International Journal of General Medicine

Dovepress
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ORIGINAL RESEARCH

Prevalence and Risk Factors Analysis of Carotid Stenosis Among Ischaemic Heart Diseases Patient in Bangladesh: A Cross-Sectional Study

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Purpose: This study aimed to evaluate the prevalence of carotid stenosis among ischaemic heart disease (IHD) patients undergoing coronary artery bypass graft (CABG) surgery and identify risk factors associated with carotid stenosis at a tertiary-level hospital in Bangladesh.

Patients and Methods: This cross-sectional study examined 200 IHD patients scheduled for isolated and elective CABG surgery, and multivariate regression analysis was used to determine the impact of independent variables on carotid stenosis with coronary artery disease. A vascular surgeon and sonographer assessed carotid stenosis, and the severity of stenosis was classified according to the current Grayscale and Doppler US diagnosis models.

Results: We observed that the prevalence of carotid artery stenosis was 13.5%, and the male was significantly higher (85.2%) in the carotid stenosis group. A multivariate regression analysis observed that age (OR 1.79), dyslipidaemia (OR 2.19), uncontrolled hypertension (OR 2.38), uncontrolled DM (OR 2.51), multivessel coronary artery disease (OR 3.79), and multiple comorbidities (OR 4.46) are potential predictors of having significant carotid stenosis in a patient undergoing CABG surgery.

Conclusion: In Bangladesh, multivessel coronary artery disease, especially in elderly patients with multiple comorbidities, are 4 (four) times higher risk to have significant carotid artery stenosis. Preoperative carotid duplex screening should be performed to curtail the risk of postoperative adverse cerebrovascular events, particularly those who have carotid stenosis associated potential risk factors.

Keywords: prevalence, carotid stenosis, coronary artery disease, ischaemic heart disease

Introduction

A strong association between atherosclerotic coronary and carotid artery stenosis has been established since atherosclerosis is a progressive and systemic inflammatory disease that is also a forerunner of multiple adverse cardiovascular events.[1,2] Moreover, several published articles have illustrated that significant carotid stenosis in a patient undergoing surgical myocardial revascularisation will increase the risk of critical neurological deficits. In a real-world scenario, approximately 30% annual mortality resulted from cardiovascular illness and about 10% mortality was caused by cerebrovascular events. The potential associated factors that play an essential role in the pathogenesis are smoking, an increased lipid profile, hypertension, and uncontrolled diabetes mellitus (DM). These risk factors also play essential roles in the pathogenesis and treatment prognosis of cerebrovascular and cardiovascular diseases.[2,3] Carotid stenosis is a potential influencing factor for cerebral ischaemic assault in patients with ischaemic heart disease (IHD) who have undergone a myocardial revascularisation procedure. Researchers have also reported that a patient undergoing coronary artery bypass graft (CABG) surgery could have an atherosclerotic lesion in the carotid artery.[3,4]

In Western countries, the observed proportion of carotid stenoses among CABG surgery patients has gradually increased from 12.8% to 22.0% over the last few decades. Nevertheless, several researchers found that 7–11% of multivessel coronary artery disease (lesion present in 2 or more coronary arteries) patients had significant >70% carotid

Received: 23 November 2021
Accepted: 18 March 2022
Published: 24 March 2022

stenosis.[5,6] In a previous study, via preoperative carotid duplex evaluation, Zhang et al found that Significant carotid artery stenosis (≥50% lesion) was present in approximately 20% of patients of multivessel coronary artery disease, and the severity of carotid stenosis was directly correlated with the extent of coronary artery disease.[7] A recent meta-analysis evaluated the link between postoperative stroke and carotid stenosis after heart surgery and found that the plausibility of perioperative neurological events ranges from 2 to 7% and depends on two critical factors: the severity of the stenosis and the methods of myocardial revascularisation.[8] Moreover, a recent European study advocates a carotid scan in IHD patients at advanced ages, such as those over 65 years of age.[9] Several published works on CABG surgery in IHD patients with significant 50–80% CAS reported a 3–10% incidence of ischaemic stroke, and the rate was significantly higher in approximately 22% of the population of patients with ≥80% carotid artery stenosis.[5–8]

Several studies have identified the potential risk factors responsible for significant carotid lesions, such as advanced age, female sex, uncontrolled diabetes, uncontrolled hypertension, peripheral vascular disease, renal dialysis, prior transient ischemic attack (TIA) or stroke, and multivessel coronary artery disease (including left main disease).[2,6–8] Although studies have failed to identify the female sex as an independent predictor of CAS, women undergoing heart surgery showed a higher risk of cardiovascular complications than men. The most acceptable explanation for this discrepancy is the presence of multiple comorbidities, especially in advanced age.[7–9]

The majority of studies on concomitant carotid stenosis and IHD patients have been carried out in developed countries. Further, few studies including the Bangladeshi population have evaluated the preponderance of carotid stenosis in patients with IHD who have undergone CABG surgery. The principal objectives of this study were to explore the prevalence and identify the influencing factors involved in the pathogenesis of atherosclerotic carotid stenosis in IHD patients in Bangladesh.

Materials and Methods

We studied 200 patients scheduled for elective isolated CABG surgery between January 2019 and March 2020 at the Bangabandhu Sheikh Mujib Medical University, and Al-Helal Specialised Heart Hospital, Bangladesh. This study was approved by the concerned departmental academic and technical committee and followed the guidelines outlined in the Declaration of Helsinki. An informed written consent form was received from every study population, and a convenience purposive sampling strategy with a standardised semi-structured datasheet was utilised to gather essential information on the study population. This study excluded IHD patients with coexisting congenital and valvular heart disease, patients undergoing emergency CABG surgery, and haemodynamically unstable patients.

Figure 1 illustrate the methodology of the study in a CONSORT flow diagram. We initially considered a total of 300 IHD patients for enrolment in the study; however, considering study inclusion criteria and patient wishes, we primarily selected 215 patients for the Carotid duplex scan. Furthermore, another 15 patients were excluded from the final statistical analysis due to incomplete data set, which we acknowledged as study limitations. The primary study endpoint determined the prevalence of CAS among the IHD patients, and the secondary endpoint evaluated the potential known atherosclerotic risk factors associated with carotid stenosis and Ischaemic heart disease among the Bangladeshi population. Statistical analyses were performed using SPSS (Statistical Package for Social Science) version 23 software. Logistic regression analysis evaluated the impact of independent variables on CAS with coronary artery disease, and statistical significance was defined at a p value ≤0.05.

Carotid Scan

CAS was assessed by a vascular surgeon and sonographer using a Philips HD II XE system equipped with a C 5.2 MHz real-time linear B mode transducer. Furthermore, experts classified the severity of CAS (<50% stenosis = mild, 50–70% stenosis = moderate, >70% stenosis = severe) using the current Grayscale and Doppler US Diagnosis models from the Society of Radiologists in Ultrasound Consensus Conference.[4] A sonographic scan was used to determine ≥50% stenosis by calculating the following parameters: the peak systolic velocity (PSV) of the internal carotid artery (ICA) is >125 cm/s, and the ratio of the PSV of ICA and CCA is more than two. The degree of stenosis was defined in a manner consistent with that of the Society of Radiologists in Ultrasound Consensus criteria, where <50% stenosis indicates none to mild stenosis with a PSV less than 125 cm/sec and an ICA:CCA value <2. Similarly, 50–69% stenosis indicates moderate

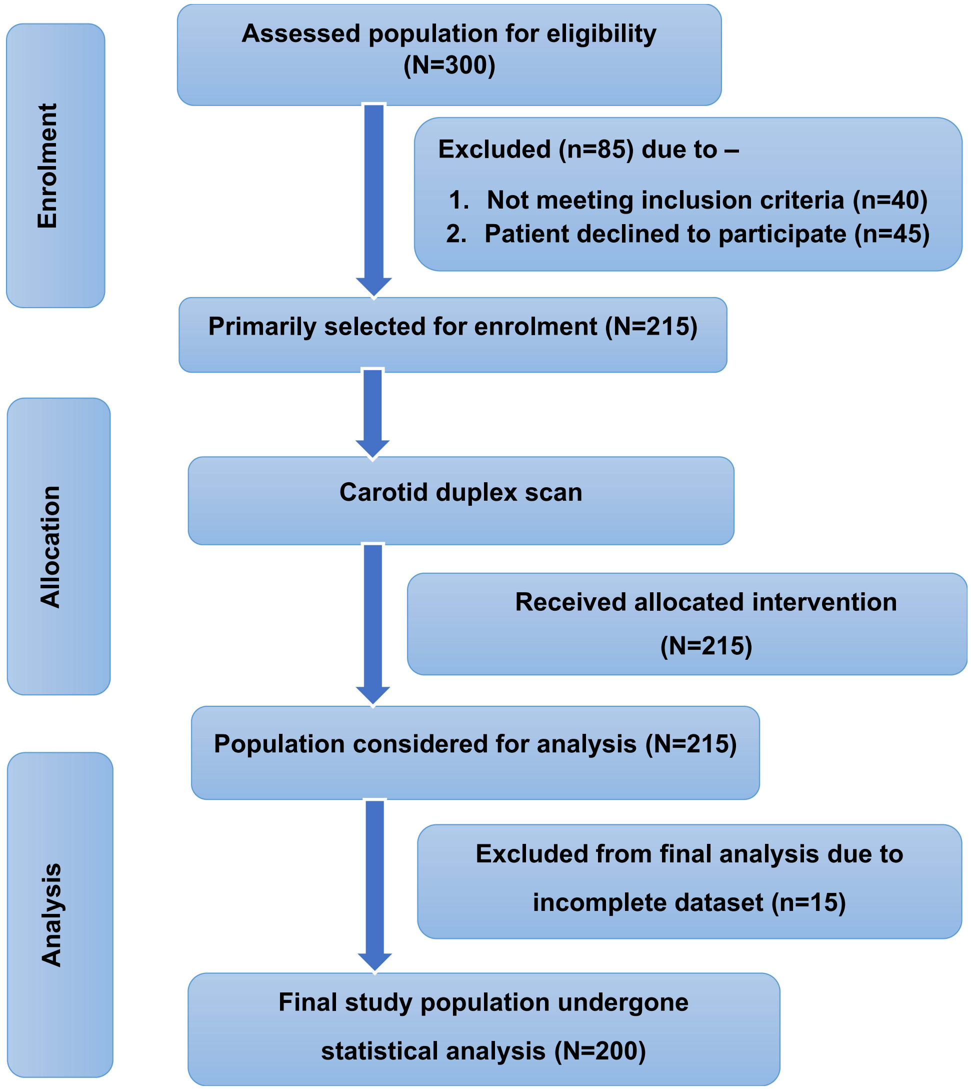

Figure 1 Study design: CONSORT flow diagram.
Note: Adapted from Schulz KF, Altman DG, Moher D. CONSORT 2010 Statement: Updated Guidelines for Reporting Parallel Group Randomised Trials. *PLoS Med.* 2010;7(3): e1000251. Copyright: © 2010 Schulz et al. Creative Commons Attribution License.[23]

lesions, which presented a PSV of 125–229 cm/sec and an ICA:CCA ratio of 2.0 to 3.9; 70–99% stenosis indicates severe lesions with a PSV ≥230 cm/sec and an ICA: CCA value ≥4. However, Grant et al observed a critical lesion or total carotid occlusion with undetectable PSV and where the ICA:CCA value was not applicable.[5] In the current study, significant (≥50% stenosis) stenosis and severe (≥70% stenosis) carotid stenosis were classified based on the North American Symptomatic Carotid Endarterectomy Trial criteria described by Hathout et al.[6]

Functional Definitions

According to the world health organisation (WHO) office, a person is considered to have a normal Body Mass Index (BMI) if it ranges from 18.5–24.9; and any deviation either below or above the range is considered unhealthy underweight or overweight, respectively.[10,11] Furthermore, unhealthy, or fatty diets are considered food with fats, free sugars and salt higher than recommended dietary allowance. Albeit regular physical activity is considered an active lifestyle; however, a sedentary lifestyle contributes little to or no physical exercise.[11] Physical inactivity and fatty or unhealthy diets are potential contributors to BMI leading to overweight (25–29.9) and obesity (BMI ≥30) which is potential risk factors for the development of cardiovascular disease, especially ischaemic heart disease and stroke.[10,11]

Results

Here, total 13.5% of the study population had significant CAS (Table 1), and the mean age was significantly higher among the carotid stenosis group (p≤0.05). Regarding sociodemographic characteristics, and lifestyle were not significantly different among the study group; however, age, BMI, and an unhealthy diet (fatty diet) showed considerable differences among the study population. In carotid stenosis group, male population were 85.2% which is significantly higher than female population. Furthermore, a considerable proportion of the carotid stenosis group patients preferred an unhealthy diet (fatty diet), and about 60.0% of the CAS patients had uncontrolled DM, hypertension, dyslipidaemia, and multiple comorbidities, which is significantly higher than that of the other study populations (p≤0.05). Patients with multivessel coronary artery disease and numerous comorbidities were more prone to developed CAS (p≤0.05; Table 1).

Table 2 illustrates the level of association of associated factors with concurrent carotid and coronary artery disease using a logistic regression model at a 95% confidence interval. A multivariate analysis showed that age (OR 1.79), dyslipidaemia (OR 2.19), uncontrolled HTN (OR 2.38), uncontrolled DM (OR 2.51), multivessel CAD (OR 3.79), and multiple comorbidities (OR 4.46) were strong predictors (p value ≤0.05) of carotid stenosis among the IHD cohort undergoing surgical myocardial revascularisation.

Table 1 The Association Between Sociodemographic Variables and Risk Factors Among the Study Population (n=200)

Sociodemographic Variables		**Study Group**		**P value**
		With Carotid Stenosis (n=27) N (%)	**Without Carotid Stenosis (n=173) N (%)**	
Age (years)	Mean ± SD	62.11±5.68	57.81±3.64	0.001[a]
Sex	Male Female	23 (85.2%) 04 (14.8%)	116 (67.1%) 57 (32.9%)	0.72[b]
Body mass index (BMI)	Overweight Normal	11 (40.7%) 16 (59.3%)	15 (8.7%) 158 (91.3%)	0.001
Lifestyle	Sedentary Active	4 (14.8%) 23 (85.2%)	33 (19.1%) 136 (78.6%)	0.86[b]
Diet	Balanced Unhealthy	6 (22.2%) 21 (77.8%)	99 (57.2%) 74 (42.8%)	0.001
Risk factors				
Uncontrolled DM	Present Absent	16 (59.3%) 11 (40.7%)	67 (38.7%) 106 (61.3%)	0.04
Uncontrolled hypertension	Present Absent	17 (63%) 10 (37%)	58 (33.5%) 115 (66.5%)	0.003
Dyslipidaemia	Present Absent	17 (63%) 10 (37%)	58 (33.5%) 115 (66.5%)	0.003
Multivessel coronary artery disease	Present Absent	13 (48.15%) 14 (51.85%)	130 (90.9%) 43 (75.4%)	0.04
Multiple comorbidity	Present Absent	16 (59.3%) 11 (40.7%)	51 (29.5%) 122 (70.5%)	0.002

Notes: [a]Student's *t*-test, [b]Fishers exact test, and a chi-squared test (χ^2) were used to measure the level of significance. A P value of ≤0.05 was considered as statistically significant. Multiple comorbidities refers to the presence of two or more morbidities.

Table 2 A Logistic Regression Model at a 95% Confidence Interval Showed the Level of Association Between the Risk Factors and Carotid Artery Stenosis

Variables in the Logistic Regression Analysis						
		Odds Ratio (OR)	95% Confidence Interval (CI)		z Statistic	Significance Level (P value)
			Lower CI	Upper CI		
Step 1[a]	Age	1.791	0.699	0.980	2.12	<0.001
	BMI	0.552	0.236	1.291	0.89	0.171
	Fatty Diet	0.994	0.091	1.101	1.15	0.01
Step 1[b]	Dyslipidaemia	2.190	0.936	5.472	2.75	0.05
	Uncontrolled HTN	2.380	0.995	5.991	2.97	0.045
	Uncontrolled DM	2.505	1.026	6.111	3.15	0.041
	Multivessel CAD	3.793	1.530	9.407	4.70	0.004
	Multiple comorbidity	4.458	1.781	11.160	5.35	0.001

Notes: 1[a] Variable(s) entered on Step 1 are sociodemographic variables, and 1[b] Variable(s) entered on Step 1 are obtained from the comorbidity analysis.
Abbreviations: BMI, body mass Index; DM, diabetes mellitus; HTN, hypertension; CAD, coronary artery disease, A P value of ≤0.05 was considered statistically significant.

Discussion

In the current study, we observed that the prevalence of carotid stenosis was 13.5% among the Bangladeshi IHD cohort. Moreover, multivariate logistic regression analysis showed that age, unhealthy diet (fatty diet), uncontrolled DM, dyslipidaemia, and multiple comorbidities were strong predictors (p value $\leq$0.05) of carotid stenosis in IHD cohorts undergoing surgical myocardial revascularisation.

In recent years, atherosclerosis has escalated to encompass all socioeconomic levels worldwide, and the status of morbidity and mortality resulting from cardiovascular disease in the lower socioeconomic population has increased rapidly over the last few decades.[3,5–8] In the developed world, cardiovascular disease has been established as an essential risk factor for morbidity and mortality as cerebrovascular diseases are increasing steadily over time.[2,4,7] Despite conservative management efforts, CABG surgery, remains the most popular treatment option for coronary artery disease patients. However, IHD patients with concomitant carotid stenosis are vulnerable to perioperative neurological adverse events such as stroke and TIA-the most common adverse events that further impede the postoperative outcome.[3–8]

Atherosclerotic lesions of the carotid artery are assessed conveniently and safely, via sonographic scanning and the advantages of the sonographic scan to detect carotid stenosis have been reported in several published articles.[2–6] Moreover, studies have shown that a carotid duplex scan has 90% or more sensitivity and specificity than any other test.[3–5,9] In a recent study, Naqvi and Lee[12] demonstrated that carotid intima-media thickness (IMT) predict cardiovascular risk, and IMT measurement at the common carotid, carotid bulb, and internal carotid artery that allows the inclusion of plaque in the measurement is emerging as the focus of duplex carotid screening for cardiovascular risk prediction. Moreover, existing studies on CIMT with duplex scan have been found to be accurate, dependable, cost-effective, and reproducible.[5–8,12–15]

In the current study, the prevalence of carotid stenosis among the study population was only 13.5%, comparable with previous studies where a prevalence of 6.1–31.7% was found based on the severity and the method of carotid screening.[3,6–10] In a recent study, Fukuda et al[13] found a 4.1–13.3% prevalence of >70% carotid stenosis, concordant with other published study findings.[5–8] Moreover, in recent studies, Mahmoudi et al[14] and Drohomirecka et al[15] demonstrated a strong correlation between IHD and significant CAS and found that about 30% and 18% of the study population, respectively, had ≥50% carotid stenosis among IHD patients scheduled for CABG surgery, similar to other study results.[3,8,12,13,16,17]

In a recent study, Siminelakis et al[18] observed that the male sex acts as a positive predictive factor for atherosclerotic carotid stenosis among IHD patients. Nevertheless, Durand and coworkers[19] reported advanced age (age ≥65 years), female sex, multivessel coronary artery disease, left main coronary disease, peripheral artery disease (PAD), prior TIA/stroke, uncontrolled hypertension, and uncontrolled DM as potential risk factors generally associated with carotid stenosis. Further, Obied et al[20] demonstrated advanced age as a possible risk factor for carotid stenosis and found a gradual increase in prevalence with increasing age among patients aged below and above 60 years, similar to the results of the present study. Published research stated that clinical characteristics might exhibit a preoperative indication for carotid colour Doppler scan among IHD patients scheduled for myocardial revascularisation surgery, in concordance with our study results. IHD patients with concurrent carotid stenosis were found to have progressive and advanced atherosclerosis disease that involved multiple vascular systems, leading to a decreased health-related quality of life.[18–22]

The current study also observed multiple sociodemographic variables and clinical influencing factors, pathognomonic for the atherosclerotic disease process involving both carotid and coronary arteries, highlighting the importance of preoperative carotid sonographic screening among IHD patients identified for elective and isolated CABG surgery. However, this study has some limitations, such as it is a cross-sectional study with a small sample size and the unavailability of carotid duplex scans in emergency settings. Although about 7% sample was excluded from the final statistical analysis, there was enough statistical significance and the Odds ratio to establish the relationship between potential risk factors and CAS, which we believe mitigated the exclusion bias. Moreover, the prevalence of CAS was consistent with existing published literature among Bangladeshi populations. Finally, as we do not analyse treatment protocols and outcomes of concurrent significant coronary and carotid artery disease, we recommended a long-term follow-up to evaluate treatment modalities and develop a precise management plan to have better treatment outcomes.

Conclusion

An elderly patient with multivessel coronary artery disease and multiple comorbidities has four times higher potentials for significant carotid stenosis. A preoperative routine carotid duplex scan will demonstrate significant lesions and optimise the risk of postoperative adverse neurological events such as stroke. Further studies are required to elaborate on these effects and determine treatment protocols for concurrent carotid stenosis and IHD in a large population group undergoing CABG procedures.

Acknowledgments

Mr. Andrew Tambyraja, Consultant Vascular Surgeon, The Royal Infirmary of Edinburgh, UK provided a factual review and helped in editing that greatly improved the manuscript.

Disclosure

The authors report no conflicts of interest in this work.

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