Coronary Revascularization Using Bilateral Internal Thoracic Arteries: Safe with Skeletonization?

Brody Wehman* and Bradley Taylor
Division of Cardiac Surgery, University of Maryland Medical Center, USA

Abstract

Substantial evidence exists supporting a long-term survival benefit with bilateral internal thoracic artery (BITA) revascularization in coronary artery bypass grafting. However, this technique remains grossly underutilized worldwide and especially in the United States. In this review, we discuss evidence for the advantages of BITA grafting as well as the associated risk of sternal wound complications. We then review a growing body of literature that suggests ‘skeletonization’ of the internal thoracic artery during harvest confers a protective benefit against sternal wound infection in patients receiving BITA.

Keywords: Bilateral internal thoracic artery; Coronary revascularization; Skeletonization; Sternal wound infection

Introduction

The left internal thoracic artery (LITA) is well established as the conduit of choice in coronary artery bypass grafting (CABG), with clear advantages over saphenous vein grafts. However, use of the right internal thoracic artery (ITA) in addition to LITA, or bilateral ITA (BITA) grafting, is used in only 4% of cases in the United States [1], in spite of substantial evidence that BITA provides a long-term survival advantage. Much of the resistance to BITA usage centers on concern for an increased risk of sternal wound complications, especially in diabetic patients.

In this review, we discuss evidence for the advantages of BITA grafting as well as the associated risk of sternal wound complications. We also review increasing evidence that skeletonization of the ITA confers a protective benefit against sternal wound infection in patients receiving BITA.

Ita Use in Cabg Surgery: Distinct Advantages

The ITA has been long established as the optimal conduit for coronary artery bypass grafting, offering superior long-term patency, freedom from re-intervention and survival rates [2-4]. This is largely attributed to the unique physiologic properties of the ITA [5,6] (Table 1).

Additionally, these clinical and physiologic benefits are complemented by the highly practical anatomic location of the ITA. Coursing parallel to and 3 to 5 centimeters from the sternum, the vessel is readily exposed in routine patients undergoing median sternotomy for CABG.

Use of Bilateral Internal Thoracic Arteries

Survival benefit

Among the earliest to describe use of BITA in CABG was Rene Favaloro while at the Cleveland Clinic in late 1960’s [7]. Pioneering surgeons from Cleveland Clinic and elsewhere continued to use BITA, reporting excellent results through the 1980’s and 1990’s [8,9]. In a landmark paper from Lytle et al in 1999, “Two Internal Thoracic Artery Grafts Are Better Than One”; the authors demonstrated superior freedom from re-operation and overall survival in patients receiving BITA versus SITA, with 5, 10 and 15 year survival rates of 94%, 84% and 67% for the BITA group and 92%, 79%, and 64% for the SITA group (p<0.001) [9]. Although this study was a retrospective, single-center review it included over 10,000 patients and used propensity matched scoring to compare those receiving SITA (n=8,123) versus BITA (n=2001) during CABG. It was the largest study to date providing evidence for the survival benefit of BITA grafting. In the years following, large retrospective studies continued to demonstrate significantly improved survival over 20 and 30-year follow-up periods for patients receiving BITA versus SITA grafting [10,11].

Yet broad conclusions on the survival benefit of BITA remain limited by lack of data from randomized, prospective studies. Accordingly, current ACC/AHA Guidelines list BITA grafting as a Class IIA recommendation, with level of evidence B, which signifies the recommendation is “based on evidence from a single randomized trial or nonrandomized studies” [12]. A systematic review in 2001 by Taggart et al. identified only 9 cohort studies and no randomized trials [13]. While this meta-analysis demonstrated superior survival in those receiving BITA, the authors acknowledged the limited nature of their findings, highlighting the need for a large randomized trial, which Dr. Taggart initiated soon thereafter. This trial, known as the Arterial Revascularization Trial (ART), is a multi-center, randomized control trial comparing bilateral versus single ITA grafting with a primary outcome of survival at 10 years. In order to detect a 5% reduction in 10 year mortality, and remain adequately powered (90%) at a 5% significance level, the trial requires enrollment of approximately 3,000 patients.


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Table 1: Physiology of the internal thoracic artery.

<table>
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<tr>
<th>Property</th>
<th>Description</th>
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<tr>
<td>Absent/ very thin vasovasorum</td>
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<tr>
<td>Dense internal elastic lamina</td>
<td>without fenestrations</td>
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<tr>
<td>High integrity of endothelium</td>
<td></td>
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<tr>
<td>Thin medial layer w few smooth</td>
<td>muscle cells</td>
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<tr>
<td>Enhanced secretion of prostacyclin and nitric oxide</td>
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patients. Recently, the one-year results were published and while no survival benefit was detected, long-term follow-up remains ongoing. There was an increased incidence of DSWI in BITA compared to SITA (1.9% vs. 0.6%, respectively), and approximately half of these occurred in diabetic patients [14].

BITA use and risk of deep sternal wound infection

Although existing long-term data point toward a survival benefit, the risk of DSWI remains a primary source of concern for cardiac surgeons considering BITA revascularization, particularly in diabetic patients. The association between wound complications and BITA use was initially reported in small series throughout the 1970's and 1980's, occurring in 1.5% to 4.0% of non-diabetic patients, and in 5.7% of diabetic patients [15-19]. A large retrospective study from Loop et al in 1990 observed that diabetic patients receiving BITA were 5 times as likely to suffer wound complications [20]. Borger et al. further demonstrated the risks associated with BITA revascularization, focusing specifically on the incidence of DSWI. In a review of over 12,000 patients, they reported the risk of DSWI in diabetic patients increased from 1.3% to 14.3% when using BITA grafting (p=0.001, odds ratio 3.2) [21]. Furthermore, they compared male diabetic versus non-diabetic patients undergoing BITA and found 20% of male diabetic patients who received BITA suffered a DSWI vs. 1.6% of male diabetic patients receiving SITA. In a recent review of the Nationwide Inpatient Sample, Itagaki et al. reviewed 1,526,360 patients who underwent CABG and compared BITA versus SITA use and development of DSWI [22]. They found that BITA was associated with a DSWI rate of 1.4%, and the presence of severe, chronic diabetes was a significant risk factor for DSWI (OR 1.57). However, the investigators reported that BITA use alone was not an independent predictor of DSWI (OR 1.03). Additionally, another recent review found no difference between DSWI presented in matched groups of SITA vs. BITA (7 of 414 [1.7%] versus 13 of 414 [3.1%]; P=0.179) and that, interestingly, the previously discussed survival benefit from BITA grafting extended to diabetic patients (median survival: SITA, 9.8 years versus BITA, 13.1 years; P=0.001) [23]. Yet while some recent reports are encouraging, the historically decreased risk for BITA did not hold for the earliest cohort of patients and 0 wound complications in 63 diabetic patients receiving BITAs. Remarkably, they reported sternal complications in only 6 (1.1%) patients and 0 wound complications in 63 diabetic patients receiving BITA. However, this study was limited by lack of a comparison group. Calafiore et al. [31] compared skeletonized vs pedicledBITA by era. In the early group, all ITA were pedicled versus the later group in which all ITA were skeletonized. The investigators found a 10% incidence of DSWI in BITA compared to SITA grafting [24]. Additionally, another recent review found no difference between DSWI presented in matched groups of SITA vs. BITA (7 of 414 [1.7%] versus 13 of 414 [3.1%]; P=0.179) and that, interestingly, the previously discussed survival benefit from BITA grafting extended to diabetic patients (median survival: SITA, 9.8 years versus BITA, 13.1 years; P=0.001) [23]. Yet while some recent reports are encouraging, the historically decreased risk for BITA did not hold for the earliest cohort of patients and 0 wound complications in 63 diabetic patients receiving BITA. However, this study was limited by lack of a comparison group. Calafiore et al. [31] compared skeletonized vs pedicledBITA by era. In the early group, all ITA were pedicled versus the later group in which all ITA were skeletonized. The investigators found a 10% incidence of DSWI in BITA compared to SITA grafting [24].
group (1.3% vs 11.1%, p=.03), as was any sternal wound infection (superficial or deep) (5.1% vs 22.2%, p=.03). Average total operative time was slightly longer in the skeletonized ITA group, but this was not statistically significant (199.3 vs 184.7 minutes, p=.3). Importantly, when compared to non-diabetic patients who underwent conventional, pedicled BITA (n=578), the investigators found no difference (1.2% vs 1.6%). The authors concluded that as long as the ITAs were skeletonized, diabetes was no longer a contraindication to BITA grafting. A similar study with a larger group of BITA patients (pedicled=300, skeletonized=150) found that when BITA were skeletonized, there was no difference in DSWI between diabetic and non-diabetic patients [33]. Additionally, they reported that skeletonization in BITA patients had an equivalent DSWI incidence as those with pedicled SITA.

Laboratory data

Dr. Frank Spencer’s group from NYU found a significant reduction of sternal blood flow in dogs that underwent a pedicled versus skeletonized ITA harvest [34]. In this study, 8 dogs underwent BITA, with one ITA harvested as a pedicle and the contralateral vessel skeletonized. Remaining blood flow to the chest wall was then measured using radioactive microspheres and a gamma counter. Blood flow to the sternal halves where the ITA had been skeletonized was significantly greater than flow to sternal halves where a pedicled graft had been harvested (2.60 +/- 0.68 versus 1.27 +/- 0.27 cm3/min/100 gm, p < 0.001). These data provide some physiologic evidence for the protective effect of skeletonization.

Results from meta-analyses

Over the last decade several extensive meta-analyses have examined skeletonization in BITA and DSWI [35-38]. Saso et al. included 12 studies for review and reported a reduction in the odds of sternal wound infection in all BITA patients receiving skeletonization (OR=.41), with an even greater reduction in diabetic patients receiving BITA (OR=.19) [35]. Another group recently reviewed 10 observational studies and 1 randomized trial to analyze a pooled total of 126,000 diabetic patients, 122,500 receiving SITA and 3800 BITA [37]. The authors found the risk ratio for DSWI in BITA versus SITA in all diabetic patients was 1.71. However, in a sub-analysis of BITA patients who underwent skeletonized harvest, there was no difference in the risk of DSWI in SITA patients. Pedicled ITA had an increased risk ratio of 1.77. Taken together, the data compiled from these meta-analyses provide us with an estimated incidence of DSWI in all patients receiving skeletonized BITA grafts of 1.1 to 1.7%, while the incidence in diabetic patients ranges from 1.2 to 2.2%.

Emerging strategies to minimize DSWI

The advent of robotic totally endoscopic coronary artery bypass (TECAB) and minimally invasive coronary artery bypass (MIDCAB) grafting provides access to the ITA and heart without sternal division. Accordingly, the incidence of DSWI and mediastinitis is virtually non-existent in published TECAB and MIDCAB literature [39]. Additionally, the increased magnification and dexterity afforded by the teleborotic system allows for safe and efficient skeletonization of the ITA. In utilizing these minimally invasive strategies, patients could enjoy the survival benefit of bilateral arterial revascularization without the associated risk of sternal wound complications.

Conclusion

Although data from randomized trials are lacking, there is substantial evidence that BITA revascularization provides a significant survival benefit in patients undergoing CAGB. Yet widespread adoption of BITA grafting will likely not occur until there is more compelling evidence that skeletonization reduces the risk of DSWI to that of SITA. The existing evidence, while retrospective in nature, support the notion that skeletonization is protective against DSWI in all patients, including diabetics. Finally, the application of minimally invasive, sternal-sparing approaches to CAGB may guide the way toward increased and safer use of BITA revascularization.

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References


