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Editorial

Is there still a role for off-pump CABG in 2015? Certainly yes☆

¿Hay todavía un lugar para la cirugía coronaria sin circulación extracorpórea en 2015? Ciertamente sí

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Conventional coronary artery bypass grafting using cardiopulmonary bypass (CPB) and cardioplegic arrest of the heart has been the gold standard technique for coronary artery bypass grafting (CABG) since the mid 1960s. The major rationale for this approach is to provide a still, bloodless operating field that optimizes the ability to do a technically perfect operation. Crucially, this technique also enables the surgeon to perform a very low risk operation and several countries currently report elective mortality rates of around 1% for CABG despite the advancing age and comorbidities of the surgical population.

In the 1980s surgeons from South America[1,2] started reporting their experience with off-pump CABG (OPCABG). While their work was motivated at least in part by economic considerations, by performing CABG without the costs of CPB the operation became accessible to a much wider population, it also became evident that this approach also had the potential to minimize the damaging affects of CPB. Three decades ago CPB was associated with a potent systemic inflammatory response syndrome, due to activation of a myriad of cellular and humoral inflammatory mediators as blood circulated through the extracorporeal circuit and was strongly linked to multi-organ dysfunction and/or failure.[3] Furthermore, CPB also generated a large amount of gaseous and particulate microemboli that was implicated in adverse neurological sequelae.[4]

These reports of OPCABG encouraged a widespread adoption of this new technique until evidence began to emerge that its proposed benefits did not materialize in randomized trials against on-pump CABG (ONCABG). Indeed evidence began to accumulate that OPCABG could result in significantly inferior outcomes when compared to ONCABG. Two particular pieces of evidence questioned the safety and efficacy of OPCABG[5,6] and, with the exception of the Far East, initiated a decline in the numbers of OPCABG worldwide.

Short term outcomes

The ROOBY trial randomized 2203 patients to ONCABG and OPCABG.[5] While there was no significant difference between OPCABG and ONCABG in the 30-day composite outcome (7.0% and 5.6%, respectively; $P=0.19$), the 1-year composite outcome was higher for OPCABG (9.9% vs. 7.4%, $P=0.04$) and accompanied by fewer grafts completed per patient than originally planned (17.8% vs. 11.1%, $P<0.001$) and lower angiographic graft patency (82.6% vs. 87.8%, $P<0.01$). The trial was, however, subsequently criticized due to the relative inexperience of the participating surgeons and large numbers of cross-overs.[7]

In 2012 Moller and colleagues reported a Cochrane Database systematic review of 86 trials of OPCABG and ONCABG that included 10,716 patients.[6] A pooled analysis showed that OPCABG increased all-cause mortality (3.7% vs. 3.1%; $P=0.04$) and resulted in fewer distal anastomoses (−0.28; 95% CI −0.40 to −0.16, $P<.00001$) with no significant differences in myocardial infarction, stroke, renal insufficiency, or coronary re-intervention but a reduced incidence of post-operative atrial fibrillation. The authors concluded 'Based on the current evidence, on-pump CABG should continue to be the standard surgical treatment. However, off-pump CABG may be acceptable when there are contraindications for cannulation of the aorta and cardiopulmonary bypass'.

The existing literature has, until recently, consisted of trials of ONCABG and OPCABG that were individually underpowered to assess their relative effects on mortality. Two larger trials have provided greater insights and, crucially so, because the participating surgeons were, unlike in ROOBY, highly experienced in both techniques having performed at least 100 OPCABG cases. Lamy and colleagues[8] randomized 4752 patients to ONCABG or OPCABG. At 30 days there was no significant difference in the rate of the primary composite outcome of death, myocardial infarction, stroke, or new renal failure requiring dialysis between ONCABG and OPCABG. At 1 year, there was again no significant difference in the hazard ratio (HR) rate of the primary composite outcome (12.1% OPCABG and 13.3% ONCABG: HR with OPCABG 0.91; 95% CI: 0.77–1.07; $P=0.24$). At 1-year repeat coronary revascularization was 1.4% for OPCABG and 0.8% for ONCABG (HR 1.66; 95% CI, 0.95–2.89; $P=0.07$) with no significant differences between the two groups quality of life measures or neurocognitive function.

In the German Off-Pump CABG trial in the Elderly (GOPCABE) 2539 patients, aged over 75 years, were randomized to OPCABG or ONCABG.[9] At 30 days there was no significant difference in the respective composite outcome of death, stroke, myocardial infarction, or new renal-replacement therapy (7.8% vs. 8.2%; HR, 0.95; 95% CI: 0.71–1.28; $P=0.74$) or of its individual components. As for CORONARY repeat revascularization occurred more frequently after OPCABG than ONCABG (1.3% vs. 0.4%; HR, 2.42; 95% CI, 1.03–5.72; $P=0.04$). At 12 months, there was no significant difference between the groups in the composite end point (13.1% vs. 14.0%; HR, 0.93; 95% CI, 0.76–1.16; $P=0.48$) or in any of the individual components.

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In contrast to the findings in these large randomized trials several large propensity matched databases have reported early benefits of OPCABG over ONCABG. While these databases have the advantage of including tens of thousands of patients and propensity matching for certain risk factors they can still be susceptible to confounding factors that may be known or unknown. Kuss and colleagues performed a propensity score analyses of 123,137 patients undergoing ONCABG or OPCABG[10] and reported that the overall hazard ratio was less than 1 for all outcomes, favoring OPCABG. This benefit was significant for mortality (HR, 0.69; 95% CI: 0.60–0.75), stroke, renal failure, red blood cell transfusion ($P < .0001$), wound infection ($P < .001$), prolonged ventilation ($P < .01$), inotropic support ($P = .02$), and intraaortic balloon pump support ($P = .05$) while the hazard ratios for myocardial infarction, atrial fibrillation, and reoperation for bleeding were not significant.

Puskas and colleagues[11] identified 876,081 patients from the STS database of whom 210,469 underwent CABG at sites that had performed more than 300 OPCABG and 300 ONCABG during the 6-year study period ("high-volume sites"). Outcomes were analyzed both for all sites and for high-volume sites and stratified by participant center and surgeon, and adjusted for 30 variables that comprise the STS CABG risk model. They reported that OPCABG was associated with a significant reduction in risk of death, stroke, acute renal failure, mortality or morbidity, and postoperative length of stay.

Long term outcomes

In 2014 Takagi and colleagues reported worse 5-year survival with OPCABG.[12] From 5 randomized trials and 17 observational studies with 104,306 patients, a pooled analysis demonstrated a 7% increase in long-term mortality with OPCABG (HR, 1.07; 95% CI, 1.03–1.11; $P = .0003$). In contrast, the same year, Chaudhry and colleagues[13] reported in a systematic review of 32 studies that OPCABG had similar 5-year survival when compared with ONCABG (HR, 1.06; 95% CI, 0.95–1.19; $P = 0.31$). They also reported that while ONCABG had a trend toward a 10-year survival advantage (HR, 1.06; 95% CI, 1.00–1.13; $P = 0.05$) this disappeared when subgroup analysis of only randomized controlled trials, registry-based studies, and propensity-matched studies was performed.

Graft patency

Zhang and colleagues[14] examined 12 randomized controlled trials, for a total of 3894 OPCABG grafts and 4137 ONCABG grafts performed during OPCAB and ONCAB. For OPCABG, meta-analysis showed an increased risk of occlusion of all grafts (HR: 1.35; 95% CI: 1.16–1.57) and saphenous vein grafts (SVGs) (HR, 1.41; 95% CI, 1.24–1.60), but no significant difference in graft occlusion of left internal mammary artery (LIMA) (HR 1.15; 95% CI, 0.83–1.59) and radial artery (HR 1.37; 95% CI, 0.76–2.47).

Neurologic injury

Focal stroke or diffuse neurologic injury, although relatively uncommon, remains one of the most devastating complications of CABG. The presence of aortic atherosclerosis has been recognized as one of the strongest predictors of overt neurological injury for over two decades.[15] Avoidance or minimization of aortic manipulation (cannulation, clamping, side biting) has been shown to reduce the risk of cerebral injury.[16] While gross disease and/or calcification of the aorta may be obvious on visual inspection or by palpation, epiaortic scanning is necessary to detect less overt disease and particularly on the endoluminal surface. We previously reported that any aortic manipulation including the use of side biting clamps resulted in an increased number of solid and gaseous microemboli even from apparently healthy aortas.[4] Although the Cochrane review[6] and two largest randomized trials[8,9] reported no significant difference in the incidence of stroke between ONCABG and OPCAB two large propensity matched registries reported a reduction in stroke with OPCABG.[10,11] However none of these studies addressed the issue of a no touch aortic technique for OPCABG. Misfeld and colleagues in meta-analyses of eight observational studies, including 5619 OPCABG patients who underwent a no touch aortic technique reported significantly lower neurologic complications (HR, 0.46; 95% CI, 0.29–0.72; $P = .0008$) than 5779 ONCABG patients who experienced some form of aortic manipulation.[17] Likewise, Emmert and colleagues[18] reported that in comparison to partial aortic clamping, OPCABG patients undergoing a non-clamping approach had a significantly reduced frequency of stroke (0.7% vs. 2.3%; HR = 0.39; CI 95%, 0.16–0.90; $P = .04$) and MACCE (6.7% vs. 10.8%; HR = 0.55; CI 95%, 0.38–0.79; $P = .001$), and these results were similar to those of the control group, who underwent no-touch total arterial revascularization (stroke rate, 0.8%; MACCE, 7.9%).

Summary

Current evidence from randomized trials strongly indicates that for most patients undergoing contemporary bypass grafting there is little to choose between ONCABG and OPCABG in terms of patient safety. This is however predicated on the assumption that the OPCABG surgeon is highly experienced in this technically more challenging method because there is robust evidence, that in the hands of inexperienced surgeons, OPCABG leads to a high rate of cross overs and less complete revascularization. Even when performed by experienced surgeons OPCABG may result in inferior venous graft patency (possibly due to the loss of the anti-platelet effect of CPB and so dual antiplatelet medication is recommended). On the other hand, there is good evidence that OPCABG when incorporating a no touch aortic technique can significantly reduce the risk of stroke. In contrast to randomized trials large propensity matched registries have reported that OPCABG reduces postoperative mortality and most aspects of morbidity. Lastly, although there is conflicting evidence whether OPCABG reduces long-term survival this is almost certainly true if performed by inexperienced surgeons who do not achieve complete revascularization.

So why is there still firmly a place for OPCABG in 2015? The answer is simple: it is because there are, undoubtedly, certain cohorts of patients who do benefit from OPCABG e.g. patients with heavily diseased calcified or porcelain aortas who are at high risk of stroke from any aortic manipulation. However to be able to perform OPCABG consistently safely and efficiently in such situations it is essential that the surgeon is confident and proficient with the technique. The dilemma, however, is that to achieve this level of competency it requires that the surgeon performs the operation regularly as no occasional operation is a good operation. The mantra from some surgeons that 'I reserve OPCABG' for my difficult cases is illogical as the worst time to change technique is when faced with a difficult operation. This also raises the question of whether this technique for CABG should be considered a sub-specialty allowing some surgeons to gain the appropriate expertise and to teach trainees. A final concluding thought is that, in terms of overall benefits to most patients undergoing CABG, it is far more important to use two internal mammary arteries, because of their superior survival advantage,[19] than whether the operation is performed on or off pump.

Conflict of interests

The author declares no conflict of interest.

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