Original Article

Use of the CHA_2DS_2-VASc Score to Predict Concurrent Critical Coronary Artery Stenosis in Patients with Severe Carotid Artery Disease

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Abstract

Background: There is a significant correlation between the severity of atherosclerosis in one arterial region and the occurrence of atherosclerotic disease in other regions. Identifying and managing vascular disease in patients with multifocal arterial disease is often complex. The CHA_2DS_2-VASc score encompasses several cardiovascular risk factors and was initially used to assess the risk of thromboembolism, stroke, and death in patients with atrial fibrillation. In recent years, this score has been proposed to predict the prognosis of various cardiovascular diseases. **Aim:** The study aimed to investigate the prevalence of concomitant coronary artery disease (CAD) and the correlation between the CHA_2DS_2-VASc score and CAD in patients who were scheduled for carotid stenting due to carotid artery stenosis (CAS) but had no history of CAD. **Methods:** A total of 452 patients were included in the study, 213 with symptomatic CAS and 239 with asymptomatic CAS. The patients were separated into two groups: those with and without. **Results:** One hundred forty-eight (32.7%) of 452 patients had critical CAD. Multivariate logistic regression analysis showed that a high CHA_2DS_2-VASc score (OR: 4.283, 95% CI: 2.903–6.321, $P < 0.001$) was an independent predictor of the development of CAD. Receiver operating characteristic curve (ROC) analysis showed 64.9% sensitivity and 82% specificity in detecting CAD of the CHA_2DS_2-VASc score at >4 cutoff [Area under ROC curve = 0.781 (95% CI: 0.724–0.838), $P < 0.001$]. **Conclusion:** When our results were analyzed, a CHA_2DS_2-VASc score of >4 was highly significant in predicting severe CAD.

Keywords: *Carotid artery stenosis, CHA_2DS_2-VASc score, coronary artery disease*

Introduction

Atherosclerosis accounts for many major adverse vascular events (e.g., coronary artery disease (CAD), stroke, and peripheral arterial disease), which then account for the majority of cardiovascular-associated morbidity and mortality. Its prevalence has increased worldwide in recent years due to adopting a Western lifestyle (typically includes a diet high in saturated fats, refined sugars, and processed foods, along with sedentary behaviors and low levels of physical activity) and is expected to reach epidemic levels.[1]

There is a significant correlation between the severity of atherosclerosis in one arterial territory and the occurrence of atherosclerotic disease in other territories. When evaluating patients with carotid, abdominal aorta, CAD, and peripheral arterial disease, 45% of patients had two regions affected, 23% had three regions affected, and 3% had four regions affected.[2] It has been claimed that 70% of patients with internal carotid artery occlusion had disease in at least one other vascular territory,

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35% in two, and 7.5% in at least three arterial beds.[2] Identifying and managing vascular disease in patients who have multifocal arterial disease is often complex and requires a rigorous diagnostic workup followed by a multimodal therapeutic approach. Extensive debate has been ongoing regarding the optimal management of such patients.

All other arterial beds should be thoroughly examined to see if they are affected by atherosclerotic occlusive disease. Studies have reported that carotid artery stenosis (CAS) affects between 2.4% and 14% of patients who require coronary artery bypass greft (CABG) surgery, underscoring the potential for multifocal arterial disease.[3] Even without a history or symptoms of CAD, one-fourth of patients with symptomatic high-grade carotid stenosis who had had carotid endarterectomy developed CAD.[4] Furthermore, various studies have indicated that the prevalence and severity of carotid stenosis are related to the severity of CAD.[5]

A few recent studies have investigated the relationship between CHA_2DS_2-VASc scores and CAD. For instance, Modi *et al*.[6] found that the CHA_2DS_2-VASc score was a strong predictor of CAD severity, even in patients without a prior history of CAD. Similarly, Tanircan *et al*.[7] noted that higher CHA_2DS_2-VASc scores were linked to stronger cardiovascular outcomes in patients with non-ST-segment elevation myocardial infarction. However, a few studies have examined the link between this score and the risk of CAD in patients undergoing carotid stenting for CAS.

The CHA_2DS_2-VASc score encompasses several cardiovascular risk factors and is clinically significant. Initially used to evaluate the risk of thromboembolism, stroke, and death in patients who faced atrial fibrillation, this score was proposed and tested in recent years for predicting the prognosis of various cardiovascular diseases beyond its original purpose.[8] However, in recent years, some researchers have proposed and tested using the CHA_2DS_2-VASc score in populations without AF beyond its development purpose, particularly in predicting the prognosis of various cardiovascular diseases.[9,10] The study aimed to examine the prevalence of concomitant severe CAD and the correlation between the CHA_2DS_2-VASc score and CAD in patients scheduled for carotid stenting due to carotid stenosis but had no history of CAD.

Materials and Methods

The data of 452 patients who underwent carotid digital subtraction angiography (DSA) and concurrent coronary angiography (CAG) at our clinic due to carotid stenosis between January 2013 and May 2023 were analyzed retrospectively. The institutional ethics committee approved the study, which was conducted based on the Helsinki Declaration (Local Ethics Committee No: 2023/955, 28/11/2023.

The medical records were examined to collect information on the patients' clinical, demographic, and laboratory characteristics. The presence of traditional cardiovascular risk variables [e.g. age, sex, diabetes mellitus (DM), hypertension (HT), dyslipidemia, and smoking] was determined. Prior to the procedure, all patients underwent a transthoracic echocardiographic examination, and the left ventricular ejection fraction (LVEF) was measured with Simpson's method. Prior to the procedure, all patients had their serum biochemistry blood levels checked, including triglyceride, total cholesterol, low-density lipoprotein-cholesterol, high-density lipoprotein-cholesterol, fasting glucose, C-reactive protein levels, and complete blood count.

The presence of DM, HT, and dyslipidemia was defined as previously stated. Patients who had smoked in the past year were classified as smokers. LVEF <40% was defined as heart failure. The patient's history and CT results were used to evaluate stroke and transient ischemic attack. The CHA_2DS_2-VASC level was determined separately for each patient hospitalized with carotid stenosis. Based on their CHA_2DS_2-VASC scores, patients were given 1 point for age 65–74 (female), congestive heart failure, HT, DM, and vascular disease and 2 points for age ≥75 and prior stroke or transient ischemic attack. All patients were given one point since they had atherosclerotic carotid artery disease.

Evaluation of carotid and coronary angiography

A joint council comprising cardiology, neurology, and cardiovascular surgery discussed patients diagnosed with carotid stenosis using duplex ultrasonography or computed tomography angiography (CTA). The study included patients recommended by the committee for percutaneous carotid artery revascularization.

The neurologist reviewed each patient's CT scan and symptomatic state prior to revascularization. Patients with ipsilateral hemisphere paralysis, transient ischemic attack (TIA), or amaurosis fugax in the past 6 months were considered symptomatic. A TIA was defined as a stroke that resolved within 24 hours with no sequelae.

The following were the inclusion criteria: Symptomatic patients with a stenosis of 50% or more significant in the carotid DSA or asymptomatic patients with a stenosis of 70% or greater in the carotid DSA were considered critical CAS. Simultaneous CAG was performed on all patients just prior to carotid revascularization. At least four distinct projections were used for a full view of

the left coronary artery system. Standard left and right anterior oblique projections were obtained for complete visibility of the right coronary artery. Bilateral CAS was considered as fitting the criteria for critical CAS in both the right and left ICA. The degree of CAS was angiographically determined with the criteria set by the North American Symptomatic Carotid Endarterectomy Trial (NASCET).[11]

The location, severity, and extent of coronary stenosis were evaluated visually and using quantitative CAG software. Critical coronary artery stenosis was defined as a stenosis of at least 70% in one of the three major coronary arteries (LAD, CX, RCA) or a stenosis of at least 50% in the left main coronary artery (LMCA). Significant coronary stenosis for the purpose of our study was defined according to 2017 US appropriate use criteria for coronary revascularization in patients with stable ischemic heart disease.[12]

Patients were excluded from the study if they met any of the following criteria: previous angiographically documented CAD history (148 patients), history of CABG (126 patients), insufficient information in hospital files (57 patients), or patients not undergoing concurrent CAG with carotid DSA (246 patients). Inclusion and exclusion criteria are shown in Tables 1 and 2.

Four hundred fifty-two of the 1029 screened patients met the inclusion criteria. All patients were provided information regarding the treatment process and potential problems prior to the procedure, and a formal consent form was acquired. For the patients whose treatment was scheduled, dual antiplatelet therapy (2 × 75 mg/day clopidogrel + 100 mg acetylsalicylic acid) was started 3 days prior to the procedure. Patients who had not previously received dual antiplatelet therapy and were scheduled to receive emergency treatment were given a 600 mg loading dose of clopidogrel. Prior to the procedure, all patients were put on statin treatment. The patients were not given sedative medicines prior to the procedure to avoid interfering with the neurological evaluation.

The Judkins technique was used for coronary angiography with femoral/radial access, depending on the surgeon's preference. The anatomical severity of coronary narrowing was quantitatively evaluated with SYNTAX (SYNergy between PCI with TAXUS™ and Cardiac Surgery) Score (SxS). Two experienced interventional cardiologists calculated the SxS using their website's latest online software version.[13]

The procedure was started under local anesthetic using intravenous (iv) heparin administration at a dose of 100 U/kg via femoral or radial access, depending on the surgeon's preference. The final treatment strategy was decided after the coronary and carotid angiography. Two experienced cardiologists carried out the procedures. In total, 148 patients had severe CAD. CAD lesions were divided into 3 as follows:

- Single-vessel disease (stenosis in one of the three major coronary arteries),
- Double-vessel disease (left main trunk disease without stenosis of the two major coronary arteries and/or right coronary disease), and
- Three-vessel disease (with stenosis in three major coronary arteries or left main trunk disease with right coronary artery stenosis).

Each patient's choice to undergo coronary revascularization was based on their symptom status and whether their angiographic findings fit current coronary revascularization guidelines. The Canadian Cardiovascular Society (CCS) classification was employed to identify the patients' symptom states.[14] In patients with symptomatic carotid disease and symptomatic CAD, treatment priority was given based on the severity and urgency of the symptoms. In patients with severe symptoms (CCS Class IV), coronary revascularization was performed prior to carotid stenting. In other patients, both conditions were carefully evaluated and treated appropriately according to the clinician's preference. As a result, in 12 patients admitted with Canadian Cardiovascular Society class IV, coronary revascularization was performed just prior to carotid stenting. In 26 patients, CABG was decided on as an elective procedure. In 12 patients, medical follow-up was recommended. Under elective conditions, 98 patients were scheduled for percutaneous coronary artery intervention. Since aortic anatomy was unacceptable, 37 of 452 patients with carotid stenosis decided to have carotid endarterectomy (CEA). Twenty-one of these patients were selected for CABG surgery. The remaining 415 patients had carotid stenting. In 27 of the patients, the contralateral carotid arteries were occluded entirely.

Carotid stent procedures of all patients were performed with Proximal Protection Devices (Mo.Ma Ultra; Invatec, Roncadelle, Italy) or distal Protection Devices (Emboshield NAV6; Abbott Vascular, California, USA; SpiderFX; Medtronic, Minnesota, USA; Angioguard; Cordis, Miami, USA). The carotid stents that were implanted were as follows: Closed-cell stent, Xact (Abbott, Abbott Park, Illinois, USA), Carotid Wallstent (Boston Scientific, MA, USA), Open-cell stent; RX AccuLink (Abbott, Redwood City, CA), and Protégé RX (Medtronic, MN, USA).

Statistical analyses

The SPSS 21.0 (Inc., Chicago, IL, USA) was used for statistical analyses. The Shapiro-Wilk test checked the distribution of quantitative variables. Descriptive data were given as mean ± standard deviation based on normality distribution. To compare normally distributed quantitative variables, an independent sample *t*-test was used. The Chi-square test was used to compare categorical variables. Univariate analysis was used to calculate the effects of different variables on CCC development. Parameters with $P < 0.10$ in univariate analysis were included in the model for multivariate regression analysis. The cutoff level of the CHA_2DS_2-VASc score to predict concurrent critical coronary artery stenosis in patients with severe carotid artery disease was determined with ROC analysis. A P value < 0.05 was taken as statistical significance.

Results

The study included 452 patients, 213 with symptomatic CAS and 239 with asymptomatic CAS. The patients were divided into 2 groups: those with and without CAD. Of the 452 patients, 148 (32.7%) had critical CAD.

Table 3 gives the baseline clinical and demographic characteristics data of the patients. DM and HT were more common in CAS patients with concomitant CAD than in those without CAD (47.9% vs 30.9%, p < 0.001; 75% vs 49.3%, p < 0.001, respectively). Also, CAD patients were older than non-CAD patients ($P < 0.001$). Other demographic features were similar between the two groups. Hemodynamic parameters such as heart rate and systolic and diastolic blood pressure did not differ significantly between patients with and without concomitant CAD [Table 1]. LVEF was also similar between the two groups. The mean CHA_2DS_2-VASc score was considerably higher in the CAD group than

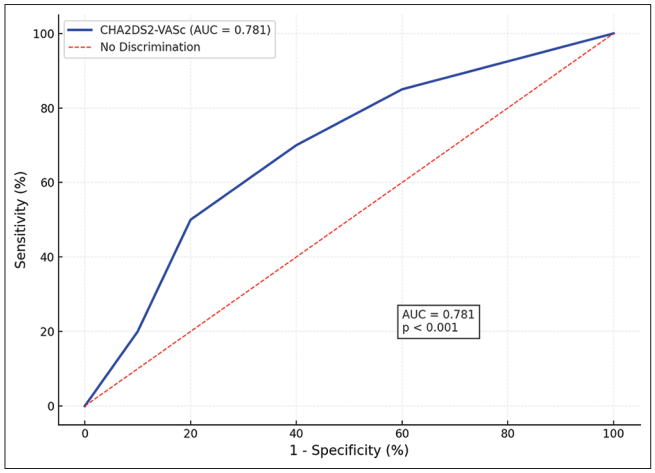

Figure 1: Receiver operating characteristic (ROC) curves for the CHA_2DS_2-VASc score in predicting concurrent severe CAD in patients with critical CAD

Table 1: Inclusion criteria of patients with CAS in this study

Criteria	Details
Age	Adults (≥18 years) with no prior history of CAD
Symptomatic CAS	Carotid stenosis of ≥50% as determined by carotid DSA (based on NASCET criteria)
Asymptomatic CAS	Carotid stenosis of ≥70% as determined by carotid DSA (based on NASCET criteria)
Bilateral CAS	Presence of critical CAS in both right and left internal carotid arteries
Diagnostic Procedures	Underwent both carotid DSA and concurrent CAG prior to carotid revascularization
CAG Protocol	At least four distinct projections were used to visualize the left coronary artery system. Standard left and right anterior oblique projections were used to visualize the right coronary artery.

CAD; coronary artery disease, CAS; carotid artery stenosis, DSA; digital subtraction angiography CAG; coronary angiography

Table 2: Exclusion criteria of patients with CAS in this study

Criteria	Details
History of CAD	Previous angiographically documented CAD (148 patients)
Prior CABG	History of prior CABG (126 patients)
Incomplete Medical Records	Patients with incomplete or missing medical records (57 patients)
Lack of Concurrent CAG with Carotid DSA	Patients who did not undergo concurrent CAG with carotid DSA (246 patients)

CABG; coronary artery bypass graft, CAD; coronary artery disease, DSA; digital subtraction angiography, CAG; coronary angiography

Table 3: Demographic data of the study populations

Variables	Coronary artery disease		
	Yes (n=148)	No (n=304)	P
Age (years)	69.2±8.6	61.3±10.1	<0.001
Women sex (n, %)	69 (46.6%)	155 (50.9%)	0.384
Diabetes Mellitus (n, %)	71 (47.9%)	94 (30.9%)	<0.001
Hypertension (n, %)	111 (75%)	150 (49.3%)	<0.001
Dyslipidemia	29 (19.5%)	69 (22.6%)	0.453
Previous TIA/stroke (n, %)	72 (48.6%)	141 (46.3%)	0.650
Heart Failure (n, %)	18 (12.1%)	21 (6.9%)	0.062
Vascular disease (n, %)	6 (4%)	7 (2.3%)	0.296
Smoking (n, %)	25 (16.8%)	48 (15.7%)	0.765
BMI (kg/m^2)	27.4±4.1	27.9±4.7	0.370
Systolic blood pressure (mmHg)	131.7±13.7	131.2±15	0.939
Diastolic blood pressure (mmHg)	82.7±8.7	80±9.9	0.270
Heart rate	83.8±14.7	81.8±14.5	0.255
LVEF (%)	56.3±11.5	55.8±10	0.717
CHA_2DS_2 VASc score	4.8±1.15	3.72±0.67	<0.001

in the non-CAD group (4.8 ± 1.15 vs 3.72 ± 0.67, $P < 0,001$, respectively).

When biochemical parameters were evaluated, the CAD group had significantly higher glucose levels, neutrophil counts, serum C-reactive protein (CRP) levels, and neutrophil/lymphocyte ratio (NLR) levels ($P = 0.003$, $P < 0.001$, $P < 0.001$, $P = 0.002$, respectively). In other blood parameters, the two groups had no significant difference [Table 4].

Table 4: Laboratory data of the study populations

Number of patients	Coronary artery disease		
	Yes (*n*=148)	No (*n*=304)	*P*
Glucose (mg/dl)	97.8±24.8	88.5±34.1	0.003
Creatinine (mg/dl)	0.87±0.21	0.85±0.29	0.620
AST (U/L)	20.2±8.3	20.7±9.9	0.667
ALT (U/L)	24.9±12.5	25.4±9.9	0.723
Total cholesterol (mg/dl)	214.9±43.2	212.6±46.7	0.553
High-density lipoprotein cholesterol (mg/dl)	34.2±9.7	35.8±10.1	0.314
Low-density lipoprotein cholesterol (mg/dl)	159.6±41.1	151.5±43.6	0.099
Triglyceride (mg/dl)	154.7±48.3	150.3±72	0.578
Hemoglobin (mg/dL)	14.6±1.4	14.8±1.5	0.606
Platelets (10^3/μL)	229.9±38	219.2±64	0.144
White blood cell (10^3/μL)	7.4±2.2	7±2.3	0.070
Neutrophil (10^3/μL)	4.6±1.6	3.9±1.7	<0.001
Lymphocyte (10^3/μL)	2.09±0.7	2.25±0.8	0.056
C-reactive protein (CRP) (mg/l)	3.97±1.6	2.57±1.9	<0.001
Albumin (g/L)	4.22±0.1	4.0±0.3	0.128
Neutrophil/Lymphocyte ratio (NLR)	2.56±1.5	2.08±1.5	0.002

Table 5: Angiographic data

Position of coronary artery disease	Coronary artery disease (*n*=148)
LMCA	9 (6%)
Left anterior descending coronary artery	90 (60%)
Left circumflex coronary artery	62 (41.8%)
Right coronary artery	101 (68.2%)
Number of diseased coronary arteries	
One-vessel disease	75 (50.6%)
Two-vessel disease	40 (27%)
Three-vessel disease	33 (22%)
Clinical symptoms in patients with significant coronary artery stenosis	
No clinical symptoms	87 (58.7%)
CCS class II	31 (20.9%)
CCS class III	18 (12.1%)
CCS class IV	12 (8.1%)
Syntax score	11.3±8.4
Position of carotid artery disease	**Carotid artery disease (*n*=452)**
Right internal carotid disease	271
Left internal carotid disease	249
Bilateral internal carotid disease	68

LMCA; left main coronary artery, CCS; Canadian Cardiovascular Society

Table 5 displays the patients' angiographic data. While 271 of 452 carotid artery patients showed severe stenosis in the right ICA, 249 had critical stenosis in the left ICA. Critical stenosis of the bilateral ICA was present in 68 patients (27 of them had complete occlusion of the contralateral carotid arteries).

When the lesion location of patients with concomitant CAD was taken into account, nine patients had considerable stenosis in the LMCA, 90 patients had critical narrowing in the LAD, 62 patients had CX, and 101 patients had critical stenosis in the RCA. Seventy-five patients had single-vessel disease, 40 had a double-vessel disease, and 33 had three-vessel disease. The mean SYNTAX score was 11.3 ± 8.4. Among these patients, 12 were CCS Class IV symptomatic, 18 were CCS Class III, and 31 were CCS Class II. In 87 patients, there were no symptoms.

The prevalence of CAD and SYNTAX scores differed significantly between unilateral or bilateral CAS patients. In patients with bilateral carotid stenosis, the prevalence of CAD was 50%, while it was 29.6% in patients with unilateral carotid stenosis ($P < 0.001$). The mean SYNTAX score in patients who had unilateral carotid stenosis was 9.8 ± 7.5 and 16.1 ± 9.7 in patients who had bilateral carotid stenosis ($P < 0.001$). Also, patients who had high CHA_2DS_2-VASc scores were more likely to have bilateral carotid stenosis, which was statistically significant (3.89 ± 0.8 vs 5.36 ± 1, $P < 0.001$). There was also a considerable positive correlation between the CHA_2DS_2-VASc score and the mean SYNTAX score ($r = 0.725$, $P < 0.001$).

Multivariate analysis was also used to evaluate the role of the CAD risk factor [Table 6]. Age, HT, DM, HF, CHA_2DS_2-VASc, glucose, neutrophil, hs-CRP, and NLR were all included in the univariate analysis associated with the development of CAD. Multivariate logistic regression analysis showed that a high CHA_2DS_2-VASc score (OR: 4.283, 95% CI: 2.903–6.321, $P < 0.001$) was an independent predictor of the development of CAD with advanced age (OR: 1.052, 95% CI: 1.024–1.081, $P < 0.001$) and high CRP level (OR: 1.211, 95% CI: 1.056–1.388, $P = 0.006$).

ROC curve analysis showed 64.9% sensitivity and 82% specificity in detecting CAD of the CHA_2DS_2-VASc score at >4 cutoff [Area under ROC curve = 0.781 (95% CI: 0.724–0.838), $P < 0.001$] [Figure 1].

Table 6: Univariate and multivariate predictors of coronary artery disease detected simultaneously in carotid artery patients

	Univariate analysis			Multivariate analysis		
	Odds Ratio	95% CI	*P*	Odds Ratio	95% CI	*P*
Age	1.088	1.063-1.113	<0.001	1.052	1.024-1.081	<0.001
Hypertension	3.080	1.994-4.757	<0.001			
Diabetes Mellitus	2.060	1.375-3.085	<0.001			
Heart Failure	1.866	0.962-3.621	0.065			
CHA2DS2-VASc score	4.908	3.512-6.859	<0.001	4.283	2.903-6.321	<0.001
Glucose	1.005	1.003-1.016	0.005			
Neutrophil	1.222	1.093-1.365	<0.001			
CRP	1.467	1.309-1.644	<0.001	1.211	1.056-1.388	0.006
NLR	1.218	1.071-1.386	0.003			

Discussion

In the present study, we revealed that 32.7% of patients with preoperative CAG were identified with concomitant severe CAD in patients who were scheduled to be stented in the carotid artery due to severe CAS. Furthermore, we demonstrated for the first time in this study that the CHA_2DS_2-VASc score, which is often used in everyday practice and is simple to calculate, may be used to predict concomitant severe CAD in patients undergoing stent implantation for critical carotid stenosis. When our results were analyzed, a CHA_2DS_2-VASc score of >4 was highly significant in predicting severe CAD.

Diseases directly related to atherosclerosis, especially ischemic stroke and CAD, are among the leading causes of death worldwide. Although the correlation between coronary and carotid artery disease was convincingly demonstrated, the incidence rate has not been thoroughly defined due to the presence of numerous asymptomatic cases. However, it is well known that the risk of ischemic stroke increases in patients with CAD, as does the incidence of myocardial infarction in stroke patients.[15–17]

Carotid artery atherosclerosis is a potential source of stroke. Up to 80% of strokes are of ischemic origin, and symptomatic carotid stenosis is involved in 15% to 30% of all ischemic strokes.[9,10,18] In patients under 70 years of age, the reported prevalence of 50% or more asymptomatic CAS is 4.8% in men and 2.2% in women. In patients aged 70 years and older, the prevalence of 50% or more asymptomatic CAS is 12.5% in men and 6.9% in women.[19]

Diagnosing the presence of concurrent CAD in patients who have carotid artery disease early and attempting to use interventions to prevent or postpone its progression and related complications appear to be a significant difficulty. It was been demonstrated that myocardial infarction or sudden cardiac death was the initial cardiac event in 56% of patients with carotid stenosis who had no prior history of CAD.[20] This explains why patients who have carotid stenosis not only are at risk of stroke but also have a very high risk of having a coronary event if they have concurrent CAD. All these suggest that a more aggressive approach to the diagnosis of concomitant CAD in patients with carotid stenosis is needed. However, the optimal treatment modality for severe carotid and coronary artery disease is still not clear. There is also an ongoing debate about the optimal timing of carotid revascularisation in patients who have concurrent coronary and carotid disease. The developments in endovascular technologies support the benefit of carotid stents because they are an acceptable treatment modality in carotid revascularization.[21]

While carotid artery stenting has increasingly replaced surgery in patients who have carotid artery disease in recent years, very few studies examined the prevalence of concomitant CAD. Depending on the features of the study participants and the instruments utilized to detect the presence of CAD, the prevalence of concomitant CAD accompanying carotid stenosis was discovered at different rates in the studies. In their study, Hofmann *et al*.[22] discovered concomitant CAD in 77% of 444 patients who underwent carotid stenting. Enomoto *et al*.[23] observed a 34.8% frequency of newly diagnosed CAD in a similar patient population. Shimada *et al*.[24] and Hertzer *et al*.[25] reported concomitant CAD in 35% and 36% of patients with carotid endarterectomy for carotid artery disease, respectively. Furthermore, different studies have revealed that the prevalence of concomitant CAD in patients with ischemic stroke ranges from 18% to 38%.[26–29] Our study discovered that 32.7% of patients with carotid artery stenting had concomitant CAD.

CRP is a positive acute phase reactant, one of the best-known and most researched inflammatory markers in the literature. As one of the first indicators used

to evaluate the degree of inflammation, hsCRP is widely used to evaluate the severity and prognosis of many cardiovascular diseases, including CAS.[30–34] CRP is involved in the formation and development of atherosclerosis.[35] The serum level of hs-CRP suggests that hs-CRP is associated with the occurrence and progression of both CAD and CAS and may therefore serve as a predictor of the severity of these diseases and cardiovascular events.[36] In our study, hs-CRP was independently associated with CAD severity in patients with CAS. This result supported our opinion that the correlation between atherosclerotic plaque burden and hs-CRP is consistent with the literature.

With the ageing of the population, there was a rapid increase in the number of elderly people. CAD is common in older people. Approximately 10% of 40-year-old men have atherosclerotic plaques, and by the age of 60, more than half of these individuals are diagnosed with atherosclerosis.[37,38] Despite the recommendations on diet and physical activity, and pharmacotherapy in the management of cardiovascular risk factors, atherosclerosis is seen in more than 80% of people as a progressive disease.[39–41] Atherosclerotic risk factors such as DM, HT, and renal dysfunction occur more frequently with age.[42] In addition, the increased amount of collagen in the vascular wall with age causes atherosclerosis and consequently hypertension and with the addition of oxidative stress leads to the development and progression of atherosclerosis. For this reason, age remains the main prognostic factor for the presence and progression of atherosclerosis. In the epdemiological study by Ness *et al*.,[43] the rate of occlusive disease detected in all arterial beds in individuals over 80 years of age was approximately 3 times higher than in middle-aged individuals. Hayek *et al*.[44] showed that PAD was more common with age in patients who had CAD. Wanamaker *et al*.[45] demonstrated that age was an independent variable for the association of CAS in patients undergoing CABG. In our study, CAD was observed more frequently in individuals with CAS with age and age was found to be an independent variable for the presence of CAD in accordance with the literature.

As a systemic inflammatory disease, atherosclerosis is characterized by intense lipid accumulation and foam cell production that can affect more than one vascular bed.[46] The development and progression of atherosclerosis is a multifactorial process. In general, exposure to major cardiovascular risk factors (e.g. age, HT, and DM) raises the risk of atherosclerosis-related diseases in different localizations (such as carotid artery disease and CAD). Risk scores that include these clinical variables (e.g. the CHA_2DS_2-VASc score) might provide more accurate results in determining the extent of atherosclerotic disease than standard risk scores alone. The CHA_2DS_2-VASc score was demonstrated to be significantly related to short- and long-term adverse clinical outcomes in several cardiovascular diseases due to its ease of administration and inclusion of most chronic diseases.[9,47–49] A study conducted with patients who had acute coronary syndrome discovered that patients with a high CHA_2DS_2-VASc score had a higher rate of major adverse cardiovascular events (MACE) in the first year following hospital discharge than those with a low score.[49] Ipek *et al*.[50] discovered that a higher CHA_2DS_2-VASc score was related to a higher no-reflow and in-hospital death risks in patients receiving primary percutaneous coronary intervention. Kurtul *et al*.[51] discovered that a high CHA_2DS_2-VASc score in patients with acute coronary syndrome is related to a higher atherosclerotic burden in the coronary arteries. Cetin *et al*.[52] revealed that the CHA_2DS_2-VASc score can predict the risk of severe CAD in patients with stable CAD. Yalim *et al*.[53] found that the CHA_2DS_2-VASc score strongly correlates with mortality in peripheral artery patients and that this scoring system can be utilized as an independent predictor of mortality.

However, whether the CHA_2DS_2-VASc score is an independent predictor of concomitant CAD in patients scheduled for stenting due to severe carotid stenosis is still unknown. The purpose of this study was to see if the calculated CHA_2DS_2-VASc score in patients with severe carotid stenosis might predict the presence of severe concomitant CAD, and it was hypothesized that patients with a high CHA_2DS_2-VASc score would have a higher risk of concomitant CAD. In conclusion, we discovered that the CHA_2DS_2-VASc score was independently related to diagnosing concomitant severe CAD in patients with severe carotid stenosis. We also discovered a link between a high CHA_2DS_2-VASc score and a high SYNTAX score. Furthermore, we also found that patients with high CHA_2DS_2-VASc scores were more likely to have bilateral carotid stenosis.

In light of these data, it is evident that an effective risk score system is needed to detect concomitant CAD in patients having carotid artery stenting and identify high-risk patients. We believe that a CHA_2DS_2-VASc score of >4 can meet this requirement because it was demonstrated to significantly predict the presence of concomitant CAD in carotid artery patients. We hope the findings shed light on which patients should undergo angiographic screening for concomitant CAD in patients who are scheduled for carotid stenting.

In conclusion, while these results are promising, larger, prospective studies are needed to confirm the utility of

the CHA_2DS_2-VASc score in broader populations and establish its role in clinical guidelines. These findings highlight the potential of the CHA_2DS_2-VASc score to improve the identification of high-risk patients, ultimately enhancing the management of patients with CAS and concomitant CAD.

Limitations

The study had some limitations that should be considered. First and foremost, it was a single-center study. There were relatively few patients and our results; the sample population may not represent the entire cohort. Another limitation of our study is that it is a retrospective design. The lack of patient follow-up was another limitation of this study. We believe that evaluating our findings with large-scale, multicenter, and prospective studies, where the effects of these variables may be limited, would be beneficial.

Author contributions

Conceptualization, OB, SK, YY; methodology, YY, SK, ZC; software, OB, SI, SK; validation, SI, ZC; formal analysis, OB, ZC; investigation, OB, YY, SK; re-resources, SI, YY; data curation, OB, SK, SI; writing—original draft preparation, OB, YY, SK; writing, review and editing, YY, SK; visualization, SI, OB, ZC; supervision, SK, YY; project administration, ZC, YY, SK. All authors have read and agreed to the published version of the manuscript.

Informed Consent Statement

Informed consent was received from the participants.

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Conflicts of interest

There are no conflicts of interest.

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