RESEARCH ARTICLE

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Our Experience in Combined Carotid Endarterectomy and Coronary Bypass Surgery: Postoperative Early Results in 480 Patients

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Objective: Due to the diffuse nature of atherosclerosis, cerebrovascular, and coronary artery disease may present simultaneously. A proportion of the patients undergoing cardiac surgery are at an increased risk for carotid artery disease (CAD) related neurological events. The ideal operation strategy is still controversial in patients with concomitant carotid artery stenosis (CAS) undergoing coronary artery bypass grafting (CABG). In this study, we aimed to evaluate the outcomes of isolated CABG versus combined surgery (CEA+CABG) in patients with CAD and to identify the possible correlation between CAD and stroke.

Materials and Methods: Between January 2017 and April 2019, medical files of a total of 480 patients who underwent carotid artery Doppler ultrasonography before CABG were retrospectively analyzed. Demographic and clinical data of the patients and carotid artery status as assessed by Doppler USG were recorded. Neurological complications were evaluated during the hospital stay.

Results: Of the patients, 312 were males and 168 were females with a mean age of 62±10.4 (range: 44 to 78) years. A statistically significantly higher number of patients with severe CAD had a preoperative history of cerebrovascular accident (P=0.048), advanced age (P=0.002), prior CEA (P=0.576), and peripheral artery disease (P=0.048). Of 36 patients with severe CAD, 21 underwent combined surgery. None of the patients treated with CEA+CABG had neurological events. The neurological in-hospital mortality and morbidity was 3.2% in 459 patients with isolated CABG.

Conclusion: Combined surgery can yield the most favorable outcomes in patients with severe CAD or symptomatic CAD accompanied by unstable angina, left main coronary artery disease, and multi-vessel disease.

Key Words: *Coronary arter bypass surgery, carotid artery stenosis, carotid endarterectomy, stroke*

Kombine Karotid Endarterektomi ve Koroner Baypas Cerrahisinde Deneyimlerimiz: 480 Hastada Postoperatif Erken Sonuçlar

Amaç: Aterosklerozun diffüz olma özelliği nedeniyle, serebrovasküler hastalık ve koroner arter hastalığı birlikte bulunabilir. Kardiyak cerrahiye giden hastaların bir kısmı karotis arter hastalığı (KAH) ve serebrovasküler hastalık nedeniyle nörolojik olaylar için yüksek risk altındadır. Koroner arter baypas greftleme (KABG) yapılan ve eş zamanlı karotis arter darlığı (KAD) bulunan hastalardaki en uygun operasyon stratejisi halen tartışmalıdır. Bu çalışmada, KAH'lı hastalarda izole KABG ile kombine (karotis endarterektomisi [KEA] + KABG) cerrahi sonuçları karşılaştırıldı ve KAH ve inme arasındaki muhtemel ilişki değerlendirildi.

Gereç ve Yöntem: Ocak 2017-Nisan 2019 tarihleri arasında, KABG öncesinde karotis arter Doppler ultrasonografisi (USG) çekilmiş toplam 480 hastanın tıbbi dosyası retrospektif olarak incelendi. Hastaların demografik ve klinik verileri ve Doppler USG ile tespit edilen karotis arter durumları kaydedildi. Hastanede kalış süreleri içindeki nörolojik komplikasyonlar değerlendirildi.

Bulgular: Hastaların 312'si erkek ve 168'i kadın olup, yaş ortalaması 62±10.4(dağılım: 44-78) yıl idi. Hastaların 36'sında ciddi KAD vardı. Ameliyat öncesi serebrovasküler olay öyküsü (P=0.048), ileri yaş (P=0.002), geçirilmiş KEA (P=0.576) ve periferik arter hastalığı (P=0.048) ciddi KAD'lı hastalarda istatistiksel olarak anlamlı düzeyde daha fazlaydı. Ciddi KAD'lı 36 hastanın 21'ine kombine cerrahi uygulandı. Kombine cerrahi uygulanan hastaların hiçbirinde nörolojik olay görülmedi. İzole KABG uygulanan 459 hastada, hastanede kalış süresince toplam nörolojik mortalite ve morbidite oranı %3.2 olarak bulundu.

Sonuç: Ciddi KAD veya semptomatik KAD ile birlikte kararsız anjina, sol ana koroner arter hastalığı ve yaygın çok damar hastalığı olan hastalarda en iyi sonuçlar kombine (KEA+KABG) cerrahi ile elde edilebilir.

Anahtar Kelimeler: *Koroner arter baypas cerrahisi, karotis arter darlığı, karotis endarterektomi, inme*

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Introduction

Patients undergoing cardiac surgery may be at an increased risk for neurological disorders due to symptomatic or asymptomatic carotid artery disease (CAD). Although many procedures are currently carried out under cardiopulmonary bypass (CPB), clinical neurological disorders can be encountered due to low blood flow and thromboembolism-related cerebral ischemia and cerebral injury (1).

Stroke is the leading cause of morbidity with a multifactorial etiology following coronary artery bypass grafting (CABG). Neurological deficits in patients undergoing CABG are mainly associated with reduced cerebral blood flow through the stenotic extra- and intracranial vessels, atherosclerotic plaque embolization from the ulcerative carotid artery plaque or aorta, post-infarction left ventricular mural thrombus or atrial thrombus embolization, air embolism which is inadequately aspirated from the heart or aorta, inflammatory thrombogenicity, inadequate antiplatelet therapy, and hemodynamic instability (1). Several studies have shown that the main cause of stroke during CABG is atherosclerotic plaque embolization (1-3). Previous transient ischemic attack (TIA) and a previous history of stroke are the major predictors of perioperative stroke (2). Cerebral blood flow is proportional to the cerebral perfusion pressure; therefore, CPB is likely to impair the cerebral artery autoregulation (4). In the case of reduced arterial perfusion pressure, cranial blood flow also decreases. A decline in the perfusion pressure of the distal carotid artery stenosis (CAS) results in inadequate cerebral blood flow in patients with>70% stenosis (5, 6). However, there is no evidence showing that CAS is a risk factor for perioperative stroke, except for severe bilateral carotid bifurcation stenosis (7).

The indication of carotid revascularization should be individualized for each patient scheduled for CABG and the decision should be made by a multidisciplinary team including a neurologist, as well (8). On the other hand, surgical treatment is controversial in asymptomatic patients with evident CAS. Prophylactic carotid endarterectomy (CEA) cannot completely reduce the perioperative stroke risk in CABG candidates with unilateral, asymptomatic CAS and, therefore, prophylactic CEA is recommended for only patients with severe bilateral CAS (70 to 99%) or previous TIA or a previous history of stroke (9). In the clinical practice, the sequence of surgical procedures depends on the severity of the neurological or cardiac pathologies in CAD patients undergoing CABG.

In the present study, we aimed to evaluate the outcomes of isolated CABG versus combined (CEA+CABG) surgery in patients with CAD and to identify a possible correlation between CAD and stroke.

Materials and Methods

Research and Publication Ethics: The study protocol was approved by the local Ethics Committee (Date: 02.04.2019/Decree No.25). The study was conducted in accordance with the principles of the Declaration of Helsinki.

This single-center, retrospective study was conducted between January 2017 and April 2019. A total of 1.155 CABG patients were screened. Of these, 480 patients who underwent carotid artery Doppler ultrasonographic (USG) examination 1 to 15 days before surgery were retrospectively analyzed using the patient files and radiology reports registered in the hospital information system. Of the patients, 21 underwent combined surgery simultaneously (CEA+CABG). These patients were later excluded from the analyses of postoperative neurological disorders and mortality.

Data including demographic and clinical characteristics of the patients, the presence of preoperative previous TIA, stroke, or prior CEA were recorded. All patients were classified according to the extent of CAS, as evidenced by carotid Doppler USG before CABG. Written informed consent was obtained from each patient.

Statistical Analysis: Statistical analysis was performed using the statistical software program SPSS 13.0 (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed in mean±standard deviation (SD), median (min-max) or number and frequency. The chi-square test was used to assess variables. Logistic regression analysis was carried out to identify predictors of CAD. A P-value of<0.05 was considered statistically significant.

Results

Of the patients, 312 were males and 168 were females with a mean age of 62±10.4 (range, 44 to 78) years. A total of 63 patients (13.1%) had peripheral vascular disease, while 36 patients (7.5%) had preoperative neurological symptoms. Eighteen patients (4.1%) had prior CEA. The majority of the patients (n=264, 55%) had the Canadian Cardiovascular Society (CCS) Class III-IV angina. The demographic and clinical characteristics of the patients are shown in Table 1.

Table 1. Demographic and clinical characteristics of the patients (n=480)

Variable	%	N
Age, year (mean±SD)	62±10.4	
Sex (Male)	65	312
Smoking	66.8	321
Diabetes	25.6	121
Hypertension	55	264
Hyperlipidemia	31.8	153
Peripheral artery disease	13.1	63
Angina, CCS Class III-IV	55	264
Congestive heart failure, NYHA Class III-IV	1.8	9
Previous MI	55	264
Previous neurological symptoms		
No	92.5	444
TIA	3.1	15
CVA	4.3	21
Total	7.5	36
Prior CEA	3.7	18

Data are given in number (n) and percentage (%), unless otherwise stated. SD: Standard deviation; CCS: Canadian Cardiovascular Society; NYHA: New York Heart Association; MI: Myocardial infarction; CABG: Coronary artery bypass grafting; TIA: Transient ischemic attack; CVA: Cerebrovascular accident; AF: Amaurosis fugax; CEA: Carotid endarterectomy.

Of all patients, 36 (7.5%) had severe CAD. Of these patients, 27 had severe unilateral CAS with a mild, moderate, or severe stenosis of the contralateral carotid artery. Nine patients had unilateral complete occlusion with mild, moderate, or severe stenosis of the contralateral side. Among 384 patients (80%), a decline of less than 50% in the vessel diameter was observed bilaterally. In 60 patients (12.5%), unilateral moderate stenosis (50 to 79%) was observed with mild or moderate stenosis of the contralateral side. Doppler USG results are summarized in Table 2.

According to the logistic regression analysis, prior CEA, peripheral artery disease (PAD), presence of preoperative neurological symptoms, and advanced age were the main predictors of severe CAD (Tables 3 and 4).

Among 36 patients with severe CAS, 21 underwent CEA+CABG simultaneously. Nine of these patients were symptomatic, while the remaining 12 patients were asymptomatic. Fifteen patients in the combined treatment group had severe unilateral CAS (80 to 90%) with a mild (50%), moderate (50 to 79%), and severe (80 to 99%) stenosis of the contralateral carotid artery. The remaining six patients had unilateral complete occlusion with moderate and severe stenosis of the contralateral side. None of the patients receiving combined treatment had any postoperative neurological complications (Table 5).

Table 2. Incidence of CAD

Severity of CAS %		n	%	Preoperative TIA or stroke	N CEA
<50	<50	384	80	18	
50-79	<50	48	10	6	
50-79	50-79	12	2.5	3	
80-90	<50	9	1.8	3	3
80-90	<50-79	12	2.5	3	6
80-90	80-90	6	1.2	3	6
100	<50	3	0.6		
100	50-79	3	0.6		3
100	80-99	3	0.6		3
Total		480	100	36	21

Data are given in number (n) and percentage (%), unless otherwise stated. CAD: Carotid artery disease; CAS: Carotid artery stenosis; TIA: Transient ischemic attack; CEA: Carotid endarterectomy.

Table 3. Risk factors for severe CAD (n=480)

Variable	<80% stenosis n=444		>80% stenosis n=36		P value
	%	n	%	n	
Age, year (mean±SD)	62.5±10		66±6.5		0.002
Sex (Male)	64.8	288	66.6	24	0.899
Smoking	66.8	297	66.8	24	0.987
Diabetes	25	121	25	9	0.524
Hypertension	54	240	66.6	24	0.398
Hyperlipidemia	31.7	141	58.3	21	0.910
Peripheral artery disease	9.4	52	58.3	21	0.001
Angina, CCS Class III-IV	55.4	246	50	18	0.717
Congestive heart failure, NYHA Class III-IV	2	9	0		0.618
Previous MI	54	240	66.6	24	0.987
Preoperative neurological symptoms	6	27	25	9	0.048

Data are given in number (n) and percentage (%), unless otherwise stated. CAD: Carotid artery disease; SD: Standard deviation; CCS: Canadian Cardiovascular Society; NYHA: New York Heart Association; MI: Myocardial infarction; CABG: Coronary artery bypass grafting; CEA: Carotid endarterectomy.

Table 4. Logistic regression analysis for CAD (n=480)

Variable	Risk factor	Relative risk	P value
Severe CAD n=36	Prior CEA	16.1	0.001
	PAD	13.3	0.001
	Preoperative neurological symptoms	5.1	0.028
	Advanced age	2.04	0.006

CAD: Carotid artery disease; CEA: Carotid endarterectomy; PAD: Peripheral artery disease.

The in-hospital neurological disorder-related mortality rate was 0.6% and the morbidity rate was 3.2% among the patients who underwent an isolated CABG. The patients (n=21) who underwent combined treatment were excluded from the analysis. Fifteen patients developed cerebrovascular accident, while three patients died from the cerebrovascular accident. Six of 15 neurological complications were observed in patients with severe CAD. Three patients had a CAS of ≥80% in the same carotid artery, while the other three patients had a CAS of 80 to 99% in the contralateral side. Nine patients with neurological complications had normal carotid arteries or a CAS of <80% (Table 6).

After 21 patients in the combined treatment group were excluded, preoperative variables were compared between the patients with and without neurological complications. The patients with neurological complications were older than those without with a mean age of 69±6.5 years versus 62.5±10.3 (P=0.0089). Of the patients with and without neurological complications, 60% and 8.7% had PAD, respectively (p=0.0836), while 40% and 2.7% of the patients with and without neurological complications had prior CEA, respectively (P=0.01223). In addition, 40% and 6.1% of the patients with and without neurological complications had severe CAD, respectively (P=0.0086), indicating a statistical significance (Table 7).

Table 5. Data of the patients receiving combined surgery (CEA+CABG) (n=21)

Severity of CAS (%)		n	Preoperative TIA or stroke	Postoperative stroke	Postoperative RIND	Exitus
80-90	<50	3	3	0	0	0
80-90	50-79	6	3	0	0	0
80-99	80-99	6	3	0	0	0
100	50-79	3	0	0	0	0
100	80-99	3	0	0	0	0

CAD: Carotid artery disease; CAS: Carotid artery stenosis; TIA: Transient ischemic attack; CEA: Carotid endarterectomy; CABG: Coronary artery bypass grafting; RIND: Reversible ischemic neurological deficit.

Table 6. Perioperative neurological events in isolated CABG patients (n=459)

Postoperative variable	<80% stenosis n=444		>80% stenosis n=15	
Neurological event	%	N	%	N
TIA		0		0
RIND		0		0
AF		0		0
CVA	1.3	6	40	6
CVA-related exitus	0.6	3		
Total	2.2	9	40	6

Data are given in number (n) and percentage (%), unless otherwise stated. CABG: Coronary artery bypass grafting; TIA: Transient ischemic attack; RIND: Reversible ischemic neurological deficit; AF: Amaurosis fugax; CVA: Cerebrovascular accident.

Table 7. Risk factors for neurological events in isolated CABG patients

	Neurological events (-) (n=444)		Neurological events (+) (n=15)		
Risk factor	%	n	%	n	**P value**
Age, year (mean±SD)	62.5±10.3		69±6.5		0.008
Sex (Male)	65.5	291	60	9	0.567
Smoking	68.2	303	60	9	0.514
Diabetes	24.3	108	40	6	0.363
Hypertension	54.7	243	60	9	0.592
Hyperlipidemia	31	138	40	6	0.501
Peripheral artery disease	8.7	39	60	9	0.083
Angina, CCS Class III-IV	54.7	243	60	9	0.592
Previous MI	54.7	243	60	9	0.592
Preoperative neurological symptoms	5.4	24	40	6	0.064
Prior CEA	2.7	12	40	6	0.012
Severe CAD (>80%)	6.1	30	40	6	0.008

Data are given in number (n) and percentage (%), unless otherwise stated. SD: Standard deviation; CCS: Canadian Cardiovascular Society; NYHA: New York Heart Association; MI: Myocardial infarction; CABG: Coronary artery bypass grafting; CEA: Carotid endarterectomy; CAD: Carotid artery disease.

Table 8. Logistic regression analysis for postoperative neurological events in isolated CABG patients

Variable	Risk factor	Relative risk	P value
Postoperative neurological events (n=15)	Prior CEA	240	0.002
	Severe CAD	19.8	0.003
	PAD	15.5	0.004
	Advanced age	2.8	0.024
	Preoperative neurological symptoms	2.3	0.052

CABG: Coronary artery bypass grafting; CEA: Carotid endarterectomy; CAD: Carotid artery disease; PAD: Peripheral artery disease.

The logistic regression analysis revealed that prior CEA, severe CAD, PAD, presence of preoperative neurological symptoms, and advanced age were the main predictors of postoperative neurological complications (Table 8).

Discussion

Stroke associated with cardiac surgery is the most important postoperative non-cardiac major complication. Carotid stenosis is associated with a higher risk of perioperative and postoperative stroke. Studies have shown that approximately 3% of patients with CABG and concomitant asymptomatic and severe carotid stenosis have a stroke. In addition, this rate increased to 5% in those with bilateral carotid stenosis (10). Therefore, carotid revascularization before CABG may reduce the incidence of stroke. Although researchers have advocated the potential benefits of varying treatment strategies due to combined or staged surgical therapy, there is no consensus in national or international clinical treatment guidelines.

Causes of stroke in open-heart surgery; atherosclerotic debris embolization from the ascending aorta, embolization of ventricular mural thrombi, air, fat, or platelet aggregates, thromboembolic events of the carotid artery, inadequate preoperative antiplatelet therapy and hemodynamic instability, and cerebral hypoperfusion (8, 11-14) have been reported. Previous studies have shown that CAS is not one of the leading causes of perioperative stroke, except for severe bilateral carotid bifurcation stenosis (7). In addition, previous stroke and TIA have been found to be the main predictors of perioperative stroke (8).

In the present study, we attempted to identify high-risk patients' preoperative predictors for CAD and to estimate the incidence of CAD using carotid artery Doppler USG examinations before elective coronary revascularization. Severe CAD was defined as ≥80% stenosis of one of the carotid arteries. We also evaluated combined treatment (CEA+CABG) and postoperative neurological complications. Our examination changed the treatment trend in the minority of patients and there was no significant correlation between these changes and reduced perioperative stroke risk.

Previous studies also recommended preoperative color Doppler USG in patients with a history of TIA or stroke within the past six months to reduce stroke risk in CABG patients (8). Consistent with our study and other retrospective studies, it is reasonable to identify high-risk patients and to perform non-invasive imaging; otherwise, the imaging of all patients who are scheduled for CABG would be time-consuming and expensive (15). In brief, preoperative carotid artery color Doppler USG is recommended for only those aged >70 years, having multi-vessel disease, PAD, and carotid murmur among those without a history of stroke or TIA within the past six months (8). In addition, it is not indicated in emergency CABG in patients without a history of stroke or TIA.

In the present study, 384 of 480 patients had mild CAS (≤50%). Moderate CAS (50 to 79%) and severe CAS (≥80%) or complete occlusion were detected in 60 and 36 patients, respectively. Faggoli et al. (12) found the rate of severe stenosis (≥75%) to be 8.7% in 539 asymptomatic patients using preoperative Doppler USG. In another study, Berens et al. (16) found an internal carotid artery (ICA) stenosis of ≥80% in 5.9% of the study population (n=1.087) aged above 65 years scheduled for cardiac surgery. These study findings are consistent with our results, indicating that doppler USG is a reliable tool for the evaluation of preoperative CAS.

In our study, prior CEA, PAD, presence of preoperative neurological symptoms, and advanced age were the main predictors of severe CAD. Of note, the mean age was older in patients with severe CAD than those without (66±6.5 years *vs.* 62.5±10 years, respectively). Similarly, Faggioli et al. (12) reported that the incidence of ≥75% CAS was 11.3% and 3.8% in patients aged above 60 years and under 60 years, respectively. In the current study, 25% of the patients with severe CAS had prior CEA in the contralateral carotid artery. The rate of patients with severe CAS without prior CEA was 2%. Consistent with our findings, Schwartz et al. (17) and Salasidis et al. (18) reported that prior CEA was a significant risk factor for severe CAS. In addition, PAD was observed in 58.3% and 9.4% of the patients with and without severe CAS, respectively (P=0.0013). Likewise, Sutton et al. (19) suggested that PAD was the major determinant for CAD in the elderly with isolated systolic hypertension. In their study, Ahn et al. (20) also reported the incidence of severe CAS (≥80%) as 5% in asymptomatic PAD patients.

In the present study, the rate of previous neurological disorders was 25% and 6% in the patients with and without severe CAS, respectively (P=0.048). Consistent with our findings, Schwartz et al. (17) found the advanced age, prior CEA, preoperative cerebrovascular symptoms, and the presence of cervical murmur and PAD to be significant risk factors for severe CAD. In our study, sex, smoking, presence of diabetes, hypertension, hyperlipidemia, angina, congestive heart failure, previous myocardial infarction were not found to be significant risk factors for severe CAD. Similarly, Schwartz et al. (17) found no significant correlation between CAD and systemic and cardiac risk factors such as hypertension, diabetes, myocardial infarction, left main coronary disease, and smoking.

Furthermore, the overall neurological in-hospital mortality and morbidity was 3.2% in 459 CABG patients in our study. Six of 15 neurological complications were observed in patients with severe CAD (≥80%), while the other six patients with less CAS (<80%) had neurological complications. Three patients died from cerebrovascular accidents. In their study, Salasidis et al. (18) found that the postoperative incidence of neurological complications was 18.2% in 22 CABG patients with severe CAS (≥80%) and 1.7% in 354 patients with less CAS (<80%). In a study including 38 patients, Yilmazkaya et al. (21) showed that none of the patients treated with combined surgery had a stroke in the postoperative period and the mortality rate due to low cardiac output was 2.6%. In another study including 128 asymptomatic cardiac surgery patients, Faggioli et al. (12) demonstrated that the stroke incidence was 14% in patients with >75% CAS. In their study including 582 patients, in another study including 300 CABG patients, Ulger et al. (22) showed that postoperative stroke was responsible for one in four deaths (1.3%) and that postoperative stroke was correlated with >50% CAS and a previous history of stroke. On the other hand, we detected 40% CVA after isolated CABG in cases with more than 80% stenosis. In cases with stenosis less than 80%, we observed CVA rate of 1.3% after CABG. The rate of exitus due to CVA was 0.6%. In our study, the stroke incidence was 1.3% in patients without severe CAS, consistent with previous studies. However, the stroke incidence was higher in our patients with severe CAS due to the small sample size with severe CAS, although not statistically significant.

More importantly, patients with neurological disorders were older than those without any neurological events in our study. In addition, PAD, CAD, and preoperative neurological symptoms were more frequent in these patients. Similarly, Gardner et al. (23) found a significant correlation between postoperative stroke and advanced age, cerebrovascular accidents, ascending aortic atherosclerosis, and prolonged CPB. In another study, Tuman et al. (24) found a stroke incidence of 0.9% and 8.9% in patients aged under 65 years and above 75 years, respectively. Faggioli et al. (12) also reported a stroke incidence of 11.3% and 3.8% in patients above 60 years and under 60 years, respectively following CABG. In our study, the stroke incidence was unable to be evaluated according to age groups. However, patients with neurological disorders were older in our study.

In a previous study including 1,1779 patients, Ricotta et al. (25) found a significant correlation between postoperative stroke and >50% CAS, redo cardiac surgery, valve surgery, and a previous history of neurological disorders. In the aforementioned study, there was also a significant correlation between postoperative mortality and >50% CAS, redo cardiac surgery, PAD, prolonged pump time, and hyperlipidemia and the authors reported a stroke rate of 1.6% and a mortality rate of 3.1%. In our study, 40% of the patients with ≥80% CAS had a cerebrovascular accident after isolated CABG, while this rate was 1.3% in patients with less than 80% stenosis. The cerebrovascular accident-related mortality rate was 0.6%.

In the current study, 21 of 36 patients with severe CAS underwent combined treatment (CEA+CABG). Nine of these patients were symptomatic, while twelve patients were asymptomatic. None of the patients treated with combined surgery had postoperative neurological complications. Bitao et al. (26) in their study with 245 coronary bypass patients, they reported a stroke rate of 9.38% and a 6-month mortality rate of 3.13% in 32 patients they applied combined surgery. Berens et al. (16) reported the incidence of stroke as 6.5% after combined surgery and 7.4% in elderly patients. Yılmazkaya et al. (21) In the study in which they examined 38 patients who underwent combined surgery, stroke was not observed in any patient in the postoperative period and they reported that the mortality due to low flow rate was 2.6%. Some authors have also suggested that combined treatment reduces the incidence of late stroke and perioperative stroke, as it is performed under the same anesthesiology session (15, 27). According to the results of our study; Combined CEA / CABG is the most ideal treatment method to be preferred in the presence of coronary artery disease and severe carotid disease.

Nonetheless, the present study has certain limitations. First, it has a retrospective design with relatively small sample size. Second, it has a single-center design that precludes the generalization of the findings. Third, we were unable to identify the etiology of stroke whether it was caused by thrombosis, embolism, or hypoperfusion in each individual patient. Further large-scale, prospective studies are needed to confirm these findings.

In conclusion, our study results show that advanced age, presence of PAD, previous cerebrovascular accidents, and prior CEA are the main risk factors for CAD. Patients having at least one of these risk factors should undergo a detailed carotid artery color Doppler USG examination before CABG, which is a reliable and non-invasive diagnostic tool. In patients with CAD accompanied by coronary artery disease, staged surgery is recommended (CEA followed by CABG), in case of a stable cardiac condition. However, CABG is associated with a higher risk for neurological complications in asymptomatic unstable angina patients with carotid artery murmurs (<50%) or moderate CAS (50 to 75%) with a previous history of stroke. In patients with severe bilateral CAD or symptomatic CAD accompanied by unstable angina, left main coronary artery disease, or diffuse multi-vessel disease, combined surgery can yield the most favorable outcomes. In patients with greater stenosis, CEA should be applied to the carotid artery supplying the dominant hemisphere first and, then, CABG should be undertaken. The contralateral carotid artery should be treated with CEA a couple of days later. Finally, the presence of CAD is one of the major determinants of mortality and morbidity following CABG in patients with atherosclerotic coronary artery disease. Therefore, these patients should be carefully evaluated before CABG to minimize postoperative complications.

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