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ROLE OF COLOUR DOPPLER IN IUGR CASES FORPREDICTION OF ADVERSE PERINATAL OUTCOME

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ABSTRACT:

Introduction: Intrauterine growth restriction (IUGR) is associated with significant perinatal morbidity and mortality. Colour Doppler velocimetry of fetal and uteroplacental circulation provides a non-invasive method to assess fetal hemodynamic compromise and predict adverse neonatal outcomes. **Aims:** To study the role of colour Doppler (MCA and uterine artery indices& umbilical artery) in predicting adverse perinatal outcomes in IUGR pregnancies. **Materials and Methods:** This prospective observational study was conducted in the Department of Radiodiagnosis at Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Ambala, from October 2024 to November 2025 after institutional ethical approval. A total of 100 antenatal women diagnosed with intrauterine growth restriction (IUGR) were included. All participants underwent colour Doppler evaluation of the middle cerebral artery (MCA) uterine artery (UtA)& umbilical artery. Doppler indices including pulsatility index (PI), resistive index (RI), and systolic/diastolic (S/D) ratio were recorded. Neonatal outcomes were documented after delivery. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were calculated for analysis. **Result:** MCA-PI showed highest accuracy for predicting NICU admission (74%). MCA S/D ratio demonstrated superior accuracy for sepsis (74%) and polycythaemia (80%). UtA-PI showed moderate predictive value for polycythaemia (72%) and hyperbilirubinemia (73%). However, Doppler indices showed limited sensitivity for hypoglycemia and hyperbilirubinemia. Overall, MCA S/D ratio and UtA-PI were the most reliable parameters for predicting selected adverse perinatal outcomes in IUGR cases. **Conclusion:** Colour Doppler velocimetry plays a valuable role in the surveillance of IUGR pregnancies by aiding in the prediction of adverse perinatal outcomes. Among the studied parameters, the MCA S/D ratio and UtA-PI demonstrated better diagnostic performance for selected neonatal complications, particularly sepsis and

polycythaemia. However, the predictive value of Doppler indices for certain metabolic complications such as hypoglycemia and hyperbilirubinemia was limited. Therefore, while colour Doppler serves as an important non-invasive tool in risk stratification and timely intervention, it should be used in conjunction with clinical and other fetal surveillance methods for optimal perinatal outcome prediction.

INTRODUCTION:

Intrauterine growth restriction (IUGR) is a significant complication of pregnancy with profound implications for perinatal morbidity and mortality. It is characterized by the failure of the fetus to achieve its genetically determined growth potential, most commonly diagnosed when estimated fetal weight is below the 10th percentile for gestational age [1,2]. IUGR is a common clinical challenge, affecting 3–10% of pregnancies worldwide [3]. Each year, nearly 30 million infants are born with growth restriction, and the burden is particularly high in developing countries, where the incidence ranges from 6% to 30% compared to 4–8% in developed nations [4]. In India, the prevalence of IUGR is strikingly higher, ranging from 9.65% among hospital-born infants to 25–30% in community-based studies. These figures highlight the urgent need for effective antenatal screening tools to detect IUGR early and intervene appropriately.

The implications of IUGR are multifaceted, with consequences extending from the perinatal to long-term adult life. In the neonatal period, IUGR is strongly associated with stillbirth, respiratory distress syndrome, hypoglycemia, hypothermia, perinatal asphyxia, and neonatal sepsis [5]. The perinatal mortality rates in growth-restricted neonates are reported to be 6–10 times higher than those of normally grown neonates. Beyond this, IUGR infants have an increased risk of neurodevelopmental delay, impaired intellectual performance, and a predisposition to chronic diseases in adulthood, including hypertension, type 2 diabetes, ischemic heart disease, and obesity [6]. This phenomenon aligns with the Barker hypothesis, which links restricted fetal growth to adverse adult health outcomes.

The etiology of IUGR is multifactorial, involving maternal, placental, and fetal factors. Maternal factors include chronic illnesses such as hypertension, renal disease, and diabetes, as well as nutritional deficiency, anemia, smoking, and poor weight gain during pregnancy [5,7]. Placental insufficiency, preeclampsia, and structural uterine anomalies represent important uteroplacental causes [8].

MATERIALS AND METHODS:

Study Setting: The present study was carried out in the Department of Radiodiagnosis Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Ambala.
Study Design: This study was done as a prospective observational study.
Study Period: The study was started after approval from the institutional scientific and ethical committee approval. The study was completed in the period from October 2024 to November 2025. This period included time for data collection, compilation analysis and write up of the thesis.
Study Population: The study population included the pregnant women (28-41weeks gestation) attending the department of Radio diagnosis for foetal sonography, referred by Department of Obstetrics and Gynaecology at Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Ambala.
Study Variables: The study variables were categorized into independent, dependent, and baseline (demographic) variables. The independent or predictor variables included Doppler indices such as umbilical artery pulsatility index (PI), resistive index (RI), and systolic/diastolic (S/D) ratio, along with uterine artery pulsatility index (UtA-PI), uterine artery resistive index (UtA-RI), and uterine artery systolic/diastolic (S/D) ratio. Additionally, Doppler status, classified as normal or abnormal, was also considered an important predictor variable.

The dependent or outcome variables comprised neonatal outcomes, including neonatal intensive care unit (NICU) admission, respiratory distress syndrome (RDS), neonatal sepsis, hypoglycemia, polycythaemia, hyperbilirubinemia, and neonatal death.

Baseline or demographic variables included maternal age, gravida status, and gestational age as determined by the last menstrual period (LMP).
Sample Size: A total of 100 antenatal women diagnosed with intrauterine growth restriction (IUGR) were included

Inclusion criteria:

1. Females with singleton pregnancy & suspected IUGR.
2. The GA of patient is between 28 to 41 weeks confirmed with known Last menstrual period (LMP).

Exclusion criteria:

1. Documented major congenital anomaly.
2. Multiple gestation.

Statistical Analysis:

Data were entered and analyzed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation, and categorical variables as frequencies and percentages. The prevalence of refractive errors was calculated, and associations with screen time and other risk factors were assessed using chi-square tests for categorical variables and independent t-tests or ANOVA for continuous variables. Correlation between screen time and severity of refractive errors was evaluated using Pearson's correlation coefficient. A p-value <0.05 was considered statistically significant.

RESULT:

Table 1: Age distribution of study subjects

Age group (years)	N	Percentage
20-24 years	31	31
25-29 years	56	56
30-34 years	4	4
35-39 years	9	9
Total	100	100
Mean ± SD	26.69 ± 3.78 years	

Table 2: Association of MCA Doppler Parameters with NICU Admission, RDS and Sepsis

Doppler Parameter	Outcome	Abnormal (Yes)	Abnormal (No)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
MCA-PI	NICU Admission	61	0	70.11	100	100	33.33	74
	RDS	27	34	56.25	34.62	44.26	46.15	45
	Sepsis	15	46	62.5	39.47	24.59	76.92	45
MCA-RI	NICU Admission	29	0	33.33	100	100	18.31	42
	RDS	17	12	35.42	76.92	58.62	56.34	57
	Sepsis	8	21	33.33	72.37	27.59	77.46	63
MCA S/D Ratio	NICU Admission	18	0	20.69	100	100	15.85	31
	RDS	14	4	29.17	92.31	77.78	58.54	62
	Sepsis	8	10	33.3	86.84	44.44	80.49	74

Table 3: Association of MCA Doppler Parameters with Metabolic Neonatal Complications

Doppler Parameter	Outcome	Abnormal (Yes)	Abnormal (No)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
MCA-PI	Hypoglycemia	10	51	71.43	40.7	16.39	89.74	45
	Polycythaemia	13	48	72.22	41.46	21.31	87.18	47
	Hyperbilirubinemia	6	55	54.55	38.2	9.84	87.18	40
MCA-RI	Hypoglycemia	2	27	14.29	68.6	6.9	83.1	61
	Polycythaemia	8	21	44.44	74.39	27.59	85.92	69
	Hyperbilirubinemia	0	29	0	67.42	0	84.51	60
MCA S/D Ratio	Hypoglycemia	0	18	0	79.07	0	82.3	68
	Polycythaemia	8	10	44.44	87.8	44.44	87.8	80
	Hyperbilirubinemia	0	18	0	79.78	0	86.59	71

Table 4: Umbilical and Uterine Artery Doppler Findings in IUGR

Doppler Parameter	Normal (n, %)	Abnormal (n, %)	Adverse Outcome Present (n, %)	Adverse Outcome Absent (n, %)	p-value
Umbilical Artery PI	58 (58.0%)	42 (42.0%)	30 (71.4%)	12 (28.6%)	**<0.001**
Umbilical Artery RI	60 (60.0%)	40 (40.0%)	28 (70.0%)	12 (30.0%)	**<0.001**
Umbilical Artery S/D Ratio	55 (55.0%)	45 (45.0%)	33 (73.3%)	12 (26.7%)	**<0.001**
Uterine Artery PI	62 (62.0%)	38 (38.0%)	25 (65.8%)	13 (34.2%)	**0.002**
Uterine Artery RI	65 (65.0%)	35 (35.0%)	22 (62.9%)	13 (37.1%)	**0.004**
Uterine Artery S/D Ratio	63 (63.0%)	37 (37.0%)	24 (64.9%)	13 (35.1%)	**0.003**

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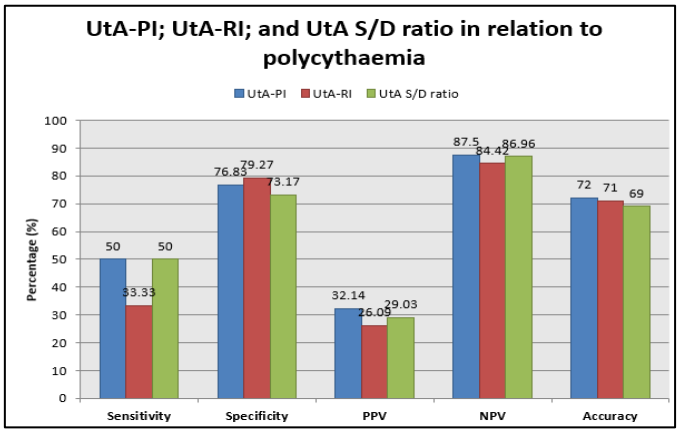

Figure 1: UtA-PI; UtA-RI; and UtA S/D ratio in relation to polycythaemia

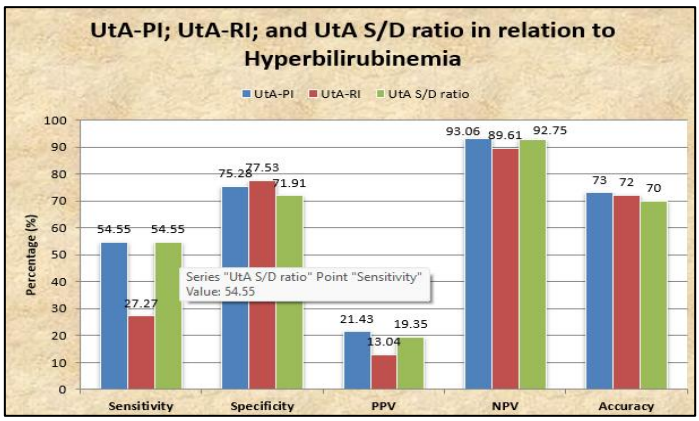

Figure 2: UtA-PI; UtA-RI; and UtA S/D ratio in relation to Hyperbilirubinemia

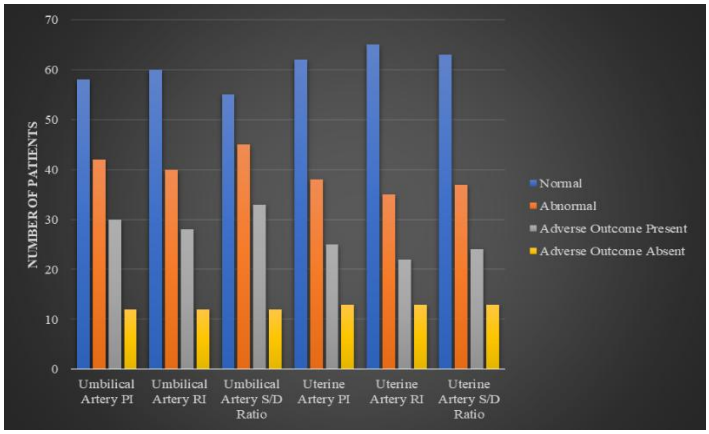

Figure 3: Umbilical and Uterine Artery Doppler Findings in IUGR

In this study, a total of 100 antenatal women with intrauterine growth restriction were evaluated. The majority of the participants (56%) belonged to the 25–29 years age group, followed by 31% in the 20–24 years category. A smaller proportion were older, with 9% in the 35–39 years group and only 4% in the 30–34 years group. The mean age of the study population was 26.69 ± 3.78 years.

In the present study, MCA-PI demonstrated the highest sensitivity (70.11%) and perfect specificity (100%) for predicting NICU admission, with an overall accuracy of 74%. MCA-RI and MCA S/D ratio also showed 100% specificity; however, their sensitivities were considerably lower (33.33% and 20.69%, respectively), resulting in reduced overall accuracies (42% and 31%). These findings suggest that MCA-PI was the most reliable MCA

parameter for predicting NICU admission among IUGR cases.

With respect to respiratory distress syndrome (RDS), MCA-PI showed moderate sensitivity (56.25%) but low specificity (34.62%), resulting in modest diagnostic accuracy (45%). MCA-RI demonstrated improved specificity (76.92%) and higher accuracy (57%). The best predictive performance was observed with the MCA S/D ratio, which showed high specificity (92.31%) and an overall accuracy of 62%, although sensitivity remained low (29.17%). This indicates that an abnormal MCA S/D ratio is more useful in confirming rather than screening for RDS.

For neonatal sepsis, MCA-PI showed relatively higher sensitivity (62.5%) but low specificity (39.47%), with an overall accuracy of 45%. MCA-RI demonstrated better specificity (72.37%) and improved accuracy (63%). The highest diagnostic performance was observed with the MCA S/D ratio, which showed high specificity (86.84%), good negative predictive value (80.49%), and the highest overall accuracy (74%). These findings suggest that among MCA parameters, the S/D ratio was the most reliable indicator for predicting neonatal sepsis.

Regarding hypoglycemia, MCA-PI demonstrated high sensitivity (71.43%) but low specificity (40.7%), with an overall accuracy of 45%, indicating a high rate of false-positive results. MCA-RI showed low sensitivity (14.29%) but better specificity (68.6%) and an accuracy of 61%. The MCA S/D ratio showed no sensitivity (0%) but relatively higher specificity (79.07%) and accuracy (68%). Overall, none of the MCA Doppler indices showed strong predictive value for neonatal hypoglycemia.

In predicting polycythaemia, MCA-PI showed high sensitivity (72.22%) but low specificity (41.46%), resulting in an accuracy of 47%. MCA-RI demonstrated a better balance between sensitivity (44.44%) and specificity (74.39%), with improved accuracy (69%). The highest diagnostic utility was observed with the MCA S/D ratio, which showed high specificity (87.8%) and the highest overall accuracy (80%). This suggests that the MCA S/D ratio is a useful parameter for predicting polycythaemia in IUGR neonates.

For hyperbilirubinemia, MCA-PI demonstrated moderate sensitivity (54.55%) but low specificity (38.2%), with a low overall accuracy (40%). Both MCA-RI and MCA S/D ratio showed zero sensitivity, indicating inability to detect affected cases, although their specificities were relatively higher (67.42% and 79.78%, respectively). Despite moderate overall accuracies (60% and 71%), the absence of sensitivity limits their clinical usefulness. Overall, MCA Doppler parameters were not reliable predictors of neonatal hyperbilirubinemia.

UtA-PI demonstrated moderate sensitivity (50%) and good specificity (76.83%), with an overall accuracy of 72%, indicating reasonable predictive value. UtA-RI showed lower sensitivity (33.33%) but slightly higher specificity (79.27%), resulting in an accuracy of 71%. The UtA S/D ratio demonstrated similar sensitivity (50%) with specificity of 73.17% and an accuracy of 69%. Overall, uterine artery Doppler parameters showed moderate diagnostic performance in predicting neonatal polycythaemia.

For predicting hyperbilirubinemia, UtA-PI demonstrated moderate sensitivity (54.55%) and good specificity (75.28%), with the highest overall accuracy (73%) among the three parameters. UtA-RI showed lower sensitivity (27.27%) but comparable specificity (77.53%), resulting in an accuracy of 72%. The UtA S/D ratio showed similar sensitivity (54.55%) and slightly lower specificity (71.91%), with an accuracy of 70%. Although uterine artery Doppler indices showed moderate diagnostic accuracy, their relatively low positive predictive values suggest limited ability to precisely identify affected neonates.

In the present prospective observational study comprising 100 antenatal women diagnosed with intrauterine growth restriction (IUGR), Doppler evaluation of both umbilical and uterine arteries showed significant association with adverse perinatal outcomes. Abnormal umbilical artery indices were observed in 40–45% of cases, with a markedly higher proportion of adverse outcomes among these patients. Specifically, abnormal umbilical artery pulsatility index (PI), resistive index (RI), and systolic/diastolic (S/D) ratio were associated with adverse outcomes in 71.4%, 70.0%, and 73.3% of cases respectively, all demonstrating strong statistical significance ($p < 0.001$).

Similarly, uterine artery Doppler abnormalities were noted in 35–38% of cases and were also significantly

correlated with adverse perinatal outcomes. Abnormal uterine artery PI, RI, and S/D ratio showed adverse outcomes in 65.8%, 62.9%, and 64.9% of cases respectively, with statistically significant p-values (p = 0.002, 0.004, and 0.003 respectively).

DISCUSSION:

The present prospective study conducted on 100 antenatal women with clinically diagnosed intrauterine growth restriction (IUGR) highlights the significant role of colour Doppler velocimetry in predicting adverse perinatal outcomes. The high incidence of neonatal complications observed—87% NICU admission, 48% respiratory distress syndrome (RDS), 24% neonatal sepsis, and 11% neonatal mortality—reflects the severity of placental insufficiency in the study population. These findings emphasize the importance of timely antenatal surveillance and reinforce the clinical utility of Doppler assessment in guiding management decisions in IUGR pregnancies.

The demographic profile revealed that most women belonged to the 25–29-year age group, with a mean age of 26.69 ± 3.78 years, and 52% were primigravidae. Similar observations were reported by Hiral Parekh et al. [3], who noted that high-risk pregnancies are frequently encountered among younger reproductive-age women. A considerable proportion of cases were between 28 and 32 weeks of gestation, indicating a substantial burden of early-onset IUGR, which is typically associated with severe placental pathology and poorer neonatal outcomes.

Uterine artery (UtA) Doppler evaluation demonstrated a persistent early diastolic notch in 29% of cases, reflecting impaired trophoblastic invasion and elevated uteroplacental resistance. Som Biswas and Srirupa Biswas [9] similarly emphasized the value of UtA Doppler in identifying pregnancies at risk of placental insufficiency. However, in the present study, UtA indices showed limited sensitivity for predicting immediate neonatal outcomes such as NICU admission and neonatal morbidities.

Umbilical artery (UA) Doppler demonstrated a stronger association with adverse outcomes. Although UA-PI showed high specificity (100%) for NICU admission, its sensitivity was low (24.14%), indicating that not all compromised fetuses exhibited abnormal UA-PI prenatally. Similar findings were reported by Fong et al. [10], who observed that abnormal UA Doppler, particularly absent or reversed end-diastolic flow, is highly specific for severe neonatal compromise but may not detect all at-risk fetuses.

Notably, the UA S/D ratio emerged as one of the strongest predictors in the present study, demonstrating 81% accuracy for neonatal mortality and 83% for neonatal sepsis. These outcomes reflect severe chronic hypoxia resulting from increased placental resistance. Baschat et al. [11] previously reported a strong association between abnormal UA flow and perinatal death. Similarly, Pradip Gaikwad et al. [2] demonstrated that abnormal UA Doppler indices significantly predict adverse neonatal outcomes. The high predictive accuracy of UA S/D ratio in the present study reinforces its clinical importance in risk stratification of IUGR fetuses.

Middle cerebral artery (MCA) Doppler assessment revealed valuable insights into fetal compensatory mechanisms. Reduced MCA-PI and RI reflect cerebral vasodilation secondary to hypoxia, known as the "brain-sparing effect." In this study, MCA-PI showed the highest predictive value for NICU admission, with 70.11% sensitivity and 74% accuracy. These findings are comparable to those of Som Biswas and Srirupa Biswas [9], who reported MCA-PI as a sensitive indicator of IUGR between 31 and 36 weeks.

The MCA S/D ratio demonstrated strong predictive accuracy for neonatal mortality (81%) and sepsis (74%). Sterne et al. [12] documented similar associations between altered cerebral Doppler ratios and fetal distress.

Although the cerebroplacental ratio (CPR) was not calculated in this study, extensive literature supports its superior predictive value. Gramellini et al. [13] demonstrated that CPR differentiates physiological smallness from pathological IUGR more effectively than individual vessel indices.

The neonatal outcome pattern observed aligns closely with previously published research. Sharbaf et al. [14] reported increased NICU admissions and perinatal mortality in IUGR cases with abnormal Doppler findings. The strong association between UA and MCA abnormalities and adverse neonatal events in the present study further validates Doppler velocimetry as a reliable prognostic tool.

The major strengths of this study include prospective design, adequate sample size, and systematic multivessel Doppler assessment. However, limitations include the absence of CPR and ductus venosus Doppler evaluation, lack of long-term neurodevelopmental follow-up, and single-center design, which may limit generalizability.

In the present prospective observational study involving 100 antenatal women diagnosed with intrauterine growth restriction (IUGR), Doppler assessment of both umbilical and uterine arteries demonstrated a statistically significant association with adverse perinatal outcomes. The findings highlight the pivotal role of fetoplacental and uteroplacental circulation in predicting fetal compromise.

The present study showed that abnormal umbilical artery pulsatility index (PI) was associated with adverse perinatal outcomes in 71.4% of cases ($p < 0.001$). This finding is consistent with the study by Gramellini D et al. [15], who demonstrated that elevated umbilical artery PI is a strong predictor of fetal hypoxia and adverse neonatal outcomes, particularly in growth-restricted fetuses. Similarly, Alfirevic Z et al. [16] reported that abnormal umbilical artery Doppler waveforms significantly correlate with increased perinatal morbidity and mortality, reinforcing the importance of PI as a sensitive indicator of placental insufficiency.

In the current study, abnormal umbilical artery resistive index (RI) was associated with adverse outcomes in 70.0% of cases ($p < 0.001$). This observation aligns with findings by Battaglia FC and Lubchenco LO [17], who noted that increased vascular resistance in the umbilical circulation reflects downstream placental pathology, contributing to compromised fetal oxygenation. Comparable results were also reported by Fleischer A et al. [18], where elevated RI values were significantly associated with poor perinatal outcomes.

Furthermore, abnormal umbilical artery systolic/diastolic (S/D) ratio in this study was associated with adverse outcomes in 73.3% of cases ($p < 0.001$), making it one of the strongest predictors among the Doppler parameters evaluated. This is in agreement with Trudinger BJ et al. [19], who first demonstrated that increased S/D ratio and absent/reversed end-diastolic flow are critical indicators of severe placental insufficiency and impending fetal compromise.

In the present study, abnormal uterine artery PI was associated with adverse perinatal outcomes in 65.8% of cases ($p = 0.002$). This is comparable to findings by Gómez O et al. [20], who reported that elevated uterine artery PI reflects impaired trophoblastic invasion and increased uteroplacental resistance, thereby contributing to fetal growth restriction and adverse outcomes. Similarly, Papageorghiou AT et al. [21] emphasized that uterine artery Doppler abnormalities are useful in early prediction of placental insufficiency and IUGR.

Abnormal uterine artery RI in this study showed adverse outcomes in 62.9% of cases ($p = 0.004$). These findings are in concordance with Cnossen JS et al. [22], who, in a systematic review, concluded that elevated uterine artery resistance indices are significantly associated with poor perinatal outcomes, although their predictive accuracy is lower compared to umbilical artery Doppler indices.

Similarly, abnormal uterine artery S/D ratio was associated with adverse outcomes in 64.9% of cases ($p = 0.003$) in the present study. This is consistent with the study by Bower S et al. [23], who demonstrated that abnormal uterine artery flow velocity waveforms, including elevated S/D ratios, are indicative of increased placental resistance and are associated with adverse fetal outcomes.

Overall, the present study demonstrated that umbilical artery Doppler indices (PI, RI, S/D ratio) had a stronger association with adverse perinatal outcomes compared to uterine artery indices. This observation is supported by Baschat AA [24], who emphasized that while uterine artery Doppler reflects maternal placental perfusion, umbilical artery Doppler directly represents fetoplacental circulation and is therefore a more reliable predictor of fetal compromise.

In summary, the present study underscores the pivotal role of Doppler velocimetry in evaluating IUGR pregnancies. The UA S/D ratio demonstrated the strongest predictive value for neonatal mortality and sepsis, while MCA-PI was the best predictor of NICU admission. MCA S/D ratio also showed significant predictive capability. UtA Doppler, though indicative of placental insufficiency, had limited sensitivity for acute neonatal outcomes. These findings support a multivessel Doppler approach for optimal fetal surveillance, consistent with international recommendations advocating combined Doppler indices for improved perinatal risk prediction.

Early identification of fetal compromise through Doppler assessment allows timely intervention and may significantly improve neonatal outcomes in IUGR pregnancies.

CONCLUSION:

The present study demonstrates that colour Doppler velocimetry plays a significant role in predicting adverse perinatal outcomes in intrauterine growth restriction (IUGR). Among the evaluated parameters, the umbilical artery S/D ratio showed the strongest association with neonatal mortality and sepsis, while middle cerebral artery PI was most useful in predicting NICU admission. MCA S/D ratio also demonstrated good predictive performance for several complications. Uterine artery Doppler, although helpful in identifying placental insufficiency, had limited accuracy for acute neonatal outcomes. Overall, a multivessel Doppler approach improves risk stratification and aids in timely intervention to optimize neonatal outcomes in IUGR pregnancies.Abnormal Doppler indices of the umbilical and uterine arteries showed a significant association with adverse perinatal outcomes in IUGR pregnancies. Umbilical artery Doppler parameters demonstrated superior predictive value, emphasizing their crucial role in fetal surveillance and timely obstetric intervention.

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