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Left thoracotomy approach for off-pump coronary artery bypass grafting surgery: 15 years of experience in 2500 consecutive patients

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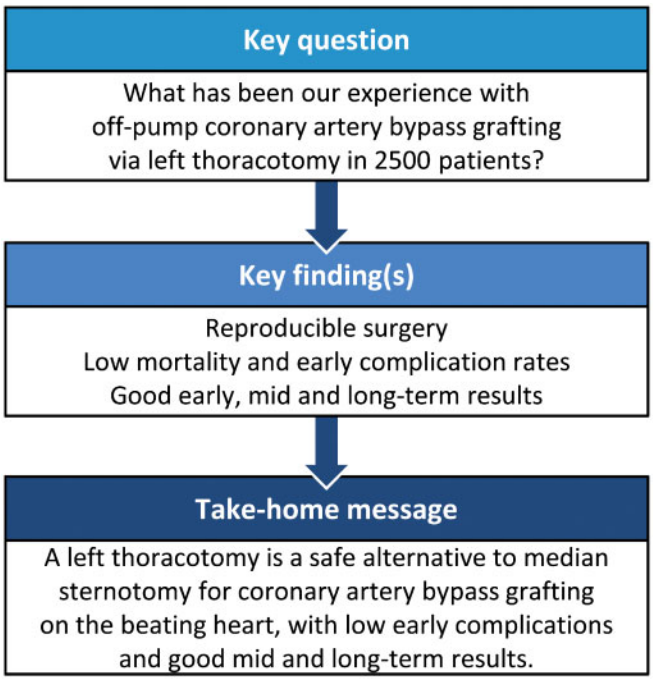

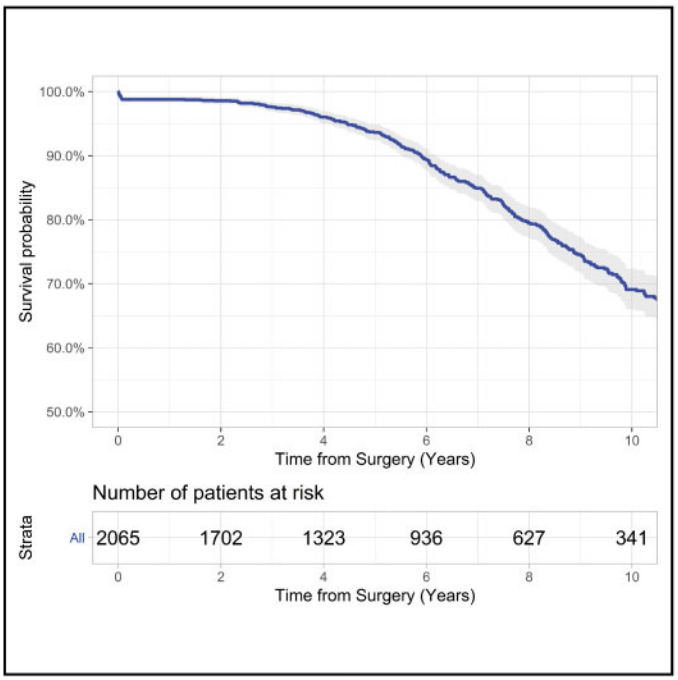

Abstract

OBJECTIVES: Our goal was to describe the experience at 2 centres with off-pump coronary artery bypass grafting using a left thoracotomy.

METHODS: From January 2002 to December 2017, a total of 2528 consecutive patients (578 women, mean age 62.3 ± 9.1 years) were operated on using this technique. Data were collected prospectively and analysed retrospectively.

Presented at the 32nd Annual Meeting of the European Association for Cardio-Thoracic Surgery, Milan, Italy, 18–20 October 2018.

RESULTS: There were no conversions to median sternotomy and 6 patients (0.2%) were converted to on-pump CABG. The mean number of grafts per patient was 2.8 ± 0. 9. The 30-day mortality rate was 1.0% (25 patients). Most patients were extubated in the operating theatre (97.3%), and 47 patients (1.9%) needed re-exploration for bleeding. Seven patients (0.3%) experienced a cerebrovascular event; 4 (0.3%) had a postoperative myocardial infarction; and 84 (3.4%) had new-onset atrial fibrillation. A total of 1510 patients (61.1%) were discharged from the hospital in the first 48 h after surgery. Long-term survival rates were 98.8%, 93.6% and 69.1% at 1, 5 and 10 years, respectively (central image). During the follow-up period, 60 patients (2.9%) were re-examined for recurrence of angina with a new coronary angiogram; of those, 24 (1.2%) required percutaneous coronary intervention and 11 (0.5%) had redo surgery.

CONCLUSIONS: A left thoracotomy is a safe alternative to a median sternotomy for coronary artery bypass grafting on the beating heart, with low early complications and good mid- and long-term results.

Keywords: Off-pump • Minimally invasive • Coronary • Survival

INTRODUCTION

A median sternotomy remains the standard approach for coronary artery bypass grafting (CABG) [1]. One of the most feared complications related to this approach is sternal dehiscence with the potential for mediastinitis, which carries an incidence of mortality between 1.4% and 3.6% despite modern, more advanced treatments [2].

To avoid this complication, many alternative approaches to full sternotomy have been proposed such as video-assisted coronary bypass grafting [3], 3rd intercostal space anterior thoracotomy (Dresden technique) [4] and minimally invasive left anterior thoracotomy [5]. Most of these techniques, however, do not allow for total revascularization unless they are combined with percutaneous coronary intervention (PCI) as a hybrid revascularization procedure [6]. However, hybrid revascularization poses challenges of its own, such as the difference of post-procedure protocols between CABG and PCI [7] and the increased risk of bleeding associated with the increased use of anticoagulation [8]. In addition, this procedure can be significantly more expensive than a single intervention [7].

Although avoiding cardiopulmonary bypass has shown some advantages, especially in high-risk patients [9], this technique has been associated with lower rates of complete revascularization and poor long-term outcome compared with conventional on-pump CABG [10], which remains a problem.

This situation led our group to pursue the development of the left thoracotomy approach, a technique that would avoid the complications of sternotomy and permit the performance of off-pump multivessel revascularization with minimal displacement of the heart [11, 12].

MATERIALS AND METHODS

Patients and data collection

This study is a retrospective analysis of prospectively collected data from a cohort of patients from 2 different regional cardiac surgical units: Fundacardio Foundation at the Hospital Metropolitano del Norte in Valencia, Venezuela (centre A, 1404 patients) and Ascardio Foundation in Barquisimeto, Venezuela (centre B, 1124 patients). Between May 2002 and December 2017, 2528 consecutive patients underwent elective or urgent/emergency CABG via a left thoracotomy.

Data were collected prospectively and analysed retrospectively. Long-term follow-up was obtained with annual outpatient visits and was available for 2067 patients (81.8%).

Operative technique

The initial operative technique previously reported [11] has undergone changes over the years. At the beginning of our experience, the patient was positioned in a lateral position because we approached the heart through a 4th/5th intercostal space with a full posterolateral thoracotomy; our primary aim was to avoid a median sternotomy and achieve good exposure. The approach to the ascending aorta for the proximal vein graft anastomosis was a challenge as was the use of bilateral internal thoracic arteries.

In our current technique, the patient is positioned 30 degrees laterally with the left arm gently elevated. The upper and lower sides of the incision are injected with 20–40 ml of 0.25% bupivacaine solution at the beginning and end of the procedure for pain management. An anterior thoracotomy (7–12 cm) is carried out and the chest is entered in the 5th intercostal space (Fig. 1). This step allows revascularization of both the left- and right-sided territories without excessive displacement of the heart. Access to the ascending aorta is achieved using pericardial suspension sutures placed on the right side of the pericardium close to the aorta to provide enough traction to perform the anastomosis (Fig. 2). Harvesting of the left internal thoracic artery (LITA) is performed under direct vision using diathermia with a long tip extension and a special bayonet forceps (CERAMO® PLANO-S, Fehling Instruments, Karlstein, Germany). After the LITA is harvested, systemic heparin is administered aiming for an activated clotting time above 350 s. The LITA is then clipped distally,

Figure 1: Surgical incision.

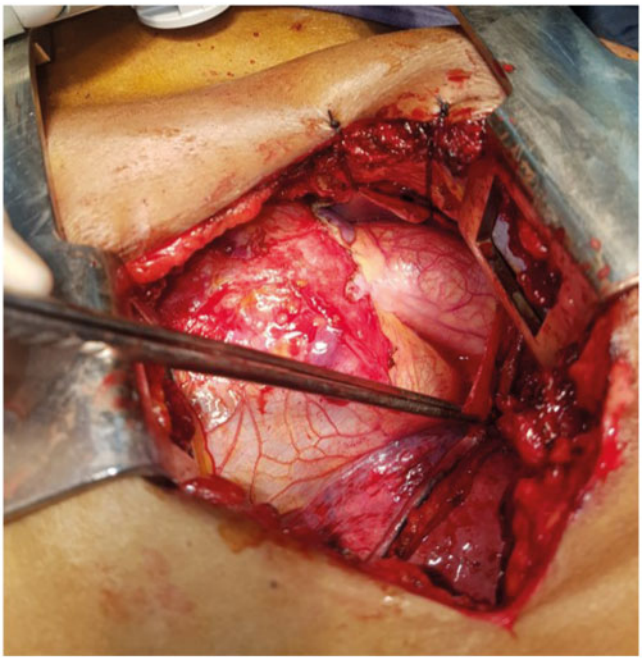

Figure 2: Exposure of the aorta and pericardial suspension.

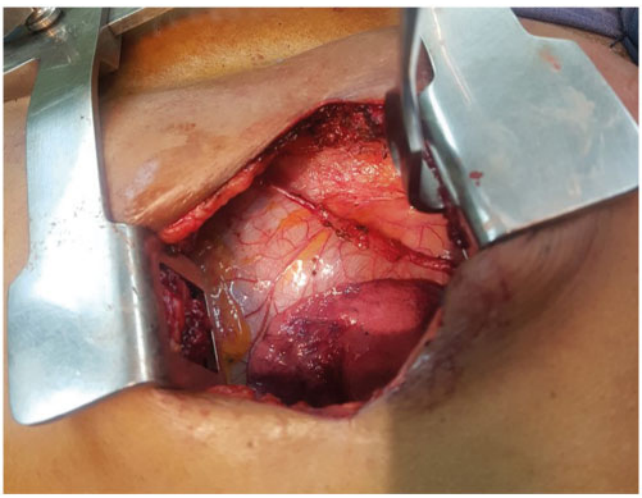

Figure 3: Harvesting of the left internal thoracic artery.

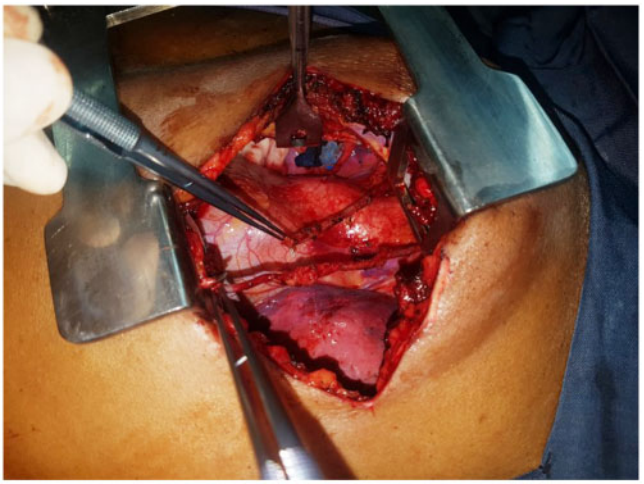

Figure 4: Harvesting of the left and right internal thoracic arteries.

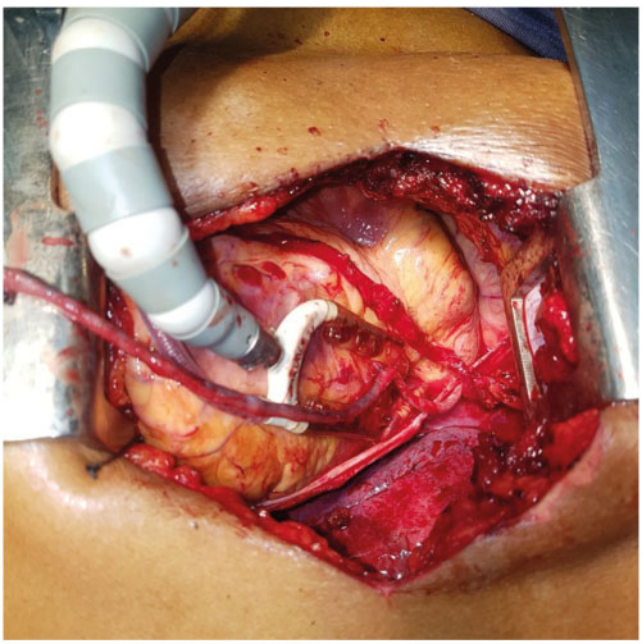

Figure 5: Anastomoses of the left internal thoracic artery to the intermediate and the right internal thoracic artery to the left anterior descending artery.

transected and gently sprayed with papaverine solution (Fig. 3). The right pleura is then opened, and 2 lap sponges are placed to gently retract the right lung and improve visualization of the right internal thoracic artery, which is then harvested in a skeletonized fashion using specially designed forceps (CERAMO® Guida Forceps, Fehling Instruments). The full length of the right internal thoracic artery is harvested (Fig. 4) and can be used as an *in situ* graft, a 'y' graft with LITA or, when extending its length, with a radial artery or a great saphenous vein graft for sequential grafting.

Once both ITAs are harvested, if we are performing an aorta-touch technique, the proximal anastomoses are done first. Access to the aorta is facilitated by partially opening the pericardium and utilizing 4 pericardial suspension sutures as described previously. The distal anastomoses are performed on the beating heart with a standard stabilizer, starting from the left anterior descending artery, the diagonal, the intermediate, the obtuse marginal and lastly the posterior descending artery or the right coronary artery. After opening the coronary artery, an intracoronary shunt is introduced in the lumen. The distal anastomoses (Fig. 5) are performed with a single running 7-0 or 8-0 polypropylene suture. Graft quality is routinely checked using transit time flow measurement (VeriQ™, Medistim, Oslo, Norway). Heparin is reversed, and 2 thoracic silicone drains are placed (Blake, Ethicon, Somerville, NJ, USA) on the left pleura and on the right across the mediastinum with care to avoid the grafts. The thoracic incision is closed in a standard manner.

Our goal is to routinely extubate patients on the operating table as part of our fast-track protocol prior to transferring them to the intensive care unit.

Once they are discharged, patients are routinely monitored during the first week after surgery at least twice a day by our team of visiting nurses. Patients are then followed up in the

Table 1: Preoperative characteristics

Variables	Centres A and B ($n = 2528$)	Centre A, n (%)
Age (years), mean ± SD (range)	63.3 ± 9.1 (28–90)	
Sex, n (%)		
Female	578 (22.9)	
Male	1947 (77.1)	
Poor EF ≤30%		128 (9.5)
Hypertension		1249 (91.5)
DM		571 (41.8)
CKD		170 (12.4)
Previous MI		616 (45.1)
Previous stroke		13 (0.9)
NYHA class III/IV		281 (20.8)
Previous PCI		101 (10.3)
PVD		167 (12.2)
Left main disease		343 (25.1)
Redo cardiac surgery		48 (3.5)
EuroSCORE, mean ± SD	3.73 ± 3.14	
Logistic EuroSCORE, mean ± SD	4.58 ± 7.56	

Data available only from centre A (Fundacardio Foundation) are specified in the centre A column; the rest of the data is available from both centres. Percentage is calculated on the available data without counting missing values.

CKD: chronic kidney disease; DM: diabetes mellitus; EF: ejection fraction; MI: myocardial infarction; NYHA: New York Heart Association functional classification; PCI: percutaneous coronary intervention; PVD: peripheral vascular disease; SD: standard deviation.

Table 2: Early postoperative characteristics

Variables	Centres A and B ($n = 2528$), n (%)	Centre A, n (%)
Re-exploration for bleeding	47 (1.9)	
Extubated in the OR		1321 (97.3)
Postoperative MI		4 (0.3)
New onset of AF	84 (3.4)	
New neurological impairment	7 (0.3)	
30-Day mortality rate	25 (1.0)	
ICU length of stay (h)		
≤24	2387 (95.7)	
>24 ≤ 48	92 (3.7)	
>48	14 (0.6)	
Hospital length of stay (h)		
≤48	1510 (61.1)	
>48 ≤ 72	830 (33.6)	
>72	132 (5.3)	

Data available only from centre A (Fundacardio Foundation) are specified in the centre A column; the remaining data are available from both centres. Percentage is calculated on the available data without counting missing values.

AF: atrial fibrillation; ICU: intensive care unit; MI: myocardial infarction; OR: operating room.

outpatient clinic at 1 and 2 weeks, 1, 2 and 6 months and then at yearly intervals.

Outcome measures and definitions

The 30-day mortality rate was defined as death by any cause that occurred at any time during the first 30 days after surgery. New neurological impairment was defined as a new postoperative stroke identified clinically and/or by computed tomographic scan that happened during the postoperative course and was determined to be a permanent neurological impairment. In addition, we collected generic data regarding in-hospital outcomes including reopening for bleeding, atrial fibrillation and duration of hospital stay. Major adverse cardiovascular events were defined as death from any cause or repeated revascularization or new major neurological event. Furthermore, we assessed 1-, 5- and 10-year survival rates, which were defined as death from any cause.

Statistical analyses

Data are presented as mean ± 1 SD for numerical continuous variables and as total number and percentages for categorical variables. Survival analysis was conducted using Kaplan–Meier methods. A parsimonious multiple logistic regression model was done to identify the independent predictors for operative mortality: This model was run only on the patients from centre A ($n = 1404$) due to lack of some preoperative variables for those from centre B. The statistical software used was R version 3.5.0, R Core Team (2018) (R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/).

RESULTS

From January 2002 to December 2017, 2528 consecutive patients (578 women, mean age 62.3 ± 9.1 years) underwent coronary artery bypass surgery on the beating heart using the left thoracotomy approach. Baseline characteristics are presented in Table 1 and early postoperative outcomes are shown in Table 2. Total arterial revascularization was achieved in 373 patients (14.7%) and only venous graft revascularization in 115 patients (4.5%). The remaining patients received a combination of arterial and venous grafts. The average number of grafts was 2.8 ± 0.9: 212 patients received 1 graft (8.3%); 479 patients, 2 grafts (18.9%); 1364 patients, 3 grafts (53.9%); and 439 (17.4%) patients had more than 3 grafts (data were not available for 40 patients).

There was no conversion to median sternotomy, and 6 patients (0.2%) were converted to on-pump CABG (2 for anaphylactic reaction to protamine and 4 for haemodynamic instability). The overall 30-day mortality rate was 1.0% (25 patients).

After multiple logistic regression modelling (with backwards selection), only 3 variables were identified as independent predictors of short-term mortality: female gender [odds ratio 9.2, 95% confidence interval (CI) 3.2–30.6; $P < 0.01$]; reoperation (odds ratio 4.5, 95% CI 0.66–18.3; $P = 0.06$); and reduced left ventricular ejection fraction (odds ratio 6.1, 95% CI 2.1–19.02; $P < 0.01$).

Most patients had a fast-track protocol and were extubated in the operating theatre (97.3%), with 47 patients (1.9%) requiring re-exploration for bleeding. Seven patients (0.3%) experienced a cerebrovascular event, 4 (0.3%) had a postoperative myocardial infarction and 84 (3.4%) had new-onset atrial fibrillation. A total of 1510 patients (61.1%) were discharged from the hospital in the first 48 h post-surgery. Readmission to the hospital in the first 30 days from discharge was 0.5%. Long-term survival rates were 98.8%, 93.6% and 69.1% at 1, 5 and 10 years, respectively. During the follow-up period, 60 patients (2.9%) required new coronary angiograms; of those, 24 patients (1.2%) required PCI and 11 (0.5%) had redo surgery (Table 3).

Table 3: Mid- and long-term follow-up

Variables	Patients from both centres (n = 2023), n (%)
New angiogram	60 (2.9)
MACCE	63 (3.1)
Redo-CABG	11 (0.5)
Redo-PCI	24 (1.2)
Late mortality	328 (15.8)[a]

Percentage is calculated on the available data without counting missing values.

[a]Survival data were available for 2067 patients (81.8%).

CABG: coronary artery bypass grafting; MACCE: major adverse cardiovascular and cerebrovascular events; PCI: percutaneous coronary intervention.

DISCUSSION

This study provides evidence that coronary artery bypass on the beating heart via a left thoracotomy is safe, with good early mid- and long-term outcome while avoiding the morbidity associated with median sternotomy. Using a relatively small incision, it is possible to mobilize both internal thoracic arteries and gain access to the ascending aorta to perform a proximal graft anastomosis. The displacement of the heart is minimal for distal coronary grafting, thereby reducing haemodynamic and electrical instability. This fact, combined with our fast-track protocol, allowed us to extubate most of the patients in the operating theatre. We were also able to discharge most patients in the first 48 h postoperatively by a combination of early extubation, mobilization and pain control, associated with close home visits by our team of nurses.

Our early and mid-term outcomes compare favourably with those of previously published large case reports and prospective randomized trials on patients having conventional sternotomy on-pump or off-pump CABG [13–15] and minimally invasive CABG [16, 17].

The slightly inferior long-term results of our cohort may be explained by the fact that our patients have the socioeconomic and health provision status of people living in a developing country [18].

Other groups have proposed that the left thoracotomy approach reduces the morbidity associated with conventional sternotomy but also may reduce postoperative pain and facilitate a quicker return to normal life activities [13–15]. However, concern remains about the applicability of the technique and the possibility of increased postoperative pain from excessive rib retraction and the occasional fracture. In the only randomized clinical trial conducted of median sternotomy versus left lateral thoracotomy, the benefits of thoracotomy, reduced inflammatory response, shorter intubation times and fewer arrhythmias were offset by longer operations, a greater need for postoperative pain relief, worse lung function at discharge and higher costs [19]. Patients' quality of life at 12 months was also similar with the 2 procedures. These results were at odds with the benefits reported in observational studies. One possible explanation for this and for the main barrier to the implementation of the left thoracotomy technique is the learning curve, a problem that is shared with most minimally invasive techniques at centres that previously used a standard technique.

Of interest, whereas at Fundacardio Foundation all the procedures were performed by the senior surgeon, the second centre, Ascardio Foundation, is a teaching hospital and left thoracotomy is the routine approach for isolated CABG operations. This situation does not affect the development of junior surgeons because they receive hands-on training for this technique.

Limitations

This study has several limitations. First, its retrospective design (prospectively collected data) might be suggestive of residual bias and unconsidered factors.

Second, our patient cohort was treated over a long period, thus possibly introducing confounding factors owing to changes in clinical practice over time, such as advances in the surgical technique, changes in medical therapy and differences in the risk profile of patients referred for cardiac surgery.

Third, due to the long time period of this cohort the variable of completeness of revascularization was not available for the entire cohort, which is a variable that demonstrates feasibility of the technique.

Despite the changes in practice over time, the current technique is in line with the latest European Society of Cardiology/European Association for Cardio-Thoracic Surgery Guidelines on Myocardial Revascularization described in Section 15, Procedural aspects of coronary artery bypass grafting and Subsection 15.1.9, Minimally invasive and hybrid procedures [20].

CONCLUSION

In conclusion, the left thoracotomy is a safe alternative to median sternotomy for CABG on the beating heart, with low early complications and good mid- and long-term results.

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Conflict of interest: none declared.

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