PJCTS 2007;VI:343-346

# CONDUITS FOR MYOCARDIAL REVASCULARIZATION... WHAT CHOICE DO WE HAVE

*Arif ur Rehman Tariq Siddiqi Nadeem Ahmad Muhammad Musharraf*

The first clinical procedure of surgical revascularization of the ischemic myocardium using conduits to bypass coronary artery narrowing or obstruction was performed in 1964 and the saphenous vein graft (VG) was shown to be patent 9 years later[1]. Since then, numerous attempts have been applied to improved the quality and results of CABG in terms of patient long-term morbidity and mortality, and undisputedly these advances have been also related to the type and use of various conduits.

The advent of arterial grafts for CABG, particularly to revascularize the territory of the anterior descending coronary artery, have led to substantial improvements in postoperative outcome and still represents the gold standard in the treatment of myocardial ischemia regardless of the well known advances in percutaneous interventions. Nonetheless, despite more than four decades of surgical revascularisation, many shortcomings related to the biological properties and response to coronary implantation of conduits are still present and evident. Careful evaluation of the appropriate surgical strategy in terms of type and configuration of grafts is therefore crucial, since this has shown to be in direct relation to patency and freedom from events, related to the return of myocardial ischemia. Several issues relating to survival of CABG conduits have been surprisingly poorly considered, and, it is becoming more and more apparent that the information from the results of experimental or clinical research should provide a basis in the search of the optimal conduit for effective and durable myocardial revascularization.

## INTERNAL THORACIC ARTERY... THE STRENGTH OF SCIENTIFIC EVIDENCE

The efficacy and durability of the internal thoracic artery (ITA) to perfuse the anterior descending coronary artery territory is well documented amidst a load of scientific evidence that has been published and available in the literature. Debate, on the contrary, still persists about the actual and real benefit of the use of double ITAs to do the same. Recently, the Cleveland Clinic group have shown that two mammary arteries are better than one[2], with improved morbidity and mortality at long term. In this era of conflict between surgical and percutaneous revascularization, the use of bilateral ITAs appears to be the effective treatment to solve and prevent myocardial ischemia. Nonetheless, the cardiac surgical community is still looking for additional evidences to conclusively elucidate the actual role of bilateral internal thoracic artery (BITA) versus single ITA.

Although single ITA has unanimously achieved the position of first choice conduit, its application and suitability in the presence of acute myocardial infarction or refractory ischemia and impending infarction remains questionable. This topic has received marginal attention, perhaps due to the substantial decline in the prevalence of emergency surgical revascularization during acute ischemic episodes.

The patency rate of vein grafts on the anterior descending coronary artery is certainly inferior to the ITA, nonetheless, as surgeons, we must think of related advantages in terms of left ventricular or mitral valve function, aiming, therefore, not only towards patient survival, but also to the quality of salvaged myocardium. Several centers advocate the institution of cardio-circulatory support while harvesting the ITA, but, although ITA take-down may take only a few minutes and, therefore, comparable to vein graft harvesting, it appears that vein grafting may still have its place in this peculiar setting.

## VENOUS GRAFTS... TIME TO ABANDON, OR RECONSIDER THEM!

Venous conduits are still routinely used in the majority of CABG procedures worldwide, although total arterial revascularization is

* *Address for correspondence:*
*National Institute of Cardiovascular Diseases*
*Karachi.*

steadily increasing. The well known limiting factors of VGs is the so called postoperative vein graft failure or disease[3], implying variable incidence of early and long-term VG dysfunction, often requiring percutaneous interventions, or new surgery. As a matter of fact, despite the extensive experience with this type of conduit, very little has been done during the past decades to enhance the knowledge and behaviour of VGs in the arterial circulation, or to optimize its evaluation and application. Indeed, it is rather common to implant VGs without having any insight or information on preoperative structure or function.

VGs, as all other components of the circulatory system, may undergo adaptive changes in relation to altered circulatory, organic, or metabolic conditions. It has already been shown that Diabetes mellitus may profoundly influence the functional and structural properties of VGs, with some cases of intra-luminal plaques prior to coronary implantation[4]. Endothelial-dependent reactivity, mainly vasodilation, has also been shown to be impaired in the presence of organic (chronic renal failure) or metabolic (diabetes mellitus) diseases. This information highlights the importance of proper preoperative assessment of conduit quality. In this way, some adverse results, either early, or long-term, deriving from poor preoperative conditions which might have benefited, had more accurate information been available, may be avoided by modifying surgical strategy (use of different VG segments or alternative conduits).

Based on the poor consideration given to the preoperative status, compromised intra-operative harvesting techniques, and postoperative factors potentially interfering with biological graft integrity, we can only be surprised, and certainly not disappointed, by the high patency rate, at long term, achieved with saphenous vein grafts. This only goes to prove that a more careful, balanced and proper approach towards vein grafts could lead to a modified management which would improve the standard of vein grafting, and, would pave the way towards achieving improved and better postoperative results.

## THE RADIAL ARTERY... IS IT FINALLY WIDELY ACCEPTED ?

The radial artery was firstly introduced as an alternative conduit in 1973 by Carpentier and collaborators, and soon after abandoned, due to evidence of peri-operative spasm or neo-intimal formation. Improvement in harvesting techniques and pharmacological control of its vasoconstrictive behavior has led to a widespread use of this arterial conduit, particularly because of the advantage of using this graft to construct Y or T conduits for off or on-pump total arterial revascularization. Recent randomized trials comparing radial artery versus vein grafts have shown an advantage of the arterial conduit and, hence, scientific evidence supports a wider application of the radial artery as a graft of third choice, after bilateral internal thoracic arteries. Nonetheless, it has become also clear that we cannot expect, as repetitively shown by several studies, the same postoperative patency rate of the radial artery as the mammary artery. Indeed, structural and functional differences in the radial artery have been shown by Mekontso-Dessap and collaborators who documented increased proliferative properties of the radial-derived smooth muscle cells[5] in vitro., which may lead to higher predisposition towards neointima formation and luminal narrowing and occlusion.

## ALTERNATIVE CONDUITS

The use of several other conduits have been variably proposed. As an arterial conduit, the gastro-epiploic artery, usually anastomosed to the right coronary-related vasculature, represents the most common alternative. However, several reports have questioned the long-term patency rate of this vessel, leading to some skepticism in relation to the actual benefits as compared to more easily procurable VGs.

Additional arterial grafts include the inferior epigastric artery, the descending branch of the lateral femoral circumflex artery, the posterior tibial artery, the thoracodorsal artery and the lateral costal arteries, but conclusive beneficial evidence in CABG procedures for all of them is seriously lacking.

As far as veins are concerned, CABG surgery using the cephalic vein or with cryopreserved vein conduits has been reported, but the overall results have been grossly disappointing. The use of cryopreserved internal thoracic artery has been also proposed. The possibility of using artificial or heterologous conduits has been also investigated with conflicting results. PTFE conduits have shown to be patent at more than 9 years[6], but other clini-

cal experiences registered dismal outcome with early occlusion and, therefore, substantial research and work is still required. Recently, stem cells seeding of artificial grafts have been investigated with promising results.

## CABG CONDUIT HARVESTING... TO SKELETONIZE OR NOT?

MINIMALLY INVASIVE TECHNIQUE OR NOT ?

Graft damage due to harvesting techniques has been markedly highlighted. Endothelial damage with sub-intimal tissue exposure and subsequent predisposition to platelet adhesion, reduced endothelial--dependent vasodilation, enhanced smooth muscle cell migration towards the intimal layers, are all hallmarks of intra-operative phenomena related to undue graft preparation. The reluctance to use techniques which imply greater conduit management is therefore understandable, like skeletonizing ITA, although functional and practical benefit has been reported. It seems advisable to advocate a skeletonizing technique if complete arterial revascularization particularly with T or Y graft configuration, or off-pump procedure is desired, since the skeletonised conduit undoubtedly offers an increased length, better vascular approach for conduit-to-conduit anastomosis, and an increased final flow. Additional advantages, although not yet conclusive, include better preserved sternal vascularity leading to reduced incidence of dehiscence or infection. However, further data, possibly with prospective and randomized trials, to definitely elucidate the effects of this harvesting procedure in terms of functional properties, the loss of innervation, vasa vasorum perfusion and, ultimately on postoperative patency rate[7] is warranted.

As regards endoscopic graft harvesting, this technique appear safe and accounts for reduced incidence of postoperative pain, infection, and quicker recovery of full limb function.

## THE CHOICE OF CABG CONFIGURATION... SINGLE OR JUMP GRAFTS, Y OR T GRAFTS?

Only a few studies have addressed the issue of which conduit configuration, single or composite, may provide the best results in terms of flow and long-term efficacy. Maniar and collaborators have shown that composite grafts to the right coronary system provide significantly worse patency than direct grafting[8]. Some concerns towards which coronary system is revascularised, have also been raised in the capability of composite graft to match the increased demand of myocardial perfusion, with respect to in-situ conduits[9]. Lemma and colleagues showed that a Y-graft configuration with the radial artery provides the same angiographic results as compared to the aorto-coronary configuration in terms of cardiac-related events.[10]

No definitive data is available in relation to the actual difference in using the right ITA or radial artery for composite grafts. It appears, therefore, advisable to design robust prospective and randomized studies to elucidate this important aspect of CABG.

As far as single or jump grafts are concerned, it seems that multiple anastomoses with one graft may achieve a better postoperative patency rate, provided that the distal anastomosis is carried out on a relatively large vessel[11]. Even in this setting, little and dated information is available, and further investigation, particularly in the new approach of extended arterial revascularization, is warranted.

## NATIVE CORONARY FLOW AND THE CHOICE OF THE CONDUIT

It is rather clear and apparent that postoperative conduit patency is directly related to the extent of native coronary artery stenosis. Several studies have shown that the application of the radial artery, in a vessel with stenosis of less than 70% is followed by an increased incidence of graft dysfunction. In the presence of competitive flow, for instance, in left main stem stenosis of less than 70%, the use of radial artery to revascularise the lateral territory may be questionable. A graft with a larger flow, like a VG, or a second ITA may provide a better functional and structural adaptation in relation to the native coronary artery flow condition.

The right coronary system represents a world of its own. Indeed, several authors have shown that the use of arterial free grafts, composite grafts, or radial artery conduit to the right coronary do not provide any additional advantage if compared to the saphenous vein. Indeed, Sabick and colleagues have recently shown that the postoperative patency rate with saphenous vein graft was equivalent or better than that obtained with ITA. At 10 years,

however, patency rate with ITA was better with a stenosis of 70% or more.[12]

## CONCLUSIONS

Despite favourable and well standardised results of CABG, postoperative graft failure still remains a major embarrassment. A more thorough knowledge of the biological properties and functional and structural adaptation of implanted grafts is imperative. The following issues, if resolved or better elucidated, might provide critical contribution towards a better postoperative result.

- Appropriate appraisal of preoperative quality of CABG conduits (particularly of vein grafts).
- The coronary system and the degree of stenosis of native coronary artery deserves careful attention in the choice of type and graft configuration.
- Appropriate postoperative management and aggressive treatment of concomitant diseases (particularly diabetes mellitus) in the postoperative period.
- Tailored pharmacological therapy to improve graft response or counteract pre and postoperative graft mal-adaptation (reduction of nitric oxide synthase and release, intimal proliferation etc).
- Intra-operative monitoring of conduit flow.
- Better understanding of graft response to harvesting or manipulation techniques.
- Improvement of postoperative anti-platelet regimen or therapy to modulate functional and structural graft adaptation.
- Adaptation of surgical strategies to patient-related factors (co-morbidities like diabetes, gender, and other anatomical factors).
- Elucidation of the effects of graft configuration on long-term patency and flow demand.

Each patient is a different individual. The nature of disease in his coronary arteries and risk factors should dictate which approach and what conduit should be chosen for a particular patient. The choice of a conduit and not a conduit of choice should dictate the way forward towards surgical strategy!

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