Retinal fluorescein angiography can predict coronary slow flow phenomenon.

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Abstract

Background and objectives—Obstructive coronary artery disease (OCAD) and coronary slow flow phenomenon (CSFP) are frequent angiographic findings for patients that have chest pain and required frequent hospital admission. The retina provides a window for detecting changes in microvasculature relating to the development of cardiovascular diseases such as arterial hypertension or coronary heart disease. The objective of this study is to asses if there is a correlation between coronary and ocular circulations in patients with CSFP and patients with obstructive coronary artery disease. **Methods**—A prospective study was conducted over ٣.٥ years, included a total of ١٠٥ patients were included in the study divided into ٤ groups : Group I (OCAD): Included ٣٠ patients with obstructive coronary artery disease, group II (CSF): Included ٣٠ patients with coronary slow-flow phenomenon and group III (Control group I"): (٣٠ patients) "No cardiac catheterization" No finding compatible with myocardial ischemia on diagnostic procedure , group IV "control group II" (١٥ patients) with normal coronary angiography. All participants were subjected to: Full history taking, full clinical examination, conventional resting Doppler-Echocardiography, stress electrocardiography, coronary angiography except (Control group I", ophthalmic artery Doppler for measuring Pulsatility index (PI) and resistance index (RI), flow mediated dilatation (FMD) for testing of peripheral endothelial function and Fluorescence angiography of retinal vessels. **Results**—Patients with CSF showed slow flow in retinal circulation (microcirculation) that presented by prolonged AVP and prolonged systemic circulation that presented by prolonged ART in comparison to patients with obstructive OCAD **(P=<٠.٠٠١)** and control groups **(P=٠.٠٠١)**. Patients with obstructive OCAD showed prolonged arm to retinal time (ART) in comparison to control groups **(P=٠.٠٠١)** but no significant difference regarding AVP **(P=٠.٨٤٥).** Also patients with CSF and patients with OCAD showed decreased FMD and increased vascular resistance indices PI & RI in ophthalmic artery Doppler in comparison to control groups **(P=٠.٠٠١)** and without significant difference in between G١ (OCAD) & G٢ (CSF) **(P=٠.٤٤٨)**. There was significant positive correlation between TIMI frame count (TFC) in all subjects with indices of vascular resistance in ophthalmic artery Doppler (PI, RI), BMI and fluorescein angiography times (ART& AVP). Also, FMD was positively correlated with Duke Score and exercise duration, while, in contrary it was negatively correlated with PI and RI but no significant correlation between FMD and total TFC (P=٠.١٨٣). **Conclusion**—Patients with coronary slow-flow phenomenon suffer from slow flow in retinal circulation. Also, retinal micro circulation may represent and reflect coronary micro circulation and it can be used as mirror image for coronary circulation for diagnosis, risk stratification and follow up of changes.

Keywords: Coronary, Ocular, Circulations, Obstructive coronary artery disease, Coronary slow-flow phenomenon.

Introduction

Coronary slow-flow phenomenon (CSFP) is a relatively rare angiographic finding observed in patients with normal or near-normal coronary arteries, it is characterized by delayed opacification of coronary arteries during angiography and it is initially reported in ١٩٧٢ by Tambe et al.,[(١)].

The frequency of CSFP is approximately ١:٥٪ in patients undergoing coronary angiography. More than ٨٠٪ of patients with CSFP often experience recurrent chest pain, almost ٢٠٪ of whom require

readmission following the same diagnosis, also CSF with poor prognostic outcomes, including fatal arrhythmias and sudden cardiac death[٢]. It is still not clear whether or not the coronary slow flow is a focal or a systemic disturbance of the vasculature that may occur simultaneously in other territories of the circulation[٣].

Although acute coronary syndrome is mainly due to an obstructive atherosclerotic lesion, multiple nonatherosclerotic causes of angina pectoris and acute myocardial infarction have been reported. Also, in angiographic evaluation as many as ٣٠٪ of patients presenting with angina pectoris can be found to have normal coronary arteries[٤]. Obstructive coronary artery disease and Coronary slow flow phenomenon are frequent angiographic findings for patients undergo coronary angiography to investigate the cause of chest pain that required frequent hospital admission but CSF with obscure pathophysiology has been defined as delayed coronary blood flow in the absence of obstructive coronary artery disease[٥].

As endothelial dysfunction is a systemic process, assessment of endothelial function in the peripheral circulation may be used as a surrogate of coronary endothelial function. This approach is attractive as it is less invasive and good correlation has been demonstrated between responses to acetyl-choline in the coronary circulation and in the forearm vessels. to being proposed as the primary etiology of atherosclerosis, endothelial dysfunction is the earliest identifiable event in the process of atherosclerotic cardiovascular disease, also proposed as etiology for CSF[٦].

Over the last ٨-١٠ years, multiple large prospective cohort studies examining the relationship between retinal vascular changes and clinical endpoints of coronary disease which have provided strong evidence for a positive correlation between the two, also recent studies have shown an association between retinal microvascular abnormalities and markers of subclinical or microvascular coronary disease[٧].

The retina is a unique site where the microcirculation can be imaged directly. Thus, it provides a window for detecting changes in microvasculature relating to the development of cardiovascular diseases such as arterial hypertension or coronary heart disease. Analysis of the retinal microvasculature provides infor-mation about the structure as well as the function of the vessels and this information can be easily obtained repeatedly over time[٨]. Retinal vascular imaging is explored in clinical settings as a risk stratification tool to aid clinicians in identifying patients with microvascular signs who are at high risk of future clinical cardiovascular and cerebro-vascular events[٩].

The aim of this study was to asses if there is correlation between coronary and ocular circulations in patients with CSFP and patients with obstructive coronary artery disease in comparison to control persons.

Patients and methods:

Patients:

The was a prospective study which carried out in the department of cardiology, Minia university hospital, Egypt during the period from October ٢٠١١ to May ٢٠١٥, ٩٠ subjects in this study were evaluated clinically and classified into three groups as follow:

Group I (OCAD): Included ٣٠ patients with obstructive coronary artery disease.

Group II (CSF): Included ٣٠ patients with coronary slow-flow phenomenon.

Group III (Control -١): Included ٣٠ healthy control persons.

Group **I**V (Control - **II**): collected retrospectively included ١٥ persons with normal coronary angiography.

Patients of group (I) were included according to a specific criteria of typical anginal pain, Findings compatible with myocardial ischemia on diagnostic proce-dures and significant obstructive coronary arteries on angiography with ٥٠٪ stenosis or more. Patients of group (II) were included with a criteria of typical anginal pain, findings compatible with myocardial ischemia on diagnostic procedures and coronary slow flow on coronary angiography and diagnosed by TIMI Frame

Count (TFC). However, persons in control group-١ were chosen by no history chest pain and no finding compatible with myocardial ischemia on diagnostic procedure, persons in control group – II were collected retrospectively with normal coronary angiography that done for diagnosis of CAD based on inconclusive results of noninvasive procedure. Persons with history of previous myocardial infarction, coronary intervention or CABG, moderate or severe valvular heart diseases, hyper-trophic, dilated and restrictive cardiomyopathy, diabetes, hypertension, obese patients (BMI ≥ ٣٠ kg/m^{٢}) and other coronary artery diseases as myocardial bridging or coronary were excluded from the study.

Methods:

All subjects included in this study were subjected to the following:

١. Full personal history and history of symptoms typical or atypical anginal chest pain.

٢. Full clinical examination including all vital signs, general examination and cardiac examination and BMI was calculated.

٣. Resting ١٢-leads ECG was performed by using Fukoda Denshi autocardiner No. FCP ٢/٥٥ and paper speed at ٢٥ mm/sec at standard ١٠ mm/mv.

٤. Conventional Resting Doppler-Echocardiography using GE Vivid-٣ Expert machine for assessment of the left ventricle (LV) dimensions, volumes, LV systolic function and diastolic function by Simpson's biplane method at apical views. Pulsed Doppler and color Doppler to evaluate all valves for exclusion of patient with moderate or severe valvular lesions.

٥. Stress electrocardiography was performed for all subjects. The exercise test was performed on a treadmill using protocol considered to be the most appropriate in each case (Bruce or modified Bruce) after full preparation of subject.

٦. Coronary Angiography study: All subjects underwent coronary angiography except control group- **I** after informed consent with mention of complications. TFC was calculated using the method of Gibson et al.,[١٠].

٧- Ophthalmic artery Doppler study the right or left eye was evaluated by color Doppler imaging for all subjects with coupling gel applied to closed eye lids, and no pressure applied on the globe with the probe during measurement and Doppler study carried out with ٧.٥ MHz liner transducer and sample volume set at ١ mm and placed in the color Doppler images of the artery then peak systolic velocity (PSV), end diastolic velocity (EDV), pulsatility index(PI) and resistance index (RI) automatically calculated by the machine according to the following equations

Pulsatility index (PI)= (PSV-EDV) / TVI

Resistive index (RI)= (PSV-EDV) / PSV

٧. Testing of the peripheral endothelial function by flow mediated dilatation (FMD) of the brachial artery for all subjects in the study by using colored duplex ultrasound with ٧.٥ MHz linear array transducer with connection to electrocardiogram cables of the device in order to have the study ECG coupled and measurement of the brachial artery diameter ٣-٥ cm above the elbow ,measurement was applied from anterior to posterior interface between media and adventitia, mean diameter was calculated from ٦ cycles synchronized with the end-diastolic at the R wave peaks to avoid errors from arterial compliance with each scan

١st scan was taken to be the basic of the flow mediated dilatation

٢nd scan was taken after applying a pneumatic tourniquet of ٤٠ mmHg above systolic blood pressure (using mercurial sphygmomanometer) for about ٥ min and the scan was taken after ٦٠ seconds after releasing the tourniquet. FMD percentage was calculated by the following equation:

FMD%=(٢nd scan – ١stscan)/١st scan x١٠٠

٨. Fluorescence angiography of retinal vessels: All subjects underwent fluorescence angiography of retinal circulation after exclusion of contraindications with adequate papillary dilatation and patient seated in front of fundus camera then red free images is captured after ٥ml of a ١٠٪ sodium fluorescin (orange water soluble dye) is administrated intravenously into an antecubital vein over ٢-٣ seconds and images was taken at approximately every second over ٢٥ seconds after injection according to Prall et al.,[١١]. We took two intervals: ١- Arterial phase (arm- to retinal time) time from injection until the dye first appears in the central retinal artery and it

can vary between ٧ to ١٥ seconds it represents systemic venous and arterial circulation flow. ٢- Retinal arteriovenous transit time: Time from the first appearance of dye in the temporal retinal arteries of the arcades to the time when the corresponding veins are completely filled is considered to be ١-٢ sec after the arterial phase.

Statistical analysis

Data was statistical analyzed by using SPSS_٢٠ software package. Categorical data was presented in the form of frequency and percentage. Quantitative data were expressed in the form of mean; SD. Kolmogorov- Smirnov for normality test was used to differentiate between parametric data and non-parametric data. One way ANOVA test was used to test the significance between groups for quantitative variables however, Chi - square ($x^{٢}$) was used for qualitative data. Duncan multi-comparison test was used. Person correlation coefficient was used to get the correlation between variables. Probability (p. value) was considered as non-significant if ≥ ٠.٠٥, Significant if < ٠.٠٥.

Results

The results showed that there were no statistically significant difference regarding age, gender, DBP, SBP and FBS among studied groups. However, there was significant increase in BMI in CSF patients when compared to OCAD group and control groups, (Table, ١).

No significant difference among groups regarding ejection fraction. But regarding LV diastolic function, there was significant increase in grade ١ diastolic dysfunction in OCAD patients when compared to CSF group and control groups. Regarding the results revealed that Flow-mediated dilatation (FMD) was significantly higher in control groups compared to CSF group and OCAD group with insignificant difference between group (I and II) (Table, ١).

Results of parameters of ophthalmic artery Doppler (RI & PI) are presented in table (١), the results showed that OCAD and CSF patients had significantly higher RI & PI as compared to control groups with no significant differences between OCAD and CSF groups. Regarding parameters of fluorescein angiography (ART & AVP) are presented in table (١), they were significantly increased in CSF patients (group II) when compared to other groups, ART only not AVP was significant prolonged in group (I) compared to control groups, however, no significant difference was found between control groups and OCAD group in AVP. In respect of the results of TIMI frame count (TFC) of coronary arteries among groups, total, LAD, LCX & RCA TFC had the same trend of results among groups. The highest values were recorded in CSF patients with a significant difference when compared to the other groups; however there was no significant differences between OCAD and control groups in all TFC measurements (figure, ١).

There is a weak negative insignificant correlation between TIMI frame count and Flow-mediated dilatation in all subjects (r=٠.١٥٦, p.=٠.١٨٣). There is significant positive correlation between TIMI frame count in all subjects and ART (r=٠.٨٠٦, p.=<٠.٠٠١), AVT (r=٠.٧٦٨, p.=<٠.٠٠١), PI (r=٠.٤١٥, p.=<٠.٠٠١), RI (r=٠.٣٠٤, p.=٠.٠٠٨) and BMI (r=٠.٤١٨, p.=<٠.٠٠١), (Table, ٢).

In ROC curve, the optimal cut-off value of ART & AVT for the prediction of CSFP were >١٦, >٢ respectively with a high sensitivity and specificity.

Table (١) : All studied variables among groups.

	Group I (OCAD) N= ٣٠	*Group II (CSF) N= ٣٠*	*Group III (Control ١) N= ٣٠*	*Group IV (Control ٢) N= ١٥*	*P value*					
					I vs II	I vs III	I vs IV	II vs III	II vs IV	III vs IV
Sex: Male. Female.	١٩ (٦٣.٣٪) ١١ (٣٦.٧٪)	١٧ (٥٦.٧٪) ١٣ (٤٣.٣٪)	١٩ (٦٣.٣٪) ١١ (٣٦.٧٪)	١٠ (٦٦.٧٪) ٥ (٣٣.٣٪)	٠.٥٩٨	١	٠.٨٢٦	٠.٥٩٨	٠.٥١٩	٠.٨٢٦
Age	٥٣.٤٦ ± ٥.٤٨	٥٠.٣٦ ± ٧.٣٦	٥١.٤٣ ± ٦.٥٣	٤٩.٤٦ ± ٧.٩٩	٠.٢٨٧	٠.٦٤٧	٠.٢٤٤	٠.٩٢٨	٠.٩٧٤	٠.٧٩٢
FBS	٩٠.٦٣ ± ٩.٣٤	٩١.١٣ ± ٩.١٣	٩١.٤ ± ٨.٦١	٩٤.١٣ ± ١٠.٨٣	٠.٩٩٧	٠.٩٨٩	٠.٦٣٥	١	٠.٧٣٨	٠.٧٨٩
DBP	٧٧.٧٦ ± ٤.٩٤	٧٨.٣٣ ± ٤.٢٢	٧٧.٩ ± ٤.٣٢	٧٣ ± ٧.٢٧	٠.٩٦٢	٠.٩٩٩	٠.٧٤٥	٠.٩٨٢	٠.٤٩٨	٠.٦٨٩
SBP	١٢٩.٦٦ ± ٣.٤٥	١٢٩.٥ ± ٣.٣١	١٢٩.٥٣ ± ٣.٩٧	١٣٠.٣٣ ± ٦.٦٧	٠.٩٩٩	٠.٩٩٩	٠.٩٥٧	١	٠.٩٢١	٠.٩٢٩
BMI	٢٤.٦٩ ± ١.٥٥	٢٦.٣ ± ١.٤	٢٥.١ ± ١.٨٣	٢٤.٣٨ ± ١.٥٦	٠.٠٠١*	٠.٧٥٩	٠.٩٢٤	٠.٠٢٤*	٠.٠٠١*	٠.٤٨٤
FMD	٩.٤٥±١.٥٥	١٠.٠٢±١.٥٥	١٦.٧±١.٣٧	١٤.٨٩±١.٣٨	٠.٤٤٨	<٠.٠٠١*	<٠.٠٠١*	<٠.٠٠١*	<٠.٠٠١*	٠.٠٠١*
RI	٠.٧٧±٠.٠١	٠.٧٧±٠.٠٢	٠.٧ ± ٠.٠٢	٠.٧١±٠.٠١	٠.٩٦٩	<٠.٠٠١*	<٠.٠٠١*	<٠.٠٠١*	<٠.٠٠١*	٠.٢٥٥
PI	١.٧٦ ±٠.٠٢	١.٧٨ ± ٠.٠١	١.٥٧± ٠.٠٥	١.٥٩ ± ٠.٠٣	٠.١٦٠	<٠.٠٠١*	<٠.٠٠١*	<٠.٠٠١*	<٠.٠٠١*	٠.١٢٦
ART	١٥.٥٦±١.٠٩	٢٨.٤٧±٤.٦	١٢.٤±١.٦	١٢.٩١±١	<٠.٠٠١*	<٠.٠٠١*	٠.٠١٧*	<٠.٠٠١*	<٠.٠٠١*	٠.٩٤٠
AVP	١.٨٢ ± ٠.١٤	٢.٨٦ ±٠.٤٩	١.٦٦±٠.١	١.٧٤±٠.١	<٠.٠٠١*	٠.١٧٧	٠.٨٤٥	<٠.٠٠١*	<٠.٠٠١*	٠.٨٢٩

Table (٢) : Correlation between TFC and other parameters

All groups	**Total TFC**	
	R	**P value**
PI	٠.٤١٥	<٠.٠٠١*
RI	٠.٣٠٤	٠.٠٠٨*
FMD	-٠.١٥٦	٠.١٨٣
AVT	٠.٨٠٦	<٠.٠٠١*
AVP	٠.٧٦٨	<٠.٠٠١*
BMI	٠.٤١٨	<٠.٠٠١*

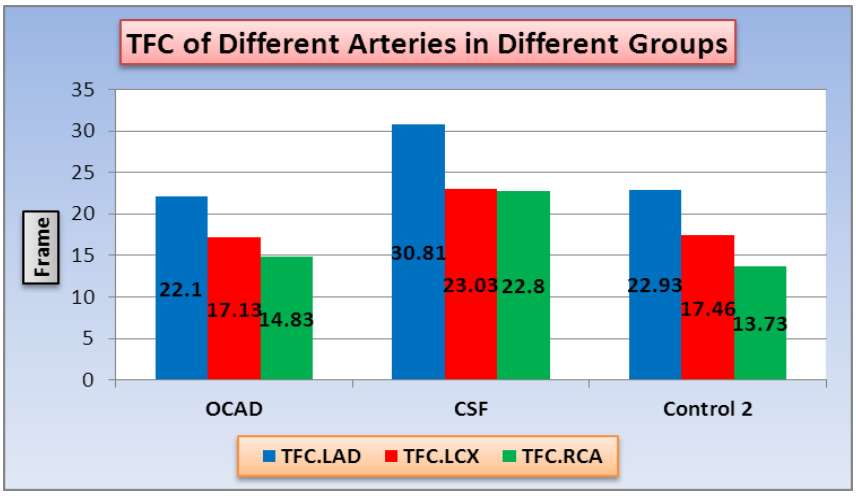
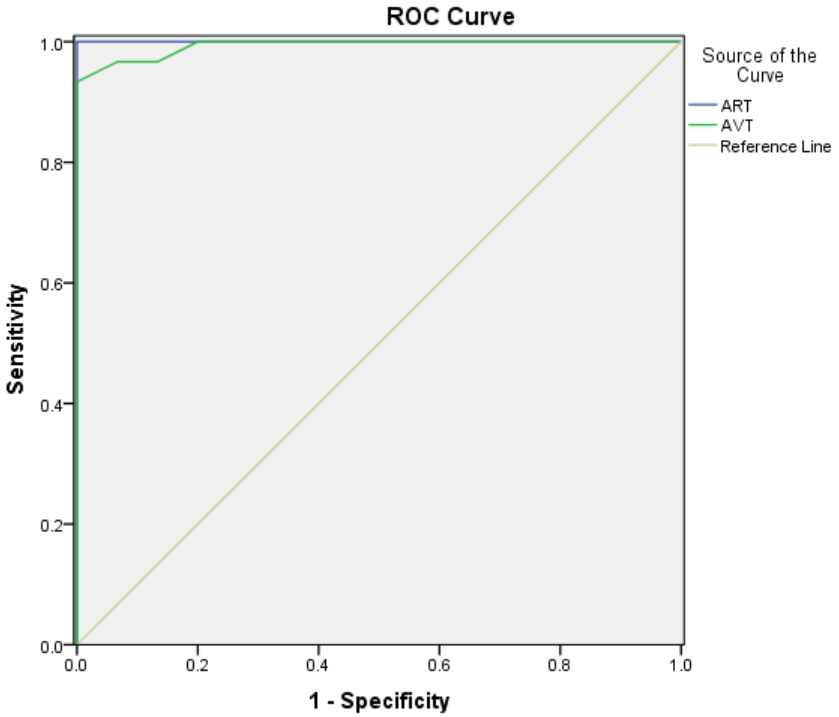


Figure (١) showed significant high of TFC between (GII) and other groups, but no difference between group ١(OCAD) and group ١V and (control group -١١.

ROC curve analysis for prediction of coronary slow flow:-

Variable	Optimal cutoff point	AUC	P value	Sensitivity	Specificity	PPV	NPV	Accuracy
ART	>١٦	١	<٠.٠٠١*	١٠٠٪	١٠٠٪	١٠٠٪	١٠٠٪	١٠٠٪
AVT	>٢	٠.٩٩٣	<٠.٠٠١*	٩٦.٦٧٪	٩٣.٣٣٪	٩٦.٧٪	٩٣.٣٪	٩٥.٦٪



ROC curve, the optimal cut-off value of ART & AVT for the prediction of CSFP were >١٦ , >٢ respectively with a high sensitivity and specificity.

Discussion

Coronary slow flow phenomenon is sometimes considered as a new category of coronary disease with unknown etiology and indefinite outcome. Several surveys have investigated the relationship between CSFP and endothelial dysfunction as a probable etiology. In the present study we tried to ascertain whether there is a correlation between coronary and ocular circulations in two groups, patients with CSF and patients with obstructive CAD in comparison with control group.

In the present study, patients with CSF had significant higher body mass index compared to other groups although it was within normal limits "٢٦.٣". These findings are in agreement with Signori et al.,[١٢] who found that BMI was ٢٥.٤ ± ٣ (kg/m^{٢}) in control group versus ٢٩.٩ ± ٥ in CSF group with P < ٠.٠٤٤ and also, Gunes et al., found that BMI was (٢٦.٥ ± ٣.٣ in CSF patients versus ٢٣.٨ ± ٢.٨ in control group ., p < ٠.٠٠١), although it was within normal limits also[١٣]. However, Mir Hossein et al**.** found that there was no significant differences between CSF and control group[١٤]. Our finding can be explained by the CSFP Patients tend to be obese and the metabolic syndrome was more frequent in CSFP in the presence with higher body mass index levels than controls[١٥].

The results of Duke Score revealed a significant difference among the studied

groups and each others. Myocardial ischemia in CSF patients could be detected by stress ECG or Holter's dynamic monitoring, which show ST-segment depression and chest pain, Regarding exercise duration, OCAD and CSF groups had significant lower means as compared to control one. Goel et al. showed that definitively positive exercise test results were more common in SCF patients than in those with normal coronary flow[١٦].

In our study, the results showed that OCAD and CSF patients had significantly higher Pulsatility index & Resestive index "indices of vascular resistance of ophthalmic artery Doppler" as compared to control groups with no significant differences between OCAD and CSF groups. In accordance with our findings, Maruyoshi et al., reported RI and PI were significantly higher in patients with CAD than in controls. Resistive index was ٠.٧ ± ٠.١ in control group versus ٠.٨ ± ٠.١ in CAD with P< ٠.٠٠١, pulsatility index ١.٥ ± ٠.٣ in control group versus ١.٧ ± ٠.٣ in CAD with P<٠.٠٠٠١ (١٧).

Hemodynamic Doppler flow changes of ophthalmic artery may reflect peripheral vascular resistance and seem to reflect diminished arterial compliance caused by systemic atherosclerosis. The relationship between OA Doppler findings and systemic atherosclerosis, however, remains unclear and the precise underlying mechanisms remain unknown, although several potential mechanisms are suggested. First, resulting from atherosclerotic changes in the ocular vessels accompanying systemic Atherosclerosis. Second, peripheral circulatory disturbance due to decreased aortic compliance because of impaired Windkessel function. In our study increase of indices of vascular resistance of ophthalmic artery Doppler in CSF and patients with obstructive CAD groups in comparison to control groups is a common feature and this means CSF may also associated with increase peripheral vascular resistance as patients with CAD and this can explained by as well as diffuse intimal thickening, widespread calcification along the coronary vessel wall and non-obstructive athermanous coronary changes that showed by using IVUS technique in CSF , also mostly other systemic vessels showed the same changes which suggests that slow coronary flow be a form of early phase of atherosclerosis and it is a systemic phenomenon and not localized to coronary arteries .

Fluorescence angiography showed that there is a high arm-to-retina circulation time (ART) in patients with CSF (٢٨.٤٧ ± ٤.٦٦ seconds) with significant difference in comparison with other groups. Patients with obstructive CAD was ١٥.٥٦ ± ١.٠٩, control group was ١٢.٤ ± ١.٦٨ with P <٠.٠٠١. This reflects the slower flow of blood in systemic circulation in patients with CSF similar to coronary slow flow and include two parts, firstly venous part from arm vein to heart and lastly from heart through carotid artery and ophthalmic artery to retina. In normal persons, Fluorescence dye is first detected in the retinal vasculature ١٢ to ١٥ seconds after dye is injected into the arm vein. Uncommonly, dye may take up to ٢٠ seconds to reach the retinal arteries in a normal person. We suspected that as ophthalmic artery is anatomically similar to coronary arteries as both are conductive arteries with the same structure less elastic tissue and more muscular tissue so slow flow that occurs in coronary arteries in G (٢) may be the same in ophthalmic artery. Similar to our results, Koç et al. found that ART was ١٩.٠ ± ٥.٧ seconds in CSF group and ١٤.١± ٣.١ in control group with p <٠.٠٠١[٢٣]. The significant difference between obstructive CAD and control group in ART can be explained by peripheral endothelial dysfunction in group (I). AVP (arteriovenous phase) time is the shortest time of retinal microcirculation and it is described as the time period between the entrance of the opaque substance to the edge of the optic disc or to the retinal artery from a distance of ٢ optic discs and the appearance of the opaque substance in the vein at the same point.

In the present study, retinal arterio-venous phase time was measured using fundus fluorescein angiography as a part of the microcirculation, it was significantly higher in CSF patients in comparison to OCAD patients and control. This agrees with a study of Koç et al. who reported that higher

AVP time ٢.٦ ± ٠.٩(seconds) in CSF group than ٢.١ ± ٠.٧ in control group with p < ٠.٠٠١[٢٣]. Retinal microcirculation similar to coronary microcirculation from anatomical and physiological view (Kamran Ikram et al., ٢٠١٣ and Wang et al., ٢٠٠٨). So, prolonged AVT may reflect slow flow and coronary microcirculation dysfunction.

Our results showed that patients with SCF had prolonged TFC for each major coronary artery in comparison to both obstructive CAD and control groups. Koç et al reported significant differences in TFC for LAD ٤٨.٢ ± ١١.٣ in CSF group versus ٢٤.١ ±٥.١ in control group with P <٠.٠٠١, LCX ٣٩.١ ±١٥.٠ versus ١٨.٨ ± ٣.٩ with p <٠.٠٠١, RCA was ٢٤.٧ ± ٩.٦ versus ١٥.٥ ±٣.٥ with P <٠.٠٠١ (٢٣). Also, Signori et al. (١٢) reported that TFC was higher in the patients with SCF than in the controls for each major epicardial coronary artery. In addition, the average TIMI frame count was higher in the patients with SCF than in the controls (٢٦± ٤ vs. in control group versus ٣٧.٩± ١٢ in CSF). In line with our findings, Ibrahim et al. reported that LAD corrected TFC was ٢١.٣ ± ٣.٥ in control group versus ٣٠.٤ ± ٤.١ in CSF group with P-value <٠.٠٠١, LCX ٢٠.٤ ± ٣.١ versus ٢٨.٢ ± ٣.٢ with <٠.٠٠١, RCA ٢١.٤ ± ٢.٩ versus ٢٩.١ ± ٣.٤, P. value <٠.٠٠١[٢٤].

There is a significant positive correlation between TFC and fluorescein angiography measurements including ART, AVP time (r =٠.٨٠٦, p < ٠.٠٠١) and (r =٠.٧٦٨, p < ٠.٠٠١). Also, Koç et al., showed in the whole study group, mean TIMI Frame counts were positively correlated significantly with the measurements of ART, AVP time (r = ٠.٦٣٣, p < ٠.٠٠١) and (r = ٠.٥١٧, p < ٠.٠٠١) respectively[٢٣]. Also our results indicated that there is significant positive correlation between TFC and indices of vascular resistance of ophthalmic artery Doppler PI (r = ٠.٤١٥, p < ٠.٠٠١) and RI (r = ٠.٣٠٤, p < ٠.٠٠٨) and that may reveal correlation between increase of coronary vascular resistance as suspected cause of prolonged TFC and increased peripheral vascular resistance. Also, there is significant positive correlation between TFC in whole study and BMI (r = ٠.٤١٨, p < ٠.٠٠١) and these data with agreement of data that Patients with CSF had higher body mass index.

In our study there was no significant correlation between FMD and TFC (r = -٠.١٥٦, p < ٠.١٨٣) including all study subjects and this with agreement of Shapour et al. reported neither frame count nor mean frame count showed any significant correlation with FMD[٢١].

Conclusion

Based on the present results, we can conclude that patients with coronary slow-flow phenomenon suffer from slow flow in retinal circulation. Also, retinal micro circulation may represent and reflect coronary micro circulation, so changes that occur in coronary circulation can occur in retinal circulation. Furthermore, retinal circulation can be used as mirror image for coronary circulation for diagnosis, risk stratification and follow up of changes in coronary circulation .

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