

Umbilical Artery Doppler and Perinatal Outcomes in High-Risk Pregnancy: A Prospective Observational Study

Maitri Patel¹, Usha Agarwal², Rohit Jain³

¹Senior Resident, Department of Obstetrics and Gynecology, GMERS Medical College, Gandhinagar, Gujarat 382016, India.

²Senior Consultant, Department of Obstetrics and Gynecology, Narayana Hospital, Jaipur, Rajasthan 302033, India.

³Associate Professor, Department of Obstetrics and Gynecology GMERS Medical College, Gandhinagar, Gujarat 382016, India.

Corresponding Author: Dr. Rohit Jain

DOI: <https://doi.org/10.52403/ijshr.20260308>

ABSTRACT

Background: High-risk pregnancies are associated with increased maternal and fetal complications due to medical, obstetric, or lifestyle factors. Umbilical artery Doppler velocimetry assesses fetoplacental circulation and may help predict adverse outcomes. This study evaluated the utility of umbilical artery Doppler in high-risk pregnancies and its correlation with perinatal outcomes.

Methods: This prospective observational study included 90 high-risk pregnant women (26 weeks to term) at Narayana Multispecialty Hospital, Jaipur. Umbilical artery Doppler indices (systolic/diastolic ratio, pulsatility index, resistance index) were recorded. Women were followed until delivery. Perinatal outcomes including preterm delivery, low birth weight, APGAR score, NICU admission, and neonatal mortality were compared between normal and abnormal Doppler groups.

Results: Abnormal Doppler findings were observed in 44.4% of women (high resistance flow 38.9%, absent end-diastolic flow 3.3%, reversed end-diastolic flow 2.2%). Abnormal Doppler group showed significantly higher mean Doppler indices

($p < 0.001$) and higher rates of preterm delivery (91.7% at 34–36 weeks), low birth weight (68.4%), low 5-minute APGAR score (87.5%), NICU admission (59.5%), respiratory distress syndrome (100%), birth asphyxia (82.4%), and neonatal mortality (100% of deaths) ($p < 0.05$ for all). Abnormal Umbilical Artery Doppler had sensitivity 66.67%, specificity 84.62%, and diagnostic accuracy 74.44% for predicting adverse perinatal outcome.

Conclusion: Umbilical artery Doppler velocimetry is a valuable non-invasive tool for identifying fetal compromise in high-risk pregnancies. Abnormal findings strongly predict adverse perinatal outcomes, supporting routine use to guide timely obstetric intervention.

Keywords: Pregnancy, High Risk; Ultrasonography, Doppler; Umbilical arteries; Perinatal outcome; Placental insufficiency.

INTRODUCTION

High-risk pregnancy is a condition in which the health and well-being of the mother, fetus, or both are exposed to an increased possibility of complications due to medical, obstetric, or lifestyle-related factors. [1]

Maternal disorders such as hypertension, diabetes mellitus, cardiac disease, renal disease, liver disorders, thyroid dysfunction, anemia, bronchial asthma, autoimmune conditions, and infections can adversely affect the course of pregnancy. Obstetric complications such as preeclampsia, gestational hypertension, gestational diabetes mellitus, intrauterine growth restriction, oligohydramnios, bad obstetric history, and previous fetal loss also contribute significantly to maternal and fetal morbidity. [2] These conditions require careful antenatal surveillance, early diagnosis, and timely intervention to reduce preventable adverse outcomes. [3]

The management of high-risk pregnancies depends on regular clinical assessment supported by reliable fetal monitoring methods. Since fetal compromise may develop gradually due to impaired placental function, early recognition of altered fetoplacental circulation is essential. [4,5] The placenta plays a central role in fetal growth by ensuring adequate transfer of oxygen and nutrients from the mother to the fetus. [6] When placental vascular resistance increases, fetal blood supply may become insufficient, leading to hypoxia, growth restriction, preterm birth, low birth weight, fetal distress, stillbirth, or neonatal complications. [7] Therefore, assessment of placental circulation is an important component of antenatal care in pregnancies at risk.

Doppler velocimetry is a non-invasive ultrasound technique that evaluates blood flow in maternal and fetal vessels. Among the various vessels studied during pregnancy, the umbilical artery is particularly important because it reflects downstream resistance in the placental circulation. Umbilical artery Doppler waveforms provide valuable information about fetoplacental hemodynamics and help identify placental insufficiency before clinical deterioration becomes evident. The commonly used Doppler indices include the systolic/diastolic ratio, resistance index, and pulsatility index. [8] In normal pregnancy, placental resistance

gradually decreases with advancing gestation, resulting in improved diastolic flow. However, abnormal findings such as high resistance flow, absent end-diastolic flow, or reversed end-diastolic flow indicate significant compromise and are associated with poor perinatal outcomes. [9]

Research have shown that abnormal umbilical artery Doppler findings are associated with increased rates of preterm delivery, low birth weight, operative delivery, low APGAR score, neonatal intensive care unit admission, respiratory distress, birth asphyxia, and perinatal mortality. [8,10] Hence, Doppler evaluation is useful not only for detecting fetal compromise but also for guiding clinical decisions regarding the timing and mode of delivery. Its use in high-risk pregnancy can help obstetricians balance the risks of continuing pregnancy against the risks of prematurity.

In view of these considerations, the present study was undertaken to assess the usefulness of umbilical artery Doppler velocimetry in high-risk pregnancies and to correlate Doppler findings with perinatal outcome.

MATERIALS & METHODS

Study design and setting

This was a prospective observational study conducted in the Department of Obstetrics and Gynecology, Narayana Multispecialty Hospital, Jaipur. The study was carried out over a period of 18 months among pregnant women with high-risk factors who attended the antenatal clinic or were admitted to the obstetrics department.

Study population

The study included pregnant women with singleton pregnancies between 26 weeks of gestation and term, having one or more high-risk factors. High-risk factors considered for inclusion were gestational hypertension, preeclampsia, chronic hypertension, overt diabetes mellitus, gestational diabetes mellitus, and bad obstetric history. Women with multiple pregnancies, fetuses with congenital anomalies, fetuses with

chromosomal malformations, maternal cardiovascular disease, and Rh alloimmunization were excluded from the study.

Sample size and sampling technique

The sample size was calculated by using the hypothesis testing method with the formula:

$$n = \frac{Z^2 p(1 - p)}{L^2}$$

where Z was taken as 1.96 at 95% confidence interval, p as 30%, based on the prevalence of high-risk pregnancy, and L as 10% margin of error. The calculated minimum sample size was 84. A total of 90 eligible women were included in the final analysis. Participants were enrolled by purposive sampling after applying the inclusion and exclusion criteria.

Data collection and clinical evaluation

Data were collected using a predesigned proforma. A detailed history was obtained from all participants, including maternal risk factors, fetal risk factors, past obstetric history, medical history, and details of previous pregnancies. General physical examination was performed, including measurement of height, weight, pulse rate, and blood pressure. Systemic examination, including cardiovascular and respiratory system assessment, was carried out in all cases. A complete obstetric examination was also performed and findings were recorded. Routine laboratory investigations included blood group and Rh typing, complete hemogram, urine analysis, liver function tests, renal function tests, serology, thyroid function test, coagulation profile, random blood sugar, and HbA1c. Fundus examination was performed in cases of hypertension and diabetes mellitus. Basic obstetric ultrasonography was done to assess fetal well-being, gestational age, amniotic fluid, placental maturity, and fetal biometry.

Doppler velocimetry

Umbilical artery Doppler velocimetry was performed using a duplex Doppler ultrasound system with a 3.5 MHz curvilinear probe and pulsed Doppler transducer. The umbilical artery was assessed by placing the probe over the maternal abdomen and recording flow velocity waveforms from a free-floating loop of the umbilical cord. The Doppler parameters assessed included systolic/diastolic ratio, pulsatility index, and resistance index. Abnormal Doppler findings were defined as high resistance flow with S/D ratio >3 , absent end-diastolic flow, or reversed end-diastolic flow.

Follow-up and management

All enrolled patients were followed up with regular antenatal examinations to assess maternal condition and interval fetal growth. Repeat Doppler evaluation was performed whenever clinically indicated or when any abnormality was detected. Patients were managed according to maternal and fetal condition. Decision regarding delivery was taken in cases of gestational age of 37 weeks in hypertensive mothers, absent end-diastolic flow, reversed end-diastolic flow, placental abruption, worsening maternal condition such as uncontrolled hypertension or deteriorating renal function, evidence of fetal distress on biophysical profile or cardiotocography, fetal alarm signals, or oligohydramnios with amniotic fluid index less than 5.

Outcome measures

The maternal and perinatal outcomes recorded included gestational age at delivery, mode of delivery, birth weight, APGAR score at 5 minutes, and need for neonatal intensive care unit admission. Adverse perinatal outcomes considered in the study were preterm delivery, low birth weight, APGAR score less than 6 at 5 minutes, NICU admission, perinatal death, respiratory distress syndrome, hyperbilirubinemia, birth asphyxia, and hypoglycemia.

Ethical considerations

The study was initiated after approval from the Institutional Ethics Committee (Approval No.: NHMECJ/JPR/2022/04). All eligible participants were informed about the nature, purpose, benefits, and possible risks of the study in a language they understood. Written informed consent was obtained from all participants before enrollment. Confidentiality and privacy of the participants were maintained throughout the study. No additional charges were applied for participation, and refusal to participate did not affect the treatment provided.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Epi Info™ version 7 (Centers for Disease Control and Prevention, Atlanta, GA, USA). Continuous variables were assessed for normality of distribution and are presented as mean $\pm$ standard deviation (SD), whereas categorical variables are presented as frequencies and percentages. Comparisons of continuous variables between the normal and abnormal umbilical artery Doppler groups were performed using the independent samples Student's t-test for normally distributed data. Associations between categorical variables were analyzed using the Chi-square test or Fisher's exact test, as appropriate, when expected cell counts were less than five. A two-tailed p -value of <0.05 was considered statistically significant.

The diagnostic performance of abnormal umbilical artery Doppler velocimetry for predicting adverse perinatal outcome was evaluated by constructing a 2×2 contingency table. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy were calculated using standard formulas.

RESULT

A total of 90 high-risk pregnant women were included in the study, of whom 50 had normal umbilical artery Doppler findings and 40 had abnormal Doppler findings. On analysis of baseline characteristics, abnormal Doppler findings were more frequently observed among women aged more than 30 years; however, the association between maternal age and Doppler status was not statistically significant. Similarly, parity did not show a significant association with Doppler findings, with abnormal Doppler observed in 50.0% of primigravida women and 40.4% of multigravida women. Among the high-risk factors, hypertensive disorders of pregnancy were the most common indication in both groups. Diabetes mellitus in pregnancy was significantly more common among women with normal Doppler findings than abnormal Doppler findings, whereas bad obstetric history and chronic kidney disease did not show statistically significant associations with Doppler status (Table 1).

Table 1. Baseline characteristics and high-risk factors according to umbilical artery Doppler findings

Variable	Normal Doppler	Abnormal Doppler	p-value
Age group			0.31
≤ 20 years	0 (0.0%)	2 (100.0%)	
21–25 years	7 (53.8%)	6 (46.2%)	
26–30 years	16 (47.1%)	18 (52.9%)	
>30 years	14 (34.1%)	27 (65.9%)	
Parity			0.36
Primigravida	19 (50.0%)	19 (50.0%)	
Multigravida	31 (59.6%)	21 (40.4%)	
High-risk factor*			
Hypertensive disorders of pregnancy	32 (51.6%)	30 (48.4%)	0.26
Bad obstetric history	6 (37.5%)	10 (62.5%)	0.10
Diabetes mellitus in pregnancy	12 (85.7%)	2 (14.3%)	0.01
Chronic kidney disease	0 (0.0%)	1 (100.0%)	0.26

*High-risk factors may overlap; therefore, totals may exceed the total study population.

With regard to the distribution of umbilical artery Doppler findings, 50 women had normal Doppler waveforms, accounting for 55.6% of the study population. Among the 40 women with abnormal Doppler findings, high resistance flow was the most common abnormality, observed in 35 cases, followed by absent end-diastolic flow in 3 cases and reversed end-diastolic flow in 2 cases. (Table 2) When abnormal Doppler patterns were assessed according to high-risk factors, high resistance flow was the predominant

abnormality across all groups. Among women with hypertensive disorders, 86.7% had high resistance flow, 10.0% had absent end-diastolic flow, and 3.3% had reversed end-diastolic flow. Among women with bad obstetric history, 90.0% had high resistance flow and 10.0% had reversed end-diastolic flow. All women with diabetes mellitus and chronic kidney disease who had abnormal Doppler findings showed high resistance flow (Table 3).

Table 2. Distribution of umbilical artery Doppler findings and abnormal Doppler patterns among high-risk groups

Doppler finding	Number	Percentage
Normal Doppler	50	55.6
High resistance flow	35	38.9
Absent end-diastolic flow	3	3.3
Reversed end-diastolic flow	2	2.2

Table 3. Abnormal Doppler pattern according to high-risk factor

High-risk factor	High resistance flow	Absent end-diastolic flow	Reversed end-diastolic flow	Total
Hypertensive disorders	26 (86.7%)	3 (10.0%)	1 (3.3%)	30
Bad obstetric history	9 (90.0%)	0 (0.0%)	1 (10.0%)	10
Diabetes mellitus	2 (100.0%)	0 (0.0%)	0 (0.0%)	2
Chronic kidney disease	1 (100.0%)	0 (0.0%)	0 (0.0%)	1

The Doppler indices were significantly higher in the abnormal Doppler group compared with the normal Doppler group. The mean umbilical artery systolic/diastolic ratio was 3.99 ± 1.43 in the abnormal Doppler group, compared with 2.21 ± 0.31 in the normal Doppler group. Similarly, the mean pulsatility index was 1.53 ± 0.61 in the abnormal Doppler group and 0.94 ± 0.19 in the normal Doppler group, while the mean resistance index was 0.83 ± 0.15 and $0.56 \pm$

0.08 , respectively. These differences were statistically significant, with p-values of <0.001 for all three indices. Amniotic fluid index also showed a significant association with Doppler findings. Among women with AFI <5 , 85.7% had abnormal Doppler findings, whereas among women with AFI ≥ 5 , only 31.9% had abnormal Doppler findings, indicating a significant association between oligohydramnios and abnormal umbilical artery Doppler (Table 4).

Table 4. Comparison of Doppler indices and amniotic fluid index between normal and abnormal Doppler groups

Parameter	Normal Doppler	Abnormal Doppler	p-value
Umbilical artery S/D ratio	2.21 ± 0.31	3.99 ± 1.43	<0.001
Pulsatility index	0.94 ± 0.19	1.53 ± 0.61	<0.001
Resistance index	0.56 ± 0.08	0.83 ± 0.15	<0.001
Amniotic fluid index			<0.001
AFI <5	3 (14.3%)	18 (85.7%)	
AFI ≥ 5	47 (68.1%)	22 (31.9%)	

Values are expressed as mean $\pm$ SD or number (%).

Obstetric outcomes varied significantly between the two Doppler groups. Preterm delivery was more common among women with abnormal Doppler findings. Among deliveries before 34 weeks, 76.9% occurred in the abnormal Doppler group, and among deliveries between 34 and 36 weeks, 91.7% occurred in the abnormal Doppler group. In contrast, among women who delivered at or beyond 37 weeks, 84.9% had normal

Doppler findings. This association between abnormal Doppler and earlier gestational age at delivery was statistically significant. Mode of delivery also differed significantly between the groups. Normal vaginal delivery was more common in the normal Doppler group, whereas lower segment cesarean section and forceps delivery were more frequent among women with abnormal Doppler findings (Table 5).

Table 5. Obstetric outcomes according to umbilical artery Doppler findings

Outcome variable	Normal Doppler	Abnormal Doppler	p-value
Gestational age at delivery			<0.001
<34 weeks	3 (23.1%)	10 (76.9%)	
34–36 weeks	2 (8.3%)	22 (91.7%)	
≥37 weeks	45 (84.9%)	8 (15.1%)	
Mode of delivery			0.0018
Normal vaginal delivery	25 (78.1%)	7 (21.9%)	
LSCS	25 (45.5%)	30 (54.5%)	
Forceps delivery	0 (0.0%)	3 (100.0%)	

Neonatal outcomes were poorer among women with abnormal umbilical artery Doppler findings. A 5-minute APGAR score of less than 6 was observed predominantly in the abnormal Doppler group, with 87.5% of such neonates belonging to this group. Low birth weight was also significantly associated with abnormal Doppler findings; among neonates weighing less than 2.5 kg, 68.4% were born to women with abnormal Doppler findings. In contrast, higher birth weight categories were more commonly associated with normal Doppler findings. NICU admission was required in 59.5% of neonates

in the abnormal Doppler group compared with 40.5% in the normal Doppler group, and this association was statistically significant. Respiratory distress syndrome, birth asphyxia, preterm birth, and neonatal mortality were also significantly more frequent in the abnormal Doppler group. Neonatal mortality was seen only among neonates born to women with abnormal Doppler findings. Hyperbilirubinemia and hypoglycemia were more frequent in the abnormal Doppler group but did not show statistically significant associations (Table 6).

Table 6. Neonatal outcomes according to umbilical artery Doppler findings

Neonatal outcome	Normal Doppler	Abnormal Doppler	p-value
5-minute APGAR score			<0.001
≥6	48 (64.9%)	26 (35.1%)	
<6	2 (12.5%)	14 (87.5%)	
Birth weight			<0.001
<2.5 kg	12 (31.6%)	26 (68.4%)	
2.5–3 kg	22 (66.7%)	11 (33.3%)	
>3 kg	16 (84.2%)	3 (15.8%)	
NICU admission			0.007
Required	17 (40.5%)	25 (59.5%)	
Not required	33 (68.8%)	15 (31.2%)	
Respiratory distress syndrome	0 (0.0%)	10 (100.0%)	0.001
Low birth weight	12 (31.6%)	26 (68.4%)	<0.001
Hyperbilirubinemia	4 (57.1%)	3 (42.9%)	0.93
Birth asphyxia	3 (17.6%)	14 (82.4%)	<0.001
Preterm birth	5 (13.5%)	32 (86.5%)	<0.001
Hypoglycemia	2 (40.0%)	3 (60.0%)	0.471
Neonatal mortality	0 (0.0%)	3 (100.0%)	0.049

The diagnostic performance of abnormal umbilical artery Doppler for predicting adverse perinatal outcome was assessed. Among 40 women with abnormal Doppler findings, 34 had adverse perinatal outcomes and 6 had normal outcomes. Among 50 women with normal Doppler findings, 17 had adverse outcomes and 33 had normal

outcomes. The sensitivity of abnormal umbilical artery Doppler for predicting adverse perinatal outcome was 66.67%, specificity was 84.62%, positive predictive value was 85.00%, negative predictive value was 66.00%, and overall diagnostic accuracy was 74.44% (Table 7).

Table 7. Diagnostic validity of abnormal umbilical artery Doppler for predicting adverse perinatal outcome

Umbilical artery Doppler	Abnormal perinatal outcome	Normal perinatal outcome	Total
Abnormal Doppler	34 (66.67%)	6 (15.79%)	40
Normal Doppler	17 (33.33%)	33 (84.21%)	50
Total	51	39	90
Validity parameter			
Sensitivity	66.67%		
Specificity	84.62%		
Positive predictive value	85.00%		
Negative predictive value	66.00%		
Diagnostic accuracy	74.44%		

DISCUSSION

The present study evaluated umbilical artery Doppler velocimetry in 90 high-risk pregnancies and demonstrated a clear association between abnormal Doppler findings and adverse perinatal outcome. In our cohort, 55.6% women had normal Doppler findings, while 44.4% showed abnormalities, predominantly high resistance flow, followed by absent and reversed end-diastolic flow. This indicates that increased placental vascular resistance is common among high-risk pregnancies and supports the role of umbilical artery Doppler as a useful surveillance tool for identifying fetuses at risk of compromise.

Hypertensive disorders of pregnancy constituted the most frequent high-risk factor in both Doppler groups. Abnormal Doppler was also observed among women with bad obstetric history, diabetes mellitus, and chronic kidney disease. High resistance flow was the commonest abnormal pattern across all risk groups. These findings are biologically plausible because abnormal trophoblastic invasion and placental insufficiency, particularly in hypertensive disorders, increase downstream resistance in the fetoplacental circulation. Similar observations were reported by Varghese S et

al., who found abnormal umbilical artery Doppler to be commonly associated with preeclampsia, oligohydramnios, and adverse maternal and fetal outcomes. [11]

The Doppler indices in the present study were significantly higher in the abnormal Doppler group. The mean S/D ratio, pulsatility index, and resistance index were all elevated with p values <0.001. These results confirm that quantitative Doppler indices reflect increased placental impedance and can distinguish pregnancies with compromised fetoplacental circulation. Reddy A et al. similarly observed that abnormal umbilical artery flow and pulsatility index were associated with adverse perinatal outcomes. [12] Smitha K et al. also reported that umbilical artery pulsatility index had high sensitivity and positive predictive value for predicting low birth weight in pregnancy-induced hypertension. [13]

Oligohydramnios showed a significant association with abnormal Doppler findings in this study. Most women with AFI <5 had abnormal Doppler waveforms, suggesting that reduced liquor may coexist with placental insufficiency and chronic fetal hypoxia. This finding is consistent with Sumathi R et al., who noted a higher

incidence of oligohydramnios among fetuses with abnormal umbilical flow velocimetry. [14]

Adverse obstetric outcomes were significantly more frequent in the abnormal Doppler group. Preterm delivery was strongly associated with abnormal Doppler, and most deliveries before 37 weeks occurred in this group. Operative delivery was also more common among women with abnormal Doppler findings. These findings are comparable to those of Urmila S et al., Harshika S et al., and Rashmi L et al., who reported higher rates of cesarean delivery, early delivery, and neonatal intensive care admission among women with abnormal Doppler indices. [15,16,17]

Neonatal outcome was notably poorer in the abnormal Doppler group. Low birth weight, low 5-minute APGAR score, NICU admission, respiratory distress syndrome, birth asphyxia, preterm birth, and neonatal mortality were significantly associated with abnormal Doppler findings. Neonatal mortality occurred only in the abnormal Doppler group. Similar results were described by Komuhangi P et al., where absent or reversed end-diastolic flow was linked to fetal death and neonatal special care admission. [18] Tolu LB et al. also found higher perinatal death and NICU admission in fetuses with abnormal umbilical artery Doppler, while Adedo AA et al. reported higher abnormal waveform patterns, preterm delivery, and mortality in fetal growth-restricted pregnancies. [19,20]

The diagnostic performance of abnormal Doppler in our study showed good specificity and positive predictive value for adverse perinatal outcome. This supports the findings of Poovathi PM et al., and Karena ZV et al., who emphasized the utility of Doppler velocimetry in predicting poor neonatal outcomes and guiding management in high-risk pregnancies. [21,22]

CONCLUSION

Umbilical artery Doppler velocimetry is a valuable, non-invasive tool for fetal surveillance in high-risk pregnancies. In the

present study, abnormal Doppler findings were significantly associated with adverse perinatal outcomes, including preterm delivery, low birth weight, low 5-minute APGAR score, increased NICU admission, respiratory distress syndrome, birth asphyxia, and neonatal mortality. High resistance flow was the most common abnormal Doppler pattern, followed by absent and reversed end-diastolic flow. Doppler indices, including S/D ratio, pulsatility index, and resistance index, were significantly higher among women with abnormal Doppler findings, indicating increased fetoplacental vascular resistance. The study also demonstrated good specificity and positive predictive value of abnormal umbilical artery Doppler for predicting adverse perinatal outcome. Therefore, routine use of umbilical artery Doppler in high-risk pregnancies can help in early identification of fetal compromise, guide timely obstetric intervention, and contribute to improved perinatal outcome.

Declaration by Authors

Ethical Approval: IEC Approval No.: NHMECJ/JPR/2022/04

Acknowledgement: None

Source of Funding: None

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

REFERENCES

1. Bhandari S, Dwa Y, Maharjan M, Bajracharya M. High risk pregnancy and its outcome in a tertiary care hospital: a descriptive cross-sectional study. JNMA J Nepal Med Assoc. 2024 Apr 30;62(273):306-310. doi: 10.31729/jnma.8561.
2. Gomindes AR, Bhakthavalsalan R, Sharma U, Johnston SL, Naushad A. Prevalence of high-risk pregnancy among pregnant women attending antenatal care camps in primary health centres in Kinaye and Vantamuri and their sub-centres. Cureus. 2022;14(7): e27355. doi: 10.7759/cureus.27355.
3. Martins JG, Biggio JR, Abuhamad A; Society for Maternal-Fetal Medicine.

- Society for Maternal-Fetal Medicine Consult Series #52: diagnosis and management of fetal growth restriction: replaces Clinical Guideline Number 3, April 2012. *Am J Obstet Gynecol.* 2020;223(4): B2-17. doi: 10.1016/j.ajog.2020.05.010.
4. Alfrevic Z, Stampalija T, Dowswell T. Fetal and umbilical Doppler ultrasound in high-risk pregnancies. *Cochrane Database Syst Rev.* 2017;6(6):CD007529. doi: 10.1002/14651858.CD007529.pub4.
5. Trudinger BJ, Giles WB, Cook CM, Bombardieri J, Collins L. Fetal umbilical artery flow velocity waveforms and placental resistance: clinical significance. *Br J Obstet Gynaecol.* 1985;92(1):23-30. doi: 10.1111/j.1471-0528.1985.tb01044.x.
6. Wang KG, Chen CY, Chen YY. The effects of absent or reversed end-diastolic umbilical artery Doppler flow velocity. *Taiwan J Obstet Gynecol.* 2009;48(3):225-31. doi: 10.1016/S1028-4559(09)60294-1.
7. Karsdorp VH, van Vugt JM, van Geijn HP, Kostense PJ, Arduini D, Montenegro N, et al. Clinical significance of absent or reversed end diastolic velocity waveforms in umbilical artery. *Lancet.* 1994;344(8938):1664-8. doi: 10.1016/S0140-6736(94)90457-X.
8. Dicke JM, Huettner P, Yan S, Odibo A, Kraus FT. Umbilical artery Doppler indices in small for gestational age fetuses: correlation with adverse outcomes and placental abnormalities. *J Ultrasound Med.* 2009;28(12):1603-10. doi: 10.7863/jum.2009.28.12.1603.
9. Byun YJ, Kim HS, Yang JI, Kim JH, Kim HY, Chang SJ. Umbilical artery Doppler study as a predictive marker of perinatal outcome in preterm small for gestational age infants. *Yonsei Med J.* 2009;50(1):39-44. doi: 10.3349/ymj.2009.50.1.39.
10. Ghosh GS, Gudmundsson S. Uterine and umbilical artery Doppler are comparable in predicting perinatal outcome of growth-restricted fetuses. *BJOG.* 2009;116(3):424-30. doi: 10.1111/j.1471-0528.2008.02057.x.
11. Varghese S, Kour G, Manchanda K, Dhar T. Abnormal umbilical artery Doppler in third trimester and perinatal outcome: a retrospective study. *Int J Reprod Contracept Obstet Gynecol.* 2016;5(7):2196-9.
12. Reddy A, Malik R, Mehra S, Singh P, Ramachandran L. Correlation of doppler studies at 34 weeks of gestation with perinatal outcome in high risk pregnancies. *Int J Reprod Contracept Obstet Gynecol.* 2017;4(6):1894-9.
13. K S, K S, T M. Study of Doppler waveforms in pregnancy induced hypertension and its correlation with perinatal outcome. *Int J Reprod Contracept Obstet Gynecol.* 2017;3(2):428-33.
14. R. S, Rodrigo MR. A prospective study on the role of umbilical artery doppler velocimetry in the perinatal outcome of growth restricted fetuses. *Int J Reprod Contracept Obstet Gynecol.* 2019;8(12):4930-8.
15. Urmila S, Beena B. Triple vessel wave pattern by Doppler studies in normal and high risk pregnancies and perinatal outcome. *J Obstet Gynaecol India.* 2010 Aug;60(4):312-6. doi: 10.1007/s13224-010-0044-x.
16. Singh H, Agrawal M, Bhake A, Singh R. Color Doppler evaluation in high-risk pregnancies and perinatal outcome. *J Datta Meghe Inst Med Sci Univ.* 2021;16(2):257-60. DOI: 10.4103/jdmimsu.jdmimsu_25_18Creative commons license
17. L. R, Bhattacharjee A. Umbilical artery Doppler indices in relation to fetal outcome in high risk pregnancy. *Int J Reprod Contracept Obstet Gynecol.* 2018;7(2):628-34.
18. Komuhangi, P., Byanyima, R., Kiguli-Malwadde, E. and Nakisige, C. Umbilical artery doppler flow patterns in high-risk pregnancy and foetal outcome in Mulago hospital. *Case Reports in Clinical Medicine.* 2013; 2(9), 554-561. doi: 10.4236/crcm.2013.29141.
19. Tolu LB, Ararso R, Abdulkadir A, Feyissa GT, Worku Y. Perinatal outcome of growth restricted fetuses with abnormal umbilical artery Doppler waveforms compared to growth restricted fetuses with normal umbilical artery Doppler

- waveforms at a tertiary referral hospital in urban Ethiopia. PLoS One. 2020 Jun 18;15(6): e0234810. doi: 10.1371/journal.pone.0234810.
20. Adedo AA, Arogundade RA, Okunowo AA, Idowu BM, Oduola-Owoo LT. Comparative study of the umbilical artery Doppler indices of healthy and growth-restricted fetuses in Lagos. J West Afr Coll Surg. 2022;12(2):63-9. doi: 10.4103/jwas.jwas_63_22.
21. Poovathi PM. Umbilical artery Doppler velocimetry and adverse perinatal outcome in high-risk pregnancies in a tertiary care center. Int J Clin Obstet Gynaecol. 2018;2(5):153-60.
22. Karena ZV, Mehta AD, Vaghela HM, Shah HR. Prediction of perinatal outcome in high-risk pregnancy by Doppler ultrasound: a prospective cohort study. Int J Reprod Contracept Obstet Gynecol. 2022;11(9): 2431-6.

How to cite this article: Maitri Patel, Usha Agarwal, Rohit Jain. Umbilical artery doppler and perinatal outcomes in high-risk pregnancy: a prospective observational study. *Int. J. Sci. Healthc. Res.* 2026; 11(3): 64-73. DOI: <https://doi.org/10.52403/ijshr.20260308>
