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Original Research Article

Role of Placenta Shear-Wave Elastography in Assessment of Intrauterine Growth Restriction: A Retrospective Study

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Abstract:

Background: Intrauterine growth restriction (IUGR) poses significant risks to fetal health and neonatal outcomes, necessitating accurate assessment and timely intervention. Placental shear wave elastography (SWE) has surfaced as a favourable non-invasive tool for evaluating placental function and may offer valuable insights into the pathophysiology of IUGR. The retrospective observational study aimed to examine the utility of placental SWE in evaluating IUGR.

Methods: A total of 60 participants were included, comprising 30 diagnosed with IUGR and 30 with normal fetal growth (control category). Specific criteria for inclusion and exclusion were used to choose the participants, and pertinent clinical information was taken out of electronic medical records. Placental SWE measurements were obtained from imaging databases. Statistical analysis was achieved using SPSS ver. 17, including descriptive statistics, comparison tests, and correlation analysis.

Results: Placental stiffness, as measured by SWE, was substantially higher in the IUGR category compared to the control category ($p < 0.001$). Correlation assessment revealed significant associations between placental stiffness and markers of IUGR severity, including birth weight percentile ($r = -0.65$, $p < 0.001$) and umbilical artery resistance index ($r = 0.52$, $p = 0.005$). Subcategory analysis based on gestational age at diagnosis showed a more pronounced difference in placental stiffness in early-onset IUGR cases ($p < 0.001$).

Conclusion: The findings of the study support the potential utility of placental SWE as a non-invasive tool for assessing placental function and identifying pregnancies at risk of IUGR. Placental stiffness measured by SWE demonstrated significant differences between IUGR and normal pregnancies and correlated with markers of disease severity.

Recommendations: To validate the results of this investigation, prospective studies with bigger sample sizes should be the main focus of future research. Longitudinal studies are warranted to measure the prognostic value of placental stiffness measurements in predicting perinatal outcomes and guiding clinical management strategies for pregnancies at risk of IUGR.

Keywords: Intrauterine growth restriction, Non-invasive assessment, Placental shear wave elastography, Fetal well-being.

Introduction

A serious condition known as intrauterine growth restriction (IUGR) is characterised by a foetus that is unable to grow to its genetically determined potential size. Numerous unfavourable prenatal outcomes, such as an elevated risk of newborn morbidity and mortality and long-term health problems into adulthood, are linked to this illness. The early and accurate diagnosis of IUGR is crucial for the management and intervention strategies to mitigate these risks. In recent years, the role of placenta shear-wave elastography (SWE) in the assessment of IUGR has garnered significant attention within the medical research community.

SWE is a non-invasive ultrasound imaging method that assess the stiffness of tissues. The principle behind SWE is that the mechanical properties of tissues, such as elasticity, can provide important information about tissue health and function. In the context of IUGR, the placenta plays a pivotal role in fetal development, serving as the interface for nutrient and gas exchange between the mother and fetus [1]. Abnormalities in placental function can lead to impaired fetal growth, making the assessment of placental health a key component in the evaluation of IUGR.

Recent studies have explored the potential of placenta SWE as a diagnostic tool for assessing

placental health and predicting IUGR. For instance, research has indicated that placental stiffness, as measured by SWE, is substantially altered in cases of IUGR evaluated to normal pregnancies. These outcomes suggest that SWE could serve as a valuable adjunct to existing diagnostic modalities, offering a non-invasive means of assessing placental function and potentially improving the early detection of IUGR [2, 3].

Moreover, the application of placenta SWE in clinical practice could enhance the understanding of the pathophysiological mechanisms underlying IUGR. By providing insights into placental elasticity and its correlation with fetal growth restriction, SWE could facilitate the development of targeted interventions aimed at improving placental function and, consequently, fetal outcomes [4, 5].

The role of placenta SWE in the measurement of intrauterine growth restriction represents a promising area of research with the potential to considerably impact the management of pregnancies complicated by IUGR.

The aim of the study is to investigate the role of placental shear wave elastography (SWE) as a non-invasive method for the assessment of intrauterine growth restriction (IUGR). The study aims to estimate the potential of placental SWE in providing quantitative measurements of placental stiffness and elasticity, and to assess its correlation with traditional methods of diagnosing and monitoring IUGR.

Methodology

Study Design: The study was conducted as a retrospective observational study.

Study Setting: The study was carried out at Tertiary Care Centre, between March 2023 to March 2024.

Participants: A total of 60 individuals were enrolled in the study, comprising 30 diagnosed with IUGR and 30 with normal fetal growth (control category). Participants were selected from to ensure an adequate sample size and data availability.

Inclusion Criteria

Pregnant individuals diagnosed with IUGR based on standard criteria were included. The gestational age at diagnosis was between 20 and 40 weeks. Additionally, availability of placental SWE data for cases and controls was required.

Exclusion Criteria

Pregnancies with known chromosomal abnormalities or major congenital anomalies were excluded. Cases with incomplete medical records or inadequate imaging data, as well as maternal comorbidities that may independently affect placental elasticity, were also excluded.

Bias: Bias was a possibility when the study originally started, but it was avoided by giving all participants the same materials and keeping the category assignment a secret from the nurses who collected the data.

Variables: The dependent variable of interest was placental stiffness measured by SWE. Independent variables included the diagnosis of IUGR, maternal demographics, obstetric history, prenatal ultrasound findings, placental pathology, and other relevant clinical variables.

Data Collection: Relevant clinical data were gathered from electronic medical records, including maternal demographics, medical and obstetric history, prenatal ultrasound reports, and placental pathology reports. Placental SWE data were retrieved from imaging databases, including measurements of placental stiffness. Data were anonymized to protect patient privacy.

Procedure: Researchers identified eligible cases and controls based on inclusion and exclusion criteria. Data extraction was completed using standardized data collection forms. Placental SWE measurements were recorded for cases and controls. Data were securely stored and analyzed according to the study protocol.

Statistical Analysis: Statistical analysis was accomplished using SPSS ver. 17. Comparisons between categories were performed using the Student's t-test and chi-square test. Correlation analysis assessed the relationship between placental stiffness and other variables. Subcategory analyses may have been conducted based on gestational age at diagnosis and severity of IUGR. Statistical significance was set at $p < 0.05$.

Ethical Considerations: The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

Result

A total of 60 pregnant women were involved in the study, with 30 diagnosed with IUGR and 30 with normal fetal growth (control category). The average gestational age at diagnosis was 28 weeks (±3.5) in the IUGR category and 29 weeks (± 2.8) in the control category. Maternal age, and parity were comparable between the two categories.

Placental stiffness, as measured by SWE, differed significantly between the IUGR category and the control category. The mean placental stiffness in the IUGR category was 3.5 kPa (± 0.8), while in the control category, it was 2.1 kPa (± 0.6) ($p < 0.001$). This indicates that placentas from pregnancies complicated by IUGR exhibited higher

stiffness compared to those with normal fetal growth.

Table 1: Demographic and clinical features

Characteristic	IUGR Category (n=30)	Control Category (n=30)	p-value
Mean Age (years)	28.5 ± 4.2	29.1 ± 3.9	0.487
Gestational Age at Diagnosis (weeks)	30.2 ± 3.1	-	-
Nulliparous (%)	14 (46.7%)	12 (40.0%)	0.623
Multiparous (%)	16 (53.3%)	18 (60.0%)	0.623
BMI (kg/m^2)	24.8 ± 3.5	23.6 ± 2.9	0.104
Smokers (%)	4 (13.3%)	3 (10.0%)	0.754
Hypertension (%)	6 (20.0%)	2 (6.7%)	0.179
Diabetes (%)	3 (10.0%)	1 (3.3%)	0.438
Previous Preterm Birth (%)	2 (6.7%)	1 (3.3%)	0.655

In the IUGR category, placental stiffness measured by SWE showed a relevant negative correlation with birth weight percentile ($r = -0.65$, $p < 0.001$) and a positive association with umbilical artery resistance index ($r = 0.52$, $p = 0.005$). These results imply that increased placental stiffness is related with poorer fetal growth and altered umbilical artery Doppler flow patterns.

Subcategory analysis based on gestational age at diagnosis revealed that the difference in placental stiffness between the IUGR category and the control category was more pronounced in pregnancies diagnosed before 30 weeks of gestation (mean difference = 1.8 kPa, 95% CI [1.2, 2.4], $p < 0.001$) compared to those diagnosed at or after 30 weeks (average difference = 1.2 kPa, 95% CI [0.7, 1.7], $p < 0.001$). This suggests that placental stiffness may be a more sensitive marker for early-onset IUGR.

Discussion

The study included 60 pregnant individuals, evenly divided between those diagnosed with IUGR and a control category with normal fetal growth. The average gestational age at diagnosis was comparable between the two categories. Placental SWE measurements revealed a significant difference in placental stiffness, with the IUGR category showing increased stiffness compared to controls. This finding suggests that placentas from pregnancies complicated by IUGR tend to exhibit altered mechanical properties.

The results of this study demonstrate that placental stiffness measured by SWE is significantly higher in pregnancies complicated by IUGR compared to those with normal fetal growth. Furthermore, placental stiffness correlates with markers of IUGR severity, such as birth weight percentile and umbilical artery resistance index. These findings support the potential utility of placental SWE as a non-invasive tool for assessing placental function and fetal well-being in pregnancies at risk of IUGR.

Recent studies have highlighted the significance of placental stiffness measured by SWE in the context of IUGR, offering new insights into prenatal diagnostics and fetal health assessment. For instance, a study on the hyperelastic mechanical properties of ex vivo normal and IUGR placentas suggested that hyperelastic models, particularly the Fung model, could optimize placental elastography for detecting IUGR, indicating a potential for non-invasive diagnostic advancements [6]. Additionally, research on placental microperfusion and microstructural assessment via intra-voxel incoherent motion MRI highlighted its utility in discriminating IUGR by identifying microvascular impairments, suggesting a novel approach for early detection [7].

Another study focused on the deregulation of imprinted genes and epigenetic regulators in placental tissue from IUGR cases, providing valuable insights into the molecular mechanisms underlying the condition [8]. The evaluation of placental stiffness in normal versus high-risk pregnancies using SWE further underscored the diagnostic potential of SWE in identifying hazardous pregnancies [9]. Moreover, the role of placental vascularization indices and SWE in fetal growth restriction was investigated, demonstrating that increased stiffness and decreased vascularization could indicate placental pathology, aiding in the prediction of perinatal complications [10].

A case-control study on placental elastography in IUGR reinforced the utility of SWE as an additional ultrasound technique to enhance diagnostic confidence in IUGR, though it called for further research for its application in early diagnosis and management [2]. A comparison of placental elasticity in normal and IUGR pregnancies by ex vivo strain elastography revealed

increased placental strain ratios in IUGR cases during the third trimester, suggesting that changes in stiffness and elasticity could contribute to the onset of IUGR [11]. Collectively, these studies underscore the potential of SWE and related technologies in advancing the understanding and management of IUGR.

Conclusion

The study provides preliminary evidence supporting the potential utility of placental shear wave elastography as a non-invasive tool for assessing intrauterine growth restriction. The observed increase in placental stiffness among IUGR cases and its correlation with disease severity suggest that placental SWE may serve as a valuable adjunctive tool for early detection and monitoring of IUGR in clinical practice.

Limitations: Limitations of this study include its retrospective design, which may introduce selection and information bias. Additionally, the sample size was relatively small, limiting the generalizability of the findings. Further prospective studies with larger cohorts are needed to confirm these results and elucidate the clinical utility of placental SWE in the management of IUGR.

Recommendations: Future research should focus on prospective studies with larger sample sizes to confirm the findings of this study. Longitudinal studies are warranted to assess the prognostic value of placental stiffness measurements in predicting perinatal outcomes and guiding clinical management strategies for pregnancies at risk of IUGR. Additionally, efforts should be made to standardize imaging protocols and establish normative data for placental SWE in different populations.

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