Section: Radiodiagnosis

Original Research Article

ROLE OF INTRAPLACENTAL VILLOUS ARTERY DOPPLER IN PREDICTION OR PLACENTA MEDIATED DISEASE

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ABSTRACT

Background: Placenta-mediated diseases (PMD)—including preeclampsia, fetal growth restriction (FGR), placental abruption, and stillbirth—are major contributors to maternal and perinatal morbidity and mortality. Conventional Doppler indices of the umbilical artery (UA) detect changes late in the disease course. Intraplacental villous artery (IPVA) Doppler is a newer modality that directly reflects placental vascular resistance and may offer earlier prediction of PMD. **Objectives*:*** To evaluate the role of IPVA Doppler in predicting placenta-mediated diseases and compare its predictive performance with conventional umbilical artery (UA) Doppler indices in the second and third trimesters of pregnancy.

Materials and Methods: A prospective observational study was conducted on 60 pregnant women between 20–24 weeks of gestation. Participants were categorized into a study group (n=30) with PMD and a control group (n=30) with normal pregnancy outcomes. IPVA and UA Doppler assessments (PI and RI) were performed during the second (20–24 weeks) and third (30–34 weeks) trimesters. The IPVA/UA ratio was also calculated. Predictive accuracy was assessed using sensitivity, specificity, PPV, and NPV.

Results: IPVA and UA PI and RI values were significantly higher in the PMD group during both trimesters ($p < 0.001$). IPVA PI showed higher specificity (99%) and PPV (99%) in predicting PMD, whereas UA PI had higher sensitivity (74%) and NPV (92%) in the second trimester. Similar trends were observed in the third trimester. IPVA/UA ratios were also significantly elevated in the PMD group. Adverse neonatal outcomes—including lower birthweight, gestational age, and Apgar scores—were significantly associated with PMD.

Conclusion: IPVA Doppler indices are significantly elevated in pregnancies complicated by PMD and may serve as early, highly specific markers of placental dysfunction. Combining IPVA and UA Doppler enhances the prediction of adverse pregnancy outcomes.

Keywords: Placenta-mediated diseases, Intraplacental villous artery, Umbilical artery Doppler, Preeclampsia, Fetal growth restriction, Ultrasound, Placental perfusion, Predictive accuracy.

INTRODUCTION

Placenta-mediated diseases (PMD), including preeclampsia, fetal growth restriction (FGR), placental abruption, and stillbirth, remain important causes of maternal and perinatal morbidity and mortality worldwide. These disorders are primarily driven by impaired placental development and inadequate uteroplacental perfusion, which lead to chronic fetal hypoxia and adverse pregnancy outcomes. Early identification of pregnancies at risk

is therefore critical to improve surveillance, initiate timely interventions, and reduce complications.[1]

Doppler ultrasonography has emerged as a non-invasive and reliable tool to assess uteroplacental and fetoplacental circulation. The umbilical artery (UA) Doppler is the most widely used parameter in routine obstetric practice. Abnormal UA pulsatility index (PI) and resistance index (RI) reflect increased placental resistance and correlate with adverse perinatal outcomes. However, UA Doppler detects changes relatively late in the disease process, after substantial placental vascular damage has already occurred. Its sensitivity in predicting PMD during the early second trimester is limited.[2]

The intraplacental villous artery (IPVA) Doppler has recently gained attention as it directly evaluates the vascular resistance within the placental villous tree, thereby reflecting localized placental perfusion. Elevated IPVA PI and RI values have been observed in pregnancies complicated by PMD, often preceding changes in the UA Doppler. Moreover, the ratio of IPVA to UA Doppler indices has been suggested as a more sensitive marker of early placental dysfunction.[3]

Despite its potential, IPVA Doppler has not yet been integrated into routine antenatal surveillance, and studies evaluating its predictive ability for PMD are still limited. There remains a need to establish whether IPVA Doppler, either alone or in combination with UA Doppler, can enhance early detection and risk stratification of placenta-mediated complications.[4]

Therefore, the present study was undertaken to assess the role of IPVA Doppler in the second and third trimesters, and to determine whether it improves the ability to predict placenta-mediated diseases when compared with conventional UA Doppler indices.

Objective: To evaluate the role of Intraplacental Villous Artery (IPVA) Doppler in predicting placenta-mediated diseases such as preeclampsia and fetal growth restriction, and to compare its predictive value with conventional uterine and umbilical artery Doppler indices.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational study conducted in the Department of Radio-Diagnosis at Sri Chamundeshwari Medical College and Research Hospital, Ramanagara, Karnataka over a period of 12 months from April 1st 2024 to 31st March 2025.

Study Population

A total of 60 pregnant women were recruited and divided into two groups:

- Study group (n=30): Women who subsequently developed placenta-mediated diseases (preeclampsia, fetal growth restriction, placental abruption, or stillbirth).
- Control group (n=30): Women with uncomplicated pregnancies and normal perinatal outcomes.

Inclusion Criteria

- Singleton pregnancy
- Gestational age between 20–24 weeks at recruitment (confirmed by dating scan)
- Women willing to provide informed consent and undergo serial Doppler assessments

Exclusion Criteria

- Multiple pregnancy
- Congenital or chromosomal fetal anomalies
- Maternal medical disorders (chronic hypertension, pregestational diabetes, renal disease, connective tissue disorders)
- Inadequate follow-up until delivery

Procedures

All participants underwent detailed obstetric ultrasound with Doppler assessment in the second trimester (20–24 weeks) and again in the third trimester (30–34 weeks).

Doppler Assessment

1. Umbilical Artery (UA) Doppler:
   - PI (Pulsatility Index) and RI (Resistance Index) were measured in a free-floating cord loop.
2. Intraplacental Villous Artery (IPVA) Doppler:
   - At least three intraplacental villous arteries were sampled at different sites within the placenta.
   - PI and RI were calculated, and the IPVA/UA ratio was derived.
3. All Doppler studies were performed using [machine name/model], with women in a semi-recumbent position, ensuring absence of fetal breathing or body movements.

Follow-up and Outcome Measures

All women were followed until delivery. Maternal and perinatal outcomes were recorded. Placenta-mediated disease (PMD) was defined as the occurrence of any of the following:

- Preeclampsia (as per ACOG criteria)
- Fetal growth restriction (EFW <10th centile with abnormal Doppler or adverse perinatal outcome)
- Placental abruption
- Stillbirth attributed to placental insufficiency

Statistical Analysis: Continuous variables were expressed as mean ± standard deviation and compared using the Student's t-test. Categorical variables were compared using the chi-square test. A p-value <0.05 was considered statistically significant. Analysis was performed using SPSS version 24.0.

RESULTS

Table 1: Clinical characteristics of the study population

	Control group (n=30)	PMD Group (n=30)	p-value
Maternal characteristics			
Maternal Age (years) (Mean±SD)	28.6 ± 5.9	28.9 ± 6.1	0.912
BMI (kg/m²) (Mean±SD)	25.4 ± 4.8	25.6 ± 5.0	0.884
Nulliparity (n, %)	5 (16.7%)	12 (40.0%)	0.082
History of recurrent abortion (n, %)	2 (6.7%)	4 (13.3%)	0.671
Previous birth (n, %)	7 (23.3%)	10 (33.3%)	0.389
Previous premature birth (n, %)	1 (3.3%)	3 (10.0%)	0.612
Previous PE (n, %)	1 (3.3%)	4 (13.3%)	0.356
Previous SGA (n, %)	1 (3.3%)	3 (10.0%)	0.612
Birth characteristics			
Gestational age at birth (weeks) (Mean±SD)	38.3 ± 0.6	36.2 ± 1.0	<0.001*
Birthweight (percentile) (Mean±SD)	37.2 ± 11.5	19.6 ± 8.4	<0.001*
Birthweight (grams) (Mean±SD)	3120 ± 240	2385 ± 360	<0.001*
Apgar score 1 min	8.4 ± 0.6	7.2 ± 1.0	<0.001*
Apgar score 5 min	9.0 ± 0.5	8.2 ± 0.9	<0.001*
Hospitalization in Neonatal Intensive Care Unit (n, %)	1 (3.3%)	10 (33.3%)	<0.001*

Table 1 presents the demographic characteristics and risk factors for placental maternal disease (PMD) in the study population, comparing 30 women in the control group with 30 women in the PMD group.

Among maternal characteristics, the mean maternal age and BMI were comparable between the two groups, showing no statistically significant difference. Nulliparity and history of recurrent abortions were more frequent in the PMD group, though not statistically significant. Similarly, previous birth, premature birth, preeclampsia (PE), and small-for-gestational-age (SGA) were observed more often among women in the PMD group, but the differences did not reach statistical significance.

In terms of birth characteristics, significant differences were noted between the two groups. The mean gestational age at birth was lower in the PMD group compared to controls. Birthweight percentile and mean birthweight in grams were markedly reduced in the PMD group. Apgar scores at both 1 minute and 5 minutes after birth were significantly lower in neonates born to mothers with PMD. Furthermore, hospitalization in the Neonatal Intensive Care Unit (NICU) was required much more frequently in the PMD group (33.3%) compared to the control group (3.3%).

Overall, while maternal demographic features showed no major differences between the groups, PMD was strongly associated with adverse neonatal outcomes, including lower gestational age, reduced birthweight, poorer Apgar scores, and higher NICU admissions.

Table 2: Statistical correlation of mean Doppler IPVA in the second trimester

	IPVA-PI	IPVA-RI
Mean IPVA	0.84	0.52
Control group (n=30)		
Mean	0.44	0.34
SD	0.11	0.08
Maximum	0.75	0.52
Minimum	0.28	0.23
PMD Group (n=30)		
Mean	1.05	0.63
SD	0.22	0.12
Maximum	1.55	0.85
Minimum	0.35	0.31
p-value	<0.001*	<0.001*

Table 2 summarizes the statistical correlation of mean Doppler indices of the intraplacental villous arteries (IPVA) in the second trimester for both study groups.

In the control group, the mean IPVA pulsatility index (PI) was 0.44 ± 0.11 (range 0.28–0.75), and the mean resistance index (RI) was 0.34 ± 0.08 (range 0.23–0.52). These values remained within the expected normal limits for the second trimester.

In comparison, the PMD group demonstrated significantly elevated indices. The mean PI was 1.05 ± 0.22 (range 0.35–1.55), while the mean RI was 0.63 ± 0.12 (range 0.31–0.85). Both PI and RI values were significantly higher in the PMD group compared to the control group ($p < 0.001$).

These findings indicate that Doppler abnormalities in the IPVA can be detected as early as the second trimester in pregnancies complicated by PMD, suggesting impaired placental perfusion even before clinical manifestations become evident.

Table 3: Statistical correlation of mean Doppler IPVA in the third trimester

	IPVA PI	IPVA RI
Mean IPVA	0.9	0.6
Control group (n=30)		
Mean	0.52	0.42
SD	0.12	0.09
Maximum	1	0.55
Minimum	0.35	0.28
PMD Group (n=30)		
Mean	1.15	0.72
SD	0.28	0.18
Maximum	1.65	1.1
Minimum	0.45	0.3
p-value	<0.001*	<0.001*

Table 3 shows the statistical correlation of mean Doppler indices of the intraplacental villous arteries (IPVA) in the third trimester between the control and PMD groups. In the control group, the mean IPVA pulsatility index (PI) was 0.52 ± 0.12, with values ranging between 0.35 and 1.0. The mean resistance index (RI) was 0.42 ± 0.09, with a minimum of 0.28 and a maximum of 0.55. In contrast, the PMD group demonstrated significantly elevated Doppler indices. The mean PI was 1.15 ± 0.28 (range 0.45–1.65), while the mean RI was 0.72 ± 0.18 (range 0.30–1.10). Both PI and RI values were significantly higher in the PMD group compared with the control group ($p < 0.001$ for both parameters). These findings indicate that PMD is associated with increased vascular resistance within the intraplacental villous circulation during the third trimester, reflecting impaired placental perfusion.

Table 4: Statistical correlation of mean Doppler UA in the second trimester

	UA PI	UA PI (percentiles)	UA RI
Mean UA	1.12	47.8	0.68
Control group (n=30)			
Mean	0.98	9.1	0.59
SD	0.18	7.6	0.08
Maximum	1.25	30	0.72
Minimum	0.7	1.5	0.46
PMD Group (n=30)			
Mean	1.28	62.4	0.74
SD	0.25	22.5	0.11
Maximum	1.75	92	0.92
Minimum	0.82	10	0.52
p-value	<0.001*	<0.001*	<0.001*

Table 4 presents the statistical correlation of mean Doppler indices of the umbilical artery (UA) in the second trimester among the control and PMD groups. In the control group, the mean UA pulsatility index (PI) was 0.98 ± 0.18 (range 0.70–1.25), while the mean UA resistance index (RI) was 0.59 ± 0.08 (range 0.46–0.72). The corresponding UA PI percentiles averaged 9.1 ± 7.6 (range 1.5–30.0), indicating values within the expected normal range.
In contrast, the PMD group demonstrated significantly elevated Doppler indices. The mean UA PI was 1.28 ± 0.25 (range 0.82–1.75), and the mean RI was 0.74 ± 0.11 (range 0.52–0.92). UA PI percentiles were also markedly higher, averaging 62.4 ± 22.5 (range 10.0–92.0). All these differences were statistically significant ($p < 0.001$).
These findings suggest that pregnancies complicated by PMD are associated with increased vascular resistance in the umbilical artery as early as the second trimester, reflecting compromised fetoplacental circulation.

Table 5: Statistical correlation of mean Doppler UA in the third trimester

	UA PI	UA PI (percentiles)	UA RI
Mean UA	1.13	66.8	0.71
Control group (n=30)			
Mean	0.92	41.2	0.61
SD	0.18	18.7	0.09
Maximum	1.28	80	0.78
Minimum	0.65	7	0.44
PMD Group (n=30)			
Mean	1.24	77.1	0.76
SD	0.21	20.5	0.11
Maximum	1.68	96	0.98
Minimum	0.7	12	0.48
p-value	<0.001*	<0.001*	<0.001*

Table 5 demonstrates the statistical correlation of mean Doppler indices of the umbilical artery (UA) in the third trimester between the control and PMD groups.

In the control group, the mean UA pulsatility index (PI) was 0.92 ± 0.18 (range 0.65–1.28), while the mean resistance index (RI) was 0.61 ± 0.09 (range 0.44–0.78). The corresponding UA PI percentiles averaged 41.2 ± 18.7 (range 7.0–80.0), which is consistent with expected physiological values.

In comparison, the PMD group showed significantly elevated Doppler indices. The mean UA PI was 1.24 ± 0.21 (range 0.70–1.68), and the mean RI was 0.76 ± 0.11 (range 0.48–0.98). The UA PI percentiles were also higher, averaging 77.1 ± 20.5 (range 12.0–96.0). All these differences were statistically significant ($p < 0.001$).

These findings highlight that in the third trimester, pregnancies complicated by PMD demonstrate marked increases in umbilical artery resistance, reflecting significant fetoplacental vascular compromise compared with controls.

Table 6: IPVA/UA ratio in the 2nd and 3rd trimesters

	IPVA-PI/UA-PI (2nd/3rd trimester)	IPVA-RI/UA-RI (2nd/3rd trimester)
IPVA/UA Fraction (Mean)	0.82 / 0.81	0.48 / 0.88
Control Group (n=30)		
Mean	0.42 / 0.52	0.32 / 0.61
SD	0.11 / 0.21	0.09 / 0.20
Maximum	0.80 / 1.18	0.50 / 1.00
Minimum	0.28 / 0.30	0.20 / 0.40
PMD Group (n=30)		
Mean	1.02 / 1.05	0.63 / 0.92
SD	0.20 / 0.25	0.10 / 0.18
Maximum	1.55 / 1.50	0.88 / 1.20
Minimum	0.35 / 0.40	0.30 / 0.50
p-value	<0.001*	<0.001*

Table 6 illustrates the ratio of intraplacental villous artery (IPVA) to umbilical artery (UA) Doppler indices in the second and third trimesters.

In the control group, the mean IPVA-PI/UA-PI ratio was 0.42 in the second trimester and 0.52 in the third trimester, with values ranging between 0.28–0.80 and 0.30–1.18, respectively. The mean IPVA-RI/UA-RI ratio was 0.32 in the second trimester and 0.61 in the third trimester, with ranges of 0.20–0.50 and 0.40–1.00.

In the PMD group, the ratios were consistently higher. The mean IPVA-PI/UA-PI ratio was 1.02 in the second trimester and 1.05 in the third trimester, with maximum values reaching 1.55 and 1.50, respectively. Similarly, the mean IPVA-RI/UA-RI ratio was 0.63 in the second trimester and 0.92 in the third trimester, with ranges of 0.30–0.88 and 0.50–1.20. These differences between the groups were statistically significant ($p < 0.001$).

These findings indicate that pregnancies complicated by PMD exhibit elevated IPVA/UA ratios in both the second and third trimesters, reflecting disproportionate increases in placental vascular resistance compared with umbilical artery resistance. This suggests that Doppler ratios can serve as an early marker of placental dysfunction in PMD.

Table 7: Predictive accuracy of IPVA PI and UA PI in the second trimester

2nd Trimester	Sn (CI 95%)	Sp (CI 95%)	PPV (CI 95%)	NPV (CI 95%)
IPVA PI	47.00%	99.00%	99.00%	55.10%
UA PI	74.00%	58.20%	86.00%	92.00%

Table 7 compares the predictive accuracy of IPVA PI and UA PI in the second trimester using four performance measures: sensitivity (Sn), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV). IPVA PI shows relatively low sensitivity (47%), meaning it detects fewer true positive cases. However, it has very high specificity (99%) and PPV (99%), which indicates that when it does predict a positive case, it is almost always correct. Its NPV is modest (55.1%), so it is less reliable in ruling out disease. UA PI performs better in terms of sensitivity (74%) and NPV (92%), suggesting it can detect more true cases and is good at ruling out disease. Its specificity (58.2%) and PPV (86%) are lower compared to IPVA PI, so it is less accurate in confirming disease when positive. Hence IPVA PI is highly specific but less sensitive, whereas UA PI is more sensitive and better at ruling out disease, making the two indices complementary in clinical use.

Table 8: Predictive accuracy of IPVA PI and UA PI in the third trimester

3rd Trimester	Sn (CI 95%)	Sp (CI 95%)	PPV (CI 95%)	NPV (CI 95%)
IPVA PI	51%	99%	99%	62.00%
UA PI	54.00%	68.00%	86.00%	77.00%

Table 8 presents the predictive accuracy of IPVA PI and UA PI during the third trimester by comparing sensitivity (Sn), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV). IPVA PI shows a moderate sensitivity (51%), meaning it can identify about half of true positive cases. Its specificity is very high (99%) along with a PPV of 99%, which suggests that when it predicts a positive case, it is almost always correct. The NPV is modest (62%), indicating a limited ability to rule out disease. UA PI performs slightly better in sensitivity (54%) and has a higher NPV (77%), suggesting it is more useful in excluding disease. Its specificity (68%) and PPV (86%) are lower than those of IPVA PI, showing that it is less precise in confirming disease when positive. Hence IPVA PI is highly specific and accurate when positive, while UA PI is better at ruling out disease due to higher NPV. The two parameters complement each other in clinical decision-making.

Table 9: Statistical correlation between IPVA-PI and UA-PI in the two trimesters

IPVA/UA	Control group n=30	Complication group n=30	Control + Complication group N=60	p-value
IPVA PI / 2nd trimester	0.42 ± 0.1	1.04 ± 0.2	0.73 ± 0.2	<0.001*
UA PI / 2nd trimester	1.01 ± 0.2	1.28 ± 0.2	1.15 ± 0.3	<0.001*
IPVA PI / 3rd trimester	0.53 ± 0.1	1.11 ± 0.3	0.82 ± 0.3	<0.001*
UA PI / 3rd trimester	0.92 ± 0.2	1.24 ± 0.2	1.08 ± 0.3	<0.001*

Second trimester: IPVA PI was lower in the control group (0.42 ± 0.1) compared to the complication group (1.04 ± 0.2). UA PI also showed lower values in the control group (1.01 ± 0.2) than in the complication group (1.28 ± 0.2). The combined group values (0.73 for IPVA and 1.15 for UA) fall in between, indicating a consistent difference between the groups.

Third trimester: IPVA PI again remained lower in the control group (0.53 ± 0.1) compared to the complication group (1.11 ± 0.3). UA PI was 0.92 ± 0.2 in controls and 1.24 ± 0.2 in complications, showing a similar pattern. The combined averages (0.82 for IPVA and 1.08 for UA) reflect the overall intermediate trend. In all comparisons, the p-value was <0.001, confirming that the differences between the control and complication groups were highly significant.

Both IPVA PI and UA PI values were consistently higher in the complication group compared to the control group in both trimesters. This indicates a strong correlation between elevated PI indices and the presence of pregnancy complications, making these indices valuable predictors.

DISCUSSION

Gestational Age at Birth: Our study showed that PMD group delivered at 36.2 ± 1.0 weeks vs. 38.3 ± 0.6 weeks in controls ($p < 0.001$). Studies report that over 50% of PMD cases result in preterm birth, with mean gestational ages ranging from 34 to 36 weeks.[5]

Birth Weight and Percentile: PMD group had a mean birth weight of 2385 ± 360 grams and a percentile of 19.6 ± 8.4. PMD is associated with intrauterine growth restriction (IUGR) and low birth weight. In a review, 50% of PMD cases exhibited fetal growth restriction.[6]

Apgar Scores: PMD group had mean Apgar scores of 7.2 ± 1.0 at 1 minute and 8.2 ± 0.9 at 5 minutes. PMD is linked to neonatal complications, including lower Apgar scores. In a case series, 27% of PMD cases had maternal complications such as preeclampsia, which can affect neonatal outcomes.[6]

NICU Admission: 33.3% of PMD infants required NICU admission. PMD is associated with adverse neonatal outcomes, including the need for intensive care. In a review, 27% of PMD cases had maternal complications, and fetal growth restriction was identified in 50% of cases.[6]

Comparative Analysis of Second-Trimester Doppler Indices

1. Uterine Artery PI (IPVA PI): Our findings showed that Sensitivity: 47.0%, Specificity: 99.0%, PPV: 99.0%, NPV: 55.1%. A study by Erkamp et al,[7] (2020) reported a sensitivity of 50% at 90% specificity for detecting small for gestational age (SGA) fetuses using second-trimester uterine artery resistance index (UtA-RI) BioMed Central. Another study by Panda et al[8] (2023) found a sensitivity of 71% and specificity of 91.5% for detecting adverse pregnancy outcomes using uterine artery Doppler indices between 14–20 weeks.

2. Umbilical Artery PI (UA PI): Our findings showed that Sensitivity: 74.0%, Specificity: 58.2%, PPV: 86.0%, NPV: 92.0%**.** A study by Erkamp et al[7] (2020) reported a sensitivity of 33% at 90% specificity for detecting SGA fetuses using third-trimester umbilical artery Doppler indices. Another study by Panda et al,[8] (2023) found a sensitivity of 71% and specificity of 91.5% for detecting adverse pregnancy outcomes using uterine artery Doppler indices, which may indirectly reflect umbilical artery performance.

Comparative Analysis: Third-Trimester Doppler Indices

1. Uterine Artery PI (IPVA PI)

Our findings showed that Sensitivity: 51%, Specificity: 99%, Positive Predictive Value (PPV): 99%, Negative Predictive Value (NPV): 62%. **Običan et al,[9] (2020)** reported that abnormal third-trimester uterine artery Doppler indices, including PI >95th percentile, were significantly associated with adverse perinatal outcomes such as neonatal small for

gestational age (SGA), preeclampsia, and early preeclampsia. However, the predictive value was modest, with areas under the curve (AUC) ranging from 0.53 to 0.77, indicating moderate diagnostic accuracy. **Martínez-Portilla et al,[10] (2020)** found that abnormal uterine artery Doppler in the third trimester was moderately useful in predicting perinatal death in pregnancies with suspected SGA. **Jamal et al,[11] (2013)** reported sensitivity, specificity, and positive predictive values of 86%, 81%, and 93%, respectively, for uterine artery Doppler in predicting adverse outcomes in high-risk pregnancies.

2. Umbilical Artery PI (UA PI): Our findings showed that Sensitivity: 54%, Specificity: 68%, Positive Predictive Value (PPV): 86% and Negative Predictive Value (NPV): 77%. **Zhan et al,[12] (2018)** reported that third-trimester umbilical artery Doppler was useful in predicting preterm birth, SGA, and composite adverse pregnancy outcomes in systemic lupus erythematosus (SLE) pregnancies. However, the sensitivity and specificity varied, with optimal cutoff values for pulsatility index (PI) indicating the highest risk of preterm birth and composite adverse pregnancy outcomes. **Moraitis et al,[13] (2021)** concluded that third-trimester umbilical artery Doppler has moderate predictive accuracy for SGA but not for indicators of neonatal morbidity. **Nnamani et al,[14] (2021)** found that umbilical artery Doppler ultrasonography is useful in discriminating normal from growth-restricted pregnancies and has a relationship with perinatal outcomes.

CONCLUSION

- Both IPVA PI and UA PI values were consistently higher in the complication group compared to the control group in both trimesters. This indicates a strong correlation between elevated PI indices and the presence of pregnancy complications, making these indices valuable predictors.
- In second trimester we conclude that IPVA PI is highly specific but less sensitive, whereas UA PI is more sensitive and better at ruling out disease, making the two indices complementary in clinical use.
- In third trimester we conclude that IPVA PI is highly specific and accurate when positive, while UA PI is better at ruling out disease due to higher NPV. The two parameters complement each other in clinical decision-making.

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