

How Safe Is it to Train Residents to Perform Coronary Surgery With Multiple Arterial Grafting? Nineteen Years of Training at a Single Institution

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The learning curve of coronary artery bypass grafting (CABG) with multiple arterial grafting (MAG) is perceived to be associated with increased surgical morbidity and potentially poorer long-term outcomes. We compared short-term outcomes and long-term survival in patients who underwent CABG with MAG performed by attending surgeons or resident trainees at a single institution over a period of 19 years. Using our institutional database, we identified 3039 patients undergoing MAG from 1996-2015. Of those, 958 (32%) were operated by residents and 2081 (68%) by attending surgeons. Propensity score matching and mixed-effects models were used to compare the 2 groups. Operative mortality rate was 0.3% and 0.4% among patients operated by residents and attending surgeons, respectively ($P = 0.71$), with no significant differences among the groups in postoperative complications. After a mean follow-up time of 11 ± 4 years, survival probability at 5, 10, and 15 years was $95.1\% \pm 0.7\%$ vs $96.4\% \pm 0.6\%$, $87.0\% \pm 1.1\%$ vs $87.8\% \pm 1.1\%$, and $76.6\% \pm 1.8\%$ vs $77.6\% \pm 1.8\%$ in the resident and attending surgeon group, respectively. Resident and attending surgeon cases showed comparable risk of death (hazard ratio [HR] = 1.01; 95% CI: 0.80-1.28; $P = 0.92$). The equipoise between the 2 groups was confirmed among cases receiving bilateral internal thoracic arteries only (HR = 0.88; 95% CI: 0.54-1.43; $P = 0.61$), radial artery (HR = 1.22; 95% CI: 0.92-1.61; $P = 0.15$), or their combination (HR = 0.74; 95% CI: 0.33-1.65; $P = 0.47$). The present analysis confirms that adequately supervised trainees can perform CABG with MAG without compromising patient safety and long-term survival.

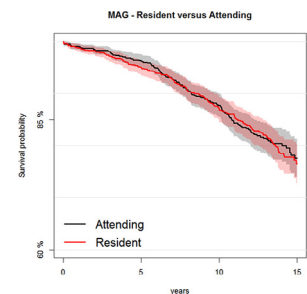
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Despite multiple arterial grafting (MAG) including bilateral internal thoracic arteries (BITA) and radial artery (RA) has been consistently shown to improve survival after coronary artery bypass

grafting (CABG), it still remains largely underused.¹⁻⁴ It is disconcerting that only 10% of patients undergoing CABG currently receive a second arterial graft in the United States, approximately 4% with BITA and 6% with RA.⁵ Moreover, among 1541 procedures performed in the SYNTAX trial and registry, 97.1% included a single arterial conduit, whereas only 22.7% received BITA grafts.⁶

The most commonly cited reason for not performing CABG with MAG, is the learning curve, perceived to be associated with increased surgical morbidity and potentially poorer long-term outcomes.^{7,8} This often results in lack of exposure to MAG procedures during cardiothoracic training program.⁷ Moreover, the



Survival in patients undergoing multiple arterial grafting (MAG) operated on by resident vs attending surgeon.

Central Message

A 19-year training experience at a single institution found that adequately supervised trainees can perform CABG with multiple arterial grafting without compromising patient safety and long-term survival.

Perspective Statement

The conflict between trainee education and patient safety, requires surgical training policies to be guided by robust clinical data and high-level evidence. We demonstrated that supervised trainees can effectively perform CABG with multiple arterial grafting without compromising patient safety. These results are expected to promote residents training in multiple arterial grafting.

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PERFORMING CABG WITH MULTIPLE ARTERIAL GRAFTING

current intense professional and public scrutiny of cardiac surgeons' results creates a hostile environment not conducive to trainees' exposure to MAG.

Here, we compared the short- and long-term outcomes of CABG with MAG performed by attending surgeons or resident trainees at the Bristol Heart Institute over a period of 19 years.

METHODS

Study Design

The study was conducted in accordance with the principles of the Declaration of Helsinki. The local audit committee approved the study, and the requirement for individual patient consent was waived. This study was a registry-based analysis involving patients with multivessel coronary artery disease who underwent elective isolated CABG using at least 2 arterial conduits from April 1996 to April 2015, at the Bristol Heart Institute, United Kingdom. We retrospectively analyzed prospectively collected data from the National Institute for Cardiovascular Outcomes Research (NICOR) registry for audit and quality assessment of adult cardiac surgery in the United Kingdom. Reproducible cleaning algorithms were applied to the database, which are regularly updated as required. Briefly, duplicate records and nonadult cardiac surgery entries were removed; transcriptional discrepancies harmonized; and clinical conflicts and extreme values corrected or removed. The data are returned regularly to the local units for validation. Further details and definition of variables are available at <http://www.ucl.ac.uk/nicor/audits/adultcardiac/datasets>.

Study Population

Patients were eligible for inclusion in the study if they had undergone isolated CABG performed by either attending surgeons or residents using at least 2 arterial conduits in the following configuration: BITA, left internal thoracic artery (LITA) and RA or BITA plus RA with or without additional saphenous vein grafts. In the present series, the RA was considered only in case of target stenosis $\geq 75\%$ and it was used as a free graft proximally connected to the ascending aorta or as a "y" graft attached to the internal thoracic artery. The internal thoracic artery was used as a pedicle graft that remained proximally connected to its respective subclavian artery (in situ) or as a free graft proximally connected to other internal thoracic artery as a "y" graft. Exclusion criteria were (1) cases performed by nonattending surgeons who had completed their training program; (2) no information available on the primary surgeon status; and (3) LITA not used.

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, 4-6 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 reviewed and assigned according to equivalent criteria. A resident case was retrospectively defined as a case in which the cardiothoracic resident performed the entire surgical procedure. A supervised operation performed by a resident was defined as one in which the attending surgeon was scrubbed in and acted as first assistant. An unsupervised operation was defined as one in which the resident had reviewed the case and planned the surgical strategy with the attending surgeon who was not scrubbed in. The decision to have a resident case was at the discretion of individual attending surgeons. There was no formal agreement on a minimum number of cases to be performed by the residents during their training program. The patients operated on by the resident were selected by assessing their suitability for training taking into account the urgency of the operation and their comorbidities, the quality of the coronary arteries, and the number of grafts required. Training in MAG progressed to gradually increasing levels of complexity including y graft and off-pump MAG (Video 1).

STUDY END POINTS

Short-term outcomes analyzed were re-exploration for bleeding, need for sternal wound reconstruction, postoperative cerebrovascular accident (defined as any confirmed neurologic deficit of abrupt onset that did not resolve within 24 hours), postoperative renal replacement therapy, need for postoperative intra-aortic balloon pump, in-hospital mortality, the occurrence of any of above complications, and length of stay was compared between 2 groups. The incidence of incomplete revascularization, defined as at least 1 diseased primary arterial territory not grafted was also investigated.

Long-term outcome investigated was all-cause mortality. This is considered the most robust and unbiased index in cardiovascular research because no adjudication is required, thus avoiding inaccurate or biased documentation and clinical assessments.⁹ Information about postdischarge mortality tracking was available for all patients (100%) and was obtained by linking the

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