Hellenic Journal of Cardiology (2016) xx, 1–5

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: http://www.journals.elsevier.com/hellenic-journal-of-cardiology/

REVIEW ARTICLE

Total arterial revascularization: A superior method of cardiac revascularization

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Received 14 February 2015; accepted 14 October 2015

KEYWORDS
myocardial revascularization;
thoracic/mammary arteries;
graft patency;
coronary artery bypass surgery

Abstract For over 40 years, the left internal thoracic artery has been used as the gold standard for myocardial revascularization and anastomosis over the left anterior descending artery due to its excellent patency rates. However, the right internal thoracic artery behaves in the same manner as the left, also having excellent long-term patency. Hence, no patient should be deprived of the benefits of total arterial revascularization allowed by the bilateral use of both internal thoracic arteries.

1. Introduction

Half a million patients per year worldwide are estimated to undergo coronary artery bypass grafting (CABG)[1] CABG remains a superior option for revascularization compared to percutaneous coronary intervention (PCI) in cases of severe coronary artery disease (CAD)[2,3] owing to its major advantage of no need for repeat intervention.[3] Accordingly, an appropriate graft selection is a sine qua non to minimize mortality and reintervention. Currently, the left internal thoracic artery to the left anterior descending coronary artery (LITA or LIMA-LAD) graft is unanimously considered the gold standard of conduits.[4] Conduit selection for the grafting of the other coronary arteries varies. Provided that half of the saphenous vein (SV) grafts are patent without significant stenoses at 10 years,[5] some surgeons have fueled an interest in total arterial revascularization using one or both internal thoracic arteries (BITA or BIMA) and other arterial conduits such as the radial artery (RA) or the right gastroepiploic artery (GEA). Given the numerous advantages of BITA grafting and arterial conduits in terms of survival and extended patency rates, patients referred for surgery should not be denied the benefits of total arterial revascularization.[6]

2. Indications-contraindications

Every eligible patient should receive total arterial revascularization, the cornerstone of which is BITA grafting. Patients with a body mass index (BMI) of over 35, diabetes

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http://dx.doi.org/10.1016/j.hjc.2016.06.002

Please cite this article in press as: Papakonstantinou NA, Baikoussis NG, Total arterial revascularization: A superior method of cardiac revascularization, Hellenic Journal of Cardiology (2016), http://dx.doi.org/10.1016/j.hjc.2016.06.002

or severe airway disease or who are undergoing radiotherapy or immunosuppression are only relatively contraindicated for BITA use.[7] If more conduits are required, the RA can be prepared at the same time as the LITA, and its harvesting is associated with favorable early outcomes.[4] Prior to harvesting, a modified Allen test is performed. If a hyperemic response to the previous ischemic hand is noticed within 5 s, the collateral ulnar circulation is adequate. Restoration of the blood circulation to the ischemic hand later than 10 s after the ulnar release excludes the RA from being used.[8] Duplex examination and pulse oximetry can also be used to preoperatively evaluate the RA and ulnar artery. Moreover, the RA should be avoided when cardiac catheterization has been recently preceded by injuring the vessel and when the RA might be used for future fistulae in patients who are receiving or who are likely to receive dialysis.[7] RAs less than 2 mm in diameter are also avoided due to the possibility of vasospasm.[9] Finally, the extent of stenosis of the target coronary vessel may also constitute a contraindication for arterial conduit use due to competitive flow. Hence, stenoses of less than 70% in the left coronary bed and less than 90% in a dominant right coronary artery should prevent the use of an arterial graft.[7]

3. Graft patencies

High occlusion rates of vein grafts due to atherosclerosis of 12%, 25% and 50% within 1 year, 5 years and 12 years after CABG, respectively,[10,11] result in an increased need for repeat revascularization. Therefore, three percent of patients who have received vein grafts undergo a repeat revascularization procedure within 5 years, 10% within 10 years and 25% within 20 years.[12] Veins appear to be 2.6 times more prone to dysfunction than arteries.[13] Consequently, grafts with superior patency rates are sought either to prolong intervals to repeat revascularization or to prevent the need for repeat operations.[1]

As many as 80% of ITA conduits have been shown to be free from failure in the third decade after CABG.[7] RITA patency is 96% at 5 years and 81% after 10 years, levels that are comparable to LITA patency of 98% and 95%, respectively.[14] Tatoulis et al. reported similar patency between RITAs and LITAs when grafted to the same target vessel of 96.5% vs. 94.5%, respectively, when grafted to the LAD and 90.5% vs. 88.5%, respectively, when grafted to the circumflex artery.[15] Several angiographic studies from 6.7 to 12 years following surgery have reported that RITA graft patency ranges from 86% to 97% at levels similar to LITA patency rates.[16–19]

Conversely, the patency rates of the RA range from 83% to 93% at one to seven years postoperatively,[20] thus demonstrating a superior patency of the RA compared to the SV.[21,22] A meta-analysis has compared 419 RA to 412 SV grafts at follow-up times beyond three years. The complete occlusion rate of the RA was 6.7% vs. 17.2% for the SV grafts. RA graft failure was also significantly lower compared to SV grafts (9.6% vs. 18.8%). The graft patency of RAs of 88.6% was superior to that of the SVs of 75.8%. Similar findings have been reported by a recent single-institution study involving 1,851 patients showing a superiority of the RA compared to the SV in terms of graft patency and graft failure,[23] as well as a meta-analysis by Athanasiou and colleagues that observed better mid-term patency (1–5 years) for RA grafts.[24]

For gastroepiploic artery grafts, the 5-year patency rates are similar to those of the SV grafts of 62% and 86% in two large studies.[25,26] However, skeletonized gastroepiploic arteries appear to have superior outcomes when compared to SV grafts.[27]

4. Morbidity-mortality

Total arterial revascularization using BITA is also advantageous in terms of long-term survival, as well as reoperation and the need for angioplasty.[28–34] A clear benefit is seen in the first postoperative decade in cases using BIMA, and its advantage becomes even more apparent during the second postoperative decade.[35,36] A retrospective study by Lytle[29] has demonstrated a survival advantage associated with the use of BITA. Survival in the BITA group was 94%, 84% and 67% vs. 92%, 79% and 64% in the LITA group at 5, 10, and 15 years postoperatively, respectively ($p<0.001$). Another study by the same authors[28] showed a survival benefit of greater than 10% for BITA grafting at 20 postoperative years, except for in patients with a small body surface area and for those of advanced age, in whom BITA was inferior to LITA in terms of survival. Survival in the BITA group was 89%, 81%, 67% and 50% vs. 87%, 78%, 58% and 37% in the LITA group at 7, 10, 15 and 20 years, respectively ($p<0.0001$). Similar results were observed by Stevens and colleagues,[30] who reported survival benefit for BIMA on the order of 5% at 10 years (88% for the single-graft group versus 93% for the BIMA group; $p<0.001$). Grau et al.[37] compared 1459 BIMA and 4854 LIMA patients. Although the in-hospital and 30-day mortality rates were not significantly different between the two groups (0.8 vs. 1.1%, respectively; $P = 0.47$), BIMA grafting was superior to LIMA with regards to long-term survival. This survival benefit was once again demonstrated to be more in favor of the BIMA group throughout the 17-year follow-up period (96 versus 91% at 5 years, 89 versus 79% at 10 years and 79% versus 61% at 15 years). Interestingly, the late mortality risk was almost twice as high in patients undergoing on-pump LIMA grafting compared to those with off-pump BIMA grafting.[37] Taggart et al.[34] performed a meta-analysis of seven observational studies comparing 11,269 LIMA patients to 4,693 BIMA patients in 2001. A significant average survival benefit of 8 years was observed throughout the follow-up for the BIMA group. Similar results showing a statistically significant survival advantage with BIMA throughout a 7.6-year follow-up period even in diabetic patients was reported by another larger meta-analysis including 27 studies that compared 19,277 BIMA to 59,786 LIMA patients. Long-term mortality was also significantly reduced among patients receiving BIMA grafting.[38] Moreover, statistically significantly lower mortality and the need for percutaneous coronary intervention and decreased myocardial infarctions after BITA use at 20 postoperative years were reported by Rankin et al.[39] More postoperative deaths were also reported for the LITA group according to a retrospective study by Konstanty-Kalandyk[40] including 147 patients with coronary artery disease and diabetes (3.67 for

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