

Paper

# Myocardial Revascularization By Off Pump Coronary Bypass Surgery (OPCABG): A Ten Year Review

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## ABSTRACT

**Background:** The use of cardiopulmonary bypass (CPB) may contribute to post-operative complications and organ dysfunction. Off pump coronary artery bypass grafting (OPCABG) avoids the use of CPB and hence is proposed to reduce these complications. We present the results of OPCABG in Northern Ireland over ten years.

**Methods:** Data was collected retrospectively from 1995 to 2005. Follow-up was done by telephonic questionnaire and from medical records within a closing interval of two months.

**Results:** 324 patients (224 male) underwent OPCABG with a median age of 62 years (range 35 to 79 years). There were 149 patients with CCS class III/IV angina and 48 with NYHA class III/IV. 148 patients had suffered a myocardial infarction in the past. 36 patients had a pre-operative predictive mortality score (EuroSCORE) of >5 and 48 patients had a preoperative LVEF of <30%. 585 bypass grafts were constructed (LAD=260, Diagonal=27, LCX/OM=123, RCA/PDA=103, RCA/PLV=72). Four patients needed to be converted from OPCABG to CPB on table. Another four patients needed re-operation due to graft related problems in the post-operative period and 6 needed post-operative Intra-aortic Balloon Pump (IABP) support. Post-operative complications included 3 TIAs, 1 complete stroke, 9 patients with renal failure and 51 patients developed atrial fibrillation post operatively. There was one peri-operative death due to pulmonary edema. Ninety percent of patients were in CCS angina class I/II and NYHA class I/II post-operatively. Forty one patients developed significant recurrence of angina requiring medical management, with 7 patients needing PCI/stenting. At the time of follow-up (median 5 years, range 3 months to 10 years) 9 patients had died.

**Conclusions:** Off pump coronary artery bypass (OPCABG) can be achieved with a low mortality and good medium to long term survival. OPCABG is associated with fewer post-op complications and comparable late coronary interventions.

**Keywords:** Off-pump, coronary artery bypass grafting, cardiopulmonary bypass, coronary artery disease, CABG, OPCABG

## INTRODUCTION

Coronary artery bypass grafting (CABG) or direct myocardial revascularisation involves the use of a vascular conduit to bypass atheromatous lesions in coronary arteries. The first recorded bypass operations were in the sixties when Goetz et al<sup>1</sup> and Kolessov<sup>2</sup> grafted pedicled internal mammary arteries to the right coronary artery and left anterior descending arteries respectively. These operations were performed without the use of cardiopulmonary bypass also known as Off-pump coronary artery bypass grafting (OPCABG).

Development of Cardiopulmonary bypass (CPB) and myocardial protection led to the development of myocardial revascularisation with cardioplegic arrest. This enabled cardiac surgeons to operate in a motionless and bloodless field; and so OPCABG was relatively abandoned for the technical advantage that CPB and cardioplegic arrest offered.

CPB is associated with activation of the complement system and the coagulation cascades which may contribute to the varying degrees of organ damage reported in the literature<sup>3,4</sup>. Blood contact with the artificial surfaces of the CPB circuit produces a well-documented diffuse inflammatory response

that affects multiple organ systems. Specific deleterious effects of the inflammatory response have been found in the heart, lungs, central nervous system, kidneys, and gastrointestinal tract<sup>3</sup>. These unavoidable side effects of CPB have led to the renewal of interest in OPCABG. Significant technological advances made in the last decade have allowed OPCABG to be performed with good success rates without the risks of CPB. This paper presents a retrospective review of our results over a ten-year period.

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## **METHODS**

All Patients who underwent OPCABG between September 1995 and March 2005 were identified from theatre records (n=324). Demographic data was obtained from medical case notes and the computerised patient data system (PATS). Formal EuroSCORE<sup>5</sup>, a validated predictor of operative mortality for cardiac surgical procedures, was calculated for each patient pre-operatively to predict the mortality. This scoring was introduced in 1999, and hence we included those patients who had the EuroSCORE computed pre-operatively and those who were operated by the senior authors (GC and PB) and excluded the rest of the patients (n=266). Operative variables recorded included: number of bypass grafts; type of conduit used; number of distal anastomoses; number of patients converted to CPB and the reasons for conversion. All the demographic, EuroSCORE and the procedure specific data were collected prospectively in this cohort of patients included for analysis, the post-discharge follow-up was done retrospectively.

All patients underwent an operation through a standard median sternotomy with the Left internal mammary artery (LIMA) harvested where indicated under direct vision. Heparin was administered at 2mg/kg prior to division of the mammary artery with supplemental doses to maintain adequate heparinisation (ACT, activated clotting time >250seconds); and reversed with protamine (1:1) after completion of the last proximal anastomosis. Aspirin or antiplatelet therapy was stopped five days before operation and recommenced immediately after the operation. Subcutaneous Enoxaparin was administered at 40mg twice daily post-operatively till the patients were mobile for deep venous thrombosis prophylaxis.

Commercially available mechanical stabilization devices such as the Octopus 2 (Medtronic Inc, Minneapolis, MN), CTS stabilizer (Guidant Inc) were used to stabilise the coronary targets on the beating heart; and pericardial traction sutures were used to position the heart where appropriate. The target coronary arteries were occluded proximally with a temporary snare using a pledgeted 4-0 polypropylene suture. Retrograde bleeding was controlled with a sterile, humidified carbon dioxide blower (Medtronic DLP, Grand Rapids, MI). Intraluminal coronary shunts (Bio-Vascular, Inc, St. Paul, MN) were used infrequently (< 10% of patients) when retrograde bleeding was excessive or when it was anticipated that occlusion of a coronary target would be poorly tolerated because of critical ischaemia.

Distal anastomoses were constructed with a continuous running 7-0 polypropylene suture. Proximal anastomoses were sewn to the aorta under a partial occlusion clamp with a continuous 6-0 polypropylene suture. All patients received postoperative care in the same Cardiac Surgery Intensive Care Unit (CSICU) with early extubation where appropriate, the aim being discharge by day 6.

### *Definitions of co-morbidities/complications:*

Postoperative variables recorded included creatine kinase isoenzyme MB (CK-MB) (as an indicator of peri-operative myocardial injury, with absolute increase of more than 10% compared to creatine kinase levels); changes in the

morphology of ST segment indicating ischaemia or infarction; incidence of ischaemic ventricular arrhythmias; Intra-Aortic Balloon pump (IABP) use and inotropic requirement as an indicator of myocardial dysfunction. Pulmonary dysfunction is defined as the long term use of bronchodilators or steroids for lung disease or prolonged ventilatory dependence due to pneumonia or ARDS. Neurological dysfunction is defined as neurological disease severely affecting ambulation or day-to-day functioning. Transient Ischaemic Attacks (TIAs) are neurological events with the signs and symptoms of a stroke which resolve completely within 24 hours. Renal failure is defined as anuria or oliguria (<10ml/hr) (with an adequate mean BP) and renal impairment is a serum creatinine >200 micromol/l or need for renal replacement therapy. Follow-up was done by telephonic questionnaire (within a closing interval of 2 months) and from medical records.

### *Statistical analysis:*

For normally distributed data the mean and standard deviations are expressed. Fisher exact test was used to determine significance between categorical variables and Mann Whitney U test for continuous variables. Binary logistic regression with confirmation by forward method was used for the multivariate analysis.

## **RESULTS**

Analyses revealed 324 patients (224 male) to have had OPCABG in the Royal Victoria Hospital between Sept 1995 and March 2005. Mean age was 62 (range 35 – 79). The study population consisted of 266 patients as outlined above, with a EuroSCORE median of 3 (range 1 – 8). Thirty six patients had a EuroScore<sup>5</sup> of more than five. There were 149 patients with CCS class III/IV angina (angina with mild exertion/angina at rest) and 48 with NYHA class III/IV (marked limitation of physical activity/unable to carry out any physical activity without discomfort). 148 patients had suffered previous myocardial infarction (MI) and 48 patients had a preoperative left ventricular ejection fraction (LVEF) of <30% on echocardiography or as estimated by ventriculogram.

A total of 585 bypass grafts were performed (Left anterior descending branch (LAD) = 260, Diagonal branch = 27, Obtuse marginal branch = 123, Posterior descending artery branch = 103, Posterior left ventricular branch = 72). The average number of grafts per patient was 2 (range 1 – 4) with a LIMA to LAD graft in 242(75%) of patients. Four patients had their operations converted to CPB; three for unstable haemodynamics and one for myocardial optimisation following a myocardial infarction intra-operatively. There were 2 peri-operative myocardial infarctions, 1 discovered on the operating table as above, the other detected post-operatively from CK-MB measurements. Four patients needed re-operation due to graft related problems in the peri-operative period, 6 patients required an intra-aortic balloon pump peri-operatively for haemodynamic instability including 1 post-operative death due to pulmonary oedema.

The median chest drainage was 781ml (range 130 to 2483ml). Median ventilatory time was 18 hours (range 2 to 168 hours). Four patients suffered cerebrovascular accidents (CVAs) peri-operatively; 3 were confirmed as TIAs and recovered fully prior to discharge and 1 patient had a complete stroke.

TABLE I:  
Comparison of the outcomes in a high risk group versus low risk group

Variable	Low-risk (n=73)	High Risk (n=58)	P value
Pre-op Neurological disease	1	5	0.08
Pre-op Renal impairment	1	7	<0.05
Pre-op Pulmonary disease	1	6	0.069
No of grafts	2.08(1-4)	2.24(1-3)	NS
Post-op CKMB	25(3-460)	30(3-187)	0.44
Ventilation (hours)	16.24(3-240)	15.87(4-24)	0.042
Blood loss (mls)	730(200-2430)	750(240-2000)	0.57
Hospital stay (days)	7.4(4-46)	7(4-19)	0.58
Adverse events	1	5	0.08
Late re-intervention	2	4	0.19

Fifty one patients developed transient atrial fibrillation post-operatively one of which was from chronic pre-operative atrial fibrillation. Nine patients developed post-operative renal failure one of which was known to have renal impairment pre-operatively and had a nephrectomy 7 years earlier. There were 6 wound infections post-operatively, one of which had a sternotomy wound dehiscence with mediastinitis and was successfully treated with debridement and rewiring.

At follow-up most patients (90%) were in CCS class I/II and NYHA class I/II post-operatively. A total of 41 patients developed a recurrence of angina, with seven needing PCI/stenting, the rest were well controlled medically. At the time of follow-up (median 5 years, range 3 months to 10 years) 9 patients had died.

#### *Surgery in high risk patients:*

The high risk group is defined as having one or more of the following: Age>75(n=8), LVEF<30% (n=48), MI within 6 weeks (n=7), pre-operative neurological dysfunction (n=5), pre-operative pulmonary dysfunction (n=6) and pre-operative renal impairment (n=7). We excluded (n=6) patients who had a non-cardiac procedure carried out together with OPCABG. We compared our results of OPCABG between the high-risk and low risk patients to see if there was any difference in the frequency of adverse events.

There were five patients who had more than two selection criteria for high-risk. Amongst high-risk patients, one developed CVA, two patients had pneumonia and two had transient renal failure not necessitating dialysis (adverse events) but none of the patients died in the perioperative period. One patient in low risk suddenly collapsed 3months after surgery, two patients in the high-risk group died, one due to a ruptured aortic aneurysm within 6months of surgery (which was known prior to his operation) and other due to a CVA and subsequent development of septicemia 10 months post-surgery. (Table I)

## DISCUSSION

This retrospective review presents the first report of the results of OPCABG in the province over ten years. Various modifications and technological advances over this period

now allow the safe performance of OPCABG in more groups of patients that previously would have been considered unsuitable. Numerous studies have demonstrated the safety and efficacy of OPCABG with favourable early outcomes and a recent meta-analysis revealed that OPCABG is a safe alternative to conventional CABG with respect to mortality, and is recommended to reduce perioperative morbidity<sup>6</sup>. We have demonstrated that using this technique, success rates (mortality) are comparable to conventional CABG using CPB.

OPCABG is unsuitable for patients with a severely dilated or hypertrophied heart; patients in cardiogenic shock; patients with mechanical complications of myocardial infarction like post-infarct ventricular septal defects (post-infarct VSD) and patients who may need concomitant valve procedures. In these cases the preferred method would be CABG with CPB. There is always the option to convert an OPCABG to conventional CABG for a number of reasons which include myocardial instability intra-operatively, intra-myocardial coronary arteries or difficult access to target vessels; but with modern technology and techniques this rarely happens.

A consensus is now emerging as to the appropriate application of OPCABG to benefit patients with a pre-operative risk of developing neurological dysfunction. These included patients with extensive carotid artery disease who have a high risk of developing a perioperative stroke<sup>4</sup>. OPCABG is ideally suited for patients who have an atherosclerotic aorta where manipulation of the aorta can be avoided by using bilateral internal mammary arteries with T configuration grafts to avoid the proximal anastomosis of the aorta. Patients with documented renal impairment who may be at increased risk of developing further renal damage, secondary to hypotension due to CPB, also benefit from OPCABG. The literature observes a trend towards a reduced need for blood transfusions, earlier weaning from ventilation and earlier discharge with the use of OPCABG even when it is employed in the elderly patient and in patients with several co-morbid conditions<sup>4,6,7</sup>. Currently, about 20% of surgical coronary revascularization at the national level is performed using OPCABG<sup>8</sup>. OPCABG is a useful strategy in the armamentarium of a modern cardiac surgeon and in carefully selected patients has proven benefit

with improved outcomes.

The outcomes of low risk patients and high risk patients were comparable (Table I). These high risk patients would have been expected to have a higher degree of complications and adverse events if they underwent conventional CABG with CPB.

This was a retrospective review and was not randomised so there is a selection bias for OPCABG. We cannot conclude from this study that OPCABG is a better alternative to CABG with CPB but we show that it is a successful and comparative option in surgical revascularisation of diseased coronary arteries. Due to advances in medical therapy older and sicker patients with other co-morbid conditions are referred for coronary bypass operations. This means an increasing proportion of patients may present with relative contraindications to CPB such as renal impairment and an increased risk of cerebrovascular accidents. For such patients a successful alternative is OPCABG.

The authors have no conflict of interest.

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