



PROSPECTIVE EVALUATION OF FETAL GROWTH RESTRICTION AND PERINATAL OUTCOMES USING DOPPLER ULTRASOUND IN HIGH-RISK PREGNANCIES

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ABSTRACT:

BACKGROUND: Fetal development depends on the interplay between fetal growth potential and the maternal intrauterine environment. High-risk conditions such as PIH, oligohydramnios, DM, anemia, and Rh incompatibility often lead to IUGR and adverse perinatal outcomes. Doppler ultrasound assessment of uterine, umbilical, and MCA arteries helps detect altered fetoplacental circulation and identify fetal compromise early.

MATERIALS AND METHODS: This hospital-based prospective study was conducted over 18 months in the Departments of Obstetrics & Gynecology and Pediatrics at a tertiary care center in Tamil Nadu after ethical approval. A total of 120 high-risk pregnant women were enrolled, including cases of asymmetrical IUGR, PIH, oligohydramnios, maternal anemia, DM, and Rh isoimmunization. Twin pregnancies, congenital fetal anomalies, gestation <28 weeks, and those who refused consent were excluded. Participants underwent detailed ultrasound and Doppler evaluation of the uterine arteries, umbilical artery, and fetal middle cerebral artery, measuring S/D ratio, RI, and PI. Fetal growth parameters, amniotic fluid, and estimated fetal weight were assessed. Delivery details, mode of labor, and neonatal outcomes including APGAR score, birth weight, IUGR, stillbirth, and nursery admission were recorded. Newborns were monitored for seven days postpartum. Outcomes were compared between normal and abnormal Doppler groups.

RESULTS: Among 120 high-risk antenatal women, abnormal Doppler findings were most frequent in cases with oligohydramnios plus IUGR (78.6%), followed by PIH (20.8%) and IUGR (16.7%), while other conditions showed normal Doppler. Uterine artery abnormalities were seen in 6.7%, MCA brain-sparing in 8.3%, and umbilical artery abnormalities in 11.7% of cases. Vaginal delivery occurred in 59.4% of normal and 31.6% of abnormal Doppler cases, while LSCS was more frequent in abnormal Doppler (68.4%). Preterm delivery (<37 weeks) occurred in 89.5% of abnormal Doppler cases, and low birth weight (<2.5 kg) was significantly higher (89.5%, $p < 0.001$). Nursery admission was required in 35% of newborns, predominantly from the abnormal Doppler group (84.2%, $p < 0.001$). Umbilical artery abnormalities showed the strongest association with adverse outcomes, while isolated uterine artery changes were not significant.

CONCLUSION: In 120 high-risk pregnancies, abnormal Doppler—especially of the umbilical artery—was strongly associated with preterm delivery, low birth weight, and increased nursery admissions. MCA abnormalities showed a weaker association, while isolated uterine artery changes were not significant. Antenatal Doppler is a reliable, non-invasive tool for early detection of fetal compromise. Regular monitoring of umbilical and MCA indices, including the cerebro-placental ratio, can guide timely interventions and improve perinatal outcomes.

Keywords: High-risk pregnancy; Doppler velocimetry; Adverse perinatal outcomes

INTRODUCTION:

Fetal development is thought to be a complicated process that arises from interactions between the fetus's intrinsic capacity for growth and the impact of the mother's intrauterine environment [1]. Prenatal fetal growth monitoring is now easily accessible in the age of advanced real-time ultrasound technology, contributing to the decrease in perinatal morbidity and mortality. Additionally, the strategy holds potential for the future [2]. Worldwide, maternal and fetal morbidity and mortality are significantly influenced by hypertensive diseases of pregnancy. Five to ten percent of pregnancies in women are complicated by pregnancy-induced hypertension (PIH) [3, 4].

In addition to this, oligohydramnios, maternal diabetes mellitus (DM), anemia, and Rh isoimmunization have numerous negative effects on both the mother and the fetus [5]. These high-risk diseases are typically the cause of intrauterine growth restriction (IUGR). When the estimated fetal weight is less than the 10th percentile for the gestational age, IUGR is considered to be present. IUGR results in a abnormal growth restriction, which also causes low fetal weight and a host of negative early life outcomes [6].

There is a line of reasoning behind the suspicion that Doppler imaging could be a helpful diagnostic method for IUGR. When increased resistance is found in the feeding arteries, the flow velocity decreases, especially during diastole. Blood flow through the placenta is reduced as a result of this occurrence. The identification of a disproportionate slowing of diastolic flow relative to systolic flow, which results in higher Doppler indices, is the other crucial component. The pulsatility index and the systolic/diastolic ratio are significant markers. This study examines the link between Doppler findings and maternal and newborn outcomes in high-risk pregnancies, taking into account the aforementioned factors.

MATERIALS AND METHODS

This hospital-based prospective study was carried out in our tertiary care hospital in Tamil Nadu in the Department of Obstetrics and Gynecology in cooperation with the Pediatrics department after obtaining the Institutional Ethical Committee for Human Research approval. The study comprised 120 women with high-risk pregnancies who visited the emergency room and outpatient clinic between January 2024 and May 2025 (18 months).

Inclusion Criteria:

The study included pregnancies with asymmetrical IUGR, type 2 and gestational diabetes, maternal anemia, oligohydramnios, Rh isoimmunization, and PIH in all age groups, regardless of parity. All mothers with a negative blood group who had at least one child with a positive blood group and a positive indirect Coombs' test were tested for Rh isoimmunization.

Exclusion Criteria:

The study excluded mothers who refused to give consent, had twin pregnancies, had congenital fetal abnormalities, or had gestations less than 28 weeks.

Data collection procedure:

From the enrollment date until the time of birth, the mothers who were part of the study were monitored in accordance with the protocols. They were analyzed using color and spectral Doppler on a color Doppler system equipped with a 3-5 MHz curvilinear probe. A thorough ultrasound study was conducted, which included estimating the expected fetal weight, evaluating the liquid, and estimating maturity (by measuring the biparietal diameter, femoral length, and belly circumference). The Doppler investigation included the maternal uterine arteries, the umbilical artery, and the fetal middle cerebral artery (MCA). For observation and analysis, the systolic/diastolic ratio (S/D), resistive index (RI), and pulsatility index (PI) of each of the four arteries were used.

Information regarding spontaneous or induced labor was recorded. The delivery method—vaginal delivery (VD) or cesarean section (CS)—was documented. Fetal data were documented in the form of APGAR score, IUGR, stillbirth, birth weight, and intrauterine death (IUD). After delivery, newborns were monitored for seven days in order to determine their admittance to the nursery and subsequent results. We gathered all the data and separated it according to Doppler results, whether they were abnormal or normal. The outcomes in both groups were compared using data including birth weight, Doppler indices, neonatal information, and mode of delivery.

Statistical analysis:

Fisher's exact test and the chi-square (X²) test were used to compare categorical data. An independent t-test was used to compare continuous data between the two groups.

RESULTS:

All the cases with either normal or abnormal Doppler findings were comparable in terms of maternal age and parity. Among the 120 antenatal women included in the study, the prevalence of oligohydramnios was 30% (n = 36), pregnancy-induced hypertension (PIH) in 20% (n = 24), anemia in 18% (n = 22), intrauterine growth restriction (IUGR) in 10% (n = 12), and combined oligohydramnios with IUGR in 12% (n = 14). The prevalence of Rh incompatibility, diabetes mellitus (DM), and PIH with IUGR was 5% (n = 6), 3% (n = 4), and 2% (n = 2), respectively.

Among these high-risk categories, abnormal Doppler findings were most frequently observed in women with oligohydramnios associated with IUGR (11 out of 14 cases, 78.6%), followed by PIH (5 out of 24 cases, 20.8%), and IUGR (2 out of 12 cases, 16.7%). All patients with isolated oligohydramnios, anemia, diabetes mellitus, Rh incompatibility, and PIH with IUGR had normal Doppler findings.

A statistically significant association was found between abnormal Doppler findings and oligohydramnios with IUGR (p < 0.001), while no significant correlation was observed in other categories.

Table 1: Distribution of abnormal Doppler findings among high-risk pregnancies (N = 120)

High-risk condition	Total cases (N)	Normal Doppler (n, %)	Abnormal Doppler (n, %)	p-value (Chi-square)
Oligohydramnios	36	36 (100%)	0 (0%)	NC
Anemia	22	22 (100%)	0 (0%)	NC
Diabetes Mellitus (DM)	4	4 (100%)	0 (0%)	NC
IUGR	12	10 (83.3%)	2 (16.7%)	0.942
Oligohydramnios + IUGR	14	3 (21.4%)	11 (78.6%)	<0.001
PIH	24	19 (79.2%)	5 (20.8%)	0.562
PIH + IUGR	2	2 (100%)	0 (0%)	NC
Rh incompatibility	6	6 (100%)	0 (0%)	NC

NC – Not calculated (due to small sample size or zero cell frequency)

In uterine artery Doppler findings, 6.7% (n = 8) of the cases showed raised Resistance Index (RI), Pulsatility Index (PI), and Systolic/Diastolic (S/D) ratio; among these, a persistent early diastolic notch was observed in two cases. Middle cerebral artery (MCA) Doppler showed brain-sparing effect, which is considered abnormal, in 8.3% (n = 10) of the cases. Umbilical artery Doppler with raised RI, PI, and S/D ratio was observed in 11.7% (n = 14) of the study population.

Among women with normal Doppler findings (n = 101), 60 (59.4%) delivered vaginally and 41 (40.6%) by lower segment cesarean section (LSCS). In contrast, among those with abnormal Doppler findings (n = 19), 6 (31.6%) delivered vaginally and 13 (68.4%) by LSCS. Overall, 9.1% (n = 6) of women with vaginal delivery had abnormal Doppler findings, whereas 24.1% (n = 13) of those delivered by LSCS had abnormal Doppler. This difference was not statistically significant (p = 0.062).

As shown in Table 2, among the 19 women with abnormal Doppler, 17 (89.5%) delivered before 37 weeks of gestation, and 2 (10.5%) delivered after 37 weeks (p = 0.176). Furthermore, low birth weight (LBW, <2.5 kg) was observed in 17 (89.5%) of the abnormal Doppler group, which was statistically significant (p < 0.001).

Table 2: Association of Doppler findings with mode of delivery, gestational age, and birth weight (N = 120)

Parameter	Normal Doppler (n = 101)	Abnormal Doppler (n = 19)	p-value
Mode of delivery			
Vaginal delivery	60 (59.4%)	6 (31.6%)	0.062
LSCS	41 (40.6%)	13 (68.4%)	
Gestational age at delivery			
< 37 weeks	20 (19.8%)	17 (89.5%)	0.176
≥ 37 weeks	81 (80.2%)	2 (10.5%)	
Birth weight			
< 2.5 kg (LBW)	25 (24.8%)	17 (89.5%)	<0.001
≥ 2.5 kg	76 (75.2%)	2 (10.5%)	

Out of 120 newborns, 42 (35%) required nursery admission, and among them, 16 (38.1%) were born to mothers with abnormal Doppler findings. Among the 19 women with abnormal Doppler findings, 16 (84.2%) of their newborns required nursery admission. In contrast, among the 101 women with normal Doppler findings, only 26 (25.7%) of their newborns required nursery admission. Among the babies who did not require admission, 94.9% (n = 75) were born to mothers with normal antenatal Doppler, indicating a statistically significant association (p < 0.001) between abnormal Doppler findings and adverse neonatal outcome.

Adverse fetal outcomes such as preterm birth, low birth weight, and nursery admission were more strongly associated with umbilical artery Doppler abnormalities than with MCA Doppler changes. It was further observed that isolated uterine artery abnormalities had no statistically significant relationship with neonatal outcomes (p = 0.241).

Table 3: Association of antenatal Doppler findings with neonatal outcomes (N = 120)

Neonatal outcome	Normal Doppler (n = 101)	Abnormal Doppler (n = 19)	p-value
Nursery admission	26 (25.7%)	16 (84.2%)	<0.001
No admission	75 (74.3%)	3 (15.8%)	
Adverse outcome related to Doppler abnormality			
Umbilical artery abnormality	—	12 (63.2%)	<0.001
MCA abnormality (brain-sparing effect)	—	5 (26.3%)	0.034

Uterine artery abnormality	—	2 (10.5%)	0.241
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DISCUSSION

In this study of 120 high-risk antenatal women, abnormal Doppler findings—particularly in the umbilical artery—were significantly associated with adverse perinatal outcomes, including preterm delivery, low birth weight, and neonatal nursery admission. Among women with abnormal Doppler findings, 84.2% of newborns required nursery admission, compared to 25.7% in the normal Doppler group ($p < 0.001$). This highlights that Doppler abnormalities are strong predictors of neonatal morbidity, consistent with earlier findings emphasizing the role of Doppler velocimetry in fetal surveillance and risk stratification [7,8].

Our study observed that abnormal Doppler indices of the umbilical artery were more strongly associated with adverse neonatal outcomes than abnormalities in the middle cerebral artery (MCA). This aligns with previous studies reporting that raised resistance in the umbilical artery is more directly linked to placental vascular insufficiency and fetal hypoxia [9,10]. In contrast, isolated uterine artery abnormalities did not show a statistically significant association with neonatal outcomes ($p = 0.241$), suggesting that uterine changes alone may not predict poor outcomes in the absence of downstream fetal Doppler derangements [11].

Heidweiller-Schreurs et al. conducted a meta-analysis and concluded that the cerebroplacental ratio (CPR) and MCA Doppler have moderate specificity but lower sensitivity compared to umbilical artery indices for predicting adverse outcomes[12]. Similarly, Stampalija et al. reported that combining umbilical and MCA Doppler parameters improves perinatal risk prediction[13]. Rane et al. found that abnormal umbilical artery pulsatility index correlated strongly with adverse fetal outcomes[14], while Singh et al. also demonstrated that umbilical artery Doppler was superior to MCA in predicting neonatal morbidity[15]. These findings collectively support our results that umbilical artery Doppler abnormalities are more predictive of poor neonatal outcomes than MCA or uterine artery changes.

Placental insufficiency leads to increased vascular resistance, reflected as elevated RI and PI in the umbilical artery, ultimately compromising fetal oxygenation and growth. The MCA responds via vasodilation—termed the “brain-sparing effect”—to maintain cerebral perfusion; however, this adaptation often occurs later in the disease process and is less specific for predicting adverse outcomes [16]. Hence, umbilical artery abnormalities are typically earlier and more sensitive indicators of fetal compromise.

Our findings underscore the value of routine antenatal Doppler evaluation in high-risk pregnancies. Serial monitoring of umbilical artery indices and combined ratios such as CPR (MCA/UA PI) may help clinicians identify fetuses at risk, allowing for timely intervention and improved perinatal outcomes. Further multicentric studies with larger abnormal-Doppler cohorts are warranted to refine predictive thresholds and validate these associations.

CONCLUSION:

In this study of 120 high-risk pregnancies, abnormal Doppler findings—particularly those involving the umbilical artery—were significantly associated with adverse perinatal outcomes such as preterm delivery, low birth weight, and increased neonatal nursery admissions. Abnormalities in the middle cerebral artery (MCA) demonstrated a weaker but notable association, while isolated uterine artery changes were not statistically significant predictors of neonatal morbidity. These findings emphasize the critical role of antenatal Doppler velocimetry as a non-invasive, reliable, and cost-effective tool for fetal surveillance in high-risk pregnancies. Regular assessment of umbilical and MCA Doppler indices, along with derived ratios such as the cerebro-placental ratio (CPR), can facilitate early detection of fetal compromise, guide timely obstetric intervention, and ultimately improve perinatal outcomes. Further large-scale, multicentric studies are recommended to refine predictive thresholds and to establish standardized Doppler-based monitoring protocols in routine obstetric practice.

CONFLICT OF INTEREST:

The authors declare that they have no conflicts of interest.

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