e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(2); 2006-2011

Original Research Article

Role of Ultrasound and Doppler Studies in High-Risk Pregnancy Management

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Received: 01-11-2025 / Revised: 15-12-2025 / Accepted: 21-01-2026

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Conflict of interest: Nil

Abstract

Background: High-risk pregnancies are associated with an increase in maternal and foetal morbidity and mortality; therefore, they must be promptly identified and successfully managed. This is because ultrasound and Doppler procedures are indispensable for the early detection of issues and the assessment of foetal and placental health.

Methodology: In September 2023–March 2024, a hospital-based prospective observational study included 95 high-risk pregnant women over 20 weeks. Ultrasound assessed biophysical profile, amniotic fluid index, and foetal biometry, whereas Doppler measured uterine, umbilical, and middle cerebral artery indices. Foetal and maternal outcomes were collected using a structured proforma using descriptive and inferential statistics.

Results: Abnormal Doppler indices were associated with adverse outcomes such as foetal distress, growth limitation, NICU admission, and perinatal mortality in 31.6% of people ($p < 0.01$). Doppler and ultrasound findings helped diagnose damaged foetuses early.

Conclusion: Ultrasound combined with Doppler evaluation serves as a valuable diagnostic and prognostic tool in high-risk pregnancy management, guiding timely interventions and improving maternal and perinatal outcomes, particularly in resource-limited settings.

Keywords: Doppler ultrasound, Fetal Doppler indices. Fetal well-being, High-risk pregnancy, Obstetric ultrasound, perinatal outcome, Uteroplacental circulation.

DOI: 10.25258/ijcpr.18.2.331

Introduction

While pregnancy is a natural physiological process, some women suffer problems that require specialised care and continual monitoring to ensure the best outcomes for both mother and child [1]. In a high-risk pregnancy, a pregnancy-related disorder endangers the mother or foetus. Certain conditions before or during pregnancy raise the risk of poor perinatal outcomes. Due to increased perinatal morbidity and death, high-risk pregnancies affect obstetric therapy despite being a tiny fraction of pregnancies.

Diagnosing and managing high-risk pregnancies reduces the risk of IUGR, pre-eclampsia, premature birth, placental insufficiency, stillbirth, and perinatal asphyxia [2]. Early detection helps clinicians prepare for neonates, arrange safe births, and intervene in at-risk pregnancies. Due to unequal healthcare access and insufficient maternal education, developing nations like India have high maternal and newborn death rates. The Sample Registration System (SRS) Report 2020 suggests that increased prenatal surveillance could reduce maternal deaths in India, where the rate is 97 per 100,000 live births [3]. To accomplish Sustainable Development Goal (SDG) 3, which aims to reduce maternal death and improve infant survival, high-risk pregnancies must be identified and managed early.

Insufficient monitoring sets the mother and foetus at risk. Untreated prenatal hypertension, gestational diabetes, anaemia, and placenta previa can kill the mother [4]. In untreated hypertension, eclampsia, HELLP syndrome, and multi-organ failure can harm the mother and the child. Foetal hypoxia,

growth restriction, and intrauterine death can result from inadequate supervision [5]. Mild foetal anomalies require objective placental and foetal circulation tests. Doppler and ultrasonography are needed because fundal height and foetal heart sounds cannot detect early foetal distress.

Modern obstetrics relies on ultrasound to explain foetal development, placental position, amniotic fluid concentration, and birth problems. Regular sonography can detect placental insufficiency-related foetal biometry growth abnormalities [6]. Greyscale ultrasonography shows anatomy but not fetoplacental or uteroplacental circulation. This situation benefits from Doppler ultrasound. Doppler imaging provides real-time blood flow data from the uterine, umbilical, and middle cerebral arteries to assess foetal oxygenation and haemodynamics non-invasively [7]. The Systolic/Diastolic (S/D) ratio, Resistance Index (RI), and Pulsatility Index quantify vascular resistance and perfusion. Infant health is strongly correlated with these parameters.

Numerous investigations have proven that Doppler ultrasonography can predict high-risk pregnancies. [8] Found a strong correlation between abnormal umbilical artery Doppler indices and negative perinatal outcomes like IUGR and newborn intensive care unit hospitalisation in the Indian Journal of Radiology and Imaging. In pre-eclamptic pregnancies, uterine and middle cerebral artery Doppler evaluations enhanced foetal compromise prediction [9].

These findings emphasise the need for multiparametric Doppler in high-risk pregnancy screening. In a global meta-analysis, [10,11] found that umbilical artery Doppler surveillance reduced neonatal mortality by approximately 29% in high-risk pregnancies compared to traditional monitoring alone. Cochrane Database of Systematic Reviews published the study [12].

Even though global data support Doppler use, regional differences in availability, awareness, and application persist, especially in resource-poor places like northern Bihar. Muzaffarpur, a major district in north Bihar, serves many rural areas with healthcare. Inappropriately, many pregnant women in this area arrive late for prenatal checkups and can't get regular ultrasounds or professional obstetric checks. Problems with high-risk pregnancies may not be identified until they become serious. A diverse patient group, including many high-risk cases referred from outlying health institutions, visits Shree Krishna Medical College & Hospital (SKMCH), a tertiary care and teaching institution. This unique cohort is ideal for researching how ultrasonography and Doppler evaluation can improve prenatal care.

This research evaluates how well ultrasound and Doppler investigations at SKMCH, Muzaffarpur, identify, follow, and treat high-risk pregnancies. This research examines regional Doppler indicators and pregnancy outcomes to improve clinical decision-making and reduce maternal-fetal issues. This study should improve Bihar's prenatal surveillance, which will support national perinatal and maternal health initiatives.

Objective

- To assess the role of ultrasound and Doppler studies in the early detection and monitoring of high-risk pregnancies.
- To evaluate the correlation between abnormal Doppler indices (uterine, umbilical, and middle cerebral arteries) and adverse maternal and fetal outcomes.
- To determine the clinical utility of ultrasound and Doppler in guiding management decisions and improving perinatal outcomes in high-risk pregnancies at Shree Krishna Medical College & Hospital, Muzaffarpur.

Materials and Methods

Study Design: In high-risk pregnant women, ultrasonography and Doppler tests were assessed in this prospective observational study, which was hosted. A prospective design allowed accurate clinical and imaging results, real-time patient monitoring, and perinatal outcomes.

Setting: Obstetrics and Gynaecology at SKMCH, Muzaffarpur, Bihar, was researched. The tertiary care teaching hospital SKMCH serves urban and rural patients, representing the region's high-risk pregnancies.

Duration: The study spanned seven months, from September 2023 to March 2024, during which all eligible high-risk pregnant women presenting to the department were recruited and followed up until delivery.

Sample Size: The study comprised 95 pregnant women who were at significant risk. Doppler indices and pregnancy outcomes were investigated with significant statistical power, and the sample size was appropriate for the study's duration.

Inclusion Criteria

- Pregnancy-Induced Hypertension (PIH)
- Gestational Diabetes Mellitus (GDM)
- Intrauterine Growth Restriction (IUGR)
- Anemia
- Other obstetric complications

Exclusion Criteria

- Multiple gestations
- Known congenital anomalies
- Inability to complete follow-up

- These criteria ensured consistency and reliability of the collected data

Tools and Techniques: Each participant had an obstetric ultrasound with amniotic fluid index, foetal development, and biophysical profile data. Also examined with Doppler were the uterine, umbilical, and middle cerebral arteries. RI, PI, and S/D ratios were measured. A systematic proforma recorded patient demographics, risk factors, ultrasound and Doppler data, and pregnancy outcomes.

Statistical Analysis: Excel data was subjected to SPSS analysis. Descriptive statistics include the mean, standard deviation, and distribution percentage. A correlation study was conducted to determine whether anomalous Doppler indices were associated with adverse mother-child outcomes. Statistical significance was indicated by a p-value that was less than 0.05.

Ethical Considerations: The study's methodology was approved by the Institutional Ethical Committee of SKMCH. In order to ensure patient privacy and ethical considerations, we mandated that participants sign an informed consent form following an explanation of the study's objectives, methodology, and potential risks.

Results

Demographic Profile: There were 95 high-risk expectant women who participated in the study. While the majority of mothers (55%) were between the ages of 21 and 30, the average age was 27.4 ± 4.6 years. The parity breakdown was as follows: 48% were first-time mothers, 35% had two or three pregnancies, and 17% were grand-multigravida. Targeted antenatal interventions in resource-limited populations are particularly important, as 60% of participants were classified as lower-middle and lower socioeconomic classes, as indicated by the socioeconomic evaluation.

Table 1: Demographic Profile of Study Population

Characteristic	Number of Cases	Percentage (%)
Age Group (years)		
18–20	12	12.6
21–25	28	29.5
26–30	24	25.3
31–35	20	21.1
>35	11	11.5
Parity		
Primigravida	46	48.4
Multigravida (2–3)	33	34.7
Grand multigravida (>3)	16	16.8
Socioeconomic Class		
Lower	25	26.3
Lower-middle	32	33.7
Upper-middle	28	29.5
Upper	10	10.5

Distribution of Risk Factors: The most prevalent risk factor in the study population was PIH, which was present in 30 women (31.6%). GDM was present in 22 women (23.2%), anaemia in 18 women (18.9%), and IUGR in 15 women (15.8%). Ten women (10.5%) had additional modest risk factors, such as hypothyroidism and prior caesarean sections.

Table 2: Distribution of Risk Factors

Risk Factor	Number of Cases	Percentage (%)
PIH	30	31.6
GDM	22	23.2
Anemia	18	18.9
IUGR	15	15.8
Others	10	10.5

Ultrasound Findings: Foetal growth restriction was identified in 17 cases (17.9%) during the ultrasound evaluation. 20 participants (21.1%) exhibited abnormal amniotic fluid index (AFI), with 12 instances of oligohydramnios and 8 cases of polyhydramnios. The absence of foetal structural anomalies in any participant was consistent with the exclusion of known congenital anomalies.

Table 3: Ultrasound Findings

Ultrasound Parameter	Number of Cases	Percentage (%)
IUGR	17	17.9
Oligohydramnios (AFI < 5 cm)	12	12.6
Polyhydramnios (AFI > 24 cm)	8	8.4
Normal Amniotic Fluid Index	75	78.9
Fetal Structural Anomalies	0	0

Doppler Findings: The Doppler assessment revealed that 25 women (26.3%) exhibited umbilical artery abnormalities, 18 women (18.9%) exhibited uterine artery abnormalities, and 15 women (15.8%) exhibited MCA abnormalities. A total of 30 participants (31.6%) exhibited at least one abnormal Doppler parameter. Abnormal Doppler indices were significantly correlated with foetal compromise.

Table 4: Doppler Findings

Doppler Parameter	Normal	Abnormal	Percentage Abnormal (%)
Umbilical Artery (UA)	70	25	26.3
Uterine Artery (UtA)	77	18	18.9
Middle Cerebral Artery (MCA)	80	15	15.8
Any Abnormal Doppler Parameter	65	30	31.6

Correlation with Maternal and Fetal Outcomes: Foetal discomfort was recorded at 23.2%, IUGR at 17.9%, NICU admission at 21.1%, and perinatal mortality at 5.3%. According to statistics, there is a significant correlation between negative perinatal outcomes and aberrant Doppler findings ($p < 0.01$). Faulty umbilical artery Doppler was associated with a 4.2-fold increase in IUGR rates ($r = 0.41$, $p = 0.004$). Combining uterine and MCA Doppler anomalies increased NICU hospitalisations ($r = 0.38$, $p = 0.007$). These results indicate that ultrasonography and Doppler can be used to identify at-risk foetuses, which can then be treated promptly to enhance the prognosis of infants.

Discussion

Interpretation of Findings: A prospective observational analysis of 95 high-risk expectant women conducted at a hospital revealed significant maternal and foetal outcomes. According to previous research conducted in India on high-risk obstetric populations, PIH was 31.6% and GDM was 23.2%. This underscores the ongoing health promotion concern of metabolic and hypertensive complications during pregnancy. These illnesses can cause IUGR, premature birth, pre-eclampsia, and gestational difficulties in mothers and foetuses. Similar to north Indian tertiary care institutes, this group exhibited significant rates of anaemia (18.9%) and intrauterine growth restriction (15.8%).

Ultrasound examination showed 17.9% of foetuses with IUGR and 21.1% with AFIs like oligohydramnios and polyhydramnios. This study shows that biophysical and anatomic evaluations can detect prenatal growth issues.

Doppler abnormalities were found in 31.6% of patients, mostly in the umbilical, uterine, and middle cerebral arteries. This pattern of vascular impairment distribution is typical of high-risk pregnancies. Placental insufficiency begins with increased umbilical circulation resistance and spreads to other foetal veins.

These data support a robust link between umbilical artery Doppler anomalies in 28-30% of high-risk pregnancies and unfavourable perinatal outcomes, such as low birth weight and NICU hospitalisations study 1,2. In hypertensive pregnancies, anomalous uterine and middle cerebral artery Doppler indices improve foetal impairment prognosis, according to study 3. Our research supports these assertions and shows how useful Doppler evaluation is in hospitals and other tertiary care settings.

Table 5: Comparison of Current Study with Existing Literature

Study	Study Type	Sample Size	Key Findings
Present Study (Muzaffarpur, 2023–24)	Prospective observational	95	Abnormal Doppler indices in 31.6%; significant correlation with fetal distress, IUGR, NICU admission, and perinatal mortality; early detection via ultrasound and Doppler guided timely interventions.
Study 1 [13]	Prospective observational	120	Umbilical artery Doppler abnormalities in 28–30% of high-risk pregnancies; strong association with low birth weight and adverse neonatal outcomes.
Study 2 [14]	Prospective cohort	100	Combined uterine and MCA Doppler evaluation improved prediction of fetal compromise in

			hypertensive pregnancies; facilitated early intervention.
Study 3 [15]	Prospective cohort	110	Doppler abnormalities (UA, MCA, UtA) significantly predicted adverse perinatal outcomes; highlighted the brain-sparing effect in chronic fetal hypoxia.

Clinical Significance of Abnormal Doppler Results

Abnormal Doppler indices can indicate compromised uteroplacental and foetoplacental circulation before clinical indications of foetal distress appear. IUGR significantly correlated with umbilical artery anomalies ($r = 0.41$, $p = 0.004$) and uterine and middle cerebral artery abnormalities with higher NICU hospitalisation rates ($r = 0.38$, $p = 0.007$). These findings support the predictive ability of non-invasive, real-time Doppler evaluations of foetal health. Initial diagnosis of abnormal blood flow patterns allowed obstetricians to enhance neonatal outcomes by administering corticosteroids, monitoring foetuses, and delivering early. This preventive care can avoid the worst outcomes stillbirth, prenatal hypoxia, and emergency caesarean sections. Placental vascular resistance affects foetal oxygenation and nutrition, according to abnormal Doppler evidence. High umbilical artery S/D ratios and resistance indices indicate placental insufficiency, while MCA "brain-sparing" patterns may indicate foetal tolerance to hypoxia. Doppler patterns can help clinicians classify pregnancies as low, moderate, or high risk and adjust monitoring and management.

Impact of Early Detection via Ultrasound and Doppler

Ultrasonography and Doppler can detect at-risk foetuses before the emergence of clinical indications. Rapid Doppler pattern recognition resulted in obstetric decision-making and a 5.3% perinatal mortality rate, despite the group's high risk. Early detection enables expectant women to receive personalised prenatal care, which may include follow-up plans, targeted therapies, and tertiary referrals. Oligohydramnios or irregular umbilical artery flow may result in premature delivery under controlled circumstances. It enhances the survival of newborns and mitigates complications. Doppler should be a standard component of prenatal care, particularly for high-risk mothers.

Unique Observations from the Muzaffarpur Cohort

The fact that 60% of mothers in this geographical cohort are low-income suggests that a lack of awareness, transportation, and financial resources impedes early antenatal care. At-risk expectant women were identified through the systematic ultrasound and Doppler screening of a tertiary care centre, despite the presence of these obstacles. The health consequences gap between rural and semi-urban mothers as well as newborns can be reduced by enhanced obstetric surveillance, even in low-resource settings. Most likely as a result of inadequate health education and counselling before pregnancy, 48.4% of first-time mothers encountered high-risk health issues. These findings stress health awareness, community engagement, and personalised interventions to minimise high-risk pregnancies.

Limitations

Despite its significance, this study has several drawbacks. A single-center design may have missed high-risk pregnancies in Bihar or India, and the 95-person sample size may limit generalisability. Because they didn't examine neonatal outcomes following the perinatal period, they can't assess Doppler-guided therapies. Operator experience and subjective Doppler measurements may affect outcomes. Future multicentric research must validate and build on these conclusions with a larger sample size, standardised methods, and longer follow-up.

Conclusion

This study reveals that ultrasound and Doppler exams are crucial for high-risk pregnancies at Shree Krishna Medical College & Hospital in Muzaffarpur. Ultrasound gave biophysical and anatomical features, whereas Doppler testing of the uterine, umbilical, and middle cerebral arteries revealed foetal haemodynamics and placental perfusion.

Abnormal Doppler indices strongly predicted foetal distress, intrauterine growth restriction, NICU hospitalisations, and perinatal mortality in clinical practice. Early detection and rapid therapies of injured foetuses improved prenatal outcomes for a high-risk and socioeconomic population. Doppler tests should be routine for high-risk pregnant women, and this study shows that systematic antenatal surveillance is possible and beneficial even in low-resource settings. Despite a small sample size and single-center design, ultrasonography with Doppler evaluation improves perinatal care, mother and baby outcomes, and clinician decision-making.

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