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The Use of Bilateral Internal Mammary Arteries for Coronary Revascularization in Patients with COPD: Is It a Good Idea?

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ABSTRACT

Background: The use of bilateral internal mammary arteries (BIMA) is limited worldwide, especially in patients with chronic obstructive pulmonary disease (COPD). Thus, we assessed the safety of the use of BIMA in COPD patients.

Methods: From cohorts of 8846 patients operated on at our center for primary isolated multi-vessel coronary bypass operations between 2002 and 2012, we studied two propensity-matched groups of patients with COPD who received either single internal mammary artery and saphenous vein grafts (SIMA group: 137 patients) or exclusively BIMA (BIMA group: 137 patients). Preoperative data were similar regarding age (63.59 ± 10.62 versus 65.55 ± 9.61 years; $P = .10$), body mass index (BMI) (28.6 ± 4.71 versus 28.42 ± 3.86 kg/m^2; $P = .72$), diabetes mellitus (32% versus 27%; $P = .08$), EuroSCORE (4.34 ± 2.23 versus 4.8 ± 2.52; $P = .09$) and ejection fraction (58.7 ± 13.08% versus 60.29 ± 14.13%; $P = .32$).

Results: No significant differences were noticed between the two groups regarding the number of peripheral anastomoses (3.07 ± 0.77 versus 3.06 ± 0.85; $P = .90$), total operation time (192.17 ± 43.06 versus 200.63 ± 39.24 min; $P = .08$), postoperative stroke (0.7% versus 0%; $P = .29$), myocardial infarction (2.92% versus 3.6%; $P = .81$), reintubation (2.9% versus 4.4%; $P = .66$), reexploration (0.7% versus 2.2%; $P = .32$), deep sternal wound infection (2.9% versus 3.6%; $P = .81$) and 30-day mortality (2.2% versus 2.9%; $P = .77$). However, postoperative blood loss (726.1 ± 468.35 versus 907 ± 890.58 mL; $P = .03$) was higher in the BIMA group.

Conclusion: COPD patients can benefit from coronary artery revascularization with BIMA; however, postoperative blood loss can be higher using this technique.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) and coronary artery disease are a common combination affecting simultaneously the same subset of patients worldwide. Although smoking is the main risk factor contributing to the incidence of both of them, they can be found independent from this risk factor [Boschetto 2012]. The incidence of COPD in patients undergoing coronary artery bypass grafting (CABG) ranges from 4% to 27% [Grover 1993; Roques 1999; Gardner 2001].

Unfortunately, COPD is associated with increased hospital mortality and morbidity after CABG [Higgins 1992; Geraci 1993; Hannan 2006]. Median sternotomy and the use of cardiopulmonary bypass, as well as the possible lung injury and trauma to the phrenic nerve during harvesting of the IMAs can have deleterious effects on pulmonary functions [Güler 2001]. Accordingly, COPD has been included in the well-established risk stratification models, such as the Society of Thoracic Surgeons score (STS score) [Shroyer 2003] and the EuroSCORE [Nashef 1999] as an independent predictor of operative mortality.

On the other hand, the long-term benefits of the total arterial revascularization of the coronary arteries using the bilateral internal mammary arteries (BIMA) have been well established in the last decade [Itagaki 2013; Dorman 2012; Kurlansky 2010]. However, many surgeons still refrain from the use of this technique, as it seems to be technically more challenging, time consuming, and associated with increased risk of bleeding and wound infection [Tatoulis 2013].

Therefore, BIMA grafting was only used routinely until the end of the last decade in around 10% of the CABG patients in Europe [Bridgewater 2008] and only 4% of the CABG patients in the USA [Tabata 2009]. Moreover, the reluctance to use BIMA is potentiated in COPD patients due to the assumed risks of wound infection, sternal instability, as well as overstretching of the arterial grafts due to the hyperinflated lungs in such patients.

The purpose of this work is to study the short-term outcomes of the use of BIMA in patients diagnosed to have COPD undergoing CABG. To our knowledge, no other study has addressed exclusively this subset of patients before.

MATERIALS AND METHODS

Patient Selection

In the period between 2002 and 2012, 8846 patients were operated on at our center for primary isolated multi-vessel CABG. During this period, the use of BIMA increased over time in our center, with more than 50% of our patients being operated on using this technique [Albert 2011]. From this cohort, we studied two propensity-matched groups of patients

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Table 1. Patients' Characteristics

	SIMA (n = 137)	BIMA (n = 137)	*P*
Age, y	63.59 ± 10.62	65.55 ± 9.61	.10
Male/Female, n (%)	117 (85.5)/20 (14.5)	108 (79.8)/29 (21.2)	.19
BMI, kg/m^2	28.6 ± 4.71	28.42 ± 3.86	.72
Ejection fraction, %	58.7 ± 13.08	60.29 ± 14.13	.32
EuroSCORE	4.34 ± 2.23	4.80 ± 2.52	.09
FEV1 (predicted)	60.72 ± 9.4	61.48 ± 8.7	.75
DM, n (%)	44 (32)	37 (27)	.08
Atrial fibrillation, n (%)	6 (4.4)	4 (2.9)	.66
Hypertension, n (%)	111 (81)	122 (89.1)	.05
Nicotine abuse, n (%)	56 (42.4)	70 (51.1)	.13
PAD, n (%)	15 (10.9)	13 (9.4)	.55
Previous stroke, n (%)	6 (4.4)	4 (2.9)	.66
Renal insufficiency, n (%)	19 (13.8)	21 (15.3)	.67
Serum creatinine, mg/dL	1.17 ± 0.64	1.14 ± 0.39	.68

with the diagnosis of COPD. The first group included 137 patients who received a single IMA and saphenous vein grafts (SVG) (SIMA group), while the second group included 137 patients who received bilateral IMAs (BIMA group) (Table 1). We excluded patients with ejection fraction (EF) <30%, previous cardiac surgery, other associated cardiac operations, emergency operations, and patients with critical preoperative state.

Operative Techniques

All operations were performed through conventional median sternotomy. IMAs were harvested as skeletonized grafts and were sprayed with papaverine at the end of preparation. Opening of the pleural cavities was avoided whenever possible; however, most of the patients had their pleural cavities opened wherever the IMAs were harvested.

On-pump patients were operated on through standard cannulation of the ascending aorta and single venous cannulation of the right atrium under systemic normothermia and antegrade cold hyperkalemic blood cardioplegia. Bypass grafting was performed under single aortic cross clamp.

Off-pump coronary artery bypass (OPCAB) was performed using suction stabilizers such as Octopus and Starfish Heart Positioner (Medtronic, Minneapolis, MN, USA) or the Axius Vacuum Stabilizer System and Xpose Access Devise (Guidant, Santa Clara, CA, USA). Intracoronary shunts were used while performing the anastomoses in all off-pump cases. A blower-mister was used to help visibility. The decision to perform the operation in on- or off-pump technique was left to the surgeon without specific criteria, with an increasing tendency in favor of off-pump technique over time [Albert 2011].

In the SIMA group, the LIMA was anastomosed to the left anterior descending artery (LAD), and the SVGs to the other coronary vessels. The proximal anastomoses of the SVGs were preferably done to the ascending aorta in case of on-pump CABG, and to the LIMA in a T-graft configuration in case of OPCAB.

On the other hand, in the BIMA group a T-graft configuration was used in all cases with the LIMA anastomosed to the LAD and the RIMA to all other target coronary arteries in a sequential manner.

Definition of Terms

- COPD: a patient who has a forced expiratory volume in one second (FEV1) <75% of predicted value, or a patient who requires pharmacologic therapy for the treatment of chronic pulmonary compromise [Clark 1994; Online STS Risk Calculator].
- DSWI: deep sternal wound infection was considered, following the guidelines of the Centers for Disease Control and Prevention [Mangram 1999], in case the infection involves deep soft tissues (e.g., fascial and muscle layers) of the sternotomy wound and at least one of the following:
  i) an organism is isolated from culture of mediastinal tissue or fluid;
  ii) evidence of mediastinitis is seen during operation;
  iii) presence of one of the following: chest pain, sternal instability, or fever more than 38°C, and either purulent discharge from the mediastinum or an organism isolated from blood culture or drainage of the mediastinal area.
- Myocardial infarction: appearance of a new Q wave in two or more contiguous leads on a 12-lead ECG and/or elevation of the cardiac isoenzymes with CKMB constituting more than 10% of the elevated CK [Clark 1994].
- Renal insufficiency: serum creatinine >1.2 mg/dL, creatinine clearance <60 mL/minute, or history of hemodialysis.
- Stroke: acute episode of focal or global neurological dysfunction that lasts for greater than 24 hours [Clark 1994].

Statistical Analysis

Data were collected according to the protocols of the German Society of Thoracic and Cardiovascular Surgery, and were tested for accuracy and reliability. JMP 5.1 software (SAS Institute, Cary, NC, USA) was used for all analyses.

To avoid selection bias, based on the surgeons' preferences to use BIMA for younger and healthier patients, we used a propensity-score matching to adjust for the confounding factors that could have been in favor of one technique over the other.

We performed a one-to-one matched analysis on the basis of the estimated propensity scores of each patient. Factors included in the analysis were age, body mass index (BMI), FEV1, ejection fraction, EuroSCORE, female sex, OPCAB, peripheral arterial vascular disease (PAD), and renal insufficiency. We assessed the goodness of fit through calculating the C-statistics (area under the receiver operating characteristic curve), which was 0.78, indicating a good comparability between the two groups.

Continuous variables were analyzed using the Student t test or Pearson test, and were presented as mean values ±

Table 2. Operative Data

	SIMA (n = 137)	BIMA (n = 137)	*P*
OPCAB	63 (46)	58 (42.3)	.44
ONCAB	74 (54)	79 (57.7)	.44
Total operation time, min	192.17 ± 43.06	200.63 ± 39.24	.08
Bypass time, min	48.96 ± 45.79	50.49 ± 45.82	.77
Cross clamp time, min	32.09 ± 30.61	37.29 ± 34.01	.17
Peripheral anastomoses	3.07 ± 0.77	3.06 ± 0.85	.90

standard deviation. Categorical variables were analyzed using a chi-square test and Fisher exact test and were presented as frequencies and percentages. A *P* value of less than .05 was considered statistically significant.

RESULTS

There were no significant differences between the two groups regarding the preoperative characteristics (Table 1).

OPCAB was performed in 63 patients (46%) in the SIMA group versus 58 patients (42.3%) in the BIMA group (*P* = .44). The number of peripheral anastomoses was 3.07 ± 0.77 in the SIMA group versus 3.06 ± 0.85 in the BIMA group (*P* = .9). The mean operative time was 192.17 ± 43.06 minutes in the SIMA group versus 200.63 ± 39.24 minutes in the BIMA group (*P* = .08) (Table 2).

Apart from the amount of postoperative blood loss, which was significantly higher in the BIMA group (907.01 ± 890.58 mL versus 726.1 ± 468.35 mL in the SIMA group, *P* = .03), there were no significant postoperative differences between the groups (Table 3).

DISCUSSION

In reviewing the literature, it is obvious that the arterial revascularization using BIMA shows excellent mid- and long-term results up to 30 years after surgery [Itagaki 2013; Dorman 2012; Kurlansky 2010]. Nevertheless, only few patients receive BIMA for their coronary revascularization, and in clinical practice patients with COPD would be often excluded from BIMA revascularization. Therefore, we studied the safety of the use of BIMA in our COPD patients. This technique did not result in increased risks of mortality, myocardial infarction, or deep sternal wound infection. However, our study showed a significantly higher amount of postoperative blood loss in the BIMA group. Fortunately, this was not associated with increased risks of reexploration for bleeding or transfusion of blood or fresh frozen plasma. Similarly, De Paulis et al showed increased postoperative blood loss in the group of patients receiving BIMA [De Paulis 2005]. The increased blood loss postoperatively after harvesting the BIMA may refer to the increase in the surface area of IMA beds on both sides in comparison to the unilateral preparation in the case of the SIMA group.

Table 3. Postoperative Outcomes

	SIMA (n = 137)	BIMA (n = 137)	*P*
30-day mortality, n (%)	3 (2.2)	4 (2.9)	.77
ICU stay, d	4.54 ± 3.48	5.04 ± 3.15	.24
Reintubation, n (%)	4 (2.9)	6 (4.4)	.66
Pneumonia, n (%)	4 (2.9)	5 (3.6)	.81
Mechanical ventilation >48 h, n (%)	5 (3.6)	8 (5.8)	.22
Myocardial infarction, n (%)	4 (2.9)	5 (3.6)	.81
Arrhythmia, n (%)	47 (34.3)	53 (38.7)	.43
Stroke, n (%)	1 (0.7)	0 (0)	.29
DSWI, n (%)	4 (2.9)	5 (3.6)	.81
Blood loss, mL	726.10 ± 468.35	907.01 ± 890.58	.03*
Reexploration, n (%)	1 (0.7)	3 (2.2)	.32
Blood transfusion, units	0.54 ± 1.20	0.93 ± 3.02	.14
FFP transfusion, units	0.13 ± 0.72	0.42 ± 3.65	.34
De novo renal failure, n (%)	4 (2.9)	5 (3.6)	.59
Max. serum creatinine, mg/dL	1.41 ± 0.89	1.47 ± 0.87	.56

*Statistically significant.

Respiratory complications represent an important field of concern for COPD patients. Daganou et al compared 2 similar groups of patients receiving either SIMA and SVGs or BIMA, but COPD was not an inclusion criteria [Daganou 1998]. They noticed significantly higher rate and severity of postoperative right lower lobe atelectasis in the BIMA group, which was referred to the pleurotomy and the extra manipulation on the right side; whereas the incidence and severity of pleural effusion, gas exchange impairment, duration of mechanical ventilation, intensive care and hospital stay, and incidence of pneumothorax, pneumonia, and wound infection were not influenced by the use of bilateral IMA grafts.

We found no significant differences between the two groups in regard to the length of postoperative stay in the intensive care unit, or the incidence of pneumonia, reintubation, and prolonged mechanical ventilation (more than 48 hours).

In the present study, the incidence of stroke was noticeably low, affecting only one patient in the SIMA group. This correlates with the fact that almost half of the patients in each group have been operated on using the OPCAB technique, reducing the manipulation to the aorta. Moreover, all the patients in the BIMA group received a LIMA-RIMA T-graft configuration, further reducing the trauma to the ascending aorta. Barbut et al demonstrated the increased risk of stroke due to embolic dislodgment of atherosclerotic plaques during surgical aortic manipulations [Barbut 1997].

Our study showed no significant differences in terms of 30-day mortality between the two studied groups, which further supports the safety of the use of BIMA in patients with COPD. Three patients died in the SIMA group due to massive pulmonary embolism, postoperative pneumonia, and malignant ventricular tachycardia, whereas four patients died in the BIMA group; two of them died from low cardiac output, while the other two died from postoperative pneumonia and massive anterior myocardial infarction.

Farinas et al studied 600 patients in 3 groups receiving either SVGs only, SIMA with SVGs, or BIMA [Farinas 1999]. They demonstrated that COPD, advanced age, and diabetes increased the hazard of death after operation in all three groups.

Mohammadi et al studied retrospectively the short- and long-term results of 1977 patients who received bilateral in situ IMAs compared to 14387 patients who received single IMA and SVGs to the other target coronary vessels [Mohammadi 2014]. They identified COPD as an independent risk factor for deep sternal wound infection as well as late mortality in the long-term follow up.

Fuster et al demonstrated the prognostic value of the severity of COPD in terms of postoperative mortality [Fuster 2006]. They showed increased mortality up to 54% in patients with severe COPD. However, the preoperative patients' characteristics showed more comorbidities in patients having more severe lung disease. The authors of the study recommended the optimization of the management in the perioperative periods through the optimal adjustment of bronchodilator therapy and respiratory physiotherapy to reduce the deleterious effects in high-risk patients. Furthermore, they demonstrated the value of the correct timing of surgery. We follow the same protocol in our clinic. Additionally, we emphasize the value of preparing the whole length of the IMAs thoroughly in a skeletonized fashion, reducing the trauma to the IMAs and their beds and providing enough length to reach all the target vessels and to avoid overstretching of the grafts. Choosing the suitable revascularization strategy according to the patient's condition is another important issue. Therefore, we exclude patients with multiple concomitant risk factors for the use of BIMA (severe obesity, diabetes mellitus, COPD, old age) from this technique.

In conclusion, our study showed the safety of the use of BIMA in the coronary revascularization of patients with COPD in comparison to patients receiving only SIMA. This might be associated with increased but probably clinically irrelevant blood loss. With the well-established long-term benefits of coronary revascularization using BIMA, more patients with COPD can potentially benefit from this technique.

REFERENCES

Albert A, Sergeant P, Florath I, Ismael M, Rosendahl U, Ennker J. 2011. Process review of a departmental change from conventional coronary artery bypass grafting to totally arterial coronary artery bypass and its effects on the incidence and severity of postoperative stroke. Heart Surg Forum 14:E73-80.

Barbut D, Yao FF, Lo Y, et al. 1997. Determination of size of aortic emboli and embolic load during coronary artery bypass grafting. Ann Thorac Surg 63:1262-7.

Boschetto P, Beghe B, Fabbri LM, Ceconi C. 2012. Link between chronic obstructive pulmonary disease and coronary artery disease: implication for clinical practice. Respirology 17:422-31.

Bridgewater B, Keogh B. 2008. On behalf of the Society for Cardiothoracic Surgery in Great Britain & Ireland. Sixth National Adult Cardiac Surgical Database Report.

Clark RE. 1994. Definitions of terms of The Society of Thoracic Surgeons National Cardiac Surgery Database. Ann Thorac Surg 58:271-3.

Daganou M, Dimopoulou I, Michalopoulos N, et al. 1998. Respiratory complications after coronary artery bypass surgery with unilateral or bilateral internal mammary artery grafting. Chest 113:1285-9.

De Paulis R, de Notaris S, Scaffa R et al. 2005. The effect of bilateral internal thoracic artery harvesting on superficial and deep sternal infection: The role of skeletonization. J Thorac Cardiovasc Surg 129:36-43.

Dorman MJ, Kurlansky PA, Traad EA, Galbut DL, Zucker M, Ebra G. 2012. Bilateral internal mammary artery grafting enhances survival in diabetic patients: a 30-year follow-up of propensity score-matched cohorts. Circulation. 126:2935-42.

Farinas JM, Carrier M, Hébert Y, et al. 1999. Comparison of long-term clinical results of double versus single internal mammary artery bypass grafting. Ann Thorac Surg 67:466-70.

Fuster RG, Argudo JA, Albarova OG. 2006. Prognostic value of chronic obstructive pulmonary disease in coronary artery bypass grafting. Eur J Cardiothorac Surg 29:202-9.

Gardner SC, Grunwald GK, Rumsfeld JS, et al. 2001. Risk factors for intermediate-term survival after coronary artery bypass grafting. Ann Thorac Surg 72:2033-7.

Geraci JM, Rosen AK, Ash AS, McNiff KJ, Moskowitz MA. 1993. Predicting the occurrence of adverse events after coronary artery bypass surgery. Ann Intern Med 118:18-24.

Grover FL, Johnson RR, Marshall G, Hammermeister KE. 1993. Factors predictive of operative mortality among coronary artery bypass subsets. Ann Thorac Surg 56:1296-307.

Güler M, Kirali K, Toker ME, et al. 2001. Different CABG methods in patients with chronic obstructive pulmonary disease. Ann Thorac Surg 71:52-7.

Hannan EL, Wu C, Bennett EV, et al. 2006. Risk stratification of in-hospital mortality for coronary artery bypass graft surgery. J Am Coll Cardiol 47:661-8.

Higgins TL, Estafanous FG, Loop FD, Beck GJ, Blum JM, Paranandi L. 1992. Stratification of morbidity and mortality outcome by preoperative risk factors in coronary artery bypass patients. A clinical severity score. JAMA 267:234-8.

Itagaki S, Cavallaro P, Adams DH, Chikwe J. 2013. Bilateral internal mammary artery grafts, mortality and morbidity: an analysis of 1526360 coronary bypass operations. Heart 99:849-53

Kurlansky PA, Traad EA, Dorman MJ, Galbut DL, Zucker M, Ebra G. 2010. Thirty-year follow-up defines survival benefit for second internal mammary artery in propensity-matched groups. Ann Thorac Surg 90:101-8.

Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. 1999. Hospital Infection Control Practices Advisory Committee. Guideline for prevention of surgical site infection, 1999. Infect Control Hosp Epidemiol 20:250-78.

Mohammadi S, Dagenais F, Voisine P, et al. 2014. Lessons learned from the use of 1,977 in-situ bilateral internal mammary arteries: a retrospective study. J Cardiothorac Surg 9:1-8.

Nashef SA, Roques F, Michel P, Gauducheau E, Lemeshow S, Salamon R. 1999. European system for cardiac operative risk evaluation (EuroSCORE). Eur J Cardiothorac Surg 16:9-13.

Online STS Risk Calculator. Available at: http://riskcalc.sts.org. Accessed October 10, 2015.

Roques F, Nashef SA, Michel P, et al. 1999. Risk factors and outcome in European cardiac surgery: analysis of the EuroSCORE multinational database of 19030 patients. Eur J Cardiothorac Surg 15:816-23.

Shroyer AL, Coombs LP, Peterson ED, et al. 2003. The Society of Thoracic Surgeons: 30-day operative mortality and morbidity risk models. Ann Thorac Surg 75:1856-64.

Tabata M, Grab JD, Khalpey Z, et al. 2009. Prevalence and variability of internal mammary artery graft use in contemporary multivessel coronary artery bypass graft surgery: analysis of the Society of Thoracic Surgeons National Cardiac Database. Circulation 120:935-40.

Tatoulis J. 2013. Total arterial coronary revascularization: patient selection, stenoses, conduits, targets. Ann Cardiothorac Surg 2:499-506.