The debate over the relative merits of off-pump coronary artery bypass grafting (OPCAB) and conventional on-pump coronary artery bypass grafting (CABG) continues unabated and remains an area of great controversy. Given the known effects of cardiopulmonary bypass (CPB) on the inflammatory and coagulation cascades, as well as a suggestion of adverse neurological sequelae, there has been a logical argument to perform surgical revascularizations without its use. Proponents of OPCAB have cited advantages in terms of neurological outcomes, renal function, blood use, cost, length of stay, arrhythmias, infections, and ventricular function. Critics assert that OPCAB is more technically demanding than conventional CABG, and, moreover, that consistent data showing sustained benefits have been lacking and that some existing data suggest inferior revascularization. At present, analyses of randomized controlled trials have generally shown that OPCAB results in outcomes equivalent to those of conventional CABG in terms of mortality, long-term neurological function, and revascularization while reducing rates of blood use, renal impairment, and cost. Given the steep learning curve of OPCAB and lack of clear long-term cardiovascular or neurological benefit, however, many surgeons have reverted to or continued to favor conventional CABG as their strategy of choice. One criticism leveled at OPCAB is that the results reported usually come from surgeons and centers that are exceptionally experienced in the technique. Given the significantly higher technical demands of OPCAB, results equivalent to conventional CABG may not be applicable to most practicing surgeons. The implication, though unproven, is that the average cardiac surgeon might experience worse outcomes when using OPCAB than with conventional CABG. Indeed, this may explain the relatively low penetration of this technique, despite some demonstrable advantages. Thus, despite high expectations and initial enthusiasm for OPCAB, only about 20% to 25% of surgical coronary revascularizations in the United States are currently performed without the use of CPB.

Can the Off-Pump Coronary Artery Bypass Debate Shed Light on Postoperative Right Heart Dysfunction?

Michael J. Davidson, MD

The debate over the relative merits of off-pump coronary artery bypass grafting (OPCAB) and conventional on-pump coronary artery bypass grafting (CABG) continues unabated and remains an area of great controversy. Given the known effects of cardiopulmonary bypass (CPB) on the inflammatory and coagulation cascades, as well as a suggestion of adverse neurological sequelae, there has been a logical argument to perform surgical revascularizations without its use. Proponents of OPCAB have cited advantages in terms of neurological outcomes, renal function, blood use, cost, length of stay, arrhythmias, infections, and ventricular function. Critics assert that OPCAB is more technically demanding than conventional CABG, and, moreover, that consistent data showing sustained benefits have been lacking and that some existing data suggest inferior revascularization. At present, analyses of randomized controlled trials have generally shown that OPCAB results in outcomes equivalent to those of conventional CABG in terms of mortality, long-term neurological function, and revascularization while reducing rates of blood use, renal impairment, and cost. Given the steep learning curve of OPCAB and lack of clear long-term cardiovascular or neurological benefit, however, many surgeons have reverted to or continued to favor conventional CABG as their strategy of choice. One criticism leveled at OPCAB is that the results reported usually come from surgeons and centers that are exceptionally experienced in the technique. Given the significantly higher technical demands of OPCAB, results equivalent to conventional CABG may not be applicable to most practicing surgeons. The implication, though unproven, is that the average cardiac surgeon might experience worse outcomes when using OPCAB than with conventional CABG. Indeed, this may explain the relatively low penetration of this technique, despite some demonstrable advantages. Thus, despite high expectations and initial enthusiasm for OPCAB, only about 20% to 25% of surgical coronary revascularizations in the United States are currently performed without the use of CPB.

The authors previously used CMRI in assessing the effects of OPCAB on left ventricle (LV) function. The current study represents a new look at the same patients. The clinical protocol randomized 60 patients to OPCAB or conventional CABG and employed serial CMRI measurements at prescribed preoperative and postoperative time points to examine ventricular function. MRI measurements examined cardiac index, ejection fraction (EF), end-diastolic volume index, end-systolic volume index, and contrast myocardial enhancement. The patients enrolled represent a particularly healthy cohort for surgical revascularization, as evidenced by a mean age of 61 and LV EF of 62%. Patients who were elderly or had impaired renal function, heart failure, or an inability to tolerate MRI (and thus all urgent procedures) preoperatively were excluded. A single surgeon with a high degree of skill in both OPCAB and conventional CABG performed all procedures, using nearly all-arterial grafting. The patients in each group received a comparable number of distal anastomoses (2.8±0.9 versus 2.9±0.8) with short CPB and ischemic times (57±18 and 41±13 minutes, respectively) in the conventional CABG group. No operative mortality occurred, and 1 patient was converted intraoperatively from OPCAB to CPB CABG because of LV dysfunc-
tion. The authors’ prior investigation of LV function revealed that OPCAB resulted in improved postoperative LV cardiac index compared with conventional CABG, though it resulted in no difference in perioperative myocardial necrosis.

The investigators hypothesized that the RV would demonstrate a similar functional benefit from OPCAB. This study represents the first use of CMRI to assess postoperative RV dysfunction and therefore may shed some light on this poorly understood phenomenon. In contrast to the proposed hypothesis and to the previous findings with respect to the LV, RV functional parameters did not differ significantly between OPCAB and conventional CABG. Of note, both groups experienced an immediate but modest postoperative fall in RV EF, which was notably due to a decrease in end-diastolic volume index with preserved end-systolic volume index. This finding may perhaps be where paradoxical septal motion comes into play; whether abnormal septal motion represents a cause or effect, however, is still unclear. In any case, the early postoperative RV dysfunction was seen to completely resolve at the 6-month time point. This result stands in contrast to earlier echocardiographic studies demonstrating sustained RV dysfunction at 1 year postoperatively.

Given the small sample size (25 OPCAB and 22 conventional CABG), it is possible that RV functional differences between the techniques could be missed. Moreover, the RV is markedly load dependent; given that breath-hold technique is required for image acquisition, patient inconsistency could result in changes in RV loading and therefore in measured RV EF. Such variability could cancel treatment effect in a small patient sample. Additional and important limitations of this study, acknowledged by the authors, are the absence of pulmonary artery pressure measurements and of delayed enhancement data. Again, given RV load dependence, variance in pulmonary pressures could significantly impact the measured RV performance and thus the results. It might be anticipated that postoperative pulmonary resistance would differ depending on the use of CPB. Furthermore, without delayed enhancement RV myocardial imaging, it is unclear whether impaired RV function resulted from myocardial infarction. Although this may be unlikely given the full functional recovery by 6 months, this information would be of importance. Finally, this cohort of patients appears healthier than the average surgical revascularization population, which could mask the potential benefits of one technique over the other in more vulnerable patients. A randomized comparison of the techniques in a more typical cohort of elderly patients with impaired ventricular function might yield different results. Another potential confounder is that the myocardial ischemia times were short in the conventional CABG group, a factor that could minimize potential differences and that could result from cardioplegic arrest. On the other hand, the use of crystalloid, rather than blood, cardioplegia could have worsened the ventricular function in the conventional CABG group. Compelling data suggest that use of blood cardioplegia enhances myocardial protection during ischemia and results in improved ventricular performance. The use of crystalloid cardioplegia for the conventional CABG procedures in this study may have resulted in a relative diminution of RV function, though again one would expect the effect to be small with this sample size. Nevertheless, the authors should be congratulated on excellent surgical outcomes and on the use of sophisticated cardiac imaging to elucidate the impact of CPB on postoperative RV dysfunction.

Undoubtedly, proponents of OPCAB will be disappointed that yet another study appears to demonstrate equivalency between the techniques. They may take heart in the possibility of confounding variables and small sample size that could mask a true difference. A true disappointment is that despite the great promise of CMRI functional assessment, we are no closer to understanding the mechanistic basis of postoperative RV dysfunction. This study does suggest that CPB and cardioplegic arrest do not account for the changes in function and also highlights the alterations in end-diastolic volume index regardless of technique used. Tissue edema or inflammation in the postoperative state could account for such an observation, and it is interesting that the use of CPB did not significantly impact this change. Of note, tissue edema imaging is gaining clinical acceptance and with higher field MRI, examination of perioperative RV tissue edema may become feasible. Future use of CMRI might elucidate this possibility and shed more light on the mechanism of postoperative RV dysfunction.

It is highly unlikely that the results of this article will tip the balance in the contentious off-pump versus on-pump debate. Ultimately, surgeons will continue to offer the technique that appears best suited to the patient at hand while conforming to their own level of experience and comfort. The good news for practitioners and patients alike is that both OPCAB and conventional CABG can offer excellent and durable results when applied appropriately by experienced surgeons. Meanwhile, we must continue to search for strategies to eliminate both left and right ventricular impairment while allowing for the best long-term myocardial revascularization.

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Disclosures

None.

References


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