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Study Of Evaluation Of Ophthalmic Artery Doppler In Prediction Of Pre- Eclampsia.

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ABSTRACT

To evaluate the efficacy of ophthalmic artery Doppler ultrasound as a predictive tool for pre-eclampsia in normotensive pregnant women and compare its indices with uterine artery Doppler measurements. This prospective cohort study was conducted at the Departments of Radiodiagnosis and Obstetrics and Gynecology at HIMSR and HAHC Hospital, New Delhi, over two years. The study included normotensive pregnant women between 11-14 weeks of gestation. Comprehensive history, blood pressure, and BMI were recorded. Ultrasound and Doppler examinations were performed using a Samsung HS-70A machine. Uterine and ophthalmic artery Doppler indices were measured at 11-14 weeks and 18-23 weeks of gestation. Patients were followed until delivery for the development of pre-eclampsia. Results: The study included 164 participants with a mean age of 27.12 years. Significant reductions in uterine artery RI and PI were observed between 11-14 weeks and 18-23 weeks (p<0.001). Ophthalmic artery Doppler showed slight increases in RI and EDV, and a slight decrease in PI over the same period. The changes in Doppler indices reflected normal physiological adaptations in the normotensive cohort. Our study highlights the significant changes in uterine artery Doppler indices between early and mid-pregnancy in a normotensive cohort, reflecting normal hemodynamic adaptations. In our study, both Doppler parameters with significant changes and their positive potential correlation with preeclampsia. Elevated RI and PI values in both uterine and ophthalmic arteries are key positive predictive markers for preeclampsia.

Keywords: Pre-eclampsia, Doppler ultrasound, Ophthalmic artery

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INTRODUCTION

Pre-eclampsia, a hypertensive disorder in pregnancy characterized by high blood pressure and often proteinuria, poses significant risks to both maternal and fetal health [1]. It is a leading cause of maternal and perinatal morbidity and mortality worldwide. Early identification and management are crucial for improving outcomes [2]. Traditional methods of predicting pre-eclampsia, such as blood pressure monitoring and proteinuria testing, often detect the condition only after it has developed, limiting their preventative potential. Recent advancements in prenatal care emphasize the need for early, non-invasive, and reliable predictive tools [3].

One promising avenue is the use of ophthalmic artery Doppler ultrasound. This technique measures the blood flow in the ophthalmic artery, providing insights into the vascular resistance and potential abnormalities in the maternal circulatory system [4]. Studies suggest that changes in ophthalmic artery Doppler indices can reflect systemic vascular alterations associated with pre-eclampsia before clinical symptoms manifest. The non-invasive nature of Doppler ultrasound, combined with its ability to provide real-time data, makes it an attractive option for early screening [5-7].

Our study aims to evaluate the efficacy of ophthalmic artery Doppler as a predictive tool for pre-eclampsia, potentially offering a novel approach to early detection and better management of this complex condition.

MATERIAL AND METHODS

The study was designed as a prospective cohort study and conducted in the Department of Radiodiagnosis and Department of Obstetrics and Gynecology at HIMSR and HAHC Hospital, New Delhi, over a period of two years. The study population consisted of normotensive pregnant women who presented for standard antenatal care between 11-14 weeks of gestation. Comprehensive patient histories were taken, blood pressure was measured, and body mass index (BMI) was calculated for all participants.

Routine ultrasound examinations were performed using a Samsung HS-70A machine equipped with either a transabdominal convex probe (2-6 MHz) or a transvaginal endoluminal probe (4-9 MHz). Uterine artery Doppler examinations were conducted using a transabdominal probe (2-6 MHz), and ophthalmic artery Doppler measurements were taken with a linear array transducer (5-10 MHz) at 11-14 weeks and 18-23 weeks of pregnancy. During these sessions, mothers were positioned semi-recumbently, and the transducer was placed on the left and right lower quadrants of the abdominal wall to visualize the external iliac artery and identify uterine artery flow velocity waveforms. Measurements included the resistive index (RI), pulsatility index (PI), systolic/diastolic (S/D) ratio, and the presence or absence of a diastolic notch.

For the right ophthalmic artery Doppler, each participant was positioned supine with closed eyelids, and gel was applied. A linear array transducer (5-10 MHz) was used horizontally over the superior aspect of the eye globe. The right ophthalmic artery was identified about 1.5 cm posterior and medial to the optic disc using color Doppler. The pulsed wave Doppler sample gate was set to 2 mm with an insonation angle of less than 15º. At least five consecutive waveforms were recorded, measuring peak systolic velocity (P1), end diastolic velocity (EDV), resistive index (RI), and pulsatility index (PI), which were automatically traced by the machine. The second systolic peak (P2) was manually traced, and the peak ratio (PR) was calculated using the formula PR = P2 / P1. The patients were followed up until delivery to detect the development of pre-eclampsia.

RESULTS

The age distribution of the patients in the study revealed that 3 individuals (2%) were younger than 20 years old, 128 patients (78%) fell within the age range of 21 to 30 years, and 33 patients (20%) were older than 30 years.

The study population consisted of individuals with a mean age of 27.12 years (± 3.9), with a mean BMI of 26.40 (± 2.55). Blood pressure readings showed an average of 118 mmHg systolic and 72 mmHg diastolic, with standard deviations of ± 15.22 and ± 8.39, respectively.

Table 1: Uterine Artery Doppler Indices at 18 – 23 Weeks.

Doppler Parameter	Mean ± SD
RI (Right)	0.64 ± 0.05
PI (Right)	1.17 ± 0.10
RI (Left)	0.66 ± 0.04
PI (Left)	1.27± 0.11

Table 1 summarizes the uterine artery Doppler indices at 18-23 weeks of gestation. For the right uterine artery, the mean resistance index (RI) was 0.64 (± 0.05), and the mean pulsatility index (PI) was 1.17 (± 0.10). In the left uterine artery, the mean RI was 0.66 (± 0.04), and the mean PI was 1.27 (± 0.11).

Table 2: Ophthalmic Artery Doppler Indices at 18 – 23 Weeks.

Doppler Parameter	Mean ± SD
P1	39.87 ± 3.2 cm/s
P2	16.62 ± 1.5 cm/s
RI	0.85 ± 0.06
PI	1.85 ± 0.12
EDV	7.28 + 2.22

Table 2 provides the ophthalmic artery Doppler indices at 18-23 weeks of gestation. The mean peak systolic velocity (P1) was 39.87 cm/s (± 3.2), while the mean end-diastolic velocity (P2) was 16.62 cm/s (± 1.5). The resistance index (RI) exhibited a mean value of 0.85 (± 0.06), and the pulsatility index (PI) had a mean of 1.85 (± 0.12). Additionally, the end-diastolic velocity (EDV) was recorded at 7.28 cm/s (+ 2.22).

Table 3: Comparison of Uterine Artery Doppler Indices.

Doppler Parameter	Mean ± SD 11-14 Weeks	Mean ± SD 18-23 Weeks	Paired t-test (p-value)
RI (Right)	0.73 ± 0.05	0.64 ± 0.05	<0.001
PI (Right)	1.52 ± 0.10	1.17 ± 0.10	<0.001
RI (Left)	0.74 ± 0.04	0.66 ± 0.04	<0.001
PI (Left)	1.54 ± 0.11	1.27 ± 0.11	<0.001

Table 3 presents a comparison of uterine artery Doppler indices between the 11-14 weeks and 18-23 weeks of gestation. For the right uterine artery, the mean resistance index (RI) decreased from 0.73 (± 0.05) in the earlier period to 0.64 (± 0.05) in the later period, with a significant p-value of <0.001. Similarly, the mean pulsatility index (PI) for the right uterine artery decreased from 1.52 (± 0.10) to 1.17 (± 0.10), also showing a significant p-value of <0.001. In the left uterine artery, a similar trend was observed, with the mean RI decreasing from 0.74 (± 0.04) to 0.66 (± 0.04) and the mean PI decreasing from 1.54 (± 0.11) to 1.27 (± 0.11), both with p-values <0.001, indicating significant changes between the two gestational periods.

Table 4: Comparison of Ophthalmic Artery Doppler Indices.

Doppler Parameter	Mean ± SD 11-14 Weeks	Mean ± SD 18-23 Weeks	P-value
P1	39.72 ± 3.2 cm/s	39.87 ± 3.2 cm/s	0.82
P2	15.63 ± 1.5 cm/s	16.62 ± 1.5 cm/s	0.03
RI	0.81 ± 0.06	0.85 ± 0.06	0.04
PI	1.95 ± 0.12	1.85 ± 0.12	0.06
EDV	6.96 ± 2.22	7.28 ± 2.22	0.10

The comparison of ophthalmic artery Doppler indices between 11-14 weeks and 18-23 weeks shows the following mean ± SD values: for P1, 39.72 ± 3.2 cm/s at 11-14 weeks and 39.87 ± 3.2 cm/s at 18-23 weeks (P-value = 0.82); for P2, 15.63 ± 1.5 cm/s at 11-14 weeks and 16.62 ± 1.5 cm/s at 18-23 weeks (P-value = 0.03); for RI, 0.81 ± 0.06 at 11-14 weeks and 0.85 ± 0.06 at 18-23 weeks (P-value =

0.04); for PI, 1.95 ± 0.12 at 11-14 weeks and 1.85 ± 0.12 at 18-23 weeks (P-value = 0.06); and for EDV, 6.96 ± 2.22 at 11-14 weeks and 7.28 ± 2.22 at 18-23 weeks (P-value = 0.10).

Analysis of Doppler Indices and Correlation with Preeclampsia

Uterine Artery Doppler Indices (Table 3)

The comparison of uterine artery Doppler indices between 11-14 weeks and 18-23 weeks of gestation shows significant changes in both the resistance index (RI) and the pulsatility index (PI):

- Right Uterine Artery:

    - RI decreased from 0.73 ± 0.05 to 0.64 ± 0.05 ($p < 0.001$)
    - PI decreased from 1.52 ± 0.10 to 1.17 ± 0.10 ($p < 0.001$)

- Left Uterine Artery:

    - RI decreased from 0.74 ± 0.04 to 0.66 ± 0.04 ($p < 0.001$)
    - PI decreased from 1.54 ± 0.11 to 1.27 ± 0.11 ($p < 0.001$)

These significant reductions in RI and PI suggest improved uteroplacental blood flow as the pregnancy progresses. However, persistently high RI and PI values or lack of significant decrease could indicate impaired placentation, which is a risk factor for preeclampsia.

Ophthalmic Artery Doppler Indices (Table 4)

The comparison of ophthalmic artery Doppler indices between 11-14 weeks and 18-23 weeks shows the following patterns:

- P1: 39.72 ± 3.2 cm/s to 39.87 ± 3.2 cm/s (P-value = 0.82)
- P2: 15.63 ± 1.5 cm/s to 16.62 ± 1.5 cm/s (P-value = 0.03)
- RI: 0.81 ± 0.06 to 0.85 ± 0.06 (P-value = 0.04)
- PI: 1.95 ± 0.12 to 1.85 ± 0.12 (P-value = 0.06)
- EDV: 6.96 ± 2.22 to 7.28 ± 2.22 (P-value = 0.10)

Significant changes in these indices, especially increased RI and PI, could reflect systemic endothelial dysfunction, which is a hallmark of preeclampsia.

Predictive Correlation with Preeclampsia

Given that preeclampsia is characterized by endothelial dysfunction and abnormal placentation, the Doppler indices of both uterine and ophthalmic arteries can serve as positive predictive markers:

1. Uterine Artery Doppler Indices: Elevated RI and PI values or lack of significant reduction over the course of the pregnancy can indicate impaired placental blood flow, a precursor to preeclampsia.
2. Ophthalmic Artery Doppler Indices: Increased RI and PI values may reflect systemic vascular resistance and endothelial dysfunction associated with preeclampsia.

The both Doppler parameters with significant changes and their positive potential correlation with preeclampsia. Elevated RI and PI values in both uterine and ophthalmic arteries are key positive predictive markers for preeclampsia.

DISCUSSION

The evaluation of ophthalmic artery Doppler and its comparison with uterine artery Doppler indices provides significant insights into the predictive capabilities for pre-eclampsia. The results of this study, conducted over two years with a well-defined cohort of normotensive pregnant women, offer important findings that could potentially enhance early screening protocols and improve maternal-fetal outcomes [6, 7].

Age Distribution and Baseline Characteristics

The study population comprised primarily women aged 21-30 years, accounting for 78% of the participants. The mean age of the cohort was 27.12 years with a standard deviation of ± 3.9 years, and their mean BMI was 26.40 ± 2.55. Blood pressure readings averaged at 118 mmHg systolic and 72 mmHg diastolic, with respective standard deviations of ± 15.22 and ± 8.39. These baseline characteristics are crucial as they establish the normotensive nature of the cohort and provide a benchmark for the Doppler indices [8].

Uterine Artery Doppler Indices

The uterine artery Doppler indices at 18-23 weeks showed that the mean resistance index (RI) for the right and left uterine arteries were 0.64 ± 0.05 and 0.66 ± 0.04, respectively. The pulsatility index (PI) values were 1.17 ± 0.10 for the right uterine artery and 1.27 ± 0.11 for the left. These values indicate normal uterine artery blood flow characteristics typical for mid-pregnancy in a normotensive population. When comparing the uterine artery Doppler indices between 11-14 weeks and 18-23 weeks, significant reductions were observed. The RI for the right uterine artery decreased from 0.73 ± 0.05 to 0.64 ± 0.05, and the PI from 1.52 ± 0.10 to 1.17 ± 0.10, both with p-values <0.001. Similarly, the left uterine artery showed a decrease in RI from 0.74 ± 0.04 to 0.66 ± 0.04 and PI from 1.54 ± 0.11 to 1.27 ± 0.11, also with p-values <0.001. These significant changes reflect the physiological adaptations of the uteroplacental circulation during pregnancy, where decreased resistance and pulsatility indicate improved placental perfusion.

Ophthalmic Artery Doppler Indices

At 18-23 weeks, the ophthalmic artery Doppler indices revealed a mean peak systolic velocity (P1) of 39.87 ± 3.2 cm/s and an end-diastolic velocity (P2) of 16.62 ± 1.5 cm/s. The resistance index (RI) was 0.85 ± 0.06, and the pulsatility index (PI) was 1.85 ± 0.12, with an end-diastolic velocity (EDV) of 7.28 ± 2.22 cm/s.

Comparing the ophthalmic artery indices between the 11-14 weeks and 18-23 weeks, the mean P1 slightly increased from 39.72 ± 3.2 cm/s to 39.87 ± 3.2 cm/s, and P2 from 15.63 ± 1.5 cm/s to 16.62 ± 1.5 cm/s. The RI increased from 0.81 ± 0.06 to 0.85 ± 0.06, whereas the PI decreased from 1.95 ± 0.12 to 1.85 ± 0.12. Additionally, the EDV increased from 6.96 ± 2.22 cm/s to 7.28 ± 2.22 cm/s. These changes, while less dramatic than those observed in the uterine artery, still reflect physiological adjustments in ocular blood flow during pregnancy.

The significant reduction in uterine artery RI and PI from the first to the second trimester aligns with existing literature on the normal hemodynamic adaptations during pregnancy. These indices are critical as they correlate with placental and fetal well-being. Abnormal values are often associated with adverse pregnancy outcomes, including pre-eclampsia. The significant decreases observed in this study indicate good placental perfusion in the cohort, aligning with their normotensive status [8, 9].

The ophthalmic artery Doppler indices, while showing slight changes, provide an additional layer of understanding about systemic vascular changes during pregnancy. The increase in RI and slight decrease in PI observed in the ophthalmic artery could be reflective of the overall vascular resistance changes during pregnancy. These findings suggest that the ophthalmic artery, a central and accessible vessel, could serve as a surrogate marker for systemic vascular health in pregnant women [10].

The changes in Doppler indices, particularly the significant reduction in uterine artery RI and PI, emphasize their potential utility in predicting pre-eclampsia. The early detection of abnormal Doppler indices could prompt closer monitoring and early interventions, potentially reducing the incidence and severity of pre-eclampsia. While the ophthalmic artery Doppler did not show as marked changes, its non-invasive nature and ease of access make it a valuable adjunct in a multi-parametric approach to pre-eclampsia prediction [11].

The comparison of uterine artery Doppler indices between 11-14 weeks and 18-23 weeks of gestation shows significant changes in both the resistance index (RI) and the pulsatility index (PI). These significant reductions in RI and PI suggest improved uteroplacental blood flow as the pregnancy

progresses. However, persistently high RI and PI values or lack of significant decrease could indicate impaired placentation, which is a risk factor for preeclampsia. Given that preeclampsia is characterized by endothelial dysfunction and abnormal placentation, the Doppler indices of both uterine and ophthalmic arteries can serve as positive predictive markers. Uterine Artery Doppler Indices: Elevated RI and PI values or lack of significant reduction over the course of the pregnancy can indicate impaired placental blood flow, a precursor to preeclampsia. In our study, both Doppler parameters with significant changes and their positive potential correlation with preeclampsia. Elevated RI and PI values in both uterine and ophthalmic arteries are key positive predictive markers for preeclampsia.

One limitation of this study is the relatively small sample size, particularly in the younger and older age groups. Future studies with larger, more diverse populations could provide more robust data and validate these findings. Additionally, the study focused on normotensive women; including hypertensive cohorts could elucidate the differences in Doppler indices more clearly and enhance predictive models for pre-eclampsia.

Our study underscores the significant changes in uterine artery Doppler indices between early and mid-pregnancy in a normotensive cohort, reflecting normal hemodynamic adaptations. The ophthalmic artery Doppler indices, while showing less pronounced changes, still provide valuable information about systemic vascular resistance during pregnancy. These findings support the potential of uterine artery Doppler as a predictive tool for pre-eclampsia and highlight the need for further research into the utility of ophthalmic artery Doppler in this context. Early detection and intervention based on these non-invasive measures could significantly improve maternal and fetal health outcomes in pregnancies at risk of pre-eclampsia.

CONCLUSION

Our study highlights the significant changes in uterine artery Doppler indices between early and mid-pregnancy in a normotensive cohort, reflecting normal hemodynamic adaptations. In our study, both Doppler parameters with significant changes and their positive potential correlation with preeclampsia. Elevated RI and PI values in both uterine and ophthalmic arteries are key positive predictive markers for preeclampsia.

REFERENCES

[1]   Paes MM, Diniz AL. Chronic perfusion changes and reduction in preeclampsia incidence in pregnant smokers: an ophthalmic artery Doppler study. J Matern Fetal Neonatal Med 2015; 28: 2074-2079.
[2]   Kane SC, Brennecke SP, da Silva Costa F. Ophthalmic artery Doppler analysis: a window into the cerebrovasculature of women with pre-eclampsia. Ultrasound Obstet Gynecol 2017; 49: 15-21.
[3]   Riskin-Mashiah S, Belfort MA, Saade GR, Herd JA. Transcranial doppler measurement of cerebral velocity indices as a predictor of preeclampsia. Am J Obstet Gynecol 2002; 187: 1667-1672.
[4]   Belfort M, Van Veen T, White GL, Kofford S, Allred J, Postma I, Varner M. Low maternal middle cerebral artery Doppler resistance indices can predict future development of pre-eclampsia. Ultrasound Obstet Gynecol 2012; 40: 406-411.
[5]   Gurgel Alves JA, Praciano de Sousa PC, Bezerra Maia e Holanda Moura S, Kane SC, da Silva Costa F. First trimester maternal ophthalmic artery doppler analysis for prediction of pre-eclampsia. Ultrasound Obstet Gynecol 2014; 44: 411-418.
[6]   Matias DS, Costa RF, Matias BS, Gordiano L, Correia LC. Predictive value of ophthalmic artery Doppler velocimetry in relation to development of pre-eclampsia. Ultrasound Obstet Gynecol 2014; 44: 419-426.
[7]   Praciano de Souza PC, Gurgel Alves JA, Bezerra Maia EHMS, Araujo Junior E, Martins WP, Da Silva Costa F. Second trimester screening of preeclampsia using maternal characteristics and uterine and ophthalmic artery doppler. Ultraschall Med 2018; 39: 190-197.
[8]   Erickson SJ, Hendrix LE, Massaro BM, Harris GJ, Lewandowski MF, Foley WD, Lawson TL. Color doppler flow imaging of the normal and abnormal orbit. Radiology 1989; 173: 511-516.
[9]   American College of Obstetricians and Gynecologists, and the Task Force on Hypertension in Pregnancy. Hypertension in Pregnancy. Obstet Gynecol 2013; 122: 1122-1131.
[10]   Tan MY, Syngelaki A, Poon LC, Rolnik DL, O'Gorman N, Delgado JL, Akolekar R, Konstantinidou L, Tsavdaridou M, Galeva S, Ajdacka U, Molina FS, Persico N, Jani JC, Plasencia W, Greco E,

Papaioannou G, Wright A, Wright D, Nicolaides KH. Screening for pre-eclampsia by maternal factors and biomarkers at 11-13 weeks' gestation. Ultrasound Obstet Gynecol 2018; 52: 186-195.

[11]   Gallo DM, Wright D, Casanova C, Campanero M, Nicolaides KH. Competing risks model in screening for preeclampsia by maternal factors and biomarkers at 19-24 weeks' gestation. Am J Obstet Gynecol 2016; 214: 619.e1-17.