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controversial topics in surgery

Coronary artery bypass

Coronary artery bypass grafting as a means of myocardial revascularisation is a remarkably successful operation. Over 25,000 procedures are carried out each year in the UK with an operative mortality of the order of 2% achieved despite an ageing surgical population. Over the last decade, a remarkable increase in the number of patients treated percutaneously by angioplasty and stenting has lead to a levelling off, or even a decline, in the number of patients treated surgically.

In an attempt to reduce further the operative morbidity and mortality by excluding that attributable to the extracorporeal circulation, several surgical groups have pioneered performing the procedure without the heart–lung machine (off-pump or OPCAB). Although not a new concept there has been a dramatic increase in its use, lead by the development of sophisticated and disposable devices for stabilising the heart to enable the demanding anastomotic technique required to suture vessels of 1–2 mm often containing degenerative plaque.

Concerns remain about the completeness of revascularisation and about the quality of the anastomoses obtained, particularly in the right and circumflex territories which are less accessible than the anterior descending artery. Although some reduction in morbidity has been demonstrated, this has not been as marked as had been hoped.

Davies and Wallwork from Papworth argue persuasively and colourfully in favour of the conventional operation and point out the difficulties in designing an appropriate, prospective, randomised, controlled clinical trial because of the apparently small differences in outcome between the two techniques.

Amrani and colleagues from Harefield, leading proponents of off-pump surgery using it in virtually 100% of patients undergoing revascularisation, extensively review the comparative literature to date.

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Case for the on-pump technique: ‘the pump is your friend’

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The advent of the cardio-pulmonary bypass (CPB) machine allowed pioneering cardiac surgeons to perform complex operations on the defective heart. Not only does CPB permit adequate end-organ perfusion during cardio-respiratory arrest, but it also allows cooling of the patient, a relatively bloodless operative field, and a stable operative site for fine anastomotic work in an unforgiving environment. With the refinement of perfusion science, the impact of the pump run on the post-operative recovery of a patient has been lessened considerably since the pioneering days. The drive to reduce the well-documented, if somewhat historical, adverse effects of CPB has resulted in attempts to perform coronary artery grafting off-bypass

(OPCAB). Despite enthusiastic proponents of the off-pump revascularisation technique, the wider cardiac surgical community is yet to be convinced, with many databases reporting an uptake rate of less than 10%.¹ Is this just another fashionable phase in the evolution of coronary revascularisation?

Mortality

As with many trials into new medical technology, early reports claimed significant improvement in both morbidity and mortality when the CPB machine was abandoned.^{2,3} The greatest attraction both for surgeon and patient towards either technique would

surely be a significant difference in risk-adjusted mortality. As the mortality of both procedures should be around 1% in low-risk cases, almost 500,000 patients would have to be recruited into a prospective, randomised, controlled study to show a significant difference between two otherwise matched, low-risk groups. Indeed, it has been the goal of many off-pump proponents to even show parity with on-pump grafting.

Off-pump coronary grafting could be compared to other ‘extreme’ sports – although undoubtedly thrilling, is there any point in ironing whilst sky-diving? A recent Scientific Statement by the American Heart Association⁴ provides a thorough review of the evidence collated to allow comparison between on-pump and off-pump revascularisation. Racz *et al.*⁵ report a large, retrospective analysis of over 68,000 patients, 9000 of whom had revascularisation performed off-pump. At 3-year follow-up, the patients in the on-pump group had a higher survival rate (89.6% versus 88.8%; $P = 0.022$).

Graft patency and re-intervention rates

A recent trial by Khan *et al.*⁶ reported on 103 patients who required at least three grafts and were randomised to either on-pump or off-pump revascularisation. Of these patients, 82 underwent re-evaluation at 3 months by angiography. Of note, the graft patency was 98% in the on-pump grafted patients, whereas this was significantly reduced ($P = 0.002$) in the off-pump patients at 88%. Indeed, in the patients who received radial artery grafts, the on-pump cohort had patency rates of 100% whereas those done off-pump had rates of 76% ($P = 0.01$). There is further evidence⁷ that off-pump surgery increases the risk of recurrent angina and repeat re-vascularisation. In a retrospective series of 812 propensity matched patients reported by the Cleveland Clinic,⁸ on-pump patients received a greater number of grafts ($P < 0.001$) and had less incomplete revascularisation ($P < 0.001$) than did OPCAB patients as judged by the operating surgeon. Racz *et al.*⁵ also reported a higher rate of repeated intervention in their cohort of off-pump patients. This suggests either incomplete revascularisation at the time of surgery, or poor long-term graft patency in the off-pump group.

Quality of life

Prospective studies⁹ have shown that quality of life indices of patients in the first year following CABG are significantly raised on the pre-operative function. However, the use of cardio-pulmonary bypass had no effect on patient’s quality of life when compared to the off-pump alternative.

Emergency conversion

A significant, and often neglected risk is the rate of emergent conversion from off-pump coronary grafting to on-pump when haemodynamic instability occurs. Patel *et al.*¹⁰ reported a

significantly higher mortality in converted patients versus off-pump patients (12% versus 1.47%; $P = 0.001$). In this series, significant morbidity in the form of stroke (6% versus 1.1%; $P = 0.02$), renal failure (6% versus 1.23%; $P = 0.02$), deep sternal wound infection (8% versus 1.54%; $P = 0.009$) and respiratory failure (28% versus 3.75%; $P < 0.001$) was associated with converted versus off-pump surgery. Likewise, Legare *et al.*¹¹ have reported that converted patients had a significantly higher mortality, required significantly more inotropes and greater postoperative blood transfusion. Care needs to be taken when compiling and reviewing comparison data to include these ‘converted’ patients in the off-pump group.

Respiratory complications

In a prospective clinical study, Montes *et al.*¹² could not detect any major protection from postoperative pulmonary dysfunction in off-pump surgery when compared to on-pump revascularisation.

Neurological outcomes

One of the major theoretical advantages of off-pump surgery is the improved neurological outcome, especially in the elderly population. Studies into the postoperative neurocognitive function show a slightly quicker decline in the on-pump patients in the first 3 months, but there is no reported comparison deficit at 1 year. Friday *et al.*¹³ studied brain MRI abnormalities following surgery and reported a similar rate of ischaemic lesions whether CPB was used or not.

Conclusions

At present, no prospective, randomised, controlled studies are sufficiently powered to settle the debate between the on- and off-pump revascularisation surgeons. This suggests that the outcome differential is likely to be trivial. However, no study in the literature reports more grafts being placed with the off-pump technique, and several authors suggest that off-pump revascularisation is more likely to be incomplete and graft patency may be compromised. The reported benefits of less neurocognitive dysfunction and reduced incidence of multi-organ failure again are yet to be confirmed. It is our opinion that if vascularisation of the coronary arterial tree is to be performed at all, then it is best done under the optimal surgical conditions available at present, with little hesitation to use the cardio-pulmonary bypass machine.

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Coronary artery bypass grafting without cardio-pulmonary bypass
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Owing to the disadvantages of cardio-pulmonary bypass (CPB), the development of technology for off-pump coronary artery bypass (OPCAB) surgery has led to a resurgence of interest in beating heart surgery in the hope of improving outcomes and lowering costs, especially in high-risk patients.¹ In the US, off-pump procedures had grown in application to an estimated 20–25% of CAB procedures in 2001. Proponents have continued to examine the efficacy of OPCAB procedures in comparison with conventional CAB grafting (CABG), but controversy exists on the selection of patients most likely to benefit with improved outcomes.

Contact of blood components with the artificial surfaces of the CPB circuit, aortic cross-clamping and reperfusion injury are the main causative factors of the major inflammatory response following cardiac surgery. Overall, it is thought that activation of complement and polymorph neutrophils, and consequent release of cytotoxins are responsible for most of the inflammatory response to CPB. In addition, CPB increases fibrinolysis, leading to post-operative bleeding and a requirement for blood transfusion.² Reports of OPCAB surgery have shown a significant decrease in peri-operative blood transfusion and mediastinal blood loss, compared with CABG with CPB.³ Earlier extubation, more

haemodynamic stability and less peri-operative renal complications have also been reported.⁴

The release of cardiac troponins was found to be significantly reduced with the OPCAB technique indicating less myocardial damage when compared with the CPB technique. Many prospective randomised trials have shown significant differences in the release of markers of myocyte death troponin T, troponin I and CK–MB (creatinine kinase muscle–brain) between CPB and OPCAB.⁴ This has been mainly attributed to the difference between the intermittent regional ischaemia caused by OPCAB and the prolonged global ischaemia caused by CPB with aorta cross-clamping, which could be the most likely explanation behind the myocardial protective effect of the OPCAB technique.¹ This could also be the explanation behind the lower incidence of atrial fibrillation with the OPCAB technique, which is a frequent (up to 30% in some reports) complication of cardiac surgery.⁵

Because most strokes are believed to result from athero-emboli, avoidance of aortic cannulation, aortic clamping, and cardiopulmonary bypass should reduce the risk of peri-operative stroke. Although recent studies have not shown a reduction in peri-operative strokes, Patel *et al*.⁶ have provided evidence of stroke reduction with OPCAB . Stamou

and colleagues⁷ demonstrated, by propensity analysis, that on-pump patients were 1.8 times more at risk than off-pump patients.

OPCAB offers the advantages in low-risk patients of decreased cost, reduced length of stay, and avoidance of transfusion. In elderly, high-risk patients, OPCAB may reduce the risk of stroke, renal failure, prolonged respiratory assistance, and perhaps death.^{1–8} However, CPB still appears to offer some advantages in patients with congestive heart failure, cardiomegaly, acute myocardial infarction, and coronary arteries that are technically difficult because of diffuse disease or inaccessible location.

Furthermore, there is a discrepancy in the reported anastomotic patency following OPCAB. Gundry and colleagues⁹ showed that the 3-year patency rates for OPCAB-performed grafts were lower than CBP-performed grafts and Omeroglu and associates¹⁰ showed a significantly lower patency rate for vein (47.1%) than for mammary grafts (95.7%) in 3-year follow-up results for OPACB. This shows that the worrying inferior patency rates which were initially reported, and triggered this issue in the first place, were no more than the usual vein graft failures that also occur with the CPB technique. Conversely, other groups have shown excellent angiographic patency following the OPCAB procedures.^{11,12}

The adverse effects of CPB have encouraged us and other surgeons to attempt the OPCAB technique in carefully selected patients first. Having observed some benefits of the OPCAB technique, we shifted to the non-selective, 100% use of OPCAB for all-comers for primary isolated CABG and proved that outcome was similar with low conversion rate.¹³ We also reviewed the initial OPCAB practice in the UK and showed reduction in risk-stratified morbidity and mortality associated with OPCAB at a multicentre level.¹⁴

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