Outcome of Coronary Artery Bypass Grafting – Strategies for Improvement

Ardawan J Rastan¹ and Volkmar Falk²

1. Department of Cardiac Surgery, Heart Centre, University of Leipzig; 2. Department of Cardiac and Vascular Surgery, University Hospital Zurich

Abstract
During recent years, new conceptual, technical and drug strategies have led to improved early and late outcomes after coronary artery bypass surgery. These new strategies can be divided into the following three groups: optimisation of pre-operative patient selection and indications for and timing of the operation; peri-procedural refinements, including new techniques and instruments to avoid extracorporeal circulation, reduce aortic manipulation and minimise surgical access; and improvements to post-operative care, such as fast-track protocols and long-term drug therapy. In summary, the wide range of the surgical armamentarium available today allows cardiovascular surgeons to adapt the surgical strategy to individual patients and the given clinical scenario. This article aims to describe clinical rationales for the adoption of new concepts, provide an introduction to technical details and discuss clinical study results where appropriate.

Keywords
Off-pump coronary artery bypass (OPCAB), endoscopic graft harvesting, minimally invasive surgery, minimally invasive direct coronary artery bypass (MIDCAB), hybrid coronary revascularisation

Pre-operative Patient Selection, Indication and Timing of the Operation
Patient Selection and Coronary Artery Bypass Grafting Indication in Stable Patients
Compared with PCI, CABG is undoubtedly the more effective revascularisation concept, with better early and long-term target vessel patency rates and less recurrent angina; however, CABG is more invasive and is associated with a significantly higher rate of minor complications and longer hospitalisation. Regarding survival analyses, most comparative PCI versus CABG studies have been performed on patients with two-vessel disease (2-VD) excluding the left anterior descending (LAD) territory and left main stem or in highly selected patients with 3-VD presenting coronary lesions that were exceptionally suitable for PCI, and thus failed to demonstrate a survival benefit of CABG over PCI. By contrast, the SyNergy between percutaneous coronary intervention with Taxus and cardiac surgery (SYNTAX) study was designed to compare for the first time modern surgical and percutaneous techniques (drug-eluting stents) as a primary treatment strategy in 1,800 randomised patients with de novo 3-VD and/or left main disease in a real-world scenario.

An important conclusion from the SYNTAX study was that the primary study end-point of the 12-month major adverse cardiac and cerebrovascular event (MACCE) rate significantly favoured CABG over PCI (12.1 versus 17.8%; p=0.0015), which was mostly based on a two-fold higher rate of repeat revascularisation in the PCI patients.¹ However, there was no difference between the two groups in terms of the safety end-point, which included all-cause death, cerebrovascular events and myocardial infarction after 12 months. The three-year follow-up data are now available, revealing a significantly lower incidence of
myocardial infarction (3.6 versus 7.1%) in the CABG patients compared with those receiving PCI. For the large subset of patients presenting 3-VD without left main disease, a significant survival benefit was found even for CABG patients (see Figure 1). By contrast, in the smaller cohort of patients with left main disease (isolated or in combination with 1-, 2- or 3-VD), there was a significant benefit of CABG over PCI only in patients with additional complex CAD (mostly 3-VD). However, in left main patients with less complex additional CAD, there were comparable results in the PCI group. The reasons for these findings are an unexpectedly high MACCE rate in this small number of surgical patients and a lower than average three-year incidence of repeat revascularisations in the PCI cohort. As a consequence, the recently published European Society of Cardiology (ESC) guidelines on myocardial revascularisation for the first time gave a class IIA recommendation for PCI for isolated ostial or midshaft lesion and only for left main with two or three vessel disease and a SYNTAX score of more than 33 left main stenting is still contraindicated.

By combining the 897 patients randomised to CABG in the SYNTAX study with the 644 patients who were not randomised (owing to coronary anatomy not suitable for PCI but who were followed in a nested SYNTAX CABG registry, the largest CABG cohort to date from a single controlled multicentre clinical trial could be analysed. These data revealed excellent contemporary CABG results with an overall early mortality rate of about 1%, which was not inferior to that seen with PCI. This low mortality rate was remarkable because only a few study exclusion criteria were defined in the SYNTAX study. A risk factor analysis of this entire SYNTAX CABG cohort revealed left main disease (p=0.049) and incomplete revascularisation (p=0.005) as coronary risk factors for adverse two-year MACCE rate. Other well-known extracardiac and cardiac predictors for two-year MACCE were arterial hypertension, EuroSCORE, peripheral vascular disease, advanced age, chronic obstructive lung disease, low ejection fraction, intra-aortic balloon pump and emergency indication. Medically treated diabetes was not a predictor. By contrast, complete surgical revascularisation was significantly protective against two-year MACCE, indicating that complete revascularisation should always be the aim whenever surgical revascularisation is performed.

The SYNTAX study also addressed differences in coronary complexity by using the SYNTAX score. The SYNTAX score was initially designed as a comprehensive angiographic scoring system to anticipate PCI complexity related to coronary pathology and to allow quantification of CAD beyond left main and three-major-vessel disease. During the SYNTAX study, the SYNTAX score was calculated for all patients by a central core laboratory, with patients divided into tertiles of low (0–22), medium (23–32) and high (≥33) SYNTAX score. Interestingly, in contrast to the PCI results, it was demonstrated that for CABG patients the overall MACCE rates at two years were not influenced by differences in the complexity of CAD (see Figure 2).

Surgical Indication and Timing in Patients with Acute Coronary Syndrome

Compared with the options for patients with stable angina pectoris (AP), there is a multitude of highly effective treatment options for acute coronary syndrome (ACS). Among these are new and refined treatment strategies using glycoprotein IIb/IIIa receptor antagonists, thienopyridines and antithrombin agents. A timely coronary angiography and a prompt invasive revascularisation strategy play a significant role in patient outcomes. The revascularisation strategy today primarily follows catheter-based PCIs; however, depending on patient status and the complexity of CAD, and in cases of chronic total coronary artery occlusion or unsuccessful or complicated PCI, an urgent or emergency operative coronary bypass procedure may be indicated. In patients with unstable angina and non-ST-segment myocardial infarction (NSTEMI), there is no reason why the choice of revascularisation modality should deviate from that used for stable angina.

Once a consensus has been reached for an operative indication, the timing of the operation must be determined based on the symptoms, the individual coronary pathology and the haemodynamic stability of the patient, as well as on the need for routine and additional diagnostics. Emergency indications are persistent or recurrent AP refractory to optimal medical treatment, sub-total non-collateralised coronary stenoses or impending or manifest cardiogenic shock. On the other hand, in patients with medically managed symptoms, chronically well collateralised coronary occlusions and stable haemodynamics, the operation may be postponed. However, the operation should still be carried out urgently within the same hospital stay or as an early elective operation. As shown recently by the
Assessment on the prevention of progression by rosiglitazone on atherosclerosis in type 2 diabetic patients with cardiac history (APPROACH) study, time from admission to CABG was not associated with an increased risk of short-term mortality.12

For ST-segment myocardial infarction (STEMI), the contemporary guidelines suggest that for suitable coronary pathologies, PCI of left main stem lesions is equivalent to a coronary bypass operation for patients who have an elevated operative risk.24 Surgical revascularisation in STEMI should always be considered when the infarct vessel cannot, or cannot sufficiently be interventionally revascularised, and is therefore indicated as an immediate procedure, analogous to PCI. Not uncommonly, the infarct vessel can be acutely re-opened and unmasks an accompanying multivessel CAD during angiography, which per se represents a primary operative indication. In this setting an urgent operation is indicated, or sooner in the case of recurrent symptoms, haemodynamic instability or critical coronary anatomy.

Peri-procedural Refinements, Including Strategies for Avoiding Extracorporeal Circulation, Reducing Aortic Manipulation and Minimising Surgical Access

In the mid-1990s, surgical strategies became available that allowed coronary artery bypass operations to be performed on the beating heart and without CPB. Since then, the number of OPCAB procedures has risen and they now account for about 30% of all coronary revascularisations worldwide, and in some countries with limited medical and financial resources the proportion exceeds 80%. In some units, OPCAB is used almost exclusively without patient selection.

Off-pump Coronary Artery Bypass

The major advantage of OPCAB procedures is the removal of the need for a heart–lung machine, which avoids all of the adverse effects associated with extracorporeal circulation and cardioplegic arrest, such as systemic inflammatory response syndrome, aortic arteriosclerotic debris or air embolisation, laminar blood flow and global myocardial ischaemia. OPCAB procedures are performed on the beating heart with only local stabilisation of the relevant coronary segment with the aim of distal anastomosis. The anastomosis is performed by incising the coronary vessel and controlling the local bleeding using proximal vessel snares, intracoronary shunts and a CO₂ blower–mister (see Figure 3).

The evolution of OPCAB surgery is of course closely associated with the development of stabilisation arms, which first became available in the early 1990s. After early experiences it was obvious that exposure of the posterior wall would require vacuum-assisted stabilisers. It was also recognised that OPCAB requires more than just cCABG procedures: a team approach and optimal anaesthesiological management are also needed to support the procedure and to avoid haemodynamic compromise.

During the last decade, several prospective randomised studies and meta-analyses comparing OPCAB and cCABG surgery have been published, focusing on low-risk or mixed-risk populations.13–15 Most of the studies failed to demonstrate significant differences between the two surgical options regarding early mortality or peri-operative MACCE rates, but OPCAB was consistently superior regarding blood loss, transfusion requirements, ventilation time, intensive care unit (ICU) and length hospital of stay and, consequently, resource utilisation. 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.16

In recent years, OPCAB revascularisation strategies have been evaluated on patients with specific cardiac and extracardiac risks. For most of these subsets of patients, single- and multicentre studies are now available. Although most of these studies were non-randomised, they demonstrated that multirisk patients and patients with severely reduced left ventricular function in particular benefit in terms of peri-operative mortality and major morbidity by avoiding CPB and cardioplegic arrest. However, because of the overall low incidence of MACCE in routine CABG surgery, large cohorts of patients – which are available only in registry meta-analyses – would be needed to demonstrate statistically significant differences in mortality, stroke and renal failure between the procedures.17–19

In a thorough meta-analysis, the International Society for Minimally Invasive Cardiac Surgery Consensus Group published evidence supporting the use of OPCAB, demonstrating that OPCAB reduces mortality, length of stay and the incidence of post-operative myocardial infarction, renal failure, atrial fibrillation and transfusion in mixed-risk and high-risk patients.

During the early OPCAB period, concerns arose regarding incomplete surgical revascularisation and impaired graft patency owing to the more challenging OPCAB technique.20–22 Two randomised controlled studies showed a significantly compromised graft patency in OPCAB compared with cCABG patients.23,24 However, both studies came under severe fire in the surgical community because OPCAB was performed by inexperienced surgical trainees during the early learning curve, which was reflected in a conversion rate from OPCAB to on-pump of more than 12% – fivefold higher than average in the US and Europe.

Today, in experienced OPCAB centres, clinical data and graft patency are comparable between the two techniques, as shown in...
Bypass Grafting

Figure 4: Intraoperative Situs of a Minimally Invasive Direct Coronary Artery Bypass Procedure via Anterolateral Mini-thoracotomy

Minimally Invasive Direct Coronary Artery Bypass

A less invasive approach is to combine OPCAB strategies with the avoidance of a full median sternotomy; this reduces surgical trauma and wound complications. The minimally invasive direct coronary artery bypass (MIDCAB) concept was introduced for patients with isolated disease of the LAD in the mid-1990s and since then has found widespread application. In some centres MIDCAB is the method of choice for surgical revascularisation of isolated LAD disease. In addition, MIDCAB is a valuable alternative to standard CABG of OPCAB in selected high-risk patients with multivessel disease and extensive co-morbidities, who are at a prohibitively high risk for sternotomy.

Standard MIDCAB is usually performed through a left anterolateral mini-thoracotomy in a 10–20° right lateral position. After a 5–6cm skin incision above the fifth intercostal space or in the infra mammary fold, take-down of the left internal mammary artery (LIMA) and its branches is performed under direct vision using special retractor systems. Alternatively, endoscopic LIMA take-down using a harmonic scalpel or telemanipulation system has been reported. The pericardium should be opened above the course of the LAD and extended to the groove between the aorta and the pulmonary artery to facilitate the identification of the LAD. To enhance exposure, one or two pericardial stay sutures may be used to position the heart. Standard reusable pressure stabilisers are then used to immobilise the target region before anastomosis (see Figure 4). MIDCAB modifications include an approach through a partial inferior sternotomy or a small anterolateral thoracotomy for multivessel bypass grafting.

Early angiographic patency rates reported for MIDCAB procedures are in the range of 94–98%, similar to those reported for sternotomy patients. At six months, patency rates of 94% have been described. Reported in-hospital mortality for MIDCAB is less than 1% and compares favourably with a rate of 1.4% for off-pump single-bypass and 3.6% for single bypass with CPB, as reported in the registry of the German Society for Thoracic and Cardiovascular Surgery, and is also lower than the 2.4% mortality rate seen in the Society of Thoracic Surgeons database. The rates of major peri-operative complications such as myocardial infarction and the need for target-vessel re-intervention are low and also comparable to those seen for standard CABG procedures. In addition, owing to anaortic surgery, peri-operative stroke is rare and the rate is considerably lower than that seen for conventional techniques (see below).

In our series of 1,918 patients who underwent MIDCAB between 1996 and 2009, the in-hospital mortality rate was 0.8% (predicted mortality by EuroSCORE 3.8%) and the stroke rate was 0.3%. Conversion to sternotomy was necessary in 1.6% of patients. A total of 745 patients received a routine post-operative angiogram, demonstrating a 96.3% early patency rate. Five-year survival was 91.5%. Freedom from MACCE and angina after five years was 88.6%. These results are in accordance with the findings of other groups.

However, MIDCAB is a highly demanding procedure that should be attempted only by surgeons who have sufficient experience in conventional and off-pump surgery. It has been shown that the complication rate of MIDCAB is significantly lowered after 100–150 MIDCAB procedures. Therefore, it is recommended that only dedicated and experienced surgeons use this procedure. Total endoscopic CABG (TECAB) is performed in a few centres. With the evolution of robotic surgery the results of off-pump TECAB have substantially improved, but larger trials are needed to determine the added benefit of this approach over MIDCAB.

Hybrid Coronary Revascularisation Concepts

The hybrid approach for patients with multivessel CAD combines the excellent long-term results of grafting a mammary artery to the LAD with the advantages of PCI to achieve complete revascularisation. The principle was first described by Angelini in 1996. The basal hypothesis of this concept is that in non-LAD territories PCI can potentially achieve similar long-term results to CABG with a somewhat higher rate of re-intervention. However, combining the benefits of two different procedures also means adding the different risks inherent to each type of procedure. The risks of a surgical procedure such as general anaesthesia, mechanical ventilation, bleeding and wound healing complications are combined with the risks of PCI, which include dual antiplatelet therapy (DAPT) and the necessity of re-interventions for in-stent restenosis or acute stent thrombosis.

Usually, a hybrid myocardial revascularisation strategy means combining a MIDCAB operation with PCI of the non-LAD territories during the same hospital stay. However, whether PCI should be performed immediately before, during or soon after the...
Hybrid concepts for coronary artery revascularisation were considered for the first time in the recently published ESC guidelines on revascularisation and were defined as a planned, intentional combination of CABG with a catheter-based intervention to other coronary arteries during the same hospital stay. It is recommended that indications for hybrid revascularisation be selected by a heart team combining surgical and PCI expertise. The limited availability of outcome data and a lack of randomised trials mean that the ESC guidelines focus only on potential clinical scenarios when hybrid revascularisation might be considered.

Complete Arterial Revascularisation

In the last 20 years there has been increasing concern about the long-term patency of vein grafts utilised for CABG compared with arterial grafts. It was thus suggested that revascularisation with arterial grafts rather than vein grafts may result in improved outcomes following CABG.

In particular, the Cleveland Clinic group reported superior survival in patients receiving bilateral mammary artery bypass grafting to the left coronary territories. This is particularly important when considering that graft occlusion can result in recurrence of angina, re-hospitalisation and re-intervention. However, to date, neither multiple arterial grafting nor complete arterial revascularisation has become the standard approach for patients undergoing CABG. This is supported by reports from large contemporary multicentre studies suggesting that the use of multiple arterial grafting is limited to approximately 10–20% of all patients undergoing CABG. There are several potential reasons why the use of complete arterial revascularisation has not appeared to increase significantly during the last two decades. Besides the fact that the procedures are longer and more technically demanding, there are two major arguments that might explain this phenomenon.

First, the benefit of an additional arterial graft to the non-LAD territories is not as scientifically well proven as it is in the LAD territory and that non-LAD territories per se do not have the same impact on survival. For example, data from the Radial Artery Penetration and Clinical Outcome Trial failed to demonstrate a significant difference in graft patency between the radial artery, the right mammary artery and a venous graft for the second largest territory in the presence of a LIMA-to-LAD bypass, which is in stark contrast to recent data from the Cleveland Clinic. Moreover, the patency of bypass grafts to the non-LAD territories depends to a greater degree on the pathology of the target artery, the grade of native vessel stenosis and the conduit quality than grafts to the LAD.

Interestingly, analysis of the entire SYNTAX CABG population revealed no significant advantage of arterial grafting over venous bypass surgery in the presence of an IMA-to-LAD anastomosis after two years. It is hoped that long-term data from the randomised Arterial Revascularisation trial (ART) will provide more evidence on this issue.

The use of different arterial grafts (second mammary, radial, gastroepiploic artery), different target vessel anatomy and the variety of options for arterial graft construction (sequential, Y-graft, T-graft, in situ, free graft) means it is difficult to carry out well-founded scientific analyses as a basis for general recommendations. Thus, in the current guidelines no recommendations are given except for the preference of LIMA-to-LAD.

Second, the advantages of arterial bypass conduits become more evident over time and thus arterial revascularisation might be more important for prognosis in patients under 65 years of age. However, contemporary bypass surgery is confronted with an increasingly ageing patient population who probably do not benefit to the same degree as younger patients. Moreover, some surgeons also fear an increased risk of sternal wound complications and a prolonged hospital stay when the second mammary artery is used. However, using the skeletonised mammary harvesting technique, it has been shown that, even in patients with diabetes, the use of a bilateral mammary artery is not associated with a significantly increased risk of wound healing problems. In summary, the selection of bypass graft material today is more demanding than in recent decades, with surgeons able to offer a flexible bypass graft concept adapted to patient age, risk profile and coronary anatomy.

Anaortic Surgery

The Achilles’ heel of contemporary CABG surgery remains the higher incidence of early neurological events compared with PCI; a cumulative rate of 2% after the first year was reported in the SYNTAX trial. OPCAB surgery offers the potential to reduce the incidence of peri-operative stroke by avoiding aortic cannulation and reducing aortic manipulation. However, most of the OPCAB studies include patients receiving partial occlusion clamping of the aorta for proximal bypass anastomosis, with the potential residual risk of cerebral debris embolisation from the arteriosclerotic ascending aorta. Anaortic surgery is defined as a CABG procedure that avoids any aortic manipulation by performing OPCAB surgery and constructing T-shaped or Y-shaped conduits that are centrally supplied by an in situ arterial graft. Usually, the in situ LIMA serves as a central conduit that delivers a second graft for the posterior and inferior coronary segments.

Recently, it was demonstrated that anaortic surgery was associated with improved neurological outcome in about 2,000 OPCAB patients and reduced the 30-day stroke risk from 0.5 to 0.1%. Anaortic surgery is thus an important option, especially for patients with an increased risk of cerebral adverse events owing to severe general arteriosclerosis including porcelain aorta. For those patients in whom at least one proximal aortic anastomosis seems appropriate, new proximal anastomotic devices are now available that are designed to offer a complete haemostatic seal without the need for an aortic side-clamp.

Endoscopic Graft Harvest

There is overwhelming and consistent evidence from meta-analyses that endoscopic graft harvesting of the saphenous vein and the radial artery is significantly beneficial with regard to non-infective wound healing problems, septic wound complications, length of hospital stay, need for surgical wound intervention, pain, neuralgia and patient satisfaction. Thus, conduit harvest should be performed routinely through limited incisions, or endoscopically.

A variety of techniques and device options for minimally invasive saphenous vein and radial artery harvesting have been described over time, and can be divided into three main groups: minimally invasive...
Bypass Grafting

techniques with direct vision, or bridging techniques; endoscopic harvesting using closed CO₂ systems; and endoscopic harvesting using open or no CO₂ systems. Irrespective of the device used, a short skin incision of 2–3cm is enough to harvest the vein (two- to three-vein conduit segments and the radial artery). Several groups have reported a fast learning curve with the endoscopic technique, with procedure duration reducing to an acceptable 20–30 minutes after the first few cases.51

In an International Society for Minimally Invasive Cardiothoracic Surgery (ISMICS) Consensus Group meta-analysis, the risk of wound complications from endoscopic vein harvesting techniques was reduced significantly by 69% compared with the open technique.59 The need for surgical intervention for wound infection was also reduced significantly. With regard to the incidence of moderate to severe post-operative pain, a reduction of 74% was evident, and the incidence of mobility disturbance at discharge was reduced by 69.

There are only a few trials focusing on cardiac outcomes and providing angiographic data on patency rates. A secondary analysis of the Project of ex-vivo vein graft engineering via transfection (PREVENT) IV trial demonstrated inferior patency rates for endoscopic versus open vein graft harvest after 12–18 months: the vein graft failure rate was 46.7% in the endoscopic versus 38.0% in the open group (p<0.001). Endoscopic harvesting was also associated with higher rates of death, myocardial infarction and repeat revascularisation.59 However, most studies found no differences in myocardial infarction, recurrent angina, coronary re-intervention and death over the short and medium term.52–54 The few trials focusing on vascular integrity and vessel wall trauma found no difference for the endoscopic versus the open technique.55

With regard to wound infections in endoscopic radial artery harvest, a lower rate was found (0–2.7%) compared with the open radial artery harvest technique.56–57 Graft patency, clinical outcome, histological integrity and in vitro vasoreactivity are equal between open and endoscopic techniques.58 Thus, endoscopic radial artery harvest should always be considered owing to better patient satisfaction and fewer wound healing complications.

Improvements in Post-operative Care, Including Fast-track Protocol and Cardiac Medication

Alongside pre- and intra-operative decisions and strategies, optimal post-operative care also significantly influences early and mid-term outcomes after CABG surgery.

Fast-track Protocol

Numerous studies have shown that early extubation or “fast-track” treatment of routine cardiac surgery patients results in a decrease in ICU and hospital length of stay and, subsequently, a reduction of hospitalisation costs.59 There are various options for the implementation of a fast-track protocol and the choice depends on local hospital conditions. Two options that allow fast recovery and transfer of the patient to the intermediate care unit within the first 12–24 hours post-operatively are fast-track protocols with extubation in the operation room followed by transfer to the ICU or extubation of the patient in the ICU early after admission. However, another fast-track protocol allows the patient to be transferred from the operation room directly to a post-anæsthetic care unit, where specially trained anaesthetic nurses and anaesthetists ensure early extubation and sufficient analgesic management.44 This potentially allows for the patient to be transferred to an intermediate care unit within the first three hours. It has been shown that this protocol, used in 421 consecutive patients, allowed patients to be extubated significantly earlier and led to a significantly shorter length of stay in the intermediate care unit and the hospital compared with standard ICU fast-track management.44 A well-functioning fast-track protocol not only leads to faster recovery of routine cardiac surgery patients, but also allows ICU resources to be concentrated on the increasing number of critically ill patients.

Post-operative Cardiac Medication

Despite improvements in post-operative stabilisation of patients on cardiac medication, the SYNTEX trial revealed significant differences between PCI and CABG patients regarding the use of cardioprotective drugs at one year in favour of PCI patients. This had to be addressed by the surgeons to optimise long-term surgical outcome.3

Although not well supported by large randomised studies, there is a wide consensus that CABG patients should receive lifetime acetylsalicylic acid (ASA) medication to prevent early and long-term graft failure.59 Recently published data also support an additional intravenous ASA bolus application (300–500mg) a few hours (six to eight hours) after CABG surgery to prevent ASA resistance during the post-operative phase.60 The additional protective value of clopidogrel in routine CABG patients is as yet unclear; however, a recently published randomised single-centre study revealed a significant benefit of DAPT on the venous bypass graft patency rate after three months compared with ASA alone.61

In patients with previous stent implantation, the post-operative antiplatelet regime has to follow the recommendation for patients who have undergone PCI; this is of utmost importance in patients with functioning drug-eluting stents.3 Whether surgical patients with ACS should also be managed with DAPT in a similar way to PCI patients needs to be evaluated in the future. Other long-term medical therapies with class I recommendation after CABG, unless contraindicated, include:

- angiotensin-converting enzyme (ACE) inhibitors for patients with a left ventricular ejection fraction under 40% and in those with arterial hypertension, diabetes or chronic kidney disease. Angiotensin receptor blockers should be used as an alternative in patients who are intolerant of ACE inhibitors;
- beta-blockers in all patients after myocardial infarction, ACS or left ventricular dysfunction; and
- lipid-lowering drugs in a high dose are indicated in all patients regardless of lipid levels.

Conclusions

There is clear evidence that CABG remains the revascularisation strategy of choice in patients with three-vessel coronary artery disease including left main stenosis. Further analyses are required to understand suboptimal surgical results in less complex left main disease; these analyses should include measurements of competitive flow phenomena and coronary flow reserve.

Arterial bypass grafting should be used liberally on an individual basis considering the patient’s age, risk profile and coronary artery pathology and there is growing evidence in favour of OPCAB in high-risk patients.


