Furthermore, our results are also entirely consistent with the recent largest randomized trial of on-pump and off-pump surgery, the CORONARY trial [5, 6], in which there were no significant differences in any clinical end-point between on-pump and off-pump surgery.

**Study limitations**

The technique of performing CABG was at the discretion of the operating surgeon. Consequently, although there is some reassurance that baseline characteristics were similar among the subgroups, it must be emphasized that the patients were not randomized to on-pump or off-pump surgery and, consequently, the trial was not powered to compare outcomes on this basis. Thus, the analysis presented in this study is wholly descriptive. It should also be noted that there was considerable variation in the proportion of off-pump CABG per individual participating surgeon and that two surgeons in particular contributed a large number of off-pump cases.

**Funding**

ART is funded jointly by a grant from the British Heart Foundation (SP/03/001) and the Medical Research Council (G0200390).

**Conflicts of interest:** none declared.

**REFERENCES**


**EDITORIAL COMMENT**

Analysis of on-pump and off-pump surgery in the Arterial Revascularization Trial

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**Keywords:** Bilateral internal mammary artery • Coronary artery bypass grafting • Coronary artery disease • Myocardial revascularization • Single internal mammary artery • Off-pump surgery

In ART, 167 surgeons performed isolated coronary artery bypass grafting (CABG) surgery in 3102 patients, an average of just over 18 cases per surgeon, during a period of 3.5 years, which is equivalent to each surgeon entering an average of 5 cases per year. This implies that entry into the trial was highly selective, and consisted
of patients who a surgeon had already decided were suitable for a SIMA or BIMA procedure. The performance of the CABG procedure on- or off-pump was at the discretion of the operating surgeon. Congratulations need to be given on the low operative and 12-month mortality rates. Compared with the SYNergy between percutaneous coronary intervention with TAXus and cardiac surgery (SYNTAX) trial, which had a 12-month mortality rate of 3.5%, the ART achieved 2.3%, implying that the study group is not comparable with the all-comers SYNTAX trial [3]. Unfortunately, no EuroSCORE risk scores are provided, making benchmarking of the in-hospital mortality with the UK national figures, for example, impossible.

Stroke remains a devastating complication after cardiac surgery. No significant difference was found in patients having on- or off-pump surgery. This is at odds with previous work [4]. The technical details of how the off-pump procedures were performed, with regard to stroke prevention (no touch, single or multiple side-biting clamp), unfortunately, are not available. The same criticism exists for the performance of cardiopulmonary bypass, and has resulted in the PerfSORT system [5].

Previous studies comparing on- and off-pump CABG surgery have either been non-randomized, or have found no difference in outcomes, or a detrimental outcome for patients undergoing off-pump revascularization [6, 7]. Operating surgeon inexperience was certainly an issue in the Randomized On/Off BYPass (ROOBY) trial [7]. In the ART, however, the largest centres contributing to the study were dedicated off-pump centres, implying that expert off-pump surgeons were competing with expert on-pump surgeons. Interestingly, the ART reports a perioperative myocardial infarction rate in the SIMA group of 1.9% for the on-pump vs 0.6% for the off-pump group (P = 0.047), and in the BIMA group of 1.9% for on-pump vs 0.6% for the off-pump group, (P = 0.04). This likely implies that the off-pump patients had coronary arteries technically easier to graft when compared with the on-pump patients.

Sternal wounds and respiratory complications remain the main reasons why BIMA use has not been widespread. In this study, off-pump had no effect on sternal wound complications. Ventilation time was significantly reduced in off-pump cases regardless of SIMA or BIMA grafting. Diabetes, renal failure and obesity (body mass index >30 kg/m²) are known covariates associated with differing morbidity, in-hospital mortality and survival for on- and off-pump cases [8, 9, 10]. Unfortunately, these were not corrected for in the analysis presented.

The ART is powered for 10-year survival, and so it is underpowered to draw conclusions at 1 year, let alone when the SIMA and BIMA groups are halved by the performance of on- or off-pump subgroups. Graft quality has to be very poor for a difference in-hospital mortality to be affected by on- or off-pump surgery. Likewise, subtle differences in anastomotic quality are unlikely to be revealed at the 12-month follow-up. Perhaps waiting for 5- and/or 10-year data would be appropriate prior to drawing any conclusion.

Off-pump CABG is clearly superior in elderly patients with a calcified ascending aorta who have composite grafting performed. On-pump is clearly superior in the setting of ST-segment changes and ongoing haemodynamic instability. As these are small patient subgroups of the normal CABG population, perhaps the failure to identify the clear superiority of one technique over the other is of no surprise.

Conflict of interest: Michael Poullis is a dedicated off-pump surgeon.

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