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Different Strategies in Simultaneous Coronary and Carotid Artery Revascularization – A Single Center Experience

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Abstract

Background: The optimal management for patients with concomitant severe coronary artery disease (CAD) and carotid artery stenosis (CAS) remains controversial. We reported our preliminary experience on a synchronous hybrid strategy.

Methods: Seven patients with synchronous percutaneous coronary intervention (PCI)/carotid endarterectomy (CEA)/coronary artery bypass grafting (CABG) and 36 patients with synchronous CEA/CABG were enrolled. Then we analyzed the demographics, risk factors and 30-day results of the 2 groups, retrospectively.

Results: The 2 groups were comparable in demographics. The operation time was 312.14 ± 40.08 minutes for synchronous PCI/CEA/CABG and 294.58 ± 47.62 minutes for synchronous CEA/CABG (P = 0.367). The intraoperative blood loss was 814.29±195.18 mL for synchronous PCI/CEA/CABG and 769.44 ± 330.21 mL for synchronous CEA/CABG (*P* = 0.731). There was no death in the 2 groups within 30 days. The incidence of primary endpoint [stroke, myocardial infarction (MI) and death] was 14.29% (1/7) in synchronous PCI/CEA/CABG group and 5.56% (2/36) in synchronous CEA/CABG group. The difference between the 2 groups was not statistically significant (*P* = 0.421).

Conclusion: Synchronous PCI, CEA and CABG may be safe and effective in the management of patients with concomitant CAS and complicated multi-vessel CAD. The current data suggested that more studies and randomized controlled trials may be necessary to define whether this strategy is suitable for these patients.

Keywords: Carotid endarterectomy (CEA), Coronary artery bypass grafting (CABG), Percutaneous coronary angiography (PCI)

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Introduction

Atherosclerosis is a systemic disease which can affect multiple arterial beds, including the coronary artery and the carotid artery.[1] Carotid artery atherosclerotic stenosis (CAS) has been reported to be an important cause of stroke worldwide and the incidence of perioperative stroke after coronary artery bypass grafting (CABG) can reach 11% in patients with severe CAS.[2-4] The best treatment strategy for patients with combined severe CAS and coronary artery disease (CAD) remains unclear.[5] It is reported that simultaneous coronary and carotid artery revascularization may decrease the incidence of stroke and perioperative mortality.[6]

Carotid endarterectomy (CEA) and CABG during the same anesthetic setting, first reported by Bernherd et al in 1972,[7] has been widely used as a revascularization strategy for concomitant carotid and coronary disease.[8] However, the optimal revascularization strategy for multi-vessel CAD, especially for those with concomitant severe CAS, is far from clear.[9] Combining percutaneous coronary intervention (PCI) and CABG may offer a choice.[10] The data of hybrid revascularization for coronary artery in patients with combined CAD and CAS is lacking. We reported our preliminary experience of synchronous PCI, CEA and CABG in the treatment of patients with combined severe CAS and CAD.

Materials and Methods

Study Population

Forty-three consecutive patients with combined CAS and CAD who received simultaneous carotid and coronary artery revascularization at the cardiovascular department of China-Japan Friendship Hospital were enrolled. Among the 43 patients, 36 received synchronous CEA and CABG, while the other 7 received synchronous PCI, CEA and CABG. Then, we collected the demographic, treatment detail and outcome data and analyzed the data. The study procedures were in accordance with institutional guidelines. All data was retrospectively collected.

Definitions

The indications for CEA were: (I) symptomatic patients (transient ischemia attack or stroke within 6 months) with 50%–99% CAS; (II) asymptomatic patients with >70%

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CAS; (III) asymptomatic patients with carotid artery occlusion and contralateral carotid artery >50% stenosis.

Coronary angiography was carried out for patients with overt CAD symptoms [stable or unstable angina pectoris, and previous myocardial infarction (MI)]. When at least one major coronary artery had >50% stenosis, CAD can be defined. The indication for simultaneous PCI and CABG were: (I) 2-vessel or 3-vessel CAD with overt symptom; (II) symptomatic CAD with left main trunk involvement; (III) right coronary artery suitable for PCI (IV) target coronary artery diameter >1.5 mm; (V) left ventricular ejection fraction (LVEF) >40%.

Surgical Management

All the patients received aspirin and statin treatment. Low molecular weight heparin was used instead of aspirin and clopidogrel 5 days before surgery. Three days after surgery, 100 mg/d aspirin was given and lasted for life. 75 mg/d clopidogrel was also given and lasted for 12 months. The whole procedure, including PCI, CEA and CABG were carried out by the same surgical team (Figure 1 shows the typical procedure).

For patients who received synchronous PCI, CEA and CABG, PCI was carried out under local anesthesia. After femoral artery puncture with the Seldinger technique, coronary artery angiography was conducted to confirm the disease segment and target vessel. Then balloon was used to pre-dilate the disease segment, release the stent and carry out post-dilation.

CEA was carried out under general anesthesia. An incision along the anterior border of the sternocleidomastoid muscle was made. After careful dissection of subcutaneous tissue, the common, external and internal carotid artery were isolated and controlled. Then a bolus heparin (1 mg/kg) was given intravenously and carotid artery was clamped. Then, we cut open the common carotid artery, extended the incision to internal carotid artery and carefully carried out the endarterectomy. Carotid artery shunt and polytetrafluoroethylene (PTFE) patch were routinely used in CEA.

CABG was carried out following CEA. The CEA incision was left open until protamine was given to reverse heparin after CABG. Both on-pump and off-pump CABG were carried out on the enrolled patients. First, we made the middle sternotomy and exposed the heart. The anterior wall of aorta was punched after lateral wall clamp to form a 4.5 mm hole for proximal anastomosis. Then, we carried out the anastomosis at the aorta side and then the coronary artery side with the harvested saphenous vein. During the procedure, we maintained activated clotting time over 300 seconds with heparin and then used protamine to reverse heparin.

Endpoint

Perioperative incidence of death, MI and stroke was defined as primary endpoint. And we also collected data for other complications including cranial nerve injury, renal failure, local infection, pneumonia and hyperperfusion syndrome.

Statistical Analysis

Mean ± SD was used for the presentation of continuous variables and percentages for discrete variables. A two-sided independent sample *t* test was used for the comparison of continuous variables. For discrete variables comparison,

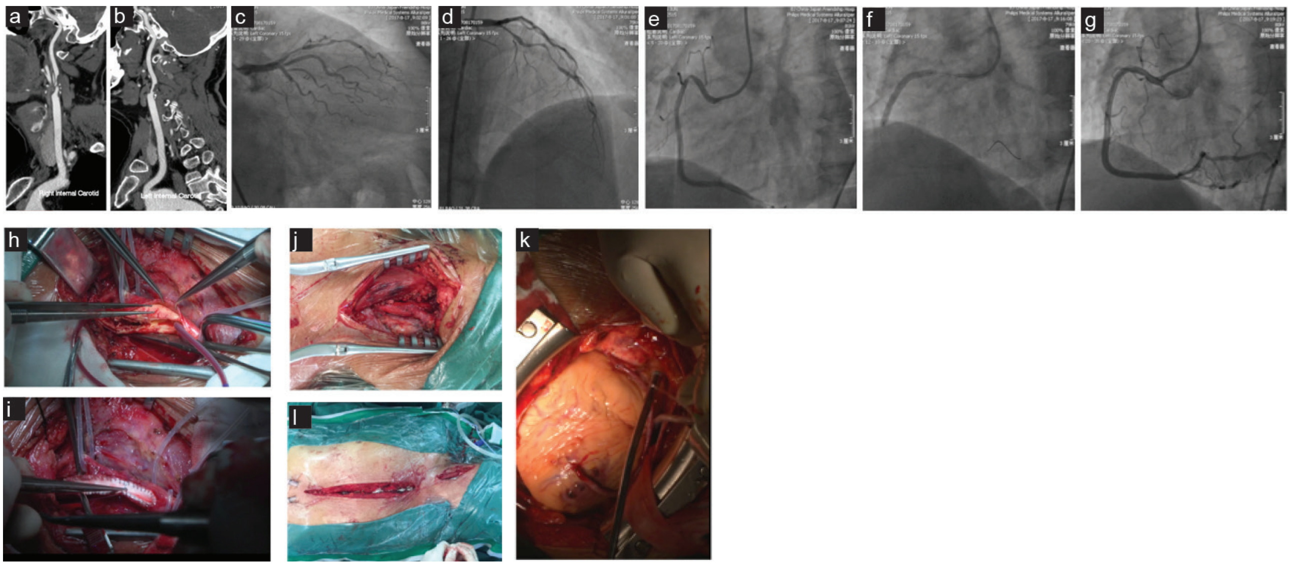

Figure 1. The Procedure of Synchronous PCI/CEA/CABG.
(**a**) CTA shows severe stenosis of right internal carotid artery; (**b**) CTA shows severe stenosis of left internal carotid artery; **c-e)** DSA shows 3-vessel coronary artery disease. (**f-g)** PCI for RCA stenosis; (**h-j)** procedure of CEA; (**k**) CABG for LAD and LCX; **l)** the incision. CTA, Computed tomography angiography; DSA, Digital subtraction angiography; PCI, Percutaneous coronary angiography; RCA, Right coronary artery; CEA, Carotid endarterectomy; CABG, Coronary artery bypass grafting.

chi-square test or Fisher exact test was performed. Relative risk (RR) and 95% confidence interval (CI) of 30-day primary endpoint was also calculated. SPSS version 22 (SPSS Inc., Chicago, IL, USA) was used for data analysis. A *P* value of <0.05 was considered statistically significant.

Results

Demographics and Clinical Features

Finally, we enrolled 43 patients (37 males; mean age 67.88 ± 5.81years) including 7 with synchronous PCI/CEA/CABG (6 males; mean age 61.86 ± 3.76 years) and 36 with synchronous CEA/CABG (31 males; mean age 62.67 ± 5.97 years). Preoperative CAS degree was 85.00 ± 8.66 and 87.08 ± 8.23 for synchronous PCI/CEA/CABG group and synchronous CEA/CABG group, respectively. The demographics was comparable in the two groups (Table 1).

Intraoperative Variables

Intraoperative details were showed in Table 2. The difference in operation time [312.14 ± 40.08 vs. 294.58 ± 47.62 min, 95% CI: (-56.43, 21.31), *P* = 0.367] and intraoperative blood loss [814.29 ± 195.18 vs. 769.44 ± 330.21, 95% CI: (-306.87, 217.78), *P* = 0.731] was not significant between the two groups. Patch angioplasty and carotid shunt was used in every procedure and most of the patients underwent off-pump CABG.

30-Day Outcomes

Table 3 shows the 30-day outcomes for both groups. The intubation time was 27.21 ± 20.43 h for synchronous PCI/CEA/ CABG and 33.27 ± 29.35 h for synchronous CEA/CABG [95% CI: (-17.49, 29.60), *P* = 0.606]. The ICU time was 44.75 ± 36.88 h for synchronous PCI/CEA/CABG and 58.68 ± 46.08 h for synchronous CEA/CABG [95% CI: (-23.48, 51.35), *P* = 0.456]. The hospital stay was 27.71 ± 7.16 d for synchronous PCI/CEA/CABG and 29.08±11.85 d for synchronous CEA/CABG [95% CI: (-8.04, 10.78), *P* = 0.770]. No death occurred in both groups within 30 days.

In synchronous PCI/CEA/CABG group, one patient suffered from stroke (presented with upper arm weakness) contralateral to the CEA side. One patient suffered from TIA ipsilateral to the CEA side. Three patients had cranial nerve injury with two patients had face numbness and one patient had tongue deviation. Two cases of hyper-perfusion syndrome and one case of acute renal failure were also observed.

In synchronous CEA/CABG group, two patients suffered from stroke (presented with aphasia and upper arm weakness, respectively) contralateral to the CEA side. Three patients suffered from TIA: two were ipsilateral and

Tables 1. Demographics and Clinical Features

Variables	PCI/CEA/CABG	CEA/CABG	P
No. of patients	7	36	
Age	61.86±3.76	62.67±5.97	0.733
Male	6 (85.71)	31 (86.11)	0.999
Hypertension	6 (85.71)	30 (83.33)	0.999
DM	5 (71.43)	29 (80.56)	0.624
Hyperlipidemia	2 (28.57)	11 (30.56)	0.999
Smoker	3 (42.86)	19 (52.9)	0.698
Carotid symptomatic			
Stroke	3 (42.86)	10 (27.78)	0.655
TIA	2 (28.57)	16 (44.44)	0.680
CAS	85.00±8.66	87.08±8.23	0.547
Contralateral lesion			0.470
Occlusion	3 (42.86)	10 (27.78)	
>70 stenosis	2 (28.57)	10 (27.78)	
50–70% stenosis	0 (0)	4 (11.11)	
<50% stenosis	2 (28.57)	12 (33.33)	
Coronary symptomatic			0.842
Stable angina	2 (28.57)	10 (27.78)	
Unstable angina	4 (57.14)	19 (52.78)	
MI	1 (14.29)	7 (19.44)	
CAD			0.546
1-vessel disease	0 (0)	6 (16.67)	
2-vessel disease	2 (28.57)	7 (19.44)	
3-vessel disease	5 (71.43)	23 (63.89)	
Left ventricular ejection fraction	0.58 ± 0.24	0.54 ± 0.10	0.461

CEA, carotid endarterectomy; CABG, coronary artery bypass grafting; TIA, transient ischemia attack; DM, diabetes mellitus; WIC, Charlson's Weighted Index of Comorbidities; CAD, coronary artery disease; MI, myocardial infarction.

Table 2. Intraoperative Variables of the 2 Groups

	PCI/CEA/CABG (7)	CEA/CABG (36)	P
Carotid shunt	7 (100)	36 (100)	0.999
PTFE patch angioplasty	7 (100)	36 (100)	0.999
Off-pump CABP	6 (85.71)	30 (83.33)	0.999
IABP	6 (85.71)	30 (83.33)	0.999
Operation time (min)	312.14 ± 40.08	294.58 ± 47.62	0.367
Blood lose (mL)	814.29 ± 195.18	769.44 ± 330.21	0.731

PTFE, polytetrafluoroethylene; CABG, coronary artery bypass grafting; IABP, intra-aortic balloon pump.

Table 3. 30-Day Outcomes of the 2 Groups

	PCI/CEA/CABG(7)	CEA/CABG(36)	P
MI	0	0	0.999
Stroke	1	2	0.421
Death	0	0	0.999
TIA	1	3	0.523
Deviation of tongue	1	4	0.999
Face numbness	2	5	0.318
Hoarseness	0	2	0.999
ICU stay (h)	44.75 ± 36.88	58.68 ± 46.08	0.456
Intubation time (h)	27.21 ± 20.43	33.27 ± 29.35	0.606
Hospital stay (d)	27.71 ± 7.16	29.08 ± 11.85	0.770
Hyper-perfusion syndrome	2	9	0.999
Wound infection	0	1	0.999
Pneumonia	0	2	0.999
Acute renal failure	1	2	0.421

MI, myocardial infarction; TIA, transient ischemia attack; ICU, intensive care unit.

one was contralateral to the CEA side. Eleven patients had cranial nerve injury with 5 had face numbness, 4 had tongue deviation and 2 had hoarseness. Nine cases of hyper-perfusion syndrome, 2 cases of pneumonia and 2 cases of acute renal failure were also observed. One patient suffered from local infection which lead to delayed healing of the sternal incision.

All cranial nerve injuries alleviated at 30 days. The difference in incidence of primary endpoint was not statistically significant [14.29% vs. 5.56%, $P = 0.421$; RR = 0.257, 95% CI: (0.268, 24.637)] between the 2 groups.

Discussion

The optimal management for combined severe CAS and CAD remains controversial. Recanalization of coronary artery first may increase the risk of stroke and recanalization of carotid artery first may increase the risk of MI.[11] Some systematic reviews and meta-analyses showed that synchronous coronary and carotid artery revascularization may be suitable for these patients.[2,12,13] Multiple revascularization strategies, such as synchronous CEA and CABG and synchronous carotid artery stenting and CABG, have been reported and the outcome is acceptable.[14,15]

CEA has been the standard treatment strategy for CAS in the last decades, and carotid artery stenting has become a feasible and safe alternative to CEA, especially for patients being considered as high risk.[16] The debate of whether CEA or carotid artery stenting is more suitable for the revascularization of carotid artery in patients with concomitant coronary and carotid disease has been a lasting debate for a long time. For coronary revascularization, few studies have evaluated the best strategy. Indeed, some controversy exists in this area, especially for patients with complicated multi-vessel CAD.

The hybrid coronary revascularization (HCR) strategy was introduced in 1990s, which grafted the left anterior descending (LAD) branch lesions with internal mammary artery and recanalized the non-LAD lesion with PCI.[17,18] The HCR procedure is preferred for patients lacking suitable grafts or have severe calcified aorta.[10,19] In our study population, patients with lesions in LAD were amenable to CABG and those with lesions in the right coronary or left circumflex artery were amenable to PCI. We carried out synchronous CEA, saphenous vein graft to the LAD and drug-eluting stenting for non-LAD lesions. The 30-day outcome was comparable to synchronous CEA and CABG. This is not strictly HCR for coronary artery as previously reported. Still, we think this strategy has some advantages. PCI can alleviate heart ischemia and avoid stirring if we carry out right coronary artery bypass grafting. When the LAD lesion is not suitable for PCI, CABG offers an additional option.[20]

In our study population, PTFE patch angioplasty and carotid artery shunt was used routinely. It is reported that the incidence of perioperative carotid artery occlusion and long-term restenosis was lower in patients with patch angioplasty.[21,22] Nevertheless, there remains some controversy in the use of carotid artery shunt. The shunt can decrease ischemic time and increase cerebral perfusion.[23,24] Also it has some limitations because it may cause cerebral embolization and intima damage.[25] In our study series, we did not observe any complication related to carotid artery shunt. So we think if the shunt was inserted carefully and gently, it will bring more benefits than complications.

Limitations may exist in our study. First, the data was collected and analyzed retrospectively. Second, the follow-up time is relatively short. Third, the sample size is relatively small. We carried out the post-hoc power analysis with G*power 3.1, supposed the occurrence of primary end point was 5% and 25% for the 2 groups, respectively, α error probability was 0.05. Then the effective size w was 0.28, the power was 0.45. So, in order to achieve a power of 0.8, we suggest that future studies should enroll at least 88 patients.

In conclusion, synchronous PCI, CEA and CABG may be safe and effective in management of patients with concomitant CAS and complicated multi-vessel CAD. The current data suggested that more studies and randomized controlled trials may be necessary to define whether this strategy is suitable for these patients.

Authors' Contribution

Study design: JZ, ZY. Data collection: ZD, PL. Data analysis: XF, JC, XZ. Writing: JZ, ZD, BM.

Conflict of Interest Disclosures

None.

Ethical Statement

The study was approved by the institutional ethics committee of our hospital (No. 2013- KY-85) and written informed consent was obtained from all patients.

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