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The role of ultrasound in detecting and monitoring fetal growth restriction

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Abstract
Fetal growth restriction (FGR) is a significant complication in pregnancy associated with increased perinatal morbidity and mortality. Ultrasound imaging plays a crucial role in the detection and monitoring of FGR, providing vital information for timely intervention and management. This review examines the current literature on the effectiveness of ultrasound in diagnosing FGR, discusses the methodologies employed, and highlights recent advancements in ultrasound technology.

Keywords: Pelvic floor disorders (PFDs), muscles, ligaments, connective tissues, pelvic organs

Introduction
Fetal growth restriction (FGR), also known as intrauterine growth restriction (IUGR), refers to a condition where a fetus does not achieve its genetically predetermined growth potential. This condition is associated with a higher risk of adverse perinatal outcomes, including preterm birth, low birth weight, and perinatal mortality. Accurate detection and continuous monitoring of FGR are essential for optimizing pregnancy management and improving neonatal outcomes. Ultrasound imaging is the primary tool used for this purpose due to its non-invasive nature and ability to provide detailed information on fetal development and well-being.

Objective
The main objective of the study is to evaluate the efficacy and advancements of ultrasound imaging in accurately diagnosing and continuously monitoring fetal growth restriction (FGR) to improve clinical decision-making and optimize perinatal outcomes.

Literature Review
The Predictive Value of Doppler Ultrasound In a seminal study, Baschat *et al.* (2007) [1], evaluated the predictive value of Doppler ultrasound for adverse perinatal outcomes in pregnancies complicated by FGR. The researchers conducted serial Doppler assessments of the umbilical artery, middle cerebral artery, and ductus venosus. Their findings demonstrated that abnormal Doppler waveforms, such as absent or reversed end-diastolic flow in the umbilical artery, were strongly associated with adverse outcomes. This study highlighted the importance of Doppler ultrasound in identifying fetuses at high risk and guiding clinical interventions.
Serial Growth Measurements Figueras and Gardosi (2011) [2], conducted a comprehensive review emphasizing the importance of serial growth measurements in detecting FGR. Their analysis showed that single-point assessments might not accurately distinguish between constitutionally small fetuses and those experiencing growth restriction. By tracking fetal growth over time, clinicians can better identify deviations from normal growth patterns, leading to more accurate diagnoses and timely management. This study reinforced the need for ongoing monitoring rather than relying solely on initial ultrasound findings.
Fetal Biometry and Estimated Fetal Weight Hadlock *et al.* (1991) [3], developed formulas for estimating fetal weight (EFW) using ultrasound biometry, including measurements of head circumference (HC), abdominal circumference (AC), femur length (FL), and biparietal diameter (BPD). Their work provided the foundation for modern fetal growth assessment and is widely used in clinical practice.

By comparing EFW to standardized growth charts, clinicians can identify fetuses below the 10th percentile for gestational age, a key indicator of FGR.

Advances in 3D and 4D Ultrasound Kalache *et al.* (2011) [4], explored the use of three-dimensional (3D) and four-dimensional (4D) ultrasound in assessing fetal growth and development. Their research demonstrated that these advanced imaging techniques offer superior visualization of fetal anatomy and movements compared to traditional two-dimensional (2D) ultrasound. 3D and 4D ultrasounds provide detailed images that can improve the detection of structural abnormalities and enhance the assessment of fetal well-being, making them valuable tools in managing FGR.

Ultrasound Elastography Sieroszewski *et al.* (2013) [5], investigated the potential of ultrasound elastography in predicting FGR. This emerging technique measures placental stiffness, which is associated with placental insufficiency, a primary cause of FGR. Their preliminary findings suggested that elastography could provide early indications of FGR, allowing for earlier interventions and improved outcomes. Although still in its early stages, this research points to a promising new application of ultrasound technology in prenatal care.

Differentiating Early and Late-Onset FGR Savchev *et al.* (2014) [6], focused on the differences between early-onset and late-onset FGR. Their study found that early-onset FGR, often related to severe placental insufficiency, typically presents with abnormal Doppler findings and requires more intensive monitoring and early delivery. In contrast, late-onset FGR may be less severe but still necessitates careful observation. This research underscored the importance of using ultrasound to differentiate between types of FGR, informing appropriate management strategies.

Longitudinal Studies and Perinatal Outcomes Lindqvist *et al.* (2017) [7], conducted a longitudinal study examining the impact of ultrasound monitoring on perinatal outcomes in pregnancies with suspected FGR. Their findings indicated that regular ultrasound assessments, including Doppler studies, significantly improved perinatal outcomes by enabling timely clinical decisions and interventions. This study reinforced the critical role of continuous ultrasound monitoring in managing FGR.

International Standards for Fetal Growth Papageorghiou *et al.* (2014) [8], contributed to the development of international standards for fetal growth by conducting a multicenter study involving diverse populations. Their research aimed to create standardized growth charts that could be universally applied, reducing variability in FGR diagnosis. The resulting growth standards have been adopted globally, enhancing the consistency and accuracy of ultrasound assessments.

Ultrasound in Detecting and Monitoring Fetal Growth Restriction

Ultrasound imaging plays a crucial role in the detection and monitoring of fetal growth restriction (FGR), providing vital information that guides clinical management and intervention. FGR, also known as intrauterine growth restriction (IUGR), is a condition where a fetus fails to achieve its genetically predetermined growth potential, often leading to adverse perinatal outcomes such as preterm birth, low birth weight, and increased perinatal mortality. The ability of ultrasound to provide real-time, non-invasive visualization of the fetus and placenta makes it the gold standard for assessing fetal growth and well-being. The primary method for detecting FGR using ultrasound involves fetal biometry, which includes the measurement of several key fetal parameters: head circumference (HC), abdominal circumference (AC), femur length (FL), and biparietal diameter (BPD). These measurements are used to estimate fetal weight (EFW), which is then compared to standard growth charts to determine whether the fetus is growing appropriately for its gestational age. An EFW below the 10th percentile is typically indicative of FGR. However, to differentiate between a constitutionally small but healthy fetus and one experiencing growth restriction, serial growth measurements are often required. This approach helps in identifying deviations from normal growth patterns over time. In addition to biometry, Doppler ultrasound is an essential tool for monitoring FGR. Doppler studies assess blood flow in key fetal vessels, including the umbilical artery, middle cerebral artery, and ductus venosus. Abnormal Doppler findings, such as absent or reversed end-diastolic flow in the umbilical artery, indicate placental insufficiency and are strongly associated with adverse outcomes. Doppler ultrasound helps in determining the severity of FGR and the risk to the fetus, guiding the timing and type of intervention needed. Recent advancements in ultrasound technology have further enhanced the ability to detect and monitor FGR. Three-dimensional (3D) and four-dimensional (4D) ultrasound provide more detailed images of fetal anatomy and can improve the assessment of fetal growth and development. These technologies offer better visualization of fetal movements and behavior, which can be indicative of fetal well-being. Additionally, the use of ultrasound elastography to measure placental stiffness is an emerging technique that shows promise in predicting FGR. Placental stiffness is associated with placental insufficiency, a primary cause of FGR, and elastography could become a valuable tool for early detection. The benefits of using ultrasound for detecting and monitoring FGR are numerous. It allows for early diagnosis, continuous monitoring of fetal health, and timely intervention, which are crucial for improving perinatal outcomes. Ultrasound is non-invasive, widely available, and relatively inexpensive compared to other imaging modalities. Its ability to provide detailed information about both fetal and placental conditions makes it indispensable in prenatal care. However, there are limitations and challenges associated with the use of ultrasound in FGR. The accuracy of fetal biometry can be influenced by factors such as fetal position, maternal obesity, and operator experience. Additionally, the use of different growth charts and reference standards can lead to variability in diagnosing FGR. Differentiating between FGR and small-for-gestational-age (SGA) fetuses, who are small but otherwise healthy, remains a challenge. Accurate differentiation is crucial for appropriate clinical management, as SGA fetuses may not require the same level of intervention as those with true growth restriction. In conclusion, ultrasound is an indispensable tool in the detection and monitoring of fetal growth restriction. Its ability to provide real-time, detailed images of fetal and placental structures allows for accurate diagnosis and continuous monitoring of fetal health. Despite its limitations, the advancements in ultrasound technology and techniques continue to enhance its efficacy in managing FGR, ultimately aiming to improve outcomes for both the fetus and the mother.

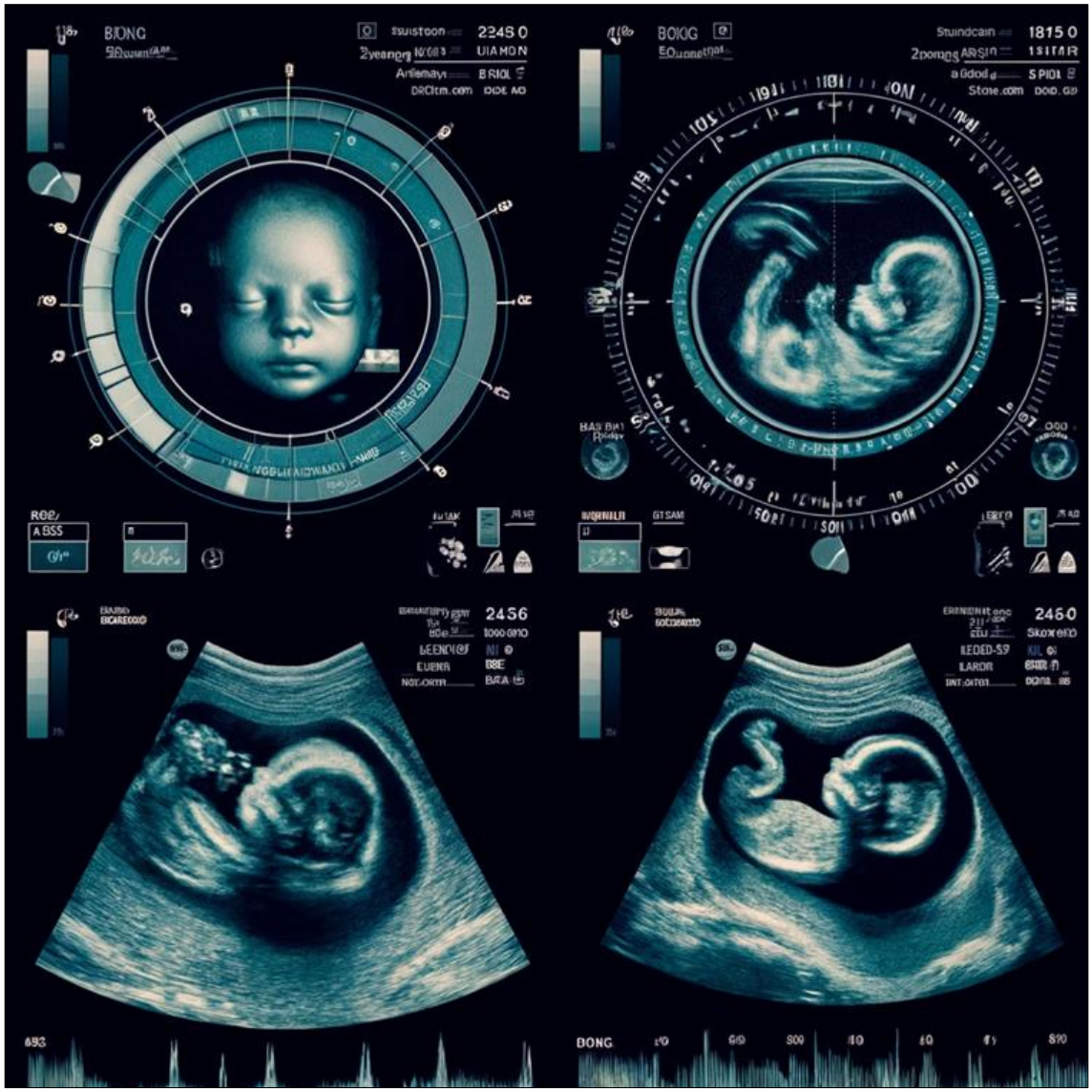

Fig 1: Detection of Fetal Growth though Ultrasound

1. Detection of FGR: Ultrasound is the gold standard for diagnosing FGR. Key parameters used in ultrasound assessment include fetal biometry, which measures the head circumference (HC), abdominal circumference (AC), femur length (FL), and biparietal diameter (BPD). The estimated fetal weight (EFW) is calculated using these measurements and compared to standard growth charts. FGR is typically defined as an EFW below the 10th percentile for gestational age.

Studies have shown that incorporating multiple biometric parameters improves the accuracy of FGR diagnosis. A systematic review by Figueras and Gardosi (2011) [2] emphasized the importance of serial growth measurements over single-point assessments to differentiate between constitutionally small fetuses and those truly experiencing growth restriction.

2. Monitoring FGR: Continuous monitoring of FGR is essential to assess fetal well-being and guide clinical decision-making. Doppler ultrasound is a critical component in this process. Doppler studies evaluate blood flow in the umbilical artery, middle cerebral artery, and ductus venosus. Abnormal Doppler findings, such as absent or reversed end-diastolic flow in the umbilical artery, are indicative of placental insufficiency and are associated with adverse outcomes.

A study by Baschat *et al*. (2007) [1] demonstrated that Doppler ultrasound could predict adverse perinatal outcomes in FGR pregnancies, allowing for timely interventions such as early delivery. Additionally, Doppler assessments can help distinguish between early-onset FGR, often related to placental insufficiency, and late-onset FGR, which may be more benign.

3. Advanced Ultrasound Techniques: Recent advancements in ultrasound technology have further enhanced the ability to detect and monitor FGR. Three-dimensional (3D) and four-dimensional (4D) ultrasound provide more detailed images of fetal anatomy and can improve the assessment of fetal growth and development. Moreover, these technologies offer better visualization of fetal movements and behavior, which can be indicative of fetal well-being.

The use of ultrasound elastography to measure placental stiffness is an emerging technique that shows promise in predicting FGR. Placental stiffness is associated with placental insufficiency, a primary cause of FGR. Early studies suggest that elastography could become a valuable tool in the early detection of FGR.

4. Limitations and Challenges: While ultrasound is a powerful tool for detecting and monitoring FGR, it has limitations. The accuracy of fetal biometry can be affected by factors such as fetal position, operator experience, and maternal body habitus. Additionally, the use of different growth charts and reference standards can lead to variability in FGR diagnosis.

Another challenge is the differentiation between FGR and small-for-gestational-age (SGA) fetuses. SGA fetuses are small but otherwise healthy, whereas FGR fetuses have restricted growth due to pathological conditions. Accurate differentiation is crucial for appropriate clinical management.

Conclusion

Ultrasound imaging is indispensable in the detection and monitoring of fetal growth restriction. It provides critical information through fetal biometry and Doppler studies, enabling early diagnosis and continuous assessment of fetal well-being. Recent advancements in ultrasound technology, such as 3D/4D imaging and elastography, hold promise for further improving the accuracy and predictive value of ultrasound in managing FGR. Despite its limitations, ultrasound remains the cornerstone of FGR management, guiding clinical decisions and optimizing pregnancy outcomes.

Conflict of Interest

Not available

Financial Support

Not available

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