On-pump versus off-pump coronary artery bypass: independent risk factors and off-pump graft patency

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Abstract

Objective: Current knowledge on off-pump coronary artery bypass (OPCAB) generally stems from single surgeons’ experience or from series where OPCABs constituted a minor fraction of coronary operations. The present center decided to venture as far into OPCAB as possible during 1999. The present series thus represents the average surgeon’s experience.

Methods: During 1999, 533 patients underwent coronary artery bypass grafting using cardiopulmonary bypass (CPB) in 368 and OPCAB in 165 including the circumflex artery (CX) area in 91. Coronary arteriography was performed before discharge in the first 103 OPCAB patients.

Results: The CPB and OPCAB groups differed as regards left ventricular ejection fraction (53 ± 13 versus 57 ± 11, P < 0.0001) and frequency of triple-vessel or left main stem disease (84% versus 32%, P < 0.0001) but were comparable as regards diabetes (12%), prior myocardial infarct (57%), unstable angina (21%), and previous heart surgery (3%). Using multivariate analyses, 30-day mortality (1.3%), P-creatine kinase myocardial band (CKMB) >80 µg/l (11.1%), re-sternotomy for bleeding (4.5%) or dehiscence (1.7%), transitory cerebral ischemia and stroke (1.7%), supraventricular tachycardia (27.4%), and hospital stay (mean 8 days) were unrelated to off- versus on-pump surgery as well as to OPCAB in triple-vessel disease. CX branches ≤1 mm, ≥5 distal anastomoses, prior heart surgery, right coronary artery (RCA) branches ≤1.5 mm, 8–21 days old myocardial infarct, female gender, and preoperative acute arrhythmia (among others) were identified as independent risk factors for mortality or increased CKMB in all 533 patients. The latter five risk factors were reproduced in the OPCAB group isolated. The patency in the 103 OPCABs was 95.3, 91.8, and 85.3% in the left anterior descending artery (LAD), CX, and RCA, respectively. Patency was inversely related to diameter of the grafted vessel in the LAD and CX areas, unlike the RCA area.

Conclusions: The results after beating heart surgery were good also in patients with triple-vessel disease, but specific gains relative to on-pump surgery could not be shown. The independent risk factors in the OPCAB group may indicate relative contraindications for OPCAB grafting.

Keywords: Coronary bypass grafting; Off pump; Beating heart; Cardiopulmonary bypass; Graft patency

1. Introduction

Off-pump coronary artery bypass (OPCAB) has attracted considerable attention due to hypothetical hazards of cardiopulmonary bypass (CPB) and possibly due to a desire to find an attractive surgical countermeasure to percutaneous management of coronary artery disease (CAD). A small non-randomized study showed less neurocognitive dysfunction following off-pump than after on-pump surgery [1]. However, the off-pump group was characterized by an aorta non-touch technique [1]. Absence of proximal anastomoses by full arterial revascularisation in multi-vessel CAD combined with epiaortic scanning to choose cannulation site for CPB has been shown to similarly reduce the incidence of neurocognitive dysfunction [2]. Furthermore, current knowledge on off-pump surgery stems to a large degree from series where OPCAB was performed in less than 20% of bypass grafting procedures [3–7]. Most OPCAB procedures were done in patients with left anterior descending (LAD) or right coronary artery (RCA) disease and generally represented the experience of a single or a few surgeons of each center [3–5,7,8].

The possible benefits of avoiding CPB prompted the present center to decide to go as far into off-pump coronary surgery as possible starting 1 January 1999. Our aim was to produce results as good as or better than those following
operations during CPB. The outcome assessment included multivariate analysis of early results as well as a control coronary angiography before discharge in the first 100 OPCAB patients. Including all patients who underwent isolated coronary artery bypass surgery during the calendar year 1999, the present series thus represents the experience of ‘the average surgeon’.

2. Material and methods

During 1999, a total of 533 patients underwent isolated coronary bypass grafting at the present center using CPB in 368 and OPCAB in 165 including grafts to the circumflex (CX) territory in 91. Before the start of this study, all five senior surgeons and two staff grade surgeons of the present center had experience in off-pump grafting to the LAD artery and RCA territories. Hemodynamic instability, small CX branches, and prior open heart surgery as well as poor left ventricular function in patients with CX disease tended to contraindicate off-pump surgery. Full revascularization was the aim in all patients. The preoperative data are shown in Table 1 and Appendix A.

All variables were recorded prospectively by the individual surgeons and ‘data-audit’ performed by the present study group. Kidney failure was defined as a preoperative P-creatinine above the upper reference level of our laboratory (125 μmol/l) while unstable angina was recorded in patients who needed continuous intravenous infusion of nitrates. Body mass index was calculated from body weight (kg) and height (cm) using standard formulas: weight/((0.53 × height) − 17.6) for men, and weight/((0.53 × height) − 27.6) for women. Peak P-creatine kinase myocardial band (CKMB) was used as an indicator of possible intraoperative myocardial damage using a direct concentration measure (μg/l) in blood samples taken electively 6 and 20 h after the operation (one patient who died with signs of complete graft failure before the first blood sample had a peak CKMB of 200 μg/l arbitrarily assigned). Since we generally see peak CKMB values of 20–70 μg/l after uncomplicated coronary bypass grafting using CPB, we chose 80 μg/l as cut-off point for increased CKMB for the present study.

2.1. Operative technique and control angiography

Surgical data are given in Table 1 and Appendix B. An arterial Y-graft [9] was constructed using the pedicled left internal mammary artery (IMA) with a free right IMA (N = 48) or radial artery (N = 1) as ‘Y-leg’ with the left IMA passed through a pericardial window in front of the phrenic nerve and the side anastomosis placed just inside the pericardium. A further four patients received a Y-graft with an additional radial artery graft in three and a saphenous vein graft in one. All patients received intravenous nitrate infusion for the first 24 h postoperative, after which those with a radial artery graft were put on oral nifedipine treatment. After completing all grafts, their flow was measured on the beating heart (before decanulation in the CPB group) with a transit time Doppler flow method [10,11]. The distal (or proximal) anastomosis was immediately re-done if flow

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Preoperative and operative data*</th>
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<tbody>
<tr>
<td></td>
<td>CPB (N = 368)</td>
</tr>
<tr>
<td>Age (years)***</td>
<td>64 ± 10 (33–84)</td>
</tr>
<tr>
<td>Weight (kg)**</td>
<td>80 ± 13 (45–126)</td>
</tr>
<tr>
<td>Body mass index*</td>
<td>1.12 ± 0.16 (0.69–1.66)</td>
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<tr>
<td>Previous PTCA/stent****</td>
<td>1% (5)</td>
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<tr>
<td>Coronary artery disease****</td>
<td>1% (2)</td>
</tr>
<tr>
<td>1-vessel</td>
<td>15% (57)</td>
</tr>
<tr>
<td>2-vessel</td>
<td>84% (309)</td>
</tr>
<tr>
<td>LV ejection fraction (%)***</td>
<td>53 ± 13 (15–75)</td>
</tr>
<tr>
<td>Conduits****</td>
<td>0</td>
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<tr>
<td>Pedicled IMA</td>
<td>1% (4)</td>
</tr>
<tr>
<td>Bilateral pedicled IMA</td>
<td>8% (30)</td>
</tr>
<tr>
<td>Arterial Y-graft</td>
<td>2% (8)</td>
</tr>
<tr>
<td>Bilateral IMAs and vein(s)</td>
<td>13% (46)</td>
</tr>
<tr>
<td>Vein(s)</td>
<td>74% (273)</td>
</tr>
<tr>
<td>Distal anastomoses****</td>
<td>2% (7)</td>
</tr>
<tr>
<td>Lowest body temperature (°C)</td>
<td>35.3 ± 1.1 (25.1–37.2)</td>
</tr>
<tr>
<td>Operation duration (min)</td>
<td>193 ± 55 (100–520)</td>
</tr>
</tbody>
</table>

* Data are % (number of patients) or mean ± standard deviation (range). PTCA, percutaneous transluminal coronary angioplasty; LV, left ventricular; IMA, internal mammary artery. ****P < 0.0001; ***P < 0.001; **P < 0.01; *P < 0.05.

** One pedicled and one free IMA (N = 4); bilateral pedicled IMAs and one radial artery (N = 5); Y-graft (pedicled left, free right IMA as ‘Y-leg’) and one radial artery (N = 3).
velocity was unacceptable relative to the quality of the grafted vessel.

2.1.1. CPB group

CPB was performed with standard equipment and techniques during normothermia (N = 299) or moderate hypothermia (32°C; N = 69) and cardiac arrest achieved with cold hyperkalemic crystalloid (N = 334) or blood (N = 34) cardioplegia. The cross-clamp time averaged 53 min (14–125).

2.1.2. Off-pump surgery

The OPCABs were performed via a midline sternotomy during partial heparinization aiming at maintaining the activated clotting time around 300 s without reversing with protamine. Mechanical stability of the coronary arteriotomy area was achieved with the Octopus™ II (Medtronic Inc., Minneapolis, MN, USA). Visibility was aided by a CO₂-water spray and hemostasis obtained by using a soft plastic flow-shunt passed into the coronary arteriotomy or by a small arterial clamp or tourniquer on the coronary artery. Elevation of the heart to expose the CX branches and to some degree the RCA branches was achieved with deep pericardial stay sutures placed above the entry of the left lower pulmonary vein, deep to the apex, and laterally to the entry of the inferior vena cava. Proximal anastomoses on the aorta and the side anastomosis of a Y-graft was made first followed by sequential revascularization of LAD, RCA, and CX areas. The sequence in case of full arterial revascularization with a Y-graft was: diagonal and LAD with the left IMA first followed by CX branches and ending with an endo-side anastomosis on the posterior descending artery with the ‘Y-leg’. The OPCAB group included ten patients who had a mini-invasive grafting of the LAD done with a pedicled left IMA via a left anterior mini-thoracotomy.

2.1.3. Control angiography

During January through September, 103 (80%) out of 129 OPCAB patients had a re-angio before discharge; in six patients the re-angio was not performed because of access problems during the preoperative angio while 20 patients declined. Ten re-angios were done acutely due to ECG changes or hemodynamic instability in the immediate post-operative period. The angiographies were performed using standard technique and equipment. Patency of each distal anastomosis (graft wide open and functioning; grades A and B) was defined according to Fitzgibbon et al. [12]. An arterial graft was considered occluded if it showed a ‘string sign’.

2.2. Statistical analysis

All statistical analyses were performed using the BMDP Dynamic version 7.0 programs [13]. Univariable comparisons between groups were done with a standard Pearson chi-square test, a non-paired t-test, or a one-way analysis of variance as appropriate. Multivariable analyses of deaths within 30 days after the operation (30-day mortality), increased CKMB, and other postoperative complications were performed using a stepwise logistic regression analysis in a comprehensive formalized analysis sequence as previously described [14]. All variables of Table 1 and Appendices A and B were considered. If not included during the standardized test sequence, it was checked if addition of OPCAB or OPCAB in triple-vessel CAD to each of the final models gave additional improvement which was not the case. The level of statistical significance was 0.05.

3. Results

The CPB and OPCAB groups were comparable as regards female gender (20%), diabetes mellitus (15%), kidney failure (13%), unstable angina (21%), acute arrhythmia (2%), and previous open heart surgery (3%) (Appendix A). The OPCAB patients were a little younger, had higher body mass indexes, more prior percutaneous angioplasty/stent procedures, but less 3-vessel CAD, and higher left ventricular ejection fraction than the CPB patients (Table 1). Full arterial revascularization dominated in the OPCAB group mainly due to the higher prevalence of 1- and 2-vessel CAD (Table 1). Patients with 3-vessel disease received more distal anastomoses (mean 4.2, range 2–8) in the CPB (N = 309) than in the OPCAB group (mean 3.6, range 3–5; N = 52; P < 0.001) mainly due to selection of severe/diffuse 3-vessel CAD to CPB. The CPB group includes 14 patients who were converted from OPCAB to CPB due to low systemic pressure (N = 3), ischemia (N = 2), arrhythmia (N = 3), redo of grafts (N = 3), or exposure problems (N = 3).

3.1. 30-day mortality, increased CKMB, and operation failure

There were seven deaths within 30 days after the operation (no one after 30 days during continued admission; Table 2). There were two deaths in the OPCAB group, both from low cardiac output failure a few hours after the operation, one involved bilateral pedicled IMAs with the right passed through the transverse sinus to an obtuse marginal (acute re-sternotomy indicated graft occlusion), and one with a Y-graft (autopsy showed an open graft without abnormalities). There were five deaths in the CPB group: two from low output failure within hours after the operation in patients with a Y-graft (one with an additional radial artery graft; no autopsy), one from multi-organ failure on the 12th day in a kidney transplanted patient, one following a thrombotic stroke on the sixth day, and one from pulmonary insufficiency on the 17th day in a patient with severe pulmonary emphysema. The three deaths with a Y-graft (one OPCAB, two CPB) involved left main stem disease and the free flow capacity of the Y-graft [9] measured in two was <100 ml/min. The final risk model for 30-day mortality in all 533 patients is shown in Table 3.
Due to only two deaths, no risk model was made exclusively in the OPCAB patients.

Increased CKMB was most prevalent in the CPB group (Table 2). The final risk model in all 533 patients (Table 4) included well-known risk factors in addition to one of the surgeons, and ‘other multi-arterial grafting’ but not CPB versus OPCAB (Table 4). Also, a ‘healing’ myocardial infarct (8–21 days old; \(N = 34\)) was related to high CKMB unlike infarcts <24 h (\(N = 3\)), 1–7 days (\(N = 2\)), or >21 days old (\(N = 262\)). The test in the OPCAB patients exclusively revealed the model shown in Table 5: a healing myocardial infarct and medium sized or small posterior descending or left ventricular branch of the RCA were associated with increased CKMB while a Y-graft (without additional grafts) and an IMA graft was associated with low CKMB.

Re-coronary bypass grafting was done as an emergency in three patients in the CPB group (two following acute coronary angiographies), and in four in the OPCAB group (three following acute angios and one an elective angio). Since no elective control angios were done in the CPB group, we chose to analyse operation failure (death, increased CKMB, and re-coronary artery bypass) only in the OPCAB group. The risk model is shown in Table 5. The risk factors included those of increased CKMB (except 8–21 days old myocardial infarct) in addition to acute arrhythmia preoperatively, and female gender. Considering all 533 patients, a pedicled RIMA passed through the transverse sinus to an obtuse marginal or intermediary coronary artery (\(N = 39\)) which was associated with ‘operation failure’ in 31% compared with 12% in the remaining patients (\(P < 0.01\)).

### 3.2. Other postoperative complications and OPCAB graft patency

Re-sternotomy for bleeding or for sternal dehiscence, cerebral complications, atrial fibrillation, and postoperative hospital stay did not differ significantly between the groups (Table 2). The independent risk factors included kidney failure (\(P = 0.02\)) and one surgeon (reducing risk; \(P = 0.02\)) for re-sternotomy for bleeding, bilateral IMA harvest (\(P = 0.006\)), insulin treated diabetes mellitus (\(P = 0.01\)), and obesity (Appendix A; \(P = 0.01\)) for sternal dehiscence, peripheral vascular disease (Appendix A; \(P = 0.006\)) and CX branches ≤1 mm for cerebral complications, increasing age (\(P < 0.0001\)) and left ventricular ejection fraction <30% (\(P = 0.01\)) for atrial fibrillation, and age ≥70 years (\(P < 0.0001\)), female gender (\(P < 0.0001\)), and diabetes mellitus (oral antidiabetics or insulin treated; \(P = 0.02\)) for a hospital stay of more than 7 days after the operation (\(N = 180\); tested in the 526 operative survivors). The independent risk factors for conversion to CPB (\(N = 14\)) in the 179 patients started off-pump included CX disease (\(P = 0.004\)), RCA branches ≤1.5 mm (\(P = 0.02\)), grafting with a single artery and veins (\(P = 0.02\)), and insulin treated diabetes mellitus (\(P = 0.04\)).

The graft patency in the 103 OPCAB patients were 92% (247 patent distal anastomoses out of 269), 95.3% in the LAD area (122/128), 91.8% in the CX area (67/73), and 85.3% in the RCA area (58/68). The patency was inversely related to size of the grafted vessel in the LAD and CX areas, but not in the RCA area (Table 6). Graft patency was 100% (46 distal anastomoses) in 14 Y-grafts with a control angio. Eight of ten pedicled right IMAs to the RCA main stem or acute margin, and five of seven to the posterior descending artery were patent, compared with 88% of 51 remaining grafts to the RCA area.

### 4. Discussion

In the present unselected series, off-pump grafting was performed in 31% of the patients with grafting to the CX
area in more than half of the OPCAB procedures, unlike most other off-pump coronary bypass series. The present CPB and OPCAB groups were comparable with regard to a whole range of pertinent risk factors but due to selection incomparable with regard to others. Triple-vessel CAD dominated in the CPB group while the OPCAB group included more obese patients and more percutaneous angioplasty/stent procedures.

Reduced mortality and morbidity in off-pump versus on-pump coronary bypass grafting can generally be explained by corresponding differences in risk profile of the patients [3]. The present 30-day mortality after off-pump surgery of 1.2% compares favorably with the mortalities of recent reports [6–8,15]. The ‘on-pump mortality’ in these reports were higher (2.1–3.4%) than the present one. Our risk analysis in the CPB and OPCAB groups joined revealed that off-pump surgery neither reduced nor increased mortality, and furthermore, identified three well-known risk factors: high age and kidney failure are integral parts of a multitude of risk scores while most surgeons may apprehend the impact of small CX branches. It has previously been shown that ‘small vessel disease’ have a disproportionately stronger impact in women than in men [16]. The presence of small CX branches may thus explain the absence of female gender in the present risk model. Furthermore, this result strongly underlines small CX branches used empirically to contraindicate off-pump surgery: the CX area can be technically demanding alone due to access problems.

A Y-graft was also a risk factor in our mortality analysis. All three deaths with a Y-graft occurred in patients with a left main stem stenosis, and the free flow capacity of the Y-graft was less than 100 ml/min which was probably insufficient. Royse et al. [17] showed that a free flow of the Y-graft of >140 ml/min indicated a two- to three-fold flow reserve after revascularization of all three main coronary areas. A Y-graft actually reduced early mortality following CPB in another study [9]. In the present OPCABs, a Y-graft predicted low peak CKMB and a low operation failure rate and the patency was 100%.

Our risk model for increased CKMB in the CPB and OPCAB groups joined gave important additional information. With a univariate comparison, the frequency of increased CKMB was lower after off-pump than on-pump surgery as in other studies [7,8,18]. However, easily apprehendable risk factors such as previous open heart surgery, a healing (8–21 days old) myocardial infarct, five or more distal anastomoses, and female gender, contrary to on-pump surgery, were the decisive risk parameters. Number of distal anastomoses in addition to low left ventricular ejection fraction and long aortic cross-clamp time were identified as independent risk factors in a CPB series [19]. ‘Other multi-arterial grafting’ was also a risk factor in the present analysis. This group included pedicled right IMAs passed through the transverse sinus to the CX area or grafted to the RCA. A pedicled right IMA predicted a high frequency of operation failure when passed through the transverse sinus and its patency when anastomosed to the RCA and its branches in the OPCAB patients was not impressive. Other authors advocate caution in the use of a pedicled right IMA to the CX and RCA areas [20,21], while it functions well on the LAD [19].

In our OPCAB group, the risk model for increased CKMB included intermediary and small RCA branches.
(diameter ≤1.5 mm) which also predicted both operation failure and conversion to CPB. Together with our observed graft patency in the RCA area, being unrelated to diameter of the grafted vessels, these factors might indicate that poor RCA branches should contraindicate off-pump surgery. This may be especially true in women since female gender was a predictor of operation failure following OPCAB. Complete revascularization with a Y-graft on the beating heart, on the other hand, independently predicted a low CKMB and a low rate of operation failure. The added technical complexity involved with a Y-graft should thus not deter one from off-pump surgery if simple rules regarding quality of the conduits and the free flow capacity measured before constructing the distal anastomoses are observed. Preoperative ‘electrical instability’ (acute arrhythmia) was a very potent predictor of operation failure in the OPCAB patients and should probably contraindicate off-pump surgery.

Our OPCAB groups tended to have more frequent re-sternotomy for bleeding or sternal dehiscence/infection than the CPB group. The latter was explained by significantly more bilateral IMA harvests and obesity in the OPCAB groups, which together with insulin treated diabetes mellitus, as in numerous other studies, constituted the independent risk factors. Others have indicated that off-pump coronary bypass is less likely to be followed by atrial fibrillation than on-pump surgery [22]. In the present study, atrial fibrillation was predicted by well-known risk factors, namely high age and low ejection fraction, and not related to CPB or OPCAB.

The present incidence of postoperative stroke and transitory cerebral ischemia was low and did not differ significantly between the CPB and OPCAB groups. The independent risk factors indicated universal atherosclerosis as the cause. CX branches ≤1 mm also increased the risk which in the off-pump situation might be related to displacement of the heart for an extended period with relative hypotension, compromised venous return to the heart and cerebral congestion. We did not submit our patients to neurocognitive testing which may be a weakness of our study.

Hospital stay vary quite significantly between reports and may to some extent be related to the local set-up of health services. We discharge our patients when they are able to take care of themselves in their own homes. We could not show any benefits with regard to shorter hospital stay associated with OPCAB. A prolonged admission was not surprisingly related to high age, female gender, and diabetes mellitus.

A prerequisite of off-pump surgery is that anastomosis quality do not suffer. So far, no randomized study comparing off-with on-pump coronary bypass with angiographic follow-up has been published. We did not perform re-angio in our CPB patients due to capacity problems. Comparisons with patencies of the past may be misleading since ‘the good half’ of CAD patients presently are managed percutaneously. However, the present patencies of 95% in the LAD, 93% in the CX, and 85% in the RCA following OPCAB compare almost exactly with recently published patencies following CPB [23,24]. A recent off-pump study revealed a 96% patency in a series where 74% of patients had one-vessel CAD [5]. Gerola et al. [24] published an 80% and Royse et al. [23] an 82% RCA anastomosis patency following CPB. In the latter study, the pedicled right IMA to the RCA had a patency of 75% (74% in the present study) compared with 92% with other grafts (88% in our study). Competing flow from a well-functioning left IMA on the LAD via septal collaterals may be part of the explanation of such results. It seems that graft material and strategy rather than CPB are the relevant determinants of anastomosis quality.

We may conclude that the results after OPCAB were good, also in patients with triple-vessel disease. However, off-pump surgery did not result in specific gains relative to on-pump coronary bypass as regards mortality and morbidity or length of postoperative hospital stay. Well-known adverse risk factors rather than CPB versus OPCAB were identified as the decisive parameters. However, our study indicates that change in operative technique and clinical practice can be safely achieved. The independent risk factors in the present OPCAB group may indicate contraindications for off-pump surgery.

References

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Appendix A. Variables that did not differ between the CPB and OPCAB groups

Female gender, N = 104; height, 174 ± 8 cm (145–196); diabetes mellitus, N = 82; diabetes mellitus stratified according to treatment (diet, N = 21, oral antidiabetic drugs, N = 43, insulin, N = 18); kidney failure, N = 71; haemodialysis, N = 2; unstable angina, N = 114; previous open heart surgery, N = 15; preoperative acute arrhythmia, N = 10 (ventricular fibrillation, N = 5; supraventricular tachycardia, N = 5); statin treated hypercholesterolemia, N = 263; morbid obesity (body mass index >1.20 indicating more than 20% overweight relative to ideal weight), N = 148; medically treated arterial hypertension, N = 139; medically treated chronic obstructive pulmonary disease, N = 29; peripheral vascular disease (intermittent claudication or previous peripheral vascular surgery), N = 26; cerebral vascular disease (previous stroke or known carotid artery stenosis), N = 12; previous one/two/three myocardial infarcts, N = 231/65/7; last myocardial infarct <24 h old, N = 3; 1–7 days old, N = 2; 8–21 days old, N = 34; >21 days old, N = 262.

Appendix B. Coronary artery segments (and their diameter) receiving a bypass anastomosis

Number of patients receiving an anastomosis to each of the following coronary artery segments (number with a sequential side-to-side anastomosis) and probe diameter of segment in mm as mean ± standard deviation and range: LAD artery, N = 506 (51), 1.6 ± 0.3, 0.5–2.5; first diagonal, N = 251 (219), 1.5 ± 0.2, 1–2; second diagonal, N = 50 (42) 1.4 ± 0.2, 1–2; third diagonal, N = 9 (4) 1.9 ± 0.3,1–2; intermediary artery, N = 84 (62) 1.6 ± 0.2, 1–2.5; first obtuse marginal, N = 271 (198), 1.5 ± 0.3, 0.5–3; second obtuse marginal, N = 210 (168), 1.5 ± 0.2, 0.5–2.5; third obtuse marginal/distal circumflex, N = 72 (69), 1.5 ± 0.2, 1–2; RCA main stem, N = 72 (3), 2.1 ± 0.3, 1–3; RCA acute margin, N = 19 (8), 1.7 ± 0.3, 1.5–2.5; posterior descending artery, N = 332 (23), 1.5 ± 0.2, 1–2.5; left ventricular branch/distal RCA, N = 44 (20), 1.9 ± 0.3, 1–2.