Original Research Article

Early outcomes of minimally invasive hybrid coronary revascularization

Vigneshwar Bakthavachalam*, M. M. Yusuf

Department of Cardiothoracic Surgery, Apollo Main Hospitals, Chennai, Tamil Nadu, India

*Correspondence:
Dr. Vigneshwar Bakthavachalam,
E-mail: drvigneshwarb@gmail.com

ABSTRACT

Background: Coronary artery bypass graft (CABG) surgery has been the gold standard for the treatment of coronary artery disease over the years. It is recommended for patients with multi-vessel coronary artery disease, left main disease, diabetics, severe left ventricular dysfunction, unsuitable anatomy for percutaneous coronary intervention (PCI), and failed PCI. The usage of the left internal mammary artery (LIMA) in the CABG to the left anterior descending (LAD) artery has proven to be superior compared to PCI. Minimally invasive hybrid coronary revascularization (MIHCR) is gaining growing interest.

Methods: This is a hospital-based prospective observational study with 200 patients followed up for a period of 30 days. This study aims to assess the early outcomes of MIHCR in the Indian population.

Results: The 30-day mortality was comparable to other studies, and the number of days in the ICU and hospital stay was shorter than the routine CABG. There was no incidence of a wound infection or stroke. Blood product usage and the need for repeat revascularization and re-exploration were less. The short-term outcomes were promising.

Conclusions: MIHCR has excellent short-term results and is safer than conventional OPCABG, as it is less invasive and avoids midline sternotomy. It also reduces the incidence of stroke and lesser usage of blood products, promoting early return of patients to their routine activities.

Keywords: MIHCR, CABG, LIMA, PCI, LAD artery

INTRODUCTION

Coronary artery bypass graft (CABG) surgery has been the gold standard for the treatment of coronary artery disease over the years. It is the recommended procedure in patients with multi-vessel coronary artery disease, left main disease, diabetics, severe left ventricular dysfunction, unsuitable anatomy for PCI, and failed PCI. The usage of the LIMA in the CABG to LAD artery has proven to be extremely superior compared to PCI. LIMA has excellent long-term patency due to the endothelium's tight junction, less muscular media, and innate Nitric oxide production.[1] The patency rate of LIMA to LAD is 95% at 10 years and 88% at 15 years.[2] The right internal mammary artery (RIMA) is being widely used as a free graft to other vessels of the left coronary system. The patency rate of the RIMA is 92% at 10 years and 79% at 15 years. However, conventional CABG has its limitations in terms of being invasive and associated with morbidity. Stroke, bleeding, wound infections, arrhythmias, prolonged ICU stay, and hospital stay have been the known common complications of conventional CABG.

MIHCR combines the benefits of PCI and off-pump OPCABG surgery; this involves IMA grafting to one or two major coronary arteries, usually the left coronaries, through a left mini-thoracotomy, followed by the stenting of the non-LAD vessels. MIHCR provides the advantage of reduced incidence of major adverse cardiac and

cerebrovascular events (MACCE) in the immediate post-operative period with the best long-term outcome.

This less invasive procedure minimizes the incidence of known complications of OPCABG and hastens recovery.[3] Another added advantage of MIHCR is that the patency of IMA can be assessed while undergoing PCI to the non-bypassed vessel. This provides an opportunity for the graft to be revised in case of need while the patient is still in the hospital.

There is a growing interest in MIHCR, and although conventional open techniques remain more popular, a study to assess the early outcomes of MIHCR in the Indian population is being undertaken here.

This study aims to assess the 30-day mortality, incidence of complications like stroke, need for re-intervention, need for repeat revascularization, usage of blood products, number of days in the ICU, number of days in the hospital post-operatively and early postoperative recovery in terms of hours on the ventilator.

METHODS

Study population

This is a hospital-based prospective observational study conducted in Apollo main hospital, Chennai. All consenting patients above 18 years of age who are undergoing primary MIHCR from March 2022 to September 2023 were included. Re-do surgeries, emergency surgery, and combined procedures were excluded. Severe chest deformities, inability for single lung ventilation, previous left thoracic surgery, and COPD were excluded. The patients with one or more non-LAD lesions suitable for PCI (SYNTAX score <22) were offered MIHCR after a multidisciplinary meeting with the cardiologist. A total of 200 patients were included in the study. IRB approval was obtained from the institutional ethical committee-bio medical research-Apollo hospitals (IEC Application number: AMH-DNB-087/11-21), Informed Consent was obtained from all the patients who met the inclusion criteria.

The patients first underwent MIDCAB via anterolateral thoracotomy in the 4th or 5th intercostal space using a 5-7 cm incision (Figure 1). LIMA/ RIMA is harvested either under direct vision or using Robotic assistance or a thoracoscope camera. Bypass Grafting is then performed under direct vision with the aid of MICS instruments. LIMA/ RIMA was grafted to the left-sided blood vessels. This is followed by the PCI to the non-grafted vessels on postoperative day 1, during which the patency of LIMA/RIMA grafts was assessed. The following post-operative data were collected-minutes in the ventilator, number of PRCs transfused, any new-onset stroke, wound infection, number of stents, need for re-exploration for bleeding, the need for repeat

revascularization, number of days in the ICU, the number of days in the hospital post-operatively. The patients were reviewed in the OPD at 30 days by the surgeon and the cardiologist.
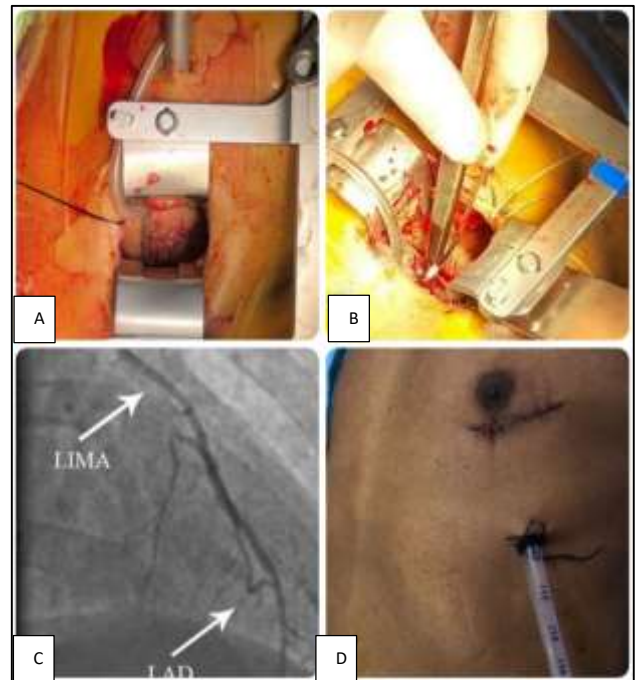

Figure 1 (A-D): MIDCAB retractor and stabilizer. LIMA to LAD anastomosis being performed via thoracotomy. Patent LIMA to LAD visualized during PCI. Post-operative image showing MID CAB incision.

Statistical analysis

The above data were statistically analyzed, and the data entry was done in an MS excel sheet. Categorical variables will be expressed by percentage. All continuous variables were tested for normality using Shapiro-Wilk's test. Normally distributed continuous variables were expressed by mean ± SD. Otherwise, the median (IQR) is the Interquartile range. Comparison of categorical variables was done by chi-square test or Fischer's exact test. Comparison of continuous variables was done by independent sample t test. Data analysis was carried out using IBM SPSS version (25.0). All $p<0.05$ were considered statistically significant.

RESULTS

Out of the 200 patients included in the study, the mean age of the patients was 60.6 years. The characteristics of the patient included in this study are shown in Table 1.

The early outcomes of MIHCR are illustrated in Table 2. The 30-day mortality was found to be 1.5%. No. of units of PRC transfusion was 14.5% with time on the ventilator found to be 471.40±193.72 minutes.

Table 1: Patient's demographics.

Patient demographics	N (%)
Gender	
Male	175 (87.5)
Female	25 (12.5)
Diabetes mellitus	150 (75)
Systemic hypertension	126 (63)
Smoking history	
Smokers	61 (30.5)
Non-smokers	126 (63)
Ex-smokers	13 (6.5)
Recent history of MI (<2 weeks)	136 (68)
History of lung disease	62 (31)
LV function	
Good LV function (EF>50%)	129 (64.5)
Mild to moderate LV dysfunction (EF 30-49%)	32 (16)
Severe LV dysfunction (EF<30%)	39 (19.5)
Pulmonary artery hypertension	
Normal to mild PAH (PA pressure <31 mmHg)	131 (65.5)
Mild PAH (PA pressure 31-55 mmHg)	65 (32.5)
Severe PAH (PA pressure >55 mmHg)	4 (2)
eGFR	
>60 ml/min/1.73 m^2	183 (91.5)
<60 ml/min/1.72 m^2	17 (8.5)
Euro-score	
<1%	133 (66.5)
1-3 %	31 (15.5)
>3%	36 (18)
Number of internal mammary arteries used	
LIMA only	151 (75.5)
LIMA and RIMA	49 (24.5)

Table 2: Early outcomes of MIHCR.

Early outcomes	Results, n (%)
30–day mortality	3 (1.5)
Wound infection	0 (0)
Post-operative stroke	0 (0)
Time on the ventilator (min)	471.40±193.72
No. of days in the ICU	2.29±1.18 days
No. of days in the hospital	4.68±1.22 days
Re-exploration for bleeding	2 (1)
Revascularization/ reintervention	2 (1)
No. of units of PRC transfusion	29 (14.5)

DISCUSSION

In this study, out of 200 patients who underwent MIHCR, 3 (1.5%) patients had mortality during the 30-day follow-up period. Patel et al in their study, showed 30-day mortality of 0.5% for the MIHCR and 0.5% for OPCABG.[4] Ibrahim et al, in their study, had a 30-day mortality of 2.9% for the OPCABG group and 2.0% for the MIHCR group.[5] Qui et al, in their study, showed a mortality of 2.0% for the OPCABG group and 0.1% for the MIHCR group. As shown above, this study has a 30-day mortality similar to that of the various MIHCR studies across the globe. However, it is lesser compared to the conventional OPCABG. In this study, the analysis showed that 3 out of 39 patients with severe LV dysfunction (EF <30%), 3 out of 36 patients with euro-score >3%, and 2 out of 13 patients with low eGFR (<60 mL/ min/ 1.73 m2) had mortality in the 30-day period which is similar to the conventional OPCABG. This shows that MIHCR is relatively safer in the high-risk group of patients.

Stroke is one of the major complications of coronary artery bypass surgery, significantly affecting the quality of life of the patients post-operatively. Adams et al in their study, had a stroke of 1.1% in the MIHCR group. Halkos et al in their study, showed a 1% incidence of stroke.[7,8] Hage et al in their study, showed a 1.0% and 2.1% incidence of stroke in the MIHCR and OPCABG groups, respectively.[9] Moreno et al in their study, showed a 2.1% and 4.1% incidence of stroke in the MIHCR and OPCABG groups.[10] Hage et al in their study, they had a stroke incidence of 4.1% in the MIHCR group and 6.8% in the OPCABG group.[9] In this study, there was strikingly no (0%) incidence of stroke among the patients post-operatively in the 30 days. This is attributed to the non-handling of the aorta intra-operatively as PCI is offered to the non-LAD vessels, thereby avoiding the great saphenous vein grafts requiring clamping of the ascending aorta for proximal anastomosis. Thus, stroke, one of the dreaded complications of conventional OPCABG, has been reduced to a minimum with the advent of MIHCR.

Sternal wound infections associated with OPCABG increase hospital stays among patients. It may be progressing to mediastinitis, which adds to mortality and morbidity. Some may require re-admissions for wound debridement. All of this adds to the morbidity and cost of the procedure, affecting the quality of life and delaying the recovery. MIHCR avoids the more invasive sternotomy. Thoracotomy used in MIHCR is less invasive and cosmetically better. Notably, there was no (0%) incidence of wound infections in this study.

The patients in this study had a mean time of 472.40±193.72 minutes (7.87±3.22 hours) on the ventilator post-operatively. Hage et al, in their study, showed that 0.7% in the MIHCR group and 4% in the OPCABG group had prolonged mechanical ventilation (>24 hours) post-operatively.[9] Patel in their study, showed that 3.9% in the MIHCR group and 3.4% in the OPCABG group had prolonged mechanical ventilation.[4] It is seen that MIHCR patients have less time on the ventilator post-operatively. The possibility of early extubation is one of the advantages of MIHCR. With the avoidance of median sternotomy, which is associated with significant pain post-operatively, restricting ventilation among the patients is a notable benefit. The occurrence of ventilator-associated infections post-

operatively is much reduced. The less time on the ventilator hastens post-operative recovery. Early institution of spirometry and early ambulation can be achieved.

Out of 200 patients in this study, 176 (88%) had no blood transfusion, 21 (10.5%) patients had one unit of PRC transfusion, 1 (0.5%) patient had two units of PRC transfusion, and 2 (1%) had three units of PRC transfusion. In total, 29 (14.5%) units of PRC were used. Patel et al in their study, showed that the MIHCR group required 29 (14%) units of PRC transfusion, and the OPCABG group required 59 (28.5%) units of PRC transfusion.[4] Hage et al in their study, showed that the MIHCR group required 21 (15%) units of PRC transfusion, and the OPCABG group required 56 (28%) units of PRC transfusion.[9] It is evident that blood transfusion is commendably low in the MIHCR when compared to conventional OPCABG. This also reduces risk of complications associated with blood transfusion.

The number of days in the ICU in this study was 2.29±1.18 days. The review of the literature showed an average ICU stay of 1.0 days for the MIHCR group and 1.8 days for the OPCABG group. In our study, the patient underwent PCI to the non-LAD vessels on either postoperative day (POD) 1 or POD 2 and was observed in the ICU following the procedure. Thus, they had a slightly higher duration in the ICU. In this study, the analysis showed that patients with severe LV dysfunction (p=0.000), low eGFR (p=0.026), and higher euro-score (p=0.000) were associated with more days in the ICU.

The total hospital stay of the patients in this study was 4.68±1.22 days. Bonatti et al in their study showed a hospital stay of 6 days, Repossini et al showed a hospital stay of 6.5 days, and Halkos et al in their study showed a hospital stay of 5 days.[4,8,9] Patel et al in a study, showed a total hospital stay of 7.1 days for the MIHCR group and 8.4 days for the OPCABG group.[4] Bachinsky et al in their study, showed a hospital stay of 5.1±2.8 days for the MIHCR group and 9.1±5.4 days for the OPCABG group.[10] It is clearly evident that MIHCR has a relatively shorter hospital stay duration when compared to conventional OPCABG. In this study, the analysis showed that patients with severe LV dysfunction (p=0.000) and higher euroscore (p=0.000) were associated with more days in the hospital.

In this study, out of 200 patients who underwent MIHCR, 2 (1%) patients had re-exploration for bleeding post-operatively. Bonatti et al, Adams et al and Halkos et al in their studies on early outcomes of MIHCR, had re-exploration rates of 3.6%, 4.3%, and 2.0%, respectively.[7,8,11] Hage et al, in a study, had a re-exploration rate of 3.5% for MIHCR and 1.5% for OPCABG.[9] Ibrahim et al in their study, had a 2.0% re-exploration rate for both MIHCR and OPCABG.[5] It is evident that in our study, the re-exploration rates were lower than those of the MIHCR groups and OPCABG groups, as shown in the review of the literature.

In this study, out of 200 patients, 2 (1%) had occluded LIMA to LAD. They underwent repeat revascularization via conventional OPCABG. Ibrahim et al in their study, showed a revascularization rate of 1.0% for OPCABG and 2% for MIHCR groups.[5] In their study, Patel et al showed a revascularization rate of 0.5% for OPCABG and 1.0% for MIHCR.[4] This study showed a similar revascularization rate compared to various MIHCR and OPCABG studies mentioned in review of the literature.

The patency rate for LIMA to LAD in our study is 99%. Bonatti et al, Halkos et al, Modrau et al and Repossini et al in their study on early outcomes of MIHCR, showed LIMA to LAD patency rates of 97.3%, 97.6%, 98%, and 100% respectively.[8,11-13]

Limitations

This study highlights only the early outcomes of MIHCR (30-day period). A long-term follow-up for a duration of 5 years would be ideal to see long-term results in terms of MACCE incidence and the need for repeat revascularization. There is no randomization of the patients in this study. The patients suitable for MIHCR were given the option to choose MIHCR. Cost and affordability for MIHCR were factors in patients' choosing MIHCR. The overall cost of MIHCR is slightly higher when compared to the conventional OPCABG.

CONCLUSION

In this study, it is shown that MIHCR has excellent short-term results compared to conventional OPCABG. It has early recovery, and it is safer among high-risk patients. It is less invasive and lasts less time in the ICU and hospital. The midline sternotomy is avoided. With thoracotomy, the wound infection has come down considerably. The incidence of stroke is negligible. There is less usage of blood products. All these factors promote the early return of the patients to their routine activities. Hence, MIHCR is fast emerging as an effective alternative to conventional OPCABG.

REFERENCES

1. Gaudino M, Taggart D, Suma H, Puskas JD, Crea F, Massetti M. The choice of conduits in coronary artery bypass surgery. Journal of the American College of cardiology. 2015;66(15):1729-37.
2. Tatoulis J, Buxton BF, Fuller JA. Patencies of 2,127 arterial to coronary conduits over 15 years. Ann Thoracic Surg. 2004;77(1):93-101.

3. Marinakis S, Chaskis E, Cappeliez S, Homsy K, De Bruyne Y, Dangotte S, et al. Minimal invasive coronary surgery is not associated with increased mortality or morbidity during the period of learning curve. Acta Chirurgica Belgica. 2022;1-8.

4. Patel NC, Hemli JM, Kim MC, Seetharam K, Pirelli L, Brinster DR, et al. Short-and intermediate-term outcomes of hybrid coronary revascularization for double-vessel disease. J Thoracic Cardiovascular Surg. 2018;156(5):1799-807.

5. Gadelkarim I, Borger MA, Davierwala PM. Hybrid coronary revascularization. AME Med J. 2020;5:41.

6. Modrau IS, Holm NR, Mæng M, Bøtker HE, Christiansen EH, Kristensen SD, et al. Hybrid Coronary Revascularization Study Group. One-year clinical and angiographic results of hybrid coronary revascularization. J Thoracic Cardiovascular Surg. 2015;150(5):1181-6.

7. Adams C, Burns DJ, Chu MW, Jones PM, Shridar K, Teefy P, et al. Single-stage hybrid coronary revascularization with long-term follow-up. Euro J Cardio-Thoracic Surg. 2014;45(3):438-43.

8. Halkos ME, Walker PF, Vassiliades TA, Douglas JS, Devireddy C, Guyton RA, et al. Clinical and angiographic results after hybrid coronary revascularization. Ann Thoracic Surg. 2014;97(2):484-90.

9. Hage A, Giambruno V, Jones P, Chu MW, Fox S, Teefy P, et al. Hybrid coronary revascularization versus off-pump coronary artery bypass grafting: comparative effectiveness analysis with long-term follow-up. J Am Heart Asso. 2019;8(24):e014204.

10. Moreno PR, Stone GW, Gonzalez-Lengua CA, Puskas JD. The hybrid coronary approach for optimal revascularization: JACC review topic of the week. J Am College Cardiol. 2020;76(3):321-33.

11. Bonatti JO, Zimrin D, Lehr EJ, Vesely M, Kon ZN, Wehman B, et al. Hybrid coronary revascularization using robotic endoscopic surgery: perioperative outcomes and 5-year results. Ann Thoracic Surg. 2012;94(6):1920-6.

12. Repossini A. Hybrid approach to multivessel coronary artery disease: a commentary. Ann Translational Med. 2016;4(1):S52.

13. Modrau IS, Holm NR, Mæng M, Bøtker HE, Christiansen EH, Kristensen SD, et al. Hybrid Coronary Revascularization Study Group. One-year clinical and angiographic results of hybrid coronary revascularization. J Thoracic Cardiovascular Surg. 2015;150(5):1181-6.