Journal of Cardiovascular Disease Research

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

## ORIGINAL RESEARCH

# Evaluation of Ophthalmic Artery Doppler Haemodynamics in patients with Chronic Heart Failure

**[1]Dr. Rohan V., [2]Dr. Ravikiran S.R., [3]Dr. Thilak K.S., [4]Dr. Vinaya Manohara Gowda**

[1-4]Senior Resident, Department of Radio Diagnosis, Mysore Medical College and Research Institute, Mysore, Karnataka, India

**Correspondence:**
Dr. Vinaya Manohara Gowda
Senior Resident, Department of Radio Diagnosis, Mysore Medical College and Research Institute, Mysore, Karnataka, India
**Email:** vinayamanoharagowda1994 @gmail.com

**Abstract**

**Aims and Objectives**: To evaluate the ophthalmic artery doppler hemodynamics in patients with chronic heart failure in Indian population.

**Methods**: Doppler parameters of ophthalmic artery of 40 patients with chronic heart failure in different stages of the disease were compared with 40 healthy volunteers (Control group). Ophthalmic artery Doppler was performed by a high frequency linear transducer. The evaluated parameters were: Systolic velocity, Diastolic velocity and RI (Resistance Index). Both the eyes of the patient and volunteers were examined and the average readings were taken for analysis.

**Results**: Mean diastolic velocity was lower ($p<0.001$) while mean resistance index was higher ($p<0.001$) in the CHF patients when compared to the control group. Mean systolic velocity was not statistically significant different between the two groups ($p=0.22$). Mean systemic arterial blood pressure was significantly lower in the CHF group (81.0 ± 11.2 mmHg) than in the control group (103.8 ± 9.8 mmHg).

**Conclusion**: Lower diastolic velocity and higher resistance index were observed in the ophthalmic artery of chronic heart failure patients when compared to the control group, which possibly reflects the compensatory flow mechanism with resultant orbital vasoconstriction in response to reduced cardiac output. Therefore, the influence of these findings on the structure and function of the optic nerve head deserves investigation.

**Keywords**: Ophthalmic artery; Doppler; Glaucoma; End diastolic velocity; Resistive Index; Chronic heart failure.

## Introduction

Glaucoma is a progressive optic neuropathy which is one of the leading cause of irreversible loss of vision worldwide and has a characteristic clinical and ophthalmoscopic findings [(1-4)].

The vascular theory describing the mechanism of glaucoma considers optic neuropathy as a consequence of insufficient blood perfusion due to either increased intraocular pressure or other associated risk factors which leads to a reduction in the ocular blood flow [(2)].

Several studies have demonstrated that the reduction in blood perfusion of optic nerve head is associated with development of glaucoma [(2,5-8)]. In the Ocular Hypertension Treatment Study, previous history of heart disease was one of the important risk factor for the development of glaucoma[(9)].

Additional evidence suggested the importance of blood flow in the pathogenesis of glaucoma

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

comes from reports of glaucomatous-like optic nerve and visual field damage in patients secondary to transient hemodynamic shock [10].

Chronic heart failure is a common and serious condition in which an abnormality of cardiac function is responsible for a failure of the heart to pump adequate amount of blood required to meet the metabolic need of the target organ [11]. A complex neuro-hormonal system is involved in the attempt to compensate heart failure, aiming to maintain adequate perfusion to the vital end organ [12].

The hemodynamic changes in the ophthalmic artery in a patient with heart failure and its possible role in the pathogenesis of glaucoma have not yet been significantly investigated. Doppler imaging is a non-invasive, easy, and fast ultrasound technique, used in practice to measure the blood flow velocity of the ophthalmic vessels. The purpose of this study was to evaluate the hemodynamic changes of the ophthalmic artery in patients with chronic heart failure using color and spectral Doppler ultrasonography.

**Aims & objectives**

To evaluate the ophthalmic artery doppler hemodynamics in patients with chronic heart failure in Indian population.

**Materials & methods**

A cross-sectional comparative study conducted in the department of Radio Diagnosis, Mysore Medical College and Research Institute from December 2021 to June 2022.

Patients with heart failure symptoms and left ventricle ejection fraction below 55% documented by echocardiography were recruited from the Outpatient Department of Medicine. Non-cardiopathic volunteers were included as a control group.

Ethical clearance was obtained from the concerned ethical committee of the hospital and informed and written consent was obtained from both the cases and healthy volunteers group before the start of the study.

Patients and volunteers were explained about the study and procedure that they were undergoing. Confidentiality of the participants was maintained throughout the study.

**A. Inclusion Criteria of the Cases**

- Patients with heart failure symptoms and left ventricle ejection fraction below 55% documented by echocardiography.
- Above 18 years of age and willing to give informed consent.

**B. Inclusion Criteria of Controls:**

- Healthy volunteers without any symptoms of cardiac failure and with good ejection fraction (~60%)
- Above 18 years of age and not willing to give informed consent.

**C. Exclusion Criteria for Cases and Controls:**

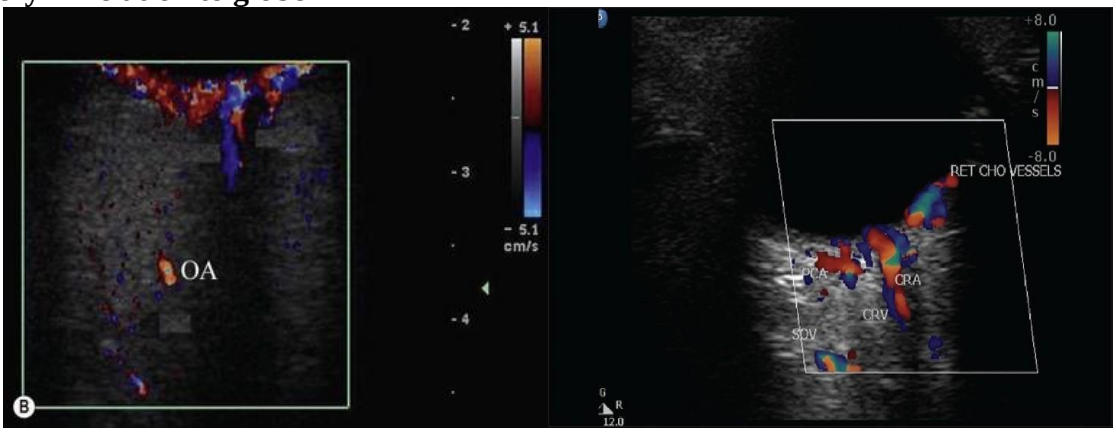
- Prior history of significant ocular disease, ocular trauma or ocular surgery, chronic corticosteroid usage (topical or systemic), secondary glaucoma, dense media opacities, retinal disease, heart transplantation, stroke or any other neurological diseases were not included in the study.
- The blood pressure readings for systolic and diastolic blood pressure were obtained after the participant was seated for 10 minutes.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

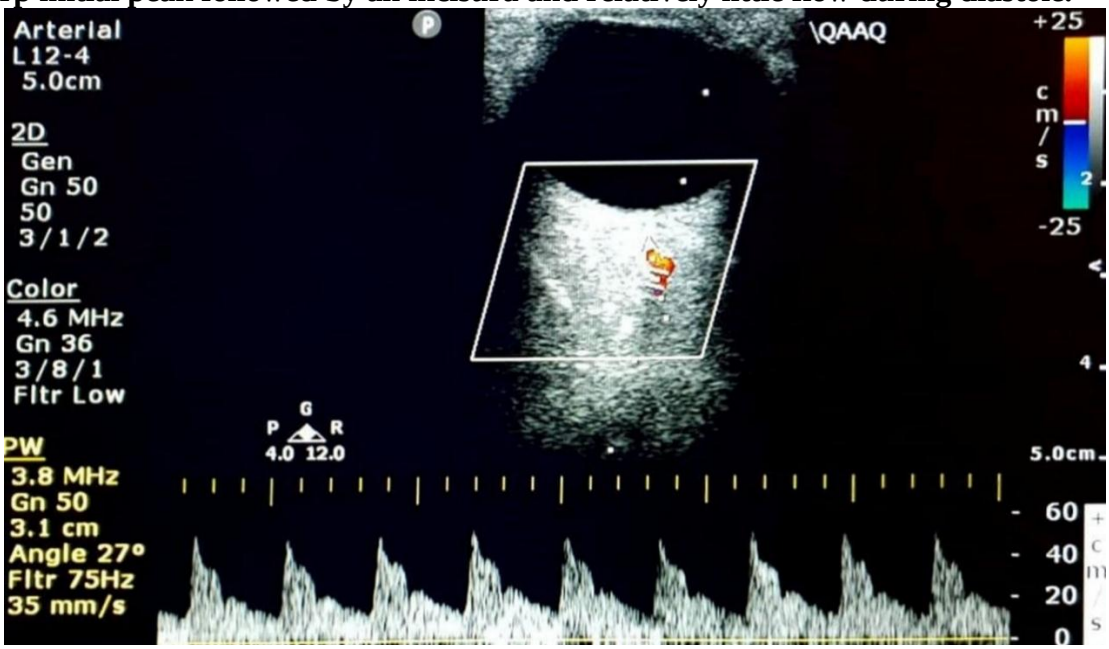
The mean arterial blood pressure was calculated according to the formula:
**Mean Arterial Blood Pressure=2/3 x Diastolic Blood Pressure + 1/3 x Systolic Blood Pressure.**
The mean ocular perfusion pressure was calculated as:
**-Mean Ocular Perfusion Pressure=2/3 x Mean Arterial Blood Pressure - Intraocular Pressure**

**Doppler evaluation of the ophthalmic artery**
**Identification of ophthalmic artery**
It is a branch of internal carotid artery. It can be consistently located with color flow imaging by scanning medial to the optic nerve approximately 15mm posterior to the globe.

**Orbital vessels on color Doppler**
**Figure 1: Color Doppler Image showing anatomy of orbital vessels and ophthalmic artery in relation to globe**




**Normal ophthalmic artery doppler waveform**
**Figure 2: The waveform of OA is typical for relatively high resistance artery. There is a sharp initial peak followed by an incisura and relatively little flow during diastole.**




Ophthalmic artery Doppler was performed by a high frequency linear transducer (L12-4) of PhillipsAffiniti70G machine.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

Patients were examined in the supine position, with head inclined at a 30° angle. The transducer was gently placed externally upon the eyelid, avoiding excess pressure. The flow velocity was measured at the medial proximal point of ophthalmic artery bilaterally. Doppler insonation angle was adjusted between 0 and 40°.
The evaluated parameters were: Systolic velocity, Diastolic velocity and RI (Resistance Index).
Both the eyes of the patient and volunteers were examined. Three measurements were taken from all patients, and their mean value was considered for the final analysis.

**Statistical Analysis**
Data were entered and managed in the Microsoft Excel 2010 spreadsheet. Variables were tabulated into means for continuous variables and percentages for categorical variables
Independent t test was used to determine the significance of differences between categorical variables and to compare means, all using a 5% significance level

**Results**
- 40 CHF patients and 40 non-cardiopathic volunteers were included in the study.
- No age or gender differences were observed between the CHF patents and the controls (Table 1).
- The results of systolic velocity, diastolic velocity and resistance index of the ophthalmic artery are summarized in table 2.
- Mean end diastolic velocity was lower ($p<0.001$) while mean resistance index was higher ($p<0.001$) in the CHF patients when compared to the control group.
- Mean peak systolic velocity was not statistically significant different between the two groups ($p=0.22$)
- Mean systemic arterial blood pressure was significantly lower in the CHF group (81.0 ± 11.2 mmHg) than in the control group (103.8 ± 9.8 mmHg).

| | **Chronic heart failure group, n=40** | **Control group n=40** |
|---|---|---|
| Age (years), mean ± SD | 51.2 ± 11 | 51.4 ± 12 |
| Male | 26 (65%) | 27 (67.5%) |
| Female | 14 (35%) | 13 (32.5%) |

***Table 1 : Table showing mean Age and gender between cases and control group***

| | **CHF group N=40 (mm Hg) mean+/-SD** | **Control group N=40 (mm Hg) mean+/-SD** | **p** |
|---|---|---|---|
| Systemic SBP | 100.6+/-12.8 | 126.1+/-12.6 | <0.001 |
| Systemic DBP | 70.1+/-10.7 | 91.4+/-8 | <0.001 |
| Mean arterial pressure | 81.0+/-11/2 | 103.8+/-9.8 | <0.001 |
| Ocular perfusion pressure | 42.2+/-7.2 | 54.4+/-7.2 | <0.001 |
| **Color Doppler of the Ophthalmic artery, Mean+/-SD** | | | |
| Systolic velocity (cm/s) | 53.02+/-8.5 | 55.52+/-9.26 | 0.220 |
| Diastolic velocity (cm/s) | 10.90+/-2.3 | 17.36+/-3.8 | <0.001 |
| Resistive index | 0.75+/-0.03 | 0.64+/-0.03 | <0.001 |

***Table 2 : Table showing mean values of SBP, DBP, Mean arterial pressure, Ocular perfusion pressure and doppler parameters with significance level between cases and control groups***

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

**Figure 3: Ophthalmic artery doppler in healthy controls showing normal resistive index. (PSV- 63.45 cm / sec. EDV – 21.12 cm / sec. RI – 0.66)**

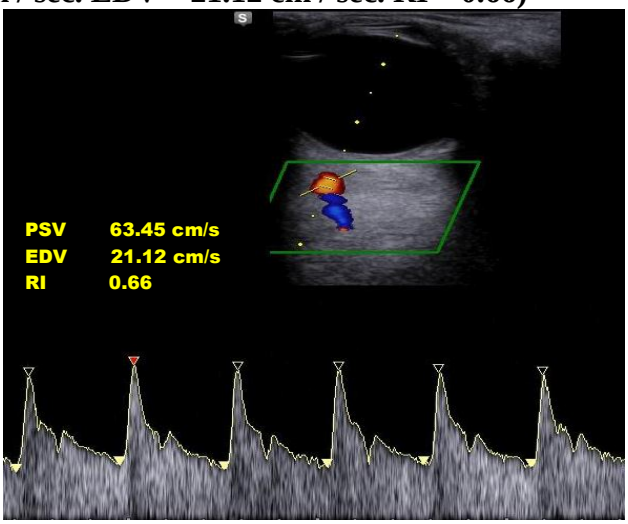
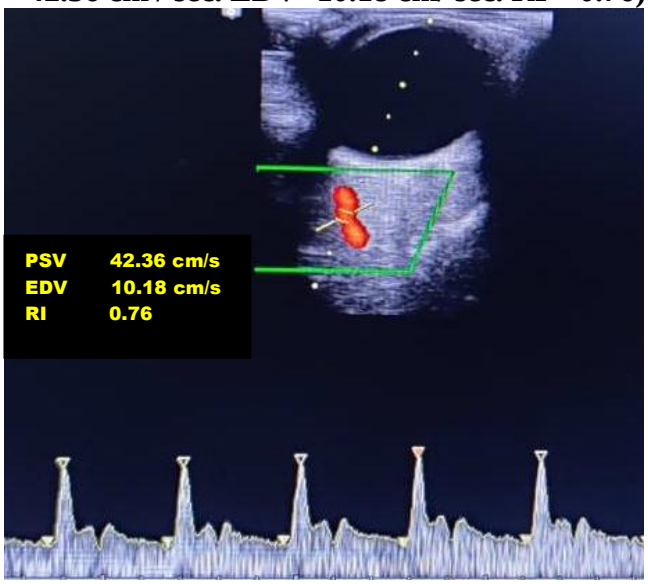



**Figure 4: Ophthalmic artery doppler in CHF patients showing low EDV and high resistive index (PSV – 42.36 cm / sec. EDV- 10.18 cm/ sec. RI – 0.76)**




## Discussion

This study evaluated the doppler indices of ophthalmic artery in patients with chronic heart failure. Low cardiac output is associated with compensatory homeostatic mechanisms of peripheral vasoconstriction in an attempt to maintain optimum blood pressure and reduced blood perfusion to critical organs such as the brain and heart [13,14]

On the other hand, the excessive vasoconstriction of the ocular vessels may be related to reduction in the perfusion with tissue death of the optic nerve head. [6]. Therefore, patients with CHF could have a higher risk of developing glaucoma secondary to hemodynamic alterations of the ocular microvasculature.

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

The finding of low diastolic blood pressure correlating with high resistance index and low diastolic velocity of the ophthalmic artery possibly reflects the pathophysiology of heart failure and presence of vasoconstriction as a compensatory response to reduced cardiac output [15].

CHF patients had lower diastolic velocity and a higher RI in ophthalmic artery as compared to those in control group. Studies with colour Doppler imaging found reduced systolic and diastolic velocity peaks, as well as, an increased RI of the retro bulbar vessels in patients diagnosed with glaucoma, when compared to healthy control subjects. [2,3,5,8,15,16] Therefore, it is possible that patients with CHF have higher risk of developing normal tension glaucoma and blood flow alterations in turn related to the pathogenesis.

This study has few limitations, such as the presence of heart disease at different stages which may have changes in the ocular microvasculature. Moreover, despite the similarity of gender and age between the studied groups, few other confounding factors were not controlled, such as carotid atherosclerosis and medication use.

## Conclusion

This study demonstrated a high resistance flow pattern in form of reduced diastolic velocity and increased resistance index in ophthalmic artery of patients with chronic heart failure. Systemic blood pressure may be a good clinical parameter in prediction and determination of cardiac patients with a higher risk of developing alteration in ophthalmic vascular flow parameters.

The results of this study suggest that heart failure could be an important risk factor for low ocular perfusion, which is considered to be an important risk factor for development of glaucoma; however, this topic deserves attention and further evaluation.

## References

1. Flammer J, Orgul S. Optic nerve blood-flow abnormalities in glaucoma. Prog Retin Eye Res. 1998;17(2):267-89.
2. Flammer J, Orgul S, Costa VP, Orzalesi N, Krieglstein GK, Serra LM, et al. The impact of ocular blood flow in glaucoma. Prog Retin Eye Res. 2002;21(4):359-93.
3. Harris A, Kagemann L, Ehrlich R, Rospigliosi C, Moore D, Siesky B. Measuring and interpreting ocular blood flow and metabolism in glaucoma. Can J Ophthalmol. 2008;43(3):328-36.
4. Weinreb RN, Khaw PT. Primary open-angle glaucoma. Lancet. 2004;363(9422):1711-20. Comment in: Lancet. 2004;364(9442):1311-2.
5. Gherghel D, Orgul S, Gugleta K, Gekkieva M, Flammer J. Relationship between ocularperfusion pressure and retrobulbar blood flow in patients with glaucoma with progressivedamage. Am J Ophthalmol. 2000;130(5):597-605. Comment in: Am J Ophthalmol. 2001; 1321(4):598-9.
6. Harris A, Rechtman E, Siesky B, Jonescu-Cuypers C, McCranor L, Garzozi HJ. The role of optic nerve blood flow in the pathogenesis of glaucoma. Ophthalmol Clin North Am. 2005;18(3): 345-53.
7. Michelson G, Langhans MJ, Groh MJ. Perfusion of the juxtapapillary retina and the neuroretinal rim area in primary open angle glaucoma. J Glaucoma. 1996;5(2):91-8.
8. Piltz-seymour JR, Grunwald JE, Hariprasad SM, Dupont J. Optic nerve blood flow is diminished in eyes of primary open-angle glaucoma suspects. Am J Ophthalmol. 2001;132(1): 63-9.
9. Gordon MO, Beiser JA, Brandt JD, Heuer DK, Higginbotham EJ, Johnson CA, et al. The Ocular Hypertension Treatment Study: baseline factors that predict the onset of primary

ISSN: 0975-3583,0976-2833 VOL13, ISSUE 05, 2022

openangle glaucoma. Arch Ophthalmol. 2002;120(6):714-20; discussion 829-30. Comment in: Arch Ophthalmol. 2004;122(7):1088-9; author reply 1089.
10. Drance SM, Morgan RW, Sweeney VP. Shock-induced optic neuropathy: a cause of nonprogressive glaucoma. N Engl J Med. 1973;288(8):392-5.
11. Remme WJ, Swedberg K; Task Force for de Diagnosis and Treatment of Chronic Heart Failure, European Society of Cardiology. Guidelines for the diagnosis and treatment of chronic heart failure. Eur Heart J. 2001;22(17):1527-60. Erratum in: Eur Heart J. 2001;22(23):2217-8. Comment in: Eur Heart J. 2002;23(5):426; author reply 426-7.
12. Saxena PR, Schoemaker RG. Organ blood flow protection in hypertension and congestiveheart failure. Am J Med. 1993;94(4A):4S-12S.
13. Almeida OP, Flicker L. The mind of a failing heart: a systematic review of the association between congestive heart failure and cognitive functioning. Intern Med J. 2001;31(5):290-5
14. Zelis R, Sinoway LI, Musch TI, Davis D, Just H. Regional blood flow in congestive heart failure: concept of compensatory mechanisms with short and long time constants. Am J Cardiol. 1988;62(8):2E-8E.
15. Almeida-Freitas, D., Meira-Freitas, D., Melo Jr, L., Paranhos Jr, A., Iared, W. and Ajzen, S., 2011. *Color Doppler imaging of the ophthalmic artery in patients with chronic heart failure*.
16. Galassi F, Sodi A, Ucci F, Renieri G, Pieri B, Baccini M. Ocular hemodynamics and glaucoma prognosis: a color Doppler imaging study. Arch Ophthalmol. 2003;121(12):1711-5.