Original Article

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Coronary Endarterectomy in Patients Undergoing Off Pump Coronary Artery Bypass Grafting: Surgical Experience in a Rural Tertiary Care Cardiac Centre

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Abstract

Background: Coronary artery bypass grafting (CABG) is the most frequently performed cardiac surgical procedures. The category of patients undergoing CABG has gradually reduced to more high risk group, requiring additional procedures like coronary endarterectomy. This study is to prove that off pump coronary endarterectomy can be performed safely with comparable morbidity and mortality as in conventional coronary endarterectomy. *Material and Methods*: 120 patients who underwent concomitant off pump coronary artery bypass grafting and coronary endarterectomy, over a period of 2 years, were included in this study. Average number of coronary bypass grafts were 2.2 ± 0.63. 80(66.8%) had left anterior descending artery (LAD), 56(46.2%) had right coronary artery and 9(7.9%) had obtuse marginal artery endarterectomies, with 62 receiving left internal mammary artery as the arterial graft to LAD. 3(2.5%) patients were converted to on pump surgery intraoperatively due to hypotension. The total surgery time, hospital stay, postoperative left ventricular ejection fraction (LVEF %), postoperative myocardial infarction (ECG changes), and drainage data was collected and compared with that of conventional surgery. All statistical analysis was done using SPSS software. Continuous variables were reported as mean±S.D. Continuous variables were compared by Chi-square test or Fischer's exact test. Differences were considered significant at $p < 0.05$. *Results:* The mean operating time was 118 ± 22minutes, postoperative drainage was 220±85 ml, and hospital stay was 5±1.3 days. Preoperative and postoperative LVEF was 46.13±4.4 and 54.37±1.6 respectively. 1 patient (0.83%) had postoperative MI. Had 1(0.83%) mortalityat 1 month due to bowel ischemia and septicaemia. *Conclusion:* We conclude that off pump coronary endarterectomyhas comparable early and late outcomes with reference to conventional endarterectomy, even for high risk patients with diffuse coronary artery disease.

Keywords: Coronary Endarterectomy; Off Pump Coronary Artery Bypass Grafting.

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Introduction

Coronary artery bypass grafting (CABG) is one of the most frequently done cardiac surgical procedures. 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 defined by old age, severe left ventricular dysfunction, previous percutaneous coronary intervention (PCI), diffuse coronary artery disease (CAD), where at least 75% of the segment distal to the lesion has a vessel diameter of < 2 mmand comorbidities such as diabetes mellitus

and peripheral vascular disease. Additional surgical procedures like coronary endarterectomy are needed for treating such high risk coronary artery disease to achieve complete revascularisation.

Coronary endarterectomy is removal of an atheromatous core by separating the external medial and adventitial layers to restore lumen of artery. It was first introduced in 1957 by Bailey etal. Earlier experiences ofcoronary endarterectomywere not satisfactory, but with refinement in surgical techniques, its benefits are now recognised.

Coronary endarterectomy on beating heart requires greater skill and surgical technique.The results of off-pump coronaryendarterectomy are encouraging and comparable with conventional coronary endarterectomy usingcardiopulmonary bypass.

Off pump coronary arterybypass surgery reduces the likelihood of acute renalfailure, reduced time of mechanical ventilation anddecreased bleeding thus requiring less number of bloodand blood products. The early results and particularlythe midterm survival rates, clinical status, and continuedgraft patency justify off-pump coronary endarterectomy in patients with severely depressed leftventricular function and diffuse coronary artery disease.Off-pump coronary endarterectomy can be performedsafely with morbidity and mortality comparable withthose of conventional coronary endarterectomy.

This study is a retrospective analysis of clinical profile and early surgical outcomes of patients undergoing off pump CABG and coronary endarterectomy in a tertiary care centre.

Materials and Methods

This is a single institutional retrospective study. 120 patients from January 2011 to January 2013, who underwent concomitant coronary endarterectomy and CABG at ACME, Pariyaram, were included. Patients who had any other associated procedure were excluded from the study. The age range of patients was 38-77 years.

Out of them, 96 were males and 34 females. Diabetes mellitus (46%) and hypertension (56%) 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 and the study had prior clearance from the institutional scientific and ethics committee.

Surgical Technique

All cases of CABG included in this study, were done off pump by performing a classical midline sternotomy. Heart was stabilised using Medtronic Octopus 4 tissue stabiliser and coronary endarterectomy was planned intraoperatively after coronary arteriotomy.

Indications included multiple significant stenosis in same coronary artery, totally occluded vessel supplying viable myocardium, occlusion along the entire length of artery, calcified vessel that makes suturing difficult and for complete revascularisation with conventional CABG.

Techniques of Coronary Endarterectomy used

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 endarterectomy was assessed by length of end atheromatous core extracted with soft, tapering and bluish end and 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 broken plaques during closed endarterectomy, densely adherent plaque to the vessel wall and 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, either a long on-lay patch angioplasty with LIMA/ saphenous vein or a free saphenous venous patch angioplasty. LIMA/ saphenous vein graft's distal end was then anastomosed to the patch.

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.Operative death was defined as death within 30 days of surgery. Low output syndrome was attributed to the need for Adrenaline >0.1µg/kg/min or Dopamine > 5 µg/kg/min. Perioperative myocardial infarction was considered on the presence 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 cardiac enzyme levels were not done. Requirement of prolonged (i.e. greater than 48 hours) ventilation or presence of pneumonia is considered respiratory failure. Occurrence of new stroke or intracranial bleeding, confirmed by computed tomography was considered as postoperative stroke. In patients with preoperative stroke, postoperative stroke was defined as worsening of neurological deficit with new radiological findings.

Antiplatelet and anticoagulants were given to every patient post operatively. Aspirin was started 6 hours post-surgery and warfarin was given next day onwards. Injection heparin was given 4 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 3 months follow up, warfarin was stopped and Clopidogrel 75 mg was added.

Data pertaining to total surgery time, hospital stay, pre and postoperative left ventricular ejection fraction (LVEF%), postoperative myocardial infarction (ECG changes), and drainage was collected and compared with the data available for conventional surgery. All statistical analysis was done using SPSS software. Continuous variables were reported as mean ± S.D. Continuous variables were compared by Chi-square test or Fischer's exact test. Differences were considered significant at $p < 0.05$.

Results

In the two year study period, 317 CABG operations were performed at our institution, excluding those with concomitant valve operations. 237(74.8%) of cases were off pump coronary bypasses (OPCAB), of which 120(50.63%) had concomitant coronary endarterectomy. The patient characteristics are mentioned in Table 1. The preoperative characteristics of patient are described in Table 2.

Table 1: Patient characteristics (N=120)

S. No.	Parameter		Value
1.	Age in years(Mean± SD)		59.85±10.43
2.	Sex ratio (M/F)		2.52:1
3.	Comorbidities	Hypertension	84(70%)
		Type II DM	91(75.8%)
		Dyslipidemia	77(64%)
		Obesity	39(32.5%)
		CVA*	12(10%)
		COPD**	31(25.8%)
		Previous PCI#	27(22.5%)
		PVOD##	14(11.6%)
		Renal dysfunction	21(17.5%)
		Emergency	28(23.3%)
4.	LVEF (%)	>55	47(39.1%)
		45-55	20(16.6%)
		35-45	27((17.5%)
		<35	26(21.6%)
		Mean ± SD	48.13±4.4
5.	Type of CAD	SVD***	12(10%)
		DVD***	24(20%)
		TVD***	84(70%)

*CVA: Cerebrovascular accident; **COPD: Chronic obstructive pulmonary disease; #PCI: Percutaneous coronary intervention;##PVOD: Peripheral vascular occlusive disease; ***SVD: Single vessel disease; ***DVD: Double vessel disease; ***TVD: Triple vessel disease

Table 2: Operative data (N=120)

SI. No.		Parameter		Value
1.		Number of grafts (Mean±SD)		2.2 ± 0.63
2.	a.	Total endarterectomies		120
	b.	Number of vessels	Single	88 (73.3%)
			Double	27 (22.5%)
			Triple	5 (4.16%)
	c.	Vessel wise	LAD*	80 (66.8%)
			RCA**	56 (46.2%)
			Diagonal	6 (5.4%)
			Ramus	4 (3.3%)
			OM#	9 (7.9%)
3.		Conversion to on pump CABG		3 (2.5%)
4.		Total vessels grafted		306
5.		Conduits used	LIMA (to endarterectomised LAD)	62
			RSVG##	244
6.		Surgery time (min)		118±22

*LAD: Left anterior descending;**RCA: Right coronary artery;#OM: Obtuse Marginal; ##RSVG: Reversed saphenous vein graft

Table 3: Post-operative data (n=120)

Sl. No.	Parameter		Value
1.	Period of ventilation(hours)(Mean ± SD)		5± 4.2
2.	Period of ICU stay (hours) (Mean ± SD)		36 ± 7.2
3.	Hospital stay (days) (Mean ± SD)		5 ± 1.3
4.	LVEF (%)	>55	59 (49.6%)
	(n=119)	45-55	32 (26.9%)
		35-45	17 (14.28%)
		<35	11 (9.2%)
		LVEF (Mean ± SD)	54.37 ± 1.3
5.	Postoperative drainage (ml) (Mean ± SD)		220 ± 85
6.	Transient CVA*		2 (1.68%)
7.	Postoperative MI** (ECG changes)		1 (0.83%)
8.	Immediate postoperative mortality		1(0.83%)
9.	Postoperative mortality at 30th day		1(0.83%)

*CVA: Cerebrovascular accident; **MI: Myocardial infarction

The mean age was 59.85±10.43 years withmale to female ratio of 3.4:1. 53 (44.1%) patients had moderate LV dysfunction with 26 (21.6%) having LVEF less than 35% on preoperative echocardiography. Majority (70%) of the cases were triple vessel disease. 28 of the 120 patients (23.3%) were operated on an emergency basis.

The mean operating time was 118±22minutes. Average number of coronary bypass grafts were 2.2±0.63 per patient. Total number of grafts performed were 306. There were 80 (66.8%) cases of LAD endarterectomy with 62 receiving LIMA as the arterial graft. 3 (2.5%) patients were converted to on pump surgery intraoperatively because of intraoperative hypotension.

The average ventilation was for 5 ±4.2 hours, with mean ICU stay of 36±7.2 hours. Patients with lower preoperative LVEF were ventilated for longer periods and had longer ICU stay. The mean postoperative drainage was 220±85 ml.The mean period of hospital stay was 5±1.3 days. Mean postoperative LVEF at discharge for the group was 54.37±1.3%, which was found to be significant statistically ($p<0.05$). 2 (1.68%) patients had transient CVA which recovered completely prior to discharge. There was 1 (0.83%) mortality in the immediate postoperative period due to postoperative myocardial infarction and subsequent low cardiac output. There was 1 (0.83%) mortality on the 30th postoperative day due to bowel ischemia (Table 3).

Discussion

There are limitedreports of coronary endarterectomy during off pump CABG procedures. Careaga and colleagues [1] and Naseri and associates [2] reported 8 and 44 cases, respectively. Off pump CABG surgery for multivessel myocardial revascularization in high-risk patients has been shown to reduce the incidence of perioperative morbidity [3,4,5] and the period of hospitalization [6].

The very low incidence of readmission to the intensive care unit and stroke in these high-risk patients. In our series the ventilation time, intensive care unit stay, and the length of hospital stay was low and comparable to available data in the literature. Two patient in our study had transient stroke with complete recovery, which concurs in the study of Naseri and associates [2], who reported no long term neurologic deficit.

Incomplete revascularization 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 revascularization of the LAD is considered as a vital determinant of the patient's prognosis [7,8].

However, LAD endarterectomy is considered to be higher risk than other territories [9] and therefore avoided by many surgeons. In our series of OPCABG with CE, the commonest site of CE was the LAD (66.8%).

Previously, the internal mammary artery (IMA) was used with caution as a conduit to an endarterectomised vessel because of concerns regarding mismatch of luminal diameter [10].

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 [11,12,13]. The use of the IMA for reconstruction of the LAD leads to reduced perioperative myocardial infarction, improved early patency, and improved 5-year survival [14]. We have therefore utilized the left IMA to LAD in 77.5% of our cases.

The endarterectomy technique of choice is still a matter of controversy [10-16]. We generally used the traction technique to perform endarterectomy. This technique was simpler, performed through a small incision, and easier to reconstruct [15,16].

The potential risks include incomplete removal of the plaque and the "snow-plow effect," namely, shearing-off of 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 [17,18]. The traction technique was therefore preferred in most cases, with careful inspection of the atheroma after removal. Extending the arteriotomy was only performed if it was thought that there 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 coronary endarterectomy with a reported incidence of 1.5% to19% [7,11,19,20], which is much higher than when not done. The incidence of MI in our patients who underwent off pump CABG with coronary endarterectomy is 0.83%, which that is in well correlation with the off pump CABG without coronary endarterectomy in the literature. Biochemical analyses for infarct using serial cardiac enzyme assays would probably show a higher incidence, especially around day 3 or 4 [21]. This was not done in our series due to financial constraints and thus limits our estimation of postoperative MI.

Naseri and associates reported a higher postoperative MI rate of 6.8% after off pump CABG with coronary endarterectomy in totally occluded or greater than 50% stenosis [2]. Djalilian and colleagues reported an increased MI rate in endarterectomised vessels performed under cardiopulmonary bypass that were not completely occluded [11]. To minimize the risk of acute graft or native-vessel thrombosis after endarterectomy, particularly for left-sided endarterectomiesroutine intravenous infusion of heparin is recommended in the immediate postoperative period, followed by warfarin for three months [11,16,22,23]. However, our practice has remained the same.

The reported incidence of early mortality after concomitant coronary endarterectomy is between 1% and 15% and is higher than that of patients undergoing CABG without endarterectomy in the same institutions [7,17,10,11,20,24-29]. Off pump coronary endarterectomy was associated with a low perioperative mortality ranging from zero in smaller case series to 2.8% in the largest study [30].

The current series has comparable early mortality of 0.83%. Furthermore, comparative studies

demonstrated comparable 30th day mortality between off pump and on pump coronary endarterectomy [31,32]. With regard to off pump CABG with coronary endarterectomy, Careaga and associates and Erylimaz and colleagues reported a 30-day mortality of 0% in their small series [1,28].

Naseri and associates compared on pump and off pump CABG with coronary endarterectomy and reported a mortality of 2.2% in a series of 44 patients with the latter technique. In our larger series of 120 high-risk patients, the early mortality of 0.83% is in conjuncture with the world literature. Early death is reported to be higher after LAD endarterectomy [9] and in patients undergoing endarterectomy of multiple coronaries [10].

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 calibre of the vessels. Naseri et al. retrospectively studied 88 patients undergoing either on- (n = 44) or off- (n = 44) pump coronary endarterectomy. Overall 30-day mortality was 3.4% (3/88; 1 off pump; 2 on pump), with postoperative MI occurring in 5.7% (5/88; 3 off pump; 2 on pump). Perioperative neurological deficit occurred in 8.0% (7/88) all of which were in the on pump group. In the present study, off pump coronary endarterectomyhad lower early or late mortality, postoperative MI or sustained neurological deficits and was comparable safety that of on pump endarterectomy [2].

Similarly, in their prospective study of 115 patients (43 off pump, 72 on pump), 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 off pump coronary endarterectomy and on pump coronary endarterectomy [5]. Off pump coronary endarterectomy was associated with reduced ICU stay (p = 0.007) and a trend towards a shorter intubation period (p = 0.060) and reduced postoperative renal failure (p = 0.075) [5].

In view of the increasing number of patients with diffuse coronary artery disease being referred for off pump CABG, and more vessels needing endarterectomy, there is a need to reassess the early and medium-term postoperative outcomes in patients undergoing primary off pump CABG with coronary endarterectomy in modern cardiac surgery. Despite the higher risk profile of the patients, in hospital morbidity (ventilation time, ICU stay, postoperative bleeding, CVA, MI), mortality and major complications in our study have remained comparable to that of on pump CABG and other similar study results.

Conclusion

We have shown that off pump CABG with concomitant coronary endarterectomy appears to have comparable early and late outcomes with reference to on pump CABG with coronary endarterectomy, even for high risk patients with diffuse coronary artery disease. Hence, diffuse disease requiring endarterectomy should not be considered a contraindication to off pump CABG with coronary endarterectomy.

Conflict of Interest

There are no conflicts of interests in this study.

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