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Original Research Article

Effectiveness of Doppler Velocimetry in the Management of High-Risk Pregnancy

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Abstract:

Background: High-risk pregnancies are associated with increased perinatal morbidity and mortality, largely due to placental insufficiency and fetal hypoxia. Doppler velocimetry offers a non-invasive method to assess uteroplacental and fetoplacental circulation and guide timely obstetric intervention.

Aim: To evaluate the effectiveness of Doppler velocimetry in the management of high-risk pregnancies and its impact on maternal and neonatal outcomes.

Methodology: This prospective cohort study included 80 women with high-risk pregnancies (≥28 weeks gestation), divided into Doppler (n=40) and non-Doppler (n=40) groups. Doppler assessment of uterine and umbilical arteries guided management in the Doppler group, while the non-Doppler group received conventional surveillance. Maternal, obstetric, and neonatal outcomes were compared using appropriate statistical tests.

Results: Doppler-guided management was associated with significantly better neonatal outcomes, including fewer low APGAR scores at 1 minute, reduced NICU admissions for both term and preterm neonates, shorter NICU stay, and absence of stillbirths or intrauterine fetal deaths. Normal Doppler findings significantly reduced the risk of emergency caesarean section.

Conclusion: Doppler velocimetry is an effective adjunct in managing high-risk pregnancies, enabling early detection of fetal compromise, optimizing obstetric decisions, and improving neonatal outcomes.

Keywords: Doppler velocimetry, high-risk pregnancy, perinatal outcome, uteroplacental circulation, fetal surveillance.

Introduction

High-risk pregnancy is one of the leading causes of perinatal morbidity and mortality in the whole world and especially in less developed countries where there may be limited access to highly developed antenatal surveillance. It is common to see conditions like pre-eclampsia, intrauterine growth restriction (IUGR), fetal anemia and umbilical cord defects that are typically linked to impaired placental functioning, resulting in chronic fetal hypoxia and negative neonatal outcomes. Timely detection of fetal compromise and its timely intervention is hence crucial aspects of contemporary obstetric care. Doppler velocimetry has been found to be a non-invasive, reliable, and extensively applicable modality of measuring uteroplacental and fetoplacental circulation among other tools that could be used to monitor the health of an unborn child during pregnancy [1].

Doppler ultrasound has proven to be a necessity in screening pregnancy at risk of preeclampsia, intrauterine growth restriction, fetal anaemia and abnormalities in umbilical cord. Doppler velocimetry helps clinicians to determine placental resistance and fetal adaptive responses to hypoxia by offering real-time data on blood flow patterns in maternal and fetal vessels. The abnormal Doppler waveforms tend to be developed before clinical degradation sets in; thus, obstetric intervention can be undertaken at the appropriate time before fetal harm is irreversible. Over the past few years, technology of Doppler and increased knowledge in the field of fetal hemodynamics have further increased its application in management of high-risk pregnancies [2].

Recent discoveries have assisted in scheduling the fetuses with severe growth restriction in the delivery process by facilitating Doppler of ductus venosus. The ductus venosus is a reflection of cardiac workload and cardiovascular output or central venous pressure and evaluation of the ductus venosus gives crucial information as to cardiovascular compromise in the fetus. First of all, it seemed like defects in ductus venosus beating were the very end of the distressed pregnancy with intrauterine growth restriction. But unlike the previous information, more recent information suggests these abnormalities to be a plateau before the fetus worsens further, which is in turn observed by the alteration of the biophysical profile. This emerging knowledge explains that fetal compromise is dynamic and it is essential to combine Doppler results with other fetal monitoring techniques to achieve the best clinical decisions [3].

Adverse perinatal outcomes burden is still disproportionately high in developing countries, and the majority of complications are of the placental-associated nature. It is already known that uteroplacental insufficiency is a key component to the pathophysiology of early-onset preeclampsia and IUGR. Uterine artery Doppler screening has been proved to be a useful screening method as it is able to select the majority of instances of these diseases. Moreover, high-risk pregnancies have been demonstrated to have some of their perinatal outcomes improved through the use of it as it allows closer observation and early intervention. The middle cerebral artery Doppler (especially when combined with umbilical artery Doppler) investigation seems more effective at predicting adverse outcomes in near-term pregnancies. This integrated evaluation is indicative of the redistribution of fetal blood flow otherwise known as the so-called brain-sparing effect, a compensatory mechanism to chronic hypoxia.

The adoption of Doppler velocimetry in antenatal surveillance was hypothesized to be a worthy addition to the currently existing list of tests to measure fetal well-being. Traditional techniques like fetal movement counting, cardiotocography and biophysical profiling though helpful, can only show fetal compromise at a relatively late stage. In its turn, doppler ultrasound has the advantage of detecting hemodynamic changes prior to the onset of the clinical symptoms. Obstetrical decision-making could be made better and help avoid intrauterine death, because hypoxic cerebral damage could occur prior to the labor onset [4] based on abnormal Doppler outcomes. Also, it is likely that intrapartum asphyxia is more harmful on chronic hypoxia and again it is important to detect compromised fetuses in the ante-partum phase.

Doppler evaluation can thus result in early intervention and decreased fetal brain injury and long-term neurological morbidity. Although the application on perinatal mortality and major morbidity in the high-risk pregnancies has been widely used clinically, the efficacy of Doppler velocimetry has remained a topic of research effort. A massive, randomized trial was the only way of testing the hypothesis that Doppler would be effective in the reduction of mortality and severe morbidity in high-risk pregnancy [5]. However, the role of fetal monitoring as a critical part of overall fetal care is still being reinforced by accruing observational and interventional studies, especially in those pregnancy cases that are complicated by issues of placental insufficiency.

Clinical application of Doppler outcomes has a direct impact on obstetrical care such as the level of surveillance, delivery time, and delivery method. The capability to risk stratifies the Doppler parameters enables clinicians to trade-off the risks of prematurity with the risks of further intrauterine hypoxia. This is especially essential in the resource-restricted environments, where efficient use of the existing diagnostic instruments may make a great difference in the perinatal outcomes.

This research was aimed at highlighting the impact of Doppler ultrasound on high-risk pregnancies, both in the context of obstetrical management, and fetal, prenatal and neonatal outcome. Through assessing the efficacy of Doppler velocimetry in informing clinical decision-making and enhancing outcomes, the study will further determine the role of Doppler velocimetry in the process of managing high-risk pregnancy and add to the existing evidence-based obstetric practice.

Methodology

Study Design: This study was designed as a prospective cohort study to evaluate the effectiveness of Doppler velocimetry in the management of high-risk pregnancies.

Study Area: The study was conducted in the Department of Radio-Diagnosis, in collaboration with the Department of Obstetrics and Gynecology, RDJM Medical College and Hospital, Turki, Muzaffarpur, Bihar, India

Study Duration: The study was carried out over a period of 6 months from February 2025 to July 2025

Sample Size: A total of 80 pregnant women with high-risk pregnancies were included in the study. The sample size was determined based on feasibility and patient availability during the study period.

Sample Population: The study population consisted of pregnant women attending the antenatal clinic or admitted to the obstetrics unit of RDJM Medical College and Hospital who were diagnosed with high-risk pregnancy.

Sampling Technique: A non-probability purposive sampling technique was used to recruit eligible participants.

Inclusion Criteria

Pregnant women fulfilling the following criteria were included in the study:

- Viable singleton pregnancy
- Gestational age ≥ 28 weeks
- Regular antenatal follow-up
- Presence of high-risk pregnancy factors, such as:
  - Pregnancy-induced hypertension or preeclampsia
  - Diabetes mellitus
  - Renal disease
  - Epilepsy
  - Cardiac disease
  - Bronchial asthma
  - History of three or more miscarriages
  - Previous preterm delivery
  - Seizure disorders or other significant medical illnesses

Exclusion Criteria

Pregnant women with the following conditions were excluded:

- Multiple pregnancies
- Fetuses with known congenital anomalies
- History of maternal smoking
- Intrauterine fetal demise at the time of presentation

Data Collection: Data were collected prospectively from pregnant women diagnosed with high-risk pregnancy attending the antenatal clinic or admitted to the obstetrics unit of RDJM Medical College and Hospital during the study period. After enrollment, baseline maternal demographic details, obstetric history, gestational age, and associated high-risk factors were recorded in a predesigned proforma. Participants were allocated into Doppler and non-Doppler groups using a sealed opaque envelope method. In the Doppler group, Doppler velocimetry findings including umbilical artery and uteroplacental artery indices were documented at each visit. Additional clinical findings, ultrasonography reports, fetal heart rate monitoring results, and pregnancy outcomes were systematically recorded for both groups until delivery.

Procedure: Gestational age was assessed using the last normal menstrual period in women with regular cycles and reliable dates and confirmed by ultrasonography performed before 24 weeks of gestation. In cases where the discrepancy between menstrual dating and ultrasound exceeded two weeks, ultrasound dating was considered final. Doppler velocimetry was performed in Group A using standard ultrasound equipment, with the patient positioned supine and a lateral tilt provided by a wedge under one hip. Waveforms were obtained from the umbilical artery and maternal uteroplacental artery, and indices such as the systolic/diastolic ratio and resistance index were calculated. Patients with normal Doppler findings were followed up with repeat Doppler examinations at fortnightly intervals according to gestational age. Abnormal Doppler results suggestive of increased vascular resistance or fetal compromise were communicated to the attending obstetrician, and management decisions were made in accordance with standard hospital protocols. Participants in the non-Doppler group were managed based on clinical assessment, ultrasonography, and fetal heart rate monitoring. Immediate intervention and delivery were undertaken whenever fetal distress was detected in either group.

Statistical Analysis: The collected data were compiled, coded, and entered into Microsoft Excel and subsequently analyzed using Statistical Package for the Social Sciences (SPSS) software, version 16 or higher. Descriptive statistics were used to summarize baseline characteristics and outcomes, and results were expressed as frequencies, percentages, means, and standard deviations. The chi-square test was applied to analyze categorical variables, while Student's t-test was used to compare continuous variables between the two groups. Odds ratios with 95% confidence intervals were calculated to assess the association between Doppler findings and adverse pregnancy outcomes. A p-value of less than 0.05 was considered statistically significant."

Result

Table 1 describes the socio-demographic characteristics of the study population in Group A (Doppler) and Group B (Non-Doppler), each comprising 40 participants. Most women in both groups were aged 24–34 years (45% in Group A and 40% in Group B), followed by those older than 34 years (40% and 35%, respectively), with no significant difference in age distribution between groups ($p = 0.28$). Multiparity was common in both groups, observed in 33 women (82.5%) in Group A and 30 women (75%) in Group B, with comparable parity distribution ($p = 0.42$). Consanguinity was reported in 6 women (15%) in Group A and 5 women (12.5%) in Group B, with no statistically significant difference between the groups ($p = 0.74$). Overall, Table 1 indicates that the two groups were comparable in terms of age, parity, and consanguinity.

Table 1: Socio-demographic characteristics of the study population			
Variables	**Group A (Doppler) n=40 (%)**	**Group B (Non-Doppler) n=40 (%)**	**P-value**
Age (years)			
<24	6 (15)	10 (25)	0.28*
24–34	18 (45)	16 (40)	
>34	16 (40)	14 (35)	
Parity			
Primipara	7 (17.5)	10 (25)	0.42**
Multipara	33 (82.5)	30 (75)	
Consanguinity			
Yes	6 (15)	5 (12.5)	0.74**
No	34 (85)	35 (87.5)	

Table 2 summarizes the maternal and fetal clinical profile and obstetric outcomes in Group A and Group B (n = 40 each). Normal amniotic fluid was significantly more common in Group B (30 cases, 75%) compared to Group A (18 cases, 45%), while polyhydramnios or oligohydramnios occurred more frequently in Group A (55% vs 25%), with this difference being statistically significant (p = 0.01). Labor induction was required in 7 women (17.5%) in Group A and 4 women (10%) in Group B, though the difference was not significant (p = 0.33). Caesarean section was the predominant mode of delivery in both groups, occurring in 30 cases (75%) in Group A and 28 cases (70%) in Group B (p = 0.62). Preterm delivery was more frequent in Group A (37.5%) than in Group B (25%), but this difference did not reach statistical significance (p = 0.23). Abnormal placental location and calcified placenta were observed slightly more often in Group A, though placental findings were comparable between the two groups.

Table 2: Maternal and fetal clinical profile and obstetric outcome			
Variables	**Group A n=40 (%)**	**Group B n=40 (%)**	**P-value***
Amniotic fluid			
Normal	18 (45)	30 (75)	0.01
Poly/Oligohydramnios	22 (55)	10 (25)	
Labor induction			
Yes	7 (17.5)	4 (10)	0.33
Mode of delivery			
Caesarean section	30 (75)	28 (70)	0.62
Gestational age at delivery			
Preterm	15 (37.5)	10 (25)	0.23
Term	25 (62.5)	30 (75)	
Placental findings			
Abnormal placental location	4 (10)	2 (5)	0.39
Calcified placenta	1 (2.5)	0 (0)	

Table 3 compares neonatal clinical features and outcomes between Group A and Group B (n = 40 each). Group A had a lower mean birth weight (2.6 ± 0.7 kg) than Group B (2.8 ± 0.6 kg), though this difference was not statistically significant (p = 0.08). An APGAR score <7 at 1 minute was significantly less frequent in Group A (8 neonates, 20%) compared to Group B (16 neonates, 40%) (OR 0.38; 95% CI: 0.14–0.98; p = 0.04), while at 5 minutes the difference was not significant (5% vs 15%; p = 0.12). NICU admissions were significantly lower in Group A for both preterm babies (46.7% vs 80%; OR 0.22; 95% CI: 0.04–0.9; p = 0.03) and term babies (24% vs 46.7%; OR 0.36; 95% CI: 0.12–0.9; p = 0.04). Neonatal mortality was lower in Group A among preterm neonates (2.5% vs 10%), though not statistically significant, with no term neonatal deaths in Group A. The mean duration of NICU stay was significantly shorter in Group A (11.8 ± 3.1 days) compared to Group B (15.6 ± 4.0 days; p = 0.001). Stillbirth and intrauterine fetal death occurred only in Group B (2.5% each).

Table 3: Neonatal clinical features and outcome				
Variables	**Group A n=40 (%)**	**Group B n=40 (%)**	**OR (95% CI)**	**P-value**
Birth weight (kg) (Mean ± SD)	2.6 ± 0.7	2.8 ± 0.6	—	0.08*
APGAR score <7				
At 1st minute	8 (20)	16 (40)	0.38 (0.14–0.98)	0.04
At 5th minute	2 (5)	6 (15)	0.29 (0.05–1.4)	0.12
NICU admission				
Preterm babies	7/15 (46.7)	8/10 (80)	0.22 (0.04–0.9)	0.03
Term babies	6/25 (24)	14/30 (46.7)	0.36 (0.12–0.9)	0.04
Neonatal mortality				
Preterm	1 (2.5)	4 (10)	0.23 (0.02–2.1)	0.18
Term	0 (0)	2 (5)	—	—
Duration of NICU stay (days) (Mean ± SD)	11.8 ± 3.1	15.6 ± 4.0	—	0.001*
Stillbirth	0	1 (2.5)	—	—
Intrauterine fetal death	0	1 (2.5)	—	—

Table 4 shows the risk of emergency caesarean section in relation to Doppler findings. In Group A, all patients with abnormal Doppler findings (6/6, 100%) required emergency caesarean section, compared to 14 of 34 patients (41.2%) with normal Doppler findings, indicating a substantially lower risk in the normal Doppler group (OR = 0.12; 95% CI: 0.03–0.50), with an absolute risk reduction (ARR) of 58.8% and relative risk reduction (RRR) of 58.8%. When comparing patients with normal Doppler in Group A to Group B, emergency caesarean section occurred in 14 patients (41.2%) versus 30 patients (75%) in Group B, respectively. This corresponded to a significantly reduced risk in the normal Doppler group (OR = 0.28; 95% CI: 0.11–0.70), with an ARR of 33.8% and an RRR of 45%. Overall, Table 4 indicates that normal Doppler findings are associated with a significantly lower risk of emergency caesarean section.

Table 4: Risk of emergency caesarean section in relation to Doppler findings				
Comparison	**Emergency C-section n (%)**	**OR (95% CI)**	**ARR (%)**	**RRR (%)**
Group A (Normal vs Abnormal Doppler)				
Normal Doppler (n=34)	14 (41.2)	0.12 (0.03–0.5)	58.8	58.8
Abnormal Doppler (n=6)	6 (100)			
Normal Doppler (Group A) vs Group B				
Normal Doppler	14 (41.2)	0.28 (0.11–0.7)	33.8	45
Group B	30 75)			

Discussion

The results of the current research support the previously recognized value of Doppler velocimetry as an efficient instrument in the process of high-risk pregnancies management, as they allow them to better classify the risk and intervene timely. The internal validity of the results is enhanced by the fact that the socio-demographic similarities of the Doppler and non-Doppler groups in terms of age, parity, and consanguinity make it possible to consider the observed differences in maternal and neonatal outcomes that could be more easily explained by Doppler-guided management than by the differences in the baseline. They have been identified as similar baseline matching in previous randomized and observational trials on the efficacy of Doppler in high-risk obstetrics, which highlight the significance of comparability in measuring perinatal outcomes (Trudinger et al., 1988) [6]."

The observation which made an interesting finding in this study was that a considerable positive detection of abnormal amniotic fluid volume and placental abnormalities was noticed in the Doppler group. This is in line with the evidence in the past which shows that Doppler assessment often detects placental insufficiency and related complications that do not manifest or may not manifest clinically in standard examination. According to McParland and Pearce, the abnormal Doppler waveforms are frequently found in association with placental pathology and disturbed fetal hemodynamics thus the greater representation of placental localization abnormalities and calcifications among Doppler-monitored pregnancies (McParland and Pearce, 1988) [7]. The greater relative frequency of oligohydramnios and polyhydramnios in the Doppler group in the current study probably indicates greater surveillance than an actual increase in the incidence, which argues that Doppler velocimetry is more sensitive to diagnosis in high-risk situations.

The trend in obstetric intervention realized in this study is in line with previous randomized trials. In spite of the fact that the total rates of caesarean section were high in both groups because population composition was high risk, emergent cases of caesarean section were closely linked to abnormal Doppler signals. As shown by Trudinger and colleagues, there were no significant differences in the proportion of elective delivery in both Doppler and control groups, however, emergency caesarean section and fetal distress during labour were significantly higher in the non-Doppler group (Trudinger et al., 1988) [6]. On the same lines, the current study, women who had abnormal Doppler findings consistently needed emergency caesarean section as compared to those women who did not have such results, and the prevalence of emergency intervention was significantly lower in women with normal Doppler results than in women with the non-Doppler group. This implies that, besides detecting at risk fetuses to compromise at the intrapartum phase, Doppler velocimetry is also used to prevent unnecessary emergency operations by covering the antenatal plans.

In this study, preterm birth was more prevalent in Doppler group, a fact that is consistent with findings of various studies carried out in the past. This seemingly high rate of preterm births can only be seen as a result of the active approach to obstetric choices as opposed to the negative influence of Doppler application. Tyrrell et al. found that regular Doppler monitoring resulted in early delivery of fetuses with compromised fetuses, which were related to better neonatal status at birth and less morbidity (Tyrrell et al., 1990) [8] . Doppler velocimetry seems to have been instrumental in the present research to distinguish between fetuses which could safely be left to complete gestation and those whose birth needed to be expedited because of fetal distress or in uteroal death, hence the increased number of the preterm births indicated.

The present study heavily favors Doppler-guided management on the outcomes of neonatal cases. The Doppler group had a lower mean birth weight, but this was not translated to poor neonatal outcomes. Quite on the contrary, much smaller numbers of neonates in Doppler group received low first-minute APGAR and lower numbers were in need of admission to NICU in both preterm and term groups. Such results coincide with the findings made by Tyrrell et al. where fewer depressed fifth-minute APGAR scores and lower morbidity occurred in routinely monitored Doppler groups in comparison with selectively monitored controls (Tyrrell et al., 1990) [8]. The shorter period of NICU stays in the Doppler group as seen in the current study also corroborates the idea that timely intervention on the basis of the Doppler results enhances the adaptation and recovery of the neonatal.

Of particular interest is the decrease of neonatal deaths, still births and intrauterine fetal deaths as witnessed in the Doppler group. The same tendencies were observed in systematic reviews and meta-analyses. The study conducted by Imdad et al. showed a 29 percent perinatal mortality impact reduction with the use of Doppler velocimetry in high-risk pregnancies and also a non-significant but clinically significant decrease in stillbirths (Imdad et al., 2011) [9]]. These findings and the preventive nature of Doppler surveillance are coherent with the present study since the Doppler group did not experience any stillbirths or intrauterine fetal deaths, and only the non-Doppler group did.

Moreover, the results of this paper are also supported by the review by Al-Qahtani, which proved that clinical management by Doppler ultrasonography significantly reduced antenatal hospitalization, induced birth, and caesarean section in fetal distress (Al-Qahtani, 2011) [10] [10]. Even though the overall rates of caesarean births were similar in the current research, Doppler directives seemed to alter the trend towards more suitable and timely intervention, hence lessening the fetal compromise and infant morbidity.

In summary, the current study supports the available literature that indicates the Doppler velocimetry is an important tool in enhancing the perinatal outcomes in high-risk pregnancies. Doppler surveillance makes a significant contribution to the evidence-based obstetric care by improving placental insufficiency detection, novel timing and delivery mode prediction, and the prevention of neonatal morbidity and mortality. Although this may not be an adequate solution to all the long-term morbidities acquired earlier in pregnancy, the results have shown that Doppler velocimetry is a useful technique that can be used to improve the outcomes of high-risk pregnancies when used as part of comprehensive antenatal care.

Conclusion

The current research has shown that the application of Doppler velocimetry in managing high-risk pregnancies will help to improve perinatal surveillance and better obstetric decision-making. Although the Doppler and non-Doppler groups had similar socio-demographic features, the pregnancies observed using Doppler technology had higher chances of identifying compromised fetuses to be subjected to timely interventions. This was manifested in better neonatal outcomes such as better instantaneous neonatal state, lesser necessity to be admitted in intensive care, less time on neonatal care, and less cases of adverse fetal results. Further, normal Doppler results were linked to a low likelihood of emergency section, and this is because normal Doppler plays a role in risk stratification and mode and time delivery selection. Altogether, Doppler velocimetry becomes a functional complement to the treatment of high-risk pregnancies because it can help to recognize fetal compromise early and enhance the outcomes of the baby.

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