may be seen in the ovaries. A leading follicle of about 10 mm can be identified at the 9th or 10th cycle day; it grows rapidly and is 20 to 24 mm in diameter just before ovulation. After ovulation, the corpus luteum develops and may have a slightly heterogeneous consistency. The wall typically appears to be thick with low-level internal echoes and circumferential blood flow. The diameter of a normal follicle or corpus luteum does not usually exceed 30 mm. A corpus luteum cyst appears as a homogeneous hypoechogenic thin-walled structure.

Any abnormality noted should be described, as appropriate: size, shape, location, echogenicity, echo pattern (cystic, solid, complex, septations), and a differential diagnosis of the most likely causes of the abnormality should be provided. Additional studies, such as Doppler velocimetry or saline infusion sonohysterography, may be useful in defining suspected lesions, or three-dimensional sonography, which may be helpful for evaluating the uterine shape in those patients with infertility.

The use of ultrasound in gynecology and ultrasound images of gynecologic disorders can be found separately:

- (See "Ultrasound differentiation of benign versus malignant adnexal masses".)
- (See "Ultrasonography of pregnancy of unknown location".)
- (See "Ultrasound evaluation of the normal menstrual cycle".)
- (See "Evaluation of the endometrium for malignant or premalignant disease".)

Pelvic floor sonography — Translabial or transperineal ultrasound is being used increasingly to evaluate the pelvic floor in the work-up of women with pelvic organ prolapse and urinary or anal incontinence. Other uses of pelvic floor sonography include evaluation of urethral diverticula, rectal intussusception, mesh location, and residual urine volume [30]. The role of pelvic floor sonography in the evaluation of women with pelvic floor symptoms is still under investigation. (See "Endorectal endoscopic ultrasound in the evaluation of fecal incontinence".)

CREDENTIALS — Sonography is an operator-dependent technology: a high level of competence can only be achieved by supervised experience with a large variety of normal and abnormal examinations.

In the United States, ultrasound examinations in obstetrics and gynecology are typically performed by diagnostic medical sonographers. Almost all of these health professionals are credentialed by the American Registry for Diagnostic Medical Sonography (ARDMS) and receive the credentials

RDMS upon completion of extensive education, training, and testing. Some sonographers are also credentialed by the American Registry of Radiologic Technologists.

The examinations are supervised and interpreted by a sonologist, who is a physician with training and experience in this area. It is up to the physician to provide a report based upon the data provided by the sonographer, and, if indicated, by personally scanning the patient to confirm or modify the differential diagnosis. In the United States, the American Institute of Ultrasound in Medicine and the American College of Radiology (ACR) have formulated guidelines for training, credentialing, continuing education, and ultrasound laboratory accreditation (available on the Internet at www.aium.org and www.acr.org) [8,31].

HUMAN FACTORS AND ERGONOMICS — Work-related musculoskeletal disorders are increasingly prevalent among those who use ultrasound technology. Some aspects of the sonographic examination that can lead to pain and musculoskeletal dysfunction may not be modifiable by the clinician, eg, the repetitive motion associated with scanning or patient obesity. Many other aspects, however, can be modified to decrease the risk of musculoskeletal disorders. These include proper positioning and posture, applying excessive force, and overuse. Many factors are important for proper positioning, but the most important are proper table positioning and height, avoidance of twisting of the neck or trunk and, most importantly, positioning the patient very close to the clinician and meticulously avoiding abduction of the scanning arm [32].

SAFETY — There are no well-documented harmful effects to the fetus from diagnostic ultrasound examination used appropriately [18]. Nevertheless, examinations should be performed only for valid medical reasons [19], for the shortest amount of time, and with the lowest level of acoustic energy that allows diagnostic evaluation [18]. (See "Basic principles and safety of diagnostic ultrasound in obstetrics and gynecology".)

GUIDELINES FROM NATIONAL ORGANIZATIONS

- American College of Obstetricians and Gynecologists (ACOG) practice bulletin: Ultrasonography in pregnancy [19]
- Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) workshop consensus statement on fetal imaging [18], which included participants from the:

  Society for Maternal-Fetal Medicine (SMFM)
  American Institute of Ultrasound in Medicine (AIUM)
  American College of Obstetricians and Gynecologists (ACOG)
  American College of Radiology (ACR)
  Society for Pediatric Radiology (SPR)
  Society of Radiologists in Ultrasound (SRU)

- AIUM practice guideline for the performance of obstetric ultrasound
- International Society of Ultrasound in Obstetrics and Gynecology (ISUOG): performance of first trimester fetal ultrasound scan [33]
- ISUOG: practice guideline for performance of routine mid-trimester fetal ultrasound scan [20]
- Royal College of Obstetricians and Gynaecologists (RCOG)
- Society of Obstetricians and Gynaecologists of Canada (SOGC)

- Asia and Oceania Federation of Obstetrics and Gynaecology [34]

SUMMARY AND RECOMMENDATIONS

- The American College of Obstetricians and Gynecologists has recommended ultrasound examination for all pregnant patients. (See 'Obstetrical sonography' above.)

- Sonography is an operator-dependent technology: a high level of competence can only be achieved by supervised experience with a large variety of normal and abnormal examinations. (See 'Credentials' above.)

- Standard orientation when performed using a transabdominal ultrasound probe is to hold it in the right hand with the mark on the thumb side, which is the side displayed on the left side of the ultrasound image. With a transvaginal probe, the mark on the probe represents the left side of the screen; therefore, if the probe is inserted into the vagina and the mark is held at 12:00, the left side of the image display represents the anterior aspect of the pelvis, and the right side of the image represents the posterior aspect of the pelvis. (See 'Transducers and probes' above.)

- Manual adjustment of settings (size, depth, focal zone, gain, tissue harmonic imaging) is important to obtain optimal images. (See 'Manual settings' above.)

- Information gained from real-time ultrasound examination can be enhanced, when indicated, by additional studies using Doppler, sonohysterography, and three-dimensional imaging. (See 'Advanced techniques' above.)

- The indications for obstetrical ultrasound examination vary by trimester and are listed in the table (table 1). (See 'Indications' above.)

- Suggested components of a basic obstetrical and gynecologic evaluation have been outlined by various groups. (See 'Basic examination' above and 'Gynecologic sonography' above.)

- Diagnostic ultrasound examination used appropriately has no harmful effects (including fetal effects). Nevertheless, examinations should be performed only for valid medical reasons, for the shortest amount of time, and with the lowest level of acoustic energy that allows diagnostic evaluation. (See 'Safety' above.)

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Topic 5388 Version 23.0

GRAPHICS

Indications for ultrasound examination during pregnancy

First-trimester ultrasonography
Indications for first-trimester ultrasonography include, but are not limited to the following:
To confirm the presence of an intrauterine pregnancy
To evaluate a suspected ectopic pregnancy
To evaluate vaginal bleeding
To evaluate pelvic pain
To estimate gestational age
To diagnose or evaluate multiple gestations
To confirm cardiac activity
As adjunct to chorionic villus sampling, embryo transfer, or localization and removal of an intrauterine device
To assess for certain fetal anomalies, such as anencephaly, in patients at high risk
To evaluate maternal pelvic or adnexal masses or uterine abnormalities
To screen for fetal aneuploidy
To evaluate suspected hydatidiform mole
Second- and third-trimester ultrasonography
Indications for second- and third-trimester ultrasonography include, but are not limited to the following:
Screening for fetal anomalies
Evaluation of fetal anatomy
Estimation of gestational age
Evaluation of fetal growth
Evaluation of vaginal bleeding
Evaluation of abdominal or pelvic pain
Evaluation of cervical insufficiency
Determination of fetal presentation
Evaluation of suspected multiple gestation
Adjunct to amniocentesis or other procedure
Evaluation of a significant discrepancy between uterine size and clinical dates
Evaluation of a pelvic mass
Evaluation of a suspected hydatidiform mole
Adjunct to cervical cerclage placement
Suspected ectopic pregnancy
Suspected fetal death
Suspected uterine abnormalities
Evaluation of fetal well-being
Suspected amniotic fluid abnormalities
Suspected placental abruption

Adjunct to external cephalic version
Evaluation of prelabor rupture of membranes or premature labor
Evaluation of abnormal biochemical markers
Follow-up evaluation of a fetal anomaly
Follow-up evaluation of placental location for suspected placenta previa
History of previous congenital anomaly
Evaluation of the fetal condition in late registrants for prenatal care
Assessment for findings that may increase the risk of aneuploidy

A sonographic study should only be performed for a valid medical indication. Nonmedical use of obstetric ultrasonography has been discouraged by major societies, including the American College of Obstetricians and Gynecologists (ACOG), the American Institute of Ultrasound in Medicine (AIUM), and the International Society of Ultrasound in Obstetrics and Gynecology.

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Graphic 58590 Version 2.0

Components of a first trimester ultrasound examination

Gestational sac location and diameter (if no embryo identified)
Presence or absence of a yolk sac (diameter)
Presence or absence of an embryo
Presence or absence of cardiac activity
Crown rump length
Number of embryos
Amnionicity and chorionicity of multiple gestations
Anatomic survey, as appropriate for gestational age*
Evaluation of the uterus, adnexa, and cul-de-sac

An embryo is usually visible when the gestational sac diameter is ≥20 mm, cardiac motion may be detected when then embryo is ≥2 mm and is usually detected when the embryo is ≥5 mm (transvaginal examination).

* At 11 to 14 weeks of gestation, anatomical assessment can include: head (cranial bones, midline falx, choroid plexus); neck (nuchal translucency thickness); face (eyes, nasal bone, mandible, lips); spine (vertebrae and overlying skin); chest (lung fields, effusions, masses); heart (regular activity, four symmetrical chambers); abdomen (stomach in left upper quadrant); bladder; kidneys; abdominal wall; cord (insertion site, number of vessels); extremities (number, hand/foot position).

Data from:

1. *ACOG Practice Bulletin No. 98. Ultrasonography in pregnancy. Obstet Gynecol 2008; 112:951.*
2. *ISUOG practice guidelines: performance of first trimester fetal ultrasound scan. Ultrasound Obstet Gynecol 2013; 41:102.*
3. *Reddy UM, Abuhamad AZ, Levine D, et al. Fetal Imaging. Executive Summary of a Joint Eunice Kennedy Shriver National Institute of Child Health and Human Development, Society for Maternal-Fetal Medicine, American Institute of Ultrasound in Medicine, American College of Obstetricians and Gynecologists, American College of Radiology, Society for Pediatric Radiology, and Society of Radiologists in Ultrasound Fetal Imaging Workshop. Obstet Gynecol 2014; 123:1070.*

Graphic 75784 Version 5.0

Components of second and third trimester ultrasound examinations

Presence or absence of fetal cardiac activity, fetal heart rate and rhythm
Fetal number
Fetal presentation
Assessment of amniotic fluid volume
Placental appearance and location
Umbilical cord vessel number and placental insertion site, if technically possible
Fetal biometry (biparietal diameter, head circumference, femoral length, abdominal circumference)
Evaluation of the uterus, cervix, and adnexa when clinically appropriate
Fetal anatomic survey*
Presence or absence of fetal movement
Evaluation of each fetus of a multiple gestation

Biometry can be used to estimate gestational age (if not previously determined), fetal weight, and fetal growth (by comparing two or more examinations over an appropriate time interval).

* Fetal anatomic survey can include the following assessments: head (intact cranium, cavum septi pellucidi, midline falx, thalami, cerebral ventricles, cerebellum, cisterna magna, choroid plexus); face (orbits, mouth, upper lip intact); neck (absence of masses); chest/heart (shape/size of chest and lungs, cardiac activity present, four-chamber view of heart, aortic and pulmonary outflow tracts, diaphragmatic hernia); abdomen (stomach in normal position, bowel not dilated, both kidneys present, cord insertion site, bladder); skeletal (spine, masses, arms and hands, legs and feet); genitalia.

Data adapted from:

1. *ISUOG: practice guideline for performance of the routine mid-trimester fetal ultrasound scan. Ultrasound Obstet Gynecol 2011; 37:116.*
2. *Executive Summary of a Joint Eunice Kennedy Shriver National Institute of Child Health and Human Development, Society for Maternal-Fetal Medicine, American Institute of Ultrasound in Medicine, American College of Obstetricians and Gynecologists, American College of Radiology, Society for Pediatric Radiology, and Society of Radiologists in Ultrasound Fetal Imaging Workshop. Obstet Gynecol 2014; 123:1070.*

Graphic 63045 Version 7.0

Normal uterine dimensions on ultrasound examination

Parameter	Nullipara	Primipara	Multipara	Menopausal ≤5 years	Menopausal >5 years
Uterine length (cm)	7.3 (0.8)	8.3 (0.8)	9.2 (0.8)	6.7 (0.7)	5.6 (0.9)
Corpus width (cm)	4.0 (0.6)	4.6 (0.5)	5.1 (0.5)	3.6 (0.5)	3.1 (0.5)
Corpus height (cm)	3.2 (0.5)	3.9 (0.5)	4.3 (0.6)	3.1 (0.4)	2.5 (0.4)

The mean and standard deviation () for uterine length, width, and height in premenopausal women (nulliparas, primiparas, multiparas) and menopausal women (less than or equal to five years of menopause, and greater than five years of menopause) without uterine or ovarian pathology. These dimensions represent the outer dimensions of the uterus, not the inner dimensions (ie, dimensions of the endometrial cavity).

Data from: Merz E, Miric-Tesanic D, Bahlmann F, Weber G, Wellek S. Sonographic size of uterus and ovaries in pre- and post-menopausal women. Ultrasound Obstet Gynecol 1996; 7:38.

Graphic 76299 Version 4.0

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