A SINGLE CENTRE EXPERIENCE WITH CORONARY ENDARTERECTOMY IN PATIENTS UNDERGOING OFF-PUMP CORONARY ARTERY BYPASS GRAFTING

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ABSTRACT

BACKGROUND
Coronary Artery Bypass Grafting (CABG) is one of the most frequently done cardiac surgical procedures. However, with the advancements in catheter-based interventional procedures, the category of patients taken up for CABG is gradually being restricted to more high-risk group. Additional surgical procedures like Coronary Endarterectomy (CE) are needed for treating such high-risk coronary artery disease to achieve complete revascularisation. Off-pump coronary endarterectomy can be performed safely with morbidity and mortality comparable with those of conventional coronary endarterectomy.

MATERIALS AND METHODS
This is a single institutional retrospective study with 480 patients underwent concomitant off-pump CE and CABG. Average number of coronary bypass grafts were 2.4±0.8. There were 321 cases of LAD endarterectomy with 246 receiving LIMA as the arterial graft. 2.9% patients were converted to on-pump surgery intraoperatively because of intraoperative hypotension.

RESULTS
The incidence of postoperative MI was 0.8%. The 30-day mortality was 0.8% from complications of bowel ischaemia and three patients with septicaemia associated with prolonged intubation. The mean operating time was 118±22 minutes.

CONCLUSION
We have shown that the effect of OPCABG with CE appears to be safe and early outcomes are encouraging. Hence, diffuse disease requiring endarterectomy should not be considered a contraindication to OPCABG. Surgical skills and the suitability criteria of the patients are very important in this regard.

KEYWORDS
Coronary Endarterectomy, Off-Pump Coronary Artery Bypass Grafting.


BACKGROUND
Coronary Artery Bypass Grafting (CABG) is one of the most frequently done cardiac surgical procedures. However, with the advancements in catheter-based interventional procedures, the category of patients taken up for CABG is gradually being restricted to more high-risk group. High-risk profile is characterised by old age, severe left ventricular dysfunction, previous Percutaneous Coronary Intervention (PCI), diffuse Coronary Artery Disease (CAD) (i.e., at least 75% of the segment distal to the lesion has a vessel diameter of <2 mm) and comorbidities such as diabetes mellitus and peripheral vascular disease. Additional surgical procedures like Coronary Endarterectomy (CE) are needed for treating such high-risk coronary artery disease to achieve complete revascularisation. CE is removal of an atheromatous core by separating the external medial and
adventitial layers to restore lumen of artery. CE was first introduced in 1957 by Bailey et al. Earlier experiences of CE in 1960s and 70s were not associated with satisfactory results. However, with refinement in technique of CE, its benefits have now been recognised. CE on beating heart requires greater skill and surgical technique. The results of off-pump coronary endarterectomy are encouraging and comparable with the conventional coronary endarterectomy using cardiopulmonary bypass. Off-pump coronary artery bypass surgery reduces the likelihood of acute renal failure, reduced time of mechanical ventilation and decreased bleeding thus requiring less number of blood and blood products. The early results and particularly the midterm survival rates, clinical status and continued graft patency justify off-pump CE in patients with severely depressed left ventricular function and diffuse coronary artery disease. Off-pump coronary endarterectomy can be performed safely with morbidity and mortality comparable with those of conventional coronary endarterectomy. This study is a retrospective analysis of clinical profile and early surgical outcomes of patients undergoing CABG+CE in a tertiary care centre.

**MATERIALS AND METHODS**

This is a single institutional retrospective study. 480 patients from January 2013 to December 2015 underwent concomitant CE and CABG were included. The age range of patients was 38–77 years with mean age of 59.8±10.43 years. Out of them, 371 were males and 109 females. Diabetes mellitus (46%) and hypertension were the major risk factors. More than half (56%) of the patients had previous Myocardial Infarction (MI). Most of the patients (68%) had triple vessel disease. All patients signed in informed consent form before surgery.

**Surgical Technique**

All cases of CABG were done off-pump. Most of the CE were planned before surgery, but final decision was taken intraoperatively after coronary arteriotomy. Indications for CE were-

a. Multiple significant stenosis in same coronary artery.

b. Total occluded vessel supplying viable myocardium.

c. Occlusion along the entire length of artery.

d. Calcified vessel that makes suturing difficult.

e. For complete revascularisation with conventional CABG.

**Technique of CE**

A. Closed or traction technique- After doing a longitudinal arteriotomy, if the vessel meets the above criteria for endarterectomy, the atheromatous core was carefully dissected and separated from the vessel wall by using fine forceps or spatula. Once the plaque is free circumferentially, gentle traction is applied first distally and then proximally. Simultaneously, counter-traction was applied with forceps to the adventitia of vessel wall while pulling and peeling the plaque from the vessel wall. A conventional distal anastomosis was then done using 7-0 polypropylene.

Completeness of CE was assessed by-

a. Length of end atheromatous core extracted.

b. Soft, tapering and bluish end.

c. Palpation of distal end of the vessel.

If on initial attempts, endarterectomy remains incomplete, either the arteriotomy was extended or a separate arteriotomy was done distally depending on the distance of the broken plaque from the initial arteriotomy.

B. Open or direct vision technique- After coronary arteriotomy, incision was extended both distally and proximally over the plaque. The atheromatous core was extracted with all side branches under direct vision. This technique was usually done for-

a. Broken plaques during closed endarterectomy.

b. Densely adherent plaque to the vessel wall.

c. Calcified and fragile plaque.

In cases with separate distal arteriotomy, anastomosis was done using 8-0 polypropylene with a 2-mm shunt in the coronary artery by one of the following techniques.

a. A long on-lay patch angioplasty with LIMA/saphenous vein.

b. Free saphenous venous patch angioplasty. LIMA/saphenous vein graft's distal end was then anastomosed to the patch.

**Proximal Portion**

Attempt was made to extract the proximal portion of the atheromatous core by traction technique. However, in severely calcified and fragile plaques, proximal portion was sharply divided. The divided intima of the vessel was tacked with 8-0 polypropylene sutures. Proximal traction of plaque was carefully done to avoid proximal dissection and occlusion of a wide septal or oblique branch.

**Perioperative Care**

Care was taken to avoid hypotension during the perioperative period. Anticoagulation Regimen. Antiplatelet and anticoagulants were given to every patient postoperatively. Aspirin was started 6 hours postsurgery and warfarin was given next day onwards. Injection heparin was given four hours post-surgery (after excluding significant
mediastinal bleeding maintaining the ACT between 150 and 200 seconds). Daily INR reports were done. Heparin was stopped once INR was between 1.5-2. Patients were discharged with 150 mg aspirin and warfarin dose adjusted. After three months follow up, warfarin was stopped and Tab. Clopidogrel 75 mg was added.

**Statistical Analysis**

All statistical analysis was done using SPSS software. Continuous variables were reported as Mean±SD. Continuous variables were compared by χ² test or Fischer's exact test. Differences were considered significant at p<0.05.

**RESULTS**

In the past four years, 5466 CABG operations were performed at our institution excluding those with concomitant valve operations. 4988 (91%) of cases were Off-Pump Coronary Artery Bypasses (OPCAB). Four hundred eighty cases out of these included CE. The patient characteristics are mentioned in Table 1. The preoperative characteristics of patient are described in Table 2. The mean age was 59.6±10.4 years with male-to-female ratio of 3.4:1. 44% patients had severe LV dysfunction with 21% having LVEF less than 15 on preoperative echocardiography. 46% patients had diabetes mellitus and 34% were smokers. The preoperative lipid profile was deranged in 20% of the patients. Majority (68%) of the cases were triple vessel disease. 28 of the 480 patients were operated in emergency. 6.67% patients had preoperative IABP. Average number of coronary bypass grafts were 2.4±0.8. There were 321 cases of LAD endarterectomy with 246 receiving LIMA as the arterial graft. 2.9% patients were converted to on-pump surgery intraoperatively because of intraoperative hypotension. The incidence of postoperative MI was 0.8%. The 30-day mortality was 0.8% from complications of bowel ischaemia and three patients with septicaemia associated with prolonged intubation. The mean operating time was 118±22 minutes (Table 3).

<table>
<thead>
<tr>
<th>Age (Years) (Mean±SD)</th>
<th>59.85±10.43</th>
<th>Previous CVA</th>
<th>8 (1.7%)</th>
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</thead>
<tbody>
<tr>
<td>Sex (M:F)</td>
<td>3:4:1</td>
<td>COPD</td>
<td>38 (7.9%)</td>
</tr>
<tr>
<td>Smoking (No %)</td>
<td>133 (34.6%)</td>
<td>Prior stent</td>
<td>34 (7%)</td>
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<tr>
<td>Hypertension (No %)</td>
<td>211 (43.9%)</td>
<td>PVD</td>
<td>11 (2.3%)</td>
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<tr>
<td>Diabetes mellitus (No %)</td>
<td>268 (46%)</td>
<td>Renal failure</td>
<td>22 (4.6%)</td>
</tr>
<tr>
<td>Dyslipidaemia (No %)</td>
<td>97 (20.2%)</td>
<td>Emergency cases</td>
<td>26 (5.8%)</td>
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<tr>
<td>Obesity (No %)</td>
<td>45 (9.3%)</td>
<td></td>
<td></td>
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<tr>
<td>Family history of CAD (No %)</td>
<td>72 (15%)</td>
<td>Preoperative medication</td>
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<td></td>
<td></td>
<td>Aspirin</td>
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<td>Ejection fraction (No %)</td>
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<td>ACE inhibitors</td>
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<tr>
<td>&gt;55%</td>
<td>101 (21%)</td>
<td>Beta blockers</td>
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<td>45-55%</td>
<td>130 (27%)</td>
<td>Diuretics</td>
<td>106</td>
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<td>30-45%</td>
<td>139 (29%)</td>
<td>Antiarrhythmics</td>
<td>11</td>
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<tr>
<td>&lt;30%</td>
<td>110 (23%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old MI (No %)</td>
<td>267 (56%)</td>
<td>CAD pattern</td>
<td></td>
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<tr>
<td>Unstable angina (No %)</td>
<td>58 (12%)</td>
<td>Single vessel disease</td>
<td>58 (12%)</td>
</tr>
<tr>
<td>Stable angina (No %)</td>
<td>77 (16%)</td>
<td>Double vessel disease</td>
<td>96 (20%)</td>
</tr>
<tr>
<td>Cardiogenic shock (No %)</td>
<td>29 (6%)</td>
<td>Triple vessel disease</td>
<td>326 (68%)</td>
</tr>
</tbody>
</table>

**Table 1. Patient Characteristics (n=480)**

| Average number of grafts (Mean±SD) | 2.4±0.8 |
| Intraoperative arrhythmia (No %)   | 4 (0.83%) |
| Total endarterectomies (No %)      |          |
| (a) Single                         | 352 (73.3%) |
| (b) Double                         | 108 (22.5) |
| (c) Triple                         | 20 (4.16)  |
| Vessel wise (No %)                 |          |
| (a) LAD                            | 321 (66.8%) |
| (b) RCA                            | 222 (46.25%) |
| (c) Diagonal                       | 26 (5.41%) |
| (d) Ramus                         | 16 (3.3%) |
| (e) OM                            | 38 (7.91%) |
| LIMA used for Endarterectomy of LAD (No %) | 246 (51.25%) |
| Conversion to On-Pump (No %)       | 14 (2.91%) |
| IABP insertion intraoperatively (No %) | 21 (4.370) |
| Operation time (min.) (Mean±SD)    | 118±22    |
| Total number of vessels bypassed   | 1221      |
| LIMA (No %)                        | 408 (33.41%) |
| Saphenous vein (No %)              | 813 (66.58%) |
| Operation time (min.) (Mean±SD)    | 118±22    |

**Table 2. Operative Data (n=480)**
Definition
Operative death- Death within 30 days of surgery.
Low output syndrome- Need for adrenaline of dopamine >5 μg/kg/min.
Perioperative MI- Positive result of new Q waves in ECG or presence of a persistent interventricular conduction defect or a progressive loss of R wave in precordial derivations along with echocardiographic evidence of new onset RWMA. Serial CK-MB levels were not done.
Respiratory failure- Requirement of prolonged (i.e. greater than 48 hours) ventilation or presence of pneumonia.
Postoperative CVA- Occurrence of new stroke or intracranial bleeding confirmed by computed tomography. In patients with preoperative stroke, postoperative stroke was defined as worsening of neurological deficit with new radiological findings.

DISCUSSION
There are few series reporting CE during OPCABG procedures. Careaga and colleagues reported 8 and 44 cases, respectively. Off-pump CABG surgery for multivessel myocardial revascularisation in high-risk patients has been shown to reduce the incidence of perioperative morbidity and the period of hospitalisation. The very low incidence of readmission to the intensive care unit (nurse-patient ratio 1:1, cardiac monitoring, immediate access to advanced cardiac life support, arterial line and pulmonary artery catheter placement, temporary pacemaker placement, mechanical ventilation, intra-aortic balloon placement and vasoactive continuous intravenous infusions), return to theatre for bleeding or tamponade, infection and stroke in these high-risk patients in our OPCABG series. The intubation time, intensive care unit stay and the length of hospital stay has remained low and comparable to the data in the literature. Two patient in our study had transient stroke with complete recovery, which concurs in the study of Naseri and associates who reported no neurologic deficit.
Incomplete revascularisation has been shown to be one of the most important factors that affects perioperative morbidity, ventricular function, reoperation rate and early and late mortality. The adequate revascularisation of the LAD is considered as a vital determinant of the patient's prognosis. However, LAD endarterectomy is considered to be higher risk than other territories and therefore maybe avoided by some surgeons. In our series of OPCABG with CE, the commonest site of CE was the LAD (66%).

Previously, the Internal Mammary Artery (IMA) has been used cautiously as a conduit to an endarterectomised vessel because of concerns regarding mismatch of luminal diameter. With CCE, however, several authors have now reported satisfactory early and late clinical outcomes and luminal patency of IMA to an endarterectomised vessel compared with great saphenous vein. The use of the IMA for reconstruction of the LAD leads to reduced perioperative myocardial infarction, improved early patency and improved 5-year survival.

We have therefore utilised the left IMA to LAD in 76% of our cases.

The endarterectomy technique of choice is still a matter of controversy. We generally use the "traction technique" to perform endarterectomy. This technique is simpler, performed through a small incision and easier to reconstruct. The potential risks include incomplete removal of the plaque and the "snowplow effect," namely, shearing-off the plaque in the side branches and there are chances of incomplete removal. To avoid this, we opened the vessel at a distal site to complete the endarterectomy. With the "open technique," the vision is better and that may lead to more complete removal of the atheroma from the coronary vessel and its side branches. The traction technique was therefore preferred in most cases with careful inspection of the atheroma after removal.
was a residual plaque in the distal vessel. Myocardial contraction in the region of the LAD artery is more vigorous than the RCA territory that helps in the extraction of the distal atheromatous core by simple traction and makes it easier as compared with removal in the RCA. Myocardial Infarction (MI) secondary to acute graft closure is a major complication after CCE with a reported incidence of 1.5% to 19%.[7,11,18,19] and is higher when CE is not performed. The incidence of MI in our patients who underwent OPCABG with CE is 0.8% (4 of 480) that is in well correlation with the OPCABG without CE in the literature. However, proper biochemical analyses for infarct would probably show a higher incidence, especially around day 3 or 4.[20] Naseri and associates[7] reported a higher postoperative MI rate of 6.8% after OPCABG with CE in totally occluded or greater than 50% stenosis. Djallian and colleagues[11] reported an increased MI rate in endarterectomised vessels performed under cardiopulmonary bypass that were not completely occluded.[11]

To minimise the risk of acute graft or native- vessel thrombosis after CCE particularly for left-sided endarterectomies,[11,16,21,22] Routine intravenous infusion of heparin is recommended in the immediate postoperative period followed by warfarin for three months. However, our practice has remained the same.

The reported incidence of early mortality after CCE is between 1% and 15%.[7,10,11,17,20,23,24,25,26,27] and is higher than that of patients undergoing CABG without CE in the same institutions. OPCAB-CE was associated with a low perioperative mortality ranging from zero in smaller case series to 2.8% in the largest study.[28] Furthermore, comparative studies demonstrate at least equivalent 30-day mortality between OPCAB-CE and ONCAB-CE.[29] In the context of OPCABG with CE, Careaga and associates[1] and Erylimaz and colleagues[28] reported a 30-day mortality of 0% in their small series. Naseri and associates[2] who compared CCE and OPCABG with CE reported a mortality of 2.2% in a series of 44 patients with the latter technique. In our larger series of 480 high-risk patients, the early mortality of 0.8% is in conjunction with the world literature. Early death is reported to be higher after LAD endarterectomy[9] and in patients undergoing endarterectomy of more than one coronary artery.[10] We had large number of patients with multiple endarterectomies. Four early deaths in our series had single vessel endarterectomy. In our experience, endarterectomy of the circumflex and RCA territory is generally unnecessary when there is diffuse disease and extensive calcification due to the small caliber of the vessels. Naseri et al[2] retrospectively studied 88 patients undergoing either on- (n=44) or off- (n=44) pump CE. Overall, 30-day mortality was 3.4% (3/88; 1 OPCAB; 2 ONCAB) with postoperative MI occurring in 5.7% (5/88; 3 OPCAB; 2 ONCAB). Perioperative neurological deficit occurred in 8.0% (7/88) all of which were in the ONCAB group. The authors conclude that OPCAB-CE confers comparable safety to ONCAB endarterectomy.

Similarly, in their prospective study of 115 patients (43 OPCAB; 72 ONCAB), Hussain et al observed comparable mortality (P=0.649), MI (P=0.576), AF (P=0.197), IABP use (P=0.295) and respiratory complications (P=0.211) between OPCAB-CE and ONCAB-CE. OPCAB-CE was associated with reduced ITU stay (P=0.007) and a trend towards a shorter intubation period (P=0.060) and reduced postoperative renal failure (P=0.075).

Owing to the increasing number of patients with diffuse coronary artery disease being referred for OPCABG, there is a need to reassess the early and medium-term postoperative outcomes in patients undergoing primary OPCABG with CE in modern cardiac surgery. Despite the higher risk profile, hospital mortality and major complications in our study have remained comparable to other studies.

CONCLUSION

We have shown that the effect of OPCABG with CE appears to be safe and early outcomes are encouraging. Hence, diffuse disease requiring endarterectomy should not be considered a contraindication to OPCABG. Surgical skills and the suitability criteria of the patients are very important in this regard.

REFERENCES