Off-pump coronary artery bypass grafting does not preserve renal function better than on-pump coronary artery bypass grafting: Results of a case-matched study

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Objective: Controversy exists regarding the perioperative renal effects of off-pump versus on-pump coronary artery bypass grafting. Large case-matched and randomized comparisons have shown conflicting results. This study focuses on this clinical controversy.

Methods: We studied 5589 consecutive patients from a single center who underwent off-pump or on-pump coronary artery bypass grafting between 2002 and 2010. All preoperative, intraoperative, and postoperative data were prospectively collected. Patients were matched by using a nearest neighbor matching estimation method for average treatment effects, with bias correction (Stata 11.2, StataCorp, College Station, Tex). The matching characteristics were age, gender, body mass index, hypertension, diabetes, peripheral vascular disease, cerebrovascular disease, left ventricular grade, preoperative serum creatinine, operative priority, and Cardiac Anesthesia Risk Evaluation score.

Results: The mean patient age was 64.9 ± 10.0 years, and 4387 (78.5%) were male. Mean calculated preoperative creatinine clearance was 82.0 ± 32.6 mL/min. Perioperative mortality was 1.5% with off-pump coronary artery bypass grafting and 1.7% with on-pump coronary artery bypass grafting ($P = .6$). The mean change in creatinine clearance, from the preoperative value to the lowest postoperative value, was –6.3 ± 14.1 mL/min with off-pump coronary artery bypass grafting versus –5.0 ± 15.5 mL/min with on-pump coronary artery bypass grafting ($P = .06$). After matching, patients undergoing off-pump coronary artery bypass grafting had a greater creatinine increase and greater loss of creatinine clearance postoperatively compared with patients undergoing on-pump coronary artery bypass grafting (both $P < .05$). Requirements for de novo postoperative dialysis were equivalent at 2.6% in off-pump coronary artery bypass grafting versus 2.1% in on-pump coronary artery bypass grafting ($P = .4$). Median postoperative hospital stay was 8 days in both groups ($P = .8$).

Conclusions: Off-pump coronary artery bypass grafting does not preserve renal function to a greater extent than on-pump coronary artery bypass grafting. In fact, a trend to the reverse exists with no clinically harmful effects. (J Thorac Cardiovasc Surg 2012;143:85-92)

ACD

When compared with conventional on-pump coronary artery bypass grafting (CABG), off-pump coronary artery bypass grafting (OPCAB) has been found to be associated, in some but not all studies, with lower rates of perioperative myocardial infarction, stroke, atrial fibrillation, and infection, and with reduced duration of ventilation, resource use, and intensive care unit and hospital stay.[1-3]

With regard to renal function, data on the effects of OPCAB versus on-pump CABG on postoperative renal impairment have been controversial. Some studies indicated that OPCAB was not associated with reduced renal morbidity,[4] whereas others suggested that OPCAB decreases the risk of renal impairment after bypass surgery.[5,6] However, available studies thus far did not include a large number of patients or did not allow for comparisons that accounted for important and prospectively captured covariates, which could affect the hemodynamic, inflammatory, and renal outcomes of the patients.[7]

The present study aimed at comparing the renal outcomes of OPCAB with that of on-pump CABG in a large, prospective series. To this end, we used multivariable and nearest neighbor case-matched observational study analyses, by which the outcomes of 5039 patients who underwent

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Abbreviations and Acronyms
CABG = coronary artery bypass grafting
CARE = Cardiac Anesthesia Risk Evaluation
OPCAB = off-pump coronary artery bypass

on-pump CABG were compared with that of 550 contemporary patients who underwent OPCAB.

MATERIALS AND METHODS

Patient Groups

The on-pump CABG group in this study includes 5039 consecutive patients who underwent on-pump, first-time CABG, performed by any 1 of 10 surgeons (with a maximum of 8 surgeons at any one time) at the University of Ottawa Heart Institute, during an 8-year study period from mid-2002 to mid-2010. The OPCAB group includes 550 consecutive patients with coronary artery disease who underwent first-time OPCAB during the same study period, carried out by the 2 surgeons (of the same 10 aforementioned CABG surgeons) who performed (and still perform) more than 25% of their coronary bypass caseload off-pump (M.R. and F.D.R.). Patients with cerebrovascular or peripheral vascular disease were preferentially referred to an OPCAB surgeon through the institutional central triage. The ultimate decision to perform OPCAB surgery was made by the operating surgeon considering patient preference, patient comorbidities, and coronary anatomy. All elective, urgent, and emergency coronary bypass operations were included. Patients undergoing redo surgery or patients who underwent concomitant procedures, such as valve repair or replacement, aortic surgery, aneurysm resection, atrial fibrillation surgery, septal defect closure, and others, were excluded from the study, unless the associated procedure resulted from a complication of the index surgery.

Preoperative, operative, and postoperative data were prospectively collected and simultaneously entered into 2 distinct and independent databases, which overlap information and were cross-verified for the purposes of the present study. Furthermore, both databases have been subjected to regular quality audits for accuracy and completeness. All patient data from the present study were de-identified and kept at the research premises; as such, individual patient consent was waived.

Operative Management

The conducts of the on-pump CABG and OPCAB operations have been extensively described.[8] All procedures were performed via a median sternotomy incision. Patients undergoing on-pump CABG received heparin to maintain their activated clotting time more than 480 seconds while on cardiopulmonary bypass. During aortic crossclamping, antegrade or retrograde cardioplegia (using cold crystalloid from 2002 to 2004, and cold blood after 2004) was intermittently administered at 20- to 30-minute intervals. Patients undergoing OPCAB received intravenous heparin to maintain the activated clotting time more than 250 seconds from the termination of conduit harvest to the completion of all anastomoses.

Unless contraindicated, after OPCAB, patients were administered, on the day of the operation, daily enteric-coated acetylsalicylic acid 81 mg and clopidogrel 75 mg. Likewise, patients undergoing CABG received enteric-coated acetylsalicylic acid 325 to 650 mg postoperatively, within 6 hours of termination of surgery, and the drug was continued at a dose of 325 mg by mouth daily without clopidogrel. Unless contraindicated, antihypertensives were resumed on the first postoperative day. Patients with a radial artery graft were prescribed a benzodiazepine or dihydropyridine calcium channel blocker for 6 months postoperatively.

No standardized postoperative hydration protocol was used in this study. Intravenous fluids were administered to OPCAB and on-pump CABG cases according to systolic blood pressure, urine output, echocardiographic left ventricular filling, central venous pressure, pulmonary artery diastolic or wedge pressure, body weight, and pulmonary function. Extubated patients who had stable hemodynamic and renal indices were placed on a diuretic protocol.

Outcome Definitions

Patients were followed for a minimum of 30 days after discharge from the hospital. Death was defined as mortality occurring in hospital at any time during the index hospitalization or within 30 days of operation. Perioperative myocardial infarction consisted of new Q-wave on 12-lead electrocardiogram, creatine kinase-MB, or troponin-T or I elevation above institutional cutoff criteria in effect at the time. Stroke was defined as a permanent new focal neurologic deficit occurring intra- or postoperatively, with focal or lateralizing signs on physical examination and computed tomography confirmation.

With regard to renal outcomes, the preoperative creatinine level used was the latest available laboratory result before surgery. The highest postoperative creatinine corresponded to the highest level recorded postoperatively during the index surgical admission. The creatinine clearance was calculated in a gender-specific manner by using the Cockcroft–Gault formula.[9] For both preoperative and postoperative creatinine clearance calculations, the weight used corresponded to the last available weight before surgery. The change in creatinine clearance was calculated by subtracting the preoperative creatinine clearance from the postoperative creatinine clearance. Patients who were receiving dialysis preoperatively were not included in the reporting and analyses of preoperative creatinine, postoperative creatinine, and creatinine clearance levels.

Statistical Methods

For all analyses, the classification of on-pump CABG versus OPCAB took place according to the intention-to-treat principle at the initiation of proximal or distal anastomotic grafting. For instance, patients who were converted from OPCAB to on-pump CABG before the initiation of grafting are considered CABG cases, and those converted to CABG after the initiation of proximal or distal grafting are considered OPCAB cases. All conversions from OPCAB to CABG, with their cause, were prospectively recorded.

Comparisons between the on-pump CABG and OPCAB groups were carried out in Stata 11.2 (StataCorp, College Station, Tex). For each renal outcome of interest, 3 types of analyses were performed: crude (ie, univariable), multivariable regression, and nearest neighbor matching. For univariable comparisons, the central limit theorem was assumed for continuous variables, and these were examined by using an unpaired Student t test. Categoric data were examined with a Fisher exact test. Multivariable comparisons of continuous and categoric renal outcomes used linear or logistic regression, respectively, and included all of the following covariates simultaneously, without the use of an automated selection procedure: age, gender, hypertension, body mass index (except for creatinine clearance outcomes), cerebrovascular disease, peripheral vascular disease, diabetes mellitus, Cardiac Anesthesia Risk Evaluation (CARE) score,[10] left ventricular grade (1–4),[11] operative priority, and preoperative creatinine (except for creatinine clearance outcomes). Finally, bias-corrected nearest neighbor matching estimations for the average treatment effect of OPCAB versus on-pump CABG on serum creatinine and creatinine clearance were performed, as described by Abadie and Imbens.[12] With the use of this technique, all observations from the 5039 patients undergoing CABG were matched to their closest matches in the opposite treatment group, namely, the 550 patients undergoing OPCAB, by allowing each observation to be used as a match more than once if necessary, with the order of matching being irrelevant; this, therefore, provided an estimate of the counterfactual treatment outcome.

All results are reported according to the intent-to-treat principle. Continuous data are expressed as means ± standard deviation, unless specified