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Evaluation of the Ultrasound Doppler Parameters of Foetal Vessels in Pregnancies with Suspected Intrauterine Growth Retardation: A Prospective Study

Research Article

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Abstract

Objective: This study investigates fetal hemodynamic changes in Intrauterine Growth Retardation (IUGR), evaluates Doppler changes in fetal arteries, and examines their association with adverse perinatal outcomes.

Materials and Methods: A prospective observational study in tertiary caremedical college &hospital (Nov 2022 - Jun 2023) included 50 IUGR-suspected pregnancies. Criteria included singleton pregnancies over 24 weeks gestation with fetal weight below the 10th percentile. Doppler indices measured were pulsatility index (PI) for the umbilical artery, middle cerebral artery, and thoracic aorta, along with cerebroplacental ratio. Outcomes assessed were gestational age at delivery, cesarean section, birth weight, NICU admissions, and perinatal deaths.

Results: Abnormal PIs were found in 34% (umbilical artery), 38% (middle cerebral artery), and 26% (thoracic aorta) of cases. An abnormal cerebroplacental ratio was observed in 13 cases. There was a significant link between abnormal Doppler findings and increased cesarean sections, NICU admissions, and perinatal deaths, with the highest risks associated with abnormal cerebroplacental ratios and reversed end-diastolic flow in the umbilical artery.

Conclusion: Abnormal Doppler indices in the middle cerebral artery, umbilical artery, and thoracic aorta significantly correlate with adverse perinatal outcomes in IUGR pregnancies. The highest association with adverse outcomes, including perinatal death, is seen with abnormal cerebroplacental ratios. This study highlights the critical role of Doppler ultrasonography in managing IUGR pregnancies, suggesting the need for further large-scale studies.

Keywords: Intrauterine Growth Retardation; Doppler Ultrasonography; Perinatal Outcomes; Cerebroplacental Ratio

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Introduction

Intrauterine Growth Retardation is defined as foetal weight below the10th percentile for gestational age [1]. While often used interchangeably, IUGR and Small for Gestational Age (SGA) are not synonymous. SGA includes a broader spectrum: foetuses with IUGR, constitutionally small but healthy foetuses, and cases misdiagnosed as small [2].Unlike most SGA cases, IUGR foetuses face increased risks of serious conditions such as hypoxemia, acidemia, and intrauterine foetal demise [2].The incidence of IUGR varies from 3-10% of all live births, increasing in specific groups like stillborn infants and women with a history of hypertension or IUGR [1]. IUGR in India is a major cause of low birth weight babies, posing significant challenges to maternal and child health and socio economic conditions [3].The prime target in antenatal care is the early identification of IUGR to prevent adverse outcomes, emphasizing the need for accurate diagnostic methods [4].Since the 1960s, ultrasonography, especially fetal biometry, has been essential in assessing fetal size and growth, surpassing traditional methods [5].Colour Doppler Ultrasound has been pivotal in studying been pivotal in studying foetal hemodynamic, providing insights into uteroplacental insufficiency and fetal acid-base base status [2].Changes in the Doppler flow velocity waveform of the umbilical artery, middle cerebral artery, and thoracic aorta are strong predictors of adverse perinatal outcomes. These include timing of delivery, caesarean sections for fetal distress, NICU admissions, and early complications in newborns like necrotizing enterocolitis and hypoxic-ischemic encephalopathy [4].Clinical Implications: The ability to predict such outcomes underscores the importance of incorporating Doppler ultrasound in routine prenatal screening for IUGR, aiding in timely intervention and management [6].

Aim and Objectives

The research sought to delve into the underlying mechanisms of fetal hemodynamic alterations in Intrauterine Growth Restriction (IUGR), examining Doppler shifts within the fetal arterial network, with a specific focus on the middle cerebral artery, umbilical artery, and thoracic aorta. Additionally, it aimed to uncover potential links between Doppler irregularities and unfavorable perinatal consequences associated with IUGR. Key objectives encompassed the computation of pulsatility index (PI) values across these arterial sites, scrutiny of variations in end-diastolic flow patterns, analysis of perinatal outcomes among participants, and elucidation of potential correlations between Doppler anomalies and adverse perinatal events.

Materials and Methods

The research took place at the Radiology Department of IQ City Medical College & Hospital, spanning from November 2022 to June 2023. The study focused on expectant mothers suspected of Intrauterine Growth Restriction (IUGR), referred by the Department of Gynecology and Obstetrics. Eligible participants met criteria including carrying a single fetus, having a gestational age of at least 24 weeks verified by previous ultrasonography, and exhibiting fetal weight below the 10th percentile or a head circumference to abdominal circumference (HC/AC) ratio exceeding 1.20 as determined by ultrasonography. Instances of significant congenital or chromosomal anomalies in pregnancies were excluded. The study adopted a prospective observational approach within a hospital setting, enrolling a sample of 50 cases chosen via systematic random sampling. Ultrasound assessments utilized the GE Volusion S8 system, incorporating a curved-array transducer (3.5-5.0 MHz), adjustable wall filter settings (50-100 Hz), and sample volume adjustments to encompass vessel diameters adequately. Before participation, each patient provided informed consent after receiving detailed explanations regarding the study's objectives, methodologies, and potential repercussions.

Fetuses included in the research exhibited estimated weights below the 10th percentile corresponding to their gestational age.

Statistical analysis was performed using the "Epi info version 7.1.4.0" software published by WHO. We grouped cases according to abnormal and normal PI and EDF for each vessel and calculated the number of adverse perinatal outcomes (cesarean section, NICU admission, and perinatal death) in each group. The Z test for proportions was used to determine the strength of association between the outcomes and Doppler abnormalities, considering a p-value less than 0.05 as significant.

Results

Throughout our research, which spanned from November 2022 to June 2023 at IQ City Medical College & Hospital, we conducted fetal biometry assessments on approximately 200 fetuses. After meticulous screening, 50 fetuses were deemed eligible for inclusion based on stringent criteria. Noteworthy is that all these selected fetuses exhibited an estimated weight below the 10th percentile for their gestational age. It is intriguing to observe that only 3 (6%) of these fetuses displayed a head circumference to abdominal circumference ratio exceeding 1.2.

We found that 16% of women had preexisting conditions, with 8% of cases involving heart disease. Additionally, 28% had significant medical histories, with 14% reporting a history of spontaneous abortion. Notably, instances of Intrauterine Fetal Death (IUFD) and perinatal death were each noted once. Throughout the study duration, 40% of these women faced at least one pregnancy complication, with oligohydramnios being the most common, affecting 28% of cases.

The gestational age of the fetuses averaged 32.5 weeks during the Doppler ultrasound examination, approximately 3.5 weeks less than the mean clinical age calculated from the Last Menstrual Period (LMP) or earlier ultrasound scans. All fetuses were estimated to weigh below the 10th percentile for their gestational age, with 44% below the 3rd percentile. The mean estimated fetal weight was 1980 grams.

Our Doppler ultrasound study revealed abnormalities in 58% of the fetuses, particularly in the pulsatility index (PI). Abnormal PI values were observed in 19 cases (65% of total abnormalities) in the middle cerebral artery (MCA), 17 cases (58%) in the umbilical artery (UA), and 13 cases (45%) in the thoracic aorta (TA). The cerebroplacental ratio was also found to be abnormal (less than 1) in 13 cases (45% of total abnormalities). Remarkably, 16 cases exhibited abnormalities in more than one vessel, including both MCA and UA, MCA and TA, UA and TA in 4 cases each, and all three vessels in another 4 cases. Isolated abnormalities in MCA, UA, and TA were found in 7, 5, and 1 case(s), respectively.

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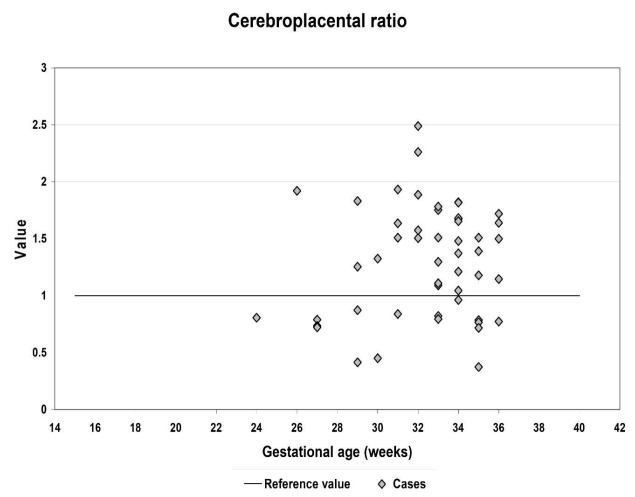

Figure 1: Diagram showing the ratio of MCA PI to UA PI in 50 fetuses examined plotted against gestational age at the time of Doppler examination. Normal reference value is 1 throughout the gestational period. Values less than 1 are abnormal (n = 13).

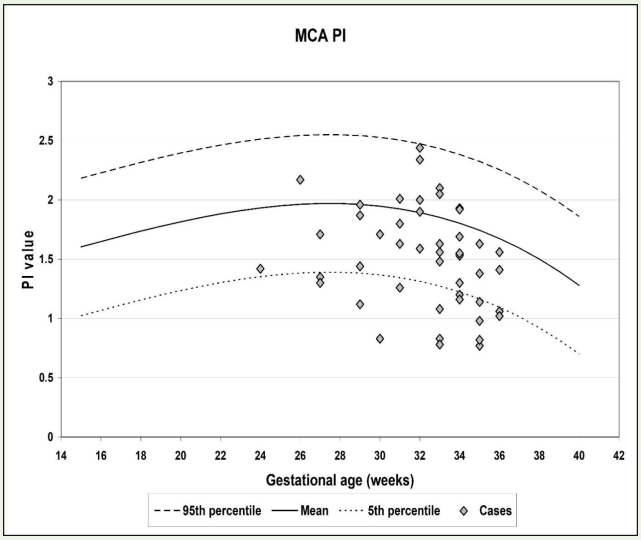

Figure 2: Diagram showing PI values obtained from MCA in 50 fetuses examined plotted against gestational age at the time of Doppler examination. Normal ranges for gestational age are shown as mean, 5th, and 95th percentiles. Values that fell below the 5th percentile are abnormal (n = 19).

Moreover, qualitative changes in the flow velocity waveform were observed in 13 cases (26%), characterized by absent or reversed end-diastolic flow (EDF). These EDF changes were noted in MCA in 4 cases, UA in 7 cases, and TA in 10 cases. In 7 cases, EDF changes were observed in more than one vessel, including both MCA and TA in 3 cases, and both UA and TA in another 3 cases. One case exhibited changes in all three vessels. All cases with EDF changes were associated with abnormal PI values.

The perinatal outcomes of the 50 fetuses examined were meticulously documented. The mean gestational age at delivery for all cases was 34.8 weeks, with an overall mean birth weight of 2271

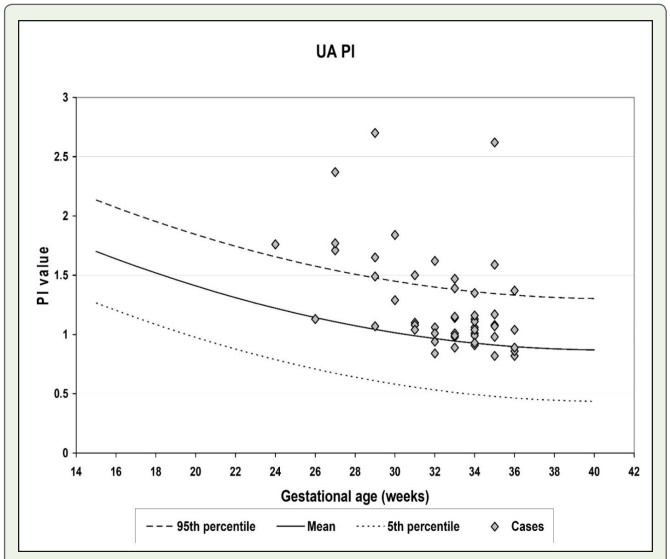

Figure 3: Diagram showing PI values obtained from UA in 50 fetuses examined plotted against gestational age at the time of Doppler examination. Normal ranges for gestational age are shown as mean, 5th, and 95th percentiles. Values that fell above the 95th percentile are abnormal (n = 17).

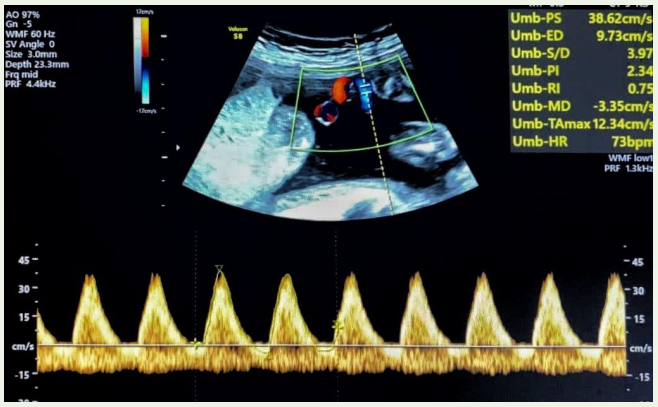

Figure 4: Umbilical artery doppler at 38 weeks of pregnancy shows reversed end-diastolic flow.

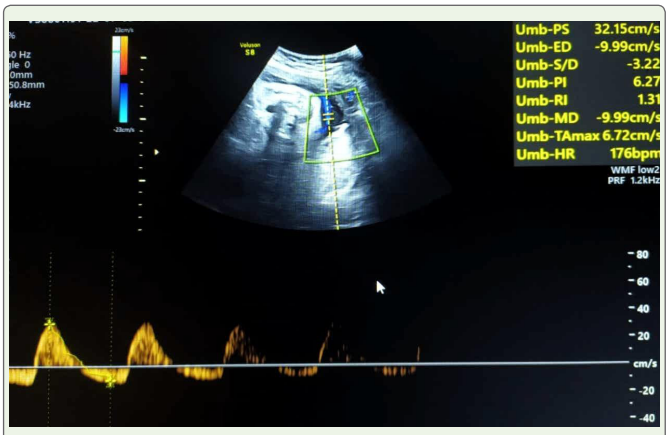

Figure 5: Umbilical artery doppler at 36 weeks of pregnancy shows reversed end-diastolic flow.

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Table 1: End-diastolic flow changes in umbilical artery, middle cerebral artery and thoracic aorta in cases of suspected IUGR

Umbilical artery	
AEDF(Absent end-diastolic flow)	6 (12%)
REDF(Reversed end-diastolic flow)	1 (02%)
Middle cerebral artery	
AEDF	3 (06%)
REDF	2 (04%)
Thoracic aorta	
AEDF	4 (08%)
REDF	5 (10%)
Distribution of changes	
AEDF in UA +TA	3 (06%)
A/REDF in MCA + TA	3 (06%)
A/REDF in MCA + UA +TA	1 (02%)
Only UA	3 (06%)
Only MCA	1 (02%)
Only TA	2 (04%)

AEDF - Absent end-diastolic flow, REDF - Reversed end-diastolic flow, UA – Uterine artery, TA – Thoracic aorta, MCA – Middle cerebral artery

Table 2: Showing the strength of association between the abnormal PI values for each vessel and abnormal cerebroplacental ratio with adverse perinatal outcomes.

		CS (29)	NICU (20)	PD (5)
MCA	Abnormal PI (19)*	14/16 (87%)	10/16 (62%)	4/19 (21%)
	Normal PI (31)	15/30 (50%)	10/30 (33%)	1/31 (3%)
	P value	**p < 0.01**	p < 0.06	**p < 0.04**
UA	Abnormal PI (17)	12/14 (85%)	9/14 (64%)	4/17 (23%)
	Normal PI (33)	17/32 (53%)	11/32 (34%)	1/33 (3%)
	P value	**p < 0.04**	p < 0.06	**p < 0.02**
TA	Abnormal PI (13)	11/12 (91%)	8/12 (66%)	1/13 (8%)
	Normal PI (37)	18/33 (54%)	12/33 (36%)	4/37 (11%)
	P value	**p < 0.02**	p < 0.07	p < 0.76
CPR	CPR < 1 (13)	9/10 (90%)	7/10 (70%)	4/13 (31%)
	CPR > 1 (37)	20/36 (55%)	13/36 (36%)	1/37 (3%)
	P value	**p < 0.04**	**p < 0.05**	**p < 0.01**

* Numbers in parenthesis are number of cases, UA – Uterine artery, TA – Thoracic aorta, MCA – Middle cerebral artery, CPR – Cerebroplacental ratio, CS – Cesarian section, NICU – Neonatal ICU admission, PD – Perinatal Death

grams. Notably, 68% of the babies born weighed less than 2500 grams. The mean gestational age at delivery and mean birth weight were significantly lower in the abnormal PI group (33.8 weeks and 1821 grams, respectively) compared to the normal PI group (35.4 weeks and 2363 grams). There were 4 stillbirths and 46 live births, with 29 cases (63% of liveborn) requiring cesarean sections due to fetal distress. Among the 46 liveborn neonates, 20 (43%) were admitted to the neonatal intensive care unit (NICU), and one neonate succumbed

Table 3: Showing the Odd's ratio and relative risk of adverse perinatal outcome for abnormal PI values for each vessel examined.

		Odd's ratio	Relative risk
MCA	**CS**	7.00 (CI 1.17 - 53.84)	1.75
	NICU	3.33 (CI 0.8 - 14.49)	1.88
	PD	8.0 (CI 0.72 - 205.95)	6.53
UA	**CS**	5.29 (CI 0.88 - 41.84)	1.61
	NICU	3.44 (CI 0.78 - 15.87)	1.87
	PD	9.85 (CI 0.87 - 255.53)	7.76
TA	**CS**	**9.17 (CI 0.99 - 212.12)**	**1.68**
	NICU	3.50 (CI 0.73 - 17.90)	1.83
	PD	0.69 (CI 0.03 - 7.91)	0.71
CPR	**CS**	7.28 (CI 0.77 - 167.93)	1.60
	NICU	**4.13 (CI 0.76 - 24.87)**	**1.94**
	PD	**16.0 (CI 1.36 - 428.19)**	**11.38**

UA – Uterine artery, TA – Thoracic aorta, MCA – Middle cerebral artery, CPR – Cerebroplacental ratio, CS – Cesarian section, NICU – Neonatal ICU admission, PD – Perinatal Death

Table 4: Showing the Odd's ratio and relative risk of adverse perinatal outcome for abnormal EDF changes for each vessel examined

		CS	NICU	PD
MCA	**AEDF**	OR = Undefined RR = 1.71	OR = 0.71 RR = 0.80	
	REDF	OR = Undefined RR = 1.71	OR = Undefined RR = 2.41	
UA	**AEDF**	**OR = 3.04** **RR = 1.41**	OR = 0.96 RR = 0.98	**OR = 10.75** RR = 7.50
	REDF			OR = Undefined **RR = 22.50**
TA	**AEDF**	OR = Undefined RR = 1.90	OR = 1.53 RR = 1.27	OR = 4.11 RR = 3.33
	REDF	OR = Undefined RR = 1.90	**OR = 2.30** **RR = 1.52**	OR = 2.47 RR = 2.22

UA – Uterine artery, TA – Thoracic aorta, MCA – Middle cerebral artery, CPR – Cerebroplacental ratio, CS – Cesarian section, NICU – Neonatal ICU admission, PD – Perinatal Death, AEDF - Absent end-diastolic flow, REDF - Reversed end-diastolic flow

during the neonatal period. The total number of cases exhibiting at least one adverse perinatal outcome was 34. Among the cesarean deliveries, 17 neonates also required NICU admission.

Our findings revealed significant associations between abnormal MCA PI and cesarean section for fetal distress ($p < 0.01$) and perinatal death ($p < 0.04$). Similarly, abnormal UA PI was linked to cesarean section ($p < 0.04$) and perinatal death ($p < 0.02$). Abnormal TA PI was significantly associated with cesarean section for fetal distress ($p < 0.02$). Additionally, an abnormal cerebroplacental ratio (less than 1) was correlated with cesarean section for fetal distress ($p < 0.04$), NICU admission ($p < 0.05$), and perinatal death ($p < 0.01$).

Odds ratios (OR) and Relative Risks (RR) were calculated for each abnormal PI, indicating that abnormal PI in all vessels identified women at increased risk of adverse perinatal outcomes. The highest risk of cesarean section for fetal distress was associated with abnormal TA PI (OR = 9.17; RR = 1.68), followed by an abnormal cerebroplacental ratio (OR = 7.28; RR = 1.60). The highest risk of NICU admission was linked to an abnormal cerebroplacental ratio (OR = 4.13; RR = 1.94), followed by an abnormal TA PI (OR = 3.50; RR = 1.83). The greatest risk of perinatal death was observed with an

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abnormal cerebroplacental ratio (OR = 16.0; RR = 11.38), followed by an abnormal UA PI (OR = 9.85; RR = 7.76).

Discussion

Our study's results are consistent with or exceed the findings of similar studies in the field, such as those conducted by Baschat et al [2], Figueras et al [7], Cruz-Martinez et al [8], Khalil et al [9], and Turan et al [10], in terms of odds ratio (OR) and sensitivity values for cerebroplacental ratio (CPR) and umbilical artery pulsatility index (UA PI). These comparisons highlight the reliability and validity of our results in the context of established research.

For instance, in the studies by Baschat et al [2] and Figueras et al [7], the OR for perinatal death associated with CPR was 10.8 and 8.9, respectively, with sensitivity values of 82% and 80%. In contrast, our study demonstrated a higher OR of 16.0 for CPR, with a remarkable sensitivity of 90%, indicating a stronger predictive value for adverse perinatal outcomes.

Similarly, when comparing UA PI, our study's OR of 9.85 and sensitivity of 86.6% are either comparable or superior to those reported in the aforementioned studies. For example, Khalil et al [9] reported an OR of 3.8 and a sensitivity of 63% for UA PI, which are lower than our findings. This suggests that our study's parameters, particularly CPR and UA PI, are effective indicators of potential adverse perinatal outcomes.

Notably, our study also observed significant associations with thoracic aorta pulsatility index (TA PI) and end-diastolic flow (EDF) changes, further enhancing the comprehensive understanding of Doppler parameters in the assessment of fetuses at risk of adverse outcomes.

However, it is important to acknowledge the limitations of our study. These include a relatively small sample size, which may affect the generalizability of the results. Additionally, the lack of ductus venosus pulsatility index (DV PI) measurement and the absence of long-term follow-up data on neonates limit the scope of our findings. Future research with larger sample sizes, inclusion of DV PI measurements, and extended follow-up periods would be valuable in validating and expanding upon our results.

Ethical Approval

The study followed the ethical principles of the Declaration of Helsinki and received approval from the IQ City Medical College & Hospital's Institutional Ethics Committee. All participants gave their informed consent after learning about the study's aims, procedures, and possible hazards. The study guaranteed confidentiality to the participants and let them know that they could quit the study anytime without compromising their medical treatment. The study protected participant privacy by anonymizing all data.

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