

EDITORIAL

The Role of Arterial Grafts in Coronary Artery Bypass Grafting: An Update

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ABSTRACT

Based on the legacy of the success of the internal thoracic artery as a bypass conduit for myocardial revascularization, the effort to achieve total arterial revascularization continued to evolve in the last 2 decades. Arterial conduits were used as alternatives to saphenous vein for coronary artery bypass grafting. In this review we attempted to assess the success and failure of these conduits and the current trend in myocardial revascularization.

INTRODUCTION

Since Loop published his landmark paper in 1986 [Loop 1986], which demonstrated the superiority of left internal thoracic artery (LITA) over saphenous vein (SV) in terms of survival and freedom from cardiac events, the use of ITA expanded. Based on the hope that other arterial conduits will achieve the success of ITA, the search began for alternative arterial grafts to accomplish total arterial revascularization. The use of the right gastroepiploic artery (RGEA) and inferior epigastric artery (IEA) started in the second half of the 1980s, and the revival of radial artery (RA) use began in the early 1990s. The expectation was that all arterial grafts would prove to have similar histological and biological characteristics and would provide results similar to LITA. In vitro studies showed that arterial grafts have different histological and biological properties [He 1995]. Although these conduits showed greater patency compared with SV, they failed to demonstrate better patient survival or freedom from cardiac events. Currently, SV is the most commonly used graft after LITA. The choice of the second graft after LITA has been largely based on personal preference and experience in various hospitals.

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This review was undertaken to evaluate the current patency rate for each graft and the effect on patient outcome of factors related to patterns of grafting. This evaluation might help to answer the important clinical question of how to select conduits for coronary bypass grafting.

HISTOLOGICAL AND BIOLOGICAL CHARACTERISTICS OF ARTERIAL GRAFTS

There is enough evidence from in vitro human and animal studies to demonstrate that arteries have more favorable histological and biological characteristics than veins as conduits for coronary artery bypass grafts (CABG) [Luscher 1988]. However, arterial grafts still vary among themselves. Histologically, the ITA is an elastic artery with 9 to 12 elastic lamellae and few smooth muscle cells dispersed between these lamellae, whereas the radial artery (RA), right gastroepiploic artery (RGEA), and inferior epigastric artery (IEA) are muscular arteries with more smooth muscle cells limited by only internal and external elastic lamellae. The comparative thickness of the combined intima and media in these arteries is as follows: RA > ITA > RGEA > IEA [van Son 1990]. Biologically, there is evidence of very little difference between arterial grafts in terms of the amount of nitric oxide produced or the vasodilatation function; however, RA and RGEA seem to have higher vasoconstrictive responses, possibly due to their muscular nature.

INTERNAL THORACIC ARTERY

Studies have shown that LITA-to-left anterior descending (LAD) grafts have superior long-term patency and survival benefits compared with other grafts implanted to targets other than LAD. Buxton et al [Tatoulis 2004] have investigated the role of the right ITA (RITA) as a second or an alternative graft to LITA. They have shown that RITA to LAD has the same patency as LITA to LAD, and that both pedicled and free RITA to right coronary artery (RCA)/posterior descending artery (PDA) have lower patency compared with pedicled or free RITA to LAD. These investiga-

tors have also shown that LITA to circumflex territory (CxOM) is associated with lower patency than LITA to LAD. They speculated that this finding could be the result of technical difficulty due to stretching of the graft to reach the target or due to smaller target with less than optimal runoff. These data show that the patency of the graft depends to a large extent on the target where the graft is implanted. The patency of LITA to LAD is 96% to 98% at 5 years, 95% to 96% at 10 years, and 88% at 15 years, and the patency of RITA to all coronaries (collective) is 75% to 96%, 81%, and 65%, respectively.

Although histologically and biologically LITA and RITA are similar, some studies failed to show survival benefit of using bilateral ITA (BITA) over single ITA (SITA). This finding may be related to the technical difficulties associated with using RITA, ie, stretching it or using it as free graft to reach the target, or due to a suboptimal target as mentioned above. However, other studies showed the survival benefits of BITA compared with SITA and the need for redo surgery [Taggart 2001]. Nevertheless, there are contradicting evidences in using BITA in high-risk groups, and in general, surgeons try to avoid using BITA in diabetic, elderly, and obese patients.

RADIAL ARTERY

After the revival of RA as a conduit for CABG by Acar in the early 1990s, the use of this conduit has expanded in the last decade. Now, most surgeons consider RA to be the second-best conduit after LITA. This popularity was gained because of the versatility of this conduit (good length, good diameter, and easiness to graft), and its performance was improved after employing better harvesting technique and the use of calcium-channel blockers perioperatively.

Because RA is more muscular than ITA, it has (in vitro) a stronger vasoconstrictive response than ITA. There are a few reports in the literature focusing on postoperative vasospasm of all arterial grafts. Most surgeons routinely use postoperative calcium-channel blockers for all patients who have had an RA graft, because they believe that RA is more prone to spasm due to its muscular nature. Knowledge is still lacking of how vasospasm develops, and the correlation between vasospasm and vessel reactivity to vasoconstrictors is not clear. Continued therapy with calcium-channel blockers after the first year does not influence the midterm angiographic status of RA grafts [Possati 1998]. The vasodilative response (in vitro) of RA is greater than that of ITA possibly because the RA produces more nitric oxide or its receptors are more sensitive to nitric oxide [Drexler 1999]. We believe that the recent better patency result of RA is not completely attributable to the use of calcium-channel blockers but is due to less invasive harvesting technique and better target choice.

The patency rate of RA at 5 years ranges between 83% and 95%. The 10-year patency rate will be determined in the next few years. Serial angiographic studies carried out in patients who had undergone RA showed that at 5 years follow-up most of the early partial irregularities disappeared, a finding that is in agreement with the initial observation of Carpentier and Acar more than a decade ago [Acar 1993]. These findings could be explained by the decreased vasocon-

strictive response (in vivo) of RA at 5 years follow-up compared with the immediate postoperative response. As is the case with other arterial grafts, it has taken some time for surgeons to adopt RA as an alternative to SV in routine CABG. This hesitancy is related to concerns regarding injury during harvesting, postoperative spasm, and competitive flow.

RIGHT GASTROEPIPLOIC ARTERY

The use of RGEA in CABG was first described by Suma in 1987. Since that time the experience with this graft has been quite extensive in some centers, especially in Japan, while others have avoided using it. This avoidance probably relates in part to the increased time required to harvest and the reluctance of some surgeons to enter the abdomen, because of reported complications such as hiatus hernia and perforation of the stomach. The unpredictable size of the RGEA and the limited number of targets in which this conduit can reach have also limited the use of this graft. This conduit is usually used with BITA and implanted to the RCA/PDA to achieve total arterial revascularization. The 5-year patency rate for RGEA ranges between 80% and 97%. The vasoconstrictive response of RGEA is more prominent than other arteries. Although there is a fear of vasospasm and decrease of flow through the graft after sympathetic activation, data presented at the 10th annual CTT meeting should alleviate these fears [Ryu 2004].

INFERIOR EPIGASTRIC ARTERY

The use of the IEA as a conduit for CABG was pioneered in 1987 by Puig. However, a relatively small number of series have been published since then. In vitro studies have shown that this conduit shares many similar histological and biological characteristics with ITA, which makes it an ideal conduit for CABG, second to ITA. However, the experience with IEA is limited compared with RA and RGEA. This could be due to the shorter length of this conduit and the occasional complications associated with harvesting, such as rectus sheath hematoma and abdominal wall necrosis. The 2-year patency rate is as low as 52.2% to 86%. However, others claim that the patency rate of this graft may remain stable beyond 1 year, which could suggest a good durability in the future [Buche 1995]. The 5- and 10-year patency rates have not been published for this graft, but could indicate unsatisfactory outcome.

SKELETONIZATION OF ARTERIAL GRAFTS

The most serious objection to the use of BITA has been an increased risk of wound complications. Advocates of skeletonized ITA (SKT-ITA) postulate that this technique reduces sternal devascularization and wound healing problems and may potentially increase the number of arterial anastomoses per patient by increasing the length of the ITA. In a recent systematic review we presented the current evidence from studies demonstrating significantly lower sternal vascularity in patients and animals undergoing harvesting of pedicled conduits compared to skeletonized conduits. We pointed out

that skeletonization is associated with fewer postoperative sternal wound complications, and it has similar levels of patency compared with pedicled grafts [Athanasios 2004]. It should be noted that there is only one study, by Sauvage et al [2003], which shows patency rates of 85% to 87% for SKT-ITA. The mean follow-up for this study was 7.4 years in a cohort of 125 patients undergoing exclusive ITA grafting, with an impressive average of 3.9 grafts per patient without excluding high-risk patients (diabetic, obese). In this study freedom from reintervention was 90.8 % at a mean of 9.8 years.

Potential advantages of SKT-ITA are the increased length and diameter of the available conduit. Skeletonization of the RITA graft allows it to reach distant target vessels such as the distal LAD in cross-arrangement and the branches of the RCA, enabling complex and complete arterial revascularization. An important disadvantage of skeletonization is that it comprises a technically demanding surgical technique, which may be time-consuming and necessitate retraining.

Recent studies show that composite grafting with the skeletonized RGEA and RA ensure sufficient diameter and length for myocardial revascularization on inferior, posterolateral, and lateral ventricular walls and can be used safely and effectively even in off-pump CAB surgery with excellent early clinical and angiographic outcome in selected patients [Kamiya 2004]. It is important to mention that follow-up periods have not been long enough to draw definitive conclusions.

Skeletonization of the ITA or RA with the ultrasonic scalpel is safe and contributes to reducing the incidence of early graft stenosis of the RA graft. A randomized study showed that RA has better early results than the RGEA, and the use of the LITA as inflow graft does not influence good RA patency [Higami 2001]. In the same study the use of the RGEA as a composite graft was not associated with satisfactory results.

Long-term follow-up with objective investigation and randomized design are required to confirm better results of composite grafting and the potential advantages of skeletonization of the arterial conduits.

THE CHOICE OF CONDUIT

There is insufficient long-term data to draw any meaningful conclusions as to whether survival is improved by the use of more arterial grafts in addition to ITA. This lack of data is not necessarily due to the inferior histological and biological characteristics of other arterial grafts compared with ITA, but because of many other limitations. These limitations include the following: first, the lack of randomized trials to answer these questions, because of the inherent difficulties in setting up these trials, and second, the great variability in the presence of predictors of survival. Observational studies have inadequate numbers of patients who have been followed for more than 10 years, especially for RA grafts. A final limitation is the suboptimal use of the second or third arterial grafts in these studies, because they have been used mainly to graft the right side of the heart rather than the left, which is associated with improved survival [Buxton 1998], and if they are grafted to the left, the grafted recipient vessels were most likely to be a secondary vessels like diagonals.

There is enough evidence to show that the use of other arterial grafts, especially RA, is associated with better patency than SV, without much of an increase in patient morbidity. The UK National Adult Cardiac Surgical Database Report 2000-2001 indicates that the second half of the 1990s saw a slow but steady increase in the number of patients undergoing total arterial revascularization, with one fifth of all patients receiving 2 or more arterial grafts. This rate is high by international standards.

LITA to LAD should be used in every patient; if not, LITA to another left system main artery should be used. Only a few conditions, such as chest wall deformity or subclavian stenosis, justify denying the patient a LITA graft. Some surgeons even advocate that LITA should not be denied to urgent patients. There is limited experience with BITA in high-risk groups such as diabetic, elderly, and obese patients. Skeletonization can potentially have a role in expanding the use of BITA in these groups of patients.

RA should not be grafted to a CA target with stenosis less than 70%, because RA is usually grafted to RCA/PDA, which is known for its disease progression, and RA has a larger diameter than LAD, which means that 70% RCA/PDA could have a more competitive flow than 50% LAD. Therefore RA should be grafted to a left-system artery such as the Cx artery. We, like others [Donatelli 1998], believe that the IEA should be used only if there is no other conduit such as ITA, RA, RGEA, or SV available.

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