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Study of the Orbital Vessels by Color Doppler in Known Diabetic Patients for Evaluation of Diabetic Retinopathy

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ABSTRACT

Background: *Diabetic retinopathy is a vascular disorder affecting the microvasculature of the retina. It is caused by changes in the blood vessels of the retina. If untreated, it may lead to blindness which is usually preventable if retinopathy is diagnosed early and treated promptly. As the prevalence of diabetes is rising, the systemic complications that include retinopathy, nephropathy, neuropathy, and involvement of the cardiovascular system are also increasing. Diabetic retinopathy is the leading cause of blindness in the world. Prevention of retinopathy needs early diagnosis. In ophthalmology, Color Doppler imaging is a new method that enables us to assess the orbital vasculature. It allows for simultaneous two-dimensional anatomical and Doppler evaluations of the retinal artery.* ***Objectives:*** *The study aims to evaluate the ocular blood flow in patients with diabetes mellitus with no ocular symptoms.* ***Methods:*** *Color Doppler evaluation of 50 diabetic patients (100 eyes) was done with Siemens Sonoline G-50 machine with a High-frequency probe (5 Mega Hertz-7.5 Mega Hertz). Doppler spectral analysis of Ophthalmic Arteries (OA) and Central Retinal Arteries (CRA) was done. The peak systolic velocity (PSV), End-Diastolic Velocity (EDV), resistive index (RI), and S/D ratio were calculated. Peak Systolic Velocity (PSV), End Diastolic Volume (EDV), and Resistance Index (RI) were measured in all patients in both eyes.* ***Results:*** *The PSV of CRA in diabetics was significantly reduced ($p \leq 0.05$). The EDV of CRA in diabetics was also significantly reduced ($p \leq 0.05$). The RI of CRA is significantly increased ($p \leq 0.05$) in diabetics. The 95% confidence interval is observed in PSV, EDV, and RI of CRA in diabetics.* ***Conclusions:*** *There was a statistically significant difference between the PSV, EDV, and RI of CRA in diabetics. This significant difference could be due to the circulatory changes in blood vessels in diabetics. No significant difference was made in OA in diabetics. This study concludes that retinal hemodynamic changes were present even before the clinical manifestations of retinopathy in diabetics.*

Keywords: Central retinal artery, Ophthalmic artery, Hemodynamic, Resistance, Diabetic

INTRODUCTION

Despite the improvement in ophthalmoscopic examination in the Outpatient Department (OPD) in Ophthalmology, to diagnose early changes in retinal arterial flow velocity, a newer imaging modality may be used for diagnosis of early changes in the central retinal artery before clinical manifestation of retinopathy [1]. Color Doppler imaging is the most promising modality that produces conventional gray-scale ultrasound images along with information regarding the direction and velocity of blood flow [2]. The present study attempted to evaluate clinically diagnosed diabetic patients without retinopathy by measuring the Retinal arterial RI by duplex color doppler study. Retinal artery ultrasound, Color Doppler imaging was first used to image various organ systems in 1979. Later in 1989 Color Doppler imaging in orbit was described by Erick's son. The eye is located superficially and is cystic. The normal anatomy and vasculature can be seen by the high-frequency transducer. Color Doppler imaging of the eye is a non-invasive procedure.

It allows visualization of the grey scale imaging and color-coded imaging both at the same time [3]. The peak systolic and end-diastolic velocities of the ophthalmic and central retinal arteries can be measured using Doppler. The resistive index can then be calculated using peak systolic and end-diastolic velocities. Orbital blood flow velocity can be qualitatively and quantitatively measured by color Doppler imaging [4]. As Doppler shift detection sensitivity is higher than conventional grey scale resolution, evaluation of very small vessels supplying the orbit can be done non-invasively. Wolfgang E. Lieb et al examined 40 normal eyes and they were able to locate the Central Retinal Artery (CRA), Posterior Ciliary Arteries (PCA), and Ophthalmic Arteries (OA) in all patients. Using the Doppler spectrum, the blood flow velocity in these vessels is assessed quantitatively.

Anatomy of Retina is a sensory tissue that lines the back of the eye. It is multilayered (10 layers) and contains photoreceptors namely rods and cones. The rods and cones convert light energy into signals which are then carried to the brain through optic nerves and interpret the signal as visual images. Tiny blood vessels in the retina take the oxygen and essential nutrients to the walls of the retina. In the center of the retina, there is a simple dimple called the fovea, which is responsible for the sharp vision in the eye. The optic nerve is a collection of nerve fibers that carries electric signals from the retina to the brain. The retina is supplied by the central retinal artery which supplies the inner retinal layer and the choroidal arteries which supply the outer retinal layers. The Central retinal artery is a branch of the ophthalmic artery. A choroidal artery is a branch of the posterior ciliary artery. Diabetic retinopathy is a vascular disorder affecting the microvasculature of the retina. It is caused by changes in the blood vessels of the retina. If untreated, it may lead to blindness. Therefore, if diagnosed and treated promptly, blindness is usually preventable [5,6]. In ophthalmology, color Doppler imaging is a new method that enables us to assess the orbital vasculature. It allows for simultaneous two-dimensional anatomical and Doppler evaluations of hemodynamic characteristics of the retinal artery [7,8].

METHODS

Color Doppler Imaging (CDI) is a safe, non-invasive, and highly reproducible procedure for evaluating hemodynamic alterations in the blood vessels. Color Doppler Imaging (CDI) combines two-dimensional (2D) ultrasonography and Doppler spectral analysis to evaluate the vascular structure. Blood flow velocities and flow patterns in an orbital vessel are very useful for the early detection of diabetic retinopathy.

Indices of Measurement

- Resistance index (RI)
- Peak systolic velocity (PSV)
- End diastolic volume (EDV)

Retrobulbar blood flow velocity was assessed by using orbital Doppler and gray-scale sonography by Siemens Sonoline G50 Color Doppler machine. Imaging of the eyes was performed in all individuals by using a Color Doppler with a 5 MHz-7.5 MHz linear-array transducer. The patients were placed in the supine position and USG gel was applied to closed eyelids and 2D and color Doppler images were obtained by using the high-frequency linear probe. The ophthalmic artery was identified in the nasal side of an eyeball, superior to the optic nerve, and it abuts the visible hypo reflective stripe representing the optic nerve. The central retinal artery arises from the ophthalmic artery and can be found anterior to the optic nerve, which is around 7.5 mm behind the ocular bulb. The posterior ciliary arteries are also supplied with blood by the ophthalmic artery, and they divide into multiple branches to supply the pial arteries. These arteries have a diameter of around 0.2 mm and form the pial network which adheres to the optic sheath and contributes to the vascularization of the optic nerve.

Study Design

Prospective Study

Inclusion Criteria

Diabetic patients without retinopathy

- The age group of 40 years-70 years.
- Both sexes were included in the study.

Exclusion Criteria

Patients having infections or inflammatory lesions, benign or malignant lesions in orbit.

Statistical Analysis Plan

All the records will be recorded by using a structural schedule (Case Report Forms) and entered into Microsoft Excel Sheet. All the records will be rechecked for completeness and consistency. Non-numeric entries will be coded numerically into nominal/ordinal distribution before analysis. Categorical variables were summarized in frequency and percent distribution and Chi-square or Fishers' exact test will be performed as appropriate (Figure 1-3).

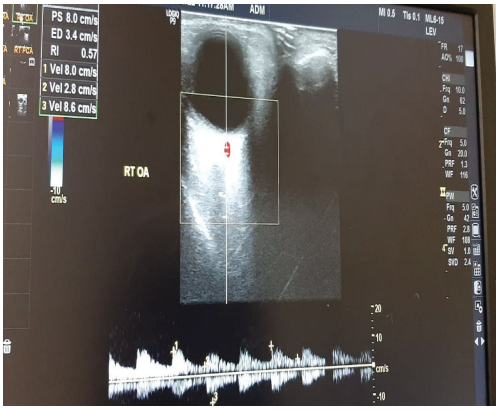

Figure 1 Color Doppler image showing high resistance flow in the ophthalmic artery

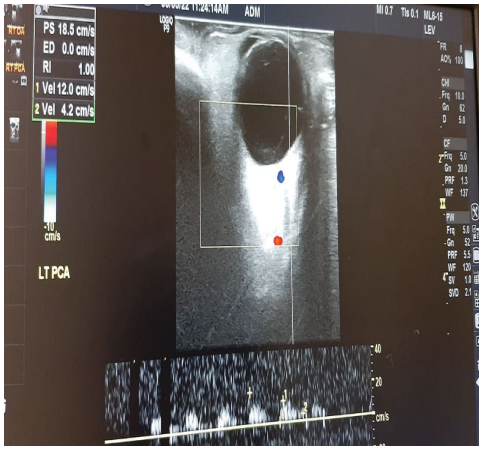

Figure 2 Color doppler image showing high resistance flow in Posterior cilliary artery

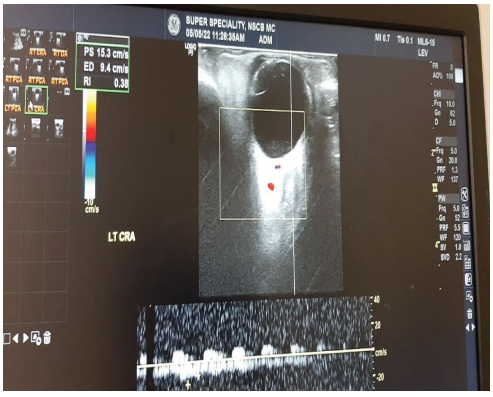

Figure 3 Color Doppler evaluation of central retinal artery showing high resistance flow

RESULTS

We studied 50 patients (100 globes), 30 men and 20 women, divided into age groups, the average age was 55 years. The majority (54%) of subjects were in the 5th decade of life with a predominance of males. The mean duration of diabetes was 8.4 years ± 1.2 years. The mean Peak Systolic Velocity (PSV) in 50 diabetic patients without retinopathy was 8.90 cm/sec ± 1.50 cm/sec ranging from 5.30 cm/sec-11.01 cm/sec. Mean End Diastolic Velocity (EDV) in 50 diabetic patients without retinopathy was 3.21 cm/sec ± 0.59 cm/sec ranging 2.5 cm/sec-5.10 cm/sec. The mean Resistive Index (RI) in 50 diabetic patients without retinopathy was 0.92 ± 0.05 ranging from 0.87-0.91.

Table 1 Distribution of patients according to age

Age	Number	Percent
40 years-50 years	9	18%
51 years-60 years	27	54%
61 years-70 years	14	28%
Total	50	100%

The maximum number of patients seen in 51-60 (54%) years of age and the minimum number of patients seen in 40-50 (18%) years of age (Table 1).

Table 2 Distribution of patients according to gender

Gender	Number	Percent
Male	30	60%
Female	20	40%
Total	50	100%

The maximum number of patients were male (60%), and female (40%) in our study (Table 2).

Table 3 Average of PSV, EDV, and RI in ocular vessels

Vessels	PSV (Mean)	EDV (Mean)	RI (Mean)
Ophthalmic artery	8.11 cm/sec ± 1.12 cm/sec	3.4 cm/sec ± 1.2 cm/sec	0.57 cm/sec ± 0.08 cm/sec
Central retinal artery	8.90 cm/sec ± 1.50 cm/sec	3.21 cm/sec ± 0.59 cm/sec	0.92 cm/sec ± 0.05 cm/sec
Posterior ciliary artery	12.0 cm/sec ± 1.20 cm/sec	4.21 cm/sec ± 1.1 cm/sec	0.92 cm/sec ± 0.04 cm/sec

PSV, EDV, and RI were increased in diabetic patients without retinopathy in all vessels (Table 3).

DISCUSSION

Due to the characteristics of eyeball location and constitution, ocular ultrasound has become an ideal method for the visualization of ocular structures and for the diagnosis of diseases that cannot be displayed on the fundus examination. The color Doppler ultrasound and pulsed Doppler has the advantage of being easily accessible, besides having no ionizing radiation and repeatedly performed as often as necessary, without leading to any additional risk to the patient, and do not need any medication before the examination. Diabetes causes disturbances in the microcirculation by endothelial dysfunction causing perfusion disorders, which will result in an ultrasound significant decrease in VPS in patients with the ocular ischemic syndrome, central retinal artery occlusion, and venous thrombosis [9-13]. The flow of the CRA should be antegrade, with low resistance, with rounded systolic peak, and continuous flow in diastole [14]. A study done by Mendivil A, Cuartero V, Mendivil MP, Titled-Ocular blood flow velocities in patients with proliferative diabetic retinopathy and healthy volunteers: a prospective study. British Journal of ophthalmology compared 43 blood flow velocities in ocular vessels (ophthalmic artery, posterior ciliary arteries, central retinal vessels, and vortex veins) of 25 patients and showed that the diabetic patients had lower blood velocities than the volunteers. Ocular blood

flow velocity was decreased in diabetic patients with proliferative diabetic retinopathy. Schmetterer L, Wolzt M. who assessed Ocular blood flow and associated functional deviations in diabetic retinopathy. The total number of subjects included in this study is 80. Each group contains 40 patients. Both eyes were examined in this study. Hence there are a total of 160 eyes with 80 eyes in each group [15,16].

CONCLUSION

From the present study, it can be concluded that there is a statistically significant increase in Retinal Arterial RI in type 2 diabetic patients without retinopathy. Increased RI in CRA, OA, and PCA showed that RI can be used to assess an index in the progression of diabetic retinopathy in patients or can also be used post-pan-retinal photocoagulation. Even though further investigations are needed to assess orbital hemodynamics in diabetic retinopathy, based on our study the results suggest that Color Doppler imaging can give information on hemodynamic changes and can be used as a supportive modality for diagnosis of diabetic retinopathy in patients.

DECLARATIONS

Conflict of Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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