American College of Radiology
ACR Appropriateness Criteria®

Growth Disturbances–Risk of Fetal Growth Restriction

Variant: 1 Growth disturbance. Low risk for fetal growth restriction. Initial evaluation.

Procedure	Appropriateness Category	Relative Radiation Level
US pregnant uterus transabdominal	Usually Appropriate	O
US duplex Doppler ductus venosus	Usually Not Appropriate	O
US duplex Doppler fetal middle cerebral artery	Usually Not Appropriate	O
US duplex Doppler fetal umbilical artery	Usually Not Appropriate	O
US duplex Doppler maternal uterine artery	Usually Not Appropriate	O
US pregnant uterus biophysical profile	Usually Not Appropriate	O

Variant: 2 Growth disturbance. High risk for fetal growth restriction. Initial evaluation.

Procedure	Appropriateness Category	Relative Radiation Level
US duplex Doppler fetal umbilical artery	Usually Appropriate	O
US pregnant uterus biophysical profile	Usually Appropriate	O
US pregnant uterus transabdominal	Usually Appropriate	O
US duplex Doppler ductus venosus	May Be Appropriate	O
US duplex Doppler maternal uterine artery	May Be Appropriate	O
US duplex Doppler fetal middle cerebral artery	Usually Not Appropriate	O

Variant: 3 Established fetal growth restriction. Follow-up evaluation.

Procedure	Appropriateness Category	Relative Radiation Level
US duplex Doppler ductus venosus	Usually Appropriate	O
US duplex Doppler fetal middle cerebral artery	Usually Appropriate	O
US duplex Doppler fetal umbilical artery	Usually Appropriate	O
US pregnant uterus biophysical profile	Usually Appropriate	O
US pregnant uterus transabdominal	Usually Appropriate	O
US duplex Doppler maternal uterine artery	May Be Appropriate	O

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Summary of Literature Review

Introduction/Background

Fetal growth restriction (FGR) is an important complication of pregnancy and is associated with significant risks of perinatal morbidity and mortality. A small-for-gestational-age (SGA) fetus is

defined as a fetus whose estimated fetal weight (EFW) is below the 10th percentile for gestational age [1,2]. FGR implies an SGA fetus that has not reached its growth potential as measured by EFW. Although some SGA fetuses are constitutionally small and not at risk for perinatal morbidity and mortality [3], others are affected by a variety of maternal or placental conditions that lead to uteroplacental insufficiency and potential adverse outcomes, such as neurodevelopmental delay [4]. Given the difficulty in differentiating fetuses who are constitutionally SGA from those with FGR, it is typical for all fetuses with an EFW below the 10th percentile to be treated comparably. Finally, some fetuses may have an EFW at or above the 10th percentile but may also be at risk for adverse outcomes because of their suboptimal rate of growth [5,6]. The diagnosis of FGR is based upon an accurate assessment of gestational age. If gestational age is uncertain, then repeat evaluation to ensure appropriate growth velocity is recommended. Many different fetal biometric growth curves exist, and it is preferable to use the growth curve that most approximates the population being studied.

As pregnancy progresses, there is an increasing demand placed on the placenta for the provision of nutrients to the developing fetus. When those demands outpace placental functional abilities, FGR can result. History of FGR, maternal hypertension, maternal vascular disease, fetal anomalies, syndromes, and chromosomal abnormalities, or a lagging fundal height on physical examination (of >2–3 cm) are potential indications for ultrasound (US) assessment of fetal biometry. After an initial US examination, serial sonography is frequently performed for evaluation of fetal growth. For those fetuses with impaired growth, evaluation of fetal well-being is crucial for optimizing fetal outcome. The goal of avoiding life-threatening fetal compromise is preserved through regular US assessment of fetal well-being. When the risk for fetal compromise appears to be greater than the risks of delivery, specifically the concern for delivery in the setting of prematurity, delivery of the pregnancy is indicated [2,7-9].

For those fetuses diagnosed with FGR, regular assessment of fetal biometry, evaluation of amniotic fluid volume, use of the biophysical profile (BPP), Doppler US, fetal heart rate monitoring, especially the nonstress test (NST), and fetal movement counting [10] can all contribute to the determination of fetal compensation or compromise. Assessment of fetal well-being is essential to the management of pregnancies with FGR. Assessment of fetal growth is best performed at a time interval of no less than once every 2 weeks and is likely to be more reliable at a frequency of every 3 to 4 weeks given the error inherent to the performance of fetal biometry. Amniotic fluid volume is an important sign of chronic fetal well-being. Amniotic fluid in the third trimester is predominantly made up of fetal urine. Chronic or worsening impairment of placental blood flow can lead to decreased fetal renal perfusion, decreased fetal urine production, and the lessening of amniotic fluid volume over time. In contrast, the BPP is predominantly an assessment of immediate fetal well-being. This test, principally focused on fetal movement, provides a current state of fetal well-being and is predictive of fetal well-being over the next week of gestation. The test also incorporates a more long-term assessment of fetal well-being, reflected in the measurement of at least one pocket of amniotic fluid measuring at least 2 × 2 cm. A reassuring BPP is associated with a very low risk of fetal loss over the succeeding week [11].

US duplex Doppler velocimetry plays a valuable role in the management of fetuses with FGR. The mainstay of assessment of those with FGR is Doppler assessment of the umbilical artery. There is normally a decrease in resistance of the umbilical artery as gestation progresses. Although the most common measure of resistance of umbilical artery flow is the systolic/diastolic ratio, we

recommend reporting the pulsatility index, which can then be potentially incorporated into a cerebral-placental ratio. Umbilical artery flow should always be antegrade, so absent or reversed diastolic flow is abnormal at any time during gestation. Decreasing impedance in the middle cerebral arteries can be seen with increased resistance in the umbilical artery, suggesting a 'brain-sparing' effect of placental insufficiency [12]. The cerebroplacental ratio, calculated by dividing the middle cerebral artery pulsatility index by the umbilical artery pulsatility index, has emerged as a predictor of adverse outcome among those fetuses with FGR, with the suggestion that it denotes brain-sparing among those most severely affected by FGR [13,14]. The cerebroplacental ratio may be an earlier predictor of adverse outcome than the BPP or abnormalities of the umbilical artery Doppler or middle cerebral artery Doppler indexes [15] or can be used for optimal timing of delivery [16]; however, there is insufficient evidence to use it as a stand-alone test. The cerebroplacental ratio at term has a strong association with adverse obstetric and perinatal outcomes. A recent meta-analysis suggests the predictive utility of cerebroplacental ratio at term is promising; however, there is insufficient evidence to demonstrate its value as a stand-alone test. Inclusion of cerebroplacental ratio as a component of clinical care may help better identify fetuses at risk of adverse outcome, and this should be tested with randomized control trials [17]. In the setting of abnormal umbilical artery Doppler velocimetry, Doppler interrogation of the fetal middle cerebral artery and venous system can offer more specific tests for the assessment of fetal well-being and can assist with the determination of delivery [2,18]. Venous Doppler flow, especially of the ductus venosus, can also be interrogated as a surrogate for forward cardiac blood flow or preserved cardiac output signifying fetal well-being. Reversed A-wave flow is abnormal throughout gestation [19]. Another measure, the myocardial performance index, is also raised among those with FGR and there is the suggestion that this abnormality may precede fetal arterial and venous Doppler abnormalities [20]. Uterine artery Doppler velocimetry can assess the maternal side of placental flow impedance and, when combined with umbilical artery Doppler velocimetry, offers better prediction of adverse perinatal outcome among fetuses with suspected FGR than either measure alone [21].

Differences in pathogenesis of FGR have led many authors to differentiate between early and late FGR. Earlier in gestation, chromosomal anomalies, syndromes, and viral infections are common etiologies for FGR [22]. A detailed fetal structural survey should be performed in cases of suspected or diagnosed FGR as approximately 10% of fetuses with FGR have congenital anomalies and 20% to 60% of fetuses with congenital anomalies are SGA. Later in gestation, placental insufficiency predominates, which is especially due to hypertension and maternal vascular disease. Symmetric FGR is more common earlier in gestation, and asymmetric FGR with 'head sparing' is thought to be more common later in gestation. Many different gestational age thresholds of early versus late FGR have been proposed. Some suggest that 28 weeks' gestation is an appropriate verge [23]; however, others suggest 32 weeks' gestation [24] or even 34 weeks' gestation as these thresholds convey different pathologies and may, in essence, represent varying etiologies [25]. The predominant theme for all pregnancies complicated by FGR is timing of the fetal well-being surveillance regimen and subsequent delivery. Knowledge of other sonographic findings, including the presence of structural defects, chromosomal abnormalities, Doppler abnormalities, fetal well-being, and the specific gestational age is essential because management is individualized based on these data.

Discussion of Procedures by Variant

Variant 1: Growth disturbance. Low risk for fetal growth restriction. Initial evaluation.

Variant 1: Growth disturbance. Low risk for fetal growth restriction. Initial evaluation. A. US Pregnant Uterus Transabdominal

A SGA fetus is defined as a fetus whose EFW is below the 10th percentile for gestational age [1,2], while FGR implies an SGA fetus that has not reached its growth potential and is at risk for adverse sequelae. Although clinical assessment can suggest fetuses at risk for FGR, US remains fundamental for the identification of fetuses with FGR through the assessment of fetal biometry. For assessment of EFW, fetal biometry typically includes assessment of fetal biparietal diameter/head circumference, abdominal diameter/abdominal circumference, and fetal femur length. Among low-risk women, Roma et al [26] in an open-label randomized trial demonstrated that routine assessment of fetal biometry at 36 weeks' gestation was significantly advantageous over routine assessment at 32 weeks' gestation for the identification of fetuses with FGR, sensitivity 38.8% versus 22.5%, respectively. FGR less than the 3rd percentile had sensitivity of 61.4% at 36 weeks as compared to 32.5% at 32 weeks' gestation [26]. Although US sensitivity is imperfect for the identification of fetuses with FGR among low-risk women, no other test has shown better sensitivity for the identification of fetuses with FGR in this population. Referral for fetal biometry for identification of FGR remains within the clinicians' purview based upon clinical suspicion of fetal SGA.

Variant 1: Growth disturbance. Low risk for fetal growth restriction. Initial evaluation. B. US Pregnant Uterus Biophysical Profile

The BPP is the mainstay of fetal well-being evaluation and consists of four parameters variably sensitive to the acute exposure of the fetus to hypoxemia: fetal breathing movements, fetal limb and body movements, fetal tone, and amniotic fluid volume (which is thought to be more of an indicator of chronic hypoxemia). The NST, which is sometimes included with the BPP as a fifth component, can be used alone as a test of acute fetal well-being status, but it is often coupled with amniotic fluid measurement, a valuable reflection of fetal hypoxemic exposure over the previous week. Each of the four (or five) components of the BPP receives a score of 0 or 2, leading to a maximum score of 8 (or 10). Scores of 8 (or 10) are strong indicators of a well-compensated fetus [27]. For those at risk for fetal demise, testing strategies usually evaluate one or more of the fetal well-being parameters at least weekly. For the well-being of those fetuses at highest risk for fetal demise, testing can often occur twice weekly or even daily, from the point of postnatal viability until delivery is indicated. Amniotic fluid volume is usually assessed at least weekly, but may be evaluated more often if it is approaching severely low levels. Daily or even more frequent testing by BPP or NST may be indicated in critical situations. To our knowledge, there are no trials evaluating the use of the BPP as an initial procedure among those at low risk for FGR.

Variant 1: Growth disturbance. Low risk for fetal growth restriction. Initial evaluation. C. US Duplex Doppler Velocimetry Maternal Uterine Artery

Doppler interrogation of both maternal uterine arteries is generally performed. Uterine artery Doppler velocimetry at the time of first-trimester nuchal translucency testing (11 to 14 weeks' gestation) did not accurately predict FGR in a prospective trial [28]. A recent paper did not support the use of maternal uterine artery evaluation as a screening tool in low-risk women in the second trimester [29]. In the third trimester, bilateral abnormalities of maternal uterine artery Doppler flow were associated with adverse perinatal outcomes (including Cesarean delivery, FGR, preterm delivery, and low Apgar scores) compared to mothers with normal or unilateral pathologic Doppler waveforms [30]. Current research does not provide sufficient recommendations on management of pregnancies with abnormal US duplex Doppler velocimetry of the maternal uterine arteries, especially as a screening tool among low-risk women.

Variant 1: Growth disturbance. Low risk for fetal growth restriction. Initial evaluation. D. US Duplex Doppler Velocimetry Fetal Umbilical Artery

Although much research has centered on the use of Doppler velocimetry of the fetal umbilical artery among fetuses with known FGR, little work has been done among fetuses in women who are felt to be at low risk for FGR. In fact, umbilical artery Doppler velocimetry has not been shown to be a useful screening tool for FGR [31].

Variant 1: Growth disturbance. Low risk for fetal growth restriction. Initial evaluation. E. US Duplex Doppler Velocimetry Fetal Middle Cerebral Artery

To our knowledge, there are no trials evaluating the use of Doppler velocimetry of the fetal middle cerebral artery as an FGR screening tool in low-risk women.

Variant 1: Growth disturbance. Low risk for fetal growth restriction. Initial evaluation. F. US Duplex Doppler Velocimetry Ductus Venosus

To our knowledge, there are no trials evaluating the use of Doppler velocimetry of the fetal ductus venosus as a FGR screening tool in low-risk women.

Variant 2: Growth disturbance. High risk for fetal growth restriction. Initial evaluation.

As discussed above, the mainstay for evaluation of a fetus for FGR is assessment of fetal biometry. This typically occurs during transabdominal US of the uterus. If a fetus is identified as having FGR, confirmation of fetal well-being, such as with a BPP, is necessary. Doppler interrogation of the umbilical artery is a useful tool for timing of delivery for those with FGR.

Variant 2: Growth disturbance. High risk for fetal growth restriction. Initial evaluation. A. US Pregnant Uterus Transabdominal

As opposed to those at low-risk for FGR, those at high-risk for FGR are especially important to identify. As discussed above, US is currently the primary method of identification of fetuses with FGR. Many various historical and clinical factors can suggest FGR, but US-derived fetal biometry is the only current means to confirm a clinical suspicion for FGR.

Variant 2: Growth disturbance. High risk for fetal growth restriction. Initial evaluation. B. US Pregnant Uterus Biophysical Profile

To our knowledge, there are no trials for the use of the BPP as an FGR screening tool in high-risk women. Nonetheless, when FGR is identified, the BPP is indispensable for assessment of fetal well-being. The BPP with or without the NST is an important test for the assessment of fetal well-being [18], which can be compromised in the setting of FGR (see the ACR Appropriateness Criteria® topic on "Assessment of Fetal Well-Being" [32]). The BPP is the mainstay of fetal well-being evaluation, which consists of four parameters variably sensitive to the acute exposure of the fetus to hypoxemia: fetal breathing movements, fetal limb and body movements, fetal tone, and amniotic fluid volume (which is thought to be more of an indicator of chronic hypoxemia). The BPP would be indicated for those at increased risk for adverse fetal outcome, such as those with identified FGR. The NST, which is sometimes included with the BPP as a fifth component, can be used alone as a test of acute fetal well-being status, but it is often coupled with amniotic fluid measurement, a valuable reflection of fetal hypoxemic exposure over the previous week. Each of the four (or five) components of the BPP receives a score of 0 or 2, leading to a maximum score of 8 (or 10). Scores of 8 (or 10) are strong indicators of a well-compensated fetus [27]. For those at risk for fetal demise, testing strategies usually evaluate one or more of the fetal well-being parameters at least weekly. For the well-being of those fetuses at highest risk for fetal demise, testing can often occur twice weekly or even daily, from the point of postnatal viability until

delivery is indicated. Amniotic fluid volume is usually assessed at least weekly, but may be evaluated more often if it is approaching abnormally low levels. Daily or even more frequent testing by BPP or NST may be indicated in critical situations.

Variant 2: Growth disturbance. High risk for fetal growth restriction. Initial evaluation. C. US Duplex Doppler Velocimetry Maternal Uterine Artery

Some data exists for screening for FGR using maternal uterine artery Doppler velocimetry among those at high risk for FGR. Lesmes et al [33] demonstrated that taking into account maternal characteristics and medical history as well as fetal biometry and uterine artery Doppler velocimetry at 19 to 24 weeks' gestation could identify 90% of FGR with a false-positive rate of 10% for those delivering at <32 weeks' gestation, with decreasing detection rates for those delivering later in gestation. Although almost two-thirds of patients would not require further screening, improved screening performance for FGR would require a subsequent evaluation at 32 or 36 weeks' gestation. A recent study also evaluated maternal uterine artery Doppler when the diagnosis of FGR was made. Those with abnormal maternal uterine artery Doppler at the time of diagnosis of FGR had a higher risk of developing abnormal fetal brain Doppler indexes and adverse perinatal outcome as compared to those with normal maternal uterine artery Doppler indexes [34].

Variant 2: Growth disturbance. High risk for fetal growth restriction. Initial evaluation. D. US Duplex Doppler Velocimetry Fetal Umbilical Artery

Fetal umbilical artery Doppler velocimetry has garnered the most research for those with known or suspected FGR. Alfirevic et al [35] in a meta-analysis of 20 controlled trials of umbilical artery Doppler US found that management incorporating umbilical artery duplex Doppler was associated with improved perinatal outcome in high-risk pregnancies, reduced antenatal admissions, inductions of labor, and Cesarean delivery for fetal distress, and reduced odds of perinatal death by 38%.

Variant 2: Growth disturbance. High risk for fetal growth restriction. Initial evaluation. E. US Duplex Doppler Velocimetry Fetal Middle Cerebral Artery

To our knowledge, there are no trials for the use of Doppler velocimetry of the fetal middle cerebral artery as a FGR screening tool in high-risk women (see the ACR Appropriateness Criteria® topic on "Assessment of Fetal Well-Being" [32]).

Variant 2: Growth disturbance. High risk for fetal growth restriction. Initial evaluation. F. US Duplex Doppler Velocimetry Ductus Venosus

Many strategies for evaluation of those with suspected FGR have involved Doppler interrogation of both the maternal uterine arteries and fetal arteries and veins, especially the ductus venosus. The use of evaluation of Doppler flow of the ductus venosus is most typically performed after an abnormal Doppler waveform of the umbilical artery. In one prospective multicenter study, ductus venosus Doppler velocimetry was shown to predict intact neonatal survival at less than 33 weeks' gestation [19].

Variant 3: Established fetal growth restriction. Follow-up evaluation.

Variant 3: Established fetal growth restriction. Follow-up evaluation. A. US Pregnant Uterus Transabdominal

Once a diagnosis of FGR has been considered and/or made, serial evaluation of fetal growth is performed to assess the degree to which the fetus is compensating within this abnormal milieu [1,8,11]. Decreasing percentile growth would suggest the need for more intensive monitoring for

assessment of fetal well-being or perhaps delivery depending upon clinical parameters, including gestational age.

Variant 3: Established fetal growth restriction. Follow-up evaluation.
B. US Pregnant Uterus Biophysical Profile

Fetuses with FGR are at increased risk for adverse perinatal outcome, and fetal well-being surveillance is indicated in these cases (see the ACR Appropriateness Criteria® topic on "Assessment of Fetal Well-Being" [32]). In the setting of FGR, a BPP is often the initial test performed to assess for fetal well-being after the age of viability. The BPP is rarely acted on in isolation (see the ACR Appropriateness Criteria® topic on "Assessment of Fetal Well-Being" [32]) but rather is assessed in the context of a risk-benefit profile for timing of preterm delivery that includes the results of BPP, NST, Doppler indexes, gestational age, maternal and fetal factors, and any additional known risk factors for preterm delivery. There is limited evidence for precise management directives as many factors must be considered for these preterm gestations [25].

An abnormal BPP is a strong argument for delivery, although gestational age is also important in making this decision. Although a periviable gestational age can be a powerful influence on the decision for delivery, a lack of reassurance of fetal well-being is a meaningful data point for deciding on pregnancy management. At or near term, an abnormal BPP is a powerful indicator for delivery. Retrospective data show that before 34 weeks' gestation, stillbirths among those with FGR followed worsening umbilical artery and ductus venosus Doppler findings and an abnormal BPP; however, precise management directives are unclear for these preterm gestations [25].

Variant 3: Established fetal growth restriction. Follow-up evaluation.
C. US Duplex Doppler Velocimetry Maternal Uterine Artery

A constant clinical challenge is the differentiation of constitutionally small fetuses from those who suffer from FGR, with the inherent associated risks for adverse outcome. A model incorporating an abnormal maternal uterine artery Doppler velocimetry with abnormal cerebroplacental ratio and EFW greater than the third percentile was shown to be useful for discriminating SGA pregnancies at risk for adverse outcome at the time of delivery [36]. Further evidence highlights the predictive value of maternal uterine artery Doppler velocimetry and birthweight. The maternal uterine artery pulsatility index among fetuses with FGR diagnosed between 20 to 28 weeks' gestation is inversely correlated with weight at delivery [23]. The addition of maternal uterine artery Doppler may be appropriate in the setting of FGR if associated with other conditions, in particular pre-eclampsia.

Variant 3: Established fetal growth restriction. Follow-up evaluation.
D. US Duplex Doppler Velocimetry Fetal Umbilical Artery

It is well documented that amongst those with FGR, abnormal umbilical artery duplex Doppler velocimetry may be associated with adverse perinatal outcome [37,38]. One well-documented Doppler abnormality that is very predictive of abnormal perinatal outcome is reversed end–diastolic umbilical artery flow. In particular, reversed umbilical artery end–diastolic flow is associated with neonatal demise [18]. Our ever-present quest to differentiate constitutionally small SGA fetuses from those with FGR has received some clarity with a recent study. The national multicenter Prospective Observational Trial to Optimize Pediatric Health (PORTO) observational study documented that adverse perinatal outcome is uncommon among those with FGR and normal umbilical artery Doppler velocimetry [39] and that abnormalities of the umbilical artery Doppler were useful for identifying fetuses at risk for adverse perinatal outcome [40], thus helping to distinguish between constitutionally small SGA fetuses and those with clinically significant FGR.

Determining the optimal time to deliver late preterm fetuses with FGR and abnormal umbilical artery Doppler velocimetry is vital for optimization of perinatal outcome. Among those with absent or reversed umbilical artery end diastolic flow, a theoretical model determined that 35 weeks' gestation was the optimal gestational age for delivery [41]. Retrospective studies demonstrated similar composite neonatal morbidity when those pregnancies with FGR and abnormal umbilical artery Doppler velocimetry were delivered at 37 weeks as compared to those with FGR but normal umbilical artery Doppler velocimetry delivered at 39 weeks' gestation [42,43]. With a median follow-up of 9 years, those with FGR and absent or retrograde diastolic flow in the umbilical artery were shown to be associated with an increased risk of adverse outcome, including mortality and developmental disorders or delay [44]. Furthermore, perinatal mortality is independently associated with absent or reversed end–diastolic flow in the umbilical artery among those with FGR [45]. There were similar outcomes for immediate versus delayed delivery among those with FGR and umbilical artery Doppler velocimetry when the clinicians were unsure about whether or not to deliver in the multicenter Growth Restriction Intervention Trial [9].

Variant 3: Established fetal growth restriction. Follow-up evaluation.
E. US Duplex Doppler Velocimetry Fetal Middle Cerebral Artery

In a systematic review, middle cerebral artery Doppler indexes, which were thought to indicate cerebral redistribution, suggested that SGA fetuses with abnormal middle cerebral artery Doppler velocimetry were associated with neurodevelopmental problems at follow-up of SGA fetuses. The authors called for more adequately controlled studies with long-term follow-up before clear conclusions could be drawn [46]. Among those with FGR after 34 weeks' gestation, as a sign of brain-sparing, only a decline in the middle cerebral artery pulsatility index was observed prior to stillbirth [25]. In addition to the use of umbilical artery Doppler as a tool for identifying fetuses at risk for adverse outcome, the PORTO study also found that interrogation of the middle cerebral artery was useful for identifying fetuses at risk for adverse perinatal outcome [40].

Variant 3: Established fetal growth restriction. Follow-up evaluation.
F. US Duplex Doppler Velocimetry Ductus Venosus

Reversed ductus venosus A-wave flow is associated with neonatal demise [18]. The Trial of Randomized Umbilical and Fetal Flow in Europe (TRUFFLE) randomized controlled trial evaluated those with FGR (26–32 weeks' gestation) and abnormal umbilical artery Doppler velocimetry and then evaluated randomized outcome based on either cardiotocographic fetal heart rate abnormalities or early or late changes in ductus venosus Doppler velocimetry. They showed no significant difference in survival without neuroimpairment among the three subgroups; however, timing of delivery based on ductus venosus waveform might produce an improvement in developmental outcome at 2 years of age [47,48]. Korkalainen et al [44] reported that in addition to abnormal umbilical artery Doppler indexes, reverse A-wave flow in the ductus venosus was associated with an increased risk for adverse outcome when evaluating those almost a decade after birth. Two-year neonatal outcome posthoc subanalysis of TRUFFLE study data suggested that delivery before 32 weeks' gestation was optimal for fetuses when both ductus venosus Doppler velocimetry and cardiotocographic fetal heart rate evaluation were sequentially assessed [49].

Summary of Recommendations

- **Variant 1**: US pregnant uterus transabdominal is usually appropriate for the initial imaging of pregnant women who are at low risk for FGR.

- **Variant 2:** US pregnant uterus transabdominal is usually appropriate for the initial imaging of pregnant women who are at high risk for FGR. For those who are found to have growth restriction, US duplex Doppler velocimetry fetal umbilical artery and US pregnant uterus BPP are usually appropriate.
- **Variant 3:** US pregnant uterus BPP, US pregnant uterus transabdominal, US duplex Doppler velocimetry fetal umbilical artery, US duplex Doppler velocimetry ductus venosus, and US duplex Doppler velocimetry fetal middle cerebral artery are usually appropriate for follow-up evaluation in pregnant women with established FGR. These procedures are complementary (ie, all tests should be performed).

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Safety Considerations in Pregnant Patients

Imaging of the pregnant patient can be challenging, particularly with respect to minimizing radiation exposure and risk. For further information and guidance, see the following ACR documents:

· ACR–SPR Practice Parameter for the Safe and Optimal Performance of Fetal Magnetic Resonance Imaging (MRI)
· ACR-SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Patients with Ionizing Radiation
· ACR-ACOG-AIUM-SMFM-SRU Practice Parameter for the Performance of Standard Diagnostic Obstetrical Ultrasound
· ACR Manual on Contrast Media
· ACR Manual on MR Safety

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides

		transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

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