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Retinal Precapillary Arteriolar Occlusion after Coronary Artery Bypass Grafting Surgery

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ABSTRACT

Background: The aim of this study is to evaluate the microembolic changes related to occlusions of precapillary arterioles in the retina during coronary artery bypass grafting (CABG) surgery using fundus photography, and to examine systemic and operational factors related to occurrent lesions.

Methods: Retinal microvascular damage was assessed by color fundus photography one day before CABG surgery, on postoperative day five, and again three months after surgery. In addition to patients' demographics, diabetes mellitus, hypertension, chronic renal failure, and hypercholesterolemia (LDL level) were examined. Smoking history was recorded. Additionally, each patient's carotid Doppler results were ranked by four degrees. Data related to the surgery were recorded.

Results: No retinal emboli were seen in any patient before surgery. In fundus photographs taken on the fifth day after surgery, retinal precapillary arteriolar occlusions were seen in 20 (28.57%) of the patients. Lesions were observed to have disappeared in the third month after surgery. There was no significant ($P > .05$) difference in age, sex, diabetes mellitus, HT ratio, tobacco consumption percentage, LDL values, and Doppler USG distribution between the two groups of patients with and without lesions. However, CABG surgery and cross-clamp removal time measured significantly ($P < .05$) longer in the group with lesions than in the group without lesions.

Conclusion: Our results show that retinal microembolism can occur after CABG surgery in association with surgery time and cross-clamp time; however, this does not cause any clinical outcome.

INTRODUCTION

During coronary artery bypass grafting (CABG) surgeries, systemic macroscopic and microscopic embolism of gas, biologic aggregates, and inorganic debris can occur [Ascione 2005; Barbut 1994; Blauth 1995; Blauth 1986; Clark 1995; Marren 1994; Padayachee 1987; Stump 1996; Taylor 1999]. Microemboli are known to occur in association with specific surgical events such as aortic cannulation, initiation of cardiopulmonary bypass, and cross-clamp removal, which now appear to be related mostly to atheroembolism from manipulation of the atherosclerotic ascending aorta, causing transient infarcts in the smaller blood vessels in multiple organs, such as the lungs, kidneys, brain, or the retina [Ascione 2005; Barbut 1994; Clark 1995; Marren 1994; Padayachee 1987; Stump 1996; Taylor 1999].

Embryologically, the retina is an extension of the diencephalon and both organs share a similar pattern of vascularization during development. There is a close anatomical correlation between both the macrovascular and the microvascular blood supply to the brain and to the retina, and the eye provides a window on the cerebral circulation [Patton 2005]. Ascione et al found that retinal microvascular changes were associated with the markers of cerebral injury [Ascione 2005].

In this study, we observed precapillary arteriolar occlusion related to embolic changes after CABG surgeries, using fundus photographs. We evaluated systemic and operational factors related to these lesions and observed if this is concurrent with any clinical outcome.

MATERIALS AND METHODS

This was a prospective study, comprising a total of 70 patients planning to undergo CABG surgery from April to November 2014 at the Cardiovascular Surgery Clinic of Medicine Hospital. The exclusion criteria of the study included emergency surgery, significant carotid artery disease, previous history of ophthalmic, neurological, or peripheral vascular disease, reoperations, and the presence of acute or suspected systemic infection.

The study included 45 men (64.3%) and 25 women (35.7%), with an age range of 42-84 (mean 63.8 ± 11.6). The study was approved by the Institutional Ethics Review Board and informed consent was obtained from all patients.

All of the operations were carried out by a single surgeon. After standard anesthesia, a Swan-Ganz catheter through the internal jugular vein was placed into all patients before the bypass surgery. All procedures were performed using a midsternotomy approach. Systemic heparinization cardiopulmonary bypass was established with arterial inflow through the ascending aorta, with venous drainage through a single two-stage right atrial cannula. Systemic body temperature was maintained at 32°C, and cardiac arrest was achieved with blood cardioplegia and cross clamp to perform all distal anastomosis. Antegrade blood cardioplegia was given every 20 minutes. Hematocrit was maintained between 20% and 25%

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Table 1. Patient Demographics*

Age	63.8 ± 11.6; 64 (42-84)
Male sex, n (%)	45 (64.3)
Female sex, n (%)	25 (35.7)
Diabetes mellitus, n (%)	26 (37.1)
HT, n (%)	49 (70.0)
Smoking history, n (%)	40 (57.1)
Cross-clamp time, min	42.0 ± 29.0; 36 (12-184)
Bypass time, min	80.3 ± 39.4; 72 (28-245)
LDL level, mg/dL	113.8 ± 31.1; 113 (50-211)
Carotid Doppler Grade I, n (%)	23 (32.9)
Carotid Doppler Grade II, n (%)	47 (67.1)

*Values are expressed as mean ± standard deviation and median (range) where indicated.

during CPB, mean arterial pressure was maintained between 50 and 70 mm Hg, and proximal anastomosis was done with partial cross-clamp removal on a beating heart. Weaning from CPB was carried out after the proximal anastomosis. At the end of surgery, patients were transferred to the intensive care unit and managed according to our unit protocols.

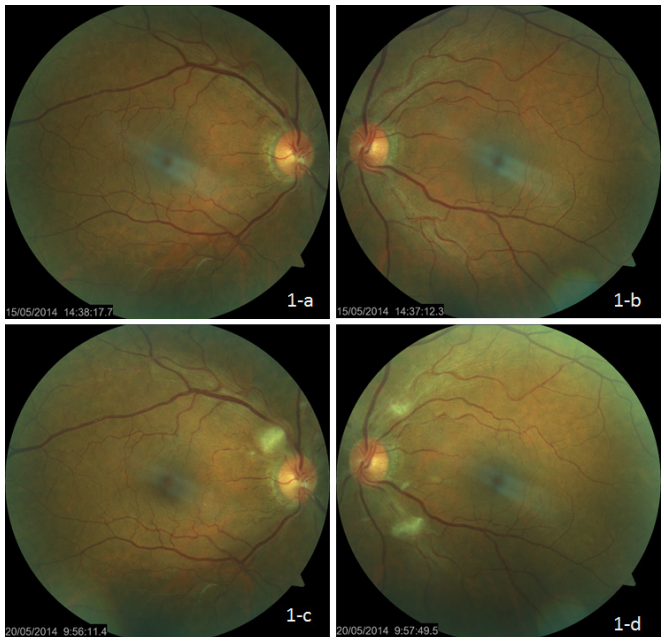
All patients were examined for diabetes mellitus, hypertension, chronic renal failure, and hypercholesteremia (LDL level), as well as demographic characteristics. Past and present smoking history of the patients was recorded. Carotid Doppler findings of each patient were ranked under four stages before surgery: grade I normal, grade II plaque present, grade III 50-75% occlusion, grade IV complete occlusion. Length of the CABG surgery and cross-clamp removal time was recorded.

Patients were evaluated by the ophthalmology clinic of Istanbul Medicine Hospital before surgery, on the fifth day after surgery, and in the third month after surgery. All participants underwent ophthalmic examination; fundoscopy was performed through patients' dilated pupils. Stereoscopic 30° color fundus photographs of the disc, macula, and retina were taken before surgery and on postoperative day five. Patients with retinal emboli or other lesions were admitted to the ophthalmology clinic in the third month after surgery.

Mean, standard deviation, median, minimum, and maximum values were used as the descriptive statistics of data. Distribution of variables was checked using a Kolmogorov-Smirnov test. An independent-samples T test and a Mann-Whitney U test were performed in quantitative data analysis. A Chi-square test was performed in qualitative data analysis. SPSS 22.0 software was used for analyses.

RESULTS

Patient demographics are summarized in Table 1. The mean duration of CABG surgery was 72 (range, 28-245) minutes, and the mean cross-clamp removal time was 36 (range, 12-184) minutes. The preoperative carotid Doppler characteristics of patients are summarized in Table 1. No in-hospital deaths or neurological complications were seen. In addition, no differences in the clinical outcomes were observed (e.g., postoperative inotropes, use of blood products).



A and B, Right eye and left eye fundus photographs before the CABG (coronary artery bypass grafting) operation. C and D, Right eye and left eye of the same patient's fundus photographs taken on the fifth day after CABG operation. New areas of cotton wool spots at the posterior pole.

No retinal emboli were detected on the preoperatively taken fundus photographs of patients. In the 20 patients (28.57%) under study, occlusive lesions of retinal precapillary arterioles in both eyes were seen on the fundus photographs taken on the fifth day after surgery. In the fundus photographs taken three months after surgery, it was observed that all the lesions were gone in all patients (Figure). In the ophthalmic examination of the patients after operation, no visual acuity change was detected.

There was no significant difference ($P > .05$) in age, sex, diabetes mellitus, HT ratio, smoking history percentage, LDL values, and carotid Doppler distributions between both groups with and without retinal lesions. However, CABG surgery time and cross-clamp removal time was measured significantly ($P < .05$) longer in the group with lesions than in the group without lesions (Table 2).

DISCUSSION

Due to the rapid increase in the number of cardiac surgeries performed in the last few years, the possibility of various end-organ damage, including brain and eyes, also increases. Retinal microemboli are considered to be one of the mechanisms of ocular disease formation after CABG surgery [Ascione 2005; Blauth 1995; Blauth 1986; Marren 1994; Moster 1998; Williams 1975].

Table 2. Patients' Characteristics between Groups with and without Retinal Lesions*

	Retinal Lesion Not Present	Retinal Lesion Present	*P*
Age	62.4 ± 12.3; 61 (42-84)	67.3 ± 9.0; 67 (54-82)	.116
Male sex, n (%)	29 (58.0)	16 (80.0)	.083
Female sex, n (%)	21 (42.0)	4 (20.0)	
Diabetes mellitus, n (%)	15 (30.0)	11 (55.0)	.051
HT, n (%)	35 (70.0)	14 (70.0)	1.000
Smoking history, n (%)	25 (50.0)	15 (75.0)	.056
Cross-clamp time, min	41.1 ± 30.4; 35 (12-184)	44.3 ± 26.0; 38 (28-149)	.046
Operation time, min	77.1 ± 41.0; 70 (28-245)	88.4 ± 35.0; 81 (60-223)	.031
LDL level, mg/dL	117.4 ± 33.1; 124 (50-211)	105.3 ± 24.2; 110 (66-162)	.144
Doppler USG Grade I, n (%)	14 (28.0)	9 (45.0)	.171
Doppler USG Grade II, n (%)	36 (72.0)	11 (55.0)	

*Values are expressed as mean ± standard deviation and median (range) where indicated. Respective data based on independent-samples t test/ Mann-Whitney U test/Pearson chi-square test. Bold values indicate statistically significant.

Retinopathy outcome has been reported in 17% to 50% of patients after CABG surgery [Ascione 2005; Shaw 1985; Williams 1975]. Our results show that after CABG surgery, cotton wool spots associated with embolic occlusions of retinal precapillary arterioles are seen on fundus photographs in 28.57% of patients. Williams in 1971 first reported that large numbers of microemboli circulate in the blood stream during open heart surgery. White plugs and specks have been observed in retinal circulation by fundoscopic examination [Williams 1975].

Blauth et al performed intraoperative fundus fluorescein angiography (FFA) in 10 patients undergoing CABG-CPB surgery; retinal microvascular damage was observed in all of them [Blauth 1986].

Shaw et al in 1985 studied 312 patients undergoing elective CABG surgery. Ophthalmological abnormalities were observed in 78 (25%) out of 312 patients. Areas of retinal infarction, producing the appearance of cotton wool spots, developed in 54 patients (17%). The infarcts were bilateral in 20 patients and unilateral in 34. In eight patients one or more retinal emboli were observed immediately after surgery. In each case the embolus consisted of a yellowish refractile body and was usually lodged at a vascular bifurcation [Shaw 1985].

Ascione et al estimated the average risk of retinal microvascular damage in CABG surgery patients to be >50% and 2% in off-pump grafting patients. They speculated that embolism may be considered the most likely mechanism because of the large amount of aortic manipulation needed during CABG-CPB surgery. Furthermore, a strong association between FFA microvascular changes and transcranial Doppler high-intensity transient signals (Doppler HITS) was observed: HITS were 14.7 times more frequent when microvascular damage was present [Ascione 2005].

In this study, we obtained statistically significant results in CABG surgery time and cross-clamp removal time, and in occlusive lesions of precapillary arterioles associated with retinal embolism. This may additionally show that there is an association between aortic manipulations and embolism.

Moreover, this study investigated whether any emboli-related permanent damage occurred in the retina of patients. In our study, we observed that emboli-related changes in the retina had disappeared in the fundus photographs taken three months after surgery. Various other studies reinforce this observation. Buyukates et al found that there was a significant reduction in RNFL thickness on the first and fifth days after CAPB surgery when compared to preoperative measurements, and that it had resolved itself to insignificant levels at the end of the first month, with the exception of the inferior quadrant peripapillary RNFL value [Buyukates 2007]. Pekel et al found that CABG surgery did not affect retinal thickness, retinal vessels, or pulsatile ocular blood flow in long-term follow up. The time interval between the CABG surgery and ophthalmic examination was between 1-20 years [Pekel 2014].

In our study we did not use the FFA, although it might give additional data about retinal blood flow and it is the most suitable method for visualization of microembolic events. As an example, Ascione et al showed in postoperative fluorescein angiograms that retinal microvascular damage was detected in 5 of the 9 CABG-CPB patients, and in color fundus photographs taken on postoperative fifth day abnormalities were indicated in 1 of 9 CABG-CPB patients [Ascione 2005]. However, our study concerned a larger number of patients, and our patients had not given informed consent for procedures such as FFA after CABG surgeries.

In conclusion, our results show that after CABG surgery, embolic occlusions of precapillary arterioles in the retina and in related retinal lesions are seen in the fundus photographs of 28.57% patients. Additionally, CABG surgery time and cross-clamp removal time is longer for patients with embolism than for patients without embolism. Therefore, retinal embolism could be avoided by shortening the surgery time and cross-clamp time. The retina plays a role in cerebral circulation, thus this result could be a marker of cerebral injury. However, in this study, clinical outcomes of the lesions were not seen.

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