Original Article



# Early results of simultaneous carotid endarterectomy and off-pump coronary artery bypass grafting: experience from a single center

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**Background:** The optimal management of patients with concomitant carotid and coronary artery disease remains controversial.

**Methods:** The records of 113 consecutive patients who underwent either simultaneous carotid endarterectomy (CEA) and off-pump coronary artery bypass grafting (CABG) (CEA/CABG, n=15) or off-pump CABG alone (CABG, n=98) between January 2013 and July 2015 were reviewed. We retrospectively analyzed the baseline characteristics and 30-day results of both groups.

**Results:** The two groups were similar with regard to age, gender, hypertension, diabetes mellitus, hyperlipidemia, smoking, chronic renal failure, prior MI, previous PCI, ejection fraction, LM or triple-vessel disease, stable and unstable angina. Peripheral vascular disease was more prevalent in the CEA/CABG group (53.3% *vs.* 6.1%, P<0.001). History of a prior stroke was also more common in CEA/CABG group (60% *vs.* 24.5%, P<0.01). The intraoperative blood loss was 780.0±352.9 mL in the CEA/CABG group and 415.3±152.7 mL in the CABG group (P<0.001). The total operating time was 295.3±49.7 min in the CEA/CABG group and 212.9±35.0 min in the CABG group (P<0.001). The rest of the intraoperative variables were not statistically different between the two groups (all P>0.05). No death within 30 days occurred in both groups. There was no significant different between the two groups in postoperative complications [stroke, myocardial infarction (MI), transient ischemic attack (TIA), atrial fibrillation/atrial flutter, cardiac tamponade, cardiac arrest, pulmonary infection, Wound infection, and bleeding requiring re-operation] (all P>0.05). The cumulative complications at 30 days was 3 (20%) in the CEA/CABG group compared with 16 (16.3%) in the CABG group (P=0.72). The differences in total intubation time, intensive care unit (ICU) stay and hospital stay were also not statistically significant (all P>0.05).

**Conclusions:** Our results showed that addition of CEA to CABG would not increase the risk of mortality and morbidity relative to patients underwent CABG alone. Our study adds to the controversy of simultaneous CEA/CABG procedure. Large-scale, multi-center, randomized clinical trials are required to further evaluate the outcomes of simultaneous CEA/CABG.

**Keywords:** Carotid endarterectomy (CEA); coronary artery bypass grafting (CABG); carotid artery disease; coronary artery disease; simultaneous

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## Introduction

Atherosclerosis is a systemic inflammatory vascular disorder, involving multiple arterial beds (1). Carotid and coronary artery disease frequently coexist in clinical practice. The reported incidence of significant carotid artery stenosis (>70%) in patients who are candidates for coronary artery bypass grafting (CABG) was between 2% to 22% (2-4). The optimal management of patients with significant carotid artery stenosis and coronary artery disease is still controversial. Several approaches have been described, including simultaneous carotid endarterectomy (CEA) and CABG, CEA followed by CABG (staged), and CABG followed by CEA (reversed staged).

Significant carotid artery stenosis has been reported as a major risk factor for perioperative stroke in patients undergoing cardiac surgery (2,5). Likewise CEA performed in patients with severe untreated coronary artery disease has been associated with high perioperative myocardial infarction (MI) rate (6-8). In order to lower the rate of mortality and risk of stroke and MI, performing simultaneous CEA and CABG has been proposed, provided that the combined procedure can be performed safely (9).

Currently, most studies involving simultaneous CEA and CABG have been retrospective analysis and descriptive in nature. The appropriate prospective, randomized trials have yet to be undertaken or even proposed (10). Therefore, each center should select and analyze its own treatment strategy and compare the results with those described in other published reports. This report describes our experience regarding simultaneous CEA and off-pump CABG.

## Methods

### *Patients*

Between January 2013 and July 2015, 15 consecutive patients affected by coronary artery disease and coexisting carotid artery stenosis (>70%) underwent simultaneous CEA and CABG in our hospital. Patients' preoperative profiles, operative details, and postoperative data were collected and compared with those of 98 patients underwent CABG alone in the same period.

In our center, preoperative carotid duplex ultrasound was performed in all patients scheduled for CABG. The percentage of diameter reduction was measured relative to the outflow vessel, according to North American Symptomatic Carotid Endarterectomy (NASCET) methodology (11). All patients were identified as having no significant stenosis (<50%), moderate (50% to 69%) to severe (70% to 99%) stenosis or a 100% occlusion of either or both carotid arteries by carotid duplex ultrasound. For patients with screening suggestive of a 70% or greater stenosis, computed tomography angiogram (CTA) or carotid angiography was done to confirm the stenosis degree.

If the patient had left main or triple-vessel coronary disease and coexisting significant carotid stenosis, we tended to perform simultaneous CEA/CABG, especially when the patient presented with unstable angina. We explained the benefits and risks of simultaneous procedure in comparison with CABG alone to all eligible patients. Informed consent was provided according to the Declaration of Helsinki (as revised in 2013). The study was authorized by the Hospital's Ethics Committee.

### *Surgical strategy*

All procedures were carried out under general anesthesia and intra-aortic balloon pump (IABP) was applied if patients presented with hemodynamic instability, hypotension or bradycardia preoperatively. Both CEA and CABG were performed by the same surgical team.

The CEA was performed first in the simultaneous CEA/CABG procedure. During the CEA procedure, an incision was made along the anterior border of the sternocleidomastoid muscle. After opening the carotid sheath, the common carotid artery, external carotid artery and internal carotid artery were exposed, and then, Intravenous heparin (1 mg/kg) was administered before clamping the carotid artery. The artery was opened through a longitudinal incision followed by an endarterectomy. In our center, carotid shunt and polytetrafluoroethylene (PTFE) patch angioplasty were used in all patients routinely. In case of bilateral internal carotid artery stenosis, CEA was performed on the side with the higher degree lesion, the side related to neurological symptoms, or the dominant hemisphere. The neck wound was left open until the heparin was reversed with protamine after CABG and cervical drainage was routinely left in place and removed 1 to 3 days after surgery.

The cardiac surgery was started after ending of CEA procedure. In our hospital, we performed CABG without cardiopulmonary bypass (CPB) as a routine procedure. Off-pump CABG was always performed through a median sternotomy. A 4.5-mm opening on the aorta was punched with a puncher, a continuous 6/0 prolene (polypropylene)

 

was used for proximal anastomosis and a continuous 7/0 prolene was used for distal anastomosis, immobilization of targeted lesion arteries and regional myocardial control were performed with an octopus stabilizer (Medtronic, Minneap-olis, MN, USA). Intracoronary shunt was not used in any patient. Bypass was performed with autologous great saphenous vein or internal mammary artery.

After the procedure, patients were monitored in the intensive care unit (ICU). Careful hemodynamic monitoring and strict control of blood pressure was initiated. Antiplatelet treatment began on the first postoperative day when surgical bleeding had stopped. Clopidogrel was continued for 3 months, whereas aspirin was continued for life.

### *End point definition*

The primary endpoint of this study was death from any cause, any stroke, perioperative MI within 30 days of the procedures. The secondary endpoint included local and systemic complications. Stroke was defined as any clinically evident focal or general neurologic deficit lasting >24 hours, with or without permanent deficit. The presence or absence of stroke was determined by postoperative neurological examination. A further evaluation with cerebral computed tomography was performed, if needed. TIA was defined as a focal ischemic neurological deficit that resolved completely within 24 hours. Perioperative MI was defined as the appearance of new Q wave with persistent ST-segment changes associated with abnormal increase of myocardial enzyme including CK-MB and troponin.

### *Statistical analysis*

All values are expressed as the mean ± SD. The $\chi^2$ test or Fischer's exact test, whichever was appropriate, was used to compare categorical data between two groups. The two-sided unpaired *t*-test was used to compare mean values. Computation was done with software SPSS 19.0 (SPSS Inc., Chicago, IL, USA). A P value <0.05 was considered to be statistically significant.

## Results

### *Baseline demographics*

Demographic and preoperative data are summarized in *Table 1*. The final study population consisted of 113 patients (80 men; mean age 64.1±8.8), of which 15 underwent simultaneous CEA/CABG and 98 underwent CABG alone. The demographic variables or risk factors, such as age, gender, hypertension, diabetes mellitus, hyperlipidemia, smoking, chronic renal failure, prior MI, previous PCI, ejection fraction, LM or triple-vessel disease, stable and unstable angina, were not statistically different between the two groups. Peripheral vascular disease was more prevalent in the CEA/CABG group (53.3% *vs.* 6.1%, P<0.001). History of a prior stroke was also more common in CEA/CABG group (60% *vs.* 24.5%, P<0.01).

All CEA/CABG patients had more than or equal to 70% stenosis of at least one carotid artery. In the contralateral carotid artery, 7 (46.7%) had no or <50% stenosis, 4 (26.7%) had 70–99% stenosis, and 4 (26.7%) had total occlusion. In the CABG group, 91 (92.9%) had no or <50% stenosis, 4 (4.1%) had 50–69% stenosis, and 3 (3.1%) had 70–99% stenosis of one of the carotid arteries. Of these patients, 1 had bilateral stenosis of >50%.

### *Intraoperative variables*

The intraoperative variables are shown in *Table 2*. All patients in two groups underwent off-pump CABG. Temporary carotid shunt and PTFE patch were routinely used during the CEA procedure. The intraoperative blood loss was 780.0±352.9 mL (range, 400–1,500 mL) in the CEA/CABG group and 415.3±152.7 mL (range, 100–1,000 mL) in the CABG group (P<0.001). The total operating time was 295.3±49.7 min (range, 225–360 min) in the CEA/CABG group and 212.9±35.0 min (range, 105–330 min) in the CABG group (P<0.001). The rest of the intraoperative variables were not statistically different between the two groups.

### *Outcome events within 30 days after surgery*

*Table 3* shows the 30-day outcomes for two groups. No death occurred in both groups. There was no significant different between the two groups in postoperative complications [stroke, MI, transient ischemic attack (TIA), atrial fibrillation/atrial flutter, cardiac tamponade, cardiac arrest, pulmonary infection, Wound infection, and bleeding requiring re-operation] (all P>0.05). Additionally, 1 patient (6.7%) in the CEA/CABG group suffered cranial nerve injury manifesting deviated tongue protrusion and resolved with no special treatment. The cumulative complications at 30 days was 3 (20%) in the CEA/CABG group compared

 

**Table 1** Baseline demographics

| Variable | CEA + CABG (n=15) | CABG (n=98) | P |
|---|---|---|---|
| Age (years) | 62.8±6.7 | 64.3±9.1 | 0.55 |
| Male | 13 (86.7%) | 67 (68.4%) | 0.22 |
| Hypertension | 13 (86.7%) | 66 (67.3%) | 0.23 |
| Diabetes mellitus | 11 (73.3%) | 49 (50%) | 0.11 |
| Hyperlipidemia | 5 (33.3%) | 41 (41.8%) | 0.53 |
| Smoking | 8 (53.3%) | 45 (45.9%) | 0.59 |
| Peripheral vascular disease | 8 (53.3%) | 6 (6.1%) | <0.001 |
| Chronic renal failure | 3 (20%) | 5 (5.1%) | 0.07 |
| Prior stroke | 9 (60%) | 24 (24.5%) | <0.01 |
| Prior MI | 1 (6.7%) | 17 (17.3%) | 0.46 |
| Previous PCI | 0 (0%) | 15 (15.3%) | 0.21 |
| Ejection fraction | 38.1%±4.8% | 41.3%±6.7% | 0.22 |
| LM or triple-vessel disease | 10(66.7%) | 84 (85.7%) | 0.07 |
| Stable angina | 2 (13.3%) | 18 (18.4%) | 1.00 |
| Unstable angina | 5 (33.3%) | 45 (45.9%) | 0.36 |

CEA, carotid endarterectomy; CABG, coronary artery bypass grafting; MI, myocardial infarction; PCI, percutaneous coronary intervention; LM, left main trunk.

**Table 2** Intraoperative variables

| Variable | CEA + CABG (n=15) | CABG (n=98) | P |
|---|---|---|---|
| IABP | 9 (60%) | 49 (50%) | 0.47 |
| Off-pump CABG | 15 (100%) | 98 (100%) | 1.00 |
| Number of grafts | 2.1±1.0 | 2.5±0.6 | 0.08 |
| IMA graft | 1 (6.7%) | 14 (14.3%) | 0.69 |
| Carotid patch | 15 | / | / |
| Shunt used | 15 | / | / |
| Blood loss (mL) | 780.0±352.9 | 415.3±152.7 | <0.001 |
| Operation time (min) | 295.3±49.7 | 212.9±35.0 | <0.001 |

CEA, carotid endarterectomy; CABG, coronary artery bypass grafting; IABP, intra-aortic balloon pump; IMA, internal mammary artery.

with 16 (16.3%) in the CABG group (P=0.72). The differences in total intubation time, ICU stay and hospital stay were also not statistically significant (all P>0.05).

## Discussion

Today patients with concomitant carotid and coronary artery disease are still a big challenge for surgeons and perioperative prevention of stroke and MI is an ongoing debate. The prevalence of significant carotid artery disease in the cardiac surgical population reflects the systemic nature of the atherosclerotic process. Carotid artery disease causes approximately a third of post-CABG stroke. Postoperative stroke is an important cause of mortality and

 

**Table 3** Outcome events within 30 days after surgery

| Variable | CEA + CABG (n=15) | CABG (n=98) | P |
|---|---|---|---|
| Mortality | 0 (0%) | 0 (0%) | 1.00 |
| Stroke | 0 (0%) | 1 (1%) | 1.00 |
| MI | 0 (0%) | 0 (0%) | 1.00 |
| TIA | 1 (6.7%) | 0 (0%) | 0.13 |
| Atrial fibrillation/atrial flutter | 0 (0%) | 2 (2%) | 1.00 |
| Cardiac tamponade | 0 (0%) | 0 (0%) | 1.00 |
| Cardiac arrest | 0 (0%) | 0 (0%) | 1.00 |
| Pulmonary infection | 0 (0%) | 7 (7.1%) | 0.59 |
| Wound infection | 1 (6.7%) | 5 (5.1%) | 0.58 |
| Bleeding requiring re-operation | 0 (0%) | 1 (1%) | 1.00 |
| Cranial nerve injury | 1 (6.7%) | / | / |
| Neck hematoma | 0 (0%) | / | / |
| HPS | 0 (0%) | / | / |
| Cumulative complications | 3 (20%) | 16 (16.3%) | 0.72 |
| Intubation time (h) | 34.2±31.6 | 35.8±43.9 | 0.89 |
| ICU stay (h) | 61.3±48.3 | 61.9±37.8 | 0.98 |
| Hospital stay (d) | 30.2±14.0 | 30.9±12.6 | 0.86 |

CEA, carotid endarterectomy; CABG, coronary artery bypass grafting; MI, myocardial infarction; TIA, transient ischemia attack; HPS, hyperperfusion syndrome; ICU, intensive care unit.

morbidity following CABG (12). Therefore, preoperative examination of the carotid artery stenosis is critical and necessary (5).

Large-scale randomized clinical trials have demonstrated that CEA is beneficial for the prevention of ischemic stroke in patients with symptomatic and asymptomatic significant carotid stenosis (11,13-15). CEA is routinely performed for patients with 70% or greater stenosis, with a documented perioperative stroke rates as low as 0.5% and mortality rates of 1.8% (16). Because the benefit of CEA has been well defined, carotid artery surgery should not be ignored in patients with concomitant significant carotid and coronary artery disease.

The management of concomitant significant carotid and coronary artery disease remains controversial. The operation can be performed in either a staged or simultaneous approach. There are reports suggesting that the staged approach, CEA followed by CABG, can lead to a higher MI rate (17-19). However, CABG followed by CEA (reversed staged approach) will increase the risk of stroke in CABG procedure (18,19). Therefore, simultaneous CEA/CABG seems to be a rational approach (20). Since the first description of simultaneous CEA and CABG was reported by Bernhard and colleagues in 1972 (6), numerous studies have reported acceptable short and long-time results with low rates of mortality and morbidity after combined carotid and coronary surgery (21,22). In addition, simultaneous CEA/CABG has shorter hospital stay, lower costs and decreased exposure to anesthesia (20,23,24).

Routinely, we perform CEA before CABG in order to avoid cerebral hemodynamic disturbances. CABG will be performed prior to CEA in unstable coronary artery disease. During the CEA procedure, carotid shunt and patch were routinely used. There is controversy on the intraoperative application of carotid shunt. On the one hand, shunt can ensure the intraoperative cerebral perfusion, thus reducing the cerebral ischemic time (25,26). On the other hand, shunt also has problems of damaging carotid intima, causing cerebral embolism and prolonging surgery (27). For the consideration of reducing cerebral ischemic time

 

and easiness of the CEA procedure, we prefer to use carotid shunt. The role of carotid patch is very clear. Carotid patch angioplasty can reduce the risk of perioperative arterial occlusion and restenosis in comparison with primary closure (28). In addition, we performed CABG using off-pump technique. Some recent evidences suggest that the associated morbidity and mortality rate of simultaneous CEA and CABG can be significantly decreased by using off-pump CABG (29,30). Off-pump CABG avoids the need for CPB which is one of the contributing factors for stroke. Moreover, off-pump CABG has advantages in decreasing homologous transfusion, hospital stay and medical costs (31,32). In our series, the 30-day mortality and morbidity rate of simultaneous CEA/CABG was comparable to CABG alone. Our results were also comparable to those reported in previous studies (10,33-36).

There were limitations to the present study. First, it was a retrospective study, and all limitations inherent in any retrospective study may also exist here. Second, the sample size was small, especially the number of the CEA/CABG group. Third, only early results were investigated and long-term follow-up results were lacking. Therefore, our results should be interpreted with caution.

In conclusion, our results showed that addition of CEA to CABG would not increase the risk of mortality and morbidity relative to patients underwent CABG alone. Our study adds to the controversy of simultaneous CEA/CABG procedure. Large-scale, multi-center, randomized clinical trials are required to further evaluate the outcomes of simultaneous CEA/CABG.

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## Footnote

*Conflicts of Interest*: All authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jxym.2017.10.03). The authors have no conflicts of interest to declare.

*Ethical Statement:* The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). Informed consent was provided according to the Declaration of Helsinki (as revised in 2013). The study was authorized by the Hospital's Ethics Committee (approval ID: No. 2013-KY-85).



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