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Minimally Invasive Total Arterial Coronary Artery Bypass Grafting in Left Main Stem Disease

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Abstract

Objective: The aim was to show that Minimally Invasive total arterial revascularization for left main stem coronary artery disease, via a left anterior Mini thoracotomy using bilateral internal thoracic arteries is feasible, reproducible and safe. Further, there has been no exclusive data or experience with minimally invasive coronary artery bypass grafting in left main stem disease. **Methods:** From April 2019 to March 2024, 41 patients with left main stem stenosis, left main equivalent disease and unprotected left main with triple vessel disease underwent off pump minimally invasive multivessel coronary artery bypass grafting using either *in situ* pedicled Bilateral Internal Thoracic arteries or Left and Right Internal Thoracic artery Y composite conduits at three centers. Bilateral Internal Thoracic arteries were harvested under direct vision. All patients had an Intra-Aortic Balloon Pump inserted via the femoral artery prior to induction of anesthesia, to prevent any hemodynamic instability, arrhythmias, and was removed following completion of the procedure in the operating room without any complications. Efficacy and outcomes were evaluated by i) Primary (MACCE)-Major Adverse Cardiac and Cardiovascular events and ii) Secondary outcome measures including total length of stay, return to full physical activity and quality of life. Mean follow-up was 1.4 years (Maximum was 2.5 years). **Results:** 41 patients with left main stem coronary artery stenosis, underwent total arterial revascularization using bilateral internal thoracic arteries. Left main stem stenosis was present in 29 patients, Unprotected left main stem stenosis with triple vessel disease in 7 and left main equivalence in 5 patients. In this cohort, 29 patients with only left main stem stenosis had 2 grafts each, 7 patients with left main and triple vessel disease had 3 grafts and 5 patients with left main equivalent disease had 2 grafts respectively. The average number of grafts was 2.2. One patient was

converted to open sternotomy as an emergency because of hemodynamic instability and myocardial revascularization was done on cardiopulmonary bypass (2.2%). The average hospital stay was 3.7 days. Ejection fraction was 45% ± 5%. There was one mortality (2.2%) but no major morbidity. The average ICU and hospital stay was 24 ± 4 hours and 3.7 days. All patients were free from major adverse cardiac and cerebrovascular events at follow-up. **Conclusions:** Multivessel total arterial revascularization using left and right internal thoracic arteries, was performed via a left anterior Mini thoracotomy on patients with left main stem disease and showed that it was safe, reproducible and will help extend the armamentarium of the surgeon in minimally invasive Coronary artery bypass grafting. Concomitantly it helped enhance the potential for shorter hospital stay, increased survival, decreased morbidity, and earlier return to full activity. Furthermore, the safety, efficacy, and outcomes of minimally invasive coronary artery bypass grafting in this high-risk group evaluated by primary and secondary outcome measures have been good in this study.

Keywords

Left Main Stem, Minimally Invasive CABG, Bilateral Internal Mammary Arteries

1. Introduction

The Left Main Stem (LMS) coronary artery is the most important coronary vessel in terms of myocardial blood supply and clinical outcomes. It has been shown, that in a right dominant coronary anatomy, the left coronary artery supplies approximately 84% of the flow to the left ventricle. Obstructive coronary artery disease (CAD) in the LMS is found in approximately 5% of patients with stable angina and in 7% of patients presenting with an acute myocardial infarction (AMI) [1]. Significant (defined as a greater than 50 percent angiographic narrowing) left main coronary artery disease (LMCAD) is found in 4 to 6 percent of all patients who undergo coronary arteriography [2] Left main stem stenosis can be treated by percutaneous coronary angioplasty and Coronary artery bypass grafting. Percutaneous coronary intervention was associated with higher all-cause, cardiac, and noncardiac mortality compared with CABG at 5 years. [3]. Minimally invasive Coronary artery bypass grafting (CABG) has been shown to be safe, reliable, and reproducible with good early and midterm outcomes [4] [5]. However, there has been no exclusive data or experience with minimally invasive coronary artery bypass grafting in left main stem disease and unprotected left main coronary artery (ULMCA). The aim was to show that Minimally Invasive total arterial revascularization for left main stem disease via a left anterior mini thoracotomy using bilateral internal thoracic arteries, is feasible, reproducible, and safe.

2. Material and Methods

A retrospective observational study was carried out on 41 patients with left main stem stenosis, left main equivalent disease and unprotected left main with triple vessel disease who underwent off pump minimally invasive total arterial Coronary artery bypass grafting from April 2019 to March 2024. The coronary artery bypass grafting was performed using either pedicled Bilateral Internal Thoracic arteries or Left and Right Internal Thoracic artery Y composite conduits. Bilateral Internal Thoracic arteries were harvested under direct vision. Efficacy and outcomes were evaluated by 1) Primary outcome measures i) MACCE (including death and a composite major cardiac and cardiovascular events 2) Hospitalization for repeat revascularization procedures and 3) Secondary outcome measures including i) Complete or functionable revascularization in the absence of complications during index hospitalisation ii) Intensive care unit stay iii) Length of postoperative stay iv) New onset Atrial fibrillation v) Wound infection vi) Procedural and post procedural blood loss vii) Quality of life measures.

3. Surgical Technique

- The patients were placed in a supine position, with slight elevation of the left side of the chest to approximately 30 degrees Intubation was done with a double-lumen endotracheal tube for single-lung ventilation, and standard invasive monitoring with arterial line, pulmonary artery catheter, and transesophageal echocardiography.
- Through a 3-inch left inframammary incision the thoracic cavity was entered through the left fifth intercostal space. The pericardium was opened in an inverted T fashion and the coronary arteries were inspected, after which the pericardiotomy was closed with interrupted 2-0 silk sutures
- The fatty attachments between the pericardium and the sternum were completely divided and on dissecting the pleura from the endothoracic fascia of the right chest wall, the Right internal thoracic artery was well visualized. Subsequently, the Right internal thoracic artery followed by the Left internal thoracic artery was harvested under direct vision. After heparinization a Left Internal thoracic artery—Right Internal Thoracic artery Y composite conduit was constructed or a pedicled Left and Right Internal thoracic artery was used for complete myocardial revascularization. Intra operative assessment of grafts was done using transit time flowmetry.

4. Configuration of Grafts

4.1. Left Main Stem Disease—29 Patients

- The Pedicled Right Internal Thoracic Artery was anastomosed to the Left anterior descending artery
- The Pedicled Left Internal Mammary Artery was anastomosed to the Intermediate /Obtuse Marginal or Distal Circumflex

This configuration was done to prevent Competitive flow between left anterior descending and obtuse marginal artery.

4.2. ULMCA—(Unprotected Left Main Coronary Artery)—7 Patients

- Left Internal Thoracic artery—Right Internal Thoracic Artery Y Composite Conduit wherein Left Internal thoracic artery was anastomosed to Left anterior descending artery and Right Internal thoracic artery Y was used sequentially to revascularize the Obtuse marginal and posterior descending artery.

4.3. Left Main with Triple Vessel Disease—5 Patients

- Left Internal Thoracic artery—Right Internal Thoracic artery y composite conduit wherein left internal thoracic artery was anastomosed to Left anterior descending artery and Right Internal thoracic artery Y was used sequentially to revascularize the Obtuse marginal and posterior descending artery.

4.4. Intra Op/Post Op Management

The majority of patients were extubated in the operating room or within an hour of transfer to the Intensive Care unit. The Intra-Aortic Balloon pump was removed in the operating room after the procedure and there were no complications. Analgesia was optimized using low dose fentanyl for 12 hours along with oral non-narcotic analgesics. All monitoring lines and chest drains were removed on the first or second postoperative morning depending on the hemodynamic status and drainage. All patients were discharged on the third or fourth post-operative day.

5. Results

A total of 41 patients with Left main stem coronary artery disease, (29 with Left main disease, 7 with Unprotected Left main coronary artery and 5 with Left main Equivalence) had off pump minimally invasive total arterial revascularization using Bilateral Internal thoracic arteries via a left anterior mini thoracotomy. (Table 1) Average number of grafts was 2.2. 5 patients had 3 grafts, 36 patients had 2 grafts. EF was 46 ± 5%. There was one mortality (2.4 %), cause of death was acute renal failure followed by multi organ failure. The Right Internal Thoracic Artery and Left Internal Thoracic artery harvest times were 28.5 ± 5.5 and 24.2 ± 6.6 respectively. (Table 2) The average operating time was 171 ± 12 min. Post-operative atrial fibrillation was present in 2 patients (4.8%). The average intraoperative blood loss was 150 ± 75 ml and post-operative blood loss was 180 ± 40 ml in the first 24 hrs resulting in blood transfusion of 0.3 ± 0.2 units. The average patient length of stay was 3.7 days. Early return to work/full activity was achieved in 38 patients (93%) in 10 - 14 days and 3 patients (7%) in 15 - 30 days. All patients were followed up, with a mean follow up of 16 months and a maximum of 29 months. (Table 3) The patients had two sets of stress tests dur-

ing follow up at 2 months & 6 months after the procedure and the studies were normal. Further, all the patients were free from any major cardiac or cerebrovascular events at a mean of 16 months. Quality of life (SF-36 scores) at 6 months both in the physical and mental components was 95%.

Table 1. Pre-operative characteristics.

No. Patients	41
Male/Female	32/9
Age, Mean ± SD (Range)	61 ± 45.5 (35 - 74)
Critical LMS	29 (70%)
Unprotected Left Main (ULMCA)	7(17.5%)
Left Main Equivalent Disease	5 (12.5%)
Elective Pre-op IABP Prior to Induction of GA	41 (100%)
Ejection Fraction, mean ± SD	46 ± 5%
Prior MI	3 (7.5%)
PVD	4 (9.7%)
Diabetes	15 (36%)
Hypertension	16 (39%)
Current Smoker	7 (17%)
Dyslipidemia	17 (41%)
NYHA	Class
No Heart Failure	8
Class 1/11	30
Class 111/1 V	3
Angina	
No Angina	10
Class 1/11	29
Class 111/1 V	2
BMI Mean	28.8

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 2. Operative characteristics.

No. grafts, mean	2.2
3 grafts (LITA-RITAY) (Unprotected Left Main)	7
2 graft (LITA-RITA Y) (LM Equivalence)	5
2 Graft (Pedicled LITA & RITA) (29 pts with LMS)	29

Continued

Time for RITA Harvest	28.5 ± 5.5
Time for LITA harvest, mean ± SD, min	24.2 ± 6.6
Total operating time, mean ± SD, min	171 ± 12

LITA indicates left internal thoracic artery; RITA indicates right internal thoracic artery. LITA-RITA Y, Left internal thoracic artery—right internal thoracic artery Y composite conduit.

Table 3. Postoperative results.

Mortality	1 (2.2%)
Post opeRative Atrial Fibrillation	3 (7.3%)
Blood Transfusion, Mean ± SD U	0.3 ± 0.2
Hospital Stay	3.7 d (mean)
Early Return to Work/Full Activity	
10 - 14 d	38 (93%)
15/30 d	3 (7%)
ICU Stay Mean ± SD (hours)	24 ± 3
Graft Patency Data (6 months)	
Stress Test at 2 Months and 6 Months (41 patients)	Normal
Quality of Life (SF-36)-6 months	95%

6. Conclusion

Coronary artery bypass grafting for left main stem disease using either On or Off pump methodology is a well-established technique. Coronary artery surgical revascularization has shown to be safe, reproducible and with good mid-term outcomes [6]-[9]. Safety and usefulness of Composite grafts for myocardial revascularization have been well established [10]. Minimally Invasive Coronary artery bypass grafting, completeness of revascularization, safety and excellent outcomes have been demonstrated in various studies including randomized controlled trials [11]-[15]. Usage of Bilateral Mammary arteries in Minimally Invasive Coronary artery bypass grafting has shown to provide good mid- and long-term results [5] [13]. Usage of in situ pedicled Internal thoracic arteries prevented competitive flow. However, the safety, feasibility and reproducibly of Minimally Invasive Coronary artery bypass grafting for left main coronary artery disease which is a high risk condition, has never been demonstrated. In our study, we have shown the safety of the technique as demonstrated by the low incidence of peri-operative and postoperative complications including mortality and morbidity and also secondary measures. The postoperative recovery was good, with the mean hospital stay being 3.7 days, and 93% of patients resuming full activity within 2 weeks, and this compared favorably with other studies [16] [17]. Furthermore, the insertion of a preinduction Intra-Aortic Balloon Pump

(IABP), reduces hemodynamic instability during induction of anaesthesia, emergent conversions, arrhythmias, inotrope usage, intra operative myocardial infarctions and also reduces intensive care unit and total length of hospital stay. The limitations of the study are that, it is a retrospective observational study and not a randomized study, the small sample size and the retrospective nature of the data. We feel that extending the armamentarium of Minimally invasive coronary artery bypass grafting for left main coronary artery disease is feasible, safe and reproducible.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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