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Sternal Wound Complications of Coronary Artery Bypass Grafting Using Bilateral Internal Mammary Arteries

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The use of bilateral internal mammary arteries (BIMA) in coronary artery bypass grafting (CABG) confers greater freedom from myocardial infarction, angina recurrence, repeat intervention and survival benefit. The main disadvantage of BIMA use is the risk of sternal dehiscence and deep sternal infection from ischemia. This has been challenged over the years. The objectives of this descriptive study were: to determine the frequency of patients who developed sternal wound complications, and describe the sternal complications seen, their treatment and duration. A secondary objective of this study was to determine factors associated with increased risk of sternal wound morbidity.

Methods: Forty-five (45) patients who underwent CABG using BIMA as performed by the authors in 3 medical centers from January 2007 until May 2012 were included. The preoperative and postoperative characteristics and outcome were recorded.

Results: The mean age was 53.2 years (range: 37-71). All except one patient were males. No patient developed sternal dehiscence or deep sternal infection - 0/45. Eight patients (17.8%) developed minor sternal wound morbidities. These morbidities included skin dehiscence, superficial sternal wound infection and foreign body granuloma. All the sternal wound morbidities were treated as outpatients and majority resolved within the first postoperative month. Multiple logistic regression analysis showed that diabetes mellitus was a risk factor for minor sternal wound morbidity with an adjusted odds ratio of 11.4 (95% CI: 1.4 - 96.1).

Conclusion: The use of BIMA during CABG was not associated with sternal wound dehiscence or mediastinitis. Diabetes mellitus was a risk factor for minor sternal wound morbidity.

Key words: Coronary artery bypass, internal mammary - coronary, anastomosis, complication, surgical wound infection, diabetes

The use of the left internal mammary artery (LIMA), also known as the left internal thoracic artery, as a conduit in coronary artery bypass grafting (CABG) has long been proven to confer excellent long-term patency and survival benefit.[1] The LIMA has a 10-year patency rate of 90% overall and 99% when grafted to the left anterior descending (LAD) artery,[2] respectively, while the saphenous vein has a 10-year patency rate of about 60%.[2,3] The superior patency rate is attributed to 1) well formed internal elastic lamina, 2) few smooth muscle cells in the media, and 3) secretion of endothelium-derived relaxing factor (EDRF) which promotes vasodilatation and inhibits platelet aggregation.[4,5] Coronary bypass using bilateral internal mammary artery (BIMA) conduits is believed to confer greater freedom from myocardial infarction, angina recurrence, percutaneous intervention or repeat operation compared to CABG using single internal mammary artery (SIMA).[6,7] The survival advantage of BIMA extends beyond 20 years.[8]

The internal mammary artery (IMA) is one of the sources of blood supply to the hemisternum. BIMA use has been implicated as a risk factor for sternal complications such as sternal dehiscence and mediastinitis particularly in certain subgroups such as patients with diabetes mellitus, obesity and chronic obstructive pulmonary disease (COPD).[9,10,12,13,] However, such an association between BIMA use and deep sternal infection or dehiscence was not supported by other studies.[14-17] The perception of increased risk of mediastinitis, among

other reasons, has discouraged most surgeons from employing BIMA grafting strategy despite the long-term benefits, particularly in the local setting. There has been no locally published data on CABG using BIMA in relation to sternal wound complications.

The primary objectives of this study were: 1) to determine the percentage of patients who developed sternal wound complications, 2) to describe the short-term morbidity profile of coronary artery bypass graft surgery using bilateral internal mammary artery conduits, 3) to describe the sternal complications seen in these patients, their treatment and duration. A secondary objective was to determine factors associated with increased risk of sternal wound morbidity in these patients.

Methods

This is a descriptive study involving review of records of patients who underwent CABG using BIMA as performed by the authors from January 2007 until May 2012 in three centers, namely the Philippine General Hospital, Makati Medical Center and The Medical City. Review of the in-patient charts and clinic records were made and the following data were recorded: age, status, diagnoses, number of coronary vessel involvement, history or diagnosis of hypertension, diabetes mellitus, smoking, COPD, previous myocardial infarction (MI), previous stroke, peripheral arterial disease, renal failure, preoperative fasting blood glucose level, preoperative ejection fraction, body mass index. Postoperative data recorded included the operation done, date of operation, number of vessels grafted, cardiopulmonary bypass time, ischemic time, 30-day morbidity and mortality, sternal wound complications (grouped into major and minor) and postoperative length of stay. Major sternal morbidity was defined as deep sternal wound infection (DSWI) and/or sternal dehiscence. Minor sternal morbidity as defined included superficial sternal wound infection (SSWI), partial skin dehiscence, cellulitis, foreign body granuloma or stitch abscess. Those who developed sternal morbidities were compared to those with no sternal morbidities in terms of preoperative and operative variables.

The study protocol was approved by the Research Ethics Board of the University of the Philippines Manila and the Institutional Review Boards of the Makati Medical Center and The Medical City.

The percentage of sternal wound morbidity was estimated at 95% confidence level. Cardiac profile, concomitant diseases, preoperative, intraoperative data and sternal morbidities were described. To determine factors associated with sternal wound morbidity, independent t-tests were used to compare preoperative and intraoperative data between patients who had morbidity and those who did not. Crude Odds ratios were estimated for the qualitative variables such as diabetes mellitus, hypertension and stroke. More important variables identified by this crude analysis were analyzed by multiple logistic regression analysis.

Results

A total of 45 patients underwent CABG using BIMA from January 2007 until May 2012 and were all included in the study. Majority, 44 of 45 (98%), were males. The mean age was 53.2 years (8.9 SD). The youngest patient was 37 years old and the oldest was 71 years old. Table 1 shows other important patient characteristics.

Table 1. Cardiac profile and concomitant diseases of patients who underwent Coronary Artery Bypass Grafting (CABG) using Bilateral Internal Mammary Arteries (BIMA).

	Number	Percentage
Coronary vessels involvement		
3-vessel disease	43	95.5
2-vessel disease	2	4.4
Previous MI	26	57.8
Hypertension	39	86.7
Diabetes mellitus	16	35.6
Previous stroke	3	6.7
Peripheral arterial disease	1	2.2
Renal failure	3	6.7
Smoking history	29	64.4
COPD	4	8.9
Obesity (BMI ≥ 30)	10	22.2

MI = myocardial infarction, COPD = chronic obstructive pulmonary disease, BMI = body mass index

Table 2 shows the preoperative and intraoperative details. The number of vessels grafted ranged from three to six with a median of four vessels grafted.

All patients underwent elective or urgent surgery. Thirty-six patients underwent CABG using conventional technique (using the heart-lung machine or pump oxygenator), one patient underwent off-pump beating heart technique (off-pump coronary artery bypass or OPCAB) and two patients underwent on-pump beating heart technique. The latter two patients had severely calcified ascending aorta (so called "porcelain aorta"), which precluded any form of aortic clamping or cannulation. The femoral artery was used for arterial access during cardiopulmonary bypass. The decision to use bilateral IMA was planned preoperatively upon the surgeon's discretion. Forty two patients had intended use of BIMA while 3 patients necessitated BIMA use - one had a history of bilateral below the knee amputation with limited availability of the greater saphenous vein for use as conduit and two others with the severely calcified ascending aorta described earlier.

No patient developed sternal dehiscence or deep sternal infection – 0/45 (95% C.I.: 0– 7.9%). Eight patients (17.8%) (95% C.I.: 8.0 -32%) developed minor sternal wound morbidities. These morbidities included skin dehiscence, superficial sternal wound infection and foreign body granuloma. Other morbidities included pneumonia, infection of the leg harvest site, gout and reoperation for bleeding. One patient developed a Stevens-Johnson syndrome type of reaction to allopurinol. The morbidities are listed in Table 3.

The patients with partial skin dehiscence were managed by re-suturing during clinic follow up consultation. Cellulitis was managed with oral antibiotic and foreign body granulomas were managed with wound care and oral antibiotics. All cases resolved with no further invasive procedures. No patient required readmissions for sternal wound complications. (Table 4) A patient with severe gouty arthritis of the knee required fluid aspiration.

Table 3. List of morbidities among 45 patients who underwent CABG using BIMA.

	Number	Percentage
Sternal wound morbidities		
Major	None	
Deep sternal wound infection	None	
Sternal dehiscence	None	
Minor	8	17.7
Skin dehiscence, partial	4	8.8
Foreign body granuloma	2	4.4
Discharge, non-purulent	1	2.2
Cellulitis	1	2.2
Other morbidities		
Pneumonia	4	8.8
Infection, leg harvest site	3	6.6
Gouty arthritis	3	6.6
Reoperation for bleeding	1	2.2
Steven's Johnson syndrome	1	2.2

Factors Associated with Minor Sternal Wound Morbidity

Patients with and without sternal morbidity were compared with respect to their laboratory and intraoperative data. (Table 5)

Table 2. Preoperative laboratory values and intraoperative data of the 45 patients who underwent CABG using BIMA.

Preoperative and Intraoperative Details	N	Mean	Standard Deviation	Minimum	Maximum
Preoperative blood glucose level, mg%	41	107.5	26.0	77.0	193.5
Preoperative ejection fraction, %	45	62.7	10.4	40.0	81.5
Cardiopulmonary bypass time, minutes	44	125.1	31.4	73.0	233.0
Ischemic bypass time, minutes	42	90.0	21.0	48.0	170.0

Table 4. Details of the 8 minor sternal morbidities as to management and duration.

Morbidity	When noted*	Treatment	When resolved*
Skin dehiscence	Two weeks	Sutured under local anesthesia as outpatient	Four weeks
Skin dehiscence	Two weeks	Sutured under local anesthesia as outpatient	Four weeks
Skin dehiscence	Two weeks	Sutured under local anesthesia as outpatient	Four weeks
Skin dehiscence	Two weeks	Sutured under local anesthesia as outpatient	Six weeks
Foreign body granuloma	Five weeks	Local wound care, antibiotics	Twelve weeks
Foreign body granuloma	Two weeks	Local wound care	Four weeks
Wound discharge, non-purulent	Two weeks	Antibiotics	Three weeks
Cellulitis	Two weeks	Antibiotics	Three weeks

*In relation to date of surgery

Table 5. Comparison of laboratory values and intraoperative data between those with minor sternal morbidity and those without sternal morbidity.

Laboratory/ Intraoperative Data	With Minor Sternal Morbidity		Without Sternal Morbidity		Difference (95% CI)	P-value*
	Mean	S.D.	Mean	S.D.		
Blood glucose, mg/dl	97.2	11.55	109.6	27.67	-12.35 (-25.7, 1.00)	0.07
Ejection fraction, %	63.5	6.41	62.5	11.17	1.03 (-5.11, 7.16)	0.80
BMI, kg/m^2	26.3	3.27	26.8	3.56	-0.48 (-3.25,2.28)	0.72
Cardiopulmonary bypass time, minutes	131.5	17.84	123.6	33.69	7.86 (-9.76,25.48)	0.36
Ischemic time, minutes	94.6	16.43	89.6	22.06	5.04 (-9.86, 19.84)	0.48

*Independent t-test, P-value, unequal variances

On the average, blood glucose levels of those without sternal morbidity were higher by 12 mg/dl but these were not statistically significant. Cardiopulmonary bypass time was higher by 8 minutes on the average among patients with morbidity compared to those without. Likewise, ischemic time was higher by 5 minutes. But these were also not statistically significant. Ejection fraction and BMI of the two groups were similar.

Blood glucose, ejection fraction and BMI were categorized and their crude and adjusted Odds ratios for sternal wound morbidity were estimated. Table 6 shows the results as well as those for the other suspected factors.

Multiple logistic regression analysis showed that diabetes mellitus is a risk factor for minor sternal wound morbidity with an adjusted odds ratio of 11.4 (95% CI: 1.4 – 96.1). Inconclusive results were obtained for the other factors examined. Some factors, such as hypertension, history of previous stroke, smoking history, high BMI and elevated blood glucose showed crude or adjusted odds ratios that are less than 1.0 suggesting protection against sternal wound morbidity. These results

Table 6. Risk factors for minor sternal wound morbidity.

Risk Factor	With minor sternal morbidity proportion (%)	Without sternal morbidity proportion (%)	Crude Odds Ratio (95% C.I.)	Adjusted Odds Ratio (95% C.I.)
Age > 50 years	6/8 (75)	19/37 (51)	2.84 (0.42 - 31.67)	2.53 (0.33-19.18)
Hypertension	7/8 (88)	32/37 (86)	1.09 (0.10 - 59.02)	0.45 (0.03 -6.65)
Diabetes mellitus	6/8(75)	10/37 (27))	8.10 (1.14- 89.93)	11.45 (1.36-96.12)
Previous MI	5/8 (62)	21/37 (57)	1.27 (0.21 - 9.35)	0.59 (0.08 - 4.13)
Previous stroke	1/8 (12)	2/37 (5)	2.50 (0.04 - 53.17)	1.54 (0.08 - 29.65)
Peripheral artery disease*	0	1/37 (3)	–	
Smoking history*	5/8 (62)	24/37 (65)	0.90 (0.15 - 6.76)	
COPD	1/8 (12)	3/37 (8)	1.62 (0.03 - 23.68)	1.98 (0.12 - 32.81)
Renal failure*	0	3/37 (8)	–	
BMI ≥30 kg/m^2	2/8 (25)	8/37 (22)	1.21 (0.10 - 8.66)	0.56 (0.06 - 4.98)
Glucose ≥ 100 mg/dl*	2/7 (28)	20/34 (59)	0.28 (0.02 - 2.08)	
Ejection fraction < 0.50*	0	5/37 (14)	–	

*Not included in the adjusted analysis

are clinically incompatible and examination of the confidence intervals showed that these results are inconclusive. (Table 5) Smoking history (a variable that is generally unreliable), glucose level (since this is related to diabetes) and factors with zero frequencies (in a 2x2 table) were not included in this adjusted analysis.

Discussion

No patient developed mediastinitis or sternal dehiscence in this series. Eight patients (17.8%) developed minor sternal wound morbidities that were managed on outpatient setting and without need for reoperation or readmission. Diabetes mellitus was found to be a significant factor for minor sternal wound morbidity.

CABG using BIMA has been found to confer greater benefit such as freedom from reoperation and extended survival over 20 years.[8] Compared to use of LIMA alone, however, this strategy has not caught on as much as expected. The main reasons postulated are: it is technically more demanding, it takes more time, its results are not immediately apparent [8] and the perceived fear of complications such as mediastinitis and sternal dehiscence.

CABG is a clean operation, thus the risk of infection is generally very low. However, deep sternal wound infection or mediastinitis is potentially life-threatening. In an earlier unpublished report, the overall incidence of deep sternal wound infection and/or sterile sternal dehiscence in the patient population of 528 CABG patients was 1.8%. The incidence rates of mediastinitis and sterile sternal dehiscence were both 0.9%. In most large series, the overall incidence of mediastinitis after CABG ranged from 0.25% to 2.3%.[18-20]

The contributory role of BIMA use in CABG to the development of mediastinitis or sternal dehiscence is controversial. In an earlier report by Kouchoukos, the incidence was as high as 6.9% for BIMA versus 1.9% for SIMA (P=0.001).[10] In a more recent meta-analysis, the incidence of mediastinitis in patients who received BIMA grafts ranged from 1.3% to 4.7% versus 0.2% to 1.2% in those who received SIMA graft.[9] On the other hand, several authors reported no significant difference in the incidence of deep sternal wound infection when patients who received BIMA grafts were compared to those who received SIMA grafts.[7,15,16,] In some smaller series, there was no incidence of mediastinitis or DSWI.[14,17]

Although this is a retrospective study and no comparison with single internal mammary artery (SIMA) grafting was made, the results indicated that CABG using BIMA is safe and feasible in properly selected patients. The authors generally used BIMA in patients

younger than 70 years old with favorable coronary anatomy and in the absence of the following characteristics: morbid obesity, poorly controlled insulin-dependent diabetes mellitus and severe chronic obstructive pulmonary disease (COPD). The coronary anatomy was one of the considerations inasmuch as the authors preferred to use both internal mammary arteries as in situ grafts. If the coronary artery target, particularly the branches of the circumflex artery, is too far distally or caudally located, an in situ RIMA or LIMA graft may not reach it without undue tension. In addition, the severity of coronary stenosis was also a consideration since the authors refrained from using the IMA for coronary arteries with less than 70% stenosis. IMA conduits anastomosed to non-critical lesions have yielded poorer results probably owing to competitive flow from the native artery.[21]

Pedicled versus Skeletonized IMA Harvesting

The internal mammary arteries were harvested in the conventional manner, with a pedicle (with accompanying veins, nerves and endothoracic fascia) to prevent inadvertent injury during dissection. Sauvage originally proposed skeletonization as an alternative method of IMA harvesting to reduce sternal infections by preserving collateral sternal blood supply and to increase arterial anastomoses.[22] A decreased rate of sternal wound infections has been found in those who have received BIMA using this technique of harvesting versus pedicled harvesting in the general population. [23] A decreased rate of sternal infection was likewise found among diabetics when skeletonization was used.[24] Hirose compared pedicled and skeletonized BIMA grafting in diabetic patients and found a lower incidence of minor wound complications in the skeletonized group but no significant difference in the incidence of mediastinitis.[25] However, there have been speculations that harvesting the IMA without the accompanying veins, vasa vasorum and innervation may adversely affect the long-term patency of the IMA thus, skeletonization has not gained universal acceptance. There is currently no hard evidence that skeletonization affects graft patency.[26] The authors have routinely preferred harvesting the IMA's with a pedicle because it was technically easier. All patients in this series were native Filipinos except two – one Malaysian and one Caucasian. Skeletonization may not be practical in the Filipino (or Asian) patient because the IMA is relatively small in caliber and is, thus, probably more prone to injury.

Minor Morbidities

Most minor sternal wound morbidities are not reported in the literature probably because they are of relatively small clinical significance. While mediastinitis is potentially fatal and requires aggressive surgical management and sternal dehiscence likewise requires surgery to close the sternum, most minor infections or morbidities are easily manageable even without readmission. The authors decided to report these minor morbidities for the sake of completeness. The partial skin dehiscence seen in four patients were located within the distal 5cm and may be related to stretch-induced ischemia from the overzealous cranking of the sternal retractor. Two patients had foreign body granuloma. As a precaution, during the last two years, the authors have sparingly placed additional interrupted stitches in the distal 5cm of the sternotomy incision among patients who are deemed at risk such as those who are obese or diabetic. The two patients in this series who developed foreign body granuloma underwent surgery within the first 24 months of the study period when bone wax was routinely used as a hemostatic agent by the authors. The primary author has refrained from using bone wax in all sternotomy cases during the latter 29 months of the study period. The use of bone wax was found to be a risk factor for the development of foreign body-related sternocutaneous fistulas in one report.[27] It has also been found to cause chronic inflammation and granuloma formation after median sternotomy in an autopsy series.[28]

In the logistic regression analysis, the diabetic mellitus was found to be a risk factor for these minor sternal morbidities. Whether minor sternal wound morbidities were related to BIMA use is unknown because the authors did not use a control (SIMA). Diabetes mellitus is a risk factor for superficial sternal wound infection (SSWI) among CABG patients in general.[29] CABG

using BIMA in diabetics is advantageous since it confers survival benefit and decreased reoperation rates similar to those in non-diabetics.[30] Therefore, diabetic patients should not be deprived the benefit of BIMA use considering that the rate of major morbidity is low and that minor morbidities are easily manageable.

Limitations of the Study

The number of patients in this sample was small and may have underestimated the true percentage of sternal dehiscence or deep sternal infection. However, since none of the 45 patients reported here developed these complications, it can be surmised that bilateral IMA usage in these CABG patients probably did not lead to an inordinately high incidence of major sternal wound complications, consistent with the low incidence reported elsewhere.[14,15,17] In the multiple logistic regression analysis, other important potential risk factors could not be included due to the small sample size.

Since this was not a controlled study, the minor sternal morbidities may not be attributed to BIMA usage. It was quite possible that diabetes mellitus may have played a bigger role in development of sternal morbidities.

This is the first report on patients who have received bilateral internal mammary artery grafts during CABG in the Philippine setting. The results hopefully provide basis for more liberal use of BIMA among Filipino patients.

Conclusion

The use of bilateral internal mammary arteries during CABG was not associated with sternal wound dehiscence or deep sternal wound infection in the study sample. Diabetes mellitus was found to be a risk factor for minor sternal wound morbidity. These morbidities were easily managed in the clinic setting and majority resolved within the first postoperative month. Diabetes mellitus should not be a contraindication to the use of BIMA in CABG.

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