AIUM Practice Parameter for the Performance of Detailed Diagnostic Obstetric Ultrasound Examinations Between 12 Weeks 0 Days and 13 Weeks 6 Days

Introduction

The American Institute of Ultrasound in Medicine (AIUM) is a multidisciplinary association dedicated to advancing the safe and effective use of ultrasound in medicine through professional and public education, research, development of clinical practice parameters, and accreditation of practices performing ultrasound.

The *AIUM Practice Parameter for the Performance of Detailed Diagnostic Obstetric Ultrasound Examinations Between 12 Weeks 0 Days and 13 Weeks 6 Days* was developed by the AIUM in collaboration with other organizations whose members use ultrasound for performing this examination (see "Acknowledgments"). Recommendations for personnel requirements, the request for the examination, documentation, quality assurance, and safety may vary among the organizations and may be addressed by each separately.

This practice parameter is intended to provide the medical ultrasound community with recommendations for the performance and recording of high-quality ultrasound examinations. The parameter reflects what the AIUM considers the appropriate criteria for this type of ultrasound examination but is not intended to establish a legal standard of care. Examinations performed in this specialty area are expected to follow the parameter with recognition that deviations may occur depending on the clinical situation.

This specialized diagnostic examination is an extension of the standard sonographic fetal assessment described in the *AIUM-ACR-ACOG-SMFM-SRU Practice Parameter for the Performance of Standard Diagnostic Obstetric Ultrasound Examinations* and the American College of Obstetricians and Gynecologist practice bulletin *Ultrasound in Pregnancy*.[1,2] The detailed obstetric ultrasound examination in the late first trimester is an indication-driven examination for women at increased risk for fetal or placental abnormalities that are potentially detectable between 12 weeks 0 days and 13 weeks 6 days' gestation. Performance and interpretation of this examination require advanced training, knowledge, and imaging

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skills, as well as the ability to effectively communicate the findings to the patient and referring physician. Thus, the performance of the detailed first-trimester ultrasound examination should be rare outside referral practices with special expertise in the identification and diagnosis of fetal anomalies and placental implantation disorders in the first trimester. Genetic counseling and diagnostic testing services should be available for patients diagnosed with fetal anomalies in early gestation.

Ultrasound imaging of the fetus was first introduced in the late first trimester as a component of risk assessment for aneuploidy and has been widely incorporated into prenatal care.[3–6] In addition to aneuploidy assessment, imaging the fetus in this period promotes accurate dating and optimal assessment of amnionicity and chorionicity in multiple gestations and provides an opportunity to evaluate the structural integrity of the fetus. Many anomalies that were historically diagnosed in the second trimester can be identified in the latter part of the first trimester by sonographers and sonologists.[7–17]

The components of this examination promote a systematic method of assessing fetal anatomy that optimizes the detection of anomalies.[17–22] Approximately 50% of major anomalies are detectable in singletons and 25% in twins in this gestational age window, although there is significant variability among organ systems.[13,14,17–25] Some malformations, such as anencephaly, alobar holoprosencephaly, ectopia cordis, body stalk abnormalities, and large abdominal wall defects, are usually identified.[14,16,17,19–23,25] Certain anomalies such as microcephaly and callosal agenesis are not sonographically detectable during this period. Anomaly detection rates increase with fetal size and may be enhanced by the use of transvaginal sonography, especially when the fetal anatomy is suboptimally visualized by the transabdominal approach.[8,11,12,19] While it is not possible to detect every abnormality, adherence to the following practice parameter will maximize the probability of detecting fetuses with major structural anomalies between 12 weeks 0 days and 13 weeks 6 days' gestation.[21] Early detection of major anomalies allows the patient the opportunity to pursue genetic diagnostic testing, obtain comprehensive multidisciplinary counseling, and maximize reproductive choices.

While a first-trimester detailed anatomic scan may detect many major anomalies, the natural history of some findings (eg, megacystis, micrognathia, abdominal cysts, and cardiac structures) is variable.[13,14,26–28] In addition, similar to other screening paradigms, false-positive and false-negative results may occur.[14,17,22,27,29,30] It must be emphasized that a first-trimester ultrasound examination does not replace the second-trimester anatomic survey.[16,22,31,32] In ongoing pregnancies at increased risk for adverse outcomes, a second-trimester detailed anatomic evaluation should be considered and recommended when appropriate.[1,33] Late first-trimester fetal anatomic and placental imaging is rapidly evolving, requiring meticulous attention to advances in the literature and interpretation of findings.

Qualifications and Responsibilities of Personnel

Physicians interpreting or performing this type of ultrasound examination should meet the specified AIUM Training Guidelines in accordance with AIUM accreditation policies.

Sonographers performing the ultrasound examination should be appropriately credentialed in the specialty area in accordance with AIUM accreditation policies.

Physicians not personally performing the examination must provide supervision, as defined by the Centers for Medicare and Medicaid Services Code of Federal Regulations 42 CFR §410.32.

Request for the Examination

The written or electronic request for an ultrasound examination must originate from a physician or other appropriately licensed health care provider or under the provider's direction. The clinical information provided should allow for the performance and interpretation of the appropriate ultrasound examination and should be consistent with relevant legal and local health care facility requirements.

Indications

A detailed late first-trimester obstetric ultrasound examination may be performed when there is an

increased risk for a fetal or placental abnormality associated with anatomic findings, potentially identifiable by ultrasound in the first trimester.

Indications include but are not limited to:

1. Previous fetus or child with a congenital, genetic, or chromosomal anomaly.[34,35]
2. Known or suspected fetal abnormality detected by ultrasound in the current pregnancy.
3. Fetus at increased risk for a congenital anomaly based on the following:
   a. 35 years or older at delivery.[34–37]
   b. Maternal pregestational diabetes.
   c. Pregnancy conceived via in vitro fertilization.[38–41]
   d. Multiple gestation.[42–45]
   e. Teratogen exposure.[46–49]
   f. Enlarged nuchal translucency.[50,51]
   g. Positive screening test results for aneuploidy, including cell-free DNA screening and serum-only or combined first-trimester screening.[52]
4. Other conditions possibly affecting the pregnancy/fetus, including:
   a. Maternal body mass index of 30 kg/m^2 or higher.[53–55]
   b. Placental implantation covering the internal cervical os under a cesarean scar site or cesarean scar pregnancy diagnosed in index gestation.[56,57]

Specifications of the Examination

General Considerations

The examination may be done transabdominally and/or transvaginally. The transabdominal examination provides a global view of the fetus, placenta, uterus, and adnexa. Higher-frequency transabdominal linear or curvilinear transducers have been used to visualize fetal anatomy, including fetal cardiac structures.[58,59] In most cases, transabdominal imaging may be sufficient; however, a transvaginal approach can optimize visualization by providing a higher resolution and is recommended if transabdominal imaging is suboptimal or an anomaly is suspected. A combined transabdominal and transvaginal approach has been reported to optimize the detection rate of fetal anomalies.[10,12,13,19] Attention should be given to adequate magnification, appropriate depth, sector size, and correct focal zone placement at the area of interest. Harmonic imaging, compound imaging, and speckle reduction may enhance the demonstration of fetal anatomy. Power and color Doppler imaging may be complementary to standard grayscale evaluation when appropriate.

As in all clinical imaging situations, the patient's body habitus and the presence of other acoustic challenges (leiomyomata, uterine position, and surgical scars) may alter the ability to see all anatomic components despite using both a transabdominal and transvaginal approach. In some circumstances, such as a suspected anomaly, repeated imaging in 1 to 3 weeks should be considered, and in other situations, the nonvisualized structure(s) may be evaluated at the time of the second-trimester detailed anatomic scan. In women of a high body mass index, structural evaluation of the fetus in the later first trimester may be advantageous.[53–55]

Imaging Parameters

Imaging parameters are listed in Table 1.

It is recognized that visualization of anatomic structures may be adequate in 1 or more planes.

1. Fetal cardiac activity should be documented by M-mode or a cine loop.
2. Fetal number should be determined.
3. In cases of multiple gestation, amnionicity and chorionicity should be assigned.

Fetal Biometry

Assessment of gestational age is critical in pregnancy management, including scheduling of obstetric screening and surveillance tests, optimizing detection of fetal growth disorders, and consideration regarding timing of delivery. Aside from assisted reproductive technology, ultrasound imaging is the most reliable method of assessing gestational age in the first trimester.[60,61] Standardization of sonographic measurements is important in maintaining consistency. For each biometric measurement, the image should be magnified to fill the majority of the image space available without compromising image quality. Nomograms are available for fetal biometric measurements.[61–70]

Crown-Rump Length

Crown-rump length (CRL) is the most commonly used and recommended sonographic method to

Table 1. Detailed Fetal Anatomic and Placental Assessment Between 12 Weeks 0 Days and 13 Weeks 6 Days

The detailed obstetric ultrasound examination in the late first trimester is an indication-driven examination for women at increased risk for fetal or placental abnormalities that are potentially detectable between 12 weeks 0 days and 13 weeks 6 days' gestation. Performance and interpretation of this examination require advanced training, knowledge, and imaging skills, as well as the ability to effectively communicate the findings to the patient and referring physician.

- Images should be acquired with appropriate attention to magnification, depth, and focal zone.
- Anatomic structures should be evaluated in at least 1 plane of imaging, although the specific plane(s) may vary depending on imaging conditions.
- It is recognized that in some imaging situations, not all required landmarks will be visualized, and follow-up imaging may be recommended.

Scanning Planes/Structures	Required	Required if Indicated or Suspicious	Comments and Observations
General			
Output display standard	√		TI for bone ratio ≤0.7[124]
Cardiac activity	√		M-mode or cine loop
Heart rate		√	M-mode
Number of fetuses and gestational sacs	√		
If multiple gestation	√		Amnionicity and chorionicity
Biometry	See text for description of technique		
Crown-rump length	√		Report the mean of 3 acceptable measurements
Biparietal diameter		√	
Head circumference		√	
Abdominal circumference		√	
Femoral length		√	
Fetal head			
A. Axial			
Transventricular			
Cranial bones (calvarium)	√		Oval shape, no bulges, appropriate ossification
Falx cerebri	√		Anterior to posterior, symmetric hemispheres of equal size
Choroid plexus	√		Fill majority of lateral ventricle
Ventricles		√	Symmetrical
Cortex		√	Thin, seen mostly anteriorly
Transthalamic			
Falx cerebri	√		
Thalami	√		
Third ventricle		√	
Posterior fossa	√		Angle posterior-inferiorly
B. Sagittal			
Thalami-midbrain	√		
Brain stem	√		
Fourth ventricle (intracranial translucency)	√		
Cisterna magna	√		
Facial structures			
A. Axial			
Orbits		√	Size and position
B. Sagittal			
Nasal bone	√		Present/absent
Profile (forehead, nasal contour, nasal bone, upper lip, mandible)	√		Forehead appearance, intact upper lip
Maxilla	√		Evaluate for maxillary gap
C. Coronal/tangential			

(Continues)

Table 1. Continued

Scanning Planes/Structures	Required	Required if Indicated or Suspicious	Comments and Observations
Retronasal triangle with ancillary bones (frontal process of the maxilla and alveolar ridge)		√	Nasal bone may be evaluated in this view
Mandible	√		Evaluate for absence of mandibular gap
Upper lip		√	Intact and contiguous
Orbits		√	May also be evaluated on axial plane
Lenses		√	
Ears		√	Seen or not seen
Neck			
A. Axial, sagittal, coronal			
Evaluation for cystic hygroma, dilated jugular lymphatic sacs, other abnormal fluid collections, or masses	√		Subjective evaluation
B. Sagittal			
Nuchal translucency evaluation	√		
Nuchal translucency measurement		√	
Comment	A measurement of the nuchal translucency is required if it appears enlarged or is part of a screening protocol for aneuploidy risk assessment. A quality assessment program is recommended to ensure that false-positive and false-negative results are kept to a minimum.[88,89]		
Fetal thorax			
A. Axial			
Cardiac position and axis	√		Subjectively assessed
Cardiac axis (angle measurement)		√	Normal axis (≈45° ± 15°), leftward
4-chamber view without color	√		Symmetric chambers, presence or absence of pericardial effusion
4-chamber view with color	√		Diastolic filling
3-vessel and trachea view with color	√		Antegrade flow
Symmetric lungs (may be evaluated in coronal plane)	√		No masses or effusions
Ribs with normal shape, length, and ossification		√	
Tricuspid valve flow		√	
B. Sagittal			
Aortic arch with color		√	Antegrade flow
Ductal arch with color		√	Antegrade flow
Diaphragm demarcation	√		Contour
Comment	While the use of Doppler should be limited in the first trimester, color flow imaging is useful to evaluate the fetal heart, great vessels, and circulation; monitor the output display standard to keep TI for bone ≤0.7.[124]		
C. Coronal			
Lungs	√		
Diaphragm demarcation	√		Contour
Fetal abdomen			
A. Axial (3 planes: at level of stomach, kidneys, and bladder/cord insertion)			
Stomach	√		Fluid-filled structure on left side of abdomen
Liver	√		Right side
Portal vein		√	Coursing away from stomach
Cord insertion into abdominal wall*	√		

(Continues)

Table 1. Continued

Scanning Planes/Structures	Required	Required if Indicated or Suspicious	Comments and Observations
Bladder with fluid	√		Sagittal measurement recommended if suspicious for anomaly
Color Doppler of umbilical arteries on each side of the bladder	√		
B. Sagittal			
Contour of anterior wall	√		No hydrops/masses
Ductus venosus flow		√	
C. Coronal			
Kidneys	√		Axial and sagittal acceptable
Color Doppler of renal vessels		√	If kidneys not well seen
Comment	*Physiologic midgut hernia should not be seen after 12 weeks 6 days. May occasionally be present and resolve later in gestation. Genetic counseling should be considered.		
Extremities			
Confirm each of the 4 extremities	√		
Confirm 3 long bones are present and subjectively normal in each extremity	√		Humerus/radius/ulna Femur/tibia/fibula
Confirm presence of hands/feet	√		
Fingers/thumb/toes		√	
3-dimensional assessment of extremities		√	
Spine			
A. Axial, longitudinal			
Vertebral elements/alignment	√		
Skin edge	√		Presence of any bulges
Scapula		√	
Placenta			
A. Axial, sagittal			
Position of the placenta, including relationship with lower uterine segment, internal cervical os, and cesarean scar site (if applicable)	√		Placental position should be reported if centrally located over internal cervical os, history of cesarean delivery, or suspicion for PAS
Umbilical cord insertion into placenta	√		
Echo texture of placenta	√		Note heterogeneity, masses, cystic spaces, or lacunae
Color Doppler evaluation		√	Required if suspicious for PAS
Myometrial thinning (subjective)/loss of retroplacental clear zone		√	
Bladder wall interface		√	
Uterine vesical vascularity		√	
Comment	In cases of suspected PAS, transvaginal imaging through a partially full bladder is recommended. A previously documented low-lying gestational sac or cesarean scar pregnancy may expand toward the fundus with advancing gestation. If the placenta is anterior and under the cesarean scar site, the villi remain anchored in that location, a characteristic of PAS.		
Uterus, adnexa, cul-de-sac			

(Continues)

Table 1. Continued

Scanning Planes/Structures	Required	Required if Indicated or Suspicious	Comments and Observations
Myometrial masses (leiomyomata)	√		Presence and number, size, and location of clinically significant masses
Müllerian duct anomalies	√		
Intrauterine linear structures	√		Synechiae, bands
Ovaries	√		
Adnexa and cul-de-sac	√		

establish or confirm gestational age up to 13 weeks 6 days.[60] Variability in predicting menstrual age by CRL is ±8%.[62] In spontaneously conceived pregnancies, ultrasound redating of a pregnancy based on CRL is supported when the CRL varies from menstrual dating by more than 7 days between 9 weeks and 13 weeks 6 days.[60] The CRL measurement in the later first trimester may be affected by fetal position and image magnification. Standardization and consistency in obtaining this measurement are critical for accuracy in gestational dating as well as risk assessment for aneuploidy.[71–77] The CRL may be smaller in fetuses with central nervous system abnormalities or chromosomal aberrations.[78] Significant intertwin crown-rump discordance has been reported in association with an increased risk of fetal anomalies and pregnancy complications in monochorionic twins.[79,80]

In spontaneously conceived multiple gestations, gestational age should be based on the results obtained from the largest fetus, so as not to overlook a growth-restricted fetus.[81]

Method of Measuring CRL Between 12 Weeks 0 Days and 13 Weeks 6 Days[75,82]

1. Fetus fills at least two-thirds of the image space available.
2. The long axis of the fetus should be perpendicular to the ultrasound beam.
3. The fetus should be in the midsagittal position with the profile, spine, and rump visible. The entire CRL should be visible.
4. The fetus should be in a neutral position with fluid between the fetal chin and anterior neck. The fetus should not be hyperextended (the angle between the chin and anterior neck should not be >90°).
5. The caliper crossbars should be placed on the outer border of the skin on the fetal head and rump. The caudal caliper should not be on the distal spine or posterior thigh or include the limbs.
6. The maximum length of the fetus from the cranial to caudal calipers should be measured in a straight line, parallel to the long axis of the fetus.
7. The numeric value is reported as the mean of 3 acceptable measurements.

Biparietal Diameter or Head Circumference

Biparietal diameter (BPD) is a reliable method of assessing gestational age in the later first trimester and has been reported to be accurate with good reproducibility.[61,66,67,73]

Biparietal diameter and head circumference (HC) may be measured as part of a detailed first-trimester anatomic examination. Biparietal diameter and/or HC should be assessed in situations in which the CRL is technically inadequate or when an anomaly is suspected.[83,84] When interpreting the BPD, attention to the method used in the nomogram is critical, as placement of the "far" caliper may be different (inner versus outer calvarial bone).[63,64,67,69]

Method of Measuring BPD and HC

1. An axial scan of the fetal head with the ultrasound beam perpendicular to the midline falx should be obtained and magnified to fill the majority of the image space without compromising image quality.
2. The fetal calvarium should not be distorted by transducer pressure or adjacent structures.
3. The brain and calvarium should appear symmetric with the midline falx centrally located. The thalami should be seen, and the third ventricle is typically visible.

4. Measurements are made at the widest diameter of the calvarium, perpendicular to the midline falx. The skin should not be included in the measurement.
5. For BPD, the crossbar of the "near" caliper should be placed on the outside edge of the bone. The crossbar of the "far" caliper may be placed on the inside edge of the bone (outer to inner) or on the outer edge of the bone (outer to outer) depending on the nomogram used.
6. For HC, the measurement is made by placing an ellipse on the outer surface of the calvarium excluding skin.

Abdominal Circumference

The abdominal circumference may be helpful in certain clinical situations such as early asymmetric growth restriction (triploidy) and skeletal dysplasias.[61,64,70]

Method of Measuring Abdominal Circumference

1. An axial scan of the fetal abdomen is obtained and magnified to fill the majority of the available image space without compromising image quality.
2. The fetal stomach and, if possible, the intrahepatic portion of the portal vein should be seen. The kidneys and umbilical cord insertion into the fetus should not be in the image.
3. One vertebral body should be identified, and a single rib on each side lateral to the spine should be seen to ensure that the abdomen is in a true axial plane and not oblique. Optimally, the cross-section of the spine is at 3 or 9 o'clock.
4. Measurements should be made along the outer skin edge. This can be done by an ellipse or 2 perpendicular diameters.

Femoral Length

Femoral length is not used for assessing gestational age due to variability in the measurement; however, it may be useful in evaluating a fetus with a suspected skeletal dysplasia.[61,71,85]

Method of Measuring Femoral Length

1. The femoral diaphysis should be magnified to fill the majority of the image space without compromising imaging quality.
2. The ultrasound beam is perpendicular to the long axis of the femur.
3. The calipers are placed at the proximal and distal ends of the ossified diaphysis. Spur artifacts at the end of the femur should not be included.
4. The longest visible diaphysis is measured.

Anatomy

The comprehensive assessment of fetal anatomy will be dependent on a variety of imaging factors, including fetal gestational age (size) and position as well as external maternal factors such as uterine orientation, presence of leiomyomata, and maternal habitus. For each anatomic area of interest, the image should be magnified to fill the majority of the image space available without compromising image quality.

Fetal Head

The fetal head is evaluated in axial and sagittal planes without significant pressure from the transducer or surrounding anatomic structures. The fetal skull should be oval in appearance, and calvarial ossification should be evident. The falx cerebri divides the brain into equal-sized symmetric halves. In the transventricular plane, the choroid plexus on each side of the falx is hyperechoic and fills the ventricular space. The choroid plexuses are not necessarily the same size or shape.[86,87] A rim of cortex can be seen around the lateral ventricles, most notably in the anterior portion of the brain. The transthalamic plane demonstrates the thalami, the cerebral peduncles, and typically the third ventricle and aqueduct of Sylvius. Angling in the axial plane toward the posterior fossa results in visualization of the semilunar fluid-filled space of the fourth ventricle. This view is commonly seen best on transvaginal imaging. The midsagittal view of the fetal head is used at this stage in gestation for measuring the nuchal translucency.[88,89] Other critical landmarks that should be visualized in the midsagittal plane include the thalami, midbrain, brain stem, intracranial lucency (fourth ventricle), and future cisterna magna.[90–94]

Severe central nervous system anomalies, such as the anencephaly-acrania sequence, alobar holoprosencephaly, and large cephaloceles, will frequently be detected by a structured evaluation of the fetal head.[13,14,16,19,21,95]

In the midsagittal view, a compressed or absent fourth ventricle or abnormal future cisterna magna may be an early sign of spina bifida; alternatively, fourth ventricle enlargement can be associated with the Dandy-

Walker continuum.[90–94] In the transthalamic view, the posterior displacement of the aqueduct of Sylvius may be a marker for spina bifida.[96] Biometry of the fetal head (BPD and HC) may be smaller than expected in cases of central nervous system abnormalities such as holoprosencephaly or neural tube defects.[83,84,97]

Some structures such as the cavum septi pellucidi and corpus callosum are not visible sonographically in the late first trimester.

Fetal Face and Profile

Midsagittal and modified coronal views are most commonly used to identify structures in the fetal profile and face. The profile should be seen in its entirety. The fetal forehead, nasal bridge, nasal bone, maxilla, and mandible should be seen. The forehead should be a normal shape (not flattened or protruding), and the nasal bone should be present. The contour of the nose and upper lip should be intact and contiguous with no maxillary protuberance. The maxilla should be intact without a maxillary gap. The presence of a maxillary gap is suspicious for a cleft palate.[98] The retronasal triangle can be used to identify the paired nasal bones, premaxillary processes, primary palate, and the mandible.[99–102] The absence of the mandibular gap raises a concern for micrognathia.[101] A sweep of the coronal planes can be used to demonstrate the orbits, lenses, and integrity of the upper lip.

Fetal Neck

The fetal neck should be evaluated for cystic hygroma, dilated jugular lymphatic sacs, or other abnormal fluid collections or masses in an axial or coronal view. The nuchal translucency should be evaluated and subjectively assessed in the midsagittal view. A precise measurement is required when it appears thickened or as part of a screening protocol for aneuploidy risk assessment. A quality assessment program is recommended to ensure that false-positive and false-negative results are kept to a minimum.[88,89]

Fetal Thorax and Heart

The heart and chest are initially evaluated with an axial view of the thorax. The ribs should appear of normal shape, length, and ossification. The fetal lungs should be symmetric without pleural effusion. Sagittal or coronal imaging will demonstrate the demarcation between the thorax and abdomen. The fetal heart should occupy approximately one-third of the chest. Two equal-sized cardiac ventricles, atria, and atrioventricular valves should be seen on the 4-chamber view. The cardiac position within the chest and cardiac axis should be subjectively assessed. If the cardiac axis appears abnormal, it should be measured (normal, $\approx 45^\circ \pm 15^\circ$).[103] The use of color Doppler imaging is essential for cardiac evaluation in this gestational age range and requires optimization for this application.[59,104] Color Doppler evaluation of the 4-chamber view facilitates assessment of the cardiac axis, as it better defines the ventricular septum than grayscale imaging.[58,104–107] Furthermore, color Doppler imaging allows for the evaluation of chamber symmetry and demonstration of distinct mitral and tricuspid flow during diastole.[23,58,104,107] The three-vessel and trachea view should be demonstrated with color Doppler and grayscale imaging when technically feasible. In the three-vessel and trachea view, the transverse aortic arch/isthmus merging with the pulmonary trunk/ductus arteriosus with antegrade flow should be demonstrated to the left side of the trachea.[58,105–107] Extended cardiac views including the longitudinal aortic and ductal arches and pulsed wave Doppler flow across the tricuspid valve and within the ductus venosus may provide a more comprehensive evaluation in those patients with suspected cardiac abnormalities.[59,108,109]

Fetal Abdomen and Pelvis

The abdomen is evaluated primarily in the axial plane at 3 levels: stomach, kidneys, and bladder. The stomach should be identified on the left and the liver on the right side of the abdomen. The portal vein may be seen coursing away from the stomach. The umbilical cord insertion into the anterior abdominal wall should be demonstrated. Power or color Doppler imaging may be used to show the umbilical arteries coursing on each side of the fetal bladder. Fluid should be seen within the fetal bladder. The fetal kidneys may be identified most easily on the coronal view, aided by the appearance of the central hypoechoic space of the renal pelvis. Power or color Doppler imaging of the renal arteries is recommended if visualization of the kidneys is inadequate. Unusual cystic collections within the fetal abdomen should be noted, as they may be harbingers of fetal anomalies.[28,110]

A physiologic herniation of the bowel into the base of the umbilical cord may be seen before 13 weeks' gestation and is a normal finding.[111,112] In some euploid

fetuses, there is delayed return of the bowel into the abdominal cavity without other complications.[113] An enlarged bladder (length in the sagittal plane of ≥7 mm) has been associated with aneuploidy and lower urinary tract obstruction; however, in the euploid fetus, it may be a transient finding with a good outcome.[26,113,114]

Fetal Spine and Extremities

The fetal extremities are easily visible between 12 weeks 0 days and 13 weeks 6 days.[115] Major limb reduction anomalies can be detected at this gestational age. Three long bones should be subjectively identified in each extremity and described if abnormal in appearance.[85,116] The presence of feet and hands should be documented. A more detailed assessment of the fingers or toes is recommended in the setting of a suspected abnormality or clinical history concerning for a musculoskeletal disorder.[14,115,116]

The fetal spine should be imaged in the longitudinal and axial planes. The spine should be evaluated with attention to irregularity, scoliosis, or interruption. The distal spine is not completely ossified at this stage in gestation. Intact skin over the spine should be demonstrated. An abnormal appearance of the posterior fossa, posterior displacement of the aqueduct of Sylvius, and a smaller-than-expected BPD may be markers of open spina bifida.[83,90,91,96,97,117]

If skeletal dysplasia is suspected, the calvarial shape, thorax and rib appearance, presence of the scapulas, and ossification of the long bones and spine may provide additional findings to narrow a differential diagnosis. The biometry of the long bones in comparison to other structures may be useful for suspected skeletal dysplasias.[85,116]

Placenta

The placental echo texture, location, and placental cord insertion should be evaluated.

In patients at risk for placenta accreta spectrum (PAS), the placenta should be examined in detail through a partially full maternal bladder. Transvaginal scanning is recommended, as it will optimize resolution and enhance visualization of the cervix, lower uterine segment, and posterior bladder wall. The area of interest should be magnified so that it occupies at least half of the ultrasound image with the focal zone at an appropriate depth. Color Doppler imaging may be optimized by using a low-velocity scale, low filters, and high gain to maximize detection of flow.[118] The location of the placenta with respect to the bladder, a cesarean scar (if present), and the internal cervical os should be evaluated. Low implantation of the gestational sac, defined as a placental implantation located posterior to a partially full maternal bladder, has been correlated with PAS; thus, follow-up ultrasound examinations in the second and third trimesters are recommended. The presence of lacunae should be noted. The appearance of the myometrium and the retroplacental hypoechoic zone between the placenta and myometrium should be evaluated. Doppler imaging may be used to investigate the placental vasculature as well as the interface with the bladder.[56,57]

The placental echo texture may be abnormal in triploidy and placental mesenchymal dysplasia.[119,120] Placentation and membrane characteristics (chorionicity and amnionicity) should be definitively determined for multiple gestations.[9,15]

Uterus and Adnexa

The uterus (including the cervix), ovaries, adnexa, and cul-de-sac should be evaluated.[121] Abnormalities should be imaged and documented.

The presence and number of leiomyomata should be documented. Measurements and the location of the largest and any potentially clinically significant leiomyomata should be reported. Linear echogenic structures (synechiae) within the uterine space should be noted. If a Müllerian duct anomaly is identified or suspected, it should be reported, recognizing that accurate characterization is optimally performed in the nonpregnant state. The ovaries and adnexa should be evaluated, and any masses should be measured and characterized. The cul-de-sac should be evaluated for the presence or absence of free fluid.

Documentation

Accurate and complete documentation is essential for high-quality patient care. Written reports and ultrasound images/cine loop that contain diagnostic information should be obtained and archived, with recommendations for follow-up studies if clinically applicable, in accordance with the AIUM Practice

Parameter for Documentation of an Ultrasound Examination.

Equipment Specifications

A detailed sonographic examination of fetal anatomy in the first trimester should be performed with high-resolution imaging systems. The highest-frequency, clinically appropriate transducer should be used, realizing that there is a trade-off between resolution and beam penetration. Fetal imaging studies performed through the anterior abdominal wall can usually be achieved with frequencies of 5.0 MHz or higher.[58,59] Acoustic shadowing, a fetal position deep within the pelvis, a retroverted uterus, and the maternal body habitus may limit the ability of higher-frequency transducers to provide optimal anatomic detail. The use of transvaginal imaging with transducer frequencies of 5 to 12 MHz enhances detection rates of structural malformations and should be used if the transabdominal approach is limited by maternal factors or when an anomaly is suspected.[11–13,19]

Power, color, and spectral Doppler imaging should be available and settings optimized to use as an adjunct to diagnosis. Harmonic imaging, compound imaging, and speckle reduction may be beneficial in enhancing visualization of fetal anatomy. Three-dimensional postprocessing may be helpful in certain clinical situations.[122,123]

Quality and Safety

Policies and procedures related to quality assurance and improvement, safety, infection control, and equipment performance monitoring should be developed and implemented in accordance with the AIUM Standards and Guidelines for the Accreditation of Ultrasound Practices.

As Low as Reasonably Achievable Principle

The potential benefits and risks of each examination should be considered. The as low as reasonably achievable ALARA principle should be observed for factors that affect the acoustic output and by considering transducer dwell time and total scanning time. Further details on ALARA may be found in the current AIUM publication Medical Ultrasound Safety.

Fetal Safety

Diagnostic ultrasound studies of the fetus are generally considered safe during pregnancy (Conclusions Regarding Epidemiology for Obstetric Ultrasound).

Diagnostic ultrasound examinations should be performed only when there is a valid medical indication (Prudent Use and Safety of Diagnostic Ultrasound in Pregnancy). The lowest possible ultrasonic exposure setting should be used to gain the necessary diagnostic information under the ALARA principle. The output display standard, an on-screen real-time display of acoustic output, should be visible and monitored for thermal and mechanical indices. Dwell time should be kept to a minimum. A thermal index (TI) for soft tissue should be used before 10 weeks' gestation, and a TI for bone should be used at or after 10 weeks' gestation when bone ossification is evident (Recommended Maximum Scanning Times for Displayed Thermal Index (TI) Values).

In keeping with the ALARA principle, M-mode imaging should be used instead of spectral Doppler imaging to document the embryonic/fetal heart rate. Doppler imaging may be used to answer specific clinical questions. Spectral pulsed Doppler imaging is associated with higher energy output and should be used judiciously as part of an evaluation for anomalies. The promotion, selling, or leasing of ultrasound equipment for making "keepsake fetal videos" is considered by the US Food and Drug Administration to be an unapproved use of a medical device. Use of a diagnostic ultrasound system for keepsake fetal imaging, without a physician's order, may be in violation of state laws or regulations.

Infection Control

Transducer preparation, cleaning, and disinfection should follow manufacturer recommendations and be consistent with the AIUM Guidelines for Cleaning and Preparing External- and Internal-Use Ultrasound Transducers Between Patients, Safe Handling, and Use of Ultrasound Coupling Gel.

Equipment Performance Monitoring

Monitoring protocols for equipment performance should be developed and implemented in accordance with the *AIUM Standards and Guidelines for the Accreditation of Ultrasound Practices*.

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References

1. American Institute of Ultrasound in Medicine. AIUM-ACR-ACOG-SMFM-SRU practice parameter for the performance of standard diagnostic obstetric ultrasound examinations. *J Ultrasound Med* 2018; 37:E13–E24.
2. American Institute of Ultrasound in Medicine. AIUM practice guideline for the performance of obstetric ultrasound examinations. *J Ultrasound Med* 2013; 32:1083–1101.
3. Nicolaides KH, Azar G, Byrne D, Mansur C, Marks K. Fetal nuchal translucency: ultrasound screening for chromosomal defects in first trimester of pregnancy. *BMJ* 1992; 304:867–869.
4. Malone FD, Canick JA, Ball RH, et al. First-trimester or second-trimester screening, or both, for Down's syndrome. *N Engl J Med* 2005; 353:2001–2011.
5. Santorum M, Wright D, Syngelaki A, Karagioti N, Nicolaides KH. Accuracy of first-trimester combined test in screening for trisomies 21, 18, and 13. *Ultrasound Obstet Gynecol* 2017; 49:714–720.
6. Alldred SK, Takwoingi Y, Guo B, et al. First trimester ultrasound tests alone or in combination with first trimester serum tests for Down's syndrome screening. *Cochrane Database Syst Rev* 2017; 3: CD012600.
7. Timor-Tritsch IE, Monteagudo A, Warren WB. Transvaginal ultrasonographic definition of the central nervous system in the first and early second trimesters. *Am J Obstet Gynecol* 1991; 164: 497–503.
8. Timor-Tritsch IE, Monteagudo A, Peisner DB. High-frequency transvaginal sonographic examination for the potential malformation assessment of the 9-week to 14-week fetus. *J Clin Ultrasound* 1992; 20:231–238.
9. Monteagudo A, Timor-Tritsch IE, Sharma S. Early and simple determination of chorionic and amniotic type in multifetal gestations in the first fourteen weeks by high-frequency transvaginal ultrasonography. *Am J Obstet Gynecol* 1994; 170:824–829.
10. Timor-Tritsch IE, Bashiri A, Monteagudo A, Arslan AA. Qualified and trained sonographers in the US can perform early fetal anatomy scans between 11 and 14 weeks. *Am J Obstet Gynecol* 2004; 191:1247–1252.
11. Timor-Tritsch IE, Fuchs KM, Monteagudo A, D'Alton ME. Performing a fetal anatomy scan at the time of first-trimester screening. *Obstet Gynecol* 2009; 113:402–407.
12. Souka AP, Pilalis A, Kavalakis Y, Kosmas Y, Antsaklis P, Antsaklis A. Assessment of fetal anatomy at the 11–14-week

ultrasound examination. *Ultrasound Obstet Gynecol* 2004; 24: 730–734.

13. Souka AP, Pilalis A, Kavalakis I, et al. Screening for major structural abnormalities at the 11- to 14-week ultrasound scan. *Am J Obstet Gynecol* 2006; 194:393–396.
14. Syngelaki A, Chelemen T, Dagklis T, Allan L, Nicolaides KH. Challenges in the diagnosis of fetal non-chromosomal abnormalities at 11–13 weeks. *Prenat Diagn* 2011; 31:90–102.
15. Wan JJ, Schrimmer D, Tache V, et al. Current practices in determining amnionicity and chorionicity in multiple gestations. *Prenat Diagn* 2011; 31:125–130.
16. Syngelaki A, Hammami A, Bower S, Zidere V, Akolekar R, Nicolaides KH. Diagnosis of fetal non-chromosomal abnormalities on routine ultrasound examination at 11–13 weeks' gestation. *Ultrasound Obstet Gynecol* 2019; 54:468–476.
17. Chen FC, Bacovsky A, Entezami M, Henrich W. Nearly half of all severe fetal anomalies can be detected by first-trimester screening in experts' hands. *J Perinat Med* 2019; 47:619–624.
18. Iliescu D, Tudorache S, Comanescu A, et al. Improved detection rate of structural abnormalities in the first trimester using an extended examination protocol. *Ultrasound Obstet Gynecol* 2013; 42:300–309.
19. Rossi AC, Prefumo F. Accuracy of ultrasonography at 11–14 weeks of gestation for detection of fetal structural anomalies: a systematic review. *Obstet Gynecol* 2013; 122:1160–1167.
20. Bromley B, Shipp TD, Lyons J, Navathe RS, Groszmann Y, Benacerraf BR. Detection of fetal structural anomalies in a basic first-trimester screening program for aneuploidy. *J Ultrasound Med* 2014; 33:1737–1745.
21. Karim JN, Roberts NW, Salomon LJ, Papageorghiou AT. Systematic review of first-trimester ultrasound screening for detection of fetal structural anomalies and factors that affect screening performance. *Ultrasound Obstet Gynecol* 2017; 50:429–441.
22. Kenkhuis MJA, Bakker M, Bardi F, et al. Effectiveness of 12–13-week scan for early diagnosis of fetal congenital anomalies in the cell-free DNA era. *Ultrasound Obstet Gynecol* 2018; 51: 463–469.
23. Becker R, Wegner RD. Detailed screening for fetal anomalies and cardiac defects at the 11–13-week scan. *Ultrasound Obstet Gynecol* 2006; 27:613–618.
24. D'Antonio F, Familiari A, Thilaganathan B, et al. Sensitivity of first-trimester ultrasound in the detection of congenital anomalies in twin pregnancies: population study and systematic review. *Acta Obstet Gynecol Scand* 2016; 95:1359–1367.
25. Syngelaki A, Cimpoca B, Litwinska E, Akolekar R, Nicolaides KH. Diagnosis of fetal defects in twin pregnancies at routine ultrasound examination at 11–13 weeks' gestation. *Ultrasound Obstet Gynecol* 2020; 55:474–481.
26. Liao AW, Sebire NJ, Geerts L, Cicero S, Nicolaides KH. Megacystis at 10–14 weeks of gestation: chromosomal defects and outcome according to bladder length. *Ultrasound Obstet Gynecol* 2003; 21:338–341.
27. Volpe P, De Robertis V, Campobasso G, Tempesta A, Volpe G, Rembouskos G. Diagnosis of congenital heart disease by early and second-trimester fetal echocardiography. *J Ultrasound Med* 2012; 31:563–568.
28. Khalil A, Cooke PC, Mantovani E, Bhide A, Papageorghiou AT, Thilaganathan B. Outcome of first-trimester fetal abdominal cysts: cohort study and review of the literature. *Ultrasound Obstet Gynecol* 2014; 43:413–419.
29. Chen FC, Bacovsky A, Entezami M, Henrich W. Nearly half of all severe fetal anomalies can be detected by first-trimester screening in experts' hands. *J Perinat Med* 2019; 47:619–624.
30. Lu J, Cheng YKY, Ting YH, Law KM, Leung TY. Pitfalls in assessing chorioamnionicity: novel observations and literature review. *Am J Obstet Gynecol* 2018; 219:242–254.
31. Chen M, Lee CP, Lam YH, et al. Comparison of nuchal and detailed morphology ultrasound examinations in early pregnancy for fetal structural abnormality screening: a randomized controlled trial. *Ultrasound Obstet Gynecol* 2008; 31:136–146.
32. Pilalis A, Basagiannis C, Eleftheriades M, et al. Evaluation of a two-step ultrasound examination protocol for the detection of major fetal structural defects. *J Matern Fetal Neonatal Med* 2012; 25:1814–1817.
33. Wax J, Minkoff H, Johnson A, et al. Consensus report on the detailed fetal anatomic ultrasound examination: indications, components, and qualifications. *J Ultrasound Med* 2014; 33: 189–195.
34. American College of Obstetricians and Gynecologists Committee on Practice Bulletins–Obstetrics, Society for Maternal-Fetal Medicine. Practice Bulletin No. 163: screening for fetal aneuploidy. *Obstet Gynecol* 2016; 127:e123–e137.
35. American College of Obstetricians and Gynecologists Committee on Practice Bulletins–Obstetrics, Society for Maternal-Fetal Medicine. Practice Bulletin No. 162: prenatal diagnostic testing for genetic disorders. *Obstet Gynecol* 2016; 127:e108–e122.
36. Gill SK, Broussard C, Devine O, et al. Association between maternal age and birth defects of unknown etiology: United States, 1997–2007. *Birth Defects Res A Clin Mol Teratol* 2012; 94: 1010–1018.
37. Goetzinger KR, Shanks AL, Odibo AO, Macones GA, Cahill AG. Advanced maternal age and the risk of major congenital anomalies. *Am J Perinatol* 2017; 34:217–222.
38. Williams C, Sutcliffe A, Sebire NJ. Congenital malformations after assisted reproduction: risks and implications for prenatal diagnosis and fetal medicine. *Ultrasound Obstet Gynecol* 2010; 35: 255–259.
39. Davies MJ, Moore VM, Willson KJ, et al. Reproductive technologies and the risk of birth defects. *N Engl J Med* 2012; 366: 1803–1813.

40. Davies MJ, Rumbold AR, Moore VM. Assisted reproductive technologies: a hierarchy of risks for conception, pregnancy outcomes and treatment decisions. *J Dev Orig Health Dis* 2017; 8: 443–447.
41. Vermey BG, Buchanan A, Chambers GM, et al. Are singleton pregnancies after assisted reproduction technology (ART) associated with a higher risk of placental anomalies compared with non-ART singleton pregnancies? A systematic review and meta-analysis. *BJOG* 2019; 126:209–218.
42. Chauhan SP, Scardo JA, Hayes E, Abuhamad AZ, Berghella V. Twins: prevalence, problems, and preterm births. *Am J Obstet Gynecol* 2010; 203:305–315.
43. Hardin J, Carmichael SL, Selvin S, Lammer EJ, Shaw GM. Increased prevalence of cardiovascular defects among 56,709 California twin pairs. *Am J Med Genet A* 2009; 149A:877–886.
44. Yu Y, Cozen W, Hwang AE, et al. Birth anomalies in monozygotic and dizygotic twins: results from the California twin registry. *J Epidemiol* 2019; 29:18–25.
45. Dawson AL, Tinker SC, Jamieson DJ, et al. Twinning and major birth defects, National Birth Defects Prevention Study, 1997–2007. *J Epidemiol Community Health* 2016; 70:1114–1121.
46. Rasmussen SA. Human teratogens update 2011: can we ensure safety during pregnancy? *Birth Defects Res A Clin Mol Teratol* 2012; 94:123–128.
47. Bascietto F, Liberati M, Murgano D, et al. Outcome of fetuses with congenital parvovirus B19 infection: systematic review and meta-analysis. *Ultrasound Obstet Gynecol* 2018; 52:569–576.
48. Leruez-Ville M, Ville Y. Fetal cytomegalovirus infection. *Best Pract Res Clin Obstet Gynaecol* 2017; 38:97–107.
49. Verberne EA, de Haan E, van Tintelen JP, Lindhout D, van Haelst MM. Fetal methotrexate syndrome: a systematic review of case reports. *Reprod Toxicol* 2019; 87:125–139.
50. Baer RJ, Norton ME, Shaw GM, et al. Risk of selected structural abnormalities in infants after increased nuchal translucency measurement. *Am J Obstet Gynecol* 2014; 211:675.e1–675.e19.
51. Jelliffe-Pawlowski LL, Norton ME, Shaw GM, et al. Risk of critical congenital heart defects by nuchal translucency norms. *Am J Obstet Gynecol* 2015; 212:518.e1–518.e10.
52. Dobson LJ, Reiff ES, Little SE, Wilkins-Haug L, Bromley B. Patient choice and clinical outcomes following positive noninvasive prenatal screening for aneuploidy with cell-free DNA (cfDNA). *Prenat Diagn* 2016; 36:456–462.
53. Romary L, Sinkovskaya E, Ali S, et al. The role of early gestation ultrasound in the assessment of fetal anatomy in maternal obesity. *J Ultrasound Med* 2017; 36:1161–1168.
54. Majeed A, Abuhamad A, Romary L, Sinkovskaya E. Can ultrasound in early gestation improve visualization of fetal cardiac structures in obese pregnant women? *J Ultrasound Med* 2019; 38: 2057–2063.
55. Toscano M, Grace D, Pressman EK, Thornburg LL. Does transvaginal ultrasound at 13–15 weeks improve anatomic survey completion rates in obese gravidas? *J Matern Fetal Neonatal Med* 2019; 1–7.
56. Cali G, Forlani F, Foti F, et al. Diagnostic accuracy of first-trimester ultrasound in detecting abnormally invasive placenta in high-risk women with placenta previa. *Ultrasound Obstet Gynecol* 2018; 52:258–264.
57. D'Antonio F, Timor-Tritsch IE, Palacios-Jaraquemada J, et al. First-trimester detection of abnormally invasive placenta in high-risk women: systematic review and meta-analysis. *Ultrasound Obstet Gynecol* 2018; 51:176–183.
58. Persico N, Moratalla J, Lombardi CM, Zidere V, Allan L, Nicolaides KH. Fetal echocardiography at 11–13 weeks by transabdominal high-frequency ultrasound. *Ultrasound Obstet Gynecol* 2011; 37:296–301.
59. Hutchinson D, McBrien A, Howley L, et al. First-trimester fetal echocardiography: identification of cardiac structures for screening from 6 to 13 weeks' gestational age. *J Am Soc Echocardiogr* 2017; 30:763–772.
60. Committee on Obstetric Practice, American Institute of Ultrasound in Medicine, Society for Maternal-Fetal Medicine. Committee Opinion No. 700: methods for estimating the due date. *Obstet Gynecol* 2017; 129:e150–e154.
61. Salomon LJ, Bernard JP, Duyme M, Dorion A, Ville Y. Revisiting first-trimester fetal biometry. *Ultrasound Obstet Gynecol* 2003; 22: 63–66.
62. Hadlock FP, Shah YP, Kanon DJ, Lindsey JV. Fetal crown-rump length: reevaluation of relation to menstrual age (5–18 weeks) with high-resolution real-time US. *Radiology* 1992; 182:501–505.
63. Altman DG, Chitty LS. New charts for ultrasound dating of pregnancy. *Ultrasound Obstet Gynecol* 1997; 10:174–191.
64. von Kaisenberg CS, Fritzer E, Kuhling H, Jonat W. Fetal transabdominal biometry at 11–14 weeks of gestation. *Ultrasound Obstet Gynecol* 2002; 20:564–574.
65. Chitty LS, Altman DG. Charts of fetal size: limb bones. *BJOG* 2002; 109:919–929.
66. Sladkevicius P, Saltvedt S, Almstrom H, Kublickas M, Grunewald C, Valentin L. Ultrasound dating at 12–14 weeks of gestation: a prospective cross-validation of established dating formulae in in-vitro fertilized pregnancies. *Ultrasound Obstet Gynecol* 2005; 26:504–511.
67. Verburg BO, Steegers EA, De Ridder M, et al. New charts for ultrasound dating of pregnancy and assessment of fetal growth: longitudinal data from a population-based cohort study. *Ultrasound Obstet Gynecol* 2008; 31:388–396.
68. Pexsters A, Daemen A, Bottomley C, et al. New crown-rump length curve based on over 3500 pregnancies. *Ultrasound Obstet Gynecol* 2010; 35:650–655.

69. Buck Louis GM, Grewal J, Albert PS, et al. Racial/ethnic standards for fetal growth: the NICHD Fetal Growth Studies. *Am J Obstet Gynecol* 2015; 213:449.e1–449.e41.
70. Afshar Y, Gutkin R, Krakow D, Cuckle H, Silverman NS, Platt LD. First-trimester abdominal circumference (versus crown rump length) improves precision in inter- and intraobserver variability. *J Ultrasound Med* 2019; 38:2161–2167.
71. Verburg BO, Mulder PG, Hofman A, Jaddoe VW, Witteman JC, Steegers EA. Intra- and interobserver reproducibility study of early fetal growth parameters. *Prenat Diagn* 2008; 28:323–331.
72. Salomon LJ, Bernard M, Amarsy R, Bernard JP, Ville Y. The impact of crown-rump length measurement error on combined Down syndrome screening: a simulation study. *Ultrasound Obstet Gynecol* 2009; 33:506–511.
73. Souka AP, Pilalis A, Papastefanou I, Salamalekis G, Kassanos D. Reproducibility study of crown-rump length and biparietal diameter measurements in the first trimester. *Prenat Diagn* 2012; 32: 1158–1165.
74. Kagan KO, Hoopmann M, Baker A, Huebner M, Abele H, Wright D. Impact of bias in crown-rump length measurement at first-trimester screening for trisomy 21. *Ultrasound Obstet Gynecol* 2012; 40:135–139.
75. Ioannou C, Sarris I, Hoch L, et al. Standardisation of crown-rump length measurement. *BJOG* 2013; 120:38–41.
76. Napolitano R, Dhami J, Ohuma EO, et al. Pregnancy dating by fetal crown-rump length: a systematic review of charts. *BJOG* 2014; 121:556–565.
77. Dhombres F, Roux N, Friszer S, Bessis R, Khoshnood B, Jouannic JM. Relation between the quality of the ultrasound image acquisition and the precision of the measurement of the crown-rump length in the late first trimester: what are the consequences? *Eur J Obstet Gynecol Reprod Biol* 2016; 207:37–44.
78. Sagi-Dain L, Peleg A, Sagi S. First-trimester crown-rump length and risk of chromosomal aberrations: a systematic review and meta-analysis. *Obstet Gynecol Surv* 2017; 72:603–609.
79. Grande M, Gonce A, Stergiotou I, Bennasar M, Borrell A. Intertwin crown-rump length discordance in the prediction of fetal anomalies, fetal loss and adverse perinatal outcome. *J Matern Fetal Neonatal Med* 2016; 29:2883–2888.
80. Stagnati V, Zanardini C, Fichera A, et al. Early prediction of twin-to-twin transfusion syndrome: systematic review and meta-analysis. *Ultrasound Obstet Gynecol* 2017; 49:573–582.
81. Khalil A, Rodgers M, Baschat A, et al. ISUOG Practice Guidelines: role of ultrasound in twin pregnancy. *Ultrasound Obstet Gynecol* 2016; 47:247–263.
82. Abuhamad A, Minton KK, Benson CB, et al. Obstetric and gynecologic ultrasound curriculum and competency assessment in residency training programs: consensus report. *J Ultrasound Med* 2018; 37:19–50.
83. Karl K, Benoit B, Entezami M, Heling KS, Chaoui R. Small biparietal diameter in fetuses with spina bifida on 11–13-week and mid-gestation ultrasound. *Ultrasound Obstet Gynecol* 2012; 40:140–144.
84. Sepulveda W, Wong AE, Andreeva E, Odegova N, Martinez-Ten P, Meagher S. Biparietal diameter–to–crown-rump length disproportion in first-trimester fetuses with holoprosencephaly. *J Ultrasound Med* 2014; 33:1165–1169.
85. Wang L, Takai Y, Baba K, et al. Can biparietal diameter-to-femur length ratio be a useful sonographic marker for screening thanatophoric dysplasia since the first trimester? A literature review of case reports and a retrospective study based on 10,293 routine fetal biometry measurements. *Taiwan J Obstet Gynecol* 2017; 56:374–378.
86. Sepulveda W, Wong AE. First trimester screening for holoprosencephaly with choroid plexus morphology ("butterfly" sign) and biparietal diameter. *Prenat Diagn* 2013; 33:1233–1237.
87. Abu-Rustum RS, Ziade MF, Abu-Rustum SE. Reference values for the right and left fetal choroid plexus at 11 to 13 weeks: an early sign of "developmental" laterality? *J Ultrasound Med* 2013; 32:1623–1629.
88. Nuchal Translucency Quality Review. Nuchal translucency quality review program. *Nuchal Translucency Quality Review website.* https://www.ntqr.org. Accessed July 7, 2019.
89. Fetal Medicine Foundation. Nuchal translucency scan. Fetal Medicine Foundation website. https://fetalmedicine.org/nuchal-translucency-scan. Accessed July 7, 2019.
90. Chaoui R, Benoit B, Heling KS, et al. Prospective detection of open spina bifida at 11–13 weeks by assessing intracranial translucency and posterior brain. *Ultrasound Obstet Gynecol* 2011; 38: 722–726.
91. Chen FC, Gerhardt J, Entezami M, Chaoui R, Henrich W. Detection of spina bifida by first trimester screening: results of the prospective multicenter Berlin IT study. *Ultraschall Med* 2017; 38:151–157.
92. Lachmann R, Sinkovskaya E, Abuhamad A. Posterior brain in fetuses with Dandy-Walker malformation with complete agenesis of the cerebellar vermis at 11–13 weeks: a pilot study. *Prenat Diagn* 2012; 32:765–769.
93. Martinez-Ten P, Illescas T, Adiego B, et al. Non-visualization of choroid plexus of fourth ventricle as first-trimester predictor of posterior fossa anomalies and chromosomal defects. *Ultrasound Obstet Gynecol* 2018; 51:199–207.
94. Volpe P, Contro E, Fanelli T, Muto B, Pilu G, Gentile M. Appearance of fetal posterior fossa at 11–14 weeks in fetuses with Dandy-Walker malformation or chromosomal anomalies. *Ultrasound Obstet Gynecol* 2016; 47:720–725.
95. Sepulveda W, Wong AE, Andreeva E, Odegova N, Martinez-Ten P, Meagher S. Sonographic spectrum of first-trimester fetal

cephalocele: review of 35 cases. *Ultrasound Obstet Gynecol* 2015; 46:29–33.

96. Ushakov F, Sacco A, Andreeva E, et al. Crash sign: a new first-trimester sonographic marker of spina bifida. *Ultrasound Obstet Gynecol* 2019; 54:740–745.
97. Simon EG, Arthuis CJ, Haddad G, Bertrand P, Perrotin F. Biparietal/transverse abdominal diameter ratio </= 1: potential marker for open spina bifida at 11–13-week scan. *Ultrasound Obstet Gynecol* 2015; 45:267–272.
98. Chaoui R, Orosz G, Heling KS, Sarut-Lopez A, Nicolaides KH. Maxillary gap at 11–13 weeks' gestation: marker of cleft lip and palate. *Ultrasound Obstet Gynecol* 2015; 46:665–669.
99. Sepulveda W, Wong AE, Martinez-Ten P, Perez-Pedregosa J. Retronasal triangle: a sonographic landmark for the screening of cleft palate in the first trimester. *Ultrasound Obstet Gynecol* 2010; 35:7–13.
100. Martinez-Ten P, Adiego B, Perez-Pedregosa J, Illescas T, Wong AE, Sepulveda W. First-trimester assessment of the nasal bones using the retronasal triangle view: a 3-dimensional sonographic study. *J Ultrasound Med* 2010; 29:1555–1561.
101. Sepulveda W, Wong AE, Viñals F, Andreeva E, Adzehova N, Martinez-Ten P. Absent mandibular gap in the retronasal triangle view: a clue to the diagnosis of micrognathia in the first trimester. *Ultrasound Obstet Gynecol* 2012; 39:152–156.
102. De Robertis V, Rembouskos G, Fanelli T, Votino C, Volpe P. Cleft palate with or without cleft lip: the role of retronasal triangle view and maxillary gap at 11-14 weeks. *Fetal Diagn Ther* 2019; 46:353–359.
103. Sinkovskaya ES, Chaoui R, Karl K, Andreeva E, Zhuchenko L, Abuhamad AZ. Fetal cardiac axis and congenital heart defects in early gestation. *Obstet Gynecol* 2015; 125:453–460.
104. Abuhamad A, Chaoui R. *First Trimester Ultrasound Diagnosis of Fetal Abnormalities*. 1st ed. Riverwoods, IL: Wolters Kluwer; 2018.
105. Quarello E, Lafouge A, Fries N, Salomon LJ. French College of Fetal Sonography. Basic heart examination: feasibility study of first-trimester systematic simplified fetal echocardiography. *Ultrasound Obstet Gynecol* 2017; 49:224–230.
106. Zheng MM, Tang HR, Zhang Y, et al. Contribution of the fetal cardiac axis and V-sign angle in first-trimester screening for major cardiac defects. *J Ultrasound Med* 2019; 38:1179–1187.
107. Wiechec M, Knafel A, Nocun A. Prenatal detection of congenital heart defects at the 11- to 13-week scan using a simple color Doppler protocol including the 4-chamber and 3-vessel and trachea views. *J Ultrasound Med* 2015; 34:585–594.
108. Pereira S, Ganapathy R, Syngelaki A, Maiz N, Nicolaides KH. Contribution of fetal tricuspid regurgitation in first-trimester screening for major cardiac defects. *Obstet Gynecol* 2011; 117: 1384–1391.
109. Wiechec M, Nocun A, Matyszkiewicz A, Wiercinska E, Latala E. First trimester severe ductus venosus flow abnormalities in isolation or combination with other markers of aneuploidy and fetal anomalies. *J Perinat Med* 2016; 44:201–209.
110. Dhombres F, Friszer S, Castaing O, Bessis R, Jouannic JM. Fetal abdominal cysts at the first trimester scan [in French]. *Gynecol Obstet Fertil* 2015; 43:491–495.
111. Timor-Tritsch IE, Warren WB, Peisner DB, Pirrone E. First-trimester midgut herniation: a high-frequency transvaginal sonographic study. *Am J Obstet Gynecol* 1989; 161:831–833.
112. Bogers H, Baken L, Cohen-Overbeek TE, et al. Evaluation of first-trimester physiological midgut herniation using three-dimensional ultrasound. *Fetal Diagn Ther* 2019; 45:332–338.
113. Kagan KO, Staboulidou I, Syngelaki A, Cruz J, Nicolaides KH. The 11–13-week scan: diagnosis and outcome of holoprosencephaly, exomphalos and megacystis. *Ultrasound Obstet Gynecol* 2010; 36:10–14.
114. Girard N, Viaris de Lesegno B, Bussiere P, Egoroff C, Cordier AG, Benachi A. Prognosis of isolated first-trimester fetal megacystis with spontaneous resolution. *Fetal Diagn Ther* 2017; 42:271–277.
115. Liao YM, Li SL, Luo GY, et al. Routine screening for fetal limb abnormalities in the first trimester. *Prenat Diagn* 2016; 36: 117–126.
116. Khalil A, Pajkrt E, Chitty LS. Early prenatal diagnosis of skeletal anomalies. *Prenat Diagn* 2011; 31:115–124.
117. Karl K, Heling KS, Chaoui R. Fluid area measurements in the posterior fossa at 11–13 weeks in normal fetuses and fetuses with open spina bifida. *Fetal Diagn Ther* 2015; 37:289–293.
118. Shainker S. *SMFM Collaborative Marker Task Force*. Washington, DC: Society for Maternal-Fetal Medicine; 2019.
119. Zalel Y, Shapiro I, Weissmann-Brenner A, Berkenstadt M, Leibovitz Z, Bronshtein M. Prenatal sonographic features of triploidy at 12–16 weeks. *Prenat Diagn* 2016; 36:650–655.
120. Nayeri UA, West AB, Grossetta Nardini HK, Copel JA, Sfakianaki AK. Systematic review of sonographic findings of placental mesenchymal dysplasia and subsequent pregnancy outcome. *Ultrasound Obstet Gynecol* 2013; 41:366–374.
121. Rao R, Platt LD. Ultrasound screening: status of markers and efficacy of screening for structural abnormalities. *Semin Perinatol* 2016; 40:67–78.
122. Martinez-Ten P, Adiego B, Illescas T, Bermejo C, Wong AE, Sepulveda W. First-trimester diagnosis of cleft lip and palate using three-dimensional ultrasound. *Ultrasound Obstet Gynecol* 2012; 40: 40–46.
123. Lakshmy SR, Deepa S, Rose N, Mookan S, Agnees J. First-trimester sonographic evaluation of palatine clefts: a novel diagnostic approach. *J Ultrasound Med* 2017; 36:1397–1414.
124. American Institute of Ultrasound in Medicine. *Statement on the Safe Use of Doppler Ultrasound During 11- to 14-Week Scans (or Earlier in Pregnancy)*. Laurel, MD: American Institute of Ultrasound in Medicine; 2016.