On-pump and off-pump coronary artery bypass grafting in patients with left main stem disease: A propensity score analysis

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Objective: This study compared safety and efficacy between off-pump coronary artery bypass grafting (OPCAB), a relatively new technique, and conventional on-pump coronary artery bypass grafting (CCAB) in patients with left main stem disease.

Methods: In a retrospective, observational, cohort study of prospectively collected data on 2375 consecutive patients with left main stem disease undergoing isolated CABG (1297 OPCAB, 1078 CCAB) between April 1996 and December 2009 at the Bristol Heart Institute, 548 patients undergoing OPCAB were matched with 548 patients undergoing CCAB by propensity score.

Results: After propensity matching, groups were comparable in preoperative characteristics. Relative to CCAB, OPCAB was associated with lower in-hospital mortality (0.5% vs 2.9%; $P = .001$), incidence of stroke (0% vs 0.9%; $P = .02$), postoperative renal dysfunction (4.9% vs 10.8%; $P = .001$), pulmonary complications (10.2% vs 16.6%; $P = .002$), and infectious complications (3.5% vs 6.2%; $P = .03$). The OPCAB group received fewer grafts than did the CCAB group (2.7 ± 0.7 vs 3 ± 0.7; $P = .001$) and had a lower rate of complete revascularization (88.3% vs 92%; $P = .04$). In multivariable analysis, cardiopulmonary bypass was confirmed to be an independent predictor of in-hospital mortality (odds ratio, 5.74; $P = .001$). Survivals at 1, 5, and 10 years were similar between groups (OPCAB, 96.8%, 87.3%, and 71.7%; CCAB, 96.8%, 88.6%, and 69.8%).

Conclusions: OPCAB in patients with left main stem disease is a safe procedure with reduced early morbidity and mortality and similar long-term survival to conventional on-pump revascularization. (J Thorac Cardiovasc Surg 2012;143:1382-8)

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The presence of significant left main stem (LMS) coronary artery disease is a well-known risk factor for cardiac-related events and is associated with a 3-year survival as low as 37%, depending on the degree of stenosis, left ventricular function, and associated coronary disease.[1,2] Medical therapy alone confers a poor survival advantage relative to surgical revascularization,[1,3,4] and the role of percutaneous revascularization techniques for critical LMS disease remains unclear.[5,6] Off-pump coronary artery bypass grafting (OPCAB) is now an established procedure, with results comparable to conventional coronary artery bypass (CCAB) with cardiopulmonary bypass.[7-9] Because of the hemodynamic instability associated with ventricular manipulation, however, patients with LMS coronary artery disease have generally been excluded from OPCAB revascularization.[10,11] Previous studies investigating the role of OPCAB in patients with LMS coronary artery disease have reported on small cohorts of patients and have lacked statistical adjustment to reduce the differences in selection bias.[12-14] The aim of this study was therefore to evaluate the early outcomes and long-term survivals after OPCAB versus CCAB in a consecutive large cohort of patients with LMS coronary artery disease by conducting a propensity score matching analysis.

MATERIALS AND METHODS

Patient Selection

The study was approved by the clinical audit committee of the University Hospital Bristol NHS Foundation Trust to meet ethical and legal requirements, and individual consent was waived. This was a retrospective, observational cohort study of prospectively collected data from consecutive patients with LMS coronary artery disease who underwent isolated coronary artery bypass grafting at the Bristol Heart Institute between April 1996 and December 2009. The data collection form was entered into a database (Patient Analysis & Tracking System; Dendrite Clinical Systems, London, UK) and included 5 sections that were filled in consecutively by anesthetists, surgeons, and intensive care unit, high-dependency unit, and ward nurses. The resulting base sample contained detailed clinical information on 2375 patients, 1297 (54.6%) of whom underwent OPCAB and 1078 (45.4%) of whom underwent CCAB. To reduce the effect of treatment selection bias and potential confounding, we used a propensity score matching analysis,[15] which resulted in 548 patients who underwent OPCAB matched with an equal number of patients who underwent CCAB.

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Abbreviations and Acronyms

CCAB = conventional coronary artery bypass grafting
LMS = left main stem
NSTS = National Strategic Tracing Service
OPCAB = off-pump coronary artery bypass grafting

Definitions

Critical LMS disease was defined as a stenosis of greater than 50% according to visual assessment of the preoperative coronary angiogram by the referring physician. In-hospital mortality included all deaths within 30 days of operation regardless of where death occurred and all deaths in hospital after 30 days among patients who had not been discharged after the index operation. A diagnosis of postoperative myocardial infarction was based on the presence of new Q waves longer than 0.04 ms or a reduction in R waves greater than 25% in at least 2 contiguous leads on electrocardiography. The need for pacing, arrhythmias, and inotropic requirements were recorded and defined as previously reported elsewhere.[14] Pulmonary complications included chest infection, ventilation failure, reintubation, and tracheostomy.[16] Postoperative blood loss was defined as total chest tube drainage. Neurologic complications included permanent and transient strokes. Renal complications included acute renal failure, defined as the requirement of hemodialysis or an elevated creatinine level (>200 mmol/L). Infectious complications included septicemia and sternal and leg wound infections, defined by positive culture and requirement for antibiotic therapy.[14]

The completeness of revascularization was determined by comparing the number of distal anastomoses with the number of diseased coronary systems observed on the preoperative coronary angiogram. If the number of distal anastomoses performed equaled the total number of coronary systems with significant disease, the completeness of revascularization index was 1. Patients who had more distal anastomoses performed than the number of vessels with angiographically significant disease had a completeness of revascularization index greater than 1 and were classified as having complete revascularization.

Patient Survival

Patient records were linked to the National Strategic Tracing Service (NSTS), which records all deaths in the United Kingdom. To establish current vital status, patients were matched against the NSTS according to name, National Health Service unique number, date of birth, sex, and postal code. All patients in this study were successfully matched against the NSTS database.

Anesthetic, Surgical Technique, and Postoperative Management

Anesthetic and surgical techniques were standardized for all patients and have been reported previously elsewhere.[10,16] In brief, for patients undergoing CCAB, cardiopulmonary bypass was instituted with the use of ascending aortic cannulation and 2-stage venous cannulation of the right atrium. The membrane oxygenator was primed with 1000 mL of Hartman crystalloid solution, 500 mL of Gelofusine (B. Braun Melsungen AG, Melsungen, Germany), 0.5-g/kg mannitol, 7 mL 10% calcium gluconate, and 6000 IU heparin. Alpha-stat pH management was used, and the systemic temperature was kept between 34°C and 36°C. Myocardial protection was achieved with intermittent hyperkalemic antegrade warm blood cardioplegia.[17,18] For OPCAB surgery, the Bristol technique was used to expose the coronaries and provide stabilization to perform the anastomoses.[10] At the end of surgery, patients were transferred to the intensive care unit and managed according to the unit protocol.[10,16]

Statistical Analysis

Continuous data were expressed as mean ± SD, and categoric data were expressed as percentages. The Kolmogorov-Smirnov test was used to check for normality of data in the 2 groups before further analysis. Differences between OPCAB and CCAB groups were compared with the use of a χ^2 test for categoric variables and *t* or Wilcoxon rank sum tests, as appropriate, for continuous variables. To reduce the effects of selection bias and potential confounding in this observational study, we developed a propensity score analysis. The propensity for OPCAB was determined without regard to outcomes by the use of a nonparsimonious multiple logistic regression analysis. All the variables listed in Table 1, the surgeons (proficient in OPCAB or CCAB), as well as years of operation (number of days of each operation from April 1 1996, divided by 365) were included in the analysis. A propensity score, indicating the predicted probability of receiving OPCAB treatment, was then calculated from the logistic equation for each patient. Finally, we used the propensity score to match patients undergoing OPCAB with those undergoing CCAB (1:1 match). Specifically, we matched each patient undergoing OPCAB patient with 1 undergoing CCAB who had a propensity score that was identical to 5 places. If this could not be done, we then proceeded to the next highest digit match (4-, 3-, 2-, and 1-digit) to make the best matches, in a hierarchic sequence until no more matches could be made. Stepwise, multivariable logistic regression modeling was used to identify independent risk factors for in-hospital mortality; a significance level of .05 was used for both entry and selection. Similarly, multivariable Cox proportional hazard modeling was used to identify independent risk factors for all-cause mortality. Covariates under consideration for all models were all baseline characteristics (as listed in Table 1), the completeness of revascularization, and the use of cardiopulmonary bypass. Results are reported as percentages and odds ratios or hazards ratios and 95% confidence intervals. Overall survival was estimated by using the Kaplan-Meier method and was expressed as a percentage. Differences in long-term survivals were assessed by log-rank tests.

All reported *P* values are 2-sided. All statistical analyses were performed with SPSS statistical software (version 15.0; IBM Corporation, Armonk, NY) and StatsDirect statistical software (version 2.7.2; StatsDirect Ltd, Altrincham, UK).

RESULTS

During the study period, 2375 patients with LMS coronary artery disease underwent isolated coronary artery bypass grafting; of these, 1297 patients (54.6%) underwent OPCAB and 1078 (45.4%) underwent CCAB. Baseline characteristics of the study population are shown in Table 1. Compared with the CCAB group, patients who underwent OPCAB were older, had a higher prevalence of hypertension, and were more likely to require an urgent operation. In addition, they had more limited coronary artery disease and better Canadian Cardiovascular Society functional class and New York Heart Association (NYHA) functional class.

After propensity score matching, there were 548 matched pairs of patients (Table 1). In the matched cohorts, there was no longer any significant difference between the 2 groups for any covariate. OPCAB was associated with lower early mortality than was CCAB ($P = .001$). Moreover, patients undergoing OPCAB were less likely to have stroke ($P = .02$), postoperative renal dysfunction ($P = .001$), pulmonary complications ($P = .002$), and infectious