Original Article

Comparison of Ophthalmic Artery & Uterine Artery Doppler Indices Among Hypertensive and Normotensive Pregnant Women of 11-37 Weeks of Gestational Age

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Abstract

Background: Hypertensive disorders of pregnancy contribute significantly to maternal and perinatal morbidity. Uterine Artery Doppler evaluates uteroplacental resistance, while Ophthalmic Artery Doppler reflects maternal vascular and cerebrovascular adaptations. This study compares both Doppler indices in hypertensive and normotensive pregnancies between 11 and 37 weeks, assessing their correlation and complementary value in antenatal risk evaluation. The objective is to assess values of Ophthalmic Artery and Uterine Artery Doppler indices at 11–37 weeks of gestational age in pregnant women along with compare and identify the association of abnormal Ophthalmic and Uterine Artery Doppler indices in hypertensive pregnant women developing abnormal fetal growth and pregnancy outcomes compared to normotensive pregnant women. **Material and Methods:** The study was conducted in the Department of Radiodiagnosis, Shridevi Institute of Medical Sciences and Research Hospital, Tumkur, Karnataka, was carried out over a period of 18 months, commencing after institutional ethical approval. The study included pregnant women to assess Ophthalmic and Uterine Doppler indices across a broad gestational age range. Purposive sampling was employed and 60 pregnant women were included in the study. **Results:** In the present study, 30 patients were full term, 22 patients delivered at early term, and 8 cases were preterm. Uncomplicated maternal outcomes were observed in 30 women, while 17 cases developed pre-eclampsia or severe pre-eclampsia. Uterine artery PI was significantly higher in hypertensive women and was significantly associated with maternal outcome. Ophthalmic Artery Doppler abnormalities demonstrated a significant association with maternal outcome. Ophthalmic Artery Peak Ratio was significantly lower in pregnancies with abnormal fetal growth ($p = 0.038$) and Mean PSV1, PSV2, and EDV showed higher values, reflecting variability in Ophthalmic Artery hemodynamics. Correlation analysis revealed relationships between Uterine and Ophthalmic Artery Doppler indices. **Conclusion:** The study demonstrates that combined Uterine and Ophthalmic artery Doppler assessment provides complementary information regarding uteroplacental resistance and maternal cerebral hemodynamics showing the positive correlation between abnormal Doppler indices associated with hypertensive disorders and adverse fetal outcomes.

Keywords: Ophthalmic Artery Doppler, Uterine Artery Doppler, Hypertensive disorders of pregnancy, pre-eclampsia, PSV1, PSV2.

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Introduction

Hypertensive disorders of pregnancy (HDP) are major causes of maternal and perinatal morbidity and mortality worldwide, particularly in low and middle income countries.[1] Pre-eclampsia is a multisystem disorder associated with serious maternal complications and adverse fetal outcomes, including intrauterine growth restriction, preterm birth, and perinatal mortality.[2] Early identification of high-risk pregnancies is essential for appropriate surveillance and timely intervention.

Pre-eclampsia is associated with abnormal placentation, defective trophoblastic invasion, incomplete spiral artery remodeling, placental ischemia, angiogenic imbalance, oxidative stress, and endothelial dysfunction, causing hypertension, multiorgan complications, impaired cerebral autoregulation, and fetal growth restriction. Uterine artery Doppler provides a non-invasive assessment of uteroplacental circulation. Parameters such as Pulsatility Index(PI) Resistive Index (RI) and Early diastolic notching help evaluate vascular resistance and predict adverse pregnancy outcomes.[3]

Pre-eclampsia also involves maternal systemic and cerebral hemodynamic alterations. Impaired cerebrovascular autoregulation may contribute to neurological complications, including headaches, visual disturbances, and eclamptic seizures. Ophthalmic artery Doppler, therefore, offers a potential complementary method for evaluating maternal

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vascular changes because the Ophthalmic artery is a branch of the Internal Carotid Artery.[4]

Ophthalmic artery Doppler assessment includes PI, RI, Peak Systolic Velocity (PSV1), End Diastolic Velocity (EDV), Second Systolic Peak Velocity (PSV2), and Peak Ratio (PR). Alterations in these parameters may reflect changes in vascular resistance and maternal circulatory adaptation. Kumari et al, demonstrated the potential of Ophthalmic artery Doppler in predicting pre-eclampsia, particularly early onset disease.[4] Systematic reviews have also identified differences in Ophthalmic artery Doppler indices between pre-eclamptic and normotensive women.[5]

While Uterine Artery Doppler evaluates uteroplacental circulation, Ophthalmic Artery Doppler provides complementary information regarding maternal vascular adaptation. Their combined assessment may improve understanding of hemodynamic changes associated with HDP.

The present study compares Uterine and Ophthalmic artery Doppler indices between hypertensive and normotensive pregnant women from 11 to 37 weeks of gestation and evaluates correlations between these indices and explores their complementary role in antenatal risk assessment.

Objectives:

1. To assess values of ophthalmic artery and Uterine artery Doppler indices at 11–37 weeks of gestational age in pregnant women.
2. To compare and identify the association of abnormal Ophthalmic and Uterine artery Doppler indices in hypertensive pregnant women developing abnormal fetal growth and pregnancy outcomes compared to normotensive pregnant women.

Pathophysiology of Pre-Eclampsia Sequence: Defective trophoblastic invasion →Incomplete spiral artery remodeling →Increased uteroplacental resistance and placental ischemia→Angiogenic imbalance, oxidative stress and endothelial dysfunction →Maternal hypertension, multiorgan dysfunction and fetal compromise.

Other mechanisms include inflammatory and immune dysregulation, reduced nitric oxide availability, increased vasoconstriction, renal glomerular endotheliosis and impaired cerebral autoregulation.

Parameter/finding	Significance
Increased PI	Increased downstream vascular resistance
Increased RI	Increased vascular impedance
Early diastolic notching	Suggests persistent uteroplacental resistance
Abnormal first-trimester Doppler	May help identify pregnancies at risk of pre-eclampsia
Abnormal second-trimester Doppler	Associated with placental insufficiency and adverse fetal outcomes

Significance of Uterine Artery Doppler

Main role: Assessment of uteroplacental circulation and prediction of placental dysfunction, particularly early onset pre-eclampsia.

Limitations: Operator dependence, technical variability, and lower predictive performance in some cases of late onset pre-eclampsia.

Role of Ophthalmic Artery Doppler: The Ophthalmic artery is a branch of the Internal Carotid Artery and provides an accessible window for assessing maternal vascular changes associated with pre-eclampsia.

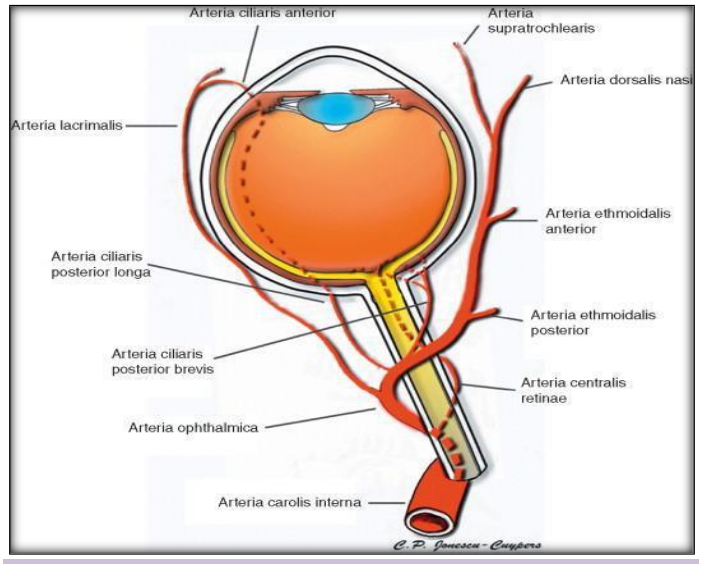


Image 1: Anatomy of Opthalmic artery

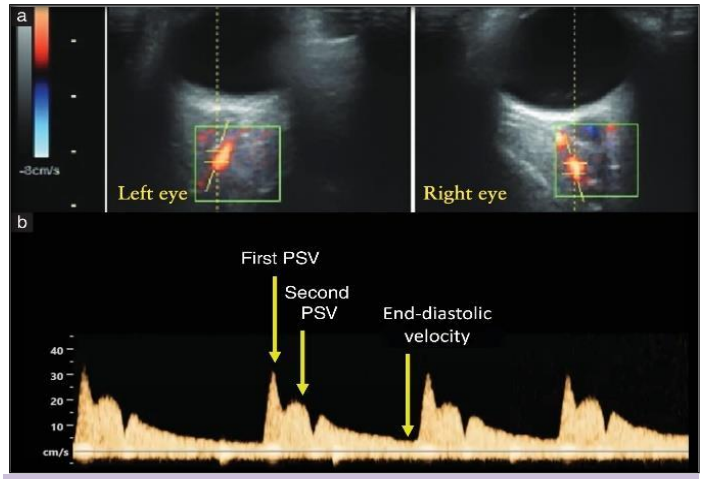


Image 2: Ophthalmic Artery waveform

Parameter	Interpretation
PI and RI	May decrease with reduced vascular resistance
PSV1	First systolic peak
PSV2	Second systolic peak, which may become more prominent
Peak ratio (PR)	PSV2/PSV1; may increase in pre-eclampsia
EDV	Reflects blood flow during diastole

Clinical significance: Ophthalmic artery Doppler may provide complementary information about maternal cerebrovascular adaptation and possible neurological involvement. However, it is not a definitive stand alone predictor of eclampsia.

Materials and Methods

Study Design: The present study was designed as a hospital based prospective study to compare Ophthalmic artery and Uterine artery Doppler indices among hypertensive and

normotensive pregnant women. The prospective design enabled systematic assessment of maternal vascular hemodynamics across different gestational ages, ranging from 11 to 37 weeks. The study aimed to evaluate differences in Ophthalmic and Uterine artery Doppler parameters associated with hypertensive disorders of pregnancy.

Study Setting: The study was conducted in the Department of Radiodiagnosis, Shridevi Institute of Medical Sciences and Research Hospital, Tumkur, Karnataka. The institution is a tertiary care, teaching hospital, providing antenatal and diagnostic services to women from urban and rural populations. Ultrasound and Doppler examinations were performed in the Department of Radiodiagnosis using GE Versana balance ultrasound equipment.

Study Duration: The study was carried out over a period of 18 months, commencing after institutional ethical approval. During this period, eligible participants were recruited, Doppler examinations were performed, and relevant clinical and demographic data were collected. The study included pregnant women between 11 weeks 0 days and 37 weeks of gestation to assess Doppler indices across a broad gestational age range.

Inclusion and Exclusion criteria: The study population comprised antenatal women aged 18–35 years with singleton pregnancies between 11 weeks 0 days and 37 weeks of gestation. Gestational age was determined using the last menstrual period and/or first-trimester ultrasonography. Women were considered eligible if they met the specified inclusion criteria and provided written informed consent before participation.

Inclusion criteria:

- Antenatal women aged between 18 and 35 years.
- Singleton pregnancy with gestational age between 11 weeks 0 days and 37 weeks.
- Willingness to participate and provision of written informed consent.

Exclusion Criteria

- Pregnant women with chronic hypertension, diabetes mellitus, renal or cardiac disease,
- Autoimmune disorders or thyroid disorders.
- Multifetal pregnancy.
- Other exclusions included ocular conditions affecting blood flow such as glaucoma, optic neuropathy, retinal vascular disease or previous ocular surgery.
- Refusal or inability to provide informed consent.

Study Sampling: Purposive sampling was employed. Eligible antenatal women attending the Radiodiagnosis Department for routine ultrasound examinations were screened consecutively and recruited upon meeting the inclusion criteria until the required sample size was achieved. Recruitment continued throughout the study period to include both hypertensive and normotensive pregnant women.

Sample Size: Sample size of 60 pregnant women were included in the study and was calculated using G*Power software (version 3.1.9.7). Based on previous literature, an effect size of 0.86 was considered for the difference in Ophthalmic artery Pulsatility Index between hypertensive and normotensive pregnant women. With a two-tailed significance level of 0.05 and 90% statistical power, the required sample size was 60 participants.

Results

Gestational Age

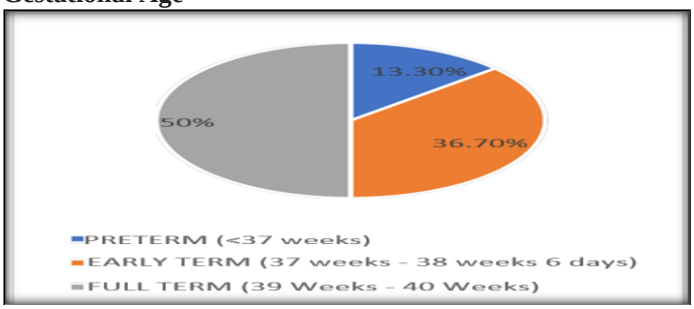


Table 1: Showing Gestational age of delivery in the study group

Gestational Age Category	Frequency (n)	Percentage (%)
<37 weeks (Preterm)	8	13.3
37–38.6 weeks (Early term)	22	36.7
39–40 weeks (Full term)	30	50.0
Total	60	100

Maternal Outcome

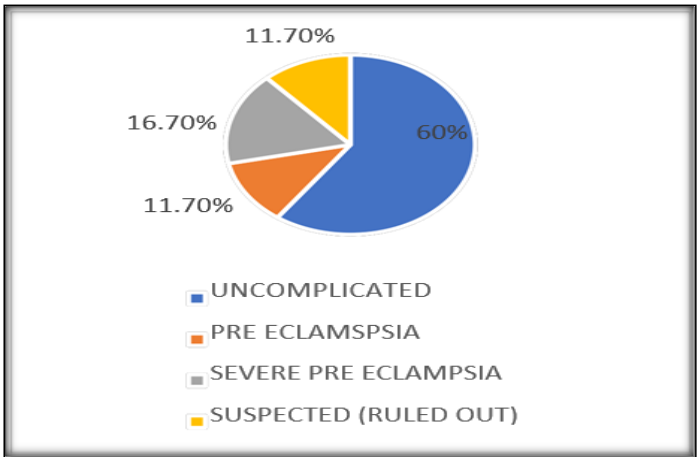


Table 2: Showing Maternal outcome in the study population

	Frequency (n)	Percentage (%)
Uncomplicated	36	60.0
Pre-eclampsia	7	11.7
Severe pre-eclamps	10	16.7
Suspected (ruled ou		11.7
Total	60	00

FETAL GROWTH

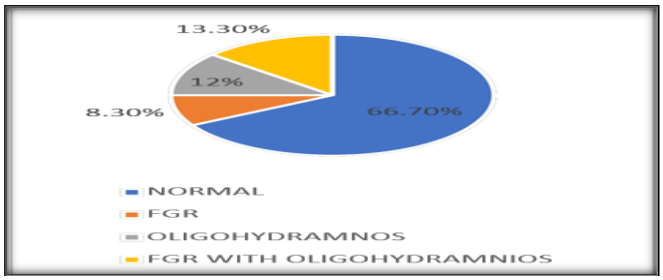


Table 3: showing fetal growth outcomes in the study population

Fetal Growth Category	Frequency (n	Percentage (%
Normal	40	66.7
FGR	5	8.3
Oligohydramnios	7	11.7
FGR with Oligohydramnios	8	13.3
Total	60	100

UTERINE ARTERY PI

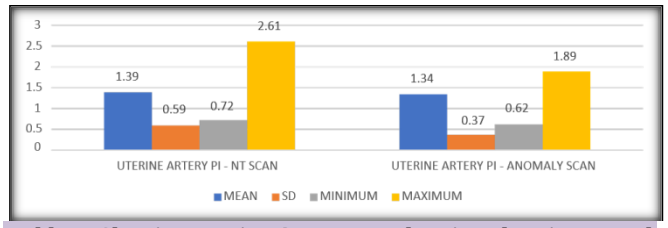


Table 4: Showing Uterine Artery PI values in values in NT and anomaly scans

The mean uterine artery PI decreased from 1.39 ± 0.59 at the NT scan to 1.34 ± 0.37 at the anomaly scan, with reduced variability.

Ophthalmix Artery Doppler Indices

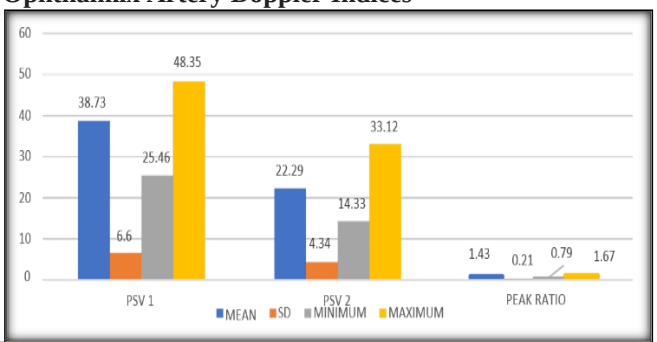


Table 5: Showing Ophthalmic artery Doppler Peak Indices

The mean Ophthalmic artery PSV1 was 38.73 ± 6.64 cm/s, with moderate variability in peak systolic blood flow velocity. The mean Ophthalmic artery PSV2 was 22.29 ± 4.34 cm/s, lower than PSV1, reflecting the characteristic second systolic peak. The mean peak ratio is 1.43 ± 0.21, indicating moderate dispersion in the ratio of systolic velocities.

OPHTHALMIC ARTERY PI AND RI VALUES:

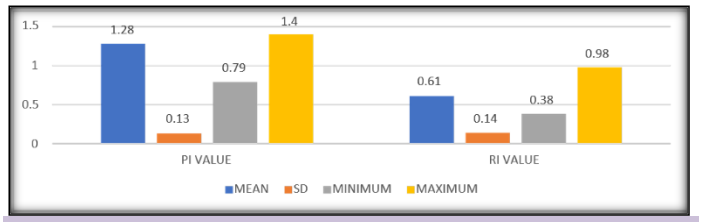


Table 6 Showing Ophthalmic artery PI AND RI Indices

The mean Ophthalmic artery PI is 1.28 ± 0.13, showing relatively low variability compared to other Doppler parameters. Most values cluster within a narrow range, suggesting stable vascular resistance in the majority of patients. The mean RI is 0.61 ± 0.14, indicating moderate variability in vascular resistance.

OPHTHALMIC ARTERY EDV

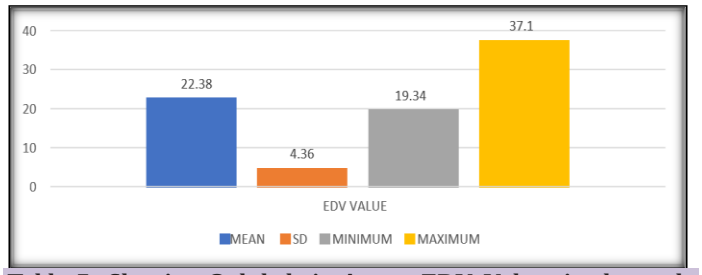


Table 7: Showing Ophthalmic Artery EDV Values in the study population

The mean EDV is 22.38 ± 4.36 cm/s, indicating variability in end-diastolic flow velocity. Higher EDV values are associated with reduced vascular resistance and improved perfusion.

COMPARISON TABLES

Table 8: Showing association between Ophthalmic Artery Doppler and Maternal Outcome

Ophthalmic Artery	Non-Hypertensive	Hypertensive	Total	Chi-square	p-value
Normal	41	11	52	6.02	0.014*
Abnormal	2	6	8		
Total	43	17	60		

A statistically significant association (p = 0.014) is observed between Ophthalmic artery Doppler findings and maternal outcome. A higher proportion of hypertensive patients show abnormal Ophthalmic artery indices compared to normotensive patients.

Table 9: Uterine Artery PI and Maternal Outcomes.

Uterine PI (NT)	Non-Hypertensive	Hypertensive	Total	Chi-square	p-value
Normal (<1.5)	39	7	46	6.18	0.013*
High (≥1.5)	4	10	14		
Total	43	17	60		

There is a statistically significant association (p = 0.013) between Uterine artery PI and maternal outcome. Elevated PI

values are more frequently observed in hypertensive patients, indicating increased uteroplacental resistance. This supports the role of Uterine artery Doppler as an early predictor of hypertensive disorders. It reflects underlying placental insufficiency.

Table 10: Ophthalmic Artery PI and Foetal growth

Group	Mean Ophthalmic PI ± SD	t-value	p-value
Normal Growth	1.30 ± 0.11	2.12	0.038
Abnormal Growth	1.21 ± 0.14		

Ophthalmic Artery PI is significantly lower in cases with abnormal fetal growth (p = 0.038), indicating altered cerebral circulation.

Table 11: Uterine Artery and Ophthalmic Artery Doppler indices correlation.

Variables Compared	Correlation (r)	p-value
UTERINE PI vs OPHTHALMIC PI	+0.42	0.001*
UTERINE PI vs OPHTHALMIC PEAK RATIO	-0.36	0.004*
OPTHALMIC PI vs RI	+0.68	<0.001*

A moderate positive correlation exists between Uterine artery PI and Ophthalmic PI, indicating that increased placental resistance is associated with changes in cerebral circulation. The negative correlation with peak ratio suggests compensatory vasodilation.

Discussion

The present study aimed to evaluate and compare Ophthalmic and Uterine artery Doppler indices in hypertensive and normotensive pregnant women between 11 and 37 weeks of gestation and assess their correlation with maternal outcomes and fetal growth parameters. It also evaluated their diagnostic performance in predicting hypertensive disorders and adverse fetal outcomes, including fetal growth restriction and oligohydramnios.

By assessing both uteroplacental resistance and maternal cerebral vascular adaptation, the study provides insights into the hemodynamic changes associated with hypertensive pregnancies. The combined Doppler approach may improve early detection, risk stratification, antenatal surveillance, and individualized management, ultimately helping reduce maternal morbidity and improve perinatal outcomes.

Half of the pregnancies (30 cases) reached full term (39-40 weeks), indicating optimal timing of delivery in most cases. [Table 1] A significant proportion (22 cases) delivered in the early term period, which is still considered clinically acceptable. Only 8 cases were preterm, reflecting a relatively low burden of prematurity.[Table 2]There were no post-term pregnancies, suggesting timely obstetric intervention.

40 fetuses showed normal growth, while 20 had abnormalities, including FGR, oligohydramnios, or both. [Table 3] These findings suggest possible placental insufficiency in hypertensive pregnancies. Velauthar et al and Nguyen T et al, reported adverse outcomes with abnormal Doppler findings, [10, 11]while, Shokry M et al and Alves JAG et al linked Ophthalmic artery peak ratio to adverse perinatal outcomes, supporting Doppler assessment for evaluating placental insufficiency and fetal complications.[12, 13]

52 women had normal Ophthalmic artery Doppler findings, while 8 women had abnormal results. [Table 4 & 5] Abnormal Ophthalmic artery Doppler was significantly associated with hypertensive status, being present in 6 of 17 hypertensive women but only 2 of 43 normotensive women, with a significant association (p = 0.014). Numerical comparison showed reduced Ophthalmic artery PI in hypertensive women(1.21 ± 0.14 vs 1.32 ± 0.10; p = 0.003) and reduced RI (0.57 ± 0.12 vs 0.64 ± 0.08; p = 0.033), reflecting reduced vascular resistance and orbital vasodilatation. These findings suggest that abnormal Ophthalmic artery Doppler indices reflect vascular adaptation and altered autoregulation associated with hypertensive pregnancy.

The present study showed mean Ophthalmic artery peak ratio of 1.43 ± 0.21 in [Table 5 & 6], EDV of 22.38 ± 4.36 cm/s. Hypertensive women had significantly lower PSV2 (p = 0.021) and peak ratio (p = 0.007), suggesting altered maternal vascular hemodynamics. While, Selima et al. identified altered second systolic peak velocity and peak ratio in severe pre-eclampsia.[14] Manchu et al. demonstrated the predictive potential of peak ratio for fetal growth restriction.[3] These findings support Ophthalmic artery Doppler as a complementary tool for evaluating maternal hemodynamic changes and assessing pregnancy related complications.

Significant association between Ophthalmic Artery Doppler findings and maternal hypertensive outcome (p = 0.014) was found.[Table 8] Among women with abnormal Doppler findings, 75% were hypertensive. Selima et al, similarly reported promising predictive performance of Ophthalmic artery Doppler for pre-eclampsia.[15] These findings support its potential role as a complementary tool for identifying high risk pregnancies and improving antenatal risk stratification.

In [Table 9 &10], we find that there was a significant inter relationship between Uterine and Ophthalmic circulations. Uterine artery PI showed a moderate positive correlation with Ophthalmic artery PI (r = +0.42, p = 0.001), is associated with measurable changes in maternal cerebral vascular resistance. Uterine artery PI also showed a negative correlation with peak ratio (r = -0.36, p = 0.004), suggesting compensatory vasodilatation in the Ophthalmic circulation. Madina et al, similarly demonstrated an inverse hemodynamic relationship between these two vascular beds: Uterine artery RI was significantly higher in pre-eclampsia (0.64 ± 0.09 vs 0.50 ± 0.08; p < 0.001), while Ophthalmic artery RI was significantly lower (0.63 ± 0.04 vs 0.70 ± 0.05; p < 0.001), and a significant negative correlation between Uterine and Ophthalmic artery RI was observed in the preeclamptic group.[15] These findings highlight the complementary roles of Uterine and Ophthalmic artery Doppler in assessing placental hypoperfusion and altered maternal vascular hemodynamics.

Strengths and Limitations

A major strength was the simultaneous assessment of Uterine and Ophthalmic artery Doppler indices in hypertensive and normotensive pregnancies. Correlation with fetal growth outcomes and comprehensive statistical analysis, including diagnostic accuracy, enhanced clinical relevance and

demonstrated potential for antenatal risk stratification.

Limitations include the small sample size, single tertiary care setting, limited subgroup representation and restricted uterine artery parameter assessment. Operator dependent Ophthalmic Doppler measurements and cross sectional evaluation further limit interpretation. Larger prospective studies are needed to validate findings and establish generalizability.

Conclusion

This study demonstrates that Uterine and Ophthalmic artery Doppler indices provide complementary information for assessing hypertensive disorders of pregnancy and fetal complications. Hypertensive pregnancies showed increased Uterine artery PI and decreased Ophthalmic artery PI, RI, peak ratio, and PSV2. Abnormal indices were associated with adverse fetal outcomes, while combined Doppler assessment strengthened risk evaluation. Significant correlations highlighted their hemodynamic relationship. Integrated assessment may improve antenatal risk stratification and guide maternal-fetal surveillance. Larger prospective studies are required to validate these findings and establish clinical applicability.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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