To beat or not to beat? From one size fits it all to an individual coronary revascularization strategy

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This editorial refers to 'Early graft patency after off-pump and on-pump coronary artery bypass surgery: a prospective randomized study', by M. Sousa Uva et al., on page 2492

For decades, coronary artery bypass grafting (CABG) was routinely performed with cardiopulmonary bypass support and cardioplegic arrest. A deloaded, non-beating heart, a bloodless surgical field, and an easy exposure were regarded to be essential for manipulations on vessel sizes of less than a pencil lead. Surgical results were excellent, mortality declined constantly, and conventional CABG (cCABG) became a success story and the ‘bread and butter’ for cardiac surgeons since it was the first-choice revascularization strategy in multivessel coronary artery disease. However, some adverse clinical consequences, such as stroke, myocardial infarction, and inflammatory response syndrome, complicated by acute lung and kidney injury have largely been attributed to cardiopulmonary bypass circuit, hypothermic cardiac arrest, and aortic manipulation. Consequently, several efforts were made in the early 1990s to reduce morbidity and mortality by looking for safer alternatives to cCABG including off-pump beating heart bypass surgery (OPCAB) in multivessel coronary artery disease.

As is often the case when new technical innovations expand and become available for routine use, advocates and opponents of OPCAB raised their voice. Initial controversies within the cardiac surgery community, however, were based more on general convictions than on scientifically proven data. During the last decade more and more prospective randomized studies and meta-analyses comparing OPCAB and cCABG surgery in low-risk patients or mixed-risk populations have become available. They usually failed to demonstrate any significant benefit of OPCAB surgery on early mortality or perioperative major cardiac and cerebrovascular events, but OPCAB was superior regarding blood loss, transfusion requirements, re-thoracotomy rate, ventilation time, intensive care unit (ICU) and hospital stay, and subsequently resource utilization. Most of the large observational studies comparing OPCAB and cCABG strategies also revealed a benefit of OPCAB concerning early mortality, myocardial infarction, and stroke rate.

In recent years efforts were made to analyse the meaning of beating heart revascularization concepts for patients with specific cardiac and extracardiac risks such as ischaemic cardiomyopathy, calcified aorta, older age, renal failure, acute coronary syndrome, left main stenosis, and others. For most of these subsets of patients, several single- and multicentre studies are available today. Even if most of them were non-randomized and thus failed to reach evidence level A according to the international guideline standards, they still allow for analysis of interim results for a patient-specific perioperative risk profile. In particular, multirisk patients and patients with severely reduced left ventricular function seem to benefit in terms of perioperative mortality and major morbidity by avoiding cardiopulmonary bypass and cardioplegic arrest.

Since the beginning of OPCAB surgery there were, in particular, concerns regarding the quality of coronary anastomoses and the completeness of revascularization, especially at the lateral wall. They were addressed rapidly by the development of sophisticated stabilizers and heart positioning devices (Figure 1). However, only 10–20% of CABG operations are performed off-pump in Europe today, which is considerably less than in North America. Especially in Asia, and particularly in India, OPCAB really took off, due to obvious financial constrains and simple and reusable techniques.

One reason for a restrictive OPCAB indication might be the surgeons’ continuing fear of a less complete and less durable surgical revascularization performed with this technique. Indeed, despite excellent stabilization devices available today, anastomotic performance remains the Achilles heel in OPCAB surgery, and the highest quality requires a significantly prolonged learning curve compared with the conventional technique. It might be speculative that the increasing complexity of coronary artery disease and decreasing case volumes with which cardiac surgeons are confronted make it more and more difficult to gain OPCAB experience today.
Surgical coronary bypass performance can be evaluated differently. The most important factor is the rate of adverse clinical endpoints such as early and late incidence of myocardial infarction, recurrent angina, and repeat revascularization. Another factor is the completeness of revascularization for which different definitions exist. The most valuable measurement of course is to assess bypass dysfunction directly by angiographic or computed tomography (CT) imaging.

In most published clinical follow-up studies no significant differences concerning recurrence of angina, reintervention rate, and late mortality were found. In contrast, the New York database of ~50,000 patients operated on between 2001 and 2004 showed that freedom from repeat revascularization was significantly higher for OPCAB after 3 years (OPCAB 89.9% vs. cCABG 93.6%), while mortality was comparable.

Completeness of revascularization is undoubtedly more difficult to measure. In general, it cannot be entirely denied that there is a selection bias of many surgeons to perform complex and multiple arterial revascularization in low-risk patients on-pump and to stay off-pump for double or triple bypass surgery in older, co-morbid patients. Thus, the total number of distal anastomoses is not a priori appropriate to consider for complete revascularization. However, in 24 randomized controlled trials with reported mean number of bypass grafts of 2284 individuals, the mean graft number was 0.19 graft per patient less (P < 0.001) in the OPCAB patients compared with cCABG subjects. Since incomplete revascularization almost always affects the non-LAD (left anterior descending) territories, it is easy to understand that incomplete revascularization in OPCAB surgery compromises repeat revascularization more than survival.

Differences in graft patency in OPCAB vs. cCABG measured by repeat coronary angiography or CT remain a matter of controversy. In experienced OPCAB centres graft patency in both techniques was comparable in randomized controlled trials such as in the SMART, OCTOPUS, or PRAQUE-4 studies. In contrast, two other randomized controlled studies surprisingly showed the opposite by demonstrating a significantly compromised graft patency in OPCAB compared with cCABG patients. The first study published in 2004 was severely criticised because of the deficiency in surgeons’ OPCAB experience, which was indicated by the small number of OPCAB procedures performed per surgeon so far and a high conversion rate. The second recently published ROBBY study performed on a total of 2203 patients and 4093 grafts evaluated in 1371 patients by angiography also demonstrated a worse graft patency and a lower completeness of revascularization in the off-pump group. This study also came under severe fire because OPCAB was performed by inexperienced surgical trainees in the majority of patients and again the conversion rate from OPCAB to on-pump was >12% and thus 5-fold higher than the average in the USA and Europe.

Sousa Uva and colleagues have presented a very well performed prospective study on 150 patients who received surgical revascularization by either cCABG (n = 74) or OPCAB (n = 73). In contrast to the previously mentioned trials the only surgeon in this PROMISS study (M.S.U.) was experienced in both cCABG and OPCAB surgery, indicated by a high volume of OPCAB procedures performed before the start of the PROMISS study, a lower than average conversion rate, and an index for completeness of revascularization of 1.0 in both study arms. The primary endpoint of the study was the rate of occluded grafts 5 weeks after surgery as assessed by 16-slice multidetector CT (MDCT). The authors found a significantly higher rate of occluded grafts in the OPCAB compared with the cCABG patients (10.2% vs 5.0%, P = 0.03), with significantly more patients with at least one occluded graft (OPCAB 26.7% vs. cCABG 12.9%, P = 0.04). These findings were found predominantly for the territory of the right coronary artery and for veins and radial arteries. Interestingly these differences were no longer statistically significant after adjustment of heparin dose, indicating that factors other than technical aspects might also play a crucial role in early graft occlusion. Since the antithrombotic protocol is usually different in OPCAB and cCABG studies on alternative perioperative anticoagulation strategies, acute aspirin resistance and post-operative dual platelet therapy are essential to clarify these findings in the future.

Irrespective of the primary study endpoint of the PROMISS study and comparably with most previous studies, the difference in graft occlusion rate could not be translated into a higher rate of adverse clinical events, which was even lower for the OPCAB cohort than for cCABG patients. This is consistent with data from the literature indicating that in contrast to acute stent thrombosis of percutaneous coronary intervention (PCI) patients, a bypass graft occlusion results in less acute myocardial infarction than repeat angina, leading to subsequent repeat revascularization.

In the study of Uva Sousa et al. 16-slice MDCT angiography was used to identify graft occlusions. Despite improvements, evaluation of patients with MDCT still has some limitations in low flow situations and thus cannot be considered as comparable with conventional coronary angiography for patients with known coronary artery disease. Diagnosis of distal anastomotic stenosis by MDCT can be difficult in some cases due to rapid heart rate, arrhythmia, and heart beat motion artefacts. Thus only graft occlusions, but not...
Conflict of interest: both certainly impact graft selection and long-term graft patency. Grades of stenoses and the need for revascularization, which are controversially discussed today regarding different approaches for coronary revascularization, may also include the ongoing controversial discussion of interventional vs. surgical coronary revascularization in multivessel and left main disease, and the use of different kinds of hybrid concepts.

What we can learn from the study of Uva Sousa et al. is that even in experienced hands OPCAB surgery is a technically challenging surgical procedure that offers the potential risk of a higher graft occlusion rate, which, however, has to be carefully and individually considered against many, many substantial clinical benefits of OPCAB surgery. As in the SYNTAX trial, optimal medical therapy such as anticoagulation and antplatelet regimes had to be adjusted after surgical revascularization. Comparably with the cardiology FAME study, cardiac surgeons had to consider competitive flow phenomena to reduce the graft occlusion rate. For this, functional flow studies are mandatory, allowing for quantification of grades of stenoses and the need for revascularization, which both certainly impact graft selection and long-term graft patency.

Conflict of interest: none declared.

References