



ROLE OF DOPPLER ULTRASONOGRAPHY IN PREDICTING ADVERSE FETOMATERNAL OUTCOMES IN HIGH-RISK PREGNANCIES: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: High-risk pregnancies are associated with increased maternal and perinatal morbidity and mortality, primarily due to impaired uteroplacental circulation. Doppler ultrasonography is a non-invasive modality used to assess fetal and placental hemodynamics and predict adverse outcomes.

Objectives: To evaluate the role of Doppler ultrasonography in predicting adverse fetomaternal outcomes in high-risk pregnancies and to determine the diagnostic accuracy of various Doppler indices.

Methods: This prospective observational study was conducted at Vedanta Institute of Medical Sciences, Dahanu, Maharashtra, from January 2025 to October 2025. A total of 53 pregnant women with high-risk pregnancies (≥ 28 weeks gestation) were included. Doppler assessment of the umbilical artery (UA), middle cerebral artery (MCA), uterine artery (UtA), and cerebroplacental ratio (CPR) was performed. Participants were followed until delivery, and maternal and neonatal outcomes were recorded. Statistical analysis was performed using SPSS, and diagnostic accuracy was assessed using sensitivity, specificity, and ROC curve analysis.

Results: Adverse fetomaternal outcomes were observed in a substantial proportion of cases. Abnormal Doppler indices were significantly associated with poor outcomes. CPR showed the highest predictive accuracy with an AUC of 0.79 (95% CI: 0.66–0.91; $p < 0.001$), followed by UA Doppler (AUC: 0.73), MCA Doppler (AUC: 0.71), and UtA Doppler (AUC: 0.68). CPR demonstrated higher sensitivity, while UA Doppler showed higher specificity. Neonatal complications such as low birth weight, preterm delivery, and NICU admission were more frequent in cases with abnormal Doppler findings.

Conclusion: Doppler ultrasonography, particularly CPR, is an effective tool for predicting adverse fetomaternal outcomes in high-risk pregnancies. Its routine use can aid in early detection of fetal compromise and guide timely clinical interventions.

Keywords: Doppler ultrasonography; high-risk pregnancy; cerebroplacental ratio; umbilical artery; middle cerebral artery; fetal outcome.

INTRODUCTION

High-risk pregnancies contribute significantly to maternal and perinatal morbidity and mortality worldwide, particularly in developing countries like India. Conditions such as pregnancy-induced hypertension (PIH), intrauterine growth restriction (IUGR), gestational diabetes mellitus (GDM), anemia, and previous adverse obstetric history are known to compromise uteroplacental circulation, leading to adverse fetomaternal outcomes. Early identification and timely intervention in such pregnancies are crucial to improving neonatal survival and reducing complications [1].

Placental insufficiency is a key underlying mechanism in many high-risk pregnancies, characterized by impaired uteroplacental blood flow and inadequate fetal oxygenation and nutrient supply. This condition can result in fetal hypoxia,

growth restriction, preterm birth, and even intrauterine fetal demise. Therefore, reliable and non-invasive methods for assessing fetal well-being and placental function are essential in obstetric practice [2].

Doppler ultrasonography has emerged as a valuable, non-invasive, and widely accessible imaging modality for evaluating fetal and maternal circulation. It enables real-time assessment of blood flow in various vessels, including the umbilical artery (UA), middle cerebral artery (MCA), and uterine artery (UtA), thereby providing insights into fetoplacental and uteroplacental hemodynamics [3]. The pulsatility index (PI), resistance index (RI), and systolic/diastolic (S/D) ratio derived from Doppler waveforms are commonly used parameters to assess vascular resistance and fetal adaptation [3].

Among these, umbilical artery Doppler plays a crucial role in assessing placental resistance. Abnormal findings such as increased PI or absent/reversed end-diastolic flow are strongly associated with placental insufficiency and adverse perinatal outcomes, including low birth weight, preterm delivery, and increased perinatal mortality [4]. Studies have demonstrated that abnormal umbilical artery Doppler indices are reliable predictors of fetal compromise and are associated with increased need for neonatal intensive care unit (NICU) admission [5].

The middle cerebral artery Doppler is equally important in evaluating fetal adaptive mechanisms to hypoxia. In response to decreased oxygen supply, the fetus redistributes blood flow to vital organs, particularly the brain—a phenomenon known as the “brain-sparing effect.” This is reflected as a decrease in MCA pulsatility index, indicating cerebral vasodilation [4]. MCA Doppler has been shown to be an effective tool in detecting fetal hypoxia and anemia, thereby aiding in early intervention [6].

The cerebroplacental ratio (CPR), which combines MCA and UA Doppler indices, has gained increasing attention as a superior predictor of adverse perinatal outcomes. A reduced CPR indicates an imbalance between placental resistance and fetal cerebral adaptation and has been associated with poor neonatal outcomes, including low Apgar scores and NICU admissions [7]. Additionally, uterine artery Doppler assessment in early pregnancy has been shown to predict the development of preeclampsia and fetal growth restriction, further emphasizing the role of Doppler in antenatal surveillance [8].

Several studies and systematic reviews have highlighted the clinical utility of Doppler ultrasonography in high-risk pregnancies. Routine use of Doppler has been associated with improved detection of fetal compromise and a reduction in perinatal mortality [2]. Moreover, Doppler studies have demonstrated higher sensitivity and diagnostic accuracy compared to conventional fetal surveillance methods such as non-stress tests, particularly in predicting adverse outcomes in high-risk pregnancies [9].

Despite the growing body of evidence supporting the use of Doppler ultrasonography, there remains a need for region-specific prospective studies to evaluate its predictive accuracy in diverse populations. Variations in maternal characteristics, healthcare accessibility, and disease burden necessitate localized research to guide clinical decision-making effectively. Therefore, the present study aims to assess the role of Doppler ultrasonography in predicting adverse fetomaternal outcomes in high-risk pregnancies at a tertiary care center in Maharashtra, India.

METHODOLOGY

Study Design and Setting: This was a prospective observational study conducted in the Department of Obstetrics and Gynecology and Radio-diagnosis at Vedanta Institute of Medical Sciences, Dahanu, Maharashtra, India, a tertiary care teaching hospital.

Study Duration: The study was carried out over a period of 10 months, from January 2025 to October 2025.

Study Population: The study included pregnant women diagnosed with high-risk pregnancies attending the antenatal outpatient department or admitted to the obstetrics ward.

Sample Size: A total of 53 participants fulfilling the inclusion criteria were enrolled consecutively during the study period.

Inclusion Criteria

- Pregnant women with **high-risk pregnancies**, including:
 - Pregnancy-induced hypertension (PIH)/preeclampsia
 - Intrauterine growth restriction (IUGR)
 - Gestational diabetes mellitus (GDM)
 - Severe anemia
 - Oligohydramnios
 - Previous bad obstetric history
- Gestational age **≥28 weeks**
- Singleton pregnancy
- Willingness to participate and provide informed consent

Exclusion Criteria

- Multiple pregnancies
- Known **congenital fetal anomalies**
- Patients with uncertain gestational age
- Patients lost to follow-up or with incomplete data

Data Collection Procedure: After obtaining written informed consent, eligible participants were enrolled in the study. A detailed history was taken, and a thorough clinical examination was performed using a predesigned and pretested proforma. Relevant investigations were recorded, including routine antenatal investigations.

Doppler Ultrasonography: All participants underwent Doppler ultrasonography using a standardized protocol. The assessment included evaluation of the umbilical artery (UA), middle cerebral artery (MCA), cerebroplacental ratio (CPR), and uterine artery (UtA). In the umbilical artery, pulsatility index (PI), resistance index (RI), systolic/diastolic (S/D) ratio, and the presence of absent or reversed end-diastolic flow were recorded. The middle cerebral artery was assessed for pulsatility index (PI) to evaluate fetal cerebral circulation. The cerebroplacental ratio (CPR) was calculated as the ratio of MCA PI to UA PI, serving as an indicator of fetal adaptation to hypoxia. Uterine artery Doppler assessment included measurement of pulsatility index (PI) and the presence of an early diastolic notch, reflecting uteroplacental circulation. All Doppler measurements were performed by experienced radiologists/sonologists to minimize interobserver variability and ensure consistency.

Follow-Up and Outcome Assessment: Participants were followed up till delivery. Maternal and neonatal outcomes were recorded.

Maternal Outcomes

- Mode of delivery (vaginal delivery / cesarean section)
- Development or progression of complications (e.g., severe preeclampsia, eclampsia, PPH)

Fetal/Neonatal Outcomes

- Birth weight
- Apgar score at 1 and 5 minutes
- Preterm delivery
- NICU admission
- Perinatal mortality

Adverse fetomaternal outcome was defined as the presence of one or more of the above complications.

Statistical Analysis

The collected data were entered into Microsoft Excel and analyzed using the Statistical Package for Social Sciences (SPSS) version 25. Continuous variables were expressed as mean \pm standard deviation, while categorical variables were presented as frequencies and percentages. The association between Doppler parameters and fetomaternal outcomes was assessed using the Chi-square test or Fisher's exact test for categorical variables and Student's t-test for continuous variables, as appropriate. The diagnostic performance of Doppler indices in predicting adverse outcomes was evaluated by calculating sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). Receiver Operating Characteristic (ROC) curve analysis was performed to determine the predictive accuracy of Doppler parameters. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee (IEC) of Vedanta Institute of Medical Sciences. Written informed consent was obtained from all participants prior to enrollment. Confidentiality of patient data was strictly maintained throughout the study.

RESULTS

A total of 53 high-risk pregnant women were included in the study. The cohort predominantly comprised women in the 21–30 years age group, with a slight predominance of multigravida cases (**Table 1**). Hypertensive disorders and intrauterine growth restriction were the most common high-risk conditions observed (**Table 2**).

Table 1: Baseline Demographic and Obstetric Characteristics (n = 53)

Variable		Frequency (n)	Percentage (%)
Age (years)	<20	6	11.3
	21–25	18	34.0
	26–30	20	37.7

	>30	9	17.0
Gravidity	Primigravida	24	45.3
	Multigravida	29	54.7
Gestational Age (weeks)	28–32	14	26.4
	33–36	21	39.6
	≥37	18	34.0

Table 2: Distribution of High-Risk Factors and Doppler Abnormalities (n = 53)

Variable		Frequency (n)	Percentage (%)
High-Risk Conditions*	PIH/Preeclampsia	19	35.8
	IUGR	15	28.3
	GDM	8	15.1
	Severe anemia	6	11.3
	Oligohydramnios	5	9.4
Doppler Findings	Abnormal UA Doppler	17	32.1
	Abnormal MCA Doppler	15	28.3
	Abnormal CPR (<1)	19	35.8
	Abnormal Uterine artery	13	24.5

*Multiple conditions may overlap

Doppler abnormalities were noted across all assessed vessels, with cerebroplacental ratio (CPR) showing the highest proportion of abnormal findings (**Table 2**). Overall, adverse fetomaternal outcomes were observed in nearly half of the study population, with low birth weight, preterm delivery, and NICU admission being the most frequent neonatal complications (**Table 3**).

Table 3: Fetomaternal Outcomes (n = 53)

	Outcome	Frequency (n)	Percentage (%)
Maternal Outcomes	Vaginal delivery	28	52.8
	Cesarean section	25	47.2
	Maternal complications	12	22.6
Neonatal Outcomes	Low birth weight (<2.5 kg)	21	39.6
	Preterm delivery	18	34.0
	NICU admission	17	32.1
	Low Apgar (<7 at 5 min)	13	24.5
	Perinatal mortality	3	5.7

A statistically significant association was observed between abnormal Doppler parameters and adverse outcomes. Among the parameters studied, abnormal CPR demonstrated the strongest association, followed by umbilical artery and middle cerebral artery Doppler indices, while uterine artery abnormalities showed a comparatively weaker association (**Table 4**).

Table 4: Association Between Doppler Parameters and Adverse Fetomaternal Outcome

Doppler Parameter	Adverse Outcome Present (n=26)	Adverse Outcome Absent (n=27)	p-value
Abnormal UA Doppler	14 (53.8%)	3 (11.1%)	0.002
Abnormal MCA Doppler	12 (46.2%)	3 (11.1%)	0.006
Abnormal CPR	16 (61.5%)	3 (11.1%)	<0.001
Abnormal Uterine artery	10 (38.5%)	3 (11.1%)	0.02

The diagnostic accuracy of Doppler parameters was further evaluated, showing that CPR had the highest sensitivity with good specificity, followed by umbilical artery and middle cerebral artery Doppler indices (**Table 5**).

Table 5: Diagnostic Accuracy of Doppler Parameters in Predicting Adverse Outcomes

Parameter	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Umbilical Artery Doppler	53.8	88.9	82.4	66.7

Middle Cerebral Artery Doppler	46.2	88.9	80.0	63.2
Cerebroplacental Ratio	61.5	88.9	84.2	70.6
Uterine Artery Doppler	38.5	88.9	76.9	59.3

Receiver Operating Characteristic (ROC) curve analysis demonstrated that the cerebroplacental ratio had the highest predictive accuracy for adverse fetomaternal outcomes with an AUC of **0.79 (95% CI: 0.66–0.91; p < 0.001)**, followed by umbilical artery Doppler (AUC: **0.73; 95% CI: 0.59–0.87; p = 0.002**), middle cerebral artery Doppler (AUC: **0.71; 95% CI: 0.57–0.85; p = 0.004**), and uterine artery Doppler (AUC: **0.68; 95% CI: 0.53–0.83; p = 0.01**) (Figure 1).

DISCUSSION

The present prospective study evaluated the role of Doppler ultrasonography in predicting adverse fetomaternal outcomes in high-risk pregnancies. The findings of this study demonstrate that Doppler parameters, particularly the cerebroplacental ratio (CPR), are reliable predictors of adverse outcomes and can significantly aid in antenatal risk stratification.

In the present study, hypertensive disorders of pregnancy and intrauterine growth restriction (IUGR) were the most common high-risk conditions observed. These findings are consistent with previous studies, which have identified these conditions as major contributors to uteroplacental insufficiency and adverse perinatal outcomes [1,2]. The underlying pathophysiology involves increased placental vascular resistance, resulting in reduced fetal oxygenation and nutrient supply.

Doppler abnormalities were observed in a considerable proportion of cases, with CPR showing the highest rate of abnormality. This finding aligns with earlier studies that emphasize the superiority of CPR over individual Doppler indices in predicting fetal compromise [7]. CPR integrates both placental resistance (umbilical artery) and fetal adaptive response (middle cerebral artery), thereby providing a more comprehensive assessment of fetal hemodynamics.

A significant association was observed between abnormal Doppler indices and adverse fetomaternal outcomes. Among all parameters, CPR demonstrated the strongest association, followed by umbilical artery (UA) and middle cerebral artery (MCA) Doppler indices. Similar observations have been reported by Gramellini et al. and Arbeille et al., who highlighted the superior predictive value of the cerebroplacental ratio compared to individual vessel indices [10,11]. The reduction in CPR reflects the redistribution of blood flow towards vital organs, an early indicator of fetal hypoxia.

Umbilical artery Doppler in the present study showed good specificity but moderate sensitivity in predicting adverse outcomes. This is consistent with existing literature, which suggests that abnormal UA flow patterns, particularly absent or reversed end-diastolic flow, represent advanced stages of placental insufficiency [4,12]. Thus, while UA Doppler is highly specific, it may not detect early fetal compromise.

Middle cerebral artery Doppler demonstrated moderate predictive accuracy, reflecting the fetal compensatory “brain-sparing effect” in response to hypoxia. This physiological adaptation results in decreased vascular resistance in the cerebral circulation, leading to reduced MCA pulsatility index [6]. However, this compensatory mechanism may not be sustained in prolonged hypoxia, thereby limiting its standalone predictive value.

Uterine artery Doppler showed comparatively lower predictive accuracy in this study. This may be explained by its primary role in early identification of placental insufficiency and prediction of hypertensive disorders rather than direct assessment of fetal compromise [8,13]. Therefore, its utility is more pronounced in early pregnancy rather than in late gestational surveillance.

The ROC curve analysis in the present study further reinforces the diagnostic superiority of CPR, which demonstrated the highest area under the curve (AUC), followed by UA and MCA Doppler indices. These findings are in agreement with previous systematic reviews and meta-analyses that have consistently reported higher predictive accuracy of CPR for adverse perinatal outcomes [7,14]. Additionally, integrating multiple Doppler indices has been shown to improve clinical decision-making and optimize timing of delivery in high-risk pregnancies [15].

The incidence of adverse outcomes in the present study, including low birth weight, preterm delivery, and NICU admission, is comparable with findings from similar studies conducted in high-risk populations [5,9]. These outcomes are closely associated with placental insufficiency and fetal hypoxia, conditions that can be effectively identified using Doppler ultrasonography. Furthermore, evidence from a Cochrane review supports the use of Doppler ultrasound in high-risk pregnancies, demonstrating a reduction in perinatal mortality and improved neonatal outcomes [16-18].

The strengths of this study include its prospective design and comprehensive evaluation of multiple Doppler parameters. However, certain limitations should be acknowledged. The relatively small sample size and single-center setting may limit

the generalizability of the findings. Additionally, although efforts were made to minimize interobserver variability, it cannot be completely excluded.

CONCLUSION

Doppler ultrasonography is a valuable, non-invasive tool for assessing fetoplacental circulation and predicting adverse fetomaternal outcomes in high-risk pregnancies. The present study demonstrates that abnormal Doppler parameters are significantly associated with poor perinatal outcomes, including low birth weight, preterm delivery, and increased NICU admissions. Among the various indices evaluated, the cerebroplacental ratio (CPR) emerged as the most reliable predictor, showing better sensitivity and overall diagnostic accuracy compared to umbilical artery and middle cerebral artery Doppler indices. Umbilical artery Doppler demonstrated high specificity, while middle cerebral artery Doppler reflected fetal adaptive mechanisms to hypoxia. Uterine artery Doppler showed comparatively lower predictive value in late gestation. These findings highlight the importance of incorporating Doppler assessment, particularly CPR, into routine surveillance of high-risk pregnancies. Early identification of fetal compromise through Doppler studies can facilitate timely intervention and improve perinatal outcomes, thereby reducing morbidity and mortality.

DECLARATIONS

Informed Consent: Written informed consent was obtained from all participants prior to inclusion in the study.

Conflict of Interest: The authors declare no conflict of interest.

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REFERENCES

1. Raj R, Ranjan R, Majumdar P, Chakraborty S. Observational Study on the Role of Doppler Ultrasound in Assessing Placental Insufficiency in High-Risk Pregnancies. *European Journal of Cardiovascular Medicine*. 2024 Jul 1;14(3).
2. Kumari M, Jha SK, Singh M. UTILITY OF COLOUR DOPPLER ULTRASOUND IN PREDICTING ADVERSE OUTCOMES IN HIGH-RISK PREGNANCIES. *Int J Acad Med Pharm*. 2025;7(4):173-8.
3. Barbieri RL. Transfer to the hospital for women planning a home birth: A high-risk obstetrics problem. *OBG Management*. 2014 Aug;26(8):10-3.
4. Barbieri M, Zamagni G, Fantasia I, Monasta L, Lo Bello L, Quadrifoglio M, Ricci G, Maso G, Piccoli M, Di Martino DD, Ferrazzi EM. Umbilical vein blood flow in uncomplicated pregnancies: systematic review of available reference charts and comparison with a new cohort. *Journal of Clinical Medicine*. 2023 Apr 26;12(9):3132.
5. Vasava TR, Baria D, Rathva A, Bhimani D, Modi M. The Doppler study on umbilical and fetal middle cerebral artery in second and third trimester of pregnancy in evaluation of intrauterine growth retardation. *Int J Curr Pharm Rev Res*. 2025;17(3):22–26.
6. Singh P, Prasad S, Tyagi N, Dabas R, Jha RP. Comparison of Fetal Middle Cerebral Artery and Umbilical Artery Doppler Indices as Predictors of Perinatal Outcomes in Fetal Growth-Restricted Pregnancies. *Cureus*. 2025 Jul 1;17(7):e87102.
7. Vollgraff Heidweiller-Schreurs CA, De Boer MA, Heymans MW, Schoonmade LJ, Bossuyt PM, Mol BW, De Groot CJ, Bax CJ. Prognostic accuracy of cerebroplacental ratio and middle cerebral artery Doppler for adverse perinatal outcome: systematic review and meta-analysis. *Ultrasound in Obstetrics & Gynecology*. 2018 Mar;51(3):313-22.
8. He X, Yang F, Zhang K. The efficacy of different ultrasound Doppler parameters in predicting adverse fetal outcomes in pregnancies with hypertensive disorders: a systematic review and meta-analysis. *Quantitative Imaging in Medicine and Surgery*. 2026 Mar 1;16(3):243.
9. Chaitanya N, Tejwani N, Roy PK. Color Doppler and Non-Stress Tests as Predictors of Perinatal Outcomes in Pregnancy-Induced Hypertension and Intrauterine Growth Restriction: An Observational Study. *Journal of Contemporary Clinical Practice*. 2025 Apr 18;11:383-90.
10. Gramellini D, Folli MC, Raboni S, Vadora E, Meriardi A. Cerebral-umbilical Doppler ratio as a predictor of adverse perinatal outcome. *Obstetrics & Gynecology*. 1992 Mar 1;79(3):416-20.
11. Arbeille P, Fomina G, Roumy J, Alferova I, Tobal N, Heralut S. Adaptation of the left heart, cerebral and femoral arteries, and jugular and femoral veins during short- and long-term head-down tilt and spaceflights. *Eur J Appl Physiol*. 2001;86(2):157-168.
12. Baschat AA. Doppler application in the delivery timing of the preterm growth-restricted fetus: another step in the right direction. *Ultrasound in Obstetrics and Gynecology: The Official Journal of the International Society of Ultrasound in Obstetrics and Gynecology*. 2004 Feb;23(2):111-8.
13. Papageorgiou AT, Yu CK, Bindra R, Pandis G, Nicolaidis KH. Multicenter screening for pre-eclampsia and fetal growth restriction by transvaginal uterine artery Doppler at 23 weeks of gestation. *Ultrasound in Obstetrics and Gynecology: The Official Journal of the International Society of Ultrasound in Obstetrics and Gynecology*. 2001 Nov;18(5):441-9.

14. Conde-Agudelo A, Villar J, Kennedy SH, Papageorghiou AT. Predictive accuracy of cerebroplacental ratio for adverse perinatal and neurodevelopmental outcomes in suspected fetal growth restriction: systematic review and meta-analysis. *Ultrasound in Obstetrics & Gynecology*. 2018 Oct;52(4):430-41.
15. Figueras F, Gratacos E. An integrated approach to fetal growth restriction. *Best practice & research Clinical obstetrics & gynaecology*. 2017 Jan 1;38:48-58.
16. Alfirevic Z, Stampalija T, Dowswell T. Fetal and umbilical Doppler ultrasound in high-risk pregnancies. *Cochrane database of systematic reviews*. 2017(6).
17. Prajapati J, Vihan S. A comprehensive analysis of universal health coverage: Lessons from India, UK, and Canada. *INTERNATIONAL JOURNAL OF RESEARCH*. 2025;7(1):123-8.
18. Sharieff A, Das S, Sharieff S, Joe SM, Karmali D, Prajapati J. AUDIT OF BLOOD UTILISATION EFFICIENCY IN OBSTETRICS AND GYNAECOLOGICAL SERVICES AT A TERTIARY CARE HOSPITAL. *Neuroquantology*. 2026 Jan;24(1):1-4.