Original Research Article

A STUDY ON ASSESSING PLACENTAL MRI AND FETAL DOPPLER INDICES IN EVALUATION OF HIGH RISK PREGNANCIES WITH FETAL GROWTH RESTRICTION

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ABSTRACT

Background: Placental MRI and Doppler ultrasound play crucial roles in the risk stratification of high-risk pregnancies, particularly in the context of intrauterine growth restriction (IUGR). Placental Doppler assessments, including measurements of the umbilical artery and middle cerebral artery, provide vital information regarding placental blood flow and fetal well-being, allowing clinicians to identify fetuses at risk for adverse outcomes. MRI offers a complementary approach by providing detailed morphological and functional insights into the placenta, such as changes in thickness, volume, and the presence of lesions, which may not be visible on ultrasound. The integration of both imaging modalities enhances the accuracy of diagnosing placental insufficiency and stratifying the risk of complications in high-risk pregnancies.
Materials and Methods: This prospective study was conducted in the Department of Radio-diagnosis over 1-year period. The study included 100 antenatal mothers who were evaluated for fetal growth restriction using ultrasound examination and placental MRI.
Results: 64% of the patients were between 29-34 weeks of gestational age. 15% had weight percentile between 5th – 10th and 25% had below 5th percentile of weight according to the gestational age. Presence of co-morbid conditions such as hypertension, diabetes, cardiac illness was associated with higher prevalence of IUGR. Uterine artery and umbilical artery anomalies were more commonly seen in severe IUGR. The Doppler indices were significantly higher in fetuses with restricted growth. Most of the T2 weighed placental images in fetuses with restricted growth were heterogenous and hyperdense.
Conclusion: Placental MRI is used in evaluating placental signal intensity ratios and correlating these with fetal morbidity and mortality, highlighting its potential as a diagnostic tool in managing IUGR and improving maternal-fetal outcomes.
Keywords: High risk pregnancy, fetal growth restriction, placental MRI, fetal Doppler.

INTRODUCTION

Intrauterine Fetal Growth Restriction (IUGR), formerly termed Intrauterine Growth Retardation, refers to fetal growth that is suboptimal for its genetic potential and gestational age, typically indicated by an estimated birth weight below the 10th percentile or an abdominal circumference under the 2.5th percentile.[1] While 80-85% of these fetuses are constitutionally small but healthy, a significant minority represent true IUGR, often linked to utero-placental insufficiency—a condition marked by compromised placental vascular adaptation, leading to restricted nutrient transfer and impaired fetal growth.

The global prevalence of IUGR varies, affecting 3-10% of pregnancies, with a notably higher incidence in Asia and in socioeconomically disadvantaged populations, rates reach 25-30%.[2] The etiology of IUGR encompasses maternal factors such as diabetes and hypertension, fetal factors like congenital anomalies, and most prominently, placental dysfunction. IUGR is associated with increased perinatal morbidity and mortality, including risks of neonatal complications like hypoglycemia, sepsis, and long-term health issues such as adult-onset diabetes and cardiovascular diseases.[3] Early detection of IUGR is critical for optimizing delivery outcomes, often necessitating advanced imaging modalities beyond traditional ultrasound, such as Doppler and MRI, to assess placental health and predict perinatal risks.[4]

Magnetic resonance imaging (MRI) has emerged as an invaluable modality for evaluating placental function and identifying intrauterine growth restriction (IUGR). This advanced imaging technique provides insights into placental perfusion, oxygenation, and morphology that are not easily discernible through conventional ultrasound.[5,6] Research indicates that MRI-based diagnostic models, which incorporate parameters such as placental infarct size, thickness-to-volume ratio, and placental shape, can accurately detect IUGR with commendable precision. Furthermore, placental MRI facilitates a more nuanced assessment of the severity of placental insufficiency in affected fetuses, with metrics such as placental globular shape and infarct involvement percentage demonstrating superior diagnostic accuracy.[7]

This study aims to evaluate the effectiveness of predicting IUGR by placental MRI versus placental Doppler studies.

MATERIAL AND METHODS

This prospective study was conducted in the Department of Radio-diagnosis over 1 year period, i.e. from April 2023 to March 2024.

The study involved antenatal mothers with singleton pregnancies over 20 weeks gestation, including those with diabetes and hypertension, who were referred for ultrasound, Doppler, or MRI evaluation of the placenta. Exclusions included first-trimester pregnancies, multiple gestations, fetuses with congenital anomalies, and patients with contraindications to MRI.

The study comprised two components: a prospective comparison of placental characteristics via ultrasound, Doppler, and MRI, and a retrospective analysis of signal intensity measurements. Ultrasound and Doppler assessments were conducted by an experienced radiologist, and MRI scans were performed within 1-2 days of ultrasound evaluation, analyzed by a second radiologist blinded to the ultrasound results. Fetal biometric data, placental volume, and Doppler indices were recorded.

The calculated Doppler values were – peak systolic velocity (PSV), end diatolic velocity (EDV), resistive index (RI), pulsatility index (PI) and Systolic/ diastolic ratio (S/D ratio) of fetal middle cerebral artery, umbilical artery, right uterine artery, intraplacental vessels and retro-placental vessels.

MRI images were analyzed for placental volume, signal intensity, and heterogeneity. Signal intensity ratios for the placenta, amniotic fluid, gluteus maximus, and fetal liver were calculated to assess and compare perinatal outcomes.

Ethical committee approval was taken from the institutional ethical committee. A written informed consent was obtained from all the patients.

RESULTS

100 singleton mothers aged 18 years and above underwent antenatal screening by ultrasound examination for estimating gestational weight. The mean gestational age of study was 31.5 weeks with most of the patients (64%) belonging to 29 – 34 weeks of gestational age. Based on the weight percentile according to gestational age, neonates were categorized into normal (>10th percentile), mild IUGR (weight percentile according to gestational age between 5th to 10th percentile) and severe IUGR (<5thpercentile according to gestational age).

Most of the patients (60%) had normal weight. 25% had severe IUGR and 15% had mild IUGR. Most of the patients with severe IUGR belonged to 29-34 weeks of gestational age while most of the patients with mild IUGR belonged to <29 weeks of gestational age. [Table 1]

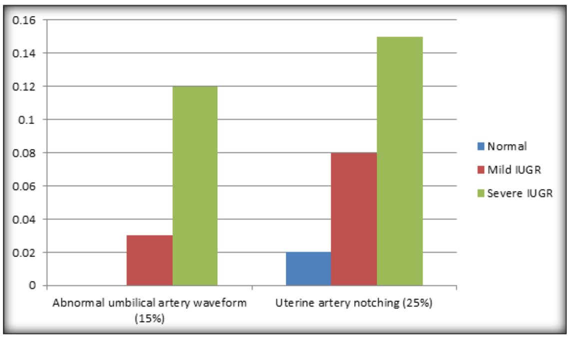

Figure 1: Abnormalities of umbilical and uterine artery

The mean values of various Doppler indices were found to be significantly higher in IUGR fetuses than in normal fetuses.

MRI scan was done on all 100 patients. Placentas were categorized by morphologic features to evaluate their association with Intrauterine Growth Restriction (IUGR). [Table 2]

A statistically significant disparity in placental morphology was observed between mild IUGR and normal fetuses ($p = 0.001$).

MRI T2 weighed signal intensity measurement was compromised by artifacts in 6 of the 100 cases. The remaining 94 placentas were categorized based on their T2-weighted MRI signal intensity into the following classifications- Grade 0 (Homogeneous and isointense); grade 1 (Homogeneous and hyperintense); Grade 2 (Homogeneous and hypointense); Grade 3 (Heterogeneous with hyperintense); Grade 4 (Heterogeneous with hypointense); Grade 5 (Heterogeneous with hyperintense cotyledons); and grade 6 (Heterogeneous with hypointense cotyledons). [Table 3]

The presence of hypo-intensity, whether homogeneous, focal, or within cotyledons, was indicative of placental fibrosis in IUGR fetuses, yielding a sensitivity of 15%, specificity of 88%, and a positive predictive value of 54%.

Signal intensity values for the placenta and fetal liver in normal gestations demonstrated a decreasing trend with advancing gestational age, whereas amniotic fluid signal intensity increased over time. In contrast, IUGR placentas exhibited elevated T1 and T2 values relative to normal placentas of the same gestational age. [Table 4]

Statistically significant correlations were identified for Placental T1 ($p = 0.042$), Placental T2 ($p = 0.036$), and Amniotic Fluid T2 ($p = 0.011$) when comparing normal placentas to IUGR placentas. Additionally, Fetal Liver T2 showed significant differentiation ($p = 0.043$) between normal fetuses and IUGR fetuses.

MRI-derived ratios for 50 patients exhibited a decreasing trend with gestational progression for the AF/PL, LIV/PL, GM/PL, PL/AF, and LIV/AF ratios, while the AF/GM, LIV/GM, and PL/LIV ratios demonstrated an increasing trend. [Table 5]

Table 1: Weight percentile based distribution of patients

Characteristic		Total % of patients	Normal (n = 60)	Mild IUGR (n = 15)	Severe IUGR (n = 25)
Gestational age (in weeks)	<29 weeks	20%	6%	8%	6%
	29-34 weeks	64%	45%	4%	15%
	>34 weeks	16%	9%	3%	4%
Hypertension		**25%**	**7%**	**5%**	**13%**
Diabetes		**21%**	**12%**	**4%**	**5%**
Cardiac illness		**10%**	**5%**	**1%**	**4%**
Bad obstetric history		**12%**	**6%**	**2%**	**4%**
Anemia		**49%**	**29%**	**5%**	**15%**

Table 2: Comparison of Doppler indices between normal and IUGR foetuses

Parameter	Mean		Pvalue
	NORMAL	<10% IUGR	
Pulsatility index of uterine artery	**1.0**	**2.2**	**0.002**
Pulsatility index of middle cerebral artery	**2.05**	**1.4**	**0.03**
Pulsatility index if retro-placental vessels	**1.67**	**0.64**	**0.04**
Peak systolic velocity of intra-placental vessels	**19.2**	**23.6**	**0.01**
Systolic/ diastolic ratio of intra-placental vessels	**1.7**	**2.8**	**0.02**
Resistive index of middle cerebral artery	**0.55**	**3.9**	**<0.005**

Table 3: Placental morphology

Placental morphology	Normal	Mild IUGR	Severe IUGR
Disc-shaped (n = 75)	40	25	10
Thin and Elongated (n = 10)	4	5	1
Globoid (n = 15)	4	7	4

Table 4: Dominant signal intensity in T2 weighed - MRI according to gestational age

Gestational age	Normal	Mild IUGR	Severe IUGR	Predominant signal intensity
<29 weeks (n = 20)	15	3	2	Group 0 (Homogeneous and iso-intense)
29-34 weeks (n = 64)	24	25	15	Group 3 (Heterogeneous with hyper-intense)
>34 weeks (n = 16)	3	8	5	Group 3 (Heterogeneous with hyper-intense)

Table 5: Comparison of MRI parameters in normal versus IUGR foetuses

Parameter	Normal	Mild IUGR	Severe IUGR
Placental T1	67.8	83	107
Placental T2	155	179	180
Amniotic Fluid T2	278	374	320
Fetal Liver T2	73.8	88.9	89.7

Table 6: MRI derived ratios

Ratio	Normal	Mild IUGR	Severe IUGR
AF/PL	2.1	2.31	2.8
LIV/PL	0.41	0.46	0.50
GM/PL	0.89	0.98	3.74
AF/GM	2.13	2.78	2.99
LIV/GM	2.01	0.78	0.22
PL/AF	0.69	0.64	0.61
PL/LIV	2.14	3.54	53
LIV/AF	0.23	0.29	1.2

DISCUSSION

Intrauterine growth restriction (IUGR) is a condition wherein the developing fetus fails to achieve its genetically predetermined growth potential. Each fetus has an inherent growth potential dictated by its genetic composition, but certain fetuses are unable to realize this potential due to maternal or environmental factors. Fetuses with an estimated weight below the 10th percentile are classified as small for gestational age (SGA). However, among these, some are constitutionally small, while others are pathologically growth-restricted, falling into the IUGR category. The identification of IUGR remains problematic, with thresholds varying between less than the 10th, 5th, or 3rd percentiles.

The earliest indication of potential IUGR is typically an estimation of abdominal circumference or fetal weight. IUGR is generally defined as an estimated fetal weight below the 10th percentile, with an asymmetrical head circumference (HC) to abdominal circumference (AC) ratio indicating altered growth dynamics. Once identified, fetuses at increased risk for adverse outcomes must be further evaluated, primarily through imaging modalities. The combination of fetal biometry with Doppler studies of the umbilical and middle cerebral arteries offers the most reliable method for identifying fetuses at risk for adverse outcomes.[8,9]

In normal pregnancies, umbilical artery Doppler indices such as the resistive index (RI), pulsatility index (PI), and systolic/diastolic (S/D) ratio typically decrease with advancing gestational age. However, in IUGR, increased placental resistance leads to elevated RI, PI, and S/D ratios, with absent or reversed end-diastolic flow in the umbilical artery serving as strong predictors of adverse perinatal outcomes. This study found that most of the fetuses with abnormal umbilical artery waveforms, including reversed diastole, had IUGR.

In the study by Gibbins et al,[10] who evaluated the use of MRI to measure placental volume as a predictor of placental insufficiency and associated adverse pregnancy outcomes in a cohort of 316 participants, found that placental volume alone was moderately predictive of complications at later gestational stages, improving the accuracy of risk assessments when combined with clinical variables. These findings suggest MRI placental volume measurement is a promising method for evaluating placental health, especially in late pregnancy.

In response to chronic hypoxia, the fetus redistributes blood flow to vital organs such as the brain, heart, and kidneys, resulting in increased diastolic flow in the MCA owing to its low-resistance. This brain-sparing effect leads to a decreased PI in the MCA, with a cerebro-placental ratio (CPR) of less than 1.08 indicating fetal compromise.11While the MCA PI was moderately significant in predicting adverse outcomes, the CPR was less predictive in this study, aligning with findings from study by Lakkar et al.[12]

Doppler evaluation of intra-placental and retro-placental arteries provided additional insight into placental pathology. In present study, significant differences were noted in the S/D ratio and peak systolic velocity (PSV) of the intra-placental arteries, as well as the RI and PI of the umbilical artery, between normal and IUGR fetuses.

Magnetic resonance imaging (MRI) offers a more detailed assessment of placental morphology and function, particularly in detecting microscopic changes such as maldevelopment of villi or alterations in the placental exchange membranes. MRI can identify changes in placental thickness, volume, and signal intensity, which may correlate with IUGR.[13] In this study, IUGR placentas demonstrated a globular shape with increased thickness and reduced volume, significantly differentiating them from normal placentas.

Hypo-intense areas on MRI, indicative of fibrotic replacement of placental tissue, were associated with IUGR, albeit with mild significance.[14] The signal intensities of T1 and T2-weighted images showed a decline with increasing gestational age, with IUGR placentas exhibiting higher intensity values, reflecting early maturation and increased calcification.

MRI signal intensity ratios, such as the placenta to amniotic fluid (PL/AF) ratio and the fetal liver to gluteus maximus (LIV/GM) ratio, were significantly different between normal and severe IUGR fetuses, suggesting their potential utility in differentiating between growth-restricted and constitutionally small fetuses.

CONCLUSION

Management of IUGR begins with detection, primarily through biometry, with abdominal circumference being the most reliable indicator of fetal size and weight. Absence of growth over a two-week period, as determined by biometry, is indicative of IUGR, necessitating placement in a high-risk surveillance group.

The present study concludes that indicators of fetal mortality and morbidity were significantly associated with maternal health conditions, particularly hypertension and other medical comorbidities, rather than diabetes. Doppler parameters, including umbilical artery EDV, RI, S/D ratio, and retro-placental flow, were predictive of morbidity. MRI parameters such as placental T2 signal intensity, PL/AF ratio, AF/GM ratio, and placental shape were also significant predictors of fetal mortality and morbidity.

Surveillance of high-risk fetuses should be individualized, with primary tools including fetal heart rate analysis, Doppler ultrasound, amniotic fluid assessment, and fetal biophysical profile assessment. Uterine artery Doppler, particularly a mean PI value >1.45 at 18-22 weeks, is useful in screening high-risk pregnancies for IUGR.

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