Obstetric Ultrasound by Family Physicians

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Obstetric ultrasound examination is a useful diagnostic procedure for family physicians who select appropriate equipment, observe indications, understand limitations, and work toward performance mastery. The knowledge obtained during an examination assists clinical decision making and reduces liability. This is particularly true for rural and underserved communities where family physicians provide the majority of prenatal and comprehensive perinatal care. Mastery of obstetric ultrasound techniques can also lead to developing amniocentesis skills and serve as an aid to external cephalic version. The equipment does not require extensive maintenance and is available at all hospitals. Many offices and group practices have found purchase of this equipment to be cost effective. Based on clinical experience in family practice and a review of the medical literature, an approach to skill acquisition and quality assurance is described.

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Family physicians who engage in the delivery of prenatal care or comprehensive perinatal care can benefit from the diagnostic information obtainable by an ultrasound examination. Rural family physicians especially need to learn to perform obstetric ultrasonography. Urban physicians can benefit from hands-on experience and skill in the performance of these diagnostic examinations as well. Educators such as Zervanos[1] have described curriculum options that provide levels of instruction tailored to meet the specific needs of the physician and his or her community. Cognitive, psychomotor, and quality assurance components must be articulated in a curriculum plan for each level of training intensity.

The ability of family physicians to learn and perform ultrasound examinations in their daily practice of obstetrics has been documented.[2–5] In addition, ultrasonography represents a gateway that facilitates the use of techniques for prenatal genetic examination and lung maturity evaluation. Physicians who perform amniocentesis to determine fetal lung maturity have reported a lower complication rate and, ultimately, a lower frequency of fetal loss.[6–10] Family physicians have found the development of amniocentesis skills extremely useful in locations where patients have limited access to these services, particularly in rural areas. Ultrasonography is the first step toward enhanced prenatal care that includes more accurate estimation of fetal age, earlier detection of twins, and amniocentesis. A detailed guide to first trimester problems has recently been published by a family physician.[11,12] Although chorionic villus sampling is beyond the scope of this review, we acknowledge that it is a useful technique. However, it is currently best performed in a tertiary care center where samples can be optimally processed.[13–15]

Ultrasonography should not be limited to any particular specialty. It will continue to be used by obstetricians, cardiologists, family physicians, urologists, and others. Logbooks, systematically retrievable records, uniform data fields, and other periodic quality assurance reviews can be used to ensure that a uniformly high standard of care is provided for patients. Standardized examination guidelines are available from the American Institute of Ultrasound in Medicine. Our family medicine group has developed our own forms and protocols.

Prenatal Diagnostic Ultrasound Examination: The Curriculum

Family physicians can perform obstetric ultrasound examinations successfully if the necessary training is provided. The purpose of this article is to briefly provide guidance in and outline a curriculum for obstetric ultra-

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Table 1. Diagnostic Ultrasound Equipment

Components
Screen—video monitor
Hardware and software
Types of transducers
Linear array—a series of crystals that fire sequentially to produce a rectangular-shaped image
Mechanical sector—a single transducer that scans in an arc and produces a pie-shaped image
Curvilinear—combines aspects of both
Applied physics
Medical diagnostic ultrasound frequency usually 3 to 7.5 MHz
Principle—the higher the frequency the better the resolution but the poorer the penetration

Table 2. Ultrasound Concepts and Terminology

Scanning frequency. Transducer frequency.
Transceiver. A device that both emits energy and detects energy. This term is derived from combining the terms *transmitter* and *receiver.*
Ultrasound transducer. A transceiver that emits ultrasound energy (sound waves) and also detects ultrasound energy (sound waves reflected back). The transducer also changes that energy from one form to another so the final product is a readable image on a screen.
Axial resolution. Resolution or image along the axis of the beam.
Lateral resolution. Resolution of objects lying in a plane perpendicular to the axis of the beam. The smaller the transducer diameter and the higher the frequency, the better the lateral resolution.
Focal zone. The region of maximum lateral resolution.
Longitudinal axis. An image created by orienting the transducer beam in the longitudinal (sagittal) plane of the patient.
Transverse axis. An image created by orienting the transducer beam in a horizontal (transverse) plane of the patient.

sonography. Specifically, the following topics are included:

- Equipment needed
- Indications for performing obstetric ultrasound examination
- Limitations and inappropriate use
- Content of the examination
- Performance mastery
- Additional skills and consultation

Equipment Needed

Office location and physician preference determine whether it is necessary for the practice to purchase its own equipment. Office-based equipment is constantly improving, and costs for mechanical sector scanners have decreased, now ranging from $20,000 to $30,000. During 5 to 10 years of this group's office experience, maintenance costs have been minimal. A maintenance contract has not been acquired, but this is a personal decision that should be based on local circumstances. Equipment for videotape or photographic documentation or both is valuable in enhancing self-improvement, patient education, and quality assurance.

Diagnostic ultrasound technology has multiple applications including gynecologic and abdominal examinations and selected echocardiographic applications. Ultrasonography is useful for guided aspiration biopsy of breast cysts. It is also useful as an adjunct to thyroid examination, scrotum examination, and paracentesis.

The portable diagnostic ultrasound equipment components are listed in Table 1. Useful terminology for the family physician is reviewed in Table 2. A family physician sonographer has described the following equipment features as useful[16]:

1. Although a linear array transducer has frequently been used for obstetrics purposes, the sector transducer (creates a pie-shaped image) is considered more versatile for obstetric scanning in all trimesters and more applicable to general abdominal scanning, and is, therefore, more cost effective (Figures 1 to 3). There are additional types of transducers (eg, mechanical, annular array, electronic phased array, linear array, and curvilinear). A detailed description of each is beyond the scope of this paper.

2. The video screen should be a minimum of 5″ in size diagonally, and the display should be capable of at least 64 shades of gray.

3. For taking measurements, freeze frame is essential. Two sets of electronic calipers should be available for on-screen display, and should be operated by track ball or joy-stick controls.

4. Inputs and outputs for recording devices will enhance information management. Alpha numeric on-screen documentation of patient name and image annotation should be possible.

5. The basic unit should be movable by hand or on a cart to enhance portability.

6. Although higher frequency transducers (5.0 or 7.5 MHz) and transvaginal transducers should be available, the 3.0- or 3.5-MHz transducer should be standard.

Software calculations for gestational age by crown-rump length, biparietal diameter, femur length, and abdominal circumference should be included as basic equipment. The user should have a choice of standard tables. Physicians should choose those tables recommended by

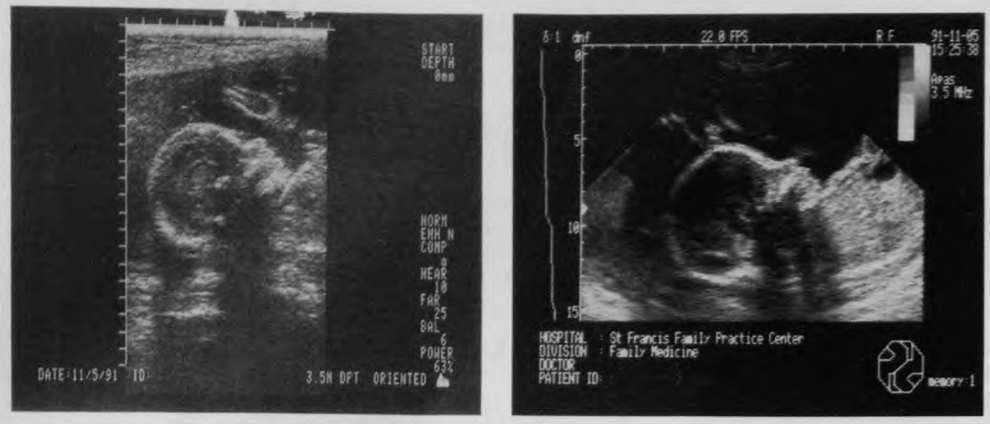

Figure 1. Linear array (left) and sector image (right) of the fetal facial profile. In addition to helping to detect midline facial defects, this view is intensely interesting to expectant parents and can be used while discussing fetal well-being and maternal health-related behaviors such as diet and smoking.

the consultants to whom they refer. More frequently, this choice is made by selecting tables that have been developed for a patient population similar to that seen by the family physician. Finally, image documentation hardware should be included in a complete package, priced no higher than $20,000 to $30,000.

Indications for Obstetric Ultrasound Examination

Many health care agencies in European countries specify that at least one ultrasound examination be performed at 16 to 20 weeks to accurately estimate fetal age, detect multiple gestation, and review maternal and fetal anatomy. A Consensus Forum of the National Institutes of Health[17] limited the indications (Table 3) because there was insufficient evidence to support recommendation of routine mandatory ultrasound. Using these guidelines, one family physician tabulated the frequency of ultrasound examinations at 80 examinations per 100 pregnancies delivered in his practice over an 8-year period.[18] These numbers included some patients scanned for complications that led to pregnancy loss.

Obstetric ultrasound examination should not be classified as "level I," "level II," or "level III." Although frequently found in the medical literature of the 1980s, this terminology has been discarded by most authorities. Originally, level I referred to a scan performed solely to determine fetal age in the British screening program for α-fetoprotein. No anatomic survey was made. Organizations such as the American Institute of Ultrasound in Medicine (AIUM), the American College of Radiology (ACR), and the American College of Obstetrics and Gynecology (ACOG) have published standards requiring complete scans. This is discussed further under the section on content of the obstetric ultrasound examination. Therefore, physician examiners should become comfortable with a universal approach that includes seeking more specialized consultation when appropriate.

Consultation frequency in one family physician ultrasound examination series was 7%.[4] Most of these consultations were requested because of ambiguities in the anatomical survey. These were the first examinations performed, and the frequency of consultation decreased with time.

Since 1980, ultrasound examination has become a useful adjunct to routine prenatal care. Although it is not mandated in all pregnancies, physicians who acquire the skill seem convinced that it helps them to practice better medicine through an enhanced understanding of fetal

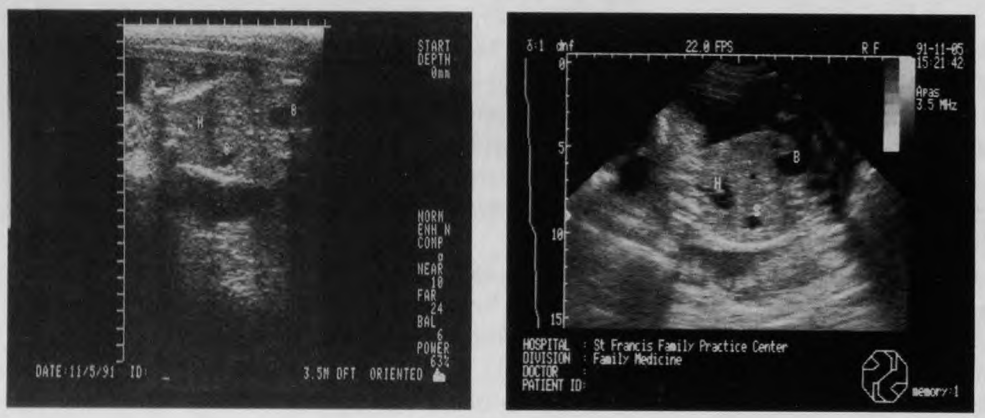

Figure 2. Linear array (left) and sector image (right) of the fetal abdomen showing the bladder (B), stomach (S), and heart (H). Documenting the presence and proper position of these landmarks helps to rule out renal agenesis, left-sided diaphragmatic hernia, and esophageal atresia.

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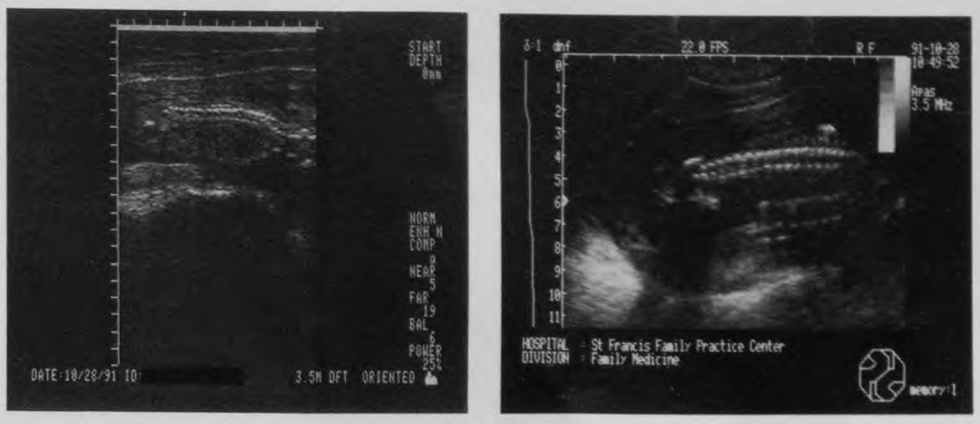

Figure 3. Linear array (left) and sector image (right) of the fetal spine in long axis. Such views, combined with additional transverse views along the spine, comprise the survey for spine defects.

and maternal physiology and anatomy.[19–21] Fragmentation of care and triangulation of management are potential liabilities for physicians who refer *all* patients for a consultative ultrasound examination.[5] Addition of this skill has not increased liability insurance premiums in the states where the authors have practiced (Washington, Tennessee, California, Missouri, Michigan, South Carolina, and Texas). We know of no case in which adding diagnostic ultrasound has increased insurance premiums for a physician who had routine obstetric coverage.

Several randomized controlled trials have recently been published. Among 4997 pregnant women who had no clinical indication for an elective ultrasound examination, 2482 were randomly selected for ultrasound screening at 15 weeks. The remainder received standard prenatal care without ultrasound examination. Since patients were less likely to be misdiagnosed as being "overdue," labor inductions were 33% less frequent in the group who received ultrasound examinations. Although twins were detected earlier, the study claimed no improved outcome in twin births. Among women who smoked, birthweight was higher in the group who visualized their infant by means of an ultrasound examination. It may be that screened women reduced their smoking in response to watching the fetus on the monitor.[22]

In Helsinki, 95% (9310) of all pregnant women entered a 19-month study comparing one-stage ultrasonographic screening with selective screening.[23] Perinatal mortality was significantly lower in the screened than in the control group. A 49.2% reduction of perinatal mortality was due to improved early detection of malformed fetuses that were aborted. Among the 4691 women who were randomly allocated to receive ultrasound screening, no differences in the number of labor inductions or in birthweight were noted. However, stratification was not done in a way similar to the previously cited study. Additionally, 100% of all twin pregnancies were detected before the 21st week in the screened group, compared with 76% of those carrying twins in the control group.

These data present the rationale ascribing some benefit to routine screening. The authors do not advocate universal screening as the standard of care at this time, and this is consistent with a recent randomized study that found no benefit from mandatory routine prenatal ultrasound examination.[24] Consensus guidelines of the National Institutes of Health are believed to be appropriate. Using conservative guidelines, approximately 47% to 58% of pregnancies will ultimately receive an ultrasound examination. Note that in the Helsinki study,[23] 54% of the controls were scanned for medical reasons. In Ewigman's study,[24] 58% of patients had an indication for ultrasound.

Table 3. Indications for Obstetric Ultrasound, Adapted from the Consensus Guidelines of the National Institutes of Health[17]

- Estimation of gestational age
  - Uncertain clinical dates
  - Elective termination of pregnancy: therapeutic abortion, indicated induction of labor, or repeat elective cesarean delivery
- Significant discrepancy between uterine size and clinical dates
- Suspected multiple gestation
- Suspected fetal death
- Vaginal bleeding of undetermined cause during pregnancy
- Suspected ectopic pregnancy or pregnancy occurring after tuboplasty or prior ectopic gestation
- Suspected polyhydramnios or oligohydramnios
- Evaluation of fetal condition in late registrants for prenatal care
- Evaluation of pelvic mass
- Suspected uterine abnormality
- Suspected hydatidiform mole
- Follow-up evaluation of placental location
- Evaluation of abnormal α-fetoprotein
- History of previous congenital anomaly
- Suspected abruptio placentae or placenta previa
- Intrauterine/contraceptive device localization
- Determination of presenting fetal part
- Estimation of fetal weight in premature rupture of membranes, premature labor, and fetus that is large for gestational age
- To assist amniocentesis or chorionic villus sampling

In one family physician's group office practice, there were 482 initial scans in over 1032 consecutive live births. Conservative guidelines for indications were used. This was a 47% scan rate. A second scan was required by 150 patients, and 78 patients had three or more scans, for a total of more than 710 scans for those 1032 live births.[18]

In a study of private practice obstetricians in Iowa, Ewigman and co-workers[25] found substantial variation of ultrasonography use. Twenty-six of 71 obstetricians ordered at least one ultrasound examination for 25% to 50% of patients. Forty-one of 71 ordered at least one ultrasound examination for 50% to 75% of their patients.

The procedure is noninvasive and safe. Initial concerns, regarding in vitro tissue damage studies, have diminished each year as millions of infants continue to grow and develop normally. The examination charge varied from $100 to $325 in 1990. This range represents our experiences in four separate practices. We are currently charging $150 for a complete ultrasound examination, CPT-4 code 76805. In the study by Ewigman et al,[25] the range of total charges was from $73 to $288. A repeat examination may be slightly less.

Limitations and Inappropriate Use

There are limitations of diagnostic obstetric ultrasound. For example, the estimated gestational age (EGA) becomes less precise as pregnancy advances, with as much as a 3-week deviation in either direction at 30 weeks EGA. Definitive exclusion of the possibility of fetal anomalies or abnormalities is impossible, and skill among sonographers varies.

Fetal and maternal anatomic characteristics sometimes determine the technical quality of the sonogram. Extreme maternal girth or a deeply seated fetal head in the third trimester may affect the quality of the examination. Image quality and processing software support are more limited in less expensive equipment; therefore, acquisition and use of high-quality equipment is encouraged.

Inappropriate uses of diagnostic ultrasound in obstetrics include routine screening of all pregnancies, determination of fetal sex (unless sex-linked abnormalities are suspected), and casual, nonsystematic evaluation.

Seeking information not obtainable at a specific level of gestation is not helpful. For example, confirmation of breech presentation before 36 weeks would not confirm a continuing breech at term.

Table 4. Content of Obstetric Ultrasound Examination by Trimester: Items to Consider

First trimester
Gestational sac
Crown-rump length—estimation of gestational age
Cardiac activity
Somatic activity
Placental location
Pelvic anatomy
Fetal number
Others
Second and third trimester
Estimation of gestation age
Biparietal diameter
Femur length
Head circumference
Abdominal circumference
Other obtainable measurement
Fetal anatomy
Head and its anatomy
Spine—longitudinal and transverse scans
Heart—chamber size* and number, rate and rhythm,* arch and descending aorta, valves
Chest—respiratory movements,* diaphragm
Abdomen—stomach, umbilical cord insertion, umbilical vein
Kidneys
Bladder
Umbilical cord—vessels*
Fetal weight—estimated
Extremities
Nonfetal anatomy
Maternal bladder and cervix
Placenta—location and grade
Amniotic fluid volume
Uterus and adnexa
Maternal gallbladder if visible*
Others
Assessment of fetal growth. Based on serial measurements and compared with previous scans plotted on a graph

Items with an asterisk (*) may or may not be readily measured. For example, the child may urinate in utero, thereby emptying the bladder. Without these items, the examination remains useful and valid. This list represents a potential "road map" of points of interest.

Content of the Obstetric Ultrasound Examination

The content of the obstetric ultrasound examination is outlined by trimester in Table 4. The most accurate time to estimate gestational age is at 6 to 12 weeks. This is a period of linear growth. An estimation of the crown-rump length at 6 to 12 weeks is very accurate when made by an experienced sonographer.

The most widely recommended time for performance of an obstetric ultrasound examination is at 17 to 23 weeks of gestational age. By this age, anatomic landmarks are more easily defined and growth remains relatively linear. A crown-rump length at 6 to 12 weeks or a biparietal diameter at 17 to 23 weeks may be equivalent since both measurements provide estimated gestational ages having 95% confidence intervals of being within 5

Table 5. Transabdominal Obstetric Ultrasound Landmarks by Time of Appearance

Landmark	Time of Appearance* (wk)
Gestational sac	5
Fetal pole	6
Crown rump length	6–12
Fetal movement	7
Cardiac activity	7
Placenta	8
Yolk sac	7–11
Embryologic period ends—fetal period begins	10
Heart is fluid-filled	12–13
Biparietal diameter	12–13
Abdominal measurements	12–13
Femur	12–13
Stomach	20
Lateral ventricles appear	12
Kidneys	17–22
Bladder	20
Heart valve motion	20
Lateral ventricles (characteristic appearance)	20
Choroid	20–24
Majority of neurologic abnormalities present	24
Genitalia	25

**Although most, but not all, features have developed by 20 weeks, the stomach, kidneys, genitalia, and choroid are not seen in every examination. Development is variable, and examinations done at an early age (15 weeks) may precede some landmarks.*
Adapted from Callen PW: Ultrasonography in Obstetrics and Gynecology. *WB Saunders Company, Philadelphia, 1983, p 346.*

to 10 days of the time of conception. Beyond 23 weeks, there is more variation in what is "normal" growth (ie, normal growth may not be linear). Some fetal anomalies can be detected at this time. The appearance of obstetric ultrasound landmarks by transabdominal imaging is summarized in Table 5. A comparison of transabdominal landmarks with transvaginal landmarks is depicted in Table 6. With the advent of endovaginal scanning, many of these structures can be clearly defined at a much earlier gestational age.

The American College of Radiology and the American Institute of Ultrasound in Medicine (AIUM) have produced and published a useful set of guidelines.[26,27] For the first trimester, the location of the gestational sac should be documented. The embryo should be identified and the crown-rump length recorded. Presence or absence of fetal life should be reported. Fetal number should be documented. Evaluation of the uterus (including the cervix) and adnexal structures should be performed.

During the second and third trimesters, fetal life, number, and presentation should be documented. An estimate of the amount of amniotic fluid (increased, decreased, normal) should be reported. The placental location should be recorded and its relationship to the internal cervical os determined.

Assessment of gestational age in the second and third trimester should be accomplished using a combination of biparietal diameter (or head circumference) and femur length. Fetal growth assessment (as opposed to age) requires the addition of abdominal circumferences. If previous studies have been done, an estimate of the appropriateness of interval change should be given.

Biparietal diameter at a standard reference level (which should include the cavum septum pellucidum, and the thalami) should be measured and recorded. Head circumference is measured at the same level as the biparietal diameter.

Femur length should be measured routinely and recorded after the 14th week of gestation. Abdominal circumference should be determined at the level of the junction of the umbilical vein and portal sinus. Evaluation of the maternal uterus and adnexal structures should be performed.

The study should include, but not necessarily be limited to, the following fetal anatomy: cerebral ventricles, view of all four chambers of the heart (as well as the position of the heart in the thorax), spine, stomach, urinary bladder, umbilical cord insertion on the anterior abdominal wall, and renal region.

Performance

Performing the obstetric ultrasound examination with skill and confidence can be developed through practice.

Table 6. A Comparison of Transabdominal and Transvaginal Sonographic Landmarks

Gestational Age by Menstrual Date (wk)	Transabdominal Landmarks	Transvaginal Landmarks
<5	None	Possible gestational sac
5	Gestational (chorionic) sac, 5 to 8 mm	Gestational (chorionic) sac, 5 to 8 mm, with or without yolk sac
6 to 7	Yolk sac present when gestational (chorionic) sac is ≥20 mm	5-mm embryo and yolk sac present when gestational sac is ≥16 mm
7	5- to 10-mm embryo with heartbeat in 25 mm gestational sac	5- to 10-mm embryo with heartbeat in 25 mm gestational sac

Adapted from Deutchman M.[11,12] Gestational sac is now called the chorionic sac. In this table, the term gestational sac *is synonymous with the term* chorionic sac.

One psychomotor performance sequence that should be considered includes:

1. The examiner meets the patient, establishes rapport, and shares expectations.
2. The examiner demonstrates an understanding of the clinical context and appropriate indications, and the ability to create medical records and documentation. All images should be labeled with date and patient identification.
3. An abdominal examination is performed and fundal height measured.
4. The transducer does not touch patient until the above steps are completed.
5. In the initial stages, the examiner obtains an orientation sequence of transverse (midline, right, left) and longitudinal (midline, right, left) views. Then he or she performs the specifics previously described (Table 4). Information obtained is later summarized in a written report, which covers biometry, the fetal survey, and the nonfetal survey.
6. Results of previous scans are compared to assess fetal growth. The *earliest* scan should be used to establish gestational age and estimated date of confinement.

Training Considerations

How many examinations must a physician perform before he or she is considered "competent"? Unfortunately, some have incorrectly equated "competency" with a "zero error" rate. Perfect studies are an elusive ideal. Among 2389 studies performed by three experienced and certified sonographers, the anatomic survey was rarely complete. Average success rates for visualization of individual organs ranged from 70% to 90%.[28] "Capable of independent scanning" may be a more useful concept than "competent."

How many supervised examinations are necessary before the physician is capable of independent scanning? This is a complex issue with no absolute answer. Ultrasound examination is a complex psychomotor skill with three main components that have different learning curves: (1) biometry to assess gestational age and fetal growth; (2) survey of fetal anatomic structures to detect anomalies; and (3) examination of the placenta, fluid, uterus, and other maternal structures.

The criteria for basic fetal biometry are well established (Table 4) and each measurement has a specific end point (ie, number) which should be reproducible within narrow limits. Studies have shown that motivated family physicians and residents can develop the ability to perform accurate, reproducible biometry after 25 to 75 examinations.[4,29] In that sense, a physician who has performed 2000 examinations is not 10 times better than one who has performed only 200. Furthermore, interobserver variability, even among expert sonographers, is a reality, with one study showing only an 87% success rate in obtaining an adequate measurement of biparietal diameter.[30] Nevertheless, by identifying specific landmarks, using multiple measurements, and repeating measurements until they are consistent, a good gestational age assessment should be possible by physicians early in their course of obstetric ultrasound study.

The content of a "basic" fetal anatomic survey has been defined by the AIUM.[27] The amount of fetal detail that can potentially be identified is continually expanding, however, as the body of sonographic knowledge, the examiner's skill, and the image quality of modern scanners expand. Anatomic survey is the part of the examination with which the beginner will feel the most uncomfortable. Even with the best of efforts, the anatomic survey will often be incomplete owing to maternal factors, fetal position, or gestational age, with average success rates for visualization of individual organs ranging from 70% to 90%. Only 1% to 2% of fetuses may have a significant anomaly detectable by prenatal ultrasound. This fact should not lead to a false sense of security and decreased vigilance during scanning. Even the least competent sonographer who misses all the anomalies he or she should see will have a 98% to 99% accuracy rate in diagnosing a normal fetus. Since fetal anomalies frequently are multiple, the finding of one abnormal or questionable feature should prompt a thorough survey, and in most cases, a referral for a second opinion examination.

Examination of the uterus and placenta to assess amniotic fluid volume and maternal structures also entails a longer learning curve. The maternal structures (such as kidneys and gallbladder) that should be examined may be related to maternal symptoms and the interest of the examining physician (Deutchman ME, Hahn RG, Rodney WM, unpublished data, 1991).

In regard to the essential tasks of the fetal anatomic survey, placenta and maternal structure evaluation, "cognitive preloading" may assist and improve the training process. Cognitive preloading is an educational method that prepares the student through lectures, readings, demonstrations, and evaluations in advance of the actual psychomotor performance of an ultrasound examination. If training includes a thorough study of fetal anomalies, signs of placenta previa and abruption, and uterine abnormalities, the physician will be much less likely to miss these in clinical practice.

Examinations during the first trimester necessitate consideration of the use of transvaginal scanning (TVS).[11] This technique is a natural complement to

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pelvic examination, and patients are often more comfortable having their own primary care physician perform a transvaginal sonographic study than being referred elsewhere for it. The transvaginal route places the transducer closer to the structures of interest, and enables the use of a higher frequency transducer, which produces more detailed spatial resolution. TVS will reveal fetal and other intrauterine structures about 1 week earlier than transabdominal scanning (Table 6), offering a time advantage that is critical to the diagnosis of ectopic pregnancy. TVS also complements the evaluation of pelvic masses and the search for free pelvic fluid in cases of suspected intraabdominal hemorrhage.

The limited view and high magnification seen with transvaginal scanning makes orientation of the examiner difficult at first. For these reasons, transvaginal scanning is most helpful when used in combination with (after) transabdominal scanning to avoid missing structures that may be out of the field of view of the transvaginal probe. Equipment appropriate for both transabdominal and transvaginal scanning is available from many manufacturers in the price range of $25,000 to $30,000.[16]

The physician learning obstetric ultrasonography will need to use multiple sources of information and training. Whenever possible, the following training strategies are recommended: (1) build a library of related literature and read it; (2) perform 25 to 75 supervised scans by tutorial or hands-on course; (3) develop a period of preceptorship that can be remote; (4) study the clinical implications of ultrasound's physics and understand limitations and artifacts affecting use of sonography; (5) attend courses where many abnormalities are presented and discussed; and (6) continue active study of the rare things that the physician must suspect to avoid missing them. (This is no different from rehearsing skills in advanced cardiac life support and advanced trauma life support: these are examples of skills that are seldom used but critical when the need arises.)

Additional Skills

Diagnostic ultrasound imaging skills are helpful in additional diagnostic and interventional procedures that benefit pregnant patients. These procedures include genetic amniocentesis, biophysical testing for fetal well-being, external version of breech fetuses, and third trimester amniocentesis for fetal lung maturity testing or investigation of possible amnionitis.

AMNIOCENTESIS

Genetic amniocentesis is a well-established procedure with a fetal loss rate generally considered to be essentially no greater, when performed by experienced physicians, than the natural miscarriage rate. Although the procedure itself is relatively straightforward, it can be tricky. Patients must be informed of the possibility of cord puncture at the time of amniocentesis. Dry or bloody taps do occur, and complications resulting from amniocentesis are possible.

Arrangements must be made before the procedure for appropriate handling of the amniotic fluid specimen by a specialized laboratory for cell culture, chromosome preparation, and analysis. Results take 10 to 20 days. It is essential that the physician be able to counsel the patient about the indications for the test, and what the test can and cannot show, and have a plan for dealing with test results if they are abnormal. This is no small challenge considering the moral dilemma that faces patients who first discover that they are carrying an abnormal fetus during the middle of the second trimester. Nevertheless, genetic amniocentesis may be appropriate for some family physicians with a close relationship with a good cytogenetics laboratory. The cost of chromosome analysis from amniotic fluid varies, but generally is approximately $600. Cases appropriate for genetic amniocentesis will arise from one of several high-risk groups.

Those patients who fall in one of the two age ranges for increased risk of trisomies, young teenagers and mothers over 35 years of age, should be considered for amniocentesis.

Patients with "true abnormal" maternal serum α-fetoprotein (MSAFP) results may benefit from amniocentesis. Correct dating of the fetus confirms that the MSAFP result was truly abnormal for the gestational age at the time the test was drawn. Patients with abnormally high MSAFP results are at increased risk for neural tube defects, while those with low MSAFP results are at increased risk for trisomies. Both need detailed sonographic scanning including fetal anatomy surveys and consideration of amniocentesis for chromosome testing and amniotic fluid α-fetoprotein testing. A request for a consultation is never wrong when the family physician is uncertain of the findings.

FETAL BIOPHYSICAL VARIABLES

Direct examination of fetal biophysical variables through ultrasound has been shown to provide insight into fetal well-being.[20] The fetal biophysical profile was developed as a way to objectively score variables including breathing movements, muscle tone, placental grade, amniotic fluid volume, and heart rate reactivity. Physicians who routinely perform obstetric ultrasound examinations can also do biophysical profiles, with much of the biophysical data being acquired while the scanning for biometry and fetal anatomic survey is in progress. Indications for bio-

physical testing include fetuses being followed for intrauterine growth retardation, premature labor, placental abruption, maternal diabetes and hypertension, and abnormally prolonged gestation.

EXTERNAL VERSION

External version of the breech fetus may avoid a cesarean section. Screening of all pregnancies at 36 weeks by physical examination using Leopold's maneuvers will identify breech presentations, which can then be confirmed sonographically. External version can then be attempted either with or without tocolysis. External version before 36 weeks should probably be avoided because of the high rate of spontaneous version; after 36 weeks, version becomes increasingly difficult because of crowding. The success rate for external version in an outpatient setting is approximately 50%.[31] The procedure is generally done with steady, gentle pressure in a forward, head-toward-rump direction. Informed consent and postversion monitoring are recommended.

TESTING FOR LUNG MATURITY

Amniocentesis near term for fetal lung maturity testing is the sonographically directed invasive procedure most likely to be of practical use in the family practice setting. It is often indicated before elective repeat cesarean section, particularly when the start of prenatal care was delayed and data required for accurate dating are not available. Fetal lung maturity testing is also helpful in deciding whether to start or stop tocolytics in the premature labor patient.

Lung maturity testing seeks the presence of surfactant in the amniotic fluid, which indicates the fetus's risk for respiratory distress syndrome (RDS). The classic test for fetal lung maturity is the lecithin to sphingomyelin (L/S) ratio. If the L/S ratio is greater than 2:1, the risk of respiratory distress syndrome is less. Caution must be used in interpreting L/S ratio results in diabetic mothers because RDS may still develop despite a numerically "mature" value. Another surfactant, phosphatidylglycerol (PG) may also be tested for, and is reported as being either present or absent. If PG is present, the risk of RDS is essentially zero. A kit test (Amniostat, IS Irvine Scientific, Santa Ana, Calif) is available for immediate testing of PG in amniotic fluid.

To perform late pregnancy amniocentesis, potential pockets of amniotic fluid are located sonographically. Pockets that are not covered by the placenta and that are free of the umbilical cord and away from the fetal face are preferred. In some cases, finding such a pocket may be difficult or even impossible. A helpful maneuver in such cases is to have an assistant elevate the fetal head by lifting it abdominally, then the tap may be performed suprapubically in the pocket between the fetal head and the endocervix. The maternal bladder must be empty to avoid obtaining urine instead of amniotic fluid via this route.

Informed consent, sterile preparation of the skin, and local anesthesia are used. After estimating the depth of insertion sonographically, a 21-gauge spinal needle is used to initiate the puncture under sonographic guidance using sterile contact gel.

The needle can be visualized as a bright echo within the fluid pocket. After removal of the stylet, short flexible tubing is used to connect the needle to a 20- to 30-mL syringe. This allows movement of the needle separate from the syringe if the fetus bumps against the needle, which is common. If blood is aspirated, the needle is repositioned (usually deeper), and a fresh syringe is used. If the needle tip is properly positioned and no fluid is obtained, the membranes may be tented over it; this can be dealt with by rotating the needle, which will usually result in penetration of the membranes. Twenty mL of fluid is recommended, but as little as 5 mL may be adequate depending on the test being done. After the fluid is obtained, the needle is withdrawn and the patient is monitored. Consideration should be given to administration of RhoGAM to Rh-negative mothers after amniocentesis.

Amniocentesis by this technique can also be done to investigate possible amnionitis in the febrile mother before or even during labor. Oligohydramnios after rupture of the membranes may make amniocentesis impossible. In such cases, amniotic fluid may be aspirated from an intrauterine pressure catheter being used to monitor labor.

Conclusions

Family physicians should be familiar with the prenatal diagnostic ultrasound examination. It is useful in increasing the understanding of maternal-fetal health during pregnancy and can be mastered by family physicians. Skill development depends on appropriate equipment, observance of indications and understanding of the limitations, and systematic practice. Performance mastery of obstetric ultrasonography may also lead to developing skills in amniocentesis and external version.

Obstetric ultrasound examination is a useful diagnostic tool for family physicians who select appropriate equipment, observe indications, understand limitations, and work toward performance mastery. In our opinion, this knowledge assists the physician in clinical decision making and reduces liability. This is particularly true for rural and underserved communities where family physicians provide the majority of prenatal and comprehensive

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perinatal care. Mastery of obstetric ultrasonography can also assist with amniocentesis, and as an aid to external cephalic version. The equipment does not require extensive maintenance, and it is available at all hospitals. Many offices and group practices have found that the purchase of this equipment produces patient-care benefits at a reasonable cost.

References

1. Zervanos NJ. Obstetric training in family practice [letter]. Am Fam Physician 1989; 40(3):53–61.
2. Hahn R, Ornstein S, Davies TC, et al. Obstetric ultrasound training for family physicians: results from a multi-site study. J Fam Pract 1988; 26:553–8.
3. Ornstein SM, Smith MA, Peggs J, et al. Obstetrical ultrasound by family physicians: adequacy as assessed by pregnancy outcome. J Fam Pract 1990; 30:403–8.
4. Rodney WM, Prislin MD, Orientale E, McConnell M, Hahn RG. Family practice obstetrical ultrasound in an urban community health center: birth outcomes and examination accuracy of the initial 227 cases. J Fam Pract 1990; 30:163–8.
5. Morgan WC, Rodney WM, Garr DA, Hahn RG. Ultrasound for the primary care physician: applications in family-centered obstetrics. Postgrad Med 1988; 83:103–7.
6. National Institute of Child and Human Development, National Institutes of Health. Mid trimester amniocentesis for prenatal diagnosis: safety and accuracy. JAMA 1976; 236:1471–6.
7. Benacerraf BR, Frigoletto FD. Amniocentesis under continuous ultrasound guidance: a series of 232 cases. Obstet Gynecol 1983; 62:760.
8. Huddleston JF. How to perform amniocentesis safely in late pregnancy. Continuing Educ Fam Physicians 1979; 10:46–53.
9. Golbus MS. Identifying and preparing patients for amniocentesis. Diagnosis 1980; 10:60–76.
10. Mennuti MT. Prenatal diagnosis—advances bring new challenges. N Engl J Med 1989; 320:661–3.
11. Deutchman M. The problematic first trimester pregnancy. Am Fam Physician 1989; 39:185–98.
12. Deutchman M. Advances in the diagnosis of first-trimester pregnancy problems. Am Fam Physician 1991; 44(Suppl):15S–30S.
13. Elias S, Simpson JL, Shulman LP, et al. Transabdominal chorionic villus sampling for first-trimester prenatal diagnosis. Am J Obstet Gynecol 1989; 160:879–86.
14. Rhoads GG, Jackson LG, Schlesselman SE, et al. The safety and efficacy of chorionic villus sampling for early prenatal diagnosis of cytogenetic abnormalities. N Engl J Med 1989; 320:609–17.
15. Cole HM. Diagnostic and therapeutic technology assessment: chorionic villus sampling: a reassessment. JAMA 1990; 263: 305–6.
16. Hahn RG. Ultrasound diagnostic systems: part I. Physicians Marketplace 1990; 24(5):6–30.
17. Diagnostic ultrasound imaging in pregnancy. National Institutes of Health. DHHS publication No. (PHS) 84-667. Washington DC: Government Printing Office, 1984.
18. Deutchman M. Eight years of ultrasound in a family physician's practice. Washington Academy of Family Physicians Scientific Assembly, May 14, 1988, Blaine, Washington.
19. Jack BW, Empkie TM. Routine obstetric ultrasound. Am Fam Physician 1987; 35(5):173–82.
20. Norman LA, Karp LE. Biophysical profile for antepartum fetal assessment. Am Fam Physician 1986; 34(4):83–9.
21. Smith GN, Frey KA, Johnson TRB. Assessing gestational age. Am Fam Physician 1986; 33(2):215–20.
22. Waldenstrom U, Nilsson S, Fall O, et al. Effects of routine one-stage ultrasound screening in pregnancy: a randomised controlled trial. Lancet 1988; 2:585–8.
23. Saari-Kemppainen A, Karjalainen O, Yolstlo P, Heinonen OP. Ultrasound screening in perinatal mortality: controlled trial of systematic one-stage screening in pregnancy: the Helsinki Ultrasound Trial. Lancet 1990; 336:387–91.
24. Ewigman B, LeFevre M, Hesser J. A randomized trial of routine prenatal ultrasound. Obstet Gynecol 1990; 76:189–94.
25. Ewigman B, Cornelison S, Horman D, LeFevre M. Use of routine prenatal ultrasound by private practice obstetricians in Iowa. J Ultrasound Med 1991; 10:427.
26. Leopold GR. Antepartum obstetrical ultrasound examination guidelines. J Ultrasound Med 1986; 5:241–2.
27. Guidelines for performance of the antepartum obstetrical ultrasound examination (AIUM). J Ultrasound Med 1991; 10:10.
28. Zador IE, Bottoms SF, Tse GM, Brindle BA, Sokol RJ. Nomograms for ultrasound visualization of fetal organs. J Ultrasound Med 1988; 7:199–201.
29. Ornstein SM, Smith MA, Peggs J, Garr D, Gonzales J. Obstetric ultrasound by family physicians: adequacy as assessed by pregnancy outcome. J Fam Pract 1990; 30:403–8.
30. Zador IE, Sokol RJ, Chik L. Interobserver variability: a source of error in obstetric ultrasound. J Ultrasound Med 1988; 7:245–9.
31. Hanss JW. The efficacy of external cephalic version and its impact on the breech experience. Am J Obstet Gynecol 1990; 162:1459–64.

Suggested Reading

1. Benson CB, Jones TB, Lavery MJ, Platt LD. Atlas of Obstetrical Ultrasound. JB Lippincott Co, Philadelphia, 1988, 364 pages
2. Fleischer AC, Romero R, Manning FA, Jeanty P, James AE. The Principles and Practice of Ultrasonography in Obstetrics and Gynecology. 4th ed. Appleton & Lange, Norwalk, Conn, 1991, 668 pages
3. Nyberg DA, Mahony BS, Petorius DH. Diagnostic Ultrasound of Fetal Anomolies: Text and Atlas. Year Book Medical Publishers, Chicago, 1990, 778 pages
4. Callen PW. Ultrasonography in Obstetrics and Gynecology. 2nd ed. WB Saunders Company, Philadelphia, 1988, 510 pages, $60
5. Sanders RC. Atlas of Ultrasonographic Artifacts and Variants. 2nd ed. Mosby Year Book Medical Publishers Inc, December 1991, 304 pages, $90
6. Powis R, Powis W. A Thinker's Guide to Ultrasonic Imaging. Urban & Schwarzenberg, Baltimore, 1984, 413 pages, $65
7. Timor-Trisch IE, Rottem S. Transvaginal Sonography. 2nd ed. Elsevier, New York, 1991, 521 pages

Organizations Selling Educational Videotapes

1. American Institute of Ultrasound in Medicine, 11200 Rockville Pike, Suite 205, Rockville, MD 20852-3139. 1-800-638-5352.
2. Bowman Gray School of Medicine, Winston-Salem, NC 27103. 1-919-748-4505 or 1-800-277-7654.
3. Thomas Jefferson University, Philadelphia, PA 19107. 1-215-955-8533.