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Risk Factors for Retinal Arteriolar Emboli in Coronary Artery Disease

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This study determined the prevalence of retinal arteriolar emboli risk factors in 148 patients (86 males) diagnosed with coronary artery disease who required coronary artery bypass graft surgery (mean ± SD age 59.1 ± 12.9 years). The prevalence of smoking was 50.7%, hypertension was 49.3%, diabetes mellitus was 27.0% and obesity was 31.1%. Retinal arteriolar emboli were detected using binocular indirect ophthalmoscopy of both eyes. They were found in 10 patients (6.8%) and identified as the cholesterol type. Patients were divided according to their baseline low-density lipoprotein cholesterol (LDL-C) serum level; retinal arteriolar emboli were significantly more frequent in patients with LDL-C levels > 100 mg/dl. These results demonstrate that the prevalence of hypercholesterolaemia and high LDL-C were increased in patients with retinal arteriolar emboli. Identification and treatment of modifiable risk factors, such as high LDL-C and hypercholesterolaemia, might be beneficial in these individuals.

KEY WORDS: Coronary artery disease; Retinal arteriolar emboli; Hypercholesterolaemia; Low-density lipoprotein cholesterol (LDL-C); Cardiovascular risk factors

Introduction

Retinal arteriolar emboli are potentially sight-threatening retinal vascular conditions seen in middle-aged and elderly people, and may cause transient blindness.[1] Retinal arteriolar emboli can be found in approximately 1% of adults > 40 years of age.[2] The frequency of retinal emboli increases with age and they are more common in men than in women.[2] Bilateral retinal emboli are rare, although multiple emboli in a single eye may be seen in up to one-third of cases.[2]

Retinal emboli appear as discrete plaque-like lesions in the lumen of the retinal arterioles.[2] Clinically, they are oval or rhomboid in shape, have a reflective (bright) or non-reflective (dull) appearance, are single or multiple and may be seen in one or both eyes. They are pathologically heterogeneous; reflective emboli seem to be composed of cholesterol crystals, whereas non-reflective types are composed of fibrin, platelets, calcium and other materials.[2] The reflective type of retinal emboli, known as Hollenhost plaques, appear bright yellow. Retinal emboli are diagnosed by binocular indirect ophthalmoscopy or by using a digital retinal camera.

The association between retinal arteriolar

emboli and increased risk of cerebrovascular disease morbidity and mortality has been well documented in the literature.[3,4] Retinal arteriolar emboli, a risk factor for stroke and, possibly, retinal artery occlusion, are associated with several cardiovascular risk factors, including smoking, dyslipidaemia and symptomatic ischaemic heart disease.[1] The prevalence of retinal arteriolar emboli is variable among the different risk factors.[1]

There are potential ocular manifestations when circulating lipoproteins are raised and these may be transient or permanent. For example, lipid accumulation has been linked with certain primary hyperlipoproteinaemias and their secondary phenotypes,[4] and retinal micro-emboli may be an associated systemic risk factor for atherosclerosis and hyperlipoproteinaemia. Atheromatous plaque located in the internal carotid artery is a possible source of retinal emboli.[4]

The present study was designed to examine the prevalence of, and the risk factors associated with, retinal arteriolar emboli in patients with atherosclerotic coronary artery disease (CAD) that required coronary artery bypass graft (CABG) surgery.

Patients and methods

PATIENT POPULATION

This observational study included patients requiring CABG surgery who had been diagnosed with atherosclerotic CAD. They were selected randomly from cardiac patients treated at Koşuyolu Heart and Research Hospital, Istanbul, Turkey in 2007 – 2008. All the patients included in the study provided verbal informed consent to participate.

All participants underwent comprehensive cardiovascular evaluation, including standardized carotid Doppler ultrasonography and coronary angiography. Risk factors were assessed from detailed complete clinical and ophthalmic examinations, and from laboratory investigations. The patients' histories of systemic atherosclerotic disease, including cerebrovascular disease, CAD and peripheral vascular disease were determined by interview. Cardiovascular disease was defined as a history of angina pectoris, myocardial infarction, or intermittent claudication. Cerebrovascular disease was defined as a history of transient ischaemic attack, reversible ischaemic neurological deficit, or stroke. As the presence of retinal arteriolar emboli is strongly associated with concomitant carotid artery disease, patients with carotid artery disease were excluded from the study. Patients who had other types of retinal disease, such as central and branch retinal arterial or venous occlusion, or surface wrinkling retinopathy were also excluded from the study. Patients with retinal vasculitis were excluded, as this is a feature that is present in various, relatively rare conditions, such as Behçet disease, lupus erythematosus, Eales disease, frosted branch angiitis, Takayasu's arteritis, Lyme borreliosis, human immunodeficiency virus infection and toxoplasmosis.

Cigarette smoking status was defined as follows: patients were classified as having never smoked if they reported having smoked < 100 cigarettes in their lifetime; as ex-smokers if they had smoked > 100 cigarettes in their lifetime but had stopped smoking for ≥ 1 year before the examination; and as current smokers if they had not stopped.

Blood pressure was measured and hypertension was defined as systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg, or the use of an antihypertensive medication. Diabetes mellitus was defined as a random blood glucose level ≥ 110 mmol/dl, use of a diabetes medication, or self-reported

diabetes. Obesity was defined as a body mass index (BMI) > 30 kg/m^2.

BIOCHEMICAL ANALYSES

Blood specimens were obtained from all study participants. Serum levels of blood glucose, total cholesterol, low-density lipoprotein cholesterol (LDL-C), very low-density lipoprotein cholesterol (VLDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides, uric acid and C-reactive protein (CRP) were determined by enzymatic procedures. The ratio of total cholesterol to HDL-C (TC/HDL-C) was calculated.

Hypercholesterolaemia was defined as a total cholesterol level ≥ 200 mg/dl and an abnormally high LDL-C level was defined as ≥ 130 mg/dl. Hypertriglyceridaemia was defined as a total triglyceride level ≥ 150 mg/dl. Hyperuricaemia was defined as a total uric acid level ≥ 8 mg/dl. The CRP levels were measured quantitatively and an abnormally high level was defined as ≥ 0.8 mg/dl. The patients were divided according to their baseline serum LDL-C levels (≤ 100 mg/dl and > 100 mg/dl) and the incidence of all potential cardiovascular risk factors was compared between the two groups.

OPHTHALMOLOGICAL STUDY

After pupil dilation, the retinas of both eyes for each patient were examined by an ophthalmologist, using binocular indirect ophthalmoscopy, to ascertain the presence and type of retinal arteriolar emboli. They were defined as: reflective/bright (cholesterol type) or non-reflective/dull (platelet–fibrin type); rhomboidal, rectangular, or round in shape; and of a mild, moderate or severe grade. Lesions that were lodged in retinal arterioles were classified as not present, questionable, or present. When present, the number of emboli (one, two, or three or more) was counted. The field in which the emboli first appeared was regarded as indicating location, with appearance only being listed once if the same embolus appeared in several fields. Where different types of emboli occurred together in the same retinal area, they were not given a specific grading because of the difficulty in correctly classifying each embolus as cholesterol or fibrin–platelet in origin based on their appearance.

Retinal arteriolar emboli were also identified by a single mydriatic retinal observation, using a standardized protocol. Binocular indirect ophthalmoscopic investigations were also used for grading of arteriovenous nicking and focal arteriolar narrowing.

STATISTICAL ANALYSIS

The prevalence of retinal arteriolar emboli was analysed as a binary outcome variable. All potential risk factors were analysed either as binary traits (e.g. hypertension, diabetes mellitus, obesity, cigarette smoking) or as per SD change for continuous variables (e.g. serum glucose, total cholesterol, LDL-C, VLDL-C, HDL-C, TC/HDL-C, triglyceride, uric acid, CRP). Continuous variables were expressed as mean ± SD and categorical variables were expressed as *n* (%). Differences between the two groups (LDL-C ≤ 100 mg/dl versus LDL-C > 100 mg/dl) were analysed using the Student's *t*-test for continuous variables and Pearson's χ^2-test for categorical variables. All analyses were performed using the SPSS® statistical package, version 12.0 (SPSS Inc., Chicago, IL, USA) for Windows®. A *P*-value of < 0.05 was considered statistically significant.

Results

A total of 148 patients with atherosclerotic CAD were included in the study. Their

demographics, disease characteristics and smoking status are summarized in Table 1. A total of 112 patients (75.7%) presented with stable angina pectoris and 36 patients (24.3%) had Q-wave myocardial infarction. The patients were divided according to their baseline serum LDL-C levels: ≤ 100 mg/dl (n = 84) and > 100 mg/dl (n = 64).

Retinal arteriolar emboli were detected in 10 patients giving an overall prevalence of 6.8% in this study population of patients with CAD requiring CABG. The frequency of retinal emboli was similar in men and women (data not shown). One patient had bilateral emboli and two patients had multiple emboli in one eye. All of the retinal arteriolar emboli detected were of the cholesterol type. None of the patients had a retinal artery occlusion or transient monocular blindness (amaurosis fugax) at presentation, so all patients included in the study were considered asymptomatic. A strong association was found between smoking and hypertension at baseline and the presence of retinal emboli (data not shown).

The relationship between retinal arterial emboli and potential cardiovascular risk factors was evaluated in patients stratified according to their baseline serum level of LDL-C (≤ 100 mg/dl or > 100 mg/dl and the results are shown in Table 2. The prevalence of retinal emboli was significantly higher in the group with LDL-C levels > 100 mg/dl compared with the group with LDL-C levels ≤ 100 mg/dl (P = 0.015). The levels of TC, LDL-C and HDL-C, and the TC/HDL-C ratio were also significantly different between the two groups ($P \leq 0.001$), indicating that abnormally high LDL-C and hypercholesterolaemia were the most consistent risk factors associated with retinal emboli.

TABLE 1:
Demographics, disease characteristics and smoking status of patients with atherosclerotic coronary artery disease grouped according to their low-density lipoprotein cholesterol (LDL-C) levels

	Total patient population (n = 148)	LDL-C ≤ 100 mg/dl (n = 84)	LDL-C > 100 mg/dl (n = 64)	Statistical significance[a]
Age (years)	59.1 ± 12.9	57.9 ± 13.9	60.7 ± 11.4	NS
Female	62 (42)	36 (43)	26 (41)	NS
Male	86 (58)	348 (57)	38 (59)	
Hypertension	73 (49.3)	40 (47.6)	33 (51.6)	NS
Diabetes mellitus	40 (27.0)	26 (31.0)	14 (21.9)	NS
Obesity	46 (31.1)	24 (28.6)	22 (34.4)	NS
Body mass index (kg/m^2)	27.9 ± 4.7	27.3 ± 4.5	28.7 ± 5.0	NS
2-CAD	52 (35.1)	25 (29.8)	27 (42.2)	NS
3-CAD	96 (64.9)	51 (60.7)	47 (73.4)	NS
PAD	3 (2.0)	2 (2.4)	1 (1.6)	NS
COPD	30 (20.3)	20 (23.8)	10 (15.6)	NS
Smoking status	75 (50.7)	41 (48.8)	34 (53.1)	NS

Values are mean ± SD or n (%).
[a]Differences between patients with LDL-C ≤ 100 or > 100 mg/dl were assessed using Student's t-test for continuous variables and Pearson's χ^2-test for categorical variables.
NS, not statistically significant (P > 0.05); 2-CAD, two-vessel coronary artery disease; 3-CAD, three-vessel coronary artery disease; PAD, peripheral arterial disease; COPD, chronic obstructive pulmonary disease.

TABLE 2:
Prevalence of retinal emboli, lipid profiles and laboratory parameters in patients with atherosclerotic coronary artery disease grouped according to baseline serum low-density lipoprotein cholesterol (LDL-C) levels

	Total patient population (*n* = 148)	LDL-C ≤ 100 mg/dl (*n* = 84)	LDL-C > 100 mg/dl (*n* = 64)	Statistical significance[a]
Retinal emboli	10 (6.8)	2 (2.4)	8 (12.5)	$P = 0.015$
TC (mg/dl)	167.1 ± 47.3	137.5 ± 27.1	205.8 ± 39.4	$P < 0.001$
LDL-C (mg/dl)	98.9 ± 39.7	71.4 ± 19.6	135.1 ± 28.8	$P < 0.001$
VLDL-C (mg/dl)	30.5 ± 14.8	29.3 ± 4.8	32.1 ± 14.6	NS
HDL-C (mg/dl)	40.4 ± 11.7	37.7 ± 12.6	43.9 ± 9.2	$P = 0.001$
TC/HDL-C ratio	4.36 ± 1.46	3.99 ± 1.46	4.86 ± 1.31	$P < 0.001$
Triglyceride (mg/dl)	151 ± 72.1	147.1 ± 77.8	156.2 ± 64.2	NS
Uric acid (mg/dl)	5.56 ± 1.30	5.46 ± 1.44	5.69 ± 1.08	NS
C-reactive protein (mg/dl)	1.114 ± 2.05	0.832 ± 0.88	1.477 ± 2.92	NS

Values are mean ± SD or *n* (%).
[a]Differences between patients with LDL-C ≤ 100 or > 100 mg/dl were assessed using Student's *t*-test for continuous variables.
NS, not statistically significant ($P > 0.05$); HDL-C, high-density lipoprotein cholesterol; TC, total cholesterol; VLDL-C, very low-density lipoprotein cholesterol.

Discussion

As the retina develops from the forebrain, retinal circulation is thought to be representative of cerebrovascular circulation.[3] The central retinal artery represents an end artery of the cerebral circulation, so vascular events that occur in the eye may also occur in the brain.[3]

There are two important clinical implications associated with retinal emboli. First, the distal portions of occluded arterioles may be in an ischaemic state and, as a result, overt retinal artery occlusion may develop.[2,5] Secondly, persons with retinal emboli, with or without retinal artery occlusion, seem to be at a higher risk of stroke and mortality from cardiovascular disease.[6 – 8]

The literature is sparse regarding the epidemiology of retinal emboli, its relation to cardiovascular disease risk factors and stroke, and the value of an extensive systemic evaluation.[1 – 3,5 – 9] Few data on the prevalence and incidence of retinal emboli exist. Information regarding risk factors for retinal arteriolar emboli and retinal vein occlusion has come from population-based studies, e.g. the Beaver Dam Eye Study in the USA[9] and the Blue Mountains Eye Study in Australia,[10] which provided age- and sex-specific population-based data on these conditions in the general community. In the Blue Mountains Eye Study,[10] 3654 Caucasians aged ≥ 49 years participated in an eye survey in 1992 – 1993. The presence of retinal emboli was determined using standardized grading of stereoscopic colour fundus photographs of both eyes.[10] Emboli were present in one or both eyes of 51 participants, indicating an overall prevalence of 1.4%.[10]

In the Beaver Dam Eye Study,[9] which included 4936 people aged 43 – 86 years at baseline, the presence of retinal emboli was similarly determined from standardized evaluation of colour fundus photographs of

both eyes. Emboli were present in one or both eyes of 61 participants, giving an overall prevalence of 1.3%.[9] From these data it may be estimated that 1.2 million people, aged 43 – 86 years, in the USA could have asymptomatic retinal emboli in at least one eye, approximately 450 000 of whom would be aged 75 – 86 years, and 400 000 people in Turkey, aged 43 – 86 years, would have asymptomatic retinal emboli in at least one eye.

The Beaver Dam Eye Study is the only population-based study to evaluate the incidence of retinal emboli in a defined community.[9] In that study, surviving participants of the baseline examination were invited for a follow-up examination 5 years later and the presence or absence of retinal emboli was determined using the same photographic grading approach.[9] Among those people without emboli at baseline, 32 had emboli detected at the follow-up examination (a 5-year incidence of 0.9%).[9] Furthermore, consistent with clinical experience that suggests these are transient phenomena, retinal emboli were not present at the 5-year follow-up in up to 90% of eyes that had retinal emboli at baseline.

Bilateral retinal emboli are rare, although multiple emboli in a single eye are detected fairly frequently.[11] Bilateral emboli were present in only two participants in the Blue Mountains Eye Study (prevalence of 0.05%),[10] and in only one participant in the Beaver Dam Eye Study (prevalence of 0.02%).[9] In contrast, 10 – 20% of eyes with retinal emboli had more than one per eye in these two populations combined;[9,10] in the Beaver Dam Eye Study, although the incidence of bilateral retinal emboli was rare, the incidence of multiple emboli in one eye occurred in 20 – 30% of cases.[9] In the Blue Mountains Eye Study,[10] cholesterol-type emboli accounted for 80% of cases, which is consistent with previous clinical evidence.

Both the prevalence and incidence of retinal emboli increases with age and they appear to be more common in men than women.[9 – 11] In the Blue Mountains Eye Study,[10] retinal emboli were found in 0.8% of persons < 60 years of age, 1.4% of those aged 60 – 69 years, 2.1% of those aged 70 – 79 years and in 1.5% of those aged ≥ 80 years. About two-thirds of the emboli were found in men and, controlling for age, men had a 2.5 times greater risk of emboli than women.[10]

In the Beaver Dam Eye Study,[9] persons aged ≥ 75 years were nine times more likely to have retinal emboli than persons aged 43 – 54 years and, controlling for age, men were twice as likely than women to have retinal emboli. The predominance of asymptomatic retinal emboli in men versus women is consistent with the known epidemiology of retinal artery occlusion and stroke, and supports the notion that retinal emboli may contribute to the development of these conditions.[2]

A wide range of cardiovascular conditions and risk factors are linked with retinal emboli, and many individuals with retinal vascular conditions also have cardiovascular risk factors, most notably hypertension.[12,13] The other important risk factor is the association of retinal emboli with carotid artery plaques and stenosis, an association that supports the aetiology of these emboli.[14] Other consistent associations with diabetes mellitus, dyslipidaemia, cigarette smoking, haemostatic factors and obesity have also been reported.[9,12,15,16]

The relationship between smoking and the incidence of retinal emboli seen in the present study is consistent with previous reports. For example, at baseline in the Blue Mountains Eye Study,[10] those who smoked were 2.6 times more likely to have retinal

emboli compared with those who did not smoke.[16] In a case–control study of 70 men with asymptomatic retinal cholesterol emboli and 21 controls, Bruno *et al.*[4] found a higher prevalence of smoking (56% versus 28%; $P < 0.001$) in persons with retinal emboli compared with those without retinal emboli.

Cardiovascular disease risk factors may have an additive effect on the occurrence of retinal emboli. For example, Mitchell *et al.*[17] demonstrated that people who reported a history of hypertension and who also smoked were six times more likely to have retinal emboli than people without a history of hypertension and cigarette smoking. In the case–control study reported by Bruno *et al.*,[3] persons with retinal emboli were more likely to have hypertension (78% versus 33%; $P < 0.001$) and to be cigarette smokers (56% versus 28%; $P < 0.001$) than controls.

Several studies have reported associations of the incidence of retinal emboli with cardiovascular disease risk factors, such as hypertension and cigarette smoking and, less consistently, with diabetes mellitus. The present study provides further confirmation of the association of cardiovascular disease and its risk factors with the incidence of retinal emboli and is consistent with data from these previous studies.[1,3–5,9,10,17]

Few studies have evaluated cardiovascular disease associations with incidence of retinal emboli. In the Beaver Dam Eye Study,[9] at the time of the 5-year examination, while controlling for age and sex, only smoking and a history of CABG surgery were associated with incidence of retinal emboli. At the 10-year follow-up, with an increased number of outcomes, the authors reported associations of high total serum cholesterol, high leucocyte count and a history of angina, and borderline associations of low serum HDL-C, diabetes mellitus and a history of myocardial infarction at baseline with a higher incidence of retinal emboli.[9] In the Beaver Dam study,[9] retinal emboli were 2.4 times more likely to occur in persons with pulse pressure in the highest quartile range than with those in the lowest quartile range. This association was not unexpected, as higher pulse pressure, a marker of increased stiffness of large elastic arteries, is related to carotid artery stenosis, stroke, coronary heart disease and congestive heart failure both in persons with and without hypertension. In the cross-sectional Blue Mountains Eye Study,[10] after controlling for age and sex, hypertension was associated with an odds ratio of 2.2. In a case–control study, hypertension was more frequent in cases compared with controls (78% versus 33%; $P < 0.001$).[10]

In the Beaver Dam Eye Study,[9] the incidence of retinal emboli was significantly associated with baseline current and past cigarette smoking and a history of coronary artery bypass. A weaker and non-significant association with alcohol consumption and a history of CABG surgery was also observed.[9] Hypertension, diabetes mellitus and ocular risk factors (e.g. retinopathy, focal retinal arteriolar narrowing and arteriovenous nicking) were not, however, significantly associated with incident retinal emboli.[9]

The presence of retinopathy in non-diabetic Beaver Dam Eye Study participants was associated with a four-fold higher risk of retinal emboli.[9] Other retinal arteriolar characteristics typical of hypertension, such as focal retinal arteriolar narrowing and arteriovenous nicking, were not associated with retinal emboli.[9] Persons with carotid artery bypass were nearly three times as likely to develop retinal emboli compared with persons without this surgery. Owing to the relative infrequency of this procedure in

the population, however, the association was not statistically significant.[9] These associations with cardiovascular disease were not unexpected, because most retinal emboli are thought to originate from mural thrombi in the carotid artery in persons with systemic atherosclerotic disease.[18]

Overall, therefore, in the Beaver Dam Eye Study,[9] retinal emboli were associated with hypertension, a history of current and past cigarette smoking and diabetes mellitus. A significant association with a higher blood pressure, a history of myocardial infarction and CABG surgery was also reported, a pattern consistent with an association with atherosclerotic cardiovascular disease.[9] On the other hand, in the Blue Mountains Eye Study,[10] although retinal emboli were associated with hypertension and cigarette smoking, an association with diabetes mellitus was not found.

Retinal microemboli or micronecrosis have been demonstrated to be associated with carotid artery disease.[1,4] Available data suggest that retinal emboli in otherwise asymptomatic people are associated with a higher risk of stroke and stroke mortality, independent of conventional risk factors. The most common aetiological factor was found to be extracranial internal carotid artery occlusion > 50% (22.1% of the sample), followed by cardiac lesions (7.8%).[14] Among 34 patients with asymptomatic retinal emboli, the source of the emboli could not be found in 13 (38.2%) of these patients.[14] Ischaemic changes detected in the retina can develop from the same origin as focal cerebral ischaemia.[10] Emboli seen in the retina may, therefore, reflect cerebrovascular events caused by carotid artery thromboembolism.[18,19] Binocular ischaemic retinopathy is not only a sign of occlusive carotid artery disease, but also an indicator of a higher risk of stroke mortality.[2,8,20] Retinal arteriolar emboli have been reported to be associated with risk of stroke and cardiovascular mortality.[3,21] Few studies have documented the prospective associations between retinal emboli and risk of stroke and stroke mortality, although Bruno *et al.*[3] reported on 70 men with retinal emboli and compared their risk of stroke with 70 controls. After 3.4 years of follow-up, the study reported a 10-fold increase in the annual rate of stroke (8.5% versus 0.8% per year in cases versus controls, respectively; $P = 0.002$) but not in myocardial infarction (5.7% versus 4.1% per year in cases versus controls, respectively).[3] Moreover, the stroke risk was independent of blood pressure and other vascular risk factors, and most of the stroke cases (71%) involved the carotid territory on the same side as the embolus.[3] The case series published by Kramer *et al.*[22] described the use of transoesophageal echocardiography to detect cardiac and aortic sources of emboli in patients with retinal artery occlusion. The authors found that 13 of 18 patients with retinal artery occlusion had cardiac and aortic pathology consistent with the source of the retinal emboli.[22] Gittinger and Kershaw[23] reported a correlation between the presence of retinal emboli and renal artery atherosclerosis. These data suggest that it may be important to consider non-carotid sources in the management of patients with retinal emboli. Hollenhorst,[24] in his case series, reported stroke or transient ischaemic attack in 63% of the group, with 34% developing stroke or cerebral transient ischaemic attacks during follow-up. In asymptomatic patients with retinal emboli in whom significant carotid artery stenosis is found, the benefits of carotid endarterectomy are manifold.[25] It is important to note that reported estimates of stroke risk might even be an underestimate of the true association because of the increased

mortality of people with retinal emboli and concomitant cardiovascular disease risk factors, resulting in a survivor cohort effect (e.g. persons with cardiovascular disease risk factors, such as cigarette smoking or hypertension, who developed retinal emboli may be more likely to die).

In conclusion, the present study demonstrated that the prevalence of hypercholesterolaemia and smoking are increased in patients with retinal arteriolar emboli. Identification and treatment of modifiable risk factors, such as smoking and hypercholesterolaemia, might be of benefit in these individuals. These findings may have implications for the management of these patients, suggesting the need for intensive and tailored secondary prevention and new therapeutic approaches. As a result, routine, thorough cardiovascular and cerebrovascular assessments are recommended, including carotid ultrasonography assessment, for all patients with asymptomatic retinal emboli.

Conflicts of interest

The authors had no conflicts of interest to declare in relation to this article.

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