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Prevalence of extracranial carotid atherosclerosis in the patients with coronary artery disease in a tertiary hospital in Malaysia

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Abstract

There is limited information regarding the prevalence of extracranial carotid atherosclerosis in the patients with coronary artery disease (CAD) undergoing coronary artery bypass graft (CABG) surgery in South East Asia. The primary objective was to assess the prevalence of extracranial carotid stenosis, raised carotid intima media thickness (CIMT), and plaques in the patients with CAD undergoing elective CABG. The secondary objective was to evaluate the risk factors for extracranial carotid atherosclerosis.

A total of 119 consecutive patients with CAD undergoing elective CABG in a tertiary hospital in Malaysia were recruited. Data on the demographic characteristics and risk factors were collected. The ultrasound carotid Doppler findings comprising of raised CIMT, plaques, and stenosis in the extracranial carotid vessels were recorded.

The mean age of the patients was 64.26 ± 10.12 (range 42–89). Most of the patients were men (73.1%). The patients consisted of 44 (37%) Malays, 26 (21.8%) Chinese, and 49 (41.2%) Indians.

A total of 67 (56.3%) patients had raised CIMT, 89 (74.8%) patients had plaques, and 10 (8.4%) patients had stenosis in the internal and common carotid arteries. The mean age of patients with plaques was higher compared to those without plaques (66.00 ± 9.63 vs 59.10 ± 9.92, $P = .001$). The body mass index (BMI) of patients with stenosis was higher compared to those without stenosis (28.35 ± 4.92 vs 25.75 ± 3.16, $P = .02$).

The patients with plaques were more likely to be older, whereas the patients with carotid stenosis were more likely to have higher BMI.

Abbreviations: AF = atrial fibrillation, BMI = body mass index, CABG = coronary artery bypass graft, CAD = coronary artery disease, CCA = common carotid artery, CIMT = carotid intima media thickness, DM = diabetes mellitus, EDV = end-diastolic velocity, ICA = internal carotid artery, MI = myocardial infarction, PSV = peak systolic velocity, SPSS = Statistical Package for Social Sciences, TIA = transient ischemic attack, UMMC = University Malaya Medical Centre.

Keywords: atherosclerosis, carotid, coronary artery bypass graft, coronary artery disease, extracranial

1. Introduction

Atherosclerosis of the large cerebral arteries accounts for 30% to 60% of all cerebral infarcts.[1] The distribution and severity of atherosclerotic cerebrovascular diseases varies among the patients of different ethnic origins.[2] Coronary artery disease (CAD) has been reported to be associated with extracranial carotid atherosclerosis.[1–5]

In a study of Caucasian patients, 14% of those undergoing coronary or peripheral arterial revascularization had extracranial carotid stenosis.[6] In Western countries, extracranial carotid atherosclerosis accounts for 30% to 40% of cases of ischemic cerebrovascular diseases.[7] Asian populations have been reported to have a lower prevalence of extracranial carotid and vertebral artery disease in comparison with Caucasian populations.[2]

Ultrasound carotid Doppler is an accurate, noninvasive method for the evaluation of significant extracranial carotid artery disease.[6,8,9] This test has a sensitivity of up to 95% and specificity of up to 90%.[6,8] Ultrasound carotid Doppler can be used to examine the 3 components of atherosclerosis: carotid intima media thickness (CIMT), plaques, and carotid stenosis.[2,10–12]

CIMT is a measure used to diagnose the extent of subclinical atherosclerosis.[13,14] In a previous study of Indian patients, a significant association between the severity of extracranial carotid atherosclerosis with the severity of coronary atherosclerosis was reported.[11] In Turkey, the mean CIMT was found to be significantly higher in the patients with triple-vessel disease in comparison to the control subjects and the patients with single-vessel disease.[15]

A recent study of Indian patients with CAD showed that when the number of vessel involved increased, the CIMT increased.[10] Another study found an increased CIMT and carotid plaques in the majority of the young Nepalese patients with CAD.[12]

The Japanese patients with severe CAD who underwent coronary artery bypass graft (CABG) had a high incidence of carotid stenosis.[16,17] Extracranial carotid artery stenosis is a risk factor for perioperative stroke in patients undergoing CABG surgery.[18,19] Therefore, carotid assessment before CABG provides important information on the risk of stroke after CABG.[20]

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There is limited data regarding the prevalence of extracranial carotid atherosclerosis in the patients with CAD undergoing CABG in South East Asia. We hypothesized that there is a low prevalence of extracranial carotid stenosis present in the patients with CAD undergoing elective CABG in Malaysia. We hypothesized that the frequencies of raised CIMT and plaques are high in these patients. Malaysia is a multiethnic country with a recorded total population of 28.4 million citizens in 2016. The citizens consist of Malays (68.6%), Chinese (23.4%), Indians (7%), and others (1%).[21]

The primary objective of this study was to determine the prevalence of extracranial carotid stenosis, raised CIMT, and the presence of plaques in the patients with CAD undergoing elective CABG. The secondary objective was to evaluate the risk factors for extracranial carotid atherosclerosis.

2. Methodology

2.1. Study design and location

This was a retrospective study conducted in the University Malaya Medical Center , a tertiary hospital located in Kuala Lumpur, Malaysia.

2.2. Patients

The consecutive patients who were scheduled to undergo elective CABG due to CAD were recruited to this study. The period of the study was from December 2015 to January 2018. The study was approved by the Institutional Ethics Committee of University Malaya Medical Centre. All of them had ultrasound carotid Doppler performed before the elective CABG surgeries were performed. The patients undergoing emergency CABG and cardiac valve operations were excluded from this study. The other patients who were excluded were the patients with unstable neurological symptoms, malignancies, and systemic immune diseases.

Data on the demographic characteristics such as age, sex, ethnic group, weight, and height were collected. Body mass index (BMI) was calculated based on the weight and height. BMI was calculated by dividing weight (in kilogram) by the square of height (in meters). Data on the vascular risk factors and previous diagnostic evaluations were collected. The echocardiography findings were recorded.

2.3. Evaluation of risk factors

We evaluated the risk factors of extracranial atherosclerosis which included age, sex, BMI, hypertension, diabetes mellitus (DM), hyperlipidemia, atrial fibrillation, smoking, family history of CAD, past history of myocardial infarction (MI), previous percutaneous coronary intervention, previous coronary bypass graft (CABG), previous ischemic stroke or transient ischemic attack (TIA), and number of the coronary vessels involved in coronary angiography.

Hypertension was defined as present if a subject took medication for hypertension, or when the systolic blood pressure was >140 mm Hg or diastolic blood pressure >90 mm Hg for ≥2 repeated measurements.[2] DM was defined as a serum glycosylated hemoglobin concentration of >5.8%, when the repeated fasting plasma glucose exceeded 126 mg/dL, or when the patients took medication for DM.[2]

Hyperlipidemia was defined as taking lipid-lowering medications, a fasting serum total cholesterol concentration ≥5.2 mmol/L, serum low-density lipoprotein cholesterol level ≥3.4 mmol/L, serum high-density lipoprotein cholesterol <1.0 mmol/L for men, or <1.3 mmol/L for women, or serum triglyceride concentration ≥1.7 mmol/L.[22]

A family history of CAD was defined as a history of CAD in any first-degree relatives. MI included ST-elevation MI and non–ST-elevation MI. The previous history of MI was documented.

2.4. Assessment of coronary angiography

Coronary angiography was performed to investigate CAD. The diameter of stenosis was calculated by quantitative coronary angiography with an automated coronary analysis system (Philips). CAD was defined as lumen diameter stenosis of >50% in ≥1 major coronary artery. Each patient was categorized into one of the following groups according to the number of diseased vessels:

- 0-Vessel disease (patients without diseased vessels)
- 1-Vessel disease (patients with disease in 1 vessel)
- 2-Vessel disease (patients with disease in 2 vessels or left main trunk disease without right coronary artery stenosis)
- 3-Vessel disease (patients with disease in 3 vessels or left main trunk disease with right coronary artery stenosis)
- 4-Vessel disease (patients with disease in 3 major vessels and minor branch such as diagonal or ramus branch)

Multivessel disease was defined as presence of 2, 3, or 4 vessel disease.

Severe CAD was defined as 3-vessel disease or 4-vessel disease.

2.5. Assessment of carotid atherosclerosis

Ultrasound carotid Doppler was performed in all the patients before the elective CABG surgeries were performed. Ultrasound carotid Doppler was done within 3 months after the cardiac events in all the patients. Phillips IU22 scanner (Seattle, WA) with a 4-MHz linear array transducer was used.

The carotid intima media thickness (CIMT) was evaluated. CIMT was measured according to the Consensus Statement from the American Society of Echocardiography Carotid Intima-Media Thickness Task Force.[3] CIMT measurements were taken at the distal 1 cm of the far wall of both common carotid arteries (CCAs) and a mean value was taken for both right and left CCA.[15] The mean CIMT was increased if ≥0.8 mm.[23]

The presence and location of plaques was assessed. A plaque was defined as a focal structural encroachment into the arterial lumen of at least 0.5 mm.[24,25] Plaque was defined as being present when the thickness of carotid intima media was ≥1.3 mm.[24,25]

- Proximal CCA-left, right.
- Distal CCA-left, right.
- CCA bulb-left, right.
- Proximal internal carotid artery (ICA)-left, right.
- Distal ICA-left, right.

The presence of carotid stenosis was recorded. The diagnostic criteria for stenosis were according to the Society of Radiologists in Ultrasound Consensus Criteria for Carotid Stenosis.[26] Carotid stenosis of 50% to 69% was defined as peak systolic velocity (PSV) ≥125 and end-diastolic velocity (EDV) ≥40.[26] In addition, the plaque caused ≥50% diameter reduction.[26]

Carotid stenosis of ≥70% was defined as PSV ≥230 and EDV ≥100.[26] In addition, the plaque caused ≥50% diameter reduction.[26] Total occlusion was defined as no detectable patent lumen on grayscale ultrasound due to presence of plaque throughout the lumen, and absence of flow in the color Doppler ultrasound.[26]

2.6. Statistical analysis

Data analysis was performed using Statistical Package for Social Sciences SPSS (Version 21.0, SPSS Inc, Chicago, IL). Continuous variables were expressed as mean ± SD. Chi square test (or Fischer exact test) was used to analyze the categorical data. Independent sample *T* test was performed to analyze the comparison between the continuous variables. A value of $P < .05$ was taken as statistically significant.

3. Results

3.1. Demographic and clinical characteristics

A total of 119 consecutive patients with CAD undergoing elective CABG were included in this study. A total of 87 (73.1%) were men. The mean age was 64.26 ± 10.12 (range 42–89). The study consisted of 44 (37%) Malays, 26 (21.8%) Chinese, and 49 (41.2%) Indians. The demographic and clinical characteristics of the study patients are presented in Table 1. No patient had previous history of CABG before ultrasound carotid Doppler. No patient had past history of TIA before the ultrasound.

3.2. Frequency of raised carotid intima media thickness, plaques, and carotid stenosis

The frequency of the patients with raised CIMT, plaques, and carotid stenosis is illustrated in Table 1. Sixty-seven (56.3%) patients had raised CIMT. Eighty-nine (74.8%) patients had plaques, and 10 (8.4%) patients had carotid stenosis.

3.3. Risk factors for raised carotid intima media thickness

Table 2 shows the association between raised CIMT and the risk factors. On univariate analysis and independent sample *T* test, the raised CIMT was not associated with any risk factor with statistical significance.

3.4. Risk factors for plaques

The association between the plaques and the risk factors is shown in Table 3. On independent sample *T* test, the patients with plaque were older (mean age 66.00 ± 9.63) compared with the patients without plaque (mean age 59.10 ± 9.92) with statistical significance ($P = .001$).

3.5. Risk factors for carotid stenosis

The association between carotid stenosis and the risk factors is illustrated in Table 4. On independent sample *T* test, the patients with carotid stenosis had higher BMI (mean 28.35 ± 4.92) compared to the patients without stenosis (mean 25.75 ± 3.16) with statistical significance ($P = .02$).

3.6. Distribution and sites of extracranial carotid stenosis

Table 5 shows the locations of the carotid stenosis. Four (3.3%) patients had carotid stenosis in the CCA; 3 (2.5%) patients had stenosis of 50% to 69% and 1 (0.8%) had ≥70% stenosis. Six (5.1%) patients had carotid stenosis in the ICA; 4 (3.4%) patients had 50% to 69% stenosis and 2 (1.7%) patients had ≥70% stenosis.

Table 1

Basic demography and ultrasound carotid Doppler findings of the study patients.

	Patients (n = 119)
Age (mean ± SD), range	64.26 ± 10.12 (42–89)
Sex (n, %)	
Male	87 (73.1%)
Female	32 (26.9%)
Ethnic groups (n, %)	
Malay	44 (37%)
Chinese	26 (21.8%)
Indian	49 (41.2%)
Body mass index (BMI), kg/m^2 (mean ± SD)	25.97 ± 3.39
Hypertension (n, %)	
Yes	106 (89.1%)
No	13 (10.9%)
DM (n, %)	
Yes	66 (55.5%)
No	53 (44.5%)
Hyperlipidemia (n, %)	
Yes	87 (73.1%)
No	32 (26.9%)
Smoking (n, %)	
Yes	37 (31.1%)
No	82 (68.9%)
AF (n, %)	
Yes	9 (7.6%)
No	110 (92.4%)
Family history of CAD (n, %)	
Yes	44 (37%)
No	75 (63%)
Past history of MI (n, %)	
Yes	24 (20.2%)
No	95 (79.8%)
Previous percutaneous coronary intervention (n, %)	
Yes	23 (19.3%)
No	96 (80.7%)
Previous stroke (n, %)	
Yes	13 (10.9%)
No	106 (89.1%)
Number of vessels (n, %)	
1-Vessel disease	1 (0.8%)
2-Vessel disease	10 (8.4%)
3-Vessel disease	108 (90.8%)
Multivessel disease (n, %)	
Yes	118 (99.2%)
No	1 (0.8%)
Raised CIMT (n, %)	
Yes	67 (56.3%)
No	52 (43.7%)
Plaques (n, %)	
Yes	89 (74.8%)
No	30 (25.2%)
Stenosis of common carotid artery (CCA) and internal carotid artery (ICA) (n, %)	
Yes	10 (8.4%)
No	109 (91.6%)

AF = atrial fibrillation, CAD = coronary artery disease, CIMT = carotid intima media thickness, DM = diabetes mellitus, MI = myocardial infarction, SD = standard deviation.

3.7. Frequency of perioperative stroke/transient ischemic attack

No patient had perioperative stroke or TIA.

Table 2

Association between raised carotid intima media thickness and the risk factors.

	With raised CIMT (n=67)	Without raised CIMT (n=52)	*P*
Age (mean ± SD)	63.82±10.43	64.83±9.77	.59
Sex (n, %)			
Male	53 (79.1%)	34 (65.4%)	.10
Female	14 (20.9%)	18 (34.6%)	
Ethnic groups (n, %)			
Malay	25 (37.3%)	19 (36.5%)	.083
Chinese	10 (14.9%)	16 (30.8%)	
Indian	32 (47.8%)	17 (32.7%)	
Ethnicity (n, %)			
Malay	25 (37.3%)	19 (36.5%)	1.00
Other ethnic groups	42 (62.7%)	33 (63.5%)	
Body mass index (BMI), kg/m^2 (mean ± SD)	25.84±3.04	26.13±3.82	.65
Hypertension (n, %)			
Yes	58 (86.6%)	48 (92.3%)	.39
No	9 (13.4%)	4 (7.7%)	
DM (n, %)			
Yes	40 (59.7%)	26 (50%)	.35
No	27 (40.3%)	26 (50%)	
Hyperlipidemia (n, %)			
Yes	51 (76.1%)	36 (69.2%)	.41
No	16 (23.1%)	16 (30.8%)	
Smoking (n, %)			
Yes	17 (25.4%)	20 (38.5%)	.16
No	50 (74.6%)	32 (61.5%)	
AF (n, %)			
Yes	6 (9%)	3 (5.8%)	.73
No	61 (91%)	49 (94.2%)	
Family history of CAD (n, %)			
Yes	21 (31.3%)	23 (44.2%)	.18
No	46 (68.7%)	29 (55.8%)	
Past history of MI (n, %)			
Yes	11 (16.4%)	13 (25%)	.26
No	56 (83.6%)	39 (75%)	
Previous percutaneous coronary intervention (n, %)			
Yes	13 (19.4%)	10 (19.2%)	1.00
No	54 (80.6%)	42 (80.8%)	
Previous stroke (n, %)			
Yes	9 (13.4%)	4 (7.7%)	.39
No	58 (86.6%)	48 (92.3%)	
Number of vessels (n, %)			
1 Vessel disease	0 (0%)	1 (1.9%)	.72
2 Vessel disease	6 (9%)	4 (7.7%)	
3 and 4 Vessel disease	61 (91%)	47 (90.4%)	
Multivessel disease (n, %)			
Yes	67 (100%)	51 (98.1%)	.44
No	0 (0%)	1 (1.9%)	

AF = atrial fibrillation, CAD = coronary artery disease, CIMT = carotid intima media thickness, DM = diabetes mellitus, MI = myocardial infarction, SD = standard deviation.

Table 3

Association between the plaques and the risk factors.

	With plaque (n=89)	Without plaque (n=30)	*P*
Age (mean ± SD)	66.00±9.63	59.10±9.92	**.001**
Sex (n, %)			
Male	64 (71.9%)	23 (76.7%)	.65
Female	25 (28.1%)	7 (23.3%)	
Ethnic groups (n, %)			
Malay	30 (33.7%)	14 (46.7%)	**.02**
Chinese	16 (18%)	10 (33.3%)	
Indian	43 (48.3%)	6 (20%)	
Ethnicity (n, %)			
Malay	30 (33.7%)	14 (46.7%)	.27
Other ethnic groups	59 (66.3%)	16 (53.3%)	
Body mass index (BMI), kg/m^2 (mean ± SD)	25.81±3.45	26.45±3.22	.37
Hypertension (n, %)			
Yes	82 (92.1%)	24 (80%)	.089
No	7 (7.9%)	6 (20%)	
DM (n, %)			
Yes	51 (57.3%)	15 (50%)	.53
No	38 (42.7%)	15 (50%)	
Hyperlipidemia (n, %)			
Yes	65 (73%)	22 (73.3%)	1.00
No	24 (27%)	8 (26.7%)	
Smoking (n, %)			
Yes	27 (30.3%)	10 (33.3%)	.82
No	62 (69.7%)	20 (66.7%)	
AF (n, %)			
Yes	7 (7.9%)	2 (6.7%)	1.00
No	82 (92.1%)	28 (93.3%)	
Family history of CAD (n, %)			
Yes	37 (41.6%)	7 (23.3%)	.084
No	52 (58.4%)	23 (76.7%)	
Past history of MI (n, %)			
Yes	18 (20.2%)	6 (20%)	1.00
No	71 (79.8%)	24 (80%)	
Previous percutaneous coronary intervention (n, %)			
Yes	19 (21.3%)	4 (13.3%)	.43
No	70 (78.7%)	26 (86.7%)	
Previous stroke (n, %)			
Yes	12 (13.5%)	1 (3.3%)	.18
No	77 (86.5%)	29 (96.7%)	
Number of vessels (n, %)			
1 Vessel disease	1 (1.1%)	0 (0%)	1.00
2 Vessel disease	8 (9.0%)	2 (6.7%)	
3 and 4 Vessel disease	80 (89.9%)	28 (93.3%)	
Multivessel disease (n, %)			
Yes	88 (98.9%)	30 (100%)	1.00
No	1 (1.1%)	0 (0%)	

AF = atrial fibrillation, CAD = coronary artery disease, DM = diabetes mellitus, MI = myocardial infarction, SD = standard deviation.

4. Discussion

4.1. Prevalence of raised CIMT in the patients with CAD undergoing CABG

Our study showed that 56.3% of the patients with CAD undergoing CABG had raised CIMT. In a previous study, the prevalence of raised CIMT in the patients with CAD undergoing CABG was 70%.[27] A further study concluded that raised CIMT was found in 59.2% of the patients with CAD irrespective of whether they had CABG or not.[28] CIMT is strongly associated with the presence of coronary atherosclerosis.[12,29]

4.2. Prevalence of plaques in the patients with CAD undergoing CABG

This study also demonstrated that 74.8% of the patients with CAD undergoing CABG had plaques. Carotid plaques were present in 30.3% of the South Korean patients with CAD.[30] In a study of Italian patients with CAD, 81% had carotid plaques.[31] Carotid plaques are independently associated with CAD.[12]

4.3. Prevalence of extracranial carotid stenosis in the Asian patients with CAD undergoing CABG

In this study, only 8.4% of the patients had extracranial carotid stenosis. In a recent study of Chinese patients undergoing elective

Table 4

Association between carotid stenosis and the risk factors.

	With stenosis (n=10)	Without stenosis (n=109)	P
Age (mean ± SD)	65.40±8.55	64.16±10.28	.71
Sex (n, %)			
Male	6 (60%)	81 (74.3%)	.46
Female	4 (40%)	28 (25.7%)	
Ethnic groups (n, %)			
Malay	5 (50%)	39 (35.8%)	.65
Chinese	2 (20%)	24 (22%)	
Indian	3 (30%)	46 (42.2%)	
Ethnicity (n, %)			
Malay	5 (50%)	39 (35.8%)	.50
Other ethnic groups	5 (50%)	70 (64.2%)	
Body mass index (BMI), kg/m^2 (mean ± SD)	28.35±4.92	25.75±3.16	**0.02**
Hypertension (n, %)			
Yes	10 (100%)	96 (88.1%)	0.60
No	0 (0%)	13 (11.9%)	
DM (n, %)			
Yes	6 (60%)	60 (55%)	1.00
No	4 (40%)	49 (45%)	
Hyperlipidemia (n, %)			
Yes	8 (80%)	79 (72.5%)	1.00
No	2 (20%)	30 (27.5%)	
Smoking (n, %)			
Yes	2 (20%)	35 (32.1%)	.72
No	8 (80%)	74 (67.9%)	
AF (n, %)			
Yes	1 (10%)	8 (7.3%)	.56
No	9 (90%)	101 (92.7%)	
Family history of CAD (n, %)			
Yes	4 (40%)	40 (36.7%)	1.00
No	6 (60%)	69 (63.3%)	
Past history of MI (n, %)			
Yes	2 (20%)	22 (20.2%)	1.00
No	8 (80%)	87 (79.8%)	
Previous percutaneous coronary intervention (n, %)			
Yes	2 (20%)	21 (19.3%)	1.00
No	8 (80%)	88 (80.7%)	
Previous stroke (n, %)			
Yes	1 (10%)	12 (11%)	1.00
No	9 (90%)	97 (89%)	
Number of vessels (n, %)			
1 Vessel disease	0 (0%)	1 (0.9%)	.05
2 Vessel disease	3 (30%)	7 (6.4%)	
3 and 4 Vessel disease	7 (70%)	101 (92.7%)	
Multivessel disease (n, %)			
Yes	10 (100%)	108 (99.1%)	1.00
No	0 (0%)	1 (0.9%)	

AF = atrial fibrillation, CAD = coronary artery disease, DM = diabetes mellitus, MI = myocardial infarction, SD = standard deviation.

CABG, the prevalence of extracranial carotid stenosis was 21.2%.[18] In a study conducted in Japan on the patients with CAD undergoing elective CABG, the prevalence of carotid stenosis was 13.7%.[9]

In our study, 5.9% of patients had carotid stenosis of 50% to 69%. Only 0.8% had stenosis of ≥70%, whereas 1.7% had total occlusion. In comparison, the Chinese study found that 14.5% of patients had carotid stenosis of 50% to 69%, whereas 4.6% of the patients had carotid stenosis of ≥70%, and 2.1% had total occlusion.[18]

In another study of Japanese patients with CAD, extracranial carotid stenosis was found in 19.6%.[2] This study consisted of patients with CAD regardless of whether they subsequently had CABG.[2] Chen et al[1] also examined carotid stenosis in a cohort of patients with CAD in Hong Kong, including those with and without CABG. In this study, ≥50% stenosis of one or more of the extracranial cerebral arteries (ICA, CCA, external carotid artery [ECA], and vertebral artery stenosis) was found in 21% of the patients.[1]

In our study, stenosis of at least 50% was seen in 3.3% of the patients in the CCA area. At least 50% stenosis was present in 5.1% in the ICA. In the study conducted in Hong Kong, at least 50% stenosis was observed in the CCA and ICA in 2% and 11% of patients, respectively.[1]

4.4. Prevalence of extracranial carotid stenosis in the Western patients with CAD undergoing CABG

The prevalence of carotid stenosis (≥50% stenosis) in patients with CAD who were scheduled to undergo CABG in the Western countries ranged from 2% to 22%.[20,32–41] The prevalence of ≥70% stenosis ranged from 7% to 11% in the studies conducted in USA.[20,42] Rates of 1% to 1.5% have been reported for carotid occlusion in CABG patients in Western countries.[18,32,43]

In other Western studies conducted in the patients with CAD, extracranial ICA, CCA, ECA, and vertebral artery stenosis of ≥50% was found in 12% to 28% of the patients.[7,44–46] In the studies of Western patients on the prevalence of carotid artery disease among patients with CAD, ≥50% ICA stenosis was found in 12% to 28% of the patients.[7,20,46,47]

4.5. Risk factors for raised CIMT and plaque formation in the patients with CAD undergoing CABG

In this study, raised CIMT was not associated with any risk factors, in agreement with a previous study.[27] Our study demonstrated that the patients with plaque were more likely to be older, similar to the findings of previous studies.[32,48,49] However, the presence of plaques was not associated with the other risk factors in our study. In a previous study, blood pressure variability was found to have an important role in the progression of atherosclerosis in various segments of the extracranial carotid artery in the patients with hypertension.[50]

4.6. Risk factors for extracranial carotid stenosis in the patients with CAD undergoing CABG

In the present study, the patients with carotid stenosis were more likely to have higher BMI compared with the patients without stenosis. The literature on increased BMI as a risk factor for extracranial carotid atherosclerosis in the patients with CAD undergoing CABG is very limited. In a recent study conducted among young patients with carotid stenosis, the average BMI was 29.[51] In another study, higher BMI was a risk factor for significant carotid atherosclerosis (higher rate of occlusion and near occlusion) in the patients aged 39 to 55 years.[52]

4.7. Management

Therefore, it should be recommended that the patients with CAD have carotid ultrasonography for screening of carotid atherosclerosis.[2,9] Fukuda et al[53] recommended that all Japanese CABG patients should undergo preoperative carotid stenosis screening, regardless of age.[18]

According to American guidelines, CABG patients older than 65 years or with the presence of certain risk factors, such as left main stem disease, hypertension, smoking, and DM should be

Table 5

Locations of the extracranial carotid stenosis.

Artery	50%–69% Stenosis (n, %)	≥70% Stenosis (n, %)	Occlusion
Stenosis at left and right common carotid arteries (CCAs)	3 (2.5%)	1 (0.8%)	0
Stenosis at left common carotid artery (left CCA)	2 (1.7%)	1 (0.8%)	0
Stenosis at left proximal common carotid artery (left prox CCA)	1 (0.8%)	0	0
Stenosis at left distal common carotid artery (left distal CCA)	1 (0.8%)	1 (0.8%)	0
Stenosis at left common carotid artery bulb (left CCA bulb)	1 (0.8%)	0	0
Stenosis at right common carotid artery (right CCA)	1 (0.8%)	0	0
Stenosis at right proximal common carotid artery (right prox CCA)	0	0	0
Stenosis at right distal common carotid artery (right distal CCA)	0	0	0
Stenosis at right common carotid artery bulb (right CCA bulb)	1 (0.8%)	0	0
Stenosis at left and right internal carotid arteries (ICAs)	4 (3.4%)	0	2 (1.7%)
Stenosis at left internal carotid artery (left ICA)	2 (1.7%)	0	1 (0.8%)
Stenosis at left proximal internal carotid artery (left prox ICA)	2 (1.7%)	0	1 (0.8%)
Stenosis at left distal internal carotid artery (left distal ICA)	2 (1.7%)	0	1 (0.8%)
Stenosis at right internal carotid artery (right ICA)	3 (2.5%)	0	1 (0.8%)
Stenosis at right proximal internal carotid artery (right prox ICA)	3 (2.5%)	0	1 (0.8%)
Stenosis at right distal internal carotid artery (right distal ICA)	2 (1.7%)	0	1 (0.8%)

screened preoperatively for carotid stenosis to evaluate the risk of perioperative major cardiovascular events.[18,54,55]

The recommendations for tandem CABG and carotid stenosis management depend on the severity of carotid stenosis (≥50%).[18,54,55] The European guidelines recommend preoperative screening for carotid stenosis in the CABG patients ≥70 years old or with the presence of multivessel CAD.[18,55,56] Imori et al[57] also recommended screening patients with CAD with multivessel disease and left main stem disease. In addition, 3-dimensional speckle tracking echocardiography measuring the multidirectional strain parameters for predicting left ventricular remodeling after ST-elevation MI can be used to evaluate for atherosclerosis.[58] Meshfree representation into cardiac medical image analysis can also be used for assessment of atherosclerosis.[59]

We propose ultrasound carotid Doppler screening for all patients with CAD undergoing CABG, especially in patients 65 years or older and in the patients with higher BMI. We recommend counseling on weight reduction, emphasizing measures such as exercise, and referral to a dietitian for proper education in dietary control.

The strength of this study was that it was the first study conducted among the multiethnic population of Malaysia on extracranial carotid atherosclerosis in the patients with CAD undergoing elective CABG.

There were several limitations in this study. Firstly, we only studied a group of consecutive patients who were referred for CABG due to CAD. Selection bias may be present, and therefore the findings regarding the relationship between carotid stenosis and CAD were relevant only to this specific group and may not be applicable to the general population. Secondly, the sample size was small. In addition, this study was a retrospective study conducted in a single tertiary center. Peripheral arterial disease (lower limb artery disease) is a risk factor for carotid stenosis and was not included in this study. Finally, the control group was not present.

In conclusion, the patients with plaques were more likely to be older, whereas the patients with carotid stenosis were more likely to have higher BMI.

Author contributions

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