# To graft or not to graft? Do coronary artery characteristics influence early outcomes of coronary artery bypass surgery? Analysis of coronary anastomoses of 5171 patients

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**Objective:** Small coronary size and extensive atherosclerosis pose operative challenges during coronary artery bypass grafting. We investigated the influence of coronary characteristics on early operative outcome.

**Methods:** Prospectively collected data for 5171 patients undergoing first-time coronary artery bypass grafting from April 1, 1999, to December 31, 2007, were analyzed. Coronary diameter estimated or probe-gauged intra-operatively was regarded as small if 1.25 mm or less. Coronary atherosclerosis was graded as none/mild or moderate/severe. Their influence on postoperative major adverse cardiac events, myocardial infarction or reinter-vention for graft failure, post-cardiotomy shock, and operative mortality, was investigated.

**Results:** Of 14,019 coronary anastomoses, 4417 coronaries (31.5%) were small and 5895 coronaries (43.4%) had moderate/severe atherosclerosis. All grafted coronaries were small in 1091 patients (21.1%). Left anterior descending, circumflex, and right coronary arteries received grafts in 94.8% of patients (n = 4903), 74.3% of patients (n = 3842), and 72.5% of patients (n = 3751), with corresponding rates of 31.7%, 31.7%, and 32.6% for small-caliber arteries, 44.4%, 33.3%, and 47.2% for moderate/severe atherosclerosis, and 0.6%, 0.5%, and 3.4% for endarterectomy. Postoperative major adverse cardiac events occurred in 236 patients (4.6%). There was no clear evidence that small caliber of half or more distal anastomoses in a patient (odds ratio, 1.36; 95% confidence interval, 0.97–1.94; P = .07) increased the risk of a major adverse cardiac event, but incomplete revascularization (odds ratio, 1.87; 95% confidence interval, 1.03–3.39; P = .04) and moderate/severe atherosclerosis of the left anterior descending artery (odds ratio 1.37; 95% confidence interval, 1.01–1.87; P = .04) did increase the risk.

**Conclusion:** Grafting small coronaries did not significantly increase the risk of an early postoperative major adverse cardiac event, but incomplete revascularization did increase the risk. Our findings support grafting small coronaries when technically feasible to prevent incomplete revascularization. (J Thorac Cardiovasc Surg 2010;140:66-72)

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The aggressive pursuit of nonsurgical revascularization selects patients with challenging coronary artery disease for surgical revascularization.[1,2] Because surgery is preferred to angioplasty and stenting for diabetic patients,[3,4]

the increasing number of this cohort of patients undergoing coronary artery bypass grafting (CABG) also contributes to this problem. Not infrequently therefore, intraoperative decisions regarding the suitability for, and prognostic benefit of, grafting these difficult coronaries become a dilemma.

The impact of grafting small coronary arteries on the outcome of CABG is not clear. Attempts to explain the comparatively poor operative outcomes in female patients by smaller-caliber coronary circulation have been unsuccessful.[5] A similar notion as the cause for the difference in operative outcome between Caucasian and UK South Asian men has not been substantiated.[6] To address this problem, early studies[7–9] used a cutoff of 1.5 mm in diameter to define small coronaries, but in current practice this coronary size would not be considered small. An additional setback of these historical series is their assessment of the impact of the size of a single coronary artery, the left anterior descending artery in most cases,[10,11] in the era when the left internal thoracic artery was not routinely used for bypass grafting. Furthermore, the influence of other coronary characteristics frequently coexistent with small luminal diameter (eg, severe atherosclerosis) was not investigated.

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│  Abbreviations and Acronyms                      │
│    CABG  = coronary artery bypass grafting       │
│    CI    = confidence interval                   │
│    ECG   = electrocardiogram                     │
│    MACE  = major adverse cardiac event           │
│    OR    = odds ratio                            │
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In the current era, with improved surgical techniques, regular use of the left internal thoracic artery, and better perioperative care, the implications of constructing anastomoses on small target coronary arteries or severely atherosclerotic vessels are not clearly defined. If these vessels are left ungrafted, however, the resulting incomplete myocardial revascularization imposes prognostic liabilities for both early and late outcomes.[12]

This retrospective study investigated the coronary artery diameter and severity of atherosclerosis in the 3 major territories of the coronary circulation in patients who underwent primary isolated CABG. The study objectives were to (1) assess the prevalence and distribution of coronary arteries with small luminal diameter (≤1.25 mm) and moderate/severe coronary atherosclerosis; (2) examine the relationship between these coronary characteristics and early major adverse cardiac events (MACEs); the combined end points of postoperative myocardial infarction/reintervention for early graft failure, postcardiotomy shock, and operative mortality; and (3) determine the incidence of incomplete myocardial revascularization and its impact on early postoperative MACE.

## MATERIALS AND METHODS
### Patients
Clinical data are prospectively collected for all patients undergoing cardiac surgery at the university teaching hospital of Castle Hill Hospital and stored in an electronic database. The database is run by dedicated data managers who regularly update and validate entries. After approval was obtained from the local medical and ethics committee and a waiver for individual patient consent, the database was interrogated, and demographic, preoperative, intraoperative, and postoperative data were retrieved for each patient who underwent isolated primary CABG at Castle Hill Hospital between April 1, 1999, and December 31, 2007.

During this period, CABG was performed predominantly with cardiopulmonary bypass and blood cardioplegic or crossclamp fibrillatory arrest; off-pump CABG constituted 7.3% of procedures (n = 379). Our main revascularization strategy involved grafting the left internal thoracic artery to the left anterior descending artery and saphenous vein conduits, harvested by the open technique, to other coronary artery targets. Other arterial conduits, such as the radial (n = 585) and right internal thoracic arteries (n = 148), were used less frequently. All anastomoses were hand-sewn, and intraoperative patency was crudely assessed by resistance to the infusion of blood or blood cardioplegia through the graft after constructing the distal anastomoses. After surgery, 300 mg of aspirin was administered per rectum within 6 hours and continued orally at 75 mg daily from the first postoperative day. Blood pressure, heart rate, central venous pressure electrocardiographic tracings, oxygen saturation, and urinary output were continuously monitored for 48 hours postoperatively. Routine 12-lead

electrocardiograms (ECGs) were performed on the first, second, and fourth or fifth postoperative days. Whenever a cardiac event was suspected, a 12-lead ECG, an assay of cardiac biomarker levels (although less consistently) (creatine kinase-MB in the early study period and troponin T in the later period), and transesophageal echocardiography were performed. Reintervention for ischemic ECG changes with hemodynamic deterioration involved reopening and regrafting for occluded grafts, unkinking grafts, and releasing extrinsic graft compression. Angioplasty was performed in 2 stable patients who had recurrent myocardial ischemia with persistent ECG changes after 5 postoperative days.

### Definitions
Coronary artery characteristics were defined on the basis of intraoperative findings. Target coronary arteries were visually assessed, palpated, and calibrated with a probe after arteriotomy. The coronary diameter was recorded as 1.0 mm, 1.25 mm, 1.5 mm, 1.75 mm, 2.0 mm, or greater than 2.0 mm. Severity of coronary atherosclerosis was graded as none, mild (discrete isolated plaques on anterior or posterior wall, not at site of arteriotomy or beyond), moderate (plaques on both anterior and posterior walls, with arteriotomy sometimes encroaching on plaques), or severe (diffuse atherosclerosis extends beyond arteriotomy site).

Coronary arteries were classified as small if their diameter was 1.25 mm or less, and the extent of coronary atherosclerosis was dichotomized into none/mild and moderate/severe. Of 5500 patients in the database, 324 were excluded from the study because they did not have complete entries for the coronary artery diameter, extent of atherosclerosis (principal independent variables, n = 228), or postoperative MACE (dependent variable, n = 96). Myocardial revascularization was considered incomplete if any of 3 ischemic territories with coronary stenoses greater than 70% did not receive a bypass graft.

### Statistical Analysis
The study primary end point was MACE, a composite of 1) postoperative myocardial infarction (new and persistent S-T changes or new Q waves on electrocardiography) or reintervention for early graft failure in the form of regrafting a coronary artery or angioplasty/stenting; 2) postcardiotomy shock requiring mechanical support with intraaortic balloon pump or ventricular assist device in addition to inotropes; and 3) operative mortality (death during hospitalization or within 30 days of surgery).

Categoric variables are reported as percentages, continuous variables with symmetric distribution are reported as mean ± standard deviation, and continuous variables with asymmetric distribution as median with the 25th and 75th percentiles are reported as interquartile range. Univariate associations with postoperative MACE were determined for each preoperative and intraoperative variable (Appendix 1) using logistic regression analysis. Preoperative and intraoperative variables that exhibited some evidence of univariate association ($P < .1$) were then included in a backward, stepwise, multifactorial logistic regression model (Appendix 2) to identify predictors for postoperative MACE. Statistical analysis was performed using the Statistical Package for the Social Sciences version 15.0 for Windows (SPSS Inc, Chicago, IL).

## RESULTS
Table 1 shows the clinical profile of the 5171 study patients. Mean age was 65 ± 9 years, and 21.5% (n = 1112) were female. The majority of patients (n = 3656, 70.7%) had 3-vessel disease, and 13.7% (n = 708) previously underwent angioplasty and stenting. Diabetes mellitus and peripheral vascular disease were present in 19.7% of patients (n = 1019) and 10.9% of patients (n = 564), respectively. Operations were predominantly elective (n = 4026,