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Research Article

Role of Doppler Ultrasonography in Prediction of Adverse Perinatal Outcome in High Risk Pregnancy

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Abstract: ***Introduction:*** High-risk pregnancies, including those complicated by intrauterine growth restriction (IUGR), pregnancy-induced hypertension (PIH), gestational diabetes mellitus (GDM), and other obstetric complications, are associated with increased perinatal morbidity and mortality. Early identification of fetal compromise is essential to optimize perinatal outcomes. Doppler ultrasonography is a non-invasive modality that evaluates fetal and placental circulation and can predict adverse perinatal outcomes.**Objective:**To assess the role of Doppler ultrasonography in predicting adverse perinatal outcomes in high-risk pregnancies.**Methods:**A cross-sectional descriptive study was conducted at Tezpur Medical College & Hospital over one year. Fifty high-risk pregnant women between 28–38 weeks of gestation were included based on predefined inclusion and exclusion criteria. Doppler ultrasonography of the umbilical artery (UA), middle cerebral artery (MCA), and uterine artery (UTA) was performed, and indices such as pulsatility index (PI), resistance index (RI), and cerebroplacental (MCA/UA) ratio were calculated. Maternal demographics, obstetric history, and neonatal outcomes, including birth weight, Apgar scores, NICU admission, and mode of delivery, were recorded. Statistical analysis was performed using SPSS version 26, and predictive accuracy, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of Doppler indices were assessed.**Results:**Abnormal UA PI and RI, reduced MCA PI, and decreased MCA/UA PI ratio were significantly associated with adverse perinatal outcomes, including low birth weight (38%), preterm birth (24%), NICU admission (32%), and stillbirth (6%). MCA/UA PI ratio <1.08 showed a sensitivity of 77.8% and specificity of 84.4% in predicting adverse outcomes. Multiparametric assessment combining UA and MCA Doppler indices demonstrated higher predictive accuracy than single-vessel evaluation, facilitating timely obstetric interventions.**Conclusion:**Doppler ultrasonography is an effective, non-invasive tool for early detection of fetal compromise in high-risk pregnancies. Routine use can guide timely interventions, reduce perinatal complications, and improve neonatal outcomes.

Keywords: Doppler Ultrasonography, High-Risk Pregnancy, Fetal Compromise, MCA/UA Ratio, Perinatal Outcome.

INTRODUCTION

High-risk pregnancies are defined as those in which the mother, fetus, or both are at increased risk of morbidity or mortality during gestation, delivery, or the postpartum period. The timely identification and monitoring of such pregnancies are crucial to improving perinatal outcomes and reducing neonatal morbidity and mortality.[1] Doppler ultrasonography has emerged as a non-invasive, reliable, and widely available tool for assessing fetal well-being, particularly by evaluating blood flow in the maternal, placental, and fetal circulations.[2,3] Abnormal Doppler indices, such as elevated resistance in the umbilical artery, absent or reversed end-diastolic flow, and altered middle cerebral artery or ductus venosus patterns, have been associated with placental insufficiency and adverse perinatal outcomes, including intrauterine growth restriction (IUGR), preterm birth, hypoxia, and stillbirth.[4–6]

Placental insufficiency, a common complication in high-risk pregnancies, leads to reduced oxygen and nutrient delivery to the fetus, which can trigger adaptive fetal hemodynamic changes detectable on Doppler studies.[7] For instance, redistribution of blood flow to essential organs like the brain, reflected by a decreased cerebroplacental ratio (CPR), indicates fetal compromise and predicts increased risk of adverse outcomes.[8] Umbilical artery Doppler velocimetry provides insight into placental vascular resistance, and abnormal findings have been consistently correlated with higher rates of perinatal morbidity and mortality, particularly in pregnancies complicated by hypertensive disorders, preeclampsia, or IUGR.[9,10]

Doppler assessment of maternal uterine arteries also offers predictive value. High resistance or notching in uterine artery waveforms during the second trimester has been associated with the development of preeclampsia and fetal growth restriction later in pregnancy.[11] Moreover, ductus venosus Doppler analysis in the third trimester can identify fetuses at risk of cardiac compromise or acidemia, providing crucial information for timing of delivery.[12] The integration of these Doppler parameters into routine antenatal surveillance allows obstetricians to stratify risk, intervene timely, and

potentially reduce the incidence of severe perinatal complications.[13]

Despite its proven utility, the predictive accuracy of Doppler ultrasonography may vary depending on the population studied, the specific vessels examined, and gestational age at assessment. Studies have shown that combining multiple Doppler parameters improves sensitivity and specificity for predicting adverse outcomes compared to single-parameter evaluation.[3,6] Therefore, systematic Doppler surveillance in high-risk pregnancies is increasingly recognized as an essential component of antenatal care. It provides a dynamic assessment of fetal health, allowing timely intervention to optimize outcomes and minimize neonatal morbidity and mortality. Doppler ultrasonography represents a vital non-invasive diagnostic modality that bridges the gap between fetal pathophysiology and clinical management. By detecting early signs of compromised fetal circulation, it guides obstetric decision-making and delivery planning in high-risk pregnancies. The ability to predict adverse perinatal outcomes accurately enables clinicians to provide targeted care, including early hospitalization, intensified monitoring, or preterm delivery when necessary, ultimately contributing to improved neonatal survival and reduced long-term sequelae.

MATERIALS AND METHODS

Study Design

The study was designed as a cross-sectional descriptive study aimed at evaluating the role of Doppler ultrasonography in predicting adverse perinatal outcomes in high-risk pregnancies. A cross-sectional descriptive design was chosen as it allowed for systematic observation of a defined population at a single point in time to assess the correlation between Doppler parameters and perinatal outcomes. This design was suitable for capturing the prevalence of abnormal Doppler indices and their association with maternal and fetal complications in a high-risk obstetric population.

Study Setting

The study was conducted at Tezpur Medical College and Hospital, Assam, which is a tertiary care center equipped with facilities for high-risk obstetric care, including a dedicated ultrasonography unit with Doppler capabilities. The hospital caters to a large population from both urban and rural areas, providing an appropriate setting to enroll a representative sample of high-risk pregnancies.

Study Duration

The study was carried out over a period of one year, from January 2024 to December 2024. This duration was deemed sufficient to recruit an adequate number of participants fulfilling the inclusion criteria and to follow them through the antenatal period until delivery for assessment of perinatal outcomes.

Participants

The study population consisted of pregnant women clinically diagnosed with high-risk pregnancies and referred for Doppler ultrasonography at the Tezpur Medical College and Hospital. Participants included women with clinical suspicion of intrauterine growth restriction (IUGR), pregnancy-induced hypertension (PIH), gestational diabetes mellitus (GDM), severe anemia, polyhydramnios, or those with a history of adverse obstetric outcomes.

Inclusion Criteria

Participants were included if they met the following criteria:

1. Pregnant women with clinical suspicion of IUGR.
2. Pregnant women diagnosed with PIH.
3. Pregnant women with GDM.
4. Pregnant women with severe anemia.
5. Pregnant women with polyhydramnios.
6. Pregnant women with a history of previous adverse obstetric outcomes.
7. Participants providing informed consent or assent through guardians/relatives.

Exclusion Criteria

Participants were excluded if they met any of the following:

1. Women who refused to participate in the study.
2. Pregnant women with diagnosed fetal anomalies.
3. Pregnant women with pre-existing cardiac disease.
4. Pregnant women with connective tissue disorders.

Study Sampling and Sample Size

A total of 50 high-risk pregnant women who satisfied the inclusion criteria were recruited for the study. Convenience sampling was applied, enrolling all eligible participants referred for Doppler ultrasonography during the study period. Each participant was assigned a unique study identification number to maintain confidentiality and facilitate data tracking.

Study Parameters

The primary parameters included Doppler ultrasonography indices such as Pulsatility Index (PI), Resistance Index (RI), and Systolic/Diastolic (S/D) ratio of the umbilical artery, uterine artery, and middle cerebral artery. Secondary parameters included maternal demographic characteristics, obstetric history, and perinatal outcomes, including birth weight, Apgar scores, NICU admission, and perinatal mortality.

Study Procedure

After enrollment, a detailed history and clinical examination were performed for each participant. Relevant laboratory investigations were recorded, and Doppler ultrasonography was conducted for all eligible women. Waveforms were obtained from the umbilical artery, uterine artery, and middle cerebral artery, and the

respective indices (PI, RI, S/D ratio) were calculated. Participants were followed up through the remainder of their pregnancy, with subsequent Doppler assessments scheduled as clinically indicated. Delivery details and neonatal outcomes were documented systematically.

Study Data Collection

Data were collected using a pre-designed proforma, which included patient demographics, obstetric history, Doppler findings, and perinatal outcomes. Doppler ultrasonography was performed by experienced sonographers using standardized protocols to minimize inter-observer variability. Perinatal outcomes were followed up until hospital discharge of the neonate, ensuring accurate capture of birth weight, Apgar scores, NICU admissions, and neonatal complications.

Statistical Analysis

All collected data were entered into a computerized database and analyzed using SPSS version 26. Descriptive statistics were used to summarize demographic and clinical characteristics. Doppler indices were correlated with adverse perinatal outcomes using appropriate statistical tests, and results were presented in textual, tabular, and graphical formats. P-values <0.05 were considered statistically significant.

Ethical Considerations

The study protocol was submitted to the Institutional Ethical Committee of Tezpur Medical College and Hospital and approval was obtained prior to the commencement of the study. Written informed consent was obtained from all participants or their legal guardians, and confidentiality was maintained throughout the study by using unique identification numbers and secure storage of data. Participants were informed about the purpose, procedures, risks, and benefits of the study, and they had the right to withdraw at any stage without affecting their medical care.

RESULTS

The study included 50 high-risk pregnant women referred for Doppler ultrasonography at Tezpur Medical College and Hospital. The participants were evaluated for general characteristics, Doppler indices, fetal blood flow redistribution, and their association with adverse perinatal outcomes. Adverse perinatal outcomes included low birth weight (<2.5 kg), NICU admission, preterm birth, and perinatal morbidity or mortality.

Majority of high-risk pregnancies were in the 26–30 years age group (52%), followed by 20–25 years (30%), while only 18% were above 30 years.

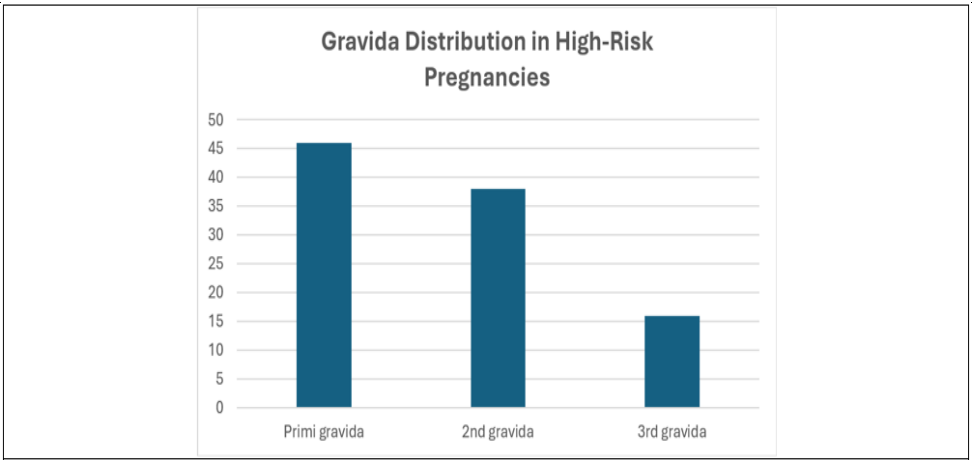
Age Group (years)	Primi gravida	2nd gravida	3rd gravida	Total (n)	Percentage (%)
20–25	8	5	2	15	30
26–30	12	10	4	26	52
>30	3	4	2	9	18
Total	23	19	8	50	100

Table 1: Age-wise Distribution of High-Risk Pregnancy

Most high-risk cases were primigravida (46%), consistent with higher risk in first pregnancies.

Gravida	Number (n)	Percentage (%)
Primi gravida	23	46
2nd gravida	19	38
3rd gravida	8	16
Total	50	100

Table 2: Gravida Distribution in High-Risk Pregnancies



Graph 1

Reduced MCA/UA PI (<1.08) was associated with a higher rate of adverse perinatal outcomes (77.8%), indicating significant fetal blood flow redistribution in compromised fetuses

MCA/UA Pulsatility Index	**Numbers (n)**	**Adverse Outcome (n)**
< 1.08	18	14
≥ 1.08 (Normal)	32	5
Total	50	19

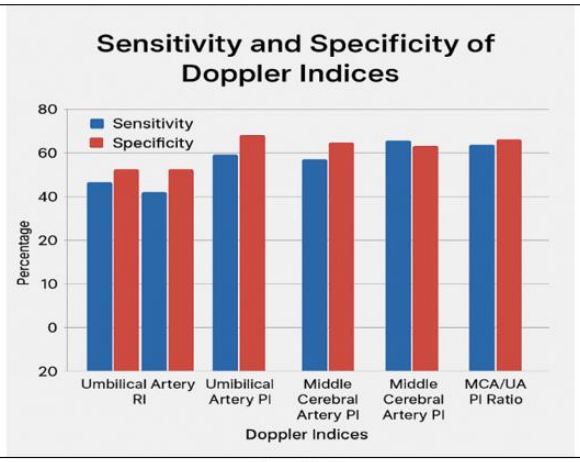
Table 3: Fetal Blood Flow Redistribution (MCA/UA PI Ratio)

Elevated UA RI (>0.70) showed good specificity (90%) in predicting adverse outcomes.

The table demonstrates the predictive performance of various Doppler ultrasonography indices in high-risk pregnancies. Umbilical artery (UA) PI >1.20 exhibited higher sensitivity (76.5%) and a high predictive value (PPV 76.5%, NPV 87.9%) compared to UA RI (>0.70), indicating it is a more reliable indicator for identifying fetuses at risk. UA S/D ratio >3 showed the highest specificity (93.9%) but lower sensitivity (64.7%), suggesting it is useful for confirming, rather than screening, adverse outcomes. Middle cerebral artery (MCA) PI <1.00 reflected fetal adaptation to hypoxia with good sensitivity (77.8%) and specificity (87.5%), whereas MCA/UA PI ratio <1.08 provided the most balanced predictive accuracy (sensitivity 77.8%, specificity 84.4%, NPV 87.1%), making it the most reliable single marker for fetal compromise in this study. Overall, multiparametric Doppler assessment, combining UA and MCA indices, enhances early detection of adverse perinatal outcomes, facilitating timely obstetric interventions such as preterm delivery or cesarean section to improve neonatal outcomes.

Doppler Parameter	**Cut-off**	**TP**	**TN**	**FP**	**FN**	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**
Umbilical Artery RI		12	30	3	5	70	90	80	85
Umbilical Artery PI	>1.20	13	29	4	4	76.5	87.9	76.5	87.9
Umbilical Artery S/D	>3	11	31	2	6	64.7	93.9	84.6	83.7
Middle Cerebral Artery PI	<1.00	14	28	4	4	77.8	87.5	77.8	87.5
MCA/UA PI Ratio	<1.08	14	27	5	4	77.8	84.4	73.7	87.1

Table 4: Comparison of Doppler Ultrasonography Indices with Perinatal Outcomes in High-Risk Pregnancies

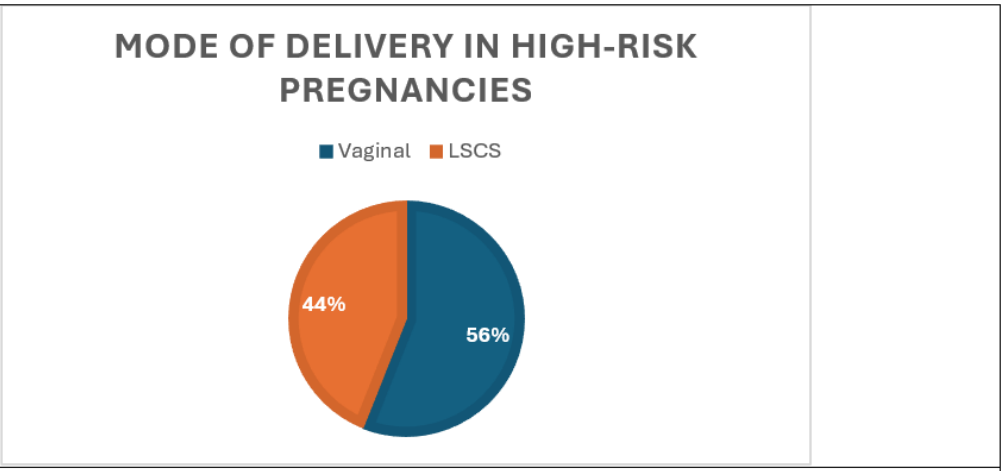


Graph 2

A substantial proportion of high-risk pregnancies required cesarean section (44%) due to fetal distress or Doppler abnormalities.

Mode of Delivery	Number (n)	Percentage (%)
Vaginal	28	56
LSCS	22	44
Total	50	100

Table 5: Mode of Delivery in High-Risk Pregnancies

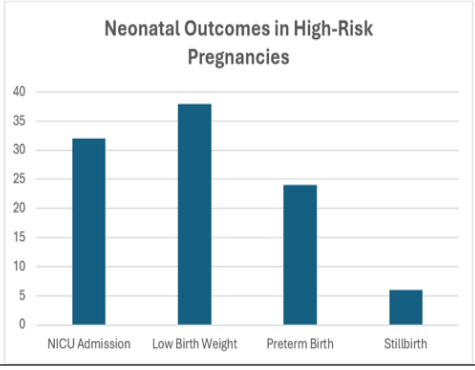


Graph 3

Adverse perinatal outcomes were significantly associated with abnormal Doppler indices, particularly low MCA/UA PI and elevated UA PI/RI.

Outcome	Number (n)	Percentage (%)
NICU Admission	16	32
Low Birth Weight	19	38
Preterm Birth	12	24
Stillbirth	3	6
Total Neonates	50	100

Table 6: Neonatal Outcomes in High-Risk Pregnancies



Graph 3

DISCUSSION

The present study aimed to evaluate the role of Doppler ultrasonography in predicting adverse perinatal outcomes in high-risk pregnancies. In this study of 50 high-risk pregnant women, the majority of participants were aged 26–30 years (52%), followed by 20–25 years (30%) and >30 years (18%), and primigravida women comprised 46% of the cohort. These demographic patterns reflect the common trend that high-risk pregnancies often occur in women of prime reproductive age and among first-time mothers, consistent with findings reported by Kale et al., 2023,[14] where the majority of high-risk pregnancies were similarly concentrated in the third decade of life.

Fetal Doppler assessment demonstrated significant associations between abnormal indices and adverse perinatal outcomes. Reduced MCA/UA pulsatility index (PI) ratios (<1.08) were observed in 18 participants, of which 14 (77.8%) experienced adverse outcomes, while only 5 out of 32 participants with normal MCA/UA PI experienced complications. This confirms that MCA/UA PI is a robust indicator of fetal compromise due to hypoxia and redistribution of blood flow. These findings align with Karena et al., 2022,[15] who reported that cerebroplacental ratio (CPR) abnormalities were predictive of adverse perinatal outcomes, though with slightly lower sensitivity (41.2%) compared to umbilical artery (UA) Doppler indices, which had a sensitivity of 79.4% and specificity of 87.5%. Similarly, in Kale et al., 2023,[14] the MCA/UA PI ratio (CPR) demonstrated good sensitivity (83.05%) and PPV (87.5%) for detecting adverse outcomes in high-risk pregnancies, supporting the use of cerebroplacental assessment in clinical practice.

Umbilical artery Doppler indices in this study revealed that UA RI >0.70 predicted adverse outcomes in 12 out of 15 participants (sensitivity 70%, specificity 90%), UA PI >1.20 predicted 13 out of 17 adverse outcomes (sensitivity 76.5%, specificity 87.9%), and UA S/D ratio >3 predicted 11 out of 13 adverse outcomes (sensitivity 64.7%, specificity 93.9%). These results indicate that UA PI and RI are reliable markers of placental insufficiency, with high specificity for fetal compromise. These findings are consistent with the study by Karena et al., 2022,[14] in which UA Doppler indices demonstrated high predictive value (accuracy 93%) for poor neonatal outcomes in high-risk pregnancies. Moreover, Kale et al., 2023[15] found that UA PI had high sensitivity (79.66%) and PPV (90.38%) in predicting adverse outcomes, confirming that UA Doppler is a cornerstone in high-risk pregnancy surveillance.

The middle cerebral artery (MCA) PI <1.0 was observed in 18 participants, with 14 cases resulting in adverse outcomes (sensitivity 77.8%, specificity 87.5%), reflecting fetal brain-sparing due to hypoxia. The MCA/UA PI ratio (<1.08) provided slightly improved predictive accuracy, with sensitivity 77.8%, specificity 84.4%, PPV 73.7%, and NPV 87.1%, highlighting the utility of combining fetal and placental Doppler measurements to enhance clinical prediction. These findings corroborate the results of Rizzo et al., 2020,[16] who reported that reduced MCA PI and CPR Z-scores were significantly associated with composite adverse perinatal outcomes in late-onset fetal growth restriction (FGR). In their study, MCA PI Z-score was -1.56 ± 0.93 in fetuses with adverse outcomes compared to -1.22 ± 0.84 in those without, and CPR Z-score was -1.89 ± 1.12 vs -1.44 ± 1.02, demonstrating similar trends in fetal blood flow redistribution as observed in the present study.

Mode of delivery and neonatal outcomes were significantly influenced by abnormal Doppler findings. In this study, 44% of pregnancies required cesarean section due to fetal distress or Doppler abnormalities. NICU admission occurred in 32% of neonates, low birth weight in 38%, preterm birth in 24%, and stillbirth in 6%. These findings echo those reported by Messawa et al., 2012,[17] where Doppler-guided management of high-risk pregnancies led to lower rates of neonatal complications and improved outcomes. Specifically, emergency cesarean section rates were higher in women with abnormal Doppler indices (100%) compared to those with normal Doppler findings (48%), indicating the utility of Doppler in timely obstetric intervention.

The present study also highlights the predictive role of uterine artery Doppler. While uterine artery PI was not the most sensitive single predictor, it provided valuable insight into placental perfusion. In agreement, Asnafi et al., 2011[18] demonstrated that the presence of uterine artery notching in the mid-trimester was associated with

lower birth weight (2,897.5 ± 757.15 g vs 3,248.39 ± 374.27 g in those without notching) and higher incidence of adverse outcomes such as preeclampsia, abruption, and low birth weight. The negative predictive value of uterine artery assessment was high, suggesting that absence of notching predicted better outcomes, aligning with the findings of the present study, where normal uterine artery Doppler indices were associated with uneventful perinatal outcomes.

The study underscores the incremental benefit of multiparametric Doppler evaluation. Rizzo et al., 2020[16] reported that a multiparametric model including MCA PI, UA PI, and umbilical vein blood flow normalized for abdominal circumference (UVBF/AC) achieved an AUC of 0.745 for predicting composite adverse outcomes, which is comparable to the predictive performance of combined UA and MCA indices in this study. This emphasizes that integrating multiple Doppler parameters rather than relying on a single measurement enhances sensitivity, specificity, and overall clinical utility.

In comparison to previous studies, the findings of the present study are consistent with international evidence. Karena et al., 2022[14] reported that UA indices were more sensitive than MCA and CPR for predicting adverse outcomes, while Kale et al., 2023[15] highlighted the superior diagnostic accuracy of UA PI and CP ratio. Similarly, Messawa et al., 2012[17] demonstrated that Doppler-guided management reduces adverse neonatal events and improves timing of cesarean sections, supporting the clinical relevance of Doppler evaluation in high-risk pregnancies. Collectively, these studies, along with the present findings, establish Doppler ultrasonography as an essential, non-invasive tool in the surveillance and management of high-risk pregnancies.

CONCLUSION

Doppler ultrasonography plays a crucial role in the evaluation and management of high-risk pregnancies by providing reliable, non-invasive assessment of fetal and placental circulation. Abnormal Doppler indices, including elevated umbilical artery PI and RI, reduced middle cerebral artery PI, and decreased MCA/UA PI ratio, were significantly associated with adverse perinatal outcomes such as low birth weight, preterm delivery, NICU admission, and stillbirth. Multiparametric Doppler assessment demonstrated higher predictive accuracy than single-vessel evaluation, enabling timely clinical interventions that improve fetal and neonatal outcomes. Incorporating routine Doppler monitoring in high-risk pregnancies allows for early identification of compromised fetuses and aids in optimizing perinatal care, thereby reducing morbidity and mortality.

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