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Cardiac Surgery

Coronary Revascularization: Choice of Conduit and Comparison of Graft Patency in CABG

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Review Article

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Abstract: Coronary Artery Bypass Grafting (CABG) remains a critical treatment for coronary artery disease (CAD), with the choice of conduit playing a significant role in determining long-term outcomes. This review explores the comparative efficacy of various graft conduits used in CABG, focusing on the Internal Thoracic Artery (ITA), Radial Artery (RA), Saphenous Vein Grafts (SVG), and Gastroepiploic Artery (GEA). Its aims to provide insights into the optimal conduit strategy for improving long-term revascularization success. The Left Internal Thoracic Artery (LITA) is considered the gold standard for coronary grafting, especially for Left Anterior Descending (LAD) artery grafting. Studies consistently report LITA grafts with 10-year patency rates exceeding 90%, far superior to SVGs, which often show patency rates below 50%. The Right Internal Thoracic Artery (RITA), although beneficial, has lower patency rates when used for Right Coronary Artery (RCA) grafting due to anatomical and technical challenges. This review critically evaluates conduit options for CABG, focusing on the comparative patency rates and clinical outcomes of grafts during the decade from 2007 to 2017. The Radial Artery (RA) is frequently used as a secondary arterial conduit, particularly for RCA grafting. While RA grafts show better long-term patency than SVGs, their use is limited by factors such as spasm and smaller vessel caliber. Bilateral Internal Thoracic Artery (BITA) grafting offers improved graft patency and survival, although it carries a higher risk of early complications like sternal wound infections. Arterial conduits, including the ITA and RA, are preferred in diabetic patients due to their superior resistance to atherosclerosis and long-term patency. Harvesting techniques, such as skeletonized grafting, further enhance graft patency. In conclusion, LITA remains the conduit of choice for LAD grafting, while RA and BITA offer valuable alternatives depending on patient-specific factors. Arterial conduits outperform venous grafts in terms of patency and clinical outcomes, reinforcing their importance in CABG.

Keywords: Coronary Artery Bypass Grafting (CABG), Internal Thoracic Artery (ITA), Left Internal Thoracic Artery (LITA), Radial Artery (RA), Saphenous Vein Grafts (SVG), Gastroepiploic Artery (GEA).

INTRODUCTION

Coronary artery disease (CAD) remains a significant contributor to global morbidity and mortality, accounting for a considerable healthcare burden[1,2]. Coronary artery bypass grafting (CABG), a well-established surgical intervention for CAD, provides durable symptom relief and survival benefits, especially in patients with multi-vessel disease or left main coronary artery stenosis[3,4]. A pivotal determinant of the long-term success of CABG is the choice of graft conduit, which influences graft patency, revascularization outcomes, and overall survival[5].

The left internal mammary artery (LIMA) is widely regarded as the gold standard conduit for revascularizing the left anterior descending artery (LAD) due to its superior patency and resistance to atherosclerosis[6,7]. However, for revascularization of other coronary territories, the radial artery (RA), right internal mammary artery (RIMA), saphenous vein grafts (SVG), and the right gastroepiploic artery (GEA) are viable alternatives, each with specific advantages and limitations[8,9].

Arterial conduits have shown a distinct survival advantage over venous grafts due to their higher long-term patency rates. The use of multiple arterial grafts has gained increasing attention, particularly in younger and high-risk patients, due to evidence suggesting improved outcomes compared to venous grafts[10]. Despite these advancements, challenges persist in conduit selection, particularly in patients with diabetes mellitus, chronic kidney disease, or other comorbid conditions that increase the risk of graft failure or surgical complications[11].

This review critically evaluates conduit options for CABG, focusing on the comparative patency rates and clinical outcomes of grafts during the decade from 2007 to 2017. It aims to provide insights into the optimal conduit strategy for improving long-term revascularization success.

I. CONDUIT OPTIONS IN CABG

Coronary artery bypass grafting (CABG) is a cornerstone surgical intervention for patients with coronary artery disease (CAD). The selection of conduits is critical in determining long-term outcomes, including graft patency, survival rates, and quality of life. Commonly used conduits include the internal thoracic artery (ITA), radial artery (RA), saphenous vein (SV), and gastroepiploic artery (GEA), each with specific advantages and challenges.

Internal Thoracic Artery (ITA)

Left Internal Thoracic Artery (LITA):

The LITA is considered the gold standard for coronary revascularization, particularly for grafting the left anterior descending (LAD) artery. A seminal study by Loop et al. demonstrated the long-term survival benefits of LITA grafting, reporting significantly improved 10-year survival rates compared to saphenous vein grafts (SVGs)[12]. Subsequent research has reinforced the durability of LITA, with 10-year patency rates exceeding 90%, positioning it as a cornerstone in arterial revascularization strategies[13].

Advantages of LITA:

- Superior long-term patency rates.
- Resistance to atherosclerosis and intimal hyperplasia.
- Robust survival benefits, particularly for LAD grafting.

Challenges with LITA:

While LITA offers excellent outcomes, its use may be limited in patients with prior thoracic surgeries or mediastinal infections.

Right Internal Thoracic Artery (RITA):

The RITA is another viable option for CABG, especially in cases requiring multi-vessel revascularization. While slightly inferior to LITA in patency, its use has expanded due to growing evidence supporting its benefits in bilateral ITA grafting. Studies indicate that RITA grafting improves outcomes in non-LAD territories, such as the right coronary artery (RCA)[14]. A meta-analysis revealed that the combination of LITA and RITA provides superior results compared to single arterial grafting[15].

Insights on RITA:

Effective for expanding arterial revascularization. Promising results in younger patient populations requiring durable grafts.

Radial Artery (RA)

The RA has gained prominence as an arterial conduit, particularly in patients unsuitable for multiple ITA grafts. Its patency rates surpass those of venous conduits, with evidence suggesting approximately 80% patency at 10 years[16]. The RA is especially advantageous in diabetic patients and for non-LAD target vessels. However, the risk of vasospasm necessitates the use of vasodilators during and after surgery[17].

Advantages of RA:

- Superior patency compared to SVGs.
- Reduced risk of atherosclerotic progression.

Challenges of RA:

- Increased risk of spasm.
- Requires expertise for harvesting and post-operative management.

Saphenous Vein (SV)

Despite being one of the most widely used conduits, SVGs exhibit lower long-term patency compared to arterial grafts. Studies report a 10-year patency rate of approximately 50% for SVGs, with failure often attributed to intimal hyperplasia and graft thrombosis[18]. Nevertheless, SVGs remain indispensable in patients with complex anatomy or limited arterial graft options[19].

Key Features of SVGs:

- Widely available and versatile.
- Essential in high-risk or multi-vessel revascularization cases.

Limitations of SVGs:

- High susceptibility to graft occlusion.
- Requires meticulous post-operative pharmacotherapy.

Gastroepiploic Artery (GEA)

The GEA is a less frequently used arterial conduit but has demonstrated acceptable outcomes in specific scenarios. It is particularly effective for RCA grafting and in patients requiring multiple arterial conduits. Studies have shown that the GEA, when used alongside ITA, offers superior patency compared to SVGs for certain territories[20].

Advantages of GEA:

- An alternative for multi-arterial grafting strategies.
- Improved patency compared to venous conduits.

Challenges of GEA:

- Technically demanding harvesting process.
- Limited anatomical accessibility and variability.

II. COMPARISON OF CONDUIT PATENCY:

LIMA: The best conduit for LAD?

The survival benefits associated with the use of the LIMA to the LAD coronary artery were established in a landmark paper named "influence of the internai-Mammary-Artery Graft on 10-Year Survival and Other Cardiac Events "from the Cleveland Clinic in 1986 by Dr Floyd D. Loop and his team.They compared patients who received an IMA graft to the LAD alone or combined with one or more SVG (n = 2306) with patients who had only SVG grafts (n = 3625) .The 10-year survival rate among the group receiving IMA graft, as compared with the group who received the venous grafts (exclusive of hospital deaths), was 93.4 percent versus 88.0 percent (P = 0.05) for those with one-vessel disease; 90.0 percent versus 79.5 percent (P < 0.0001) for those with two-vessel disease; and 82.6 percent versus 71.0 percent (P < 0.0001) for those with three-vessel disease.After an adjustment for demographic and clinical differences by Cox multivariate analysis, they found that patients who had only vein grafts had 1.6 times greater risk of death throughout the 10 years,1.4 times incidence of late MI,1.25 times of hospitalization for cardiac events and 2 times incidence of cardiac reoperation as compared with those who received an internal-mammary-artery graft.So, the study recommended that Internal- mammary-artery grafting for lesions of the anterior descending coronary artery is preferable whenever indicated and technically feasible[21,22,23,24,25,26]. Lopes et al. reported substantially inferior patency rates with saphenous vein grafts (SVG), of which approximately 75% are occluded or significantly diseased at 10 years. Single IMA graft has a 10 year rate of angiographic patency exceeding 90%, as compared with 50% for venous graft[27,28,29,30]. The highest patency rates have been documented when the IMA (either in situ or as a Y or free graft) is placed to the left- sided coronary vessels. Inferior rates have been documented when the IMA is placed to the right coronary artery probably due to size discrepancy,progression of disease at the crux or lower amount of viable myocardium[31,32,33].

In search of a second conduit: Arterial or venous?

Robust evidence suggests that the use of an artery, rather than a vein, to graft to the second target vessel is associated with survival advantage.(Ref Multiple Arterial Grafts improve Late Survival of Platierits Undergoing Coronary Artery Bypass Graft Surgery Analysis of 8622 Patients With Multivessel Disease, 2012).The benefits of a second arterial graft apply also to high-risk patients, such as those with reduced ventricular function or unstable angina[34,35,36,37,38].

Bilateral or Single IMA Grafting, Which one is best?

Sample was divided into two groups.Group A received a single IMA graft to the LAD plus supplemental vein or radial-artery grafts to other coronary arteries.Group B received both left and right IMA grafts to the two most important coronary arteries on the left side with supplemental vein or radial- artery grafts to other coronary arteries. Anastomosis of an IMA graft to the RCA was not permitted because of concerns about inferior long term patency.In this 5-year analysis, there were no significant differences between the two groups in all causes like mortality and in the composite rate of death from any cause, Ml, or stroke.Moreover BIMA grafting was associated with significantly higher rates of early stenal wound complications[39,40,41,42,43].

Controversial findings compared to this RCT, a meta-analysis comparing bilateral internal mammary artery with left internal mammary artery for coronary artery bypass grafting published in 2013 has demonstrate an increase in long-term survival in patients receiving BIMA as a primary grafting strategy over those receiving a LIMA. Limitations of the study is no randomized controlled trials were included in this meta-analysis. So their recommendation was until the long-term results of the RC trial are published, they offer best available evidence in favor of BIMA over LIMA for CABG[44,45,46,47]. A post hoc analysis of the trial data suggested that more careful dissection of the internal thoracic artery (the skeletonized technique) was associated with a lower risk of stemal wound complications regardless of whether single or bilateral internal thoracic-artery grafts were used[48,49].

RA vs. RIMA grafting

A Very few studies available. Only 1 RCT compared the RA and the RITA. the RAPCO (Radial Artery Patency and Clinical Outcomes, 2013) trial found no difference in the patency of the 2 conduits and a non-significant tendency to better event-free survival for the RA at the 6-year follow-up. Compared with the RITA, the RA seems a better choice cause - safer for patients at risk for post-operative stemal complications (diabetes, obesity, chronic pulmonary disease).Harvesting of the RA is extremely safe and well tolerated does not affect surrounding vascularization and healing[50,51]. A recent sub study of the RAPS (Radial Artery Patency Study, 2014) focusing only on diabetic patients reported a very strong protective effect against graft occlusion with use of the RA, making the use of this conduit in diabetics particularly attractive[52]. Another study comparing sternal complications with RA or RITA - reported clear clinical benefits with use of the RA, in high risk patients like DM[53].

GEA vs RA and GEA vs RIMA

A recent network meta-analysis of RCT comparing all conduits used in coronary surgery has found the GEA to be associated with the highest risk of functional and complete graft occlusion making GEA less popular through out the world[54,55,56]. Two recent series reported that use of the GEA instead of the SV, to graft the RCA in patients having BITA to the left coronary system leads to a significant increase in late survival (Ref skeletonized gastroepiploic anery is superior to saphenous vein in patients with bilateral internal thoracic arterial grafts, 2011).However, other studies have not confirmed this finding. Very few evidence is available regarding he comparison between GEA & RA as well as between GEA & RIMA[57,58].

CONCLUSION

In summary, arterial conduits, particularly the LIMA, are the preferred choice for CABG due to their superior long-term patency and survival benefits. The use of additional arterial conduits, such as the RA and GEA, further improves outcomes, especially in patients with multivessel disease. While bilateral ITA grafting offers improved survival rates, careful patient selection and surgical techniques are necessary to minimize complications. The use of venous grafts, although still common, is associated with inferior long-term patency and should be reserved for cases where arterial grafting is not feasible.

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