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Review

Barriers to the universal adoption of bilateral internal mammary artery grafting

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HIGHLIGHTS

- Internal mammary artery grafting is the "gold standard" of revascularization.
- Bilateral internal mammary artery grafting may improve long term survival.
- Information on outcomes of the technique from randomized trials is limited.
- The technique is not generic and may be prohibitive in certain patient subsets.
- Technical excellence is required for the procedure and it is challenging to teach.

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ABSTRACT

The left internal mammary artery (LIMA) graft is considered the "gold standard" of coronary artery bypass grafting (CABG). This conduit provides increased survival, symptomatic relief, increased freedom from myocardial infarction, and increased freedom from re-intervention when compared to saphenous venous grafting. It has a remarkable long term patency rate with clinical and angiographic outcomes that are unmatched by other conduits. Given the fact that patients often require more than one graft during a coronary revascularization procedure, the prospect of bilateral internal mammary artery (BIMA) grafting has been very appealing to some surgeons. BIMA grafting has been extensively studied via multiple retrospective and prospective cohort studies and findings have indicated that BIMA grafting can have an increased survival benefit when compared to LIMA grafting alone. As a result, this technique has accrued increasing popularity over the course of the last decade. Yet, questions still remain on whether BIMA grafting is the optimal treatment modality for patients in terms of long-term prognosis. There is limited data at the present time from randomized controlled trials and only 4–12% of CABGs performed today utilize BIMA grafting. Concerns regarding perioperative complications, which patient subsets are at higher risks for complications from the technique, and the technical challenges involved in utilizing and teaching the technique have limited its widespread use.

1. Background

Coronary artery bypass grafting (CABG) remains one of the most common cardiac surgical procedures performed worldwide today [1–6]. It has been demonstrated to provide symptomatic relief and increase long-term survival in patients with coronary artery disease (CAD) [1–6]. This is mainly attributed to the fact that a good majority of these patients are treated with the left internal mammary

Abbreviations and Aacronyms: CABG, coronary artery bypass grafting; LIMA, left internal mammary artery; LAD, left anterior descending coronary artery; SVG, saphenous vein graft; RIMA, right internal mammary artery; SIMA, single internal mammary artery; BIMA, bilateral internal mammary artery.

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artery (LIMA) to left anterior descending (LAD) artery graft during their CABG surgery. The benefits of the LIMA to LAD graft have been clearly proven and this graft is considered the "gold standard" of coronary revascularization [1–6]. The LIMA to LAD graft has remarkable long term patency rate, which can be as high as 95–98% at 10 years [1–6], as opposed to saphenous vein grafts (SVG), which have high early failure rates, ranging from 6.2% to 30%, averaging approximately 20% throughout the literature [1–6].

Given the clearly demonstrated benefits and efficacy of the LIMA graft, the prospect of utilizing bilateral internal mammary artery (BIMA) grafting has appealed to many surgeons and has been a topic of debate. The respective strengths and weaknesses of BIMA grafting have been analyzed via retrospective and prospective cohort studies. A meta-analysis of seven observational studies comprising 15,962 patients (11,269 LIMA and 4693 BIMA) was performed in 2001 by Taggart et al. [7]. This pivotal meta-analysis revealed that the BIMA subset displayed significantly greater survival when compared to the LIMA group.

This resulted in further non-randomized studies which compared outcomes of BIMA grafting with SIMA grafting. In an updated meta-analysis of 27 observational studies comprising 79,063 patients (59,786 LIMA and 19,277 BIMA) by Weiss et al., in 2013, an increase in long-term survival was demonstrated in patients undergoing BIMA grafting when compared to patients undergoing LIMA grafting [6]. In a more recent meta-analysis of 9 observational studies comprising 15,583 patients (8270 SIMA and 7313 BIMA) by Yi et al., in 2014, an increase in long-term survival was once again demonstrated in patients undergoing BIMA grafting [8]. Despite the fact that no randomized controlled trial data were utilized in these meta-analyses, it appears that there are noticeable survival benefits conferred by BIMA grafting when compared to SIMA grafting alone.

Interestingly, although current evidence appears to support the benefits conferred by BIMA grafting, barriers to its universal adaptation linger. This is apparent from the fact that only approximately 4–12% of CABGs performed today utilize BIMA grafting over LIMA plus SVG grafting [6]. Hence, while the evidence for BIMA grafting is encouraging, its implementation into clinical practice has been comparatively small [6]. Therefore, the question arises at to what the barriers are to the universal adoption of BIMA grafting as a standardized practice.

2. Challenges

Information on the long term outcomes of BIMA grafting from randomized trials is presently limited. Although a number of observational studies supporting utilization of BIMA grafting have been presented [6–9], data from one of the only randomized controlled trials (Arterial Revascularization Trial also called ART) evaluating long-term survival with regard to BIMA grafting is still pending [6]. Initial results, however, have shown no significant differences between BIMA grafting and single internal mammary artery (SIMA) grafting in terms of 30-day or one-year mortality, rate of stroke, myocardial infarction, or repeat revascularization [9]. On the other hand, there was an increased necessity for sternal wound reconstruction in the BIMA grafting group compared to the SIMA grafting group (1.9% vs. 0.6%). The fact that there were no significant benefits seen in the aforementioned variables, coupled with the observation that there is a higher frequency of sternal wound reconstruction, may discourage surgeons from performing the procedure [6].

Many cardiac surgeons also have concerns that BIMA grafting may be associated with increased early morbidity and mortality [6]. Major concerns include fact that it is a more technically challenging operation with a higher probability of deep sternal wound infections (DSWI) and its ensuing complications. The level of skill, experience and concentration required are greater than that required for a standard operation [6]. Also, the incidence of DSWI has been reported to range widely from 0.3% to as high as 14% in BIMA grafting. The risks of DSWI have been attributed to the diminished sternal perfusion resulting from the bilateral harvest of the IMA required for BIMA grafting [6]. This issue becomes even more problematic in patients with diabetes, which is a well-known comorbidity associated with DSWI. BIMA grafting has been observed to be associated with increased risk of DSWI in patients with severe, chronic diabetes [10]. Although this should not justify denial of BIMA grafting in the majority of such patients who could benefit from it, consideration should be given to what techniques could be utilized to diminish mortality and morbidity.

Skeletonization of the IMA has been shown to reduce the risk of DSWIs from the BIMA grafting procedure in diabetic patients. This decrease in DSWIs was not observed in BIMA grafting performed via a pedicled harvest [6]. Hence, in order to minimize the rate of DSWIs in these patients, the complexity of the procedure increases due to the necessity for a skeletonized harvest. Skeletonization is frequently performed with an ultrasonic scalpel, whereby excess tissue surrounding the artery is removed and the side branches are controlled. The disadvantage is that the operating time is further increased as BIMA harvesting is usually performed sequentially, as opposed to simultaneously as seen in radial artery and saphenous vein grafts.

The advantages of the skeletoninizing technique is that it serves to minimize chest wall trauma, achieve maximal length, and facilitate the ease of sequential grafting. Exposure of the IMA is usually achieved by retracting the pleura laterally, while leaving the pleural curtain intact. Low power diathermy is utilized with long, fine-tipped forceps and the endothoracic fascia is meticulously incised directly below and along the length of the IMA. The use of a harmonic scalpel is frequently preferred by surgeons. The low power and minimal handling technique is essential to prevent injury, avulsion, dissection, and arterial spasm. The medial internal mammary vein is located at the subclavian vein and divided after double ligation on both sides, if required. This serves to optimize the final length of the IMA and facilitate proximal harvesting. The superior aspect of the subclavian vein is exposed proximally and swept downward to provide exposure of the proximal IMA. Identification and division of the proximal branches of the IMA are carried out very carefully to prevent proximal steal syndrome and phrenic nerve injury as BIMA harvesting may predispose to the rare but grave risks of bilateral phrenic nerve injury. The IMA is harvested utilizing blunt and sharp diathermy dissection and by dividing the branches via scissors after both sides are clipped. The IMA is proximally harvested from above the subclavian vein to its bifurcation while taking care to ensure that all the major branches are divided. After systemic heparinization, the IMA is divided distally and sprayed with papaverine solution and wrapped in warm papaverine soaked gauze.

Increasing the complexity, operating time, and potential risks of the procedure in patients with such pre-existing comorbidities may be unfavorable to some cardiac surgeons. Other minor concerns involve the placement of the right internal mammary artery (RIMA) graft. As emphasized prior, the LIMA to LAD graft is considered the "gold-standard" for coronary revascularization. In utilizing the RIMA graft, the rationales behind where to place it (right coronary artery versus circumflex) and how to place it (in situ versus free graft versus 'Y' graft) are not as clearly delineated [6]. It is worth noting that the patency rates of the RIMA grafting have been reported to be somewhat inferior when compared to the patency rates of LIMA grafting irrespective of where the graft site involved is located [6]. Also, interestingly, a relatively recent report by