ORIGINAL ARTICLE

Sternal wound complications after coronary artery bypass grafting with bilateral internal mammary artery grafting. Report of a tertiary referral hospital in northern Mexico

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Objective. **We sought to evaluate the complications of surgical wound in patients undergoing myocardial revascularization with bilateral vs unilateral harvest of the internal mammary artery, from the population of northern Mexico.** *Material.* **A total of 178 patients were analyzed. Forty-five consecutive cases of the bilateral internal mammary artery harvested group and 133 randomized patients in the unilateral harvested group, from January 1, 2017 to September 30, 2019 at our institution. The analysis was done by means of inferential statistics of qualitative variables, comparisons of quantitative characteristics between the two groups and estimation of relative risk (RR).** *Results.* **We found 4.4% of surgical wound complications in the double internal mammary artery harvested group, 2.2% corresponding to superficial infection of the surgical, 2.2% surgical wound dehiscence. As risk factors, for women who underwent bilateral internal mammary artery grafting have a RR of 1.35 (95% CI 0.19-9.71, p = 0.043), patients with type 2 diabetes mellitus a RR of 1.22 (95% CI, 0.027-5.62, p = 0.551), and patients with BMI > 30 had a RR of 1.29 (95% CI, 0.13-12.96).** *Conclusions.* **There are no differences in the incidence of complications related to the type of surgery. Risk factors related to surgical wound complications are the female gender, type II diabetes mellitus, and overweight.**

Key words: **Coronary artery bypass grafting; Coronary artery bypass grafting, arterial; Internal mammary artery grafting, bilateral; Internal mammary artery grafting, single; Mediastinitis; Surgical wound, Complications.**

Objetivo. **Evaluar las complicaciones de herida quirúrgica en pacientes sometidos a revascularización miocárdica con procuración bilateral vs unilateral de la arteria mamaria interna, de la poblacion del norte de Mexico** *Material.* **Se analizaron un total de 178 pacientes, 45 casos consecutivos del grupo de procuración bilateral de arteria mamaria y 133 pacientes aleatorizados en el grupo de procuración unilateral, del 01 de Enero de 2017 al 30 de Septiembre de 2019 en nuestra institución. El análisis se realizó mediante estadística inferencial de las variables cualitativas, comparaciones de las características cuantitativas entre los dos grupos y estimación de riesgo relativo (RR).** *Resultados.* **Encontramos un 4.4% de complicaciones de herida quirúrgica en el grupo deprocuración de doble arteria mamaria, 2.2% correspondiente a infección superficial de herida quirúrgica, 2.2% dehiscencia de herida quirúrgica. Como factores de riesgo las mujeres que se les realizó procuración de arteria mamaria bilateral tuvieron un RR de 1.35 (IC 95% 0.19-9.71, p=0.043), los pacientes con diabetes mellitus tipo 2 el RR fue de 1.22 (IC 95% 0.027-5.62, p=0.551) y los pacientes con IMC>30 un RR de 1.29 (IC 95%,0.13-12.96).** *Conclusiones.* **No hay diferencias en la incidencia de complicaciones relacionadas al tipo de intervención quirúrgica. Los factores de riesgo relacionados a las complicaciones de herida quirúrgica son el género femenino, diabetes mellitus tipo II y sobrepeso.**

Palabras clave: **Revascularización arterial total; Arteria mamaria interna izquierda; Arteria mamaria interna bilateral; Herida quirúrgica; Mediastinitis; Procedimiento quirúrgico, complicaciones.**

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In Mexico, the Mexican Institute of Social Security (IMSS) is responsible for medical coverage and almost half the population of the country (55 million). Cardiovascular diseases rank right up the list of causes for fatality with ischemic heart disease still being one of the main causes among

Mexican population, with a total of 19, 543 deaths (28.15% of the total mortality) between 2015 and 2017 [1]. Our institution receives patients with cardiovascular disease in seven states in northern Mexico. We perform more than 1,600 surgical procedures, out of them 450 in adults (nearly one third of the total) corresponding to coronary artery bypass surgery. To date, in Mexico there are no enough studies demonstrating the prevalence of this complication and the comorbidities in the short and long terms. Therefore, the need to generate information leading us in the management of this pathology becomes imperative.

Bilateral internal mammary artery (BITA) harvesting for total arterial myocardial revascularization enables a further success in coronary artery bypass grafting (CABG). Multiple studies support improved survival, far lessened fatal event rate, improved clinical condition and symptoms, and better quality of life.

Graft patency is much better by using arterial conduits, especially regarding the internal mammary artery (IMA). Unless both mammary arteries no amenable for usage, at least the left internal thoracic artery (LITA) to left anterior descending (LAD) artery is a must in all patients undergoing CABG. The use of saphenous vein graft is related to a suboptimal lower graft patency. Therefore, a second bilateral IMA should always be considered in all patient while considering life expectancy, risk factors for sternal wound complications, stenotic degree of the target vessel, graft quality, and surgical team skills and experience [2].

The surgical strategy using both IMAs for CABG has been utilized for over 30 years. According to STS national database, BITA usage ranks around 3%-4% of CABG. Time-consuming, hard to do it, and any possible wound complication have been the most prominent reasons to avoiding using BITA. The ART trial demonstrated an absolute risk for sternal reconstruction after BITA of 1.0-1.5%. Subsequent analysis also showed the skeletonized IMA harvesting is associated with lower risk for sternal wound complications. Actually, current evidence is in favor of using BITA in patients with a reasonable low risk for sternal wound complications and long-life expectancy. ART trial outcome at 10-year follow-up is up in the air [3].

Several studies available in the literature support the use of total arterial grafts in CABG in terms of better graft patency, long-term survival, and lower risk for sternal dehiscence or infection [3].

Multivessel disease in young patients may benefit from arterial grafts and BITA due to the poor quality of the saphenous vein grafts, prior CABG with no available veins for grafts, and other demographic reasons. However, there is still controversial in the real world the use of BITA because of anecdotical histories about surgical wound complications [4,5].

The purpose of this study is to describe the incidence of SWI (sternal wound infection) after CABG with BITA (Group 1) vs SITA (Single Internal Thoracic Artery) (Group 2). Secondary end points were other patient factors related to SWI.

MATERIAL

This observational, retrospective cohort study involved 1350 patients undergoing myocardial revascularization from 2017 to 2019. A total of 178 patients were analyzed, 45 consecutive cases with BITA harvesting (group 1) and 133 patients randomized in the SITA (group 2), with myocardial revascularization (on CABG), from January 01, 2017 to September 30, 2019. Complete arterial revascularization was attempted in all cases and was defined as any diseased coronary system (stenosis > 70%) receiving at least 1 (artery or vein) graft insertion. This relationship (graft insertion / lesion > 70%) was evaluated for the LAD, circumflex artery, and right coronary artery systems in all patients. Documented infections were categorized according to Centers for Disease Control criteria. Total infection was defined as the presence of any one of the following superficial, deep or sternal dehiscence.

Surgical technique

The operation was performed through a full median sternotomy. All patients were on cardiopulmonary bypass using a single two-stage venous drainage and ascending aortic cannulation; the patients were cooled to 30 C. After aortic cross-clamping, and antero-retrograde intermittent blood cardioplegia was infused. The harvesting of the mammary arteries was carried out through a half-pediculate technique, and nitroglycerin was topically used on a gauze wrapping the harvested artery. In an attempt to preserve native flow, in 90% of group 1 patients, RITA was anastomosed to LAD, and LITA was anastomosed to the left system (ramus intermediate, diagonal or circumflex). In 100% of group 2, the SITA, LITA was grafted to the LAD artery in all patients. And in the rest of the territories of both groups, saphenous vein was used by means of "no-touch" technique.

Statistical analysis

The data was collected in a database in the Microsoft Excel program. This base was transformed into the format of the SPSS statistical program version 23, where each variable defined according to its characteristics was catalog. The characteristics of the distribution curve were determined with the Kolmogorov-Smirnov test. Statistical analysis was performed summarizing each variable according to its nature, and distribution curve: nominal variables as percentage, continuous numerical variables as mean and standard deviation or median and interquartile interval. Inferential statistics of qualitative variables by $\chi 2$. Level of statistical significance $p < 0.05$.

Comparisons of quantitative characteristics between the two groups by Student t or Mann-Whitney. Regarding the estimation of relative risk, the patients in the exposed group were captured for consecutive cases, while the unexposed group was taken a significant systematic randomized sample of the total population with similarity of characteristics clinical demographics in the same timeline as the group exposed. The variables collected were demographic and clinical variables were age, sex, BMI, DM, HAS, smoking, COPD, kidney disease, TCI disease, trivascular disease, previous AMI,

functional class, EuroSCORE II, pre-surgical IVF. Intraoperative variables: time of CBP, aortic cross-clamping, number of anastomosis, bilateral AMI procurement. Post-operative variables were reintervention due to bleeding, length of hospital stay from surgery to discharge, complication of surgical wound, treatment by complication, time of occurrence of complication, mortality.

Data collection and follow-up

Sample collection: Records of patients who met the selection criteria were reviewed, the confidentiality of the subjects is maintained at all times. Variables were collected in the data collection sheet performed *ex profeso* for the study. Variables in data collection sheet include demographic and clinical variables: age, sex, BMI, DM, HAS, smoking, COPD, kidney disease, ICT disease, multivessel (3VD) disease, previous AMI, functional class, EuroSCORE II, preoperative LVEF. Intraoperative variables were time of CEC, aortic clamping, number of anastomoses, bilateral AMI procurement. Post-operative variables: re-intervention due to bleeding, length of hospital stay from surgery to discharge; complication of surgical wound, treatment by complication, time of occurrence of complication, mortality. The data was collected in a database in the Microsoft Excel program. This base was transformed into the format of the SPSS 23 statistical program, where each variable was defined according to its characteristics. Report and writing of results: after the statistical analysis of the data, we proceeded to the critical interpretation of the results, comparison with other authors, the research question was answered and then the final report was written with the data obtained.

RESULTS

A total of 182 patients were included from January 01, 2017 to September 30, 2019, in two groups 47 patients operated on for myocardial revascularization with BIMA harvest (Group 1), of which 2 were eliminated from the study by death prior to 45 days of follow-up, and 135 patients randomized for revascularization. myocardial infarction with SIMA harvest (Group 2), (2 eliminated by death before 45 days). A total of 178 patients met the inclusion criteria.

From the BIMA group, a total of 45 patients vs 133 patients from the SIMA group, with a mean age of 53.3 year ± 9.4vs 62.08 years ± 9.6, respectively (p=0.0). Out of them, 40 (88.9%) were male sex and 5 (11.1%) of the BIMA group versus the male 106 (79.8%) and the female 27 (20.3%) of the SIMA group (p=0.165).

Among the cardiovascular risk factors of the BIMA group 24 (53.3%) were overweight and 9 (20%) obesity grade I vs 74 (55.6%) overweight and 22 (16.5%) SIMA group (p=0.815), smoking 25 (55%) in the BIMA group vs 72 (54.1%) in the SIMA group (p=0.860). In relation to diabetes we found 21 (46.7%) diabetic patients, which correspond to 8 (17.8%) insulin-dependent and 13 (28.9%) in the bilateral mammary artery group vs. 49 (36.8%) diabetic patients, 28 (21.1%) insulin-dependent and 49 (36.8%) non-insulin-dependent in the SIMA group (p=0.420), in arterial hypertension Systemic (HAS) 39 (86.7%) of the BIMA group suffered from it vs 110 (82.7%) of the SIMA group (p= 0.530). Among the preoperative characteristics we found in the lower percentage COPD in only 4.4% in the group of BIMA harvest vs. 3% in the SIMA, as well as 0% for nephropathy vs. 5.3% respectively. The left ventricle ejection fraction in the bilateral procuration group was 48.4% ± 11.01 vs 48.74% ± 10.79 of the unilateral procuration group (p=0.85). The functional class was the largest percentage of patients in functional class II and III 36 (80%), 8 (17.8%) respectively in the BIMA vs 100 (75.2%), 28 (21.1%) in the SIMA group (p=0.700). The Euro Score II was 1.16% ±.48 in the bilateral harvesting group vs 1.63% ±1.03 in the unilateral harvesting group (p= 0.005) **(Table 1).**

Among the documented intraoperative variables, we found that the average number of bypasses of the BIMA group was 3±0.64 vs 3.09±0.72, and 2.2% presented superficial infection vs 7.5% of patients in the unilateral group, 7 with superficial wound infection and 3 deep infection (p=0.620). In-hospital stay was 6.69±3.6 days in the bilateral group versus 7.44±6.76 in the unilateral group (p=0.477).

When performing the subgroup analysis in patients who presented complications of surgical wound, incidence and risks were estimated, finding female gender as variables of interest. Women who underwent bilateral mammary artery harvesting have a RR of 1.35 (95% CI 0.19-9.71 p=0.043) although it is statistically the CI crosses the unit, which does not make it clinically relevant, patients with DMII who underwent BIMA have 1.22 times (95% CI 0.027-5.62, p=0.551) more risk of developing infection than those subjected to unilateral procurement, as well as overweight with a RR of 1.29 (95% CI, 0.13-12.96). However, there were no statistical difference or significant risk **(Table 2).**

DISCUSSION

Sternal wound infection is a substantial complication after CABG surgery as its occurrence is associated with a significant increase in-hospital length of stay, organ failure, procedural cost and risk of death [6].

Despite studies favoring the use of BITA, it is underutilized; namely, 20% in Europe, < 4.5% in the United States, 12.6% in Australia, and approximately 30% in Japan [7,8]. Moreover, a 10-year survival was demonstrated significantly higher in BIMA patients than in patients with SITA [9-10]. An average of 450 myocardial revascularization surgeries per year are performed in our hospital center; approximately 3% of our total procedures are performed as BITA.

In 2003, Lu et al. [11] published a study on infection and complication of sternal wound in which a total of 4,228 patients were included, of whom 109 (2.6%) developed sternal infection after myocardial revascularization procedure, deep infection in 28 patients (0.7%), 81 patients (1.9%) developed superficial infection. The characteristics that reported the highest risk of complication in these patients were BMI

Table 1. Demographic and clinical characteristics

VARIABLE	BITA	SITA	*p* value
Preoperative variables			
Number of cases (n)	45	133	
Age (years)	53.3 ± 9.4	62.08 ± 9.6	0.000
Gender			0.165
Male	40 (88.9%)	106 (79.8%)	
Female	05 (11.1%)	27 (20.3%)	
Body-mass index	27.9 ± 3 .97	27.7 ± 4.86	0.815
Normal	9 (21.0%)	28 (21.1%)	
Overweight	24 (53.3%)	74 (55.6%)	
Grade 1 obesity	9 (20%)	22(16.5%)	
Grade 2 obesity	3 (6.7%)	5 (3.8%)	
Grade 3 obesity	0	4 (3.0%)	
Diabetes mellitus II	21 (46.7%)	77 (57.9%)	0.420
Insulin-dependent	8 (17.8%)	28 (21.1%)	
Non-insulin-dependent	13 (28.9%)	49 (36.8%)	
Smoking	25 (55%)	72 (54.1%)	0.860
NYHA			0.700
I	0	3 (2.3%)	
II	36 (80%)	100 (75.2%)	
III	8 (17.8%)	28 (21.1%)	
IV	1 (2.2%)	2 (1.5%)	
EuroSCORE II (%)	1.16 ± 0.48	1.63 ± 1.03	0.005
Systemic arterial hypertension	39 (86.7%)	110 (82.7%)	0.530
Chronic pulmonary obstructive disease	2 (4.4%)	4 (3%)	0.640
Chronic kidney disease	0	7 (5.3%)	0.110
Left ventricle ejection fraction (%)	48.4 ± 11.01	48.74 ± 10.79	0.850
Previous myocardial infarction	16 (35.6%)	55 (41.4%)	0.492
Multivessel dissease (3VD)	30 (66.7%)	108 (81.2%)	0.043
Left main coronary stenosis	18 (40%)	61 (45.9%)	0.490
Intraoperative variables			
Grafts (n)	3 ± 0.64	3.09 ± 0.72	0.450
Cardiopulmonary bypass time (min)	111.42 ± 37.63	89.25 ± 30.81	0.000
Aortic cross-clamping time (min)	71.89 ± 27.56	53.91 ± 19.26	0.000
Postoperative variables			
Reoperation for bleeding	1 (2.2%)	9 (6.8%)	0.252
Postoperative in-hospital lenght of stay (days)	6.69 ± 3.6	7.44 ± 6.76	0.477
Surgical wound complications	2 (4.4%)	10 (7.5%)	0.620
Dehiscence	1 (2.2%)	0	
Superficial infection	1 (2.2%)	7 (5.25%)	
Deep infection	0	3 (2.25%)	

BITA: Bilateral internal thoracic artery harvesting; SITA: Single internal thoracic artery harvesting.

> 30kg/m^2, NYHA > 3, insulin-dependent diabetes mellitus, peripheral vascular disease, poor left ventricular ejection fraction, prolonged surgery, greater number of grafts, BITA use, prolonged mechanical ventilation, re-exploration for bleeding, elevated blood loss in the intensive care unit, use of intra-aortic balloon pump (IABP) [11].

Similar report was presented in our population, corresponding mainly in individuals between the sixth and seventh decade of life, chiefly male with comorbidities such as

Table 2. Surgical wound complications. Subgroups analysis.

SUBGROUP	BITA	SITA	Relative Risk ((95% CI)	*p* value
	COMPLICATED/TOTAL OF PATIENTS (%)			
Age (years)				0.247
> 70 years	0/3 (0%)	4/31 (12.9%)	0	
< 70 years	2/42 (4.76%)	6/102 (5.8%)		
Gender				0.043
Female	1/5 (20%)	4/27 (14.81%)	1.35 (0.19 - 9.71)	
Male	1/40 (2.5%)	6/106 (5.6%)		
Diabetes mellitus II	2/21 (9.52%)	6/77 (7.79%)	1.22 (0.027 - 5.62)	0.551
Obesity (Body-mass index >30kg/m^2)	1/12 (8.3%)	2/31 (6.45%)	1.29 (0.13 - 12.96)	0.944
Smoking	1/25 (4%)	4/72 (5.55%)	0.72 (0.08 - 6.14)	0.384
Chronic pulmonary obstructive diseae	0/2 (0%)	0/4 (0%)	0	1.000
Chronic kidney disease	0/0 (0%)	0/7 (0%)	0	1.000
Left ventricle ejection fraction <50%	1/21 (4.76%)	6/65 (9.23%)	0.52 (0.07 - 4.04)	0.557
Reoperation for bleeding	0/1 (0%)	2/9 (22%)	0	0.139

BITA: Bilateral internal thoracic artery harvesting; SITA: Single internal thoracic artery harvesting.

obesity, smoking, diabetes and hypertension that occurred in more than half of the patients [12-14].

It is noteworthy that in our study population, the rate of global surgical wound complication was higher in the group of patients with SITA (7.5%), compared to the group of BIMA (4.4%), mostly superficial infections, but 3 patients had deep infection, all of them in the SIMA group. There is a discrepancy in the medical literature regarding the risk of surgical wound infection with these two techniques, while some reports founded BIMA has a higher risk of developing surgical wound infections others have concluded that the risk of infection is similar in both groups [12].

In an study by Jonkers et al. [15] at the Maastricht University Hospital, Netherlands, all patients over the age of 15 who underwent cardiac surgery were included and followed up for 90 days after surgery. The wounds were classified as superficial wounds (skin involvement and subcutaneous cell tissue) and deep infections (osteomyelitis, mediastinitis). Of 1885 patients, they reported 25 cases (1.3%) of deep infection, and 145 cases (7.7%) of superficial infection within 90 days of the postoperative period. The mean time for both deep infection was 14 days, and for superficial infection 15 days. The prevalence of superficial infection was higher in revascularized patients where BITA was present. The rate of deep infection was slightly higher in patients with combined CABG procedure plus valve replacement procedure [15]. Combined procedures were not included in our series.

This our series of cases concluded that the risk of postsurgical complications such as wound infections and bleeding re-interventions is higher in patients with SITA than BITA, but with no statistically significant difference.

We have to consider that the use of BITA was harder, more time-consuming as aortic cross-clamping and extracorporeal circulation times. Also, a more extensive harvesting IMA was needed in order to avoid any additional and unnoticed tension after the performed anastomosis. Of course, we are very aware surgical times can be shortened as surgical team skills acquired. Nevertheless, the long-term benefits for patients should be considered and compared with the previous idea about these patients become more infected, accordingly what has been demonstrated in this our study [16].

Despite several publications have remarked the use of LITA as skeletonized, especially in patients with diabetes mellitus [17-20], our experience is pointing towards using it as partially skeletonized, with good results is recommended, presenting no deep infections or mediastinitis. In addition, we have always handled the strategy by performing myocardial revascularization at least one graft in each of the three zones, and considering that in both groups, 90% of patients had two vessel disease, in two different zones.

We can conclude that the use of IMA is the future of the CABG surgery. Multiple studies have shown better survival, fewer fatal events, significant reduction of symptoms and improved quality of life, yet it remains underused by the challenges posed to the surgeon, longer operating time and risk of complications [3-5,9,13]. Despite studies that favor the use of BITA, it remains underutilized, according to data from 20% in Europe, <4.5% in the US, 12.6% in Australia, and about 30% in Japan [7].

There is no greater risk of surgical wound infection after myocardial revascularization with BITA technique compared than SITA. There are no differences in the incidence of com-

plications related to the type of surgical intervention. The risk factors related to surgical wound complications are female gender, diabetes mellitus, and overweight.

Therefore, it should be considered to adapt this behavior in more patients who can benefit by increasing their quality of life and prognosis, considering that it is an easily reproducible procedure, which does not generate greater costs, and that, as we have already proved in this study, there is no additional risk for further complications.

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