

Estimation of Normative Values of Maternal Artery Doppler Velocimetry in Second Trimester in Indian Population: A Cross-sectional Study

NARLEEN KAUR¹, AMANDEEP SINGH², DEEPTI NAIK³

ABSTRACT

Introduction: Ophthalmic artery is the first branch of the internal carotid artery and provides an indirect approach to flow pattern and velocimetry information to less approachable intracranial circulation.

Aim: To obtain the normative reference value of maternal Ophthalmic Artery Doppler (OAD) velocimetry in the second trimester.

Materials and Methods: The present cross-sectional study was conducted on 700 patients who visited the hospital for antenatal ultrasound in the second trimester at the Department of Radiodiagnosis and Imaging, Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar, Punjab, India. Maternal OAD was performed with a GE Voluson E8 Expert BT12 (Wipro GE) using a linear 5-10 MHZ transducer. After recording the patient history, various doppler indices like First Peak Systolic Velocity (PSV1), Second PSV2, Pulsatility Index (PI), End Diastolic Velocity (EDV), Resistivity Index (RI), Systolic to Diastolic ratio (S/D) and PSV2 to PSV1 ratio (PSV ratio: PSV2/PSV1) were recorded. Descriptive analyses were performed using Statistical Package

for Social Sciences (SPSS) version 25.0 to compute frequencies, percentages, means, and standard deviations.

Results: A total of 700 subjects were included with a mean age of 28.28 ± 5.63 and a mean Body Mass Index (BMI) of 25.89 ± 2.71 kg/mm². The mean systolic blood pressure and diastolic blood pressure was 117.87 ± 8.38 and 78.42 ± 5.70 , with Mean Arterial Pressure (MAP) 91.49 ± 5.75 . The OAD velocimetry revealed the mean PSV1 value of 33.05 ± 6.71 cm/sec, PSV2 value of 16.22 ± 3.66 cm/sec. Similarly, mean PSV2/PSV1 and EDV values were 0.49 ± 0.07 and 5.76 ± 1.54 cm/sec, respectively. The other doppler parameters like mean PI, RI and S/D values were 2.43 ± 0.34 , 0.82 ± 0.04 , and 6.07 ± 1.85 .

Conclusion: Establishing reference values for maternal OA doppler parameters is crucial for distinguishing between normal and pathological pregnancies. Change from normal values may indicate a pathological state like increased vascular resistance, which usually results at around 20th week of gestation. These changes may be the earliest indication of future development of preeclampsia, which requires earlier detection for proper management.

Keywords: Intracranial vasculature, Ophthalmic artery, Preeclampsia

INTRODUCTION

The ophthalmic artery is the first branch of the internal carotid artery and has anatomical, embryological, and functional similarities with the intracranial vasculature and is an easily approachable artery for doppler assessment [1]. Various haemodynamic changes occur in pregnancy related to the compliance of the blood vessels [1]. Preeclampsia (PE) usually manifests at around 20 weeks of gestational age, as increased vascular resistance of systemic vasculature induced by abnormal placental vascular response and endothelial dysfunction is at around the 20th week of gestation [2,3].

The OAD velocimetry most commonly used are the PSV, EDV, RI, and PI [4-6]. A relatively newer velocimetry parameter known as Peak Ratio (PR), which is calculated by dividing the second to PSV1 [7]. PE is a multisystemic disorder characterised by abnormal vascular response to placenta formation, a hypercoagulable state, and endothelial dysfunction [8,9]. It is one of the most common causes of morbidity and mortality, with a global incidence of 5 to 10% [10]. It presents with complications in the eyes in 30 to 100% of patients [11]. The current emphasis has been on the association of ophthalmic artery velocimetry changes in the potential development of PE, but there has been a scarcity of normative data of the OAD velocimetry in the second trimester. Therefore, the present study aimed to provide and establish the normal OAD values in the second trimester of pregnancy in the Indian population.

MATERIALS AND METHODS

The present cross-sectional study was conducted on 700 patients who visited for antenatal ultrasound in the second trimester at the Department of Radiodiagnosis and Imaging, Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar, Punjab, India, over a duration of one and a half years. Clearance for the study was obtained from the Institutional Ethical Committee (Ref No. SGRDU/Cont/Thesis/24-534). Written informed consent in the vernacular language of each patient was taken.

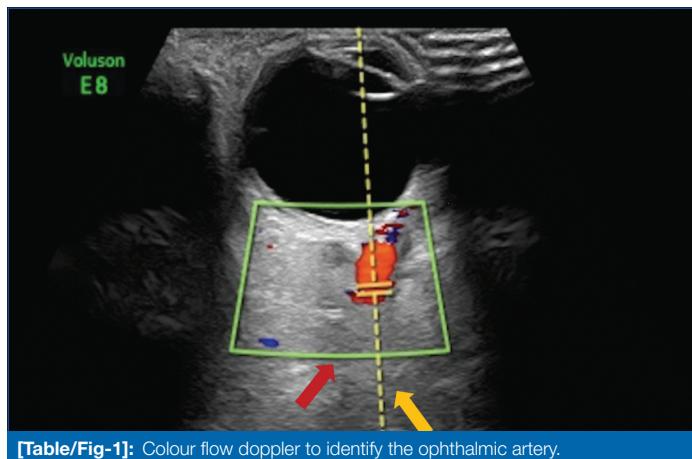
Inclusion and Exclusion criteria: Females at 18 to 24 weeks of gestation presenting to the Department of Radiodiagnosis for a routine antenatal visit were included in the present study. Patients known to be hypertensive before conception, patients on medications other than supplementation routinely used in pregnancy (e.g., Iron supplements, multivitamins, etc.), patients who are already on treatment for PE, patients with known ophthalmic pathology, and pregnancies with congenital abnormalities in the foetus were excluded.

Study Procedure

Demographic data like the maternal age and Body Mass Index (BMI), and relevant clinical history were obtained from the participants.

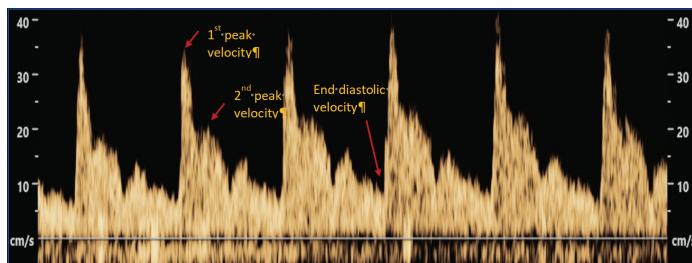
Ultrasonographic technique: Ultrasonography was performed using a GE Voluson E8 Expert BT12 (Wipro GE) using a linear 5-10 MHZ transducer. The patient was placed in the supine position to rest for five minutes. The transducer was then placed transversely and

gently over her closed upper eyelid after application of conduction gel. Colour flow Doppler was used to identify the ophthalmic artery, which is found superiorly and medially to the hypoechoic band representing the optic nerve [Table/Fig-1]. A radiologist with more than nine years of experience performed the technique. Pulsed-wave doppler was then used to record three to five similar waveforms from each eye alternatively (i.e., first the right eye, then the left eye, followed by the right eye and then the left eye again). A similar technique has been performed in a previous study [10]. The angle of insonation was to be kept $<20^\circ$. To minimise any potential adverse effects on the eyes, the duration of the examination of each eye is a few seconds, and a special preset was used with a marked reduction in output power and a maximum mechanical index of 0.4.



[Table/Fig-1]: Colour flow doppler to identify the ophthalmic artery.

The following indices were used for analysis: PSV1, PSV2, PI, ratio of second to PSV1 (PR), RI, and S/D. The first PSV, EDV, RI, PI, and S/D were automatically obtained by the machine, the second PSV was measured manually, and the ratio of the second to the first PSV was calculated [Table/Fig-2]. The average value of the two readings of each parameter was taken from the right and left eyes. The PR was calculated by dividing the second PSV by the first PSV.



[Table/Fig-2]: This image represents the spectral waveform of the ophthalmic artery with the arrows representing the first PSV, second PSV and the End Diastolic Velocity (EDV).

STATISTICAL ANALYSIS

The data collected was first entered in Microsoft Excel. Descriptive analyses were performed using SPSS version 25.0 to compute frequencies, percentages, means, and standard deviations.

RESULTS

The mean age of the participants was 28.28 ± 5.63 years. The mean BMI among all the subjects came out to be 25.89 ± 2.71 . The total number of subjects below the age of 20 years was 64 (9.4%) [Table/Fig-3]. A total of 293 (41.8%) subjects were labeled as normal, 356 (50.8%) as overweight and 51 (7.4%) as obese [Table/Fig-4]. The mean systolic blood pressure and diastolic blood pressure among subjects was 117.87 ± 8.38 and 78.42 ± 5.70 , respectively. The MAP was 91.49 ± 5.75 .

The OAD parameters were also calculated to their mean values, with a mean PSV1 of 33.05 ± 6.71 cm/sec, a mean PSV2 value of 16.22 ± 3.66 cm/sec, a mean PR value of 0.49 ± 0.07 , and a mean

EDV of 5.76 ± 1.54 . The other Doppler parameters, like mean PI, RI, and S/D, were 2.43 ± 0.34 , 0.82 ± 0.04 , and 6.07 ± 1.85 , respectively, with a p-value of <0.001 [Table/Fig-5].

Age group	Frequency (N=700)
Up to 20 years	64 (9.4%)
21-30 years	451 (64.1%)
>30 years	185 (26.5%)

[Table/Fig-3]: Age distribution of subjects (N=700).

BMI	Frequency (N=700)
Normal	293 (41.8%)
Overweight	356 (50.8%)
Obese	51 (7.4%)

[Table/Fig-4]: BMI distribution of subjects (N=700).

Velocimetry parameters	Values (N=700)
PSV1	33.05 ± 6.71
PSV2	16.22 ± 3.66
PSV2:PSV1	0.49 ± 0.07
PI	2.43 ± 0.34
RI	0.82 ± 0.04
S/D	6.07 ± 1.85
EDV	5.76 ± 1.54

[Table/Fig-5]: Ophthalmic Artery Doppler (OAD) velocimetry parameters among subjects (n=700).

DISCUSSION

The OAD is a non-invasive method of assessing real-time cerebrovascular parameters. It can provide useful and appropriate knowledge of cerebral manifestations of pregnancy-related hypertension [12]. Various studies have shown lower ophthalmic artery PI values and higher PR values in women with hypertensive diseases of pregnancy [13,14]. Other cerebral arteries, embryologically and functionally related to the ophthalmic artery, also demonstrated lower flow resistance in the second trimester of pregnancy among women who were to develop PE [15,16].

A study was conducted by Alves JA et al., on 409 singleton pregnancies between 11 and 14 weeks' of gestation [17]. In their study, mean \pm SD values for maternal OAD parameters were RI= 0.81 ± 0.12 , PI= 2.06 ± 0.57 , PSV= 36.41 ± 12.1 , PD1= 21.07 ± 7.62 , and PR= 0.58 ± 0.11 .

In a longitudinal study conducted by Corrêa-Silva EP et al., on 63 low-risk pregnant women, researchers observed a decreasing trend in PI and RI of the OA and PI of the Central Retinal Artery (CRA) as gestation progressed. However, the PR of the OA did not show significant changes. The present study provided percentile-based reference values for each gestational age [18].

Carneiro RS et al., on 276 healthy women between 20 to 39 weeks of gestation concluded that OA Doppler measurements did not vary significantly during healthy pregnancies, suggesting stability in these parameters across gestation. The parameters measured in their study were PI, RI, PSV, Peak Diastolic Velocity (PDV), End Diastolic Flow Velocity (EDFV) and PR [19].

A study involving 289 healthy pregnant women between 20 and 40 weeks of gestation assessed the RI, PI, and PR of the OA. The findings indicated a significant inverse correlation between gestational age and both RI and PI, suggesting a decrease in vascular resistance as pregnancy progresses. PR values remained relatively stable throughout gestation. The study also demonstrated high intraobserver reproducibility and strong correlation between measurements in the right and left eyes, supporting the reliability of OA Doppler assessments in clinical practice [20].

A study comparing OA doppler parameters between twin and singleton pregnancies found no significant differences in PI and PR values. This suggests that the same reference values established for singleton pregnancies can be applied to twin pregnancies for these specific indices. However, a significant difference was observed in RI values between the groups, indicating that RI may require separate reference considerations in twin gestations [21].

The establishment of normative OAD values during the second trimester has significant potential for application in clinical settings, especially for the prediction and monitoring of hypertensive disorders in pregnancy. As cerebral haemodynamic changes often precede clinical symptoms, the ability to detect these alterations non-invasively using OAD can offer a promising opportunity for earlier diagnosis. Normative Doppler indices- such as PI, RI, and PR- serve as reference benchmarks that enable clinicians to detect deviations suggestive of increased risk for PE. Incorporating these measurements into routine antenatal screening can aid in risk stratification and timely referral to specialist care. Moreover, serial assessment of these parameters can be particularly useful in high-risk patients, where changes in OAD values over time may inform the trajectory of disease progression and the need for intensified monitoring or intervention.

Limitation(s)

The study did not follow participants longitudinally through pregnancy; thus trends across all trimesters or individual changes over time were not assessed. Conducted at a single tertiary care center, which may limit the generalisability of the results to other regions or healthcare settings within India. Participants were selected from an antenatal clinic, which may not reflect the characteristics of the general pregnant population in the community.

CONCLUSION(S)

Establishing reference values for maternal OA doppler parameters is crucial for distinguishing between normal and pathological pregnancies. Change from normal values may indicate a pathological state like increased vascular resistance, which usually results at around 20th week of gestation. These changes may be the earliest indication of future development of preeclampsia, which, when interpreted in the context of maternal history and other risk factors, can offer a non-invasive, accessible, and informative tool for the early identification and monitoring of hypertensive disorders in pregnancy, ultimately contributing to improved maternal and foetal outcomes.

REFERENCES

- [1] Kane SC, Brennecke SP, da Silva Costa F. Ophthalmic artery Doppler analysis: A window into the cerebrovasculature of women with pre-eclampsia. *Ultra Obstet Gynecol.* 2017;49:15-21.
- [2] Brown MA, Magee LA, Kenny LC, Karumanchi SA, McCarthy FP, Saito S, et al. Hypertensive disorders of pregnancy: ISSHP classification, diagnosis, and management recommendations for international practice. *Hypertension.* 2018;72(1):24-43.
- [3] Tranquilli A, Dekker G, Magee L, Roberts J, Sibai BM, Steyn W, et al. The classification, diagnosis and management of the hypertensive disorders of pregnancy: a revised statement from the ISSHP. *Pregnancy Hypertension: An International Journal of Women's Cardiovascular Health.* 2014;4(2):97-104.
- [4] Carneiro RS, Sass N, Diniz AL, Souza EV, Torloni MR, Moron AF. Ophthalmic artery Doppler velocimetry in healthy pregnancy. *Int J Gynaecol Obstet* 2008;100:211-15.
- [5] Diniz ALD, Moron AF, dos Santos MC, Sass N, Pires CR. Doppler velocimetry of ophthalmic and central retinal arteries in normal pregnancies. *Rev Bras Ginecol Obstet.* 2005;27(4):168-173. Doi:10.1590/S0100-72032005000400002.
- [6] Diniz AL, Moron AF, dos Santos MC, Sass N, Pires CR, Debs CL. Ophthalmic artery Doppler as a measure of severe pre- eclampsia. *Int J Gynaecol Obstet* 2008;100:216-20.
- [7] Nakatsuka M, Takata M, Tada K, Kudo T. Effect of a nitric oxide donor on the ophthalmic artery flow velocity waveform in pre-eclamptic women. *J Ultrasound Med.* 2002;21:309.
- [8] Hata T, Senoh D, Hata K, Kitao M. Ophthalmic artery velocimetry in pregnant women. *Lancet.* 1992;340:182-83.
- [9] Naemi M, Saleh M, Saleh M. Ophthalmic artery doppler indices changes in preeclampsia dear colleague. *J Obstet, Gynecol Cancer Res.* 2023;8(2):125-30.
- [10] Diniz AL, Meneses VF, Freitas MA, Paes MM, Naves WU, Sass N. Performance of ophthalmic artery doppler velocimetry in the complementary diagnosis of preeclampsia. *The J Mat-Fet Neonat Med.* 2022;35(25):9078-85.
- [11] Olatunji RB, Adekanni AJ, Obajimi MO, Roberts OA, Ojo TO. Maternal ophthalmic artery Doppler velocimetry in pre-eclampsia in Southwestern Nigeria. *Int J Women's Health.* 2015;20:723-34.
- [12] Nemeth J, Kovacs R, Harkanyi Z, Knézy K, Sényi K, Marsovszky I. Observer experience improves reproducibility of color Doppler sonography of orbital blood vessels. *J Clin Ultrasound.* 2002;30:332-35.
- [13] Hata T, Hata K, Senoh D, Makihara K, Takamiya O. Ophthalmic artery velocimetry in normal pregnancy and in pregnancy-induced hypertension. *J Perinat Med.* 1997;25(4):362-66.
- [14] Kalafat E, Laoret A, Khalil A, Da Silva Costa F, Thilaganathan B. Ophthalmic artery Doppler for prediction of pre-eclampsia: systematic review and meta-analysis. *Ultrasound Obstet Gynecol.* 2018;51(6):731-37.
- [15] Stalmans I, Vandewalle E, Anderson DR, Costa VP, Frenkel RE, Garhofer G, et al. Use of colour Doppler imaging in ocular blood flow research. *Acta Ophthalmol.* 2011;89:e609-e630.
- [16] Belfort M, VanVeen T, White GL, Kofford S, Allred J, Postma I. Low maternal middle cerebral artery Doppler resistance indices can predict future development of pre-eclampsia. *Ultrasound Obstet Gynecol.* 2012;40:406-11.
- [17] Alves JA, Yang B, de Sousa PC, Bezerra Maia E, Holanda Moura S, Kane S, et al. Reference values of maternal ophthalmic artery doppler variables in the first trimester of normal pregnancy. *J Clin Ultrasound.* 2014;42(4):199-204. Doi: 10.1002/jcu.22122. Epub 2014 Jan 13. PMID: 24691939.
- [18] Corrêa-Silva EP, Surita FG, Barbieri C, Morais SS, Cecatti JG. Reference values for Doppler velocimetry of the ophthalmic and central retinal arteries in low-risk pregnancy. *Int J Gynaecol Obstet.* 2012;117(3):251-56. Doi: 10.1016/j.ijgo.2012.01.012. Epub 2012 Mar 31. PMID: 22465556.
- [19] Carneiro RS, Sass N, Diniz AL, Souza EV, Torloni MR, Moron AF. Ophthalmic artery Doppler velocimetry in healthy pregnancy. *Int J Gynaecol Obstet.* 2008;100(3):211-15.
- [20] de Oliveira CA, de Sá RA, Velarde LG, Marchiori E, Netto HC, Ville Y. Doppler velocimetry of the ophthalmic artery in normal pregnancy: reference values. *J Ultrasound Med.* 2009;28(5):563-69. Doi: 10.7863/jum.2009.28.5.563. PMID: 19389894.
- [21] Monteiro VNP, Moreira de SRA, de Oliveira CA, Vellarde G. Doppler velocimetry of the ophthalmic artery behavior in twin pregnancy. *Ultrasound Quarterly.* 2020;36(3):263-67. | Doi: 10.1097/RUQ.0000000000000480.

PARTICULARS OF CONTRIBUTORS:

- Junior Resident, Department of Radiodiagnosis, Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar, Punjab, India.
- Professor, Department of Radiodiagnosis, Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar, Punjab, India.
- Professor, Department of Radiodiagnosis, Sri Guru Ram Das Institute of Medical Sciences and Research, Amritsar, Punjab, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Amandeep Singh,
469, East Mohan Nagar, Sultanwind Road, Amritsar, Punjab, India.
E-mail: dr.amancs@gmail.com

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

PLAGIARISM CHECKING METHODS:

- Plagiarism X-checker: May 07, 2025
- Manual Googling: Jul 09, 2025
- iThenticate Software: Jul 16, 2025 (11%)

ETYMOLOGY:

Author Origin

EMENDATIONS:

5

Date of Submission: **Apr 20, 2025**

Date of Peer Review: **May 21, 2025**

Date of Acceptance: **Jul 17, 2025**

Date of Publishing: **Jan 01, 2026**