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Is Carotid Artery Stenting an Alternative to Simultaneous Carotid Endarterectomy Performed for Carotid Artery Stenosis in Patients Undergoing Isolated Coronary Bypass Surgery?

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ABSTRACT

Background: Treatment method in patients with coronary artery disease undergoing coronary bypass surgery with accompanying carotid artery disease is still a hot topic among clinicians. This study is designed to investigate if there is an effect on myocardial infarction, cerebrovascular events and mortality during postoperative period of simultaneous carotid endarterectomy with coronary bypass surgery compared to staged carotid artery stenting before coronary bypass surgery.

Methods: 102 patients (79 male, 23 female) who underwent simultaneous carotid endarterectomy with coronary bypass surgery or staged carotid artery stenting with coronary bypass surgery in the same center with the same surgical team were divided into 2 groups and retrospectively reviewed. Group 1 (n = 71) had coronary artery bypass surgery under general anesthesia with carotid endarterectomy followed by cardiopulmonary bypass with heart team decision. Again with heart team decision, Group 2 (n=31), patients at high-risk for carotid endarterectomy (serious cardiac disease, severe chronic obstructive pulmonary disease, superiorly located lesions), received carotid artery stents in the interventional radiology department and a month later, coronary bypass surgery was performed with cardiopulmonary bypass under elective conditions.

Results: Median of patient age was 67.5 (45-83) years. Twenty-two patients (31%) in Group 1 and 19 patients (56.3%) in Group 2 had neurological symptoms, which was statistically significant (P = .004). During the early postoperative term, three patients (4.2%) in Group 1 and two patients (6.5%) in Group 2 died (P = .64). Five patients (7.0%) in Group 1 and two patients (6.5%) in Group 2 developed neurological symptoms during the early postoperative term (P > .05). Likewise, two patients (2.8%) in Group 1 and five patients (16.1%) in Group 2 developed myocardial infarction following carotid intervention (P = .03).

Conclusions: In patients with significant carotid artery stenosis undergoing coronary bypass surgery with cardiopulmonary bypass, in comparison to simultaneous carotid endarterectomy with coronary bypass technique and carotid artery stenting followed with coronary bypass technique showed no difference in combined endpoint (postoperative myocardial infarction, neurological events, and mortality). With proper tools and according to the decisions made by heart teams, both management strategies can be safely performed.

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INTRODUCTION

Peripheral artery and carotid artery diseases are common in patients with coronary artery disease due to the systemic nature of atherosclerosis. For this reason, 40-50% of patients with severe carotid artery lesions have coronary artery disease. In addition, 3-16% of coronary artery disease patients have accompanying carotid artery disease [Minami 2000].

Stroke is one of the most serious postoperative complications following coronary artery bypass grafting (CABG). In recent studies, the frequency of severe perioperative strokes in patients undergoing CABG has varied between 0.3% and 3.9% [Karimi 2008]. Currently, carotid endarterectomy (CEA) is the standard therapy in the treatment of carotid artery stenosis [Aydin 2014]. Since the early 90s, balloon dilatation angioplasty and carotid artery stenting (CAS) are used as alternatives to CEA surgery with the same low morbidity and mortality rates seen in CEA surgery [Boztosun 2012].

The proper treatment management strategy in cases with simultaneous coronary artery and carotid artery disease is still widely debated. Combined CABG and CEA surgeries report mortality rates as 2-12% and stroke rates as 1-15% in various studies [Bozoğlan 2012]. North America Symptomatic Carotid Endarterectomy Trial (NASCET) and European Carotid Surgery Trial (ECST) studies proved the superiority of endarterectomy over medical management in symptomatic cases with carotid artery stenosis over 70% for prevention of ischemic strokes [NASCET Collaborators 1991; ECST 1998].

The popularity and availability of rapidly progressing carotid angioplasty and stent implantations in high-risk patients (those with congestive heart failure, low left ventricle ejection fraction, advanced age [>80 years], chronic obstructive pulmonary disease [COPD], advanced bilateral carotid artery disease or total occlusion of contralateral internal

carotid artery) as an alternative treatment to CEA, with the consensus from cardiology, neurology, cardiovascular surgery and radiology departments, is still debated [Yadav 2004]. In previous studies, endovascular treatment methods gained non-inferior results in comparison with CEA [Aydıner 2007].

Carotid and Vertebral Artery Transluminal Angioplasty Study (CAVATAS), done in 2001 with 504 symptomatic patients, compared carotid endarterectomy and carotid angioplasty. No significant difference was observed between the groups in terms of stroke and death in the first 30 days of surgery (9.9-10%, respectively) [CAVATAS 2001]. In a randomized, controlled and multicenter Carotid Revascularization Endarterectomy and Stenting Trial (CREST) study, CEA and CAS were compared in symptomatic and asymptomatic cases. In this study, primary end point was defined as perioperative stroke, myocardial infarction or death, or unilateral stroke on the same side until the 4th year of surgery. Primary end points were seen on 7.2% of CAS and 6.8% of CEA patient groups. There were no significant differences in terms of perioperative death, stroke, or myocardial infarction [Brott 2010].

This study is designed to investigate whether simultaneous CABG and with CEA or staged CAS and CABG based on heart team decision have an effect on myocardial infarction, neurologic events, and mortality rates during the postoperative period or not.

MATERIALS AND METHODS

Data of 102 patients who received isolated CABG and carotid artery interventions for carotid artery stenosis together with coronary artery disease between January 2007 and May 2014 in a single center were investigated retrospectively. Demographic and clinical properties, preoperative risk factors, operation techniques, operation notes, postoperative myocardial infarction, neurological complications (transient ischemic attack, hemiplegia, and hemiparesis), mortality and morbidity rates, and early to middle-term clinical outcomes of the patients were reviewed. The study consists of 79 (77.5%) male and 23 (22.5%) female patients with an average age of 65.4 ± 7.9 (range: 45-83, median: 67.5) years.

During preoperative term, color Doppler ultrasonography (CDUS) was employed in all patients who required surgery for coronary artery disease. In patients diagnosed with carotid artery stenosis over 70% in CDUS, the stenosis rates were confirmed using either digital subtraction angiography or computerized tomography angiography. NASCET criteria states that the carotid artery lesion is severe if lesion diameter is >70% in symptomatic and >80% in asymptomatic patients [Gray 2009]. All patients went under cardiopulmonary bypass (CPB) with isolated CABG and CEA or CAS. Patients with increased risk for CEA intervention (increased cardiopulmonary bypass risk, unsuitable neck anatomy, stenosis following CEA, previously received neck dissection or radiotherapy, carotid artery stenosis in a superior location, advanced COPD, those with congestive heart failure, decreased left ventricle ejection fraction, advanced age [>80 years], advanced bilateral carotid artery disease or total occlusion of contralateral internal carotid artery) were referred to CAS with the consensus of a heart team consisting of a neurologist, a cardiologist, a cardiovascular surgeon, and an interventional radiologist. CAS was not performed in high-risk patients with significantly widened aortic arch, widespread peripheral vascular disease or severe aorta tortuosity that makes endovascular interventions difficult, allergy and/or sensitivity to medications used (aspirin, heparin, clopidogrel etc.), coagulopathy, hemorrhaging diathesis, progressive stroke, spontaneous intracranial hemorrhage history within last year and severe renal insufficiency with heart team consensus. In addition, patients with congenital heart disease (atrial septal defect, ventricular septal defect etc.), valvular heart disease, and disease of the aorta who underwent surgery were also excluded from the study. Patients' follow-up during intensive care period, in-hospital period, and outpatient period was done by the same surgical team. Patients who received CAS were also followed by neurology and interventional radiology departments.

Patients were divided into 2 groups. Group 1 consisted of patients with combined CEA + CABG surgery. Group 2 patients received progressive CAS with CABG. 71 patients (69.6%) in Group 1 were operated under general anesthesia in a single setting with CEA followed by CPB and isolated CABG by the same surgical team. 31 patients (30.4%) in Group 2 with symptomatic internal carotid arterial lesions were treated with a self-expanding hybrid stent in carotid artery, and post-dilatation was performed after stent implantation in the interventional radiology clinic. Those patients were treated with low molecular weight heparin and clopidogrel for 7 days after stenting and were prescribed with acetylsalicylic acid combined with clopidogrel for three weeks. A month later, CPB and isolated CABG were performed on those patients under elective conditions. Stump pressure measurements were not done in Group 1 patients and no intraluminal carotid artery shunts or intraoperative cerebral monitoring tools were used. Filtration system was used in all patients in the carotid artery stenting group.

Patients' clinical and demographic properties were recorded after a thorough review of patient records, discharge reports, operation notes, lab results, and radiological images received from the radiology archive. Neurologically asymptomatic patients were defined as patients with carotid artery stenosis without any previous neurologic events from carotid or vertebrobasilar area. Patients with previous stroke or transient ischemic attack (TIA) in carotid artery or vertebrobasilar system before admission were defined as neurologically symptomatic patients. Patients with persistent postoperative stroke lasting longer than 24 hours after surgery and with new focal neurological deficit foci caused by new ischemic damage were defined as having neurological deficit.

Patient follow-up after discharge was done in early term (first month), middle term (2-36 months), and late term (37-91 months) following surgery.

This study is in accordance with criteria defined in Declaration of Helsinki and approved by Kocaeli University Faculty of Medicine Ethics Committee.

Anesthesia Technique

0.5 mg alprazolam was orally administered in all patients included in the study on the night before surgery. Intramuscular midazolam 5 mg was used for premedication 30 minutes before surgery. Midazolam was not given to CAS patients. Anesthesia induction was done using IV midazolam (0.1 mg/kg), fentanyl (0.01 mg/kg), and rocuronium (0.6 mg/kg). Rocuronium (0.15 mg/kg) and midazolam (0.03 mg/kg) were used intravenously for anesthesia maintenance. Local anesthesia in CAS patients was done using lidocaine HCl.

Operative Technique

Carotid artery endarterectomy was performed in all patients before median sternotomy. Endarterectomy procedure was performed primarily on the side with a greater rate of stenosis. Intraoperative cerebral monitoring devices were not used in patients. Under general anesthesia, carotid artery was explored from a longitudinal incision starting from the anterior side of sternocleidomastoid muscle to sternoclavicular articulation. 5000 IU IV unfractioned heparin was administered to all patients before carotid artery clamping. Arteriotomy was performed beginning from the common carotid artery to the internal carotid artery. Plaque was removed in one piece. Distal end of the plaque was transected and fixated if necessary. Arteriotomy was primarily closed in patients with internal carotid artery diameters over 6 mm; saphenous vein or Dacron patches were used for internal carotid arteries with small diameter (<6 mm). Following the end of the carotid procedure, the operation site was temporarily closed until the end of the cardiac procedure. This is done mainly to decrease the risk of hematoma caused by high-dose heparin during cardiac procedure.

At least 2 days before carotid artery stenting procedure, patients were administered a loading dose of 300 mg acetylsalicylic acid and 600 mg clopidogrel and antiaggregant treatment was continued with oral 100 mg acetylsalicylic acid and 75 mg clopidogrel. In order not to affect neurological examination results, sedatives were not given to patients before the procedure. Philips Integris V (Philips Medical Systems, Amsterdam, Netherlands) Digital Subtraction Angiography was used for imaging during interventional procedures. The stent used during the procedure was Carotid WALLSTENT Monorail Endoprosthesis (Boston Scientific, USA) and the filter was either FilterWire EX (Boston Scientific Natick, Marlborough, MA, USA) or ANGIOGUARD RX Emboli Capture Guidewire System (Cordis, Minneapolis, MN, USA). Both common carotid arteries were selectively catheterized and the images obtained were used to pinpoint size, location, degree of stenosis, and ulceration of the lesions. All patients received 100 U/kg IV unfractioned heparin. Patients were monitored during the operation using arterial pressure readings and electrocardiogram monitoring. After completion of diagnostic angiography, 8F JR4 guidewire catheter (Launcher, Medtronic, Minneapolis, USA) was inserted to target the lesion's proximal side using 0.035 mm hydrophilic guidewire. Pre-dilation was made using 3.0 × 15 mm coronary balloon in patients with severe stenosis over 90% or stenosis which did not allow the passage of a filter or stent. Before stenting, a filter was used to prevent from embolism in all patients. Distal embolism prevention filter was placed in stent stenosis areas either on its own or by covering the opened stenosis area. Residual stenosis below 30% was defined as optimum. Post-dilation was done (5-6 mm) in patients without optimal arch. After the procedure, control angiography was performed in all patients. 28 (90.3%) patients in CAS group were treated with 7-day low molecular weight heparin and 75 mg clopidogrel in the next day of surgery. The rest of the patients began their treatment (3-9.7%) 2 days after the operation with the same regime. All patients were prescribed with daily 75 mg clopidogrel and 100 mg acetylsalicylic acid for 3 weeks following discharge from the hospital.

In Group 1, after completion of CEA, and in Group 2, after a month of CAS procedure, median sternotomy was performed in all patients under general anesthesia. Saphenous vein grafts and left internal mammary artery (LIMA) flaps were prepared. Systemic heparin was administered. All operations were done under CPB with aortic and right atrial cannulation, using membrane oxygenator, roller pump, and non-pulsatile flow. Anterograde blood cardioplegia was used for myocardial protection. Systemic mild hypothermia (30-32 °C) and high perfusion pressures (70-80 mmHg) were established. All of the distal anastomoses were done on the arrested heart. All of the proximal graft anastomoses were done onto the ascending aorta with partial clamp on beating heart in all of the patients. Heparin was neutralized by approximately 3 mg/kg of protamine sulphate following termination of CPB. Vacuum drain was used in CEA patients in order to prevent a pressure build-up caused by a hematoma before closure of neck incision.

During CPB, hypotension was avoided in intraoperative and early postoperative periods. Following admission to the intensive care unit (ICU), patients did not receive any narcotic, analgesic, or deep sedative medications and they were extubated as soon as possible. The neurology department closely inspected the patients' pupil reflexes, anisocoric status, sleep/awake status, answer to verbal stimuli, examinations of sensory and motor functions of the extremities and cranial nerves. Heparin, antiaggregant, and anti-lipid treatments were started following discharge. 62 (87.3%) patients in Group 1 and 23 (74.2%) patients in Group 2 were in the inpatient room on the first postoperative day of CABG operation.

Statistical Analysis

Statistical analysis was performed using the SPSS software version 12.0 (SPSS, Chicago, IL, USA). Among the data measured, the ones showing normal distribution were mentioned as mean ± standard deviation, and the ones not showing normal distribution were mentioned as median (minimum-maximum). The data obtained by counting were shown as percentages (%). Among the data measured, the normality of distribution was evaluated by histogram or Kolmogorov-Smirnov test, and the homogeneity of distribution was evaluated by Levene's test for equality of variance. Among the data measured, the difference between the groups was evaluated by Student t test in normal and homogenous distribution and

Table 1. Demographic and Clinical Properties of the Patients

Characteristics	Group 1: Simultaneous CABG + CEA (n = 71)	Group 2: Two stage CABG + CAS (n = 31)	*P*
Mean age	64.7 ± 7.9	67.1 ± 7.8	.28**
Male, n (%)	55 (77.5)	24 (77.4)	.99*
Female, n (%)	16 (22.5)	7 (22.6)	.99*
Hypertension, n (%)	56 (78.9)	25 (80.6)	.84*
Diabetes mellitus, n (%)	32 (45.1)	24 (77.4)	.003*
Smoking, n (%)	46 (64.8)	19 (61.3)	.73*
Hyperlipidemia, n (%)	13 (18.3)	18 (58.1)	.0001*
Symptoms seen >6 months, n (%)	22 (31)	19 (61.3)	.004*
Left main lesion >50%, n (%)	14 (19.7)	5 (16.1)	.67*
Ejection fraction	52.3 ± 12.4	46.8 ± 13.2	.04**
Three vessel disease, n (%)	54 (76.1)	22 (71)	.59*
Bilateral carotid stenosis (>60%), n (%)	28 (39.4)	23 (74.2)	.001*
AMI history, n (%)	25 (35.2)	5 (16.1)	.052*
Obesity, n (%)	8 (11.3)	3 (9.7)	.56*
Family history, n (%)	58 (81.7)	23 (74.2)	.39*
Peripheral artery disease, n (%)	13 (18.3)	7 (22.6)	.61*
COPD, n (%)	2 (2.8)	8 (25.8)	.001*

AMI indicates acute myocardial infarction; COPD, chronic obstructive pulmonary disease.
*Pearson Chi-Square test or Fisher's Exact test; **Mann-Whitney U test.

by Mann-Whitney U test in distribution that is not normal and homogenous. Among the data obtained by counting, the differences between the groups were evaluated by parametric or non-parametric Pearson Chi-Square test or Fisher Exact test according to the distribution being parametric or not. In case of a *P* value less than .05 among the groups, the difference was accepted as significant.

RESULTS

The demographic characteristics and clinical data of the patients are summarized in Table 1. Presence of diabetes mellitus (*P* = .003), hyperlipidemia (*P* = .0001), neurological symptoms prior to surgery (*P* = .004), bilateral carotid artery stenosis over 60% (*P* = .001), left ventricle ejection fraction (*P* = .04), and chronic obstructive pulmonary disease (COPD) (*P* = .001) were significantly different between the groups.

Table 2 shows the distribution of CEA and CAS. In patients with carotid endarterectomy, arteriotomies were closed primarily in 66 patients (93%) and saphenous vein patch was used in 5 patients (7%) for this purpose.

Table 2. Distribution of CEA and CAS

Carotid Intervention Side	Group 1: Simultaneous CABG + CEA (n = 71)	Group 2: Two stage CABG + CAS (n = 31)	Total
Left, n (%)	37 (52.1)	9 (29.0)	46 (45.1)
Right, n (%)	34 (47.9)	20 (64.5)	54 (52.9)
Bilateral, n (%)	0 (0.0)	2 (6.5)	2 (2.0)
Total, n (%)	71 (100.0)	31 (100.0)	102 (100.0)

The intraoperative and postoperative data of the patients are shown in Table 3. There were no statistically significant differences between the two groups in terms of intraoperative and postoperative patient data. The average length of stay in the hospital was 7.7 ± 3.9 (median: 6, range: 5-27) days in Group 1 and 5.8 ± 1.7 (median: 6, range: 5-14) days in Group 2. When compared regarding the length of stay in the hospital, there was a statistically highly significant difference between the groups (*P* = .006).

Atrial fibrillation occurred during the postoperative period in 13 patients (18.3%) in Group 1 and 6 patients (19.4%) in Group 2 without any significant difference (*P* > .05). Inotropic support was used in 9 patients (12.7%) in Group 1 and 10 patients (32.3%) in Group 2 with a significant difference between the groups (*P* = .03). Two patients (2.8%) in Group 1 and 5 patients (16.1%) in Group 2 developed myocardial infarction during postoperative inpatient or in early postoperative (one month) periods following CEA and CAS interventions, with a statistically significant difference (*P* = .03). Myocardial infarction was seen in four patients during intensive care unit stay following CAS and one after CABG in Group 2.

The mortality and morbidity results in the inpatient period and postoperative 30-days are summarized in Table 4. During the postoperative inpatient and early postoperative periods (first month), five patients (7%) in Group 1 and two patients (6.5%) in Group 2 developed neurological symptoms, but no significant difference was detected (*P* > .05). Neurological symptoms were TIA (two patients, 2.8%), right-sided hemiplegia (one patient, 1.4%), left-sided hemiplegia (two patients, 2.8%) in Group 1 and TIA (one patient, 3.2%), and right-sided hemiplegia (one patient, 3.2%) in Group 2. In retrospective review of all 102 patients, three patients (4.2%) in Group 1 and two patients (6.5%) in Group 2 died during inpatient period and early postoperative period. No significant difference was detected (*P* = .64).

Average length of follow-up period was 41.0 ± 22.6 (median: 39.5, range: 6-91) months in Group 1 and 44.6 ± 23.8 (median: 46, range: 8-90) months in Group 2 and no significant difference was observed (*P* = .46). No patient in any of the groups had neurological symptoms or died during the follow-up period after the first month of surgery.

During the perioperative and follow-up period combined end point (including stroke, mortality, myocardial infarction)

Table 3. Intraoperative and Postoperative Data of the Patients

Characteristics	Group 1: Simultaneous CABG + CEA (n = 71)	Group 2: Two stage CABG + CAS (n = 31)	*P*
Aortic cross clamp time, min	49.6 ± 12.6 (median: 51, range: 19-80)	49.8 ± 10.6 (median: 53, range: 26-74)	.83**
Cardiopulmonary bypass time, min	72.8 ± 14.2 (median: 74, range: 31-97)	73.9 ± 12.1 (median: 77, range: 51-96)	.73**
Number of anastomoses	3.3 ± 0.9 (median: 3, range: 1-5)	3.5 ± 0.9 (median: 4, range: 2-5)	.28**
Use of left internal mammary artery	64 (90.3%)	27 (87.1%)	.73*
Use of blood products	31 (43.7%)	13 (41.9%)	.87*
Amount of drainage, mL	473 ± 205 (median: 400, range: 150-1100)	521 ± 249 (median: 400, range 200-1200)	.53**
Intubation time, h	6.8 ± 3.3 (median: 6, range 4-22)	7.1 ± 2.6 (median: 6, range: 7-17)	.15**
Stay in the intensive care unit, h	27.6 ± 21.7 (median: 20, range: 14-128)	25.5 ± 15.1 (median: 20, range: 16-86)	.93**

*Pearson Chi-Square test or Fisher's Exact test; **Mann-Whitney U test.

was 12.7% in CEA group and 16.1% in the CAS group, which was statistically insignificant (*P* = .77).

Clinical variables and preoperative properties of 7 patients who developed postoperative neurological symptoms and others without any neurological symptoms which might affect a neurologic event are summarized in Table 5. When both groups were compared, only hyperlipidemia (*P* = .03) and presence of symptoms for longer than 6 months (*P* = .02) seemed to be a statistically significant factor.

DISCUSSION

In this study, we compared patients with unilateral or bilateral carotid artery stenosis who underwent both CEA and isolated CABG during the same period under general anesthesia or CAS under local anesthesia and isolated CABG surgery one month after stenting. During follow-up period for one month, five patients (7%) in Group 1 and two patients (6.5%) in Group 2 developed neurological events. However, we did not find any significant difference between these two intervention methods. One of the main results of this study is that there were no significant differences between the techniques in terms of neurological complications, length of hospitalization period, and mortality. After discussion with heart team in high-risk cases, staged CAS and CABG may be an alternative to simultaneous CEA and CABG.

Myocardial infarction following carotid artery intervention (CEA and CAS) was significantly higher in stenting group with high-risk patients, which is in accordance with the results found in the literature [Sheffet 2010]. As a result, cardiac monitoring before, during, and after CAS interventions is deemed essential in high-risk patients who undergo CAS for CEA.

Morbidity and mortality caused by stroke is one of the main health problems worldwide. Almost 20% of all ischemic strokes are caused by carotid artery stenosis. Internal carotid artery stenosis is an especially important cause of ischemic stroke [Grau 2001]. Stroke following CABG surgery is a catastrophic complication that has an incidence rate of approximately 2% [Mahmoudi 2011]. Neurological complications seen after CABG have an important effect on morbidity and mortality, as well as an increase in hospitalization and ICU periods of the patient, and increases in treatment costs [Yıldırım 2004].

Decision for revascularization in patients with carotid artery stenosis depends on the signs and symptoms of the affected carotid artery, degree of internal carotid artery stenosis, age and sex of the patient, coexisting diseases, and life

Table 4. Morbidity and Mortality during Hospitalization and within One-Month Period

	Group 1: Simultaneous CABG + CEA (n = 71)	Group 2: Two stage CABG + CAS (n = 31)	*P*
Mortality, n (%)	3 (4.2)	2 (6.5)	.63
Ipsilateral stroke, n (%)	2 (2.8)	1 (3.2)	.67
Any form of stroke, n (%)	3 (4.2)	1 (3.2)	.64
Transient Ischemic Attack (TIA), n (%)	2 (2.8)	1 (3.2)	.67
Death/TIA, n (%)	1 (1.4)	0 (0.0)	.70
Death/any form stroke, n (%)	1 (1.4)	0 (0.0)	.70
Combined end point (death, stroke, myocardial infarction), n (%)	9 (12.7)	5 (16.1)	.77

Table 5. Preoperative Clinical and Demographic Properties That Might Affect Postoperative Neurological Complications

	Variables	Neurological complication incidence rate, n (%)	*P**
Sex	Male	4 (5.1)	.19
	Female	3 (13.0)	
Acute myocardial infarction history	Yes	1 (3.3)	.67
	No	6 (8.3)	
Left main coronary artery lesion >50%	Yes	2 (8.3)	.67
	No	5 (6.4)	
Bilateral carotid artery lesion	Yes	2 (4.0)	.44
	No	5 (9.6)	
Family history	Yes	7 (8.6)	.34
	No	0 (0.0)	
Hyperlipidemia	Yes	5 (16.1)	.03
	No	2 (2.8)	
Obesity (BMI >30 kg/m^2)	Yes	2 (18.2)	.17
	No	5 (5.5)	
Tobacco use	Yes	6 (9.2)	.42
	No	1 (2.7)	
Peripheral artery disease	Yes	0 (0.0)	.34
	No	7 (8.5)	
Diabetes mellitus	Yes	3 (5.4)	.70
	No	4 (8.7)	
Chronic obstructive pulmonary disease	Yes	1 (10.0)	.53
	No	6 (6.5)	
Hypertension	Yes	4 (4.9)	.15
	No	3 (14.3)	
Symptoms longer than 6 months	Yes	6 (14.6)	.02
	No	1 (1.6)	
Three vessel disease	Yes	3 (3.9)	.07
	No	4 (15.4)	

*Pearson Chi-Square test or Fisher's Exact test.

expectancy [ESC Guidelines 2012].

The proper management strategy in cases with carotid artery stenosis and coexisting coronary artery disease is still debated. Combined CEA and CABG operations report a mortality rate of 2-12% and stroke rate of 1-15% [Bozoğlan 2012]. In our study, calculated risk of occurrence of early term "any form of stroke" was 4.2%, ipsilateral stroke was 2.8%, TIA was 2.8% and death was 4.2%, which are in accordance with previous results found in the literature.

In randomized trials, superiority of CEA performed by many surgeons in low-risk patients over medical management is proved with low perioperative complication rates. NASCET study reported stroke and death rates as 5.6% and ACAS study reported the same rates as 2.7% [Inzitari 2000; Executive Committee for ACAS Study 1995]. In carotid artery stenosis patients with coexisting coronary artery disease, CABG surgery and a simplified procedure such as CAS can decrease the negative consequences of widespread atherosclerotic disease drastically. Today, the debate over which treatment method (stenting or carotid endarterectomy) is better in patients with carotid artery stenosis is ongoing [Huh 2003].

CAS method is gaining more popularity as a less invasive and relatively new interventional procedure in treatment of high-risk carotid artery stenosis patients. Patients in particular with advanced age (>75 y), low left ventricle ejection fraction (<30%), unstable angina, multiple arterial disease, acute myocardial infarction in the last 30 days, cardiac or vascular surgery within the last 30 days, COPD (FEV_1<50%), advanced contralateral stenosis or occlusion, congestive heart failure, restenosis caused by CEA, and stenosis formation following radiotherapy have very high intraoperative and postoperative short term ischemic stroke and death rates after CEA. CAS interventions in such high-risk patients are becoming more and more prominent within clinicians and interventional radiologists as an alternative treatment in these cases. Thus, it seems likely that the debate over the efficacy and reliability of stenting in carotid artery diseases will continue for a long time in the future [Daniel 2006; Safian 2006].

CAS procedure is a relatively new method compared to surgical endarterectomy and its efficiency and reliability is shown in many studies. The first randomized trial that compared endovascular and surgical treatment is the CAVATAS study. In this study, no significant difference was seen in terms of disabling stroke or death between CAS and CEA [CAVATAS 2001]. Likewise, another trial called Stenting and Angioplasty with Protection in Patients at High Risk for Endarterectomy (SAPPHIRE) reported short-term stroke and death risk as 3.7% in CAS and 5.3% in CEA group. In this study, self-expanding nitinol stent and embolism protection device (EPD) were used in CAS group and 70% of the cases were asymptomatic. In addition, myocardial infarction incidence rates, which was defined as the end point in this study, were calculated as 1.9% in CAS and 5.3% in CEA group, which was different from other studies. When one-year follow-up results published in this study were reviewed, stroke or death risk was 12.8% in CAS and 20.1% in CEA group (P = .048). The long-term results of this study showed that there were no significant differences between CAS and CEA in terms of procedural stoke, death or myocardial infarction risks and simultaneous stroke or death risks defined as end points [Yadav 2004].

There were five randomized controlled trials completed on time or interrupted early before 2005. Meta-analysis including those study results within 30 days of the follow-up period showed no significant difference in terms of stroke

or death, disabling stroke or death, myocardial infarction and death [Coward 2005].

Usage of embolic protection devices during CAS is still a matter of controversy. Garg et al systematic review showed a decrease in neurological complications with usage of embolic protection devices during CAS [Garg 2009]. Another prospective study said that EPD + CAS patient group (n = 666) inpatient death or stroke rates were 2.1%. Meanwhile the same rates was 4.9% in only CAS patient group (n = 789), and the study defends that embolic protection devices are useful in those cases (P = .004) [Zahn 2004]. We used EPDs in all of our CAS patients.

CREST study, which reviews patient choice, experience of surgeons, and patient risk profiles published in 2010, is a multicenter randomized controlled study that aims to define which treatment choice is more beneficial (CAS or CEA) in symptomatic or asymptomatic patients. This study has the lowest percentage of risk among all the randomized and controlled trials done on this subject. In terms of primary end points (stroke, death, myocardial infarction, and ipsilateral stroke), no significant difference was observed between the techniques at the end of 4-year follow-up period (7.2%-6.8%) [Sheffet 2010].

In a study performed by Naylor et al that consisted of 760 patients operated for CAS and CABG, 87% of the patients were neurologically asymptomatic and 82% had unilateral carotid artery stenosis. After the procedure, patients were followed for 30 days and reported a death/stroke rate of 9.1% [Naylor 2009].

If CAS is performed before elective CABG, the need for dual antiplatelet therapy usually delays cardiac surgery for 4-5 weeks [ESC/EACTS Guidelines 2014]. Lopes et al study done on 49 carotid artery stenosis patients with coexisting coronary artery disease reported their experience in CAS interventions before CABG. The study reported a mortality rate of 8%, major stroke rate of 2%, and minor stroke rate of 2%. It was emphasized that CABG was performed 5-6 weeks after CAS intervention and antiplatelet drugs were stopped 7 days prior to surgery [Lopes 2002]. In our study, we also performed CABG surgery in the CAS patient group 4 weeks after initial CAS intervention and antiplatelet treatments were stopped and low molecular weight heparin was administered to the patients 7 days prior to CABG surgery.

In conclusion, even though simultaneous CEA and CABG have a reasonable morbidity and mortality rate, CAS before CABG surgery can also be considered as an alternative treatment method in patients with high-risk and bilateral carotid artery stenosis. According to the studies stated above and other studies mentioned in the literature, the decision of the heart team which includes neurologist, radiologist, cardiologist and cardiovascular surgeon will definitely increase the success rate of the treatment as well as decrease complication rates.

Limitations

In our study, high-risk patients were referred CAS based on heart team decision and the groups were not matched. The study was performed in a single center with a small sample size. Future prospective studies with larger sample size in a randomized design are needed to clarify this issue.

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