How safe is it to train residents to perform off-pump coronary artery bypass surgery?

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Abstract

A best evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was, in [patients undergoing off-pump CABG] are [postoperative mortality and morbidity outcomes] acceptable when performed by [trainees]? Altogether more than 597 papers were found using the reported search, of which 8 represented the best evidence to answer the clinical question. Six retrospective cohort studies directly compared the performance of trainees and experienced surgeons in off-pump coronary artery bypass graft surgery. Of the remaining papers, one recorded the performance of trainees in on- and off-pump operations and finally one paper evaluated a single trainee’s performance in off-pump coronary artery bypass graft surgery, both supervised and unsupervised, over a 1-year period. It is important to note that the two respective cohort studies included in our analysis compared similar cohorts of patients. However, both studies were included in our paper as they provide additional information regarding trainee performance. The authors, journal, date and country of publication, patient group studied, study type, relevant outcomes and results of these papers are tabulated. Although a heterogeneous range of postoperative complications were recorded in the identified studies, we were able to determine that, overall, there was no significant difference in the 30-day mortality seen in operations performed by trainees or experienced surgeons. The incidence of myocardial infarction and stroke were also similar among cases performed by both groups. However, senior surgeons were more likely to operate on patients with more complex or severe disease, or those requiring more urgent operations. Therefore, it was not possible to directly compare outcomes between trainees and experienced surgeons in operations of similar complexity. However, we conclude that despite the absence of randomized controlled trials comparing the performance of trainees and experienced surgeons in off-pump coronary artery bypass (OPCAB) surgery, the evidence provided in this paper supports the involvement of trainees in performing off-pump coronary artery bypass graft surgery as a reliable and safe alternative to on-pump coronary artery bypass graft surgery in selected cases.

Keywords: Review • Off-pump coronary artery surgery • Training • Outcomes

INTRODUCTION

A best evidence topic was constructed according to a structured protocol. This is fully described in the ICVTS[1].

THREE-PART QUESTION

In [patients undergoing off-pump CABG] are [postoperative mortality and morbidity outcomes] acceptable when performed by [trainees]?

CLINICAL SCENARIO

You are a cardiothoracic surgeon experienced in both on- and off-pump coronary bypass surgery. You are now taking on a new cardiothoracic trainee with no experience in off-pump coronary bypass surgery. To what level can you expect to train this trainee over a period of 6–12 months?

SEARCH STRATEGY

A search of MEDLINE from 1950 to July 2013 was performed using Ovid as an interface. [exp*off pump coronary artery bypass surgery/OR beating heart/OR off-pump/OR off pump/OR opcab/OR op cab/OR exp*myocardial revascularization] AND [training/OR learning/OR teaching]. Reference lists of articles generated by the above search were screened.

SEARCH OUTCOME

A total of 597 papers were generated from this search of which 45 were related to the clinical question. Of these, 37 papers were
### Table 1: Best evidence papers

<table>
<thead>
<tr>
<th>Author, date, journal and country</th>
<th>Study type (level of evidence)</th>
<th>Patient group</th>
<th>Outcomes</th>
<th>Key results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Asimakopoulos et al. (2006), Ann Thorac Surg, UK [2]</td>
<td>Retrospective cohort study (level 3 evidence)</td>
<td>Retrospective study of 251 OPCAB operations during 2002–2003 performed by supervised trainees (33%) compared with consultant surgeons (67%)</td>
<td>EuroSCORE (median) Stroke 30-day mortality Postop stay (median, days) ICU stay (median, h)</td>
<td>Consultant versus trainee 4 vs 4 (P = 0.11) 0.6 vs 1.2 (P = 0.55) 2.4 vs 0 (P &lt; 0.31) 6 vs 6 (P = 0.016) 24 vs 22 (P = 0.016)</td>
<td>Small sample size and low rates of outcome measures are the main limitations of this study. However, low rates of outcome measures are reassuring. Overall, performance was the same or better for the trainee than for the consultant</td>
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<tr>
<td>D. Karagounis et al. (2006), Interact CardioVasc Thorac Surg, UK [3]</td>
<td>Retrospective cohort study (level 3 evidence)</td>
<td>A retrospective study of 232 patients undergoing off-pump coronary revascularization</td>
<td>EuroSCORE (median) Stroke ICU stay (median, h) Postop stay (median, days) 30-day mortality Average number of grafts</td>
<td>Consultant versus trainee 4 vs 4 (P &lt; 0.11) 0.5 vs 0.8% (P = 0.74) 24 vs 22 (P = 0.016) 6 vs 6 (P = 0.95) 1.5% vs 0 (P = 0.17) 3.3 vs 7.3 (no P-value)</td>
<td>Small sample size is the main limiting factor of this study. This also limited the subgroup analyses of patient outcomes. However, the authors conclude that, with appropriate supervision, trainees of all levels can be taught OPCAB</td>
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<tr>
<td>P. Murzii et al. (2012), J Thorac Cardiovasc Surg, UK [4]</td>
<td>Retrospective cohort study (level 3 evidence)</td>
<td>A retrospective review of 5566 patients who underwent OPCAB during 1996–2009</td>
<td>Reoperative surgery In-hospital mortality Blood loss (ml, mean) Stroke TIA Hospital stay (mean, days)</td>
<td>Consultant versus supervised trainee versus unsupervised trainee 1.6 vs 0.6 vs 1% (P = 0.3) 1.3 vs 1.2 vs 0.8% (P = 0.7) 784 vs 787 vs 825 (P = 0.2) 0.2 vs 0.5 vs 0% (P = 0.1) 0.3 vs 0.6 vs 0.5% (P = 0.6) 7.7 vs 7.9 vs 7.7 (P = 0.8)</td>
<td>This study is limited as it is not clear when trainees would be considered to achieve senior surgeon status. Again, low outcome rates were reported. The authors conclude that OPCAB is a safe technique that can be taught successfully to trainees</td>
</tr>
<tr>
<td>A. Asimakopoulos et al. (2002), Ann Thorac Surg, UK [5]</td>
<td>Retrospective cohort study (level 3 evidence)</td>
<td>A retrospective study of 969 CAB operations performed by trainees (56.4%) ONCAB and (43.6%) OPCAB during 1999 and 2001. Of these 71% were supervised and 29% were unsupervised All trainee surgeons had performed a minimum of 30 ONCAB before performing OPCAB in this study</td>
<td>30-day mortality Periop MI Stroke TIA Total blood loss (ml) ICU stay (mean, days) Hospital stay (mean, days)</td>
<td>OPCAB versus ONCAB supervised versus OPCAB unsupervised 0.5 vs 0.5 vs 0% 2 vs 2 vs 2% 0.4% vs 0 vs 0 0.7 vs 0.7 vs 0.8% 853.9 vs 910.7 vs 832.9 1.2 vs 1.1 vs 1.4 7.0 vs 7.2 vs 7.1</td>
<td>The study is limited as the level of experience of surgical trainees is not known</td>
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Continued
### Table 1: (Continued)

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<td>Chen et al. (2009), Thorac Cardiovasc Surg, UK [6]</td>
<td>Retrospective cohort study (level 3 evidence)</td>
<td>Retrospective analysis of 250 OPCAB operations performed by two trainees (80%) and a supervisor (20%)</td>
<td>Conversion to ONCAB 30-day mortality Reoperation for bleeding Perioperative MI Postop renal complications ICU stay (mean, h) Postop stroke Life-threatening arrhythmia Mediastinitis Respiratory failure Sepsis Postoperative IABP use Sepsis Operating time</td>
<td>Trainee (A1 + 2) versus Trainee (B1 + 2) versus experienced surgeon $P &gt; 0.5$ $P &gt; 0.5$ $96 \text{ vs } 98 \text{ vs } 98%$ $96 \text{ vs } 98 \text{ vs } 98%$ $96 \text{ vs } 98 \text{ vs } 98%$ $96 \text{ vs } 98 \text{ vs } 98%$ $0 \text{ vs } 1 \text{ vs } 0%$ ($P = 0.404$) $1 \text{ vs } 1 \text{ vs } 4%$ ($P = 0.469$) Similar among all groups except A1 versus C ($264 \pm 38 \text{ vs } 246 \pm 27 \text{ min}$) $P = 0.012$</td>
<td>Cumulative sum failure analysis for the cardiac surgical trainees showed small step elevation during the first 30 cases; however, the remaining cases proceeded smoothly and the 80% alert lines were never breached. Limitations of this study include disparities in training time (24 vs 28 months) for the two trainees. Furthermore, trainees had different surgical backgrounds.</td>
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<tr>
<td>Karamanoukian et al. (2000), Ann Thorac Surg, USA [7]</td>
<td>Retrospective cohort study (level 3 evidence)</td>
<td>A retrospective review of a single trainee’s performance of OPCAB in 166 cases during 1997–1998</td>
<td>Average number of grafts, conversion to conventional CABG</td>
<td>OPCAB versus ONCAB 2.4 vs 4, 3.2% (no P-value available)</td>
<td>It is unclear if the work of a single resident’s training is representative of the cardiothoracic trainee population. The selection criteria were unclear and may be subject to selection bias. The authors state that trainees can be safely taught the surgical skills to perform OPCAB.</td>
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<tr>
<td>Bakaeen et al. (2009), Ann Thorac Surg, USA [8]</td>
<td>Retrospective cohort study (level 3 evidence)</td>
<td>A retrospective review of 1042 OPCAB surgery cases performed in a single institution during 1997–2007 by staff (4%), CT2 (59%) and CT1 (37%) surgeons</td>
<td>Postoperative stroke Perioperative MI Mediastinitis ICU stay (median, days) Renal failure Reoperation for bleeding 30-day mortality Operating time (min)</td>
<td>Staff vs CT2 vs CT1 $0.0 \text{ vs } 2.1 \text{ vs } 1.8%$ ($P = 0.581$) $4.3 \text{ vs } 0.2 \text{ vs } 0.5%$ ($P &lt; 0.001$) $0.0 \text{ vs } 1.8 \text{ vs } 0.5%$ ($P = 0.151$) $2.8 \text{ vs } 2.9 \text{ vs } 2.0$ ($P = 0.751$) $0 \text{ vs } 1.5 \text{ vs } 1.3%$ ($P = 0.696$) $2.1 \text{ vs } 0.8 \text{ vs } 1.8%$ ($P = 0.330$) $2.1 \text{ vs } 1.5 \text{ vs } 0.8%$ ($P = 0.537$) $401.5 \pm 79.8 \text{ vs } 415.3 \pm 71.1 \text{ vs } 441.8 \pm 64.0$ ($P &lt; 0.001$)</td>
<td>This study was limited by the very small proportion of operations performed by staff surgeons. Lower academic seniority is associated with increased operating time but has no effect on outcome.</td>
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<td>Messina et al. (2010), Eur J Cardiothorac Surg, Italy [9]</td>
<td>Retrospective cohort study (level 3 evidence)</td>
<td>A retrospective review of 1333 OPCAB operations performed in a single institution by three experienced surgeons (73.3%) and four trainees (26.7%) during 1998–2006</td>
<td>30-day mortality 4-year survival Rates of freedom from new revascularization</td>
<td>OPCAB versus ONCAB $1 \text{ vs } 0.6%$ $97.4 \pm 1.1 \text{ vs } 94.3 \pm 4.1%$ ($P = 0.41$) $96 \pm 0.7 \text{ vs } 95.3 \pm 1.4%$ ($P = 0.3$)</td>
<td>The level of supervision trainees received and involvement in operations of supervisors has not been clarified in this paper. Trainees can be safely taught the surgical skills to perform OPCAB with similar medium-term outcomes to those of expert surgeons.</td>
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MI: myocardial infarction; IABP: intra-aortic balloon pump; TIA: transient ischaemic attack.
excluded because they showed duplicated data, they did not answer the clinical question or they were not written in English. Eight studies were selected to provide the best evidence. These are presented in Table 1.

RESULTS

Asimakopoulos et al. [2] investigated clinical outcomes in 251 OPCAB cases performed by trainees or consultants. Patients operated on by the consultant were more likely to have had unstable angina, impaired left ventricular function or previous cardiac surgery. No significant differences in postoperative mortality or morbidity rates, reoperation rates for re-bleeding, haemofiltration or in intensive care unit readmission rates were seen. The study is limited by its small sample size and low incidence of outcome measures; therefore, many results did not reach statistical significance. The authors suggest that trainees are able to perform safe supervised OPCAB.

Karagounis et al. [3] investigated the impact of teaching trainees OPCAB surgery by comparing 125 trainee operations to 198 performed by an experienced consultant. Consultant-led operations were more likely to deal with patients with unstable angina, ejection fractions less than 30% and those who have had previous cardiac surgery who received over four grafts. Thirty-day mortality and postoperative morbidity, including reoperation rates for bleeding, haemofiltration and hospital stay, were similar between the groups. This study is limited due to its small sample size.

Murzi et al. [4] analysed 5566 cases of OPCAB performed by supervised trainees, unsupervised trainees and senior surgeons. Senior surgeons were more likely to operate on patients with left ventricular dysfunction, peripheral vascular disease, extensive coronary artery disease, higher EuroSCOREs, those requiring more urgent operations and those who have had previous percutaneous coronary interventions than patients of trainees. However, no significant difference in complication or mortality rates between these groups was found. The definition of senior surgeon status was not clarified by the authors.

Caputo et al. [5] later compared the performance of trainees in OPCAB with on-pump coronary artery bypass (ONCAB) surgery in 2422 cases. The study groups were similar and trainees were categorized as supervised or unsupervised. However, the levels of experience of these trainees are unknown. There was no significant difference in mortality rate, stroke, blood loss or ICU length of stay across the groups. During the study period, there was a significant increase in the number of OPCAB procedures undertaken and the number of grafts per patient in the trainee group. It is important to note that this patient cohort was also studied by Murzi et al. [4], however, the additional comparison between on- and off-pump CAB operations warranted its inclusion in this review.

Chen et al. [6] evaluated the performance of two trainee cardiac surgeons with an experienced supervising surgeon in OPCAB surgery. The trainee surgeons were assessed by comparing their first and last 50 cases. Trainees had different surgical backgrounds and training times for cardiac surgery varied in the range of 24–28 months. There was no significant difference in the incidence of mortality, stroke, intra-aortic balloon pump, reoperation for bleeding, perioperative myocardial infarction, renal failure, mediastinitis, respiratory failure or sepsis rates between the two groups.

Karamanoukian et al. [7] retrospectively evaluated a single trainee’s experience of CAGB surgery following the completion of a 2-year training programme. The reason for selection of this trainee is unknown and may be subject to bias. Of a total of 166 cases, 61 were performed off-pump. The conversion rate to ONCAB was 3.2%. The programme taught ONCAB initially with the introduction of OPCAB after the first year of teaching. The authors recommend that trainees should perform 50 supervised cases before reaching competency; however, they offer no evidence to support this statement.

Bakaeen et al. [8] retrospectively compared ONCAB surgery performed by different grades of surgeons in 1042 cases. Only 4% of operations were performed by staff surgeons. They showed that longer operative times correlated with reduced experience (P < 0.05). However, the 30-day mortality and survival rates of patients (mean follow-up, 1485 ± 1015 days) were not significantly different across the groups.

Messina et al. [9] retrospectively analysed 1333 OPCAB operations performed by experienced surgeons and supervised trainees. However, the level of supervision and involvement of supervisors in each case remains unclear. There were significant preoperative differences in patient groups. No statistical difference was found between 30-day mortality, 4-year survival or need for new revascularization. The data suggest that OPCAB procedures can be safely performed by trainees with results that are maintained over time.

CLINICAL BOTTOM LINE

Despite the absence of randomized, controlled trials comparing the performance of trainees and experienced surgeons in OPCAB, the evidence provided in this paper supports the involvement of trainees in OPCAB as a reliable and safe alternative to ONCAB in selected cases.

Conflict of interest: none declared.

REFERENCES