Study of outcome of Minimal-access Off-pump multi-vessel CABG Using Bilateral Internal Thoracic Arteries

Sanjay Kumar[1], Pradeep Nambiar[2]

ABSTRACT

Introduction: Usage of Bilateral Internal Thoracic arteries (BITA) in CABG has shown excellent long term survival and a very low rate of reintervention. The use of BITA in patients with diabetes has been a matter of debate because of the risk of sternal wound infection. A multivessel minimally invasive off pump CABG technique has been developed using BITA through a sternal sparing approach.

Material and Methods: Over a period of 5 years from August 2011 to August 2016, off pump minimally invasive multivessel CABG using BITAs was performed on 819 patients through a 2 inch left minithoracotomy incision. The complete revascularization of the myocardium was done using the LITA-RITA Y composite conduit. Coronary artery stabilization for anastomoses was done by using epicardial stabilizers introduced through the minithoracotomy.

Results: 819 patients comprising of 753 (92%) diabetics, had minimally invasive total arterial myocardial revascularization using BITAS (LITA - RITA Y composite conduit) via a left minithoracotomy. 171 (21%) patients had 4 grafts and 557 (68%) had 3 grafts with an average number of grafts of 3.1. Ejection Fraction was 40.5 +/- 5.2%. 6 (0.7%) patients died and 5 (0.6%) had to be re-explored for bleeding. In 4 (0.4%) cases we opted for an early elective conversion to sternotomy due to hemodynamic instability. The harvesting time for RITA and LITA were 28.5+/-10.2 and 22.2 +/-7.6.minutes respectively. The overall operating time was 175.8+/-21.6 min. 651 patients (79%) were extubated in the operating room (OR). The total time in the OR (including extubation) was 295.5+/- 32.5 minutes. Most of the patient were discharged on third postoperative day. During follow up at 12 month, graft patency was assessed using Coronary angiograms in 195 (23%), CT angiograms in 172 (21%) patients. All these grafts were patent. 284 patients (34%) had normal stress test. Reintervention angioplasty was needed in 4 patients (0.4%).

Conclusions: The early outcomes of Minimal access OPCAB using BIMA have been good and coronary angiograms showed widely patent grafts. This technique is a safe and reproducible option in coronary artery bypass grafting. It is less invasive and offers safe usage of bilateral internal thoracic arteries with its associated benefits, without related complications of a median sternotomy, especially in diabetics.

Keywords: Outcome of Minimal-access, Multi-vessel CABG, Thoracic Arteries

INTRODUCTION

Minimally invasive Coronary Artery Bypass Grafting through a left mini-thoracotomy on its own or associated with hybrid coronary revascularization is being increasingly adopted and seems to be a promising and safe procedure.[1,2] We have shown the feasibility harvesting of bilateral internal thoracic arteries (BITAs) under direct vision through a left mini-thoracotomy incision and usage of the harvested BITAS as a LITA – RITA Y composite conduit for total arterial revascularization with excellent early outcomes.[3] The aim was to show that total arterial revascularization via a left mini thoracotomy using BITAs was not only feasible but a safe and reproducible procedure with excellent mid-term outcomes.

MATERIAL AND METHODS

From August 2011 to August 2016, a total of 819 patients underwent minimally invasive total arterial coronary artery bypass grafting (CABG) through a 2.5-3 inch left mini thoracotomy incision. Both internal thoracic arteries were harvested under direct vision and complete revascularization was done using the LITA-RITAY composite conduit, followed by flow study of the grafts. Patients with left main stem disease and low ejection fraction <25% had an Intra-Aortic Balloon Pump inserted prior to induction of anaesthesia. Patients with low ejection fraction and a dilated LV were grafted on an empty beating heart using the peripheral Femoro-Femoral cardio-pulmonary bypass methodology. Intra operative assessment of grafts was done using Transit Time Flowmetry (TTFM) and postoperative graft patency was checked using Coronary angiograms, CT Coronary angiograms or Stress test. Patients with pectus excavatum and severe chronic obstructive pulmonary disease with room air Po2 < 60 were exclusion criteria for the procedure. All patients had both internal thoracic arteries studied during coronary angiogram preoperatively. Preoperative characteristics are detailed in Table 1.

The patients were placed in a supine position. The left side of the chest is elevated to approximately 30 degrees. The non-dominant arm is tested for normal modified Allen test preoperatively. This arm is not used for any arterial cannulation and kept abducted and draped on the table in case the radial artery was required. The patients were intubated with a double-lumen endotracheal tube for single-lung ventilation, and standard invasive monitoring with arterial line, pulmonary artery catheter, and transesophageal echocardiography was done. In patients with either significant left main stem disease or poor LV function (EF <25%) an Intra-Aortic Balloon Pump was inserted prior to induction of anaesthesia. A vascular Doppler and skin-marking pencil were used in surface marking of the RITA and the LITA. In the 5th left intercostal space two fingerbreadths lateral to the LITA surface

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marking, 2.5 – 3 inch left inframammary incision was made to enter the thoracic cavity. We used a minimal access intercostal retractor (Fehling Inc) to spread the ribs. The pericardium was opened in an inverted T fashion to inspect the coronary arteries. A Thorac-Pro internal thoracic artery (ITA) (Fehling Surgical Instruments Inc., Karlstein, Germany) retractor was then used in tandem with the minimal access intercostal retractor, and the chest was elevated [Figure 1b]. The left hemi thorax was thoroughly inspected, and flow in the LITA was studied with a vascular Doppler. The fatty attachments between the pericardium and the sternum were completely divided, and on dissecting the pleural from the endothoracic fascia of the right chest wall, the RITA was well visualized.

We made a 0.5-in subxiphoid incision to insinuate a langenbeck retractor on the undersurface of the sternum. A traction with a Rultract ITA retractor elevated the lower third of the sternum. This manouvre greatly enhanced visualization of the distal end of the RITA. We used this same incision to insert a pleural drain. [Figure 1b].

We open the right pleura widely. This helps in having access to the circumflex vessels by positioning heart without any hemodynamic compromise. The cautery is used at a very low setting to harvest RITA in a skeletonized fashion from the subclavian vein proximally to its distal bifurcation. The harvested RITA length was more than adequate to reach the right coronary-posterior descending artery. Subsequently, the LITA was harvested in a standard manner. Following pericardiotomy, the left anterior descending artery was exposed. The pericardial incision was extended to the diaphragm and to the phrenic nerve on the left side and as far as possible to the right for the exposure of the lateral and inferior wall vessels. After heparinization, a LITA-RITA Y composite conduit was constructed, and this was used for complete myocardial revascularization by the off-pump CABG technique using only the Guidant Acrobat coronary artery stabilizer [Figure 1c]. Patients with low ejection fraction and a dilated LV were grafted on an empty beating heart using the peripheral Femoro –femoral cardio pulmonary bypass methodology. Intra op assessment of grafts was done using Transit Time Flow Metry (TTFM).

We used traction sutures on the pericardial edges and rotate the operating table to right to facilitate the positioning of the heart. We first anastomosed the LITA to the LAD and to diagonal when needed. It was followed by the RITA Y for sequential grafting of the circumflex and inferior wall vessels [Figure 1c].

Most of the patients were extubated on the table and were mobilized within an hour of return from the operating room (OR). Analgesia was optimized using a low dose fentanyl infusion for the first 12 – 24 hours along with oral analgesics. Depending on the hemodynamic status, we removed invasive monitoring lines and chest drains on the first or second postoperative day. Most of the patients were discharged on the third post- operative day.

RESULTS

819 patients had minimally invasive total arterial myocardial revascularization using BITAS (LITA - RITA Y composite conduit) via a left mini-thoracotomy. 171 (21%) patients had 4 grafts and 557 (68%) had 3 grafts with mean number of grafts was 3.1. EF was 40.5 +/- 5.2. EF was 40.5 +/- 5.2. Intra operative TTFM was done in 703 patients totaling 2390

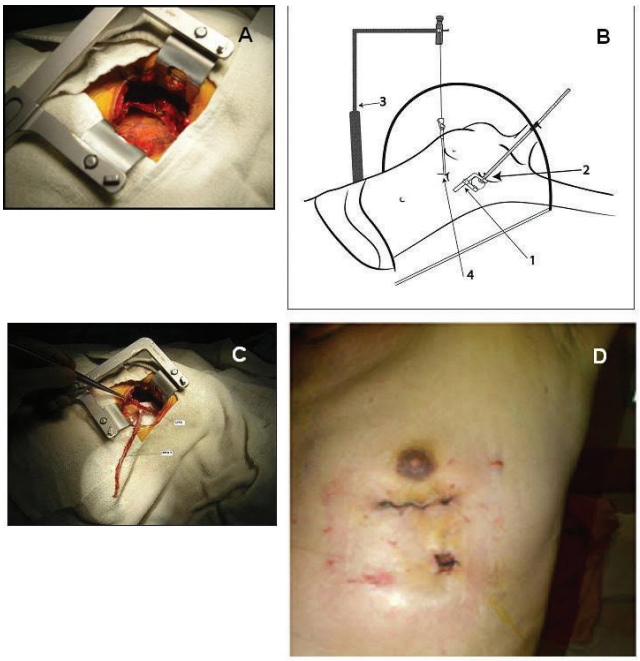

Figure-1: (A) Left minithoracotomy. (B). Line drawing: positioning of the MICS instruments and the Rultract retractor for harvesting the BITAs. The instruments have been numbered: 1, MICS-CABG intercostal retractor; 2, Thorac-Pro ITA retractor; 3, Rultract retractor; 4, Rultract retractor elevating the lower end of the sternum via a subxiphoid incision. BITAs indicate bilateral internal thoracic arteries; ITA, internal thoracic artery; MICS-CABG, Minimally invasive coronary surgery- Coronary artery bypass grafting; (C). LITA –RITA Y (Left Internal Thoracic Artery –Right Internal Thoracic Artery Y Composite Conduit; (D). Minithoracotomy wound closed

grafts and 10 (0.4%) grafts had to be revised. There were 6 deaths (0.7%). Five patients died due to sepsis and multi-organ failure and two died because of acute renal failure. 4 (0.4%) had an elective conversion to sternotomy due to hemodynamic instability. 5 patients (0.6%) had re-exploration for bleeding. 4 (0.4%) patients required re intervention angioplasty. 80 (9.8%) patients had critical left main stem disease and 36 (4.5%) with poor LV function (<25%) were operated. All patients with significant LMS had an Intra-Aortic Balloon Pump (IABP) inserted prior to induction of anaesthesia and patients with poor LV function (<25%) and dilated hearts had their grafting done on an empty beating heart with cardio pulmonary bypass established via femoro - femoral peripheral cannulation. Overall operating time was 175.8+/-21.6 min. The RITA and LITA harvest times were 28.5+/- 10.2 and 22.2 +/-7.6. minutes respectively. 651 patients (79%) were extubated on the table. The total time in the operating room (including extubation) was 295.5+/- 32.5 minutes. The incidence of postoperative atrial fibrillation and pleural effusion was minimal in our study. The strategy for prevention of postoperative atrial fibrillation was as follows: intravenous (IV) bolus of 150 mg of amiodarone before the initial anastomosis followed by another IV bolus of 150 mg amiodarone and 2 grams of IV magnesium sulphate at completion of revascularization. We continued an infusion of 900 mg of amiodarone for 24 hours in the postoperative period. We monitor QT intervals regularly in the postoperative ECG. The average hospital stay was 3.1 days. The patients were discharged on 200 milligrams of oral amiodarone twice a day to

be continued for a week.

798 patients (89%) had complete follow-up was complete with mean period of follow-up was 12.8 months (range 5 – 20.5 months. 99.3% of patients were free from major adverse cardiac and cerebrovascular events. Imaging studies were done at 12 months to check for graft patency. As majority of the patients who underwent surgery were feeling well and had no complaints, only 195 (23%) consented for an angiogram. 172 (21%) patients opted for a Coronary CT angiogram and 284 (34%) consented for a stress test. 6 (0.8%) patients had recurrence of angina among phase 2 patients and required reintervention angioplasty. Rest of the grafts studied by Coronary angiogram and computed tomographic angiogram were patent and the stress test done showed normal results. There was no late mortality. Distribution of conduits and the target vessels is detailed in Table 2 and operative characteristics and results are shown in Tables 3

DISCUSSION

Calafiore and colleagues popularized minimally invasive CABG through a small left anterior thoracotomy and reported the largest series, extending the indication to patients with multivessel coronary disease.[4] McGinn et al have shown that in MICS CABG, applicability, revascularization completeness, morbidity profile, and safety were excellent and were maintained despite rapid procedural adoption.[5]

No. patients	819
Male/female	572/247
Age, mean +/- SD (range)	64.5 +/- 8.5 (32 – 91)
Weight	60 – 150 Kg
EF, mean +/- SD	40 +/ - 5.2
Critical LMS + preop IABP	80 (9.8%)
Poor LV function + preop IABP (<25%)	36 (4.5%)
Diabetic	753 (92%)
Prior MI	442 (54%)
COPD	101 (12.3%)
PVD	94 (11.5%)
Renal dysfunction	52 (6.35%)
Neurologic (CVA/TIA)	15 (1.83%)
BMI, mean	27.3

BMI indicates body mass index; COPD, chronic obstructive pulmonary disease; EF, ejection fraction; IABP, intra-aortic balloon pump; LMS, left main stem; LV, left ventricular; MI, myocardial infarction; preop, preoperative; PVD, peripheral vascular disease.

Table-1: Preoperative Characteristics

Usage of BITAs in CABG has shown improved survival and increased freedom from reintervention.[6] Total arterial revascularization with composite arterial grafts has clearly improved the midterm and long-term outcomes.[7] However, the use of BITAs has not been optimal in CABG because of increased incidence of sternal complications especially in patients with diabetes.[18]

Subramanian and colleagues reported BITA harvesting with robotic assistance and minimal access multivessel coronary artery bypass.[8] Robotic assistance greatly enhances visualization and thereby results in harvesting longer lengths of conduits, which is essential for multivessel grafting.[10,11] In our study, we made a 0.5-in subxiphoid incision through which a langenbeck retractor was insinuated on the undersurface of the sternum and

Operative Characteristics	
No. grafts, mean	3.1
4 grafts	171 (21%)
3 grafts (LITA-RITAY)	558 (68%)
2 grafts (LITA-RITAY)	66 (8%)
1 graft (LITA-RITAY)	24 (3%)
Time for RITA harvest, mean +/- SD, min	28.5 +/- 10.2
Time for LITA harvest, mean +/- SD, min	22.2 +/- 7.6
Total time in OR (including extubation Mean +/- SD, min	295.5 +/- 32.5 min
Total operating time, mean +/- SD, min	175.8 +/- 21.6
Extubation in OR	651 (79%)
Conversion to sternotomy	4 (0.4%)
Postoperative Results	
Mortality	6 (0.7%)
Re-exploration for bleeding	5 (0.6%)
Postoperative AF	21 (2.56%)
Blood transfusion, mean +/- SD, U	0.4 +/- 0.05
Hospital stay	3.1 d (mean)
Graft patency data	
Coronary angiogram,	195 (23%)
CT angiogram,	172 (21%)
Stress test,	284 (34%)
Reintervention (Angioplasty)	4 (0.4%)

LITA indicates left internal thoracic artery; LITA-RITA Y, left internal thoracic artery right internal thoracic artery Y composite conduit; OR, operating room; AF indicates atrial fibrillation; CT, computed tomographic.

Table-2: Operative, postoperative data and graft patency data

LITA-RITA Y				**LITA Radial Y**	
Target Coronary	**LITA**	**LAD / Diag**	**RITA Y Seq**	**Radial Y Seq**	**Saph.Vein**
LAD	819	818	--	--	1
Diagonal	79	79	--	--	--
Ramus	128	--	122	6	--
OM	572	--	566	4	2
Distal CX	229	--	227	2	--
PDA	646	--	638	4	4
Distal right	36	--	36	--	--

Coronary artery targets are greater than 1.25 m. Total number of grafts, 2516; Mean number of grafts, 3.4

CX indicates circumflex artery; LAD, left anterior descending artery; LITA, left internal thoracic artery; LITA-RITA Y, left internal thoracic artery- right internal thoracic artery Y composite conduit; OM, obtuse marginal artery; PDA, posterior descending artery; RITA, right internal thoracic artery.

Table-3: Distributions of Conduits and Target Vessels

traction was given using a Rultract ITA retractor. This manouvre enhanced visualization of the lower thirds of the RITA and the LITA and also increased the space required for manipulation of the heart. The elevation of the undersurface of the sternum helps in manipulations of minimal access instruments within the thorax and visualization of distal ends of both the RITA and the LITA. We could harvest conduits of more than adequate length for complete arterial revascularization. A pleural drain was inserted through epigastric incision. Our sternal sparing approach obviates the risk of wound dehiscence in our predominantly diabetic cohort of patients.

Using conventional video assisted thoracoscopic instruments harvesting of ITAs has limitations of lack of precision and instrumentation issues.[8] The introduction of robots has added to the total endoscopic harvest of the ITAs; however, the limitations have been the cost factor, availability, and steep learning curve.[9]

The technique of minimal access multivessel CABG has been described using peripheral arterial cannulation and cardioplegic arrest.[12,13] Our technique encompassed a method in which through a 2-in left mini-thoracotomy, BITAs of adequate length were conveniently harvested in a skeletonized manner under direct vision. LITA- RITA Y composite graft was used for total arterial off-pump complete myocardial revascularization. This grossly reduced the invasiveness and complications associated with sternotomy.

We have used the Maquet Acrobat Suv coronary artery stabilizer for stabilization and positioning of all coronary targets. Vassiliades et al has used port-access stabilizers for endoscopic CABG for LITA to left anterior descending artery anastomoses.[14] Our regular use of intraoperative transesophageal echocardiography and monitoring with Pulmonary artery catheter while positioning the heart for various grafts averts any hemodynamic instability.

Most of our patients were extubated in the operating room. We found that overall operating times was comparable or many a times better than standard CABG operating time. Initially in our series postoperative pain was controlled with paravertebral block using continuous sensoricaine infusion for 24 hours but a persistent hypotensive episode in one of the patients after sensoricaine infusion led us to change our practice and thereafter analgesia was optimized using a low dose fentanyl infusion for the first 12 – 24 hrs along with oral analgesics. The hospital stay was minimal, with the mean hospital stay being 3.1 days. This compares favorably with other studies.[6] Financial benefits for both the patient and the hospital were also observed. The early and midterm outcomes have been good, coronary angiograms/CT angiograms at 12 months have shown excellent graft patency and only four patients required rei-ntervention due to recurrence of angina.

Diegeler et al have shown minimally invasive direct coronary artery bypass grafting to be a safe procedure and have also shown this in patients with multiple-vessel coronary artery disease and for patients with severely reduced left ventricular (LV) function.[15] In our study, we have shown the safety of the technique as demonstrated by the low incidence of peri and post-operative morbidity and mortality. Patients with recent myocardial infarction or cerebrovascular accident or severe chronic obstructive pulmonary disease with pO2 of less than 60mm on room air arterial blood gas or moderate to severe renal dysfunction, are not suitable candidate for this technique.

In patients with left main stem disease and with very poor LV function (<25%) having multivessel disease, an Intra-Aortic Balloon Pump (IABP) was introduced before induction of anaesthesia to mitigate risk. Few of the patients with low ejection fraction had their grafting done on an empty beating heart with cardio pulmonary bypass established via the peripheral cannulation technique. (Femoro-Femoral Bypass). This technique, we feel, is reproducible; requires the same infrastructure for formal coronary bypass surgery, with the exception being the acquisition of minimally invasive cardiac surgical instrumentation; and can be done on an empty beating heart to aid in training.

The potential advantages of minimally invasive CABG using BITAS, include long-term survival benefit conferred by BITA grafts and elimination of the risk of sternal wound infection, in addition to the established advantages of minimally invasive coronary artery surgery. This approach has the potential for further optimization with hybrid revascularization strategies.[16] This technique is also safely reproducible as shown by Kikuchi et al.[16]

MICS-CABG and HCR are viable alternatives to conventional CABG, offering a less invasive approach to coronary revascularization. This may be especially beneficial to high-risk and diabetic patients and may be more easily adopted by surgeons due to a minimal investment with regard to training and facility acquisition.[17,18]

CONCLUSION

We feel that our technique will help optimize MICS and the use of BITAs with its associated benefits, without the invasiveness and related complications of a median sternotomy, especially in patients with diabetes. We found decreased patient mortality, morbidity, shorter hospital stay, early return to active life, good cosmesis and graft patency and excellent early and midterm outcomes. This technique can also be extended to patients with left main stem disease, poor LV function and can be done on an empty beating heart using peripheral cannulation for cardiopulmonary bypass.

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