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Clampless off-pump surgery reduces stroke in patients with left main disease

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ABSTRACT

Background: Surgical revascularization is the most appropriate therapy for patients with significant left main coronary-artery disease (LMD). An incidence of perioperative stroke remains an issue when compared to the early outcomes to percutaneous coronary intervention (PCI). This study evaluates the safety and impact of standardized "clampless" OPCAB techniques, composed of either complete in situ grafting or "clampless" device enabled techniques for stroke reduction in patients undergoing surgical revascularization for LMD.
Methods: Between 1999 and 2009, 1031 patients with LMD underwent myocardial-revascularization at our institution. Of these, 507 patients underwent "clampless" OPCAB and 524 patients underwent conventional on-pump CABG (ONCABG). Data-collection was performed prospectively and a propensity-adjusted regression-analysis was applied to balance patient characteristics. LMD was defined as a stenosis >50% and endpoints were mortality, stroke, a cardiac-composite (including death, stroke and myocardial-infarction); a non-cardiac composite and complete-revascularization.
Results: In OPCAB patients, the cardiac composite (3.0% vs. 7.8%; propensity-adjusted (PA)OR = 0.27; CI95% 0.12–0.65; p = 0.003) as well as the occurrence of stroke (0.4% vs. 2.9%; PAOR = 0.04; CI95% 0.003–0.48; p = 0.012) were significantly lower while the mortality-rate was well comparable between groups (1.8% vs. 2.5%; PAOR = 0.44; CI95% 0.11–1.71; p = 0.24). The non-cardiac composite was also significantly decreased after OPCAB (8.9% vs. 19.7%; PAOR = 0.55; CI95% 0.34–0.89; p = 0.014) and complete revascularization was achieved for similar proportions in both groups (95.1% vs. 93.7%; p = 0.35).
Conclusions: This study shows the superiority of OPCAB for patients with LMD with regards to risk-adjusted outcomes other than mortality. A "clampless OPCAB strategy", effectively reduces stroke yielding similar early outcomes as PCI.

1. Introduction

Left main coronary artery disease (LMD) is an established predictor for major adverse cardiac and cerebro-vascular events [1] and is associated with a higher calcific load in the aorta and other arteries [1].

According to recent guidelines (American Heart Association (AHA) and the newly formed guidelines of the European Society of Cardiology/European Association of Cardiothoracic Surgery (ESC/EACTS)), coronary artery bypass grafting (CABG) remains the method of choice for patients with LMD [6,31] and although the appropriateness of surgical revascularization for these patients has also been confirmed by various randomized controlled trials suggesting CABG to be superior to PCI [14,21,28], the acceptance of this technique lacks to increase significantly, demonstrated by the high incidence of PCI [3,4,15,20,21,24,28,29].

The main argument against CABG is the higher incidence of stroke when compared to PCI [14,15,20,21,28]. However, the inferior neurological outcomes reported in previous studies resulted from the preferred use of conventional CABG strategies requiring cardio–pulmonary bypass and aortic cross-clamping techniques, all well-known predictors for worse neurological outcomes [2,8,11,27].

In contrast, off pump coronary artery bypass surgery (OPCAB) has been demonstrated to decrease the incidence of stroke [26,27] in particular when complete in-situ grafting (double IMA and/or T- or Y-grafting) or a "clampless strategy" for proximal anastomosis is performed [11,13,16,23]. Despite this knowledge, only 15% of all patients in the surgical arm of the recently published SYNTAX landmark trial

Abbreviations: CABG, coronary artery bypass grafting; OPCAB, off pump coronary bypass; PCI, percutaneous coronary intervention; MVD, multi-vessel disease; LMD, left main disease; MACCE, major adverse cardiac and cerebro-vascular events; IMA, internal mammary artery.

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underwent off-pump surgery [21,28] while it was completely disregarded in numerous other trials [3,4,15,20,21,24,28,29].

In this study, we evaluate the safety of a standardized off-pump approach in patients with LMD with a specific focus on “clampless strategies” to improve neurological outcomes.

2. Material and methods

This study was designed to focus on patients suffering significant left main disease (including patients with LMD + 1-vessel, LMD + 2-vessel or LMD + 3-vessel disease).

From 1999 to 2009, 1031 patients suffering from significant LMD underwent surgical revascularization at our institution. Of these, 507 patients received clampless OPCAB and 524 conventional on-pump CABG applying cardio–pulmonary bypass and aortic cross clamping. Preoperative risk stratification was performed using the EuroScore risk model. Demographics and preoperative variables are summarized in Table 1.

2.1. Surgical technique

CABG was performed using standard cardio–pulmonary bypass techniques and proximal anastomosis was done with complete clamping of the aorta. OPCAB was performed as previously described [8,9]. In brief, Heparin was administered to obtain active clotting time (ACT) in excess of 350 s and repeated if necessary. Epicardial temporary pace maker wires were placed, before a stabilizer (Octopus®4 Tissue Stabilizer, Medtronic, Minneapolis, USA) was used to expose the target vessel. A shunt (ClearView® Intracoronary Shunt, Medtronic, Minneapolis, USA) was routinely inserted and a mister blower (Guidant, Indianapolis, USA) with CO_2 and water was used to clear the surgical field. Routine ultrasound flow measurement (MediStim QuickFit®) of all grafts was done.

2.2. Clampless strategies

In patients with severe aortic calcification, as seen on preoperative chest X-ray and/or angiography a truly no touch complete in situ grafting strategy was planned. However, if this was not feasible and in all other cases, proximal anastomoses were carried out in a clampless fashion using the heartstring device (HEARTSTRING™ Proximal Seal System, Guidant, Indianapolis, USA) [5] (Fig. 1). In brief, and in conjuncture with intraoperative trans esophageal echocardiography (TEE) guidance on ascending aortic plaque, digital palpation was done to identify a soft (non-calcified) segment of aorta. Thereafter a circular aortotomy was created using the aortic-punch device before the coiled heartstring was inserted. The anastomosis was then performed with a continuous 6-0 Prolene suture. After completion of the anastomosis and before tightening of the suture the device was removed [10].

Table 1
Preoperative characteristics and demographics.

Parameter	OPCAB n = 507	ONCABG n = 524	P-value
Age (yrs)	66 ± 10	63 ± 9	0.0001
Male (%)	81.1	84.5	0.16
EuroScore	3.7 ± 1.1	4.0 ± 1.1	0.001
EF (%)	58 ± 14	57 ± 14	0.20
Sinus rhythm (%)	97.3	96.8	0.82
Atrial fibrillation (%)	2.7	2.3	0.81
Left main disease + 1-VD (%)	0.8	1.0	1.00
Left main disease + 2-VD (%)	20.5	14.7	0.017
Left main disease + 3-VD (%)	78.7	84.4	0.02
CCS 4 (%)	14.8	18.1	0.21
NYHA 4 (%)	0.9	2.5	0.08
Redo surgery (%)	4.3	8.0	0.02
Hypercholesterinemia (%)	66.7	76.3	0.005
Hypertension (%)	52.9	62.8	0.001
Positive family history (%)	33.3	31.9	0.64
Diabetes (%)	25.4	21.6	0.16
Smoking (%)	55.1	59.7	0.16
Adipositas (%)	53.6	41.4	0.0001
Acute MI (<90d) (%)	17.0	21.8	0.06
Previous MI (>90d) (%)	36.5	43.3	0.026
COPD (%)	5.1	8.0	0.078
Cerebrovascular disease (%)	2.6	1.5	0.28
PAD (%)	15.6	16.2	0.79
Renal disease (%)	5.3	1.7	0.007

EF = ejection fraction, CCS = Canadian Cardiovascular Society Angina Classification, 1-VD = 1-vessel disease, 2-VD = 2-vessel disease, 3-VD = 3-vessel disease, NYHA = New York Heart Association, PAD = peripheral artery disease, COPD = chronic obstructive pulmonary disease, MI = myocardial infarction.

2.3. Strategy for revascularization

Surgical revascularization was mainly started by LIMA to LAD grafting. After this the right coronary system was approached, and finally the circumflex territory was revascularized. In patients with left main disease, LAD and circumflex arteries were always grafted, regardless of the degree of stenosis. All other vessels with significant lesions (>70%) were identified preoperatively in the angiogram and selected as target for revascularization. LMD was defined as stenosis of the main stem of the left coronary-artery of more than 50%. As always decision making included visual assessment by the surgeon of target vessels, and in cases where targets appeared to be too small grafting to that branch was not done.

2.4. Primary endpoints

Primary endpoints included mortality, stroke and a cardiac composite endpoint including death, stroke, and myocardial infarction. Additionally, another composite endpoint including major non-cardiac adverse events such as respiratory failure, renal failure and bleeding was created. For patients undergoing emergent conversion to an ONCAB procedure, the ‘intention-to-treat’ methodology was applied. Stroke was defined as a new onset of a neurological deficit that appeared and remained at least partially evident for more than 24 h after its onset and occurred during or after the CABG procedure.

2.5. Secondary endpoint

To precisely assess completeness of revascularization in each case, an ‘Index of Complete Revascularization’ (ICOR) was calculated for each patient. The ICOR was defined as the total number of distal anastomoses divided by the number of the affected coronary vessels reported on the preoperative coronary angiogram. As previously reported, complete revascularization was assumed when all affected coronary territories (LAD, CX and/or RCA) were treated and the number of distal anastomoses was greater than that of diseased vessels (ICOR > 1) [8,18].

2.6. Data collection and statistical analysis

Data-collection was performed prospectively. Local institutional review board (IRB) approval included a waiver of informed and signed consent. Continuous data are presented as mean ± standard deviation and are compared using the Mann–Whitney test. Categorical data are presented as number and percentage and are compared using the chi-square test or Fisher's exact test as appropriate. Odds ratios with 95% confidence intervals are computed using univariate logistic regression. A propensity score (PS) was computed using logistic regression and a non-parsimonious model with numerous preoperative variables to balance characteristics between OPCAB and on-pump groups. The c-statistic was 0.89. In this computation, missing values in preoperative variables were replaced using multiple imputation regression methods. The PS then was divided into quintiles and analyzed as a categorical variable. PS adjusted logistic regression analysis was performed to assess binary endpoints and two-way analysis of variance for continuous endpoints. All analyses were performed using SPSS 18 (SPSS Inc., Chicago, IL). P-values < 0.05 are assumed to be statistically significant.

The data-set of preoperative variables for the non-parsimonious PS-score model included patient characteristics such as cardiovascular risk-factors and co-morbidities including cerebral-vascular events, peripheral artery disease (PAD), chronic-obstructive pulmonary-disease (COPD) and renal-failure. Cardiac-related preoperative conditions were: preceding myocardial-infarction (MI), MI within 3 months prior to surgery, preceding cardiogenic-shock, congestive heart-failure, arrhythmias, number of diseased coronary-vessels, previous CABG, elective, urgent/or emergent presentation, previous PTCA, previous stent implantation, NYHA class, CCS class, logistic EuroScore and others.

The authors of this manuscript have certified that they comply with the Principles of Ethical Publishing in the International Journal of Cardiology.

3. Results

3.1. Patient demographics

Patient demographics and preoperative characteristics including EuroScore, cardiovascular risk factors and co-morbidities are summarized in Table 1.

3.2. Intra-operative data and complete revascularization

The number of diseased vessels (2.78 ± 0.43 vs. 2.93 ± 0.28; p < 0.001) and subsequently the total number of distal anastomoses (3.43 ± 0.92 vs. 3.81 ± 0.85; p < 0.001) were both lower in the OPCAB group respectively. OPCAB patients received significantly more arterial grafts when compared to ONCABG patients (1.68 ± 0.87 vs. 1.30 ± 0.84; p < 0.001)