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REVIEW ARTICLE

Benefits and Limitations with Ultrasound Imaging in the First Trimester

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ABSTRACT

Widespread use of home pregnancy tests and the availability of first trimester genetic screening many ultrasound imaging studies being performed before 14 weeks gestation. While these scans are believed to be safe, the additional time and expense has led to questioning about its value unless indicated by vaginal bleeding, persistent nausea, potential teratogen exposure, medical complications associated with early reproductive loss or an congenital anomalies, repetitive early pregnancy loss, or desire for genetic testing. A scan at or beyond 7 weeks allows for confirmation of viability and accuracy of gestational dating by crown rump measurement. The observation of either a subchorionic hematoma or an abnormal configuration of the uterine cavity alerts the provider to the greater risk of a spontaneous abortion, placental abruption, preterm delivery, or fetal growth restriction. Gestational trophoblastic disease can be diagnosed earlier with subsequent performance of an ultrasound-directed suction curettage before morbid conditions worsen. Certain congenital anomalies can be diagnosed as early as the 11 to 14th week. Multifetal gestations can be diagnosed early with chorionicity determined between the 6th and 12th week. Nearly all maternal adnexal masses are small and require no follow-up imaging by the 15th week unless large (> 5 cm), complex, or discomfort ensues. Experience of the sonographer, resolution capabilities of the imaging machinery, maternal obesity, and fetal positioning limit interpretation capabilities. Technological refinements with three-dimensional (3D) imaging and higher definition resolution hold promise for improved accuracy in anatomic and blood flow studies.

Keywords: Early pregnancy, Fetal development, Limitations, Pelvic anatomy.

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INTRODUCTION

The widespread use of easily available home pregnancy testing permits the early diagnosis of pregnancy, sometimes even before the expected onset of the next menses. Home testing is undertaken by most reproductive age women who are inclined to seek earlier prenatal care. While it is always encouraged that they seek the earliest prenatal care, the issue is often raised about the need for early imaging studies. An early baseline ultrasound exam is recommended when there is uncertain menstrual dating, vaginal bleeding, a history of repetitive early pregnancy loss, a teratogen exposure, or maternal medical complications.[1] In many circumstances, however, the indication for imaging is marginal or invalid.

The average number of imaging studies per pregnancy has increased. Substantial advances in magnification and signal processing have improved the ability to visualize embryonic and early fetal anatomy. We estimate that up to half of all patients seeking early prenatal care at our university clinical setting undergo early gestational imaging. Most undergo an imaging study by 14 weeks gestation for maternal genetic screening. The objective of the review is to highlight the benefits and limitations of ultrasonography in the first trimester ($\leq$ 14 weeks).

EARLY DATING AND PREGNANCY FAILURE

When performed cautiously, early imaging is believed to be safe.[1] The gestational sac is first viewed as a small, empty fluid-filled cyst at approximately 5 weeks from onset of the last menses. The yolk sac, measuring 3 to 5 mm in diameter, makes its appearance at 6 weeks. The embryonic pole or crown rump length is seen adjacent to the yolk sac as early as 6 weeks. The heartbeat is usually viewed by 6 to 7 weeks. In general, the most accurate means for determining the estimated due date is by measuring this length, rather than either measuring the gestational sac diameter or relying on the onset of the last menses.[2]

Variations in this early sequence of development can be worrisome and perhaps demonstrate early pregnancy failure. Early failure, as defined by the Society of Radiologists Multispecialty Panel in 2013, would be confirmed by 8 weeks or beyond.[3] Overzealous medical or surgical intervention before confirmation of nonviability can eliminate or severely damage a viable intrauterine gestation.[2]

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FETAL MALFORMATIONS

Approximately 2 to 3% of all newborn infants have one or more major structural malformations which relate to 20% of all infant deaths.[4,5] The etiology is unknown in about two-thirds of cases, and teratogen-induced effects (e.g. maternal fever, medications, infection) account for only a very small percent of all defects. The natural history of fetal development plays a very important role in interpreting early sonograms. Examples of normal morphologic differentiation up to 13 weeks include small ventricular septal defects that undergo spontaneous closure, hydronephrosis, indirect evidence of spina bifida and midgut rotation.[6,7] Furthermore, detection of abnormal intracranial formations, such as hydrocephalus and abnormalities of the fetal cerebellum and corpus callosum may not be possible until mid-gestation.

Nuchal translucency (NT) is the sonographic measurement of the subcutaneous fluid between the soft tissue of the cervical spine and skin of an 11 to 13w6d fetus (crown rump length corresponding to 45–84 mm).[1] When performed using strict imaging requirements, it can aid, along with serum analytes, in determining the risk of aneuploidy. A thickness of 3 mm or more is also associated with many structural anomalies, including cardiac defects that affect ductus venosus flow, diaphragmatic hernia, omphalocele and skeletal anomalies. Thickening may be accompanied with abnormal or delayed lymph angiogenesis or extracellular matrix abnormalities. When found to be 3.5 mm or more, patients should be offered detailed sonography and fetal echocardiography even if a karyotype and microarray are normal.[8]

The early suspicion of a wide range of fetal structural anomalies can occur as early as 11 to 14 weeks gestation.[9,10] Rossi et al reviewed 19 studies involving 78,002 fetuses undergoing ultrasound exams and reported a malformation prevalence of 12 per 1,000 pregnancies at 11 to 14 weeks.[7] Half of those cases with malformations were viewed sonographically. Cardiac defects were the most common, while the highest diagnostic rate was achieved for neck anomalies.

Fetal malformations may be categorized as to the frequencies of detection at 11 to 14 weeks' gestation.[6,7,9] Nearly all cases with acrania, anencephaly, ectopia cordis, and encephalocele can be diagnosed. Detection rates in half or more cases are possible for fetuses with a cystic hygroma, gastroschisis, ompahalocele, holoprosencephaly, hypoplastic left heart, and other cardiac anomalies. Detection rates occur in less than half of all cases with spina bifida, hydrocephalus, skeletal dysplasia, facial clefting, Dandy-Walker cyst, and aortic coarctation. Examples of malformations that are undetectable at or before 14 weeks included corpus callosum agenesis, bladder exstrophy, cystic adenomatoid malformation, cerebellar hypoplasia, duodenal atresia, hydronephrosis, renal agenesis, bowel obstruction and extralobar sequestration.

The normal appearance of cardiac anatomy at any time of pregnancy does not exclude the presence of heart defects that may develop with advancing gestational age or postnatally. With experience, many major cardiac lesions can be suspected before 14 weeks. The sensitivity of early fetal echocardiography for major congenital heart disease varies from 10% in low-risk populations to over 50% in high-risk groups.[11,12] Despite its feasibility, fetal echocardiography at early pregnancy is more difficult than at 18 to 22 weeks. Overall, standard cardiac views can be obtained in > 75% of echocardiograms at 11 to 14 weeks compared with > 85% in those performed at mid-gestation.[13] Early detection of defects that may resolve *in utero* later, such as ventricular septal defects, may cause unnecessary parental stress and pregnancy intervention.

MULTIPLE GESTATIONS

Routine prenatal ultrasonography is valuable for the early detection of a multiple gestation. Early imaging is also useful in determinating of chorionicity, screening for certain fetal anomalies, and as a baseline for evaluating fetal growth and cervical length measurements. A positive diagnosis can be made by viewing. multiple gestational sacs with yolk sacs by 5 weeks and multiple embryos with cardiac activity by 6 to 7 weeks. If two gestational sacs are seen on early ultrasound, the chance of delivering twins is 57%, while it is 87% if two embryonic poles with cardiac activity are viewed.[13,14] Those percentages are less with triplets. Early sonographic visualization of twins may instead represent a singleton in bicornuate uterus, singleton with a subchorionic hemorrhage, or a vanishing twin.

Because 20% of twins are monochorionic, and therefore, at risk for higher perinatal mortality, early determination of chorionicity is essential. Before 8 weeks', clearly separate gestational sacs, with each surrounded by a thick echogenic ring, is suggestive of dichorionicity. If separate echogenic rings are not visible, monochorionicity is likely. In such situations, counting the number of yolk sacs may assist in establishing amnionicity. The presence of two fetal poles with only one yolk sac suggests a monoamniotic gestation. The sensitivity for predicting monochorionicity is nearly 100% by the end of the first trimester. Use of a membrane thickness cutoff of 2 mm has been reported to correctly assign chorionicity, and visualization of a triangular projection of the placenta between the layers of the dividing membrane (twin peak) is a sign for diagnosing dichorionicity.

The accuracy of early ultrasonography for detecting congenital fetal anomalies in multiple gestations has not been adequately studied in large series. Serial ultrasonography is the most accurate method to assess for fetal anomalies and growth, making early diagnosis and gestational dating to be of particular relevance.

With the availability of late first-trimester pregnancy reduction procedures in higher-order multiple gestations, interest in first-trimester screening tests for fetal abnormalities has increased. Data are insufficient, however, to generate recommendations for the widespread combined screening for aneuploidy. Relying on an increased NT measurement is reasonable because of limitations of serum marker results in this setting. Care must be taken when interpreting NT measurements in monochorionic twins, as increased thickening in one fetus may represent a twin-twin transfusion rather than an elevated aneuploidy risk.[14]

PLACENTA

The early gestational scan usually permits excellent views of the surrounding anatomy. Sonographically, the placenta is a homogenous mass in which its location is not well-characterized.[14] The principle placental lesion that can be identified sonographically is the hematoma which can be retroplacental, marginal, or subchorial. Hematomas may resemble a small crescent-shaped fluid collection that is hyperechoic to isoechoic in the 1st week after hemorrhage, hypoechoic in 1 to 2 weeks, and anechoic after the 1st few weeks. Most hematomas in early gestation are of no clinical consequence and, therefore, not mentioned during the exam if the patient does not complain of vaginal bleeding. More extensive collections have been associated with higher rates of spontaneous abortion, placental abruption, fetal growth restriction, preterm delivery, and an adherent placenta.[8,14] Reimaging those affected areas is worthwhile with a subsequent mid-gestation exam.

UTERUS AND CERVIX

Gestational trophoblastic disease is strongly suspected early in gestation with the classic intrauterine sonographic findings of a 'snowstorm effect' with clear vesicles occupying the uterine cavity either entirely (complete trophoblastic disease) or incompletely with evidence for fetal parts (partial molar pregnancy). Multiple maternal theca lutein cysts are also common. Uterine evacuation is often complete with an utrasound-guided suction curettage. With early diagnosis, and treatment, the likelihood is lower of developing major morbid events (preeclampsia, hyperthyroidism, and persistent nausea and vomiting).

Uterine leiomyomas are found in approximately 2% of all pregnancies and often diagnosed unexpectedly in early gestation.[14] Their location varies but can be concerning if found in the cervix or broad ligament. Often, these tumors remain stable in size and do not lead to fetal growth restriction, preterm delivery, or placental abruption. The stimulatory effects of pregnancy on myoma growth are unpredictable, however. Furthermore, myomas can be confused with other adnexal masses, especially during early gestation. Once diagnosed sonographically, myomas do not require surveillance with serial sonography unless associated with other complications or become enlarged at the time of the routine midgestation scan.

Uterine structural abnormalities from müllerian fusion defects are often best viewed sonographically in early gestation. The reported population prevalence ranges from 0.4 to 5.0%, and rates are higher among women with recurrent early pregnancy loss.[8,14] The distribution of uterine anomalies are as follows: bicornuate, 39%; septate, 34%; didelphic, 11%; arcuate, 7%; and unicornuate, 5%.[14] Transabdominal views may help to maximize the viewing field, but transvaginal scans provide improved resolution. Risks in later gestation depend on the uterine defect but include spontaneous abortion, preterm birth and malpresentation.[2,8] Some women with uterine anomalies and repetitive pregnancy losses may benefit from elective cervical cerclages at 12 to 14 weeks' gestation. Every case would benefit by the midgestation scan with cervical length measurement.

Retroflexion of the uterus in the sagittal plane can infrequently lead to incarceration in the sacral hollow. It represents the leading cause of abdominal discomfort, pelvic pressure, and voiding dysfunction in early gestation. The incarcerated uterus must be repositioned to its normal anatomical position by pushing it out of the pelvis during ultrasound imaging and with or without conscious sedation or spinal analgesia. Use of a soft pessary may be helpful to prevent reincarceration during the next few weeks.

Cervical insufficiency is not a condition that is typically diagnosed in early gestation. Many such cases have a history and clinical findings that make it difficult to verify as classic cervical incompetence.[15] Interest has been focused on the predictive value of transvaginal sonography to measure cervical length and the presence of funneling of the amniotic membranes. These measurements are of questionable value in early gestation, however, and are usually reserved until beyond 14 weeks', regardless whether it is a singleton or multiple gestation.

ADNEXAL MASSES

Many adnexal masses are detected during routine prenatal sonography or during imaging for other

indications including evaluation of pelvic pain symptoms. Sonographic characteristics of common ovarian masses include (1) a simple anechoic cyst with smooth walls suggestive of a physiological corpus luteal cyst or benign cystadenoma, (2) cystic structure with diffuse internal low-level echoes suggestive of an endometrioma or hemorrhagic corpus luteum, or (3) a complex adnexal cyst with accentuated lines and dots that represent hair within a mature cystic teratoma.

Approximately 1 in 1000 pregnant women undergoes surgical exploration with resection of an adnexal mass usually being planned at 14 to 20 weeks.[11] If the corpus luteum is removed before 10 weeks' gestation, progestational support is recommended. As a cystic benign-appearing mass that is < 5 cm often requires no additional surveillance, because, it typically resolves by the early second trimester. Tumors between 5 and 10 cm in diameter should be carefully evaluated by sonography along with color Doppler and possibly magnetic resonance imaging (Schmeler).[16] Sonography often aids in the diagnosis of torsed adnexal mass. With color Doppler, presence of an ovarian mass with absent flow strongly correlates with torsion.

LIMITATIONS WITH EARLY GESTATION IMAGING

Experience of the sonographer staff, imaging equipment, and maternal characteristics impact the accuracy of reporting fetal anomalies between 11 and 14 weeks. Skillsets required in imaging and costs in time and equipment also influence detection rates. More focused attention by the operator on specific organs, such as the fetal heart may enhance accuracy of the imaging study. The presence of associated anomalies and maternal risk factors, such as diabetes, morbid obesity, alcohol and a prior affected fetus stimulate more attention. Maternal obesity and fetal positioning often prohibit complete visualization, especially on transabdominal imaging alone. Furthermore, maternal obesity is associated with a lower detection rate of fetal anomalies and a greater need for repeat scanning.[17,18]

SUMMARY

Refinements in ultrasound technology and more widespread imaging studies in early pregnancy have led to more accurate gestational dating, diagnosis of early pregnancy failure, confirmation of a multifetal gestation, and suspicion of certain major structural abnormalities, and evaluation of the maternal pelvic anatomy. The capability to either reassure a high-risk woman about normal intrauterine images or to offer comprehensive counseling and offer options in cases of nonviability or strongly suspected lethal or major malformations have shifted prenatal diagnoses to earlier gestational ages. Stricter sonographic criteria for early nonviability guard against unnecessary intervention. Any subchorionic hematoma, abnormal uterine contour, or enlarged adnexal mass requires further examination beyond 14 weeks. Maternal obesity and multifetal pregnancies are now more common and further limit visibility. Enhancement with three-dimensions imaging and higher definition resolution will improve accuracy further in structure an blood from examinations.

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