Cardiovascular Topics

The relationship between epicardial adipose tissue and choroidal vascularity index in patients with hypertension

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Abstract

Objective: The choroidal vascularity index (CVI) is a method that measures the density of blood vessels in the choroidal layer and can be used to evaluate the effects of hypertension. In this study we aimed to investigate the relationship between epicardial fat thickness (EFT) and CVI in patients with hypertension.

Methods: This prospective study included 112 patients diagnosed with hypertension and 120 healthy individuals. Patients' demographic data such as age, gender, weight, height, body mass index (BMI), smoking status, and presence of coronary artery disease and diabetes mellitus were recorded. BMI was calculated by dividing a patient's weight in kilograms by their height in metres squared. EFT was measured by echocardiography and CVI was calculated using the optical coherence tomography method.

Results: The mean CVI was found to be 66.57 ± 2.21 in the patient group and 69.22 ± 2.39 in the control group and the difference was significant ($p < 0.001$). The mean EFT was found to be 5.23 ± 3.25 mm in the patients and 2.57 ± 1.97 mm in the control group and the difference was statistically significant ($p = 0.003$). According to Spearman's correlation analysis, there was a significant positive correlation between BMI and EFT ($r = 0.379$, $p < 0.001$) and a significant negative correlation between CVI and EFT ($r = –0.412$, $p < 0.001$).

Conclusion: The CVI value was significantly lower and the EFT value was significantly higher in patients with hypertension compared to non-hypertensive patients. There was a significant positive correlation between EFT and BMI and a significant negative correlation between EFT and CVI.

Keywords: hypertension, epicardial adipose tissue, epicardial fat thickness, choroidal vascularity index, optical coherence tomography

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Hypertension is the leading risk factor for the development of cardiovascular disease and has a profound impact on the microvasculature in the end-organs, including the brain, kidney, heart and eye.[1] The retinal vasculature especially has attracted much non-ophthalmological attention within this context.[2] Studies on retinal microvascular phenotypes have demonstrated that hypertension can lead to abnormal signs on the retina.[2,3] In addition, ocular findings of hypertension have been found to be indicative of optic neuropathy, choroidopathy and retinopathy. Changes in the retinal and choroidal layers are important indicators that can be used to evaluate the effects of hypertension.[4]

The choroidal vascular index (CVI) is a method that measures the density of blood vessels in the choroidal layer and can be used to evaluate the effects of hypertension. CVI has been recently proposed as a new marker for evaluation of choroidal changes with optical coherence tomography (OCT).[5] The development of OCT has revolutionised ocular imaging. For the first time, using cross-sectional images of ocular tissue in micrometre scale, resolution with OCT could be obtained in a non-invasive and non-contact manner. It has been shown in a recent study that a significant decrease in CVI indicated an affected choroid layer in patients with hypertension.[6]

In recent years, studies have focused on several extra-abdominal fat deposits, including epicardial adipose tissue (EAT) because of its close association with obesity, hypertension and cardiovascular disease.[7] EAT is a newly recognised ectopic visceral adipose tissue around the myocardial surface between the myocardium and visceral pericardium. In the case of inflammation, EAT promotes insulin resistance, dyslipidaemia and hypertension via endocrine activities.[8] The effect of hypertension on EAT has not yet been fully understood, but it is thought that an increase in EAT may increase the effect of hypertension.

Several studies have been performed in order to investigate the relationship between hypertension and the size of EAT depots.[9] Based on this information, in this study we aimed to investigate whether there was a relationship between epicardial fat thickness (EFT) and CVI in patients with hypertension.

Methods

This prospective study included 112 patients diagnosed with hypertension and 120 healthy individuals as the control group. The study was conducted between June and October 2023 in the ophthalmology and cardiology clinics of Abant Izzet Baysal University Training Hospital.

The study protocol was approved by the local ethics committee of our hospital (date: 06.06.2023 no: 2023/170). Due to the prospective design of the study, written consent was obtained from the participants. This study was conducted in accordance with the ethical principles of the Declaration of Helsinki revised in 2023.

Patients with malignant hypertension, cerebrovascular disease, atrial fibrillation, hepatic or renal dysfunction, and those with major non-cardiovascular diseases such as haematological disease, auto-immune disease and chronic obstructive pulmonary diseases were excluded from the study. In addition, to rule out any confounding effect on the study results, all morbidly obese individuals [body mass index (BMI) > 39.9 kg/m^2] were also excluded.

Patients' demographic data such as age, gender, weight, height, BMI, smoking status, and presence of coronary artery disease (CAD) and diabetes mellitus (DM) were recorded. BMI was calculated by dividing the patients' weight in kilograms by their height in metres squared. EAT was measured by echocardiography and CVI was calculated using the OCT method. The data obtained were compared between the groups and a potential relationship between EFT and CVI was investigated.

All echocardiographic examinations were performed by the same experienced cardiologist who was blinded to the participants' data. A Vivid 7® cardiac ultrasound system (GE Medical Systems; Horten, Norway) with a 2.5- to 3.5-MHz transducer was used in the measurement of EAT thickness. In line with the recommendations by the American Society of Echocardiography, parasternal and apical views were obtained. Accordingly, the EAT thickness was measured from the standard parasternal long-axis view on the wall of the right ventricle, perpendicular to the aortic annulus at end-systole. The EAT was determined as the echo-free space between the outermost border of the myocardium and the visceral layer of the pericardium. The thickest point of EAT was measured three times and the measurements were averaged (Fig. 1).

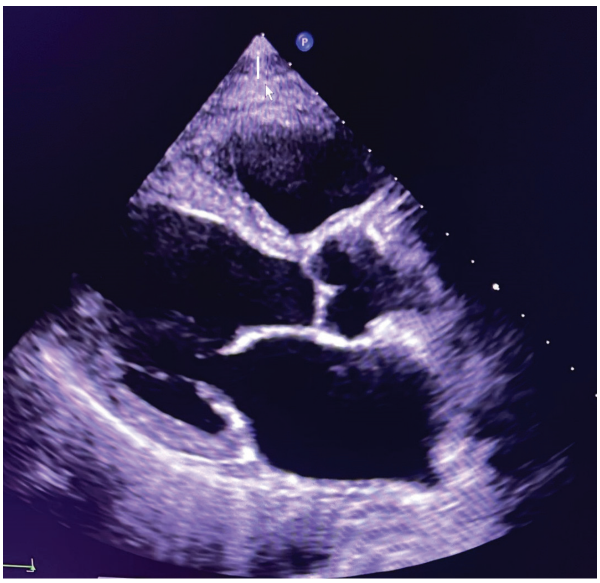

Fig. 1. Measurement of EFT with echocardiography.

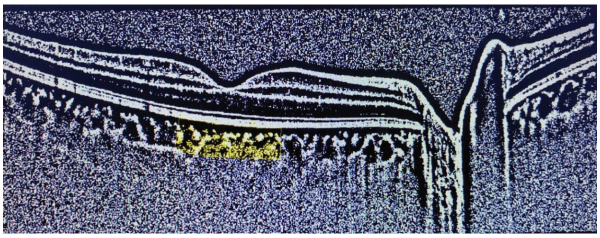

Fig. 2. Measurement of CVI with the binarisation method.

The OCT-based CVI was measured using the binarisation method in all acquired scans. It was calculated by dividing the vascular area of the choroid layer by the total choroidal area. The CVI value was obtained as the ratio of luminal area, which was indicated by using the colour threshold, to total choroid area, which was added to the region of interest, as described by Agrawal *et al.*[9] A higher CVI indicates a higher proportion of blood vessels in the choroid layer (Fig. 2).

Statistical analysis

Data obtained in this study were statistically analysed utilising the SPSS version 25.0 (SPSS, Statistical Package for Social Sciences, IBM Inc, NY, USA) software. Normality of the variables was tested using the Kolmogorov–Smirnov method. Comparisons between continuous variables were made with the Independent *t*-test. Continuous variables are expressed as mean ± standard deviation, while the categorical variables are given as frequency (*n*, %). Spearman's correlation analysis was used to determine the correlations between the variables. A p-value < 0.05 was considered statistically significant.

Results

A total of 112 patients diagnosed with hypertension were assigned to the patient group and 120 healthy individuals were in the control group. Of the participants, 153 (65.9%) were female and 79 (34.1%) were male. The mean age of all participants was 51.81 ± 13.58 years. The mean age was 59.23 ± 13.25 years in the patient group and 45.38 ± 13.60 years in the control group. No statistically significant difference was found between the groups in terms of age and gender. Descriptive and clinical features of the patient and control groups are given in Table 1.

The mean CVI was found to be 66.57 ± 2.21 in the patient group and 69.22 ± 2.39 in the control group, and the difference was statistically significant (p < 0.001). The mean EFT was

Table 1. Descriptive and clinical features of the groups

	Patient group (n = 112)		*Control group (n = 120)*		
Parameters	*mean*	± SD	*mean*	± SD	p-*value*
Age (years)	59.23	13.25	45.38	13.60	0.238
Height (cm)	163.21	9.48	167.48	7.39	0.427
Weight (kg)	78.10	9.93	70.83	14.99	0.004
Body mass index (kg/m^2)	29.47	4.26	26.24	5.74	0.001
Pulse (bpm)	71.40	8.96	73.67	7.24	0.142
Systolic blood pressure (mmHg)	141.92	18.32	122.75	12.59	< 0.001
Diastolic blood pressure (mmHg)	81.83	11.20	75.92	7.04	0.001

Table 2. CVI and EFT parameters in hypertension, DM, CAD and smokers

	CVI (%)	p-*value*	*EFT (mm)*	p-*value*
Hypertension				
Yes	66.57 ± 2.21	< 0.001	5.23 ± 3.25	0.003
No	69.22 ± 2.39		2.57 ± 1.97	
CAD				
Yes	67.80 ± 2.61	0.926	7.24 ± 1.30	< 0.001
No	68.04 ± 2.68		3.21 ± 1.82	
DM				
Yes	67.88 ± 2.34	0.799	5.68 ± 1.86	0.016
No	68.13 ± 2.76		3.48 ± 1.85	
Smokers				
Yes	68.02 ± 2.71	0.993	3.44 ± 2.94	0.423
No	67.97 ± 2.63		4.06 ± 2.9.6	

CVI, choroidal vascularity index; EFT, epicardial fat thickness; CAD, coronary artery disease; DM, diabetes mellitus.

found to be 5.23 ± 3.25 mm in the patient group and 2.57 ± 1.97 mm in the control group, and the difference was statistically significant ($p = 0.003$).

CAD was found in 24 (10.34%) and DM in 28 (12.06%) participants. The mean CVI value was found to be 67.80 ± 2.61 in the patients with CAD and 68.04 ± 2.68 in those without CAD. There was no statistically significant difference between the groups in terms of CVI ($p = 0.926$). The mean EFT was found to be 7.24 ± 1.30 mm in the patients with CAD and 3.21 ± 1.82 in those without CAD, and the difference was statistically significant ($p < 0.001$).

The mean CVI was 67.88 ± 2.34 in the patients with DM and 68.13 ± 2.76 in those without DM. There was no statistically significant difference between the groups in terms of CVI ($p = 0.799$). The mean EFT was 5.68 ± 1.86 mm in the patients with DM and 3.48 ± 1.85 in those without DM, and the difference was statistically significant ($p = 0.016$).

A total of 27 (11.63%) participants were smokers. The mean CVI was found to be 68.02 ± 2.71 in the smokers and 67.97 ± 2.63 in the non-smokers. No significant difference was found between the two groups ($p = 0.933$). The mean EFT was measured as 3.44 ± 2.94 mm in the smokers and 4.06 ± 2.9.6 mm in the non-smokers, and the difference was not statistically significant ($p = 0.423$) (Table 2).

According to Spearman's correlation analysis, there was a significant positive correlation between BMI and EFT ($r = 0.379$, $p < 0.001$) and a significant negative correlation between CVI and EFT ($r = –0.412$, $p < 0.001$) (Table 3, Fig. 3).

Discussion

In recent studies, there has been high interest in evaluating the relationship between cardiovascular changes and microvascular structures.[10] The main purpose here is to evaluate the effect of cardiovascular diseases with non-invasive procedures. For this reason, studies have frequently examined the relationship between coronary artery disease, atherosclerosis risk factors, hypertension and retinal and choroidal microvascular structures in the eye. It has been examined whether the narrowing in capillary structures is related to other vascular structures and cardiovascular structures.[11]

In our study, we investigated the relationship between EFT and CVI in patients with hypertension. We found a statistically significant negative correlation between CVI and EFT values.

EFT is defined as visceral brown adipose tissue between the visceral pericardium and myocardium and it covers more than three-quarters of the heart surface.[12] The thickness of EAT can vary among individuals and may have clinical implications. EAT is believed to have both protective and detrimental effects on the heart, as it can produce both anti- and pro-inflammatory molecules. It has been proposed that EAT thickness or EFT may be used as a risk indicator for hypertension and cardiovascular morbidity.[13]

Recent studies have reported that increased EFT may serve as a new cardiometabolic risk factor and is associated with hypertension.[14] In a study by Eroglu *et al.*, the mean EFT value was found to be 6.3 ± 1.7 mm in hypertensive and 5.3 ± 1.6 mm in non-hypertensive patients ($p < 0.001$). In the same study, hypertension was reported to be a contributing factor to the development of EFT.[15]

Similarly, in our study the mean EFT value was significantly higher in patients with hypertension (5.23 ± 3.25 mm) compared to the control group (2.57 ± 1.97 mm) ($p = 0.003$). In addition, BMI, which is one of the major indicators of hypertension, was significantly associated with EFT ($r = 0.379$, $p < 0.001$). Unlike our study, Castanheira *et al.* found no correlation between EFT and BMI values. However, in that study the sample was not overweight.[16]

The choroid layer provides oxygen and nutrients to the outer layer of the retina and the retinal pigment epithelium. A healthy choroidal vasculature is necessary for normal functioning of the retina. Morphological abnormalities of the choroid layer may indicate systemic microvascular injury, and choroidal thickness

Table 3. Correlations between CVI, EFT and BMI ($n = 112$)

	BMI	*CVI*	*EFT*
BMI Correlation coefficient	1.000	–0.056	0.379*
Significance (two-tailed)	0.000	0.561	0.000
CVI, Spearman's rho Correlation coefficient	–0.056	1.000	–0.412*
Significance (two-tailed)	0.561	0.000	0.000
EFT Correlation coefficient	0.379*	–0.412*	1.000
Significance (two-tailed)	0.000	0.000	

CVI, choroidal vascularity index; EFT, epicardial fat thickness; BMI, body mass index. *Correlation is significant at the 0.01 level (two-tailed).

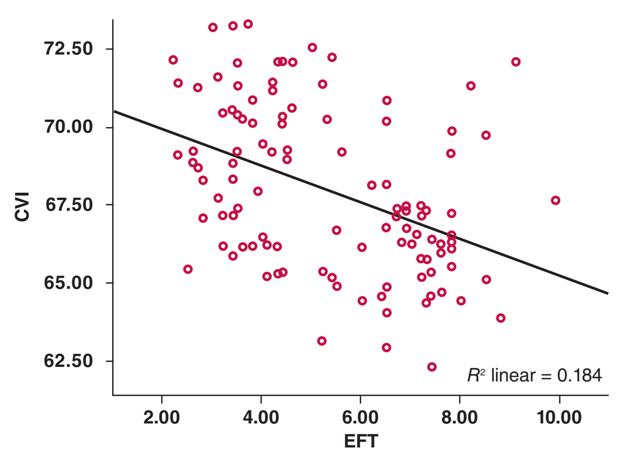

Fig. 3. Correlation between the CVI and EFT values.

has been reported to be associated with renal haemodynamics in essential hypertension.[17] The consequences of hypertension on ocular structures include hypertensive choroidopathy, retinopathy, retinal vascular occlusions, optic neuropathy, glaucoma, and age-related macular degeneration.[18] Increased systemic blood pressure has also been demonstrated to reduce choroidal thickness.[19]

Hypertension can have systemic effects on blood vessels throughout the body, including those in the eye, which can potentially influence the CVI. The CVI is a novel parameter used in ophthalmology and optometry to measure and assess the vascularity or blood vessel density in the choroid layer.[5,20] The CVI is determined using various imaging techniques, such as OCT or enhanced depth imaging OCT. In the present study, we determined the CVI using the OCT modality.

In a study by Aşıkgarip *et al.*, CVI was found to be significantly decreased in hypertensive patients compared to the healthy controls.[6] In our study, the mean CVI was found to be 66.57 ± 2.21 in the patient group and 69.22 ± 2.39 in the control group, and the difference was statistically significant ($p < 0.001$). Our finding is consistent with previous studies.

In their study, Ağca *et al.* showed that there was a significant deterioration in retinal microvascular structures in CAD patients. They evaluated these vascular changes with optical coherence angiography (OCTA) and suggested that the OCTA device could be used as a non-invasive method for screening purposes in the evaluation of vascular involvement in CAD patients.[21] In our study, there was a decrease in CVI in hypertensive CAD patients, but it was not statistically significant. This may have been due to the small number of patients.

As is seen in our study and the above studies, hypertension affects both the CVI and EFT. Therefore, in the present study, we also investigated a potential relationship between CVI and EFT. To the best of our knowledge, there is no study in the literature that has investigated the association between CVI and EFT in patients with hypertension. In our study, while CVI was significantly lower and EFT was significantly higher in the hypertensive group, there was a statistically significant negative correlation between CVI and EFT as a result of Spearman's correlation analysis ($r = –0.412$, $p < 0.001$).

This study has some limitations. First, the study was conducted in a single centre. Second, our study sample was relatively small. However, given the study being the first in the literature to examine the relationship between CVI and EFT, we believe that our findings will be a guideline for further more comprehensive studies.

Conclusion

The CVI was significantly lower and the EFT value was significantly higher in patients with hypertension compared to non-hypertensive subjects. There was a significant positive correlation between EFT and BMI and a significant negative correlation between EFT and CVI. In this study, the correlation between the decrease in the CVI and the increase in EFT suggested that cardiac effects may have started when the ocular symptoms related to hypertension began. Additionally, CVI can be used as a non-invasive method to evaluate the cardiac effects of hypertension. However, further prospective studies with a larger series of participants are needed to support our results.

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