The Internal Mammary Artery and Vein as Recipient Vessels for Microvascular Breast Reconstruction:

Are We Burning a Future Bridge?

Maurice Y. Nahabedian, MD, FACS

Abstract: Clinical applications for the internal mammary artery include use as an arterial conduit for coronary revascularization and as a recipient artery for microvascular reconstruction of the breast. This study was completed in an attempt to resolve the controversy over which indication should have priority. Five hundred twenty women with breast cancer who underwent breast reconstruction were reviewed. Of these, 240 were 50 years of age or more and were evaluated for cardiac disease. Three components were studied that included analysis of factors related to cardiac function (prior cardiac surgery, specific cardiac disorders, and cardiac medications), analysis of risk factors related to cardiac disease (hypertension, diabetes mellitus, and tobacco use), and analysis of factors related to the reconstruction (selection of recipient vessels, type of reconstruction). The women were stratified based on age—50 to 59 years, 60 to 69 years, and older than 70 years—to analyze trends based on advancing age. Results demonstrated that the incidence of coronary artery disease was 2 in 240 women (0.8%) and that the incidence of factors related to cardiac function and the incidence of risk factors related to cardiac disease appear to increase with advancing age. The internal mammary vessels were used in 35 of 114 free tissue transfers with no adverse sequelae. No woman in whom the internal mammary artery was used has developed coronary artery disease. The 2 women with coronary artery disease were reconstructed with implants. Based on the results of this study, the author thinks that use of the internal mammary artery as a recipient vessel for microvascular reconstruction of the breast is justified. Options for future coronary revascularization would include the opposite internal mammary artery when available, a saphenous vein graft, or angioplasty.

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From Johns Hopkins University, Baltimore, MD.

Reprints: Maurice Nahabedian, MD, Johns Hopkins Hospital, 601 North Caroline Street, 8152C, Baltimore, MD 21287. Tel: 410-955-9477; fax: 410-614-1296; E-mail: mnahabed@jhmi.edu

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Clinical applications for the internal mammary artery (IMA) include use as an arterial conduit for coronary revascularization or as a recipient artery for microvascular reconstruction of the breast.[1–5] The principle argument supporting the use of the IMA as an arterial conduit for coronary revascularization is that it has been demonstrated to maintain a higher patency rate and prolong patient survival when compared with saphenous vein grafts.[3,4] Thus, use of the IMA as a recipient vessel for free tissue transfer is becoming increasingly controversial, especially because its use is becoming more widespread. A principle reason for using the IMA as a recipient vessel is that it eliminates the need to dissect the axilla, which has a well-defined risk of lymphedema and sensory nerve damage.

Modified radical mastectomy for invasive breast cancer has been performed for many years. After the axillary dissection, the thoracodorsal artery and vein were easily visualized and little effort was required to prepare them for microvascular anastomosis.[6] However, with the increasing role of skin-sparing mastectomy and sentinel lymph node biopsy, modified radical mastectomies are becoming less common. The thoracodorsal vessels are usually poorly visualized and more difficult to access after this technique. In light of a partially dissected axilla, the reconstructive surgeon has 2 choices for recipient vessels: the thoracodorsal or the internal mammary artery and vein.[7] Use of the thoracodorsal vessels usually requires additional skin incisions and additional axillary surgery, whereas use of the IMA does not.

The purpose of this study was to analyze women with breast cancer who were at least 50 years of age and to determine whether the use of the IMA as a recipient vessel for microvascular breast reconstruction would adversely impact future options for coronary revascularization. Women were identified and stratified into 2 groups: those who had a history of cardiac disease before the diagnosis of breast cancer and those who had various risk factors for coronary artery disease (CAD). A paradigm for selecting the type of reconstruction based on the cardiac history is discussed.

METHODS

This was a retrospective review of women with breast cancer over a 6-year consecutive period. During this time interval, 520 women of all ages with breast cancer were identified who had either a modified radical or simple mastectomy with some form of reconstruction. The average age was 48 years (range, 24–77 years). From this total, a subset of 240 women was generated who were at least 50 years old, and was analyzed for cardiac disease and risk factors for cardiac disease. All women were not included because this would have a dilutional effect on the data analysis given that cardiac disease is more prevalent with advancing age. The factors related to cardiac disease included a history of cardiac dysfunction (eg, CAD), cardiomyopathy, and valvular dysfunction), prior cardiac operations, and the use of medication to improve cardiac function. The risk factors for cardiac disease that were analyzed included a history of tobacco use, diabetes mellitus, hypertension, and patient age. All women in this study had reconstructive surgery performed by the principal surgeon (M.Y.N.) and included a variety of flaps and implants.

Women were stratified into 3 groups based on age that included women who were 70 years old and older, between 60 and 69 years, and between 50 and 59 years respectively. The data were analyzed based on factors related to cardiac function, the presence of risk factors related to CAD, and factors related to the reconstruction. The technique for preparation of the IMA has been previously described.[8] The data were analyzed in a manner that ensured HIPPA compliance.

RESULTS

A total of 240 women with breast cancer were analyzed. Of these, 15 were at least 70 years old, 59 were between 60 and 69 years, and 166 were between 50 and 59 years of age. Table 1 summarizes the results of the analysis.

Analysis of Factors Related to Cardiac Function

Of the 240 women, a prior history of cardiac disease was documented in 8.75%, use of medication to improve cardiac medication was documented in 2.5%, and a prior cardiac operation had been performed in 1.6%. The percentage of women with underlying cardiac disorders increased with advancing age and included 7.2% of women between 50 and 59 years, 11.9% of women between 60 and 69 years, and 13.3% of women who were at least 70 years of age. The percentage of women who had prior cardiac operations also increased with advancing age and was 0.6% when between 50 and 59 years, 3.4% when between 60 and 69 years, and 6.6% in the group at least 70 years of age. The use of medication to improve cardiac function was reported in 1.2% of women between 50 and 59 years, 6.8% of women between 60 and 69 years, and in 0% of women 70 years old or older.

Of the 4 cardiac operations, 2 were because of CAD in which a 3-vessel coronary artery bypass graft (CABG) was performed. These operations were performed 2 and 3 years before the diagnosis of breast cancer at the ages of 64 and 59 years respectively. The left IMA as well as a saphenous vein graft were used in both women. The other 2 operations included a cardiac transplantation secondary to viral cardiomyopathy and an atrial septal defect repair during infancy. Use of the IMA was not necessary for the latter 2 operations. Thus, of the 240 women evaluated in this study, the IMA was used for coronary artery bypass in 2 women (0.8%).

TABLE 1. Patient Analysis Results

Age, y	n	Cardiac Medications	Cardiac Operations	Past Cardiac History	Tobacco	Diabetes	Hypertension
>70	15	Yes, 0 No, 15	Yes, 1 No, 14	Yes, 2 No, 13	Yes, 0 No, 14 Quit, 1	Yes, 1 No, 14	Yes, 4 No, 11
60–69	59	Yes, 4 No, 55	Yes, 2 No, 57	Yes, 7 No, 52	Yes, 4 No, 48 Quit, 7	Yes, 6 No, 53	Yes, 16 No, 43
50–59	166	Yes, 2 No, 164	Yes, 1 No, 165	Yes, 12 No, 154	Yes, 19 No, 128 Quit, 19	Yes, 6 No, 160	Yes, 29 No, 137
Total	240	Yes: 6 No: 234	Yes, 4 No, 236	Yes, 21 No, 219	Yes, 23 No, 190 Quit, 27	Yes, 13 No, 127	Yes, 49 No, 191

Analysis Risk Factors Associated With Cardiovascular Disease

The risk factors analyzed included tobacco use, diabetes mellitus, and hypertension. Of the 240 women, current tobacco use was acknowledged in 10%, prior tobacco use was reported in 11%, and no tobacco use was reported in 79%. The incidence of current tobacco use decreased with advancing age and was 11.5% in the 50- to 59-year-old group, 7% in the 60- to 69-year-old group, and was 0% in women 70 years or older. Diabetes mellitus was diagnosed in 5.4% of all women. Age stratification demonstrated an incidence of 3.6% when 50 to 59 years, 10.2% when 60 to 69 years, and 6.7% when 70 years or older. The incidence of hypertension was 20.4% for all women and appeared to increase with advancing age. Age stratification demonstrated hypertension in 17.5% of women between 50 and 59 years, 27.1% in women between 60 and 60 years, and 26.6% in women 70 years or more. Of the 2 women who had a CABG requiring use of the internal mammary artery, risk factors included hypertension alone in 1 woman and no hypertension, tobacco use, or diabetes mellitus in the other woman.

Analysis of Factors Related to the Reconstruction

The IMA was used in 35 of 240 women (14.6%) older than 50 years, in 35 of 114 free tissue transfers (31%), and in 9 of 23 bilateral free tissue transfers (39%). Of the 240 women who were 50 years of age or older, the reconstruction included a free tissue transfer in 114 (free TRAM flap, n = 59; deep inferior artery epigastric flap, n = 51; superior gluteal artery perforator flap, n = 4), implant in 95, pedicle transverse rectus abdominis musculocutaneous flap in 21, latissimus dorsi flap in 8, and a skin graft in 2. For the free tissue transfers, the recipient vessels included the thoracodorsal in 79 (69%) and the internal mammary in 35 (31%). This included 23 women who had bilateral reconstruction, of which the thoracodorsal was used in 14 and the internal mammary was used in 9. For all women in whom the IMA was used (n = 35), risk factors included hypertension in 8 (23%), current tobacco use in 3 (8.6%), prior tobacco use in 3 (8.6%), diabetes mellitus in 2 (5.7%), mitral valve prolapse in 1 (2.9%), and a cardiac murmur in 1 (2.9%). Of the 2 women who had a previous history of CAD and underwent CABG, both were reconstructed with implants. Reconstruction with an implant was also performed in the woman who had an atrial septal defect repaired and in the woman who underwent cardiac transplantation. Complications such as pneumothorax, abnormal chest wall contour, respiratory difficulty, and chronic pain were not observed in any woman after the use of the internal mammary vessels.

DISCUSSION

The IMA has been used for revascularization of the coronary vessels since 1970.[9] The advantages of the IMA when compared with saphenous vein bypass grafts for CABG have been well described.[9–12] The patency rate of the IMA that is anastomosed to the left anterior descending artery is 95% at 1 year with a minimal decline over time, whereas the patency rate for the saphenous vein graft is 90% at 1 year and declines at A rate of 3% per year for the next 5 years.[9–11]

Use of the internal mammary artery and vein as recipient vessels for free tissue transfer was first reported in 1980.[13] The advantages, based on the vascular anatomy, of the internal mammary vessels as opposed to other recipient vessels in the vicinity such as the thoracodorsal have been described.[8,14–18] The diameter of the internal mammary vessels at the level of the fourth rib ranges from 0.99 to 2.55 mm for the artery and 0.64 to 4.45 mm for the vein.[14,15] In contrast, the diameter of the thoracodorsal vessels ranges from 1.5 to 3.0 mm for the artery and 2.5 to 4.5 mm for the vein.[15,16] The blood flow rate of the IMA ranges from 15 to 35 mL/minute (mean, 25 mL/minute) and the blood flow rate of the thoracodorsal artery ranges from 2 to 8 mL/minute (mean, 5 mL/minute.[17,18] These anatomic and physiologic studies have provided the basis and support for use of the IMA as a recipient vessel for free tissue transfers. These blood flow rates are also responsible for the superiority of the IMA over the saphenous vein graft for CABG.

The clinical advantages and disadvantages for use of the IMA as a recipient vessel have been summarized by Ninkovic et al.[8] Advantages include constant location, large caliber, easy access, maximum freedom for flap positioning, and improved flow dynamics. Disadvantages include a thin wall vein, respiratory movement, pneumothorax, and that the IMA cannot be used for future coronary revascularization. Thus, given the advantages of the IMA for both coronary revascularization and breast reconstruction with free tissue transfer, it was the intent of this study to determine whether its use was justified for breast reconstruction. In an attempt to resolve this controversy, a review of the current epidemiologic data regarding CAD in women is necessary. It is important to keep in mind that the purpose of this paper is not to instruct plastic surgeons on how to manage CAD, but merely to present factual data regarding current trends in the management of CAD.

The prevalence of CAD in the United States is almost 62 million, with 52% of those affected being women and 48% being men.[19] Approximately 25 million are older than the age of 65 years. The American Heart Association has evaluated various factors that predispose to cardiovascular disease, including tobacco use, hypercholesterolemia, physical inactivity, obesity, diabetes mellitus, hypertension, and poor nutrition. Of these, tobacco use, diabetes mellitus, and hyper-

tension were analyzed in this study. Nutritional status, cholesterol levels, activity level, and obesity were not analyzed because this information was not available for all women in this study.

The prevalence of coronary heart disease in women increases by approximately 3% every 10 years, ranging from 5.5% (45–54 years) to 16.1% (>75 years).[19] The age-adjusted death rate for women with coronary heart disease in the year 2000 exceeded that of breast cancer fivefold in the United States (332.8/100,000 vs 61.5 per 100,000). The mean age of patients who required CABG was 64 years in women and 60 years in men according to the Bypass Angioplasty Revascularization Investigation.[20] In addition, of all deaths in women for all reasons, the number dying from cardiovascular disease is 1 in 2.4, and the number dying from breast cancer is 1 in 29. These statistics imply that CAD is more prevalent and deadly than breast cancer, and it can therefore be argued that the internal mammary vessels should not be used as recipient vessels for microvascular reconstruction of the breast, but should be preserved in case coronary revascularization becomes necessary. However, to analyze this statement properly, it is necessary to review the current trends in the management of CAD in women.

Historically, CABG has been the treatment of choice for patients with advanced CAD. Review of the literature regarding CABG has revealed important information to support this.[3,21–24] In a recent study of 3052 patients evaluating arterial conduits, coronary revascularization was achieved using a saphenous vein graft alone in 602 patients (19.5%), a single IMA artery in 2092 patients (68.5%), and bilateral IMA grafting in 368 patients (12%).[21] The mean age of the patients who had coronary revascularization was 54 years for the double IMA group, 62 years for the single IMA group, and 68 years for the saphenous vein group. The percentage of women in this study ranged from 8.4% in the bilateral IMA group to 29.2% in the saphenous vein group. It has been generally regarded that CABG procedures in women resulted in a higher operative mortality with decreased long-term benefit in women compared with men.[22] However, in a recent study Kurlansky et al[24] have demonstrated no gender difference in operative morbidity or mortality with a 15-year actuarial survival of 53.7% for women and 50.9% for men. This has been attributed primarily to the IMA because of its increased patency rate. In a study of 833 patients, Olearchyk and Magovern[3] demonstrated a patency rate of 87.9% for the internal mammary and 63.3% for the saphenous vein at a mean follow-up of 18.9 months.

Based on these data, it is clear that a CABG in which the IMA is used is superior to a CABG in which the saphenous vein graft is used as the revascularization conduit. However, the current practice for improving coronary circulation is not solely dependent on CABG. Review of the current statistics from the American Heart Association has revealed that the less invasive techniques to improve coronary circulation, such as angioplasty, are dramatically increasing.[19] Current techniques of angioplasty include percutaneous transluminal angioplasty (PCTA) and placement of endovascular stents. In the year 2000, of 522,000 women who had a procedure to improve coronary flow, 374,000 women (72%) had angioplasty, and this included 198,000 women who had PCTA and 166,000 women who had stent placement. In contrast, only 148,000 women (28%) had CABG during the same time period. Age analysis has demonstrated that 93.4% of angioplasty procedures are performed on patients older than 45 years, with 51% being performed after the age of 65 years. For CABG, 96.6% are performed after the age of 45 years and 55% are performed after the age of 65 years.

As the number of angioplasty procedures continues to increase, the clinical benefits and limitations are becoming better understood. Numerous studies have been performed that compare CABG with angioplasty using meta-analysis.[25–27] In a recent study comparing CABG with PCTA that incorporated 13 trials and 7964 patients, it was found that CABG was associated with a lower 5-year mortality, less angina, and fewer revascularization procedures when compared with PCTA. However there was no survival advantage at 1, 3, and 8 years.[25] In another study comparing CABG to stenting, it was demonstrated that the overall and event-free survival were not significantly different, but that secondary revascularization was more common when stents were used.[26] Another recent study that compared CABG, using the IMA, with angioplasty, with PCTA or stents has demonstrated that both techniques result in a low and comparable incidence of death and myocardial infarction.[27] However, stent use was associated with a high need for secondary intervention resulting from stenosis.

It is clear that use of the IMA has advantages for both coronary revascularization and free tissue transfer. Thus, use of the IMA as a recipient vessel is based on a variety of factors that includes analysis of patient comorbidities and reconstructive technique. Women with known comorbidities such as cardiovascular disease are often interested in and encouraged to pursue simpler operations such as expander/implant reconstruction. This is primarily to minimize the operative time and optimize postoperative recovery. Women without cardiovascular comorbidities are candidates for reconstruction using autologous tissue or implants. When a free tissue transfer technique has been selected, the decision regarding recipient vessels is based on various factors. When the reconstruction is unilateral or bilateral and the axilla has not been dissected (eg, simple mastectomy with or without sentinel lymph node biopsy), the internal mammary artery and vein are used for the previously mentioned reasons. Current data have demonstrated that the risk of lymphedema has been reduced from 10 to 20% after axillary lymph node

dissection to 1% after sentinel lymph node biopsy.[28,29] Dissection of the thoracodorsal artery and vein in these situations can result in perilymphatic and perivascular scar that can increase the risk for lymphedema and result in altered sensation resulting from trauma to the intercostobrachial nerves.[30] In addition, leaving the axilla undisturbed will preserve the ability to perform safely a future axillary lymph node dissection without risk to the anastomosis, such as in the case of a positive sentinel lymph node.[31] When a modified radical mastectomy is performed and the thoracodorsal vessels are exposed or partially exposed, these vessels are used. For delayed reconstruction, the internal mammary vessels are used.

I recognize that this study has not completely resolved the controversy over which procedure should have priority. However, it has provided factual data and information that support use of the internal mammary vessels for microvascular breast reconstruction. Limitations of this study are twofold. The first is that the reverse situation was not analyzed; that is, analysis of those women with CAD who have had previous coronary artery revascularization and who have had a history of breast cancer. This evaluation was not possible with the existing data base; however, future collaboration with cardiac surgeons is warranted. The second limitation is that it remains unclear what percentage of women who have had breast cancer and breast reconstruction will ultimately require coronary artery revascularization in the future. The answer to this question may be available in a few years as the length of follow-up is increased.

In conclusion, this study has demonstrated that the incidence of cardiovascular disease in women with breast cancer who have had reconstruction is 0.8%. Thus, it is my opinion that the IMA can be used safely as a recipient vessel with minimal future risk. In women with preexisting CAD who are interested in breast reconstruction, expander/implant reconstruction is preferred. For women with preexisting CAD who insist on autologous tissue, a pedicle tissue transfer (latissimus dorsi flap or transverse rectus abdominis musculocutaneous flap) or free tissue transfer using the thoracodorsal artery and vein as the recipient vessel is recommended. In women without preexisting CAD, all options can be recommended safely. For women who later develop CAD and require a coronary revascularization procedure, options are available. Given that the majority of breast reconstructions in this study in which the IMA was used were unilateral (74%), the opposite IMA is available when needed. When both IMAs are used for breast reconstruction, options include saphenous vein grafts or angioplasty. As the future of coronary revascularization continues to evolve and less invasive techniques are developed, new bridges will become available and the use of the internal mammary bridge may become obsolete.

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