

DOPPLER ULTRASOUND FINDINGS IN PREGNANCIES COMPLICATED BY PRETERM LABOUR

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Abstract

Introduction: Maternal and neonatal morbidity are higher in cases of preterm labour, especially if there is coexisting placental dysfunction and fetal compromise. Doppler ultrasound is a non-invasive technique that can be used to assess uterine and fetoplacental circulation and may be useful in identifying pregnancies at risk for adverse perinatal outcomes.

Objective: To assess Doppler ultrasound parameters in pregnancies complicated by preterm labour and to assess the relationship between these parameters and fetal compromise and adverse perinatal outcomes.

Methods: This was a prospective observational study of 100 pregnant women who came to the hospital with a history of preterm labour between 28 and 36+6 weeks of gestation at a tertiary-care hospital in Rawalpindi, Pakistan, from February to July 2025. Uterine artery, umbilical artery, and middle cerebral artery ultrasound Doppler evaluation was performed on participants. The cerebroplacental ratio was determined, and the patients were followed up until delivery. Maternal, obstetric, Doppler, and neonatal outcomes were recorded.

Results: Doppler abnormalities were found in 38% of the subjects. Abnormal cerebroplacental ratio (26%), abnormal umbilical artery Doppler (24%), abnormal middle cerebral artery Doppler (21%), and abnormal uterine artery Doppler (19%) were observed. Women with abnormal Doppler results were at higher risk for adverse outcomes, such as NICU admission, low birth weight, low Apgar score, respiratory morbidity, and emergency cesarean delivery.

Conclusion: Abnormal Doppler findings were associated with increased perinatal morbidity in pregnancies complicated by preterm labour. Doppler assessment can be used to assist in fetal monitoring and delivery planning.

INTRODUCTION

Preterm labour is an obstetric problem as it is related to significant neonatal respiratory, neurological, infectious and developmental issues. Fetal compromise may be hard to predict, especially when combined with placental dysfunction and/or fetal growth restriction. Doppler ultrasonography is a non-invasive technique that can be used to evaluate the maternal and foetal circulation and can detect haemodynamic abnormalities. Recent studies have suggested that fetoplacental Doppler indices, in conjunction with placental biomarkers, may further enhance the prediction of preterm delivery in cases of Fetal Growth Restriction (FGR) (1). Antenatal Doppler measurements also aid in the prediction of adverse perinatal outcomes in complicated pregnancies (2). The Doppler assessment measures the blood-flow velocity and resistance in uteroplacental and fetoplacental circulations. Uterine artery Doppler is a measure of maternal vascular adaptation and placental implantation, and umbilical artery Doppler is a measure of placental resistance and fetal-placental perfusion.

Fetal circulatory redistribution can be shown by Doppler of the middle cerebral artery (MCA). Uterine artery Doppler during labour has been evaluated in research and shown to be associated with perinatal outcome, encouraging the use of Doppler for maternal circulation (3). Placental biomarkers and fetoplacental Dopplers have also been shown to be potentially useful for prediction of preterm delivery in growth-restricted pregnancies (4). Fetal growth restriction is especially relevant in preterm labour as placental insufficiency can affect fetal tolerance of labour as well as increase the risk of preterm delivery. In some instances, early-onset disease may progress to clinical signs before they are apparent, and clinical surveillance is useful. The development of prediction models for early-onset fetal growth restriction highlights the need to combine maternal and fetal variables to predict adverse perinatal outcomes (5). Doppler results can also help with clinical evaluation to detect a high resistance or adaptation of the baby's circulation

in the placenta, thereby helping with delivery decisions.

Significant haemodynamic disturbances can be seen in complex pregnancies. There are potential challenges to surveillance related to single intrauterine death, growth abnormalities, and disorders of placental vascular sharing in twin gestations. The complexity of twin pregnancies is illustrated by the outcomes after a single intrauterine death, which requires fetal monitoring (6). Biological indicators can be used in addition to imaging; microRNA-210-3p is a molecule found in the vagina that has been studied as a biomarker of early fetal growth restriction and is being studied in the context of broader evaluation of placental dysfunction (7). These might apply if there are abnormalities of the placenta associated with preterm labour. Abnormal placentation, increased vascular resistance, and fetal compromise are all associated with preeclampsia.

However, composite Doppler indices of amniotic, umbilical, and cerebral circulation have been studied to predict adverse outcomes in pregnancies complicated by preeclampsia, indicating the potential for assessing vascular compartments (8). Other studies investigating early-onset fetal growth restriction also highlight the importance of systematic assessment of perinatal risk if the timing of intervention is taken into account (9). The observations are applicable to preterm labour because vascular abnormalities can be used to assess fetal risk and to identify pregnancies that are at risk and need closer monitoring. The cerebroplacental ratio is a combination of cerebral and placental resistance which represents the adaptation of the fetus to decreased oxygen supply. A number of studies have investigated the relationship between cerebroplacental, umbilical-cerebral, and cerebroplacental-uterine ratios with adverse perinatal outcomes in FGR (10).

For pregnancies complicated by early twin-to-twin transfusion syndrome, fetoscopic laser surgery depends on a detailed evaluation of the fetal and placental circulation, and outcome depends on the severity of the disease (11). When the fetus or

placenta is the reason for a premature delivery, Doppler evaluation can be helpful. Fetal Doppler findings may be affected by treatment and should be taken into account when interpreting. Antenatal cortico-therapy given when preterm delivery is expected has been linked to Doppler changes in the growth-restricted fetus with abnormal umbilical flow and severe early-onset preeclampsia (12). Gestational age, disease severity, and treatment exposure should be taken into account in measurements. There are also newer imaging techniques that are being investigated, such as the use of diffusion-derived vessel density from simplified intravoxel incoherent motion imaging as a biomarker of placental dysfunction in early preeclampsia (13). Conventional Doppler is still useful because it is non-invasive, easy to access and can be used for serial surveillance.

Another important aspect of fetal haemodynamic evaluation is umbilical circulation. Abnormal umbilical blood flow could be a sign of increased resistance of the placenta and decreased exchange between the placenta and the fetus. A true umbilical knot is a fetal anomaly that can be detected in utero and is an example of how ultrasound surveillance could be used to prevent unnecessary premature delivery and to keep the fetus safe (14). Umbilical venous blood flow has also been correlated with placental pathological changes in gestational diabetes, which indicates that venous measurements can also provide a more informative assessment of placental function (15). These results extend Doppler evaluation beyond single arterial resistance indices.

When labour starts prematurely, the association between Doppler abnormalities and delivery outcome is especially significant. In growth-restricted pregnancies undergoing induction, the pathological cerebroplacental ratio has been studied in relation to adverse delivery outcome, and the importance of fetal cerebral redistribution is emphasized (16). Placental vascular pathology has been shown to affect outcomes in monochorionic twin pregnancies complicated by twin-to-twin transfusion syndrome and selective fetal growth restriction, demonstrating that

vascular pathology can have an impact after laser treatment (17). Focused Doppler assessment in preterm labour is still relevant despite the amount of information available in fetal growth restriction and in pregnancies complicated by hypertension or diabetes. Preterm labour is a very diverse event, and uterine, umbilical, and cerebral Doppler parameters can be used to assess the circulatory status of the fetus, to define pregnancies that are at higher risk, and to shed light on the link between placental perfusion, fetal adaptation, and preterm birth.

Objective: To assess Doppler ultrasound parameters in pregnancies with preterm labour and to compare the relationship of Doppler parameters with fetal compromise, abnormal placental circulation and adverse perinatal outcome during hospital stay.

Materials And Methods

Study Design: Prospective observational study.

Study Setting: Department of Obstetrics and Gynecology, a tertiary-care teaching hospital in Rawalpindi, Pakistan.

Study Duration: February 2025 – July 2025.

Sample Size: 100 pregnant women.

Sample Technique: Consecutive sampling.

Inclusion criteria: Pregnant women aged 18 to 40 years, with singleton pregnancies and clinically diagnosed preterm labour between 28 and 36+6 weeks were included. Eligible participants were those who had been documented with fetal cardiac activity and were willing to have Doppler ultrasound assessment. Gestational age was determined by the reliable menstrual history or first trimester ultrasound if available.

Exclusion criteria: Women with multiple pregnancies, major fetal congenital anomalies, intrauterine fetal death, placenta previa and active major bleeding, or existing indications for immediate delivery prior to Doppler assessment were excluded. Patients who did not have complete clinical records and those who refused to participate were also excluded.

METHODS

Following informed consent, demographic and obstetric data were collected on a structured data collection form. Data on the clinical features of preterm labour, antenatal complications, blood pressure, parity, and maternal age were recorded. The same machine with the same transducer was used for obstetric ultrasound for all participants. The uterine arteries, umbilical artery, and middle cerebral artery were assessed using Doppler. Pulsatility index, resistance index, and systolic/diastolic ratio were noted when technically feasible. The middle cerebral artery pulsatility index (PI) was divided by the umbilical artery pulsatility index (PI) to obtain the cerebroplacental ratio (CPR). The Doppler abnormalities were classified by gestational age-specific reference ranges. The participants were then followed up until delivery. Data were collected on mode of delivery, gestational age at

delivery, birth weight, Apgar scores, admission to the neonatal intensive care unit (NICU), and other poor perinatal outcomes. The Doppler parameters were correlated with pregnancy and neonatal outcomes to see if there was any clinical association. Data were analyzed statistically using appropriate descriptive and inferential tests, and $p < 0.05$ was considered statistically significant.

Results

100 pregnant women with preterm labour (28–36+6 weeks) were included. The mean maternal age was 29.4 ± 5.1 years, and the mean gestational age at presentation was 33.2 ± 2.1 weeks. Fifty-eight women (58.0%) were multiparous, and 42 (42.0%) were primiparous. Abnormal Doppler parameters were present in 38 women (38.0%), while 62 women (62.0%) had Doppler parameters within the gestational-age-specific reference ranges (Table 1).

Table 1. Maternal and Doppler characteristics of study participants

Characteristic	n (%) / Mean $\pm$ SD
Total participants	100 (100)
Maternal age, years	29.4 ± 5.1
Gestational age, weeks	33.2 ± 2.1
Primiparous	42 (42.0)
Multiparous	58 (58.0)
Normal Doppler findings	62 (62.0)
Abnormal Doppler findings	38 (38.0)
Abnormal uterine artery Doppler	19 (19.0)
Abnormal umbilical artery Doppler	24 (24.0)
Abnormal MCA Doppler	21 (21.0)
Abnormal cerebroplacental ratio	26 (26.0)

The most common abnormal findings were the cerebroplacental ratio (26 women, 26.0%), umbilical artery pulsatility index (24 women, 24.0%), middle cerebral artery pulsatility index (21

women, 21.0%), and uterine artery Doppler (19 women, 19.0%). Graph 1 shows the distribution of Doppler findings

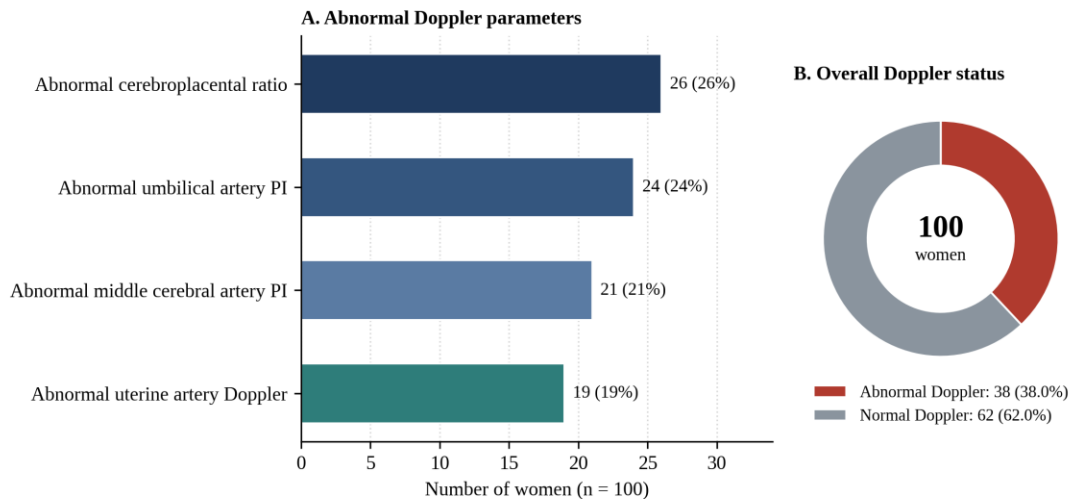


Figure 1. Distribution of abnormal Doppler parameters (A) and overall Doppler status (B). PI, pulsatility index.

In all, 31 neonates (31.0%) were admitted to the NICU, 27 neonates (27.0%) weighed less than 2.5 kg, and 18 neonates (18.0%) had an Apgar score of less than 7 at 5 minutes. Women with abnormal Doppler were more likely to have adverse outcomes. NICU admission occurred in 21 (55.3%) versus 10 (16.1%), low birth weight in 19 (50.0%) versus 8 (12.9%), and Apgar score below 7 in 13 (34.2%) versus 5 (8.1%) of those with abnormal and normal Doppler findings, respectively (Table 2).

Table 2. Perinatal outcomes according to Doppler findings

Outcome	Abnormal Doppler (n = 38)	Normal Doppler (n = 62)	p-value
NICU admission	21 (55.3%)	10 (16.1%)	<0.001
Birth weight <2.5 kg	19 (50.0%)	8 (12.9%)	<0.001
Apgar <7 at 5 minutes	13 (34.2%)	5 (8.1%)	0.002
Emergency cesarean delivery	18 (47.4%)	15 (24.2%)	0.018
Respiratory morbidity	16 (42.1%)	11 (17.7%)	0.006

Abnormal Doppler findings were also more common with emergency cesarean delivery (47.4% versus 24.2%, $p=0.018$) and neonatal respiratory morbidity (42.1% versus 17.7%, $p=0.006$). The association of Doppler status with each adverse outcome, along with the odds ratios, is shown in

Graph 2. In general, women with preterm labour who had abnormal antenatal Doppler parameters had higher perinatal morbidity, especially an abnormal cerebroplacental ratio and elevated umbilical artery resistance.

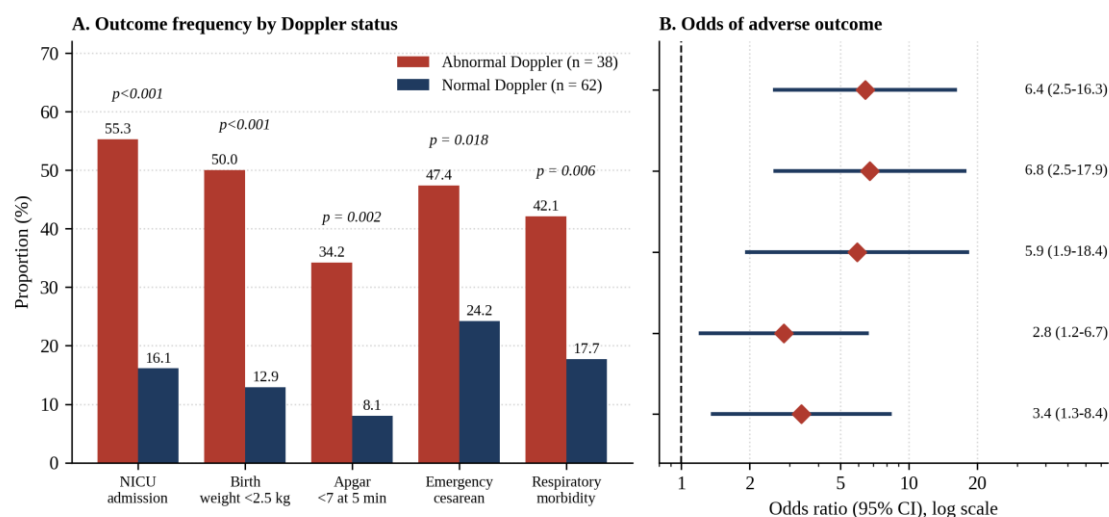


Figure 2. Adverse perinatal outcomes by Doppler status (A) and odds ratios with 95% confidence intervals (B).

DISCUSSION

In the present study, Doppler ultrasound parameters were investigated in 100 women with preterm labour, and abnormal Doppler parameters were found in 38% of the women. The most common abnormality was the cerebroplacental ratio, with altered umbilical artery and middle cerebral artery measurements being the next most common abnormalities. The results here confirm the utility of Doppler assessment in detecting pregnancies with placental resistance and fetal circulatory adaptation that may be impaired. Placental Doppler indices have been reported to be useful predictors of preterm birth in pregnancies complicated by fetal growth restriction (FGR) (1), especially in combination with placental growth factor. Likewise, antenatal Doppler studies have been shown to be useful for predicting adverse perinatal outcomes in women with maternal diabetes, and have been shown to be useful in other high-risk obstetric populations (2).

In this study, 19% of women had uterine artery Doppler abnormalities. Uterine artery evaluation is useful for information about the maternal uteroplacental circulation, and may suggest impaired placentation or increased vascular resistance. The current population was women with preterm labour and not low-risk term

pregnancies, but the role of uterine artery assessment is supported by prospective studies showing associations with perinatal outcomes based on uterine artery Doppler during labour (3). In a previous study, Hong et al. also showed that placental markers and fetoplacental Doppler parameters can be used to predict preterm delivery for fetoplacental Doppler parameters in pregnancies complicated by fetal growth restriction (4). The results indicate Doppler abnormalities could be a sign of underlying placental dysfunction that leads to premature delivery.

The relationship between abnormal Doppler and poor neonatal outcome was significant in this study. Women with abnormal Doppler results were more likely to be admitted to the NICU, to have low birth weight, low 5-minute Apgar score, respiratory morbidity, and emergency cesarean delivery. The results are biologically plausible, as placental underperfusion may lead to inadequate oxygen and nutrient supply to the fetus, which would lead to circulatory redistribution and a decreased tolerance of labour. Van de Meent et al. created a prediction model for adverse perinatal outcomes in EO-FGR and showed the value of combining several maternal and fetal risk factors for the assessment of perinatal risk (5). Therefore, Doppler assessment may be an important part of a

more comprehensive risk stratification for pregnancies that are at risk of premature delivery. Doppler interpretation is more complicated in multiple pregnancies. The present study was conducted on singleton pregnancies, but data from twin gestations show that there are significant fetal risks associated with abnormal placental conditions. Al-Alaiyan et al. reported the results of twin pregnancies with one intrauterine death, emphasizing the importance of close monitoring of the mother and surviving fetus in complicated twin pregnancies (6). Likewise, Bigagli et al. studied miR-210-3p in the vagina as a possible biomarker of early fetal growth restriction, highlighting the growing interest in the identification of placental dysfunction by complementary biological markers (7). Similarly, Doppler ultrasonography can be used as an easily accessible physiological index of fetal adaptation in the event of threatened preterm delivery. Another condition in which abnormal placental circulation can lead to fetal compromise and premature delivery is preeclampsia. The present study found that the APCR was relatively common and was linked to poor neonatal outcomes.

Müller et al. studied the amniotic-umbilical-to-cerebral ratio as a possible diagnostic marker for poor outcomes in pregnancies complicated by preeclampsia, arguing that the use of combined vascular indices might provide clinically relevant information (8). The OPTICORE study protocol also highlighted the importance of serial fetal assessment by proposing to study the timing of optimal antenatal corticosteroid and the perinatal risk in early-onset fetal growth restriction (9). These results highlight the need to use Doppler interpretation in conjunction with gestational age, maternal disease, and fetal condition. The most common Doppler parameter that was abnormal in the current study was the cerebroplacental ratio. This ratio includes middle cerebral artery and umbilical artery resistance and may represent fetal redistribution due to impaired placental function. Khanjani et al. did report correlations between cerebroplacental ratio, umbilical-cerebral ratio and cerebro-placental-uterine ratio and adverse perinatal outcomes in fetal growth restriction (10).

Fetal growth restriction was not a criterion for inclusion in the present study, but the nature of the adverse outcome patterns is suggestive of the possibility that abnormal fetal haemodynamic adaptation can play a role in preterm labour, regardless of the cause. Another mechanism that must be monitored closely in TTS is the severe placental vascular imbalance; fetoscopic laser surgery has shown the complexity of the fetal circulation compromise (11). Antenatal treatment should also be taken into account when interpreting Doppler measurements. In pregnancies complicated by early-onset severe preeclampsia and fetal growth restriction, administration of steroids to the mother has been linked to changes in fetal Doppler indices, especially when there is a problem with the umbilical artery Doppler (12). Therefore, Doppler measurements taken before and after corticosteroid treatment cannot be directly compared without taking into account the timing of treatment. New imaging modalities may give further information on placental vascularity. He et al. have reported that diffusion-derived vessel density (VD) is a potential biomarker for placental dysfunction in early preeclampsia, highlighting the growing importance of quantitative imaging methods in the assessment of abnormal placentation (13). However, conventional Doppler is still useful for repeated antenatal assessment as it is widely available and non-invasive.

Umbilical circulation abnormalities are especially significant because if there is increased resistance, there is a possibility that there is impaired exchange of the placenta. In the present study, 24% of the subjects had abnormal umbilical artery Doppler, and these abnormalities were associated with increased adverse neonatal morbidity. Bohiltea et al. emphasized the need for prenatal ultrasound surveillance when the umbilical cord is involved in a true knot, as appropriate diagnosis and surveillance could help minimize the risks of foetal compromise and unnecessary iatrogenic prematurity (14). In pregnancies complicated by gestational diabetes mellitus (GDM), Phaloprakarn et al. also showed an association between umbilical venous blood flow and

placental pathology (15). These observations indicate that there is potential for complementary information to be gained from assessment of both arterial and venous circulation on placental and fetal haemodynamics.

The higher the incidence of adverse outcomes in women with abnormal Doppler, the same is true for fetal cerebral redistribution. Bar Noy-Traub et al. compared pathological cerebroplacental ratios between growth-restricted pregnancies that were induced for labor and assessed the correlation between the ratios and adverse delivery outcomes (16). Their conclusions are especially relevant since labour imposes extra physiological stress on a fetus whose placenta is limited in reserve. Likewise, Ortiz et al. have reported the effects of laser treatment in twin-to-twin transfusion syndrome with selective fetal growth restriction, where the presence of selective fetal growth restriction affects fetal outcome after treatment for the underlying placental vascular disorder (17). The results of the present study confirm the correlation between Doppler abnormalities and risk of NICU admission, LBW, low Apgar score, respiratory morbidity, and emergency cesarean delivery, which indicates the value of Doppler surveillance in the comprehensive assessment of preterm labour. Doppler data is not a standalone examination, but clinical, gestational age, fetal growth, cardiotocography, maternal status, and other obstetric considerations are important when deciding on management and timing of delivery.

Conclusion

Doppler ultrasound is a useful non-invasive technique to assess fetal and placental haemodynamics in pregnancies at risk of preterm labour. In this study, a significant number of women had abnormal Doppler results, and these women had higher rates of adverse perinatal outcomes, such as admission to the neonatal intensive care unit, low birth weight, low Apgar scores, respiratory morbidity, and emergency cesarean delivery. In particular, abnormal cerebroplacental ratio and umbilical artery indices were highly significant markers of impaired fetal-placental circulation. These results indicate

Doppler assessment could help the clinician in determining the pregnancies that need closer fetal monitoring and careful delivery planning. But Doppler should be used in conjunction with gestational age, maternal clinical condition, fetal growth, and other fetal surveillance methods, not as a single indicator to guide management. Standardized Doppler assessment could enhance the identification of fetal compromise and timely obstetric care to prevent unnecessary perinatal morbidity and improve neonatal outcomes in the context of an evaluation of preterm labor.

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