Training residents in off-pump coronary artery bypass surgery: A 14-year experience

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Objective: Off-pump coronary artery bypass grafting (OPCAB) is an established procedure in many cardiothoracic centers. For it to be widely applicable, however, teaching methods must be developed for surgical trainees. Early clinical outcomes and long-term survival of patients who underwent OPCAB at our institution by trainees supervised and unsupervised were compared with those of patients whose procedures were performed by senior surgeons. To evaluate evolution of training, outcomes were analyzed according to 3 different periods (1996–1999, 2000–2004, 2005–2009) and trainee seniority level.

Methods: This was a retrospective, observational cohort study of prospectively collected data from 5566 consecutive patients who underwent isolated OPCAB performed by trainees (1589, 28.6%; 1111 supervised, 478 unsupervised) and by senior surgeons (3977, 71.4%).

Results: Patients of senior surgeons were more likely to have left ventricular dysfunction ($P = .001$), peripheral vascular disease ($P = .05$), more extensive coronary artery disease ($P = .001$), and higher EuroSCOREs than patients of trainees. In addition, trainees were less likely to have performed urgent operations ($P = .02$) or reoperations ($P = .03$) but more likely to have operated on patients with previous percutaneous coronary intervention ($P = .006$). Early clinical outcomes and long-term survival were similar between groups and not related to trainee seniority, level of supervision by senior surgeon, or period during which training took place.

Conclusions: OPCAB is a safe and reproducible surgical technique that can be taught successfully to cardiothoracic trainees. Clinical outcomes are unrelated to level of supervision or seniority of trainees. (J Thorac Cardiovasc Surg 2012;143:1247-53)

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Residents in cardiothoracic surgery have recently been confronted with the need to gain experience in off-pump coronary artery bypass grafting (OPCAB) as an alternative approach to coronary revascularization. Senior cardiac surgeons are fully aware of the importance of training the next generation of surgeons, but at the same time they have an overriding responsibility to ensure patients' safety and good clinical outcomes. Various academic centers have evaluated the safety of training residents to perform cardiac surgery.[1-7] Limited information, however, is available on the impact of training in OPCAB for an extended period and in particular on the effect of seniority level of trainees on clinical outcomes. At our institution, OPCAB has evolved rapidly in the last 14 years, and cardiothoracic trainees have been exposed to this new technique as an integral part of their surgical program.[3,8-10] The purpose of this study was to compare the performances of trainees, supervised or unsupervised, with those of senior surgeons with respect to early clinical outcome and long-term survival in patients undergoing OPCAB operations. Finally, to evaluate the evolution of training, outcomes were then analyzed according to 3 different time periods (1996–1999, 2000–2004, 2005–2009) and the seniority level of trainees.

MATERIALS AND METHODS

Data Collection

The study was approved by the clinical audit committee of the University Hospitals Bristol 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 who underwent isolated OPCAB operations at the Bristol Heart Institute between April 1996 and November 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 5566 patients, of whom 3977 (71.4%) were operated on by senior surgeons and 1589 (28.6%) were operated on by

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Abbreviation and Acronym
OPCAB = off-pump coronary artery bypass grafting

cardiothoracic trainees (478 [30%] unsupervised). Early clinical outcome and long-term survival were analyzed comparing the operations performed by trainees and senior surgeons. To evaluate the evolution of the training in OPCAB, operations performed by trainees were divided into 3 subgroups according to the periods in which they were carried out (1996–1999, 2000–2004, 2005–2009). Finally, clinical outcomes were evaluated according to the seniority level of trainees in the UK specialist training program in cardiothoracic surgery or equivalent (Calman year 1–6).

Training Program

The Bristol Heart Institute is a regional cardiac surgical center and part of the UK national training program. The UK cardiothoracic training program is conducted over a 6-year period, and admission to it requires successful completion of a 2-year basic surgical training program. Two to three National Training Numbers were allocated to our unit at any time during the study period. In addition, 4 to 6 clinical research or service clinical fellows completed the surgical rota. Seniority level of trainees with official training numbers was defined according to year of training in the UK specialist program in cardiothoracic surgery (Calman year 1–6). For trainees who did not have an official UK training number (research or clinical fellows), the level of experience was retrospectively reviewed and assigned according to equivalent criteria.

Definitions

In-hospital mortality included all deaths within 30 days of operation, irrespective of where the death occurred, and all in-hospital deaths after 30 days among patients who had not been discharged after the index operation. Perioperative myocardial infarction, pacing, arrhythmias, and inotropic requirement were recorded and defined as previously reported elsewhere.[11] Pulmonary complication included chest infection, ventilation failure, reintubation, and tracheostomy. 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). Infective complication included septicemia and sternal and leg wound infections, defined by positive culture and requirement for antibiotic therapy.[11]

The completeness of revascularization was identified by comparing the number of distal anastomoses with the number of diseased coronary systems observed on the preoperative angiogram. If the number of distal anastomosis 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 diseases had a completeness of revascularization index greater than 1 and were classified as having a complete revascularization.

A supervised operation performed by a trainee was defined as one in which the senior surgeon was scrubbed in and acted as first assistant. An unsupervised operation was defined as one in which the trainees had reviewed the case and planned the surgical strategy with the senior surgeon who was not scrubbed in at the operating theater but was available, generally in his or her office.

Patient Survival

Patient records were linked to the National Strategic Tracing Service administrative mortality database, which records all the deaths in the United Kingdom. To establish current vital status, patients were matched against the National Strategic Tracing Service for patient name, National Health Service unique number, date of birth, and post code. Importantly, the cause of death was neither considered nor available in this study; thus the study compared all-cause mortality among the groups.

Anesthetic and Surgical Technique

Anesthetic technique consisted of propofol infusion at 3 mg/(kg · h) combined with alfentanil hydrochloride (INN alfentanil) infusion at 0.5 to 1 μg/(kg · min). Neuromuscular blockade was achieved by 0.1 to 0.15 mg/kg pancuronium bromide or vecuronium, and the lungs were ventilated to normocapnia with air and oxygen (45% to 50%). Heparin (100 IU/kg) was administered before the start of the first anastomosis to achieve an activated clotting time of 250 to 350 seconds. On completion of all anastomoses, protamine was given to reverse the effect of heparin and return the activated clotting time to preoperative levels.

The method of exposure to perform the anastomoses consisted of a technique that has been previously reported elsewhere.[12] Stabilization was achieved with a reusable stainless steel stabilizer (Abbey Surgical Limited, Mitcham, UK) developed at our institution. Since the beginning of 1999, all anastomoses have been performed with an intracoronary shunt to ensure distal perfusion (Flothru Biovascular Inc, St Paul, Minn). Postoperative management was according to standard protocols as previously detailed elsewhere.[13]

Statistical Analysis

All statistical analysis was performed with SPSS statistical software (version 15.0; BM Corporation, Armonk, NY) and StatsDirect (version 2.7.2; StatsDirect Ltd, Cheshire, UK). 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 before further analysis. Differences between the groups were compared with the use of the Student t test or with the analysis of variance where appropriate for continuous variables and with the χ^2 test where appropriate for categoric variables. Nonparametric methods were used for variables that were not normally distributed. Stepwise multivariable regression analysis was used to identify independent risk factors for in-hospital mortality, with a significance level of .05 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 grade of the first operator (senior surgeon and trainees), and the completeness of revascularization. Overall survival was estimated by using the Kaplan-Meier method and was expressed as a percentage. All reported P values are 2-sided.

RESULTS

Trainees Versus Senior Surgeons

Between April 1996 and November 2009, a total of 5566 OPCAB procedures were performed at our institution, of which 3977 (71.4%) were done by senior surgeons (n = 9) and 1589 (28.6%) were done by trainees (n = 15; Table 1). Of the operations performed by the trainees, 478 (30%) were unsupervised. Preoperative patient characteristics are shown in Table 1 and were similar between groups with respect to sex, diabetes mellitus, chronic obstructive pulmonary disease, Canadian Cardiovascular Society class, left main stem stenosis, and intra-aortic balloon pump requirement. Trainees operated on patients with a significantly lower proportion of left ventricular dysfunction ($P = .001$), lower proportion of peripheral vascular disease ($P = .05$), less extensive coronary artery disease ($P = .001$), and thus a lower EuroSCORE ($P = .001$). In addition, trainees