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Original Research Article

Role of Doppler Parameters in Pregnancy for Predicting Adverse Outcome

Kapila Suguna Deepti[1*], Ivvala Sai Prathyusha[2], Kompalli J Satyasiva Raghuteja[3], M Naren Satya Srinivas[4]

[1]MRCOG(UK), MS(OBG), FMAS, Diploma in Cosmetic Gynecology, Assistant Professor, Department of Obstetrics and Gynecology, Gitam Institute of Medical Sciences And Research, Visakhapatnam
[2]MS(OBG), FMIS, DMAS, Consultant Obstetrician and Gynaecologist, Naren ultrasound and fetal medicine center, Visakhapatnam
[3]MD(Radiodiagnosis), Associate Professor, Department of Radiodiagnosis, Gitam Institute of Medical Sciences and Research, Visakhapatnam
[4]MD(Radiodiagnosis), FIAOGU, Consultant Radiologist and Fetal Medicine Specialist, Naren Ultrasound and Fetal Medicine Center, Visakhapatnam

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Corresponding Author: Dr. Kapila Suguna Deepti
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Abstract:

Introduction: Identifying fetuses at a higher risk of perinatal compromise is crucial for improving outcomes in pregnancies affected by late-onset fetal growth restriction (FGR). Unlike early-onset FGR, where blood flow in the umbilical artery is a standard for identification and management, late-onset FGR often exhibits normal umbilical artery flow. Consequently, more accurate predictors are needed for adverse outcomes in late-onset FGR pregnancies.

Aim: To assess the role of Doppler parameters in pregnancy, focusing on their significance in assessing maternal and fetal well-being.

Material and Methods: This prospective study, conducted at a tertiary care center from January 01st, 2023 to December 31st, 2023, focused on fifty cases of high-risk pregnancies in the third trimester. This study was conducted at GITAM Institute of Medical Sciences and Research, Vishakhapatnam. Patients meeting inclusion criteria included antenatal women of 3rd trimester referred to department of Radiodiagnosis for Doppler study. Exclusions comprised patients in labor upon admission, those refusing delivery at the center, and cases involving twins.

Result: In the current study, several vascular indices have been examined to assess their characteristics within the sample. The "UA-S/D" variable exhibits a mean value of 2.4270 with standard deviation of 0.56224. The standard error of the mean, reported as 0.07951, additionally, other vascular indices have been investigated. Specifically, "UA RI" has a mean of 0.544, "UA PI" has a mean of 0.558, "MCA PI" has a mean of 0.724, and "MCA RI" has a mean of 0.742. The standard deviations for these variables indicate the extent of variability around their respective means. For example, "UA RI" has a small standard deviation of 0.081

Conclusion: Multi-vessel color Doppler ultrasound studies play a crucial role in monitoring patients having adverse pregnancy outcome. Notably, it outperformed the individual assessments of umbilical artery pulsatility index (UA PI).

Keywords: UA-SD, UA PI, UA RI, MCA PI, birth weight.

Introduction

Complications during pregnancy can stem from pre-existing maternal conditions (chronic medical disorders, hemoglobinopathy), previous obstetric issues, and maternal characteristics (age, obesity). Health problems diagnosed during pregnancy, labor, and delivery include pregnancy-induced hypertension, pre-eclampsia, eclampsia, anemia, and gestational diabetes. Impaired placentation-related issues like preeclampsia, placental abruption, intrauterine growth restriction, and oligohydramnios may lead to maternal and fetal complications, even death. Uncontrolled gestational diabetes poses risks, including unexplained fetal death, childbirth complications, increased operative vaginal delivery risk, and early neonatal death. Overall, these factors underscore the need for vigilant monitoring and timely interventions to mitigate adverse outcomes for both the mother and the fetus. [1] Fetal growth restriction (FGR) refers to the failure of a fetus to attain its expected

intrauterine growth and developmental potential. This condition, affecting 3-10% of pregnancies and approximately 20% of stillbirths, poses risks of increased perinatal morbidity and mortality, as well as potential long-term consequences like neurological, cardiovascular, endocrine, and cognitive developmental disorders. Defining FGR is challenging due to the multifaceted nature of fetal growth, and it cannot be solely determined by a single biometric measurement. FGR is categorized into two main types: early-onset and late-onset, each characterized by distinct gestational age onset, ultrasound findings, and pathological features. Early-onset FGR, often linked to maternal vascular malperfusion of the placenta, manifests with abnormal transformation of spiral arteries, placental villi pathology, and multifocal infarcts, contributing to placental insufficiency. In contrast, late-onset FGR, identified after 32 weeks' gestation, exhibits milder and less specific placental lesions, with alterations in the diffusion of oxygen and nutrients. Understanding these distinctions is crucial for effective management and intervention strategies tailored to the specific characteristics of FGR. [2]

Identifying fetuses at a higher risk of perinatal compromise is crucial for improving outcomes in pregnancies affected by late-onset fetal growth restriction (FGR). Unlike early-onset FGR, where blood flow in the umbilical artery is a standard for identification and management, late-onset FGR often exhibits normal umbilical artery flow. Consequently, more accurate predictors are needed for adverse outcomes in late-onset FGR pregnancies. Various Doppler indices have been proposed for this purpose. Low pulsatility index (PI) in the middle cerebral artery (MCA) or cerebroplacental ratio (CPR), indicating reduced impedance to flow in fetal cerebral circulation, has been linked to abnormal acid–base status and neonatal special care unit admission.

Additionally, increased resistance in uterine arteries is associated with a higher risk of Cesarean section (CS) due to fetal distress. Recently, assessing blood flow in the umbilical vein (UV) has emerged as a more effective method for identifying late-onset FGR fetuses at an elevated risk of perinatal compromise. These refined Doppler parameters offer valuable insights for timely interventions and improved management of late-onset FGR pregnancies. [3]

Doppler parameters play a crucial role in monitoring and assessing the well-being of both the mother and the developing fetus during pregnancy. Doppler ultrasound, a non-invasive diagnostic technique, measures the blood flow in various vessels using the Doppler Effect.

In pregnancy, Doppler parameters are commonly utilized to evaluate the blood flow in the umbilical artery, uterine arteries, and fetal middle cerebral artery. These assessments aid in detecting potential complications such as fetal growth restriction, preeclampsia, and other placental disorders. Specifically, abnormal Doppler waveforms, such as increased resistance in the umbilical artery, may indicate inadequate oxygen and nutrient supply to the fetus, necessitating close monitoring and potential intervention. [4] Conversely, normal Doppler parameters provide reassurance regarding fetal well-being and guide healthcare providers in making informed decisions about the management of the pregnancy. Overall, Doppler ultrasound plays a pivotal role in enhancing prenatal care by enabling timely detection of potential issues and facilitating appropriate interventions to optimize maternal and fetal outcomes.

Aim

To assess the role of Doppler parameters in pregnancy, focusing on their significance in assessing maternal and fetal well-being.

Objectives

- To assess the correlation between Doppler parameters, specifically in the umbilical artery, and fetal growth throughout different stages of pregnancy.
- To examine the role of Doppler ultrasound in predicting adverse perinatal outcomes, including preterm birth and low birth weight.

Material and methods

This prospective study, conducted at a tertiary care center from January 01st, 2023 to December 31st, 2023, focused on fifty cases of high-risk pregnancies in the third trimester.

This study was conducted at GITAM institute of medical sciences, Vishakhapatnam. Patients meeting inclusion criteria included antenatal women of 3rd trimester referred to department of Radiodiagnosis for Doppler study. Exclusions comprised patients in labor upon admission, those refusing delivery at the center, and cases involving twins. Doppler vascular studies utilized a GE Voluson S8 ultrasound with a high pass filter, obtaining readings from both uterine arteries and the central part of the umbilical cord. The study, conducted with patient consent and ethical committee approval, aimed to contribute valuable insights into the association between Doppler parameters and perinatal outcomes in high-risk pregnancies.

In this study, blood flow velocity in the uterine artery was measured just cranial to the anatomical crossing of the external iliac artery. Two parameters were studied: a) Pulsatility Index (PI),

considered abnormal if >1.2, and b) the presence of an early diastolic notch. These parameters were then converted into Uterine Artery Scores (UAS) according to the system described by Hernandez et al. The UAS ranged from 0 to 4, with 0 indicating normal blood velocity waveforms in both arteries and 4 indicating the presence of four abnormal parameters (high PI and notching in both arteries). Umbilical artery Doppler was considered abnormal if the PI of the umbilical artery exceeded 2 standard deviations for gestational age, along with the absence or reversal of end diastolic flow. Repeat Doppler assessments were performed after one week if the patient did not deliver, and the last Doppler findings closer to delivery were correlated with perinatal outcomes.

Perinatal outcome variables included cesarean delivery for fetal indication, birth weight, perinatal/neonatal mortality, neonatal intensive care unit (NICU) admission, and neonatal morbidity. Descriptive statistics, such as percentages, means, and ranges, were calculated. The predictive capacity of the UAS and umbilical artery parameters was evaluated in terms of sensitivity, specificity, and positive and negative predictive values using the statistical package SPSS. This comprehensive approach aimed to assess the effectiveness of Doppler parameters in predicting and understanding perinatal outcomes in high-risk pregnancies.

Result

In the current investigation, the average age of the study subjects was 25.50 years, with a standard deviation of 4.586 years, indicating a degree of variability in ages within the sample. The standard error of the mean (SEM) was 0.649. Majority of the study subjects(64%) were primigravida, rest 36% were multigravida, In the present study 12% study subjects were had gestational hypertension, 10% study subjects had pre-eclampsia, 54% mother were had oligohydramnios, 2% mother had gestational diabetes. In the current study, several vascular indices have been examined to assess their characteristics within the sample. The "UA-S/D" variable exhibits a mean value of 2.4270 with standard deviation of 0.56224. The standard error of the mean, reported as 0.07951, additionally, other vascular indices have been investigated. Specifically, "UA RI" has a mean of .544, "UA PI" has a mean of .558, "MCA PI" has a mean of .724, and "MCA RI" has a mean of .742. The standard deviations for these variables indicate the extent of variability around their respective means. For example, "UA RI" has a small standard deviation of .0812, On the other hand, "UA PI" exhibits a slightly larger standard deviation of .1180, indicating relatively more variability in the sample.

Table 1: Association of vascular indices with the maternal conditions

		UA-S/D	UA RI	UA PI	MCA PI	MCA RI
		Mean	Mean	Mean	Mean	Mean
Ologohydramnios	absent	2.46+-0.49	0.6+-0.05	0.6+-0.11	0.7+-0.07	0.8+-0.07
	present	2.40+-0.62	0.5+-0.09	0.5+-0.12	0.7+-0.1	0.7+-0.08
	P value	0.74	0.32	0.38	0.27	0.42
Gest hypertension	absent	2.46+0.56	0.5+-0.07	0.6+-0.11	0.7+-0.09	0.7+-0.07
	present	2.20+0.54	0.6+-0.13	0.6+-0.16	0.8+-0.08	0.7+-0.11
	P value	0.30	0.47	0.58	0.21	0.42
Gest diabetes	absent	2.41+-0.56	0.5+-0.08	0.6+-0.12	0.7+-0.09	0.7+-0.078
	present	3.12+-0.0	0.5+-0.0	0.7+-0.0	0.8+-0.0	0.9+-0.0
	P value	0.21	0.59	0.23	0.39	0.048
Pre-eclampsia	absent	2.41+-0.55	0.5+-0.07	0.5+-0.11	0.7+-0.07	0.7+-0.07
	present	2.54+-0.72	0.6+-0.1	0.6+-0.15	0.8+-0.16	0.7+-0.15
	P value	0.64	0.10	0.10	0.14	0.95

The table presents a detailed analysis of various vascular indices, including "UAS/D,""UA RI,""UA PI,""MCA PI," and "MCA RI," stratified by the presence or absence of specific maternal conditions, namely Oligohydramnios, Gestational Hypertension, Gestational Diabetes, and Pre-eclampsia. Individuals with Oligohydramnios, exhibit slightly lower mean values for "UA-S/D,""UA RI," and "UA PI" compared to those without the condition. However, the differences are not statistically significant, as indicated by the p-values of 0.74, 0.32, and 0.38, respectively. The means for "MCA PI" and "MCA RI" show no substantial difference between the two groups, with p-values of 0.27 and 0.42.In the case of Gestational Hypertension, generally have lower mean values for all vascular indices compared to those without the condition, but again, none of these differences reach statistical significance (p-values ranging from 0.21 to 0.58).For Gestational Diabetes, individuals display higher mean values for all vascular indices, and the mean for "UA-S/D" is statistically significant with a p-value of 0.048.

Finally, in the context of Pre-eclampsia, there are no statistically significant differences in mean values for the vascular indices between those with

and without the condition, as reflected by the p-values ranging from 0.10 to 0.95.

Table 2: Association of vascular indices with the neonatal outcomes

			UA-S/D	UA RI	UA PI	MCA PI	MCA RI
		no	Mean	Mean	Mean	Mean	Mean
Mode of delivery	Caesarian	28	2.51+-0.63	0.6+-0.07	0.6+-0.12	0.7+-0.1	0.7+-0.09
	vaginal	22	2.32+-0.46	0.5+-0.08	0.5+-0.10	0.7+-0.07	0.7+-0.05
	P value		0.24	0.10	0.06	0.58	0.79
NICU ADMISSION	absent	12	2.15+-0.61	0.5+-0.07	0.5+-0.08	0.7+-0.08	0.8+-0.05
	Present	38	2.51+-0.52	0.5+-0.08	0.6+-0.12	0.7+-0.09	0.7+-0.08
	P value		0.05	0.60	0.16	0.74	0.43
N.SEPSIS	absent	37	2.51+-0.56	0.5+-0.07	0.5+-0.11	0.7+0.08	0.8+-0.05
	present	13	2.20+-0.53	0.6+-0.08	0.6+-0.13	0.7+-0.11	0.7+-0.12
	P value		0.09	0.01	0.04	0.14	0.009
PRETERM	absent	40	2.45+-0.58	0.5+-0.07	0.5+-0.11	0.7+-0.08	0.7+-0.06
	Present	10	2.34+-0.51	0.6+-0.09	0.6+-0.13	0.7+-0.11	0.7+-0.13
	P value		0.58	0.04	0.06	0.87	0.61
N.DEATH	absent	49	2.44+-0.56	0.5+-0.07	0.6+-0.11	0.7+-0.08	0.7+-0.08
	present	01	1.92+-0	0.7+-0.0	0.8+-0.0	0.9+-0.0	0.7+-0.0
	P value		0.37	0.05	0.037	0.045	0.61

The table shows association of various vascular indices, including "UA-S/D,""UA RI,""UA PI,""MCA PI," and "MCA RI," with different medical conditions and outcomes related to pregnancy and delivery. Starting with the mode of delivery, the table indicates that for individuals undergoing Caesarean delivery, there is a slightly higher mean value for "UA-S/D" (2.51) compared to those with vaginal delivery (2.32). However, this difference is statistical non-significance with a p-value of 0.24. Similar trends are observed for the other vascular indices, but none of the p-values are below the level of 0.05.Babies with sepsis have mother with lower mean "UA-S/D" (2.20) compared to those without (2.51), and this difference is statistically significant with a p-value of 0.01. Similar statistically significant trends are observed for "UA RI" and "MCA PI."The table also explores the association between vascular indices and preterm birth. Individuals with preterm birth have a higher mean "UA RI" compared to those without, and this difference is statistically significant with a p-value of 0.04. Other vascular indices do not exhibit significant differences based on preterm birth. Lastly, the occurrence of death is examined. Those with a death outcome have lower mean values for "UA-S/D,""UA RI," and "MCA PI," and these differences are statistically significant with p-values of 0.05, 0.037, and 0.045, respectively. The means for "UA PI" and "MCA RI" do not show significant differences based on the presence or absence of death.

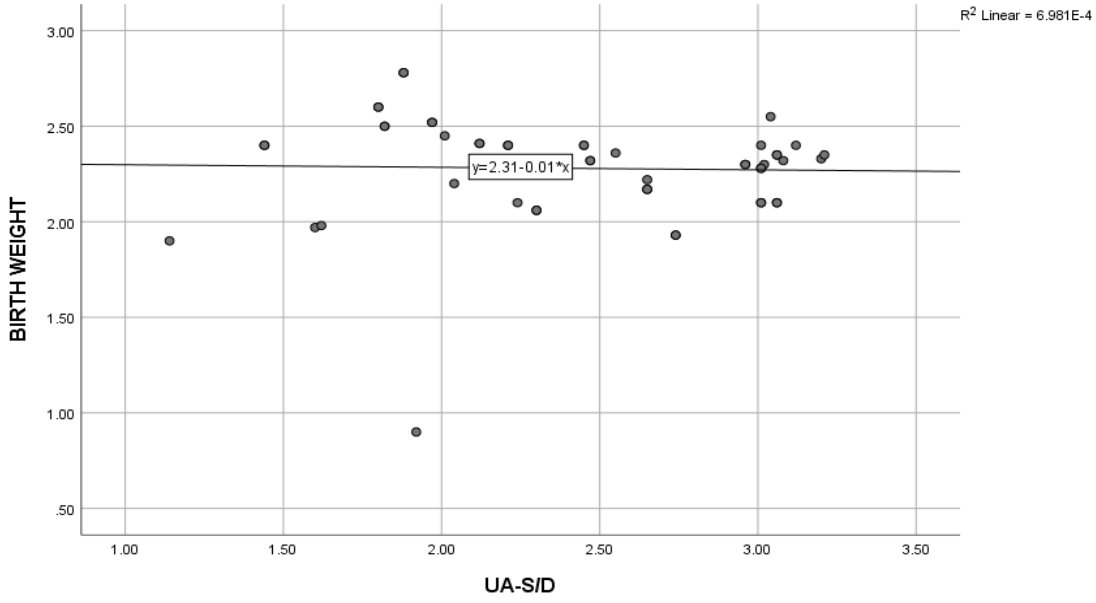

Figure 1: Association of birth weight of baby with UA-SD of mothers

Figure 1 shows Association of birth weight of baby with UA-SD of mothers, on applying regression analysis there is no association of birth weight of baby and UA-SD of mothers, with r square about 0.

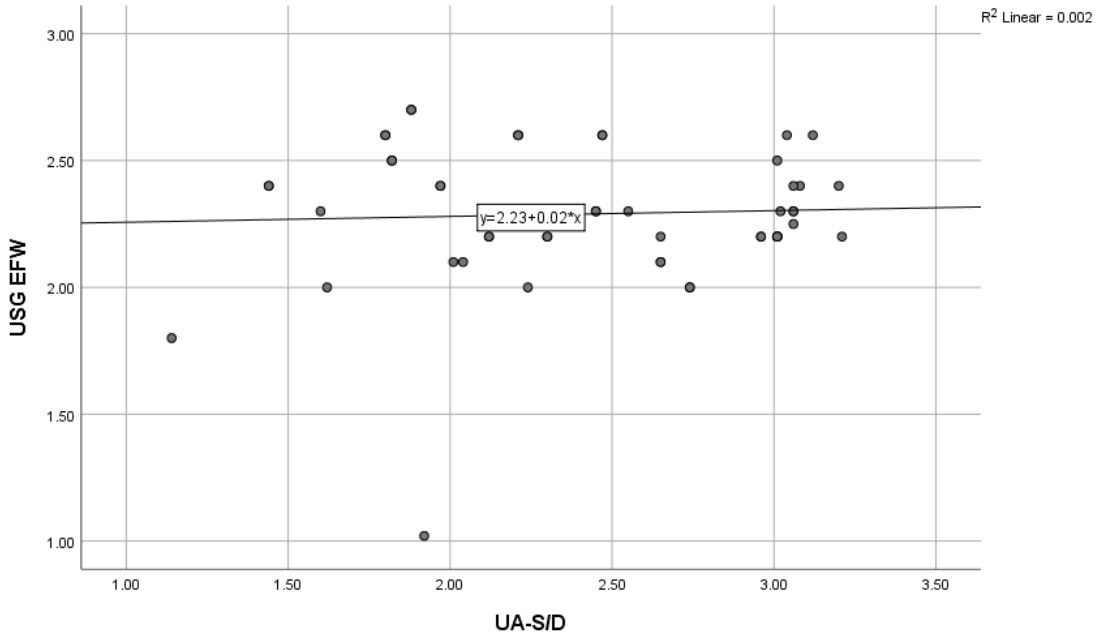

Figure 2: Association of USG EFW of baby with UA-SD of mothers

Fig 2 shows Association of USG EFW of baby with UA-SD of mothers, on applying regression analysis there is no association of USG EFW of baby and UA-SD of mothers, with r square about 0.002.

Discussion

Doppler ultrasound studies play a crucial role in identifying abnormal vascular resistance patterns in compromised fetuses. By utilizing Doppler technology, healthcare professionals can assess the blood flow within the placenta and surrounding areas, providing valuable insights into the hemodynamic changes associated with abnormal fetuses. Abnormal Doppler findings may include increased resistance in the uterine arteries and altered blood flow patterns in the umbilical artery, suggesting potential complications for the fetus.

The significance of Doppler ultrasound lies in its ability to detect these vascular abnormalities at an early stage, enabling timely and targeted interventions. Early identification of compromised fetuses allows healthcare providers to implement appropriate management strategies, such as close monitoring, medical interventions, or, in severe cases, timely delivery. This proactive approach is crucial for mitigating the risks associated with pregnancy-induced hypertension and improving outcomes for both the mother and the unborn child.

In the current research investigation, the demographic characteristics of the study subjects were explored, revealing an average age of 25.50 years, with a standard deviation of 4.586 years. This aligns with the study conducted by Pradip R. Gaikwad et al, [5] where they reported a mean maternal age of 26.9 years. Comparisons with other relevant studies, such as those conducted by Smitha et al [6] and Ozeren et al [7], indicate variations in mean maternal age, with reported values of 23.4 and 27.6 years, respectively. Regarding gravidity status, the present study observed that the majority of subjects (64%) were primigravida, while the remaining 36% were multigravida. These findings are consistent with the study conducted by Pradip R. Gaikwad et al [5], which reported 54.72% of patients as primigravidas. In contrast, studies by Mohd Khalidet al [8] and Lakhkar BN et al [9] showed higher proportions of primigravida patients, with percentages of 77.7% and 60.3%, respectively.

In terms of pregnancy-related conditions, the present study identified that 12% of the study subjects had gestational hypertension, 10% had pre-eclampsia, 54% exhibited oligohydramnios, and 2% had gestational diabetes. These findings provide insights into the prevalence of these conditions within the study population. Comparisons with other studies may offer additional context and contribute to a broader understanding of the incidence and distribution of these pregnancy-related complications across different populations.

In the current study, the "UA-S/D" variable has been examined, revealing a mean value of 2.4270

and a standard deviation of 0.56224. Additionally, the standard error of the mean is reported as 0.07951. The umbilical artery Doppler, represented by the "UA-S/D" ratio, serves as a crucial index indicating resistance to blood flow in the fetoplacental circulation. This parameter holds a strong correlation with the presence or absence of fetal hypoxia and acidosis. Placental vascular insufficiency can lead to a decrease in diastolic flow, causing an increase in the umbilical artery S/D ratio, particularly when values are 2 standard deviations or higher above the mean for the gestational age. Advanced stages of placental vascular insufficiency may manifest as absent diastolic flow (AEDF) and reverse diastolic flow (REDF), the latter being an ominous sign necessitating prompt delivery due to the presence of fetal hypoxia.

The study also references the evaluation of umbilical artery Doppler abnormalities, considering a ratio above the 95th percentile for gestational age as abnormal. This approach aligns with the findings of Lakhkar BN et al [9] where the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of Umbilical Artery Resistance Index (RI) to predict adverse perinatal outcomes were reported. Predicting adverse perinatal outcomes in the present study are also found to be consistent with studies conducted by Smitha et al [6], Ozeren et al [7], Lakhkar BN et al [9], Gramellinni et al [10], and Yoon et al [11].

In the present study, a lower mean value of umbilical artery systolic/diastolic ratio (UA-S/D) has been observed to be associated with adverse neonatal outcomes, including sepsis and low birth weight. The evaluation of these arteries during the 23-25 weeks of gestation has been suggested as a valuable screening test for the risk of conditions such as preeclampsia and intrauterine growth restriction (IUGR). Notably, the study specifically correlates abnormal uterine artery Doppler findings with adverse perinatal outcomes.

In pregnancies affected by pregnancy-induced hypertension (PIH), inadequate invasion leads to increased resistance in spiral arteries, resulting in impedance of blood flow in uterine arteries. Uteroplacental Doppler, particularly the evaluation of uterine artery Doppler, emerges as a crucial predictor of clinical deterioration and an indicator of poor neonatal outcomes. The umbilical artery Doppler is highlighted as a vital method for diagnosing and prognosticating intrauterine growth restriction (IUGR). Increased umbilical artery Doppler pulsatility index (PI) is considered a potential marker for detecting compromised fetuses, especially when combined with other parameters such as cerebroplacental ratio (CPR). The presence of absent or reverse end-diastolic flow in the umbilical artery is noted to correlate with fetal compromise. It is noteworthy that even mild placental insufficiency beyond 34 weeks of gestation can lead to an increase in placental villous vascularization, subsequently decreasing impedance to flow. Consequently, umbilical artery flow may appear normal in compromised small-for-gestational-age (SGA) babies near term, while uterine artery Doppler may indicate abnormalities. This distinction becomes crucial for understanding and managing adverse perinatal outcomes.

The findings of the present study align with previous research, such as the work by Vergani et al [12] which reported a higher frequency of adverse perinatal outcomes in cases with abnormal uterine artery Doppler compared to those with normal uterine artery velocimetry in fetuses with growth restriction beyond 34 weeks of gestation. The study also notes a higher prevalence of abnormalities in uterine artery Doppler compared to umbilical arteries in gestations beyond 34 weeks, encompassing conditions like pre-eclampsia, oligoamnios, and previous history of birth of a small-for-gestational-age baby (BOH), in addition to fetal growth restriction. These observations underscore the importance of Doppler evaluations in predicting and managing complications associated with various pregnancy-related conditions.

Conclusions

Multi-vessel color Doppler ultrasound studies play a crucial role in monitoring patients having adverse pregnancy outcome. Notably, it outperformed the individual assessments of umbilical artery pulsatility index (UA PI). The inclusion of uterine artery Doppler evaluation contributed to predicting adverse pregnancy outcomes. Proves useful in the decision-making process, especially for determining the optimal timing of delivery.

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