

Coronary: Short Report

Comparison of Robot-Assisted Multivessel Minimally Invasive Direct Coronary Artery Bypass and Hybrid Revascularization



Zhandong Zhou, PhD, MD,¹ Karikehalli A. Dilip, MD,¹ Anna Gleboff, MPH, MS,¹ Ahmad Nazem, MD,¹ Gary Randall Green, MD,¹ Anton Cherney, MD,¹ and Charles J. Lutz, MD¹

ABSTRACT

BACKGROUND This study compares 2 minimally invasive coronary revascularization approaches: robot-assisted multivessel minimally invasive direct coronary artery bypass (MIDCAB) and the hybrid approach combining MIDCAB with subsequent percutaneous coronary intervention.

METHODS A retrospective review was conducted on cases of robotic MIDCAB performed at our institution between 2012 and 2022. Two groups of patients were analyzed: the surgery group (undergoing robotic multivessel MIDCAB) and the hybrid group. Surgical procedures included robotic left internal mammary artery harvest and anastomosis, with percutaneous coronary intervention performed within 30 days in the hybrid group.

RESULTS There were 105 patients in the surgery group and 81 patients in the hybrid group. Both groups had similar characteristics, except that the surgery group had older patients. There were no mortalities in either group. Post-operative atrial fibrillation rates were higher in the surgery group. Length of stay and other postoperative complications did not differ significantly between the groups.

CONCLUSIONS Multivessel robotic MIDCAB can be safely performed with comparable outcomes to the hybrid approach. The hybrid technique, being less demanding, is the preferred in most centers. However, multivessel robotic MIDCAB offers the advantage of complete revascularization and potentially more durable results. Patients with complex non-left anterior descending lesions may not be suitable for the hybrid approach.

(Ann Thorac Surg Short Reports 2024;2:226-230)

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Advancements in surgical techniques have led to the development of minimally invasive approaches for coronary revascularization, comparable to traditional procedures while reducing surgical trauma and enhancing recovery of the patient. Two approaches are robot-assisted minimally invasive direct coronary artery bypass (MIDCAB) and the hybrid approach, combining robotic MIDCAB with percutaneous coronary intervention (PCI). This manuscript compares these 2 options.

IN SHORT

- Robot-assisted multivessel minimally invasive direct coronary artery bypass yields comparable outcomes to the hybrid coronary revascularization.
- Multivessel robotic minimally invasive direct coronary artery bypass offers the advantage of achieving complete revascularization and potentially more durable results.

Minimally invasive techniques offer advantages over conventional sternotomy procedures, including smaller

Accepted for publication Nov 27, 2023.

Presented at the Second Annual Meeting of The Society of Thoracic Surgeons Coronary Conference, Miami, FL, Jun 3-4, 2023.

¹Department of Cardiac Surgery, St Joseph's Health Hospital, Syracuse, New York

Address correspondence to Dr Zhou, St Joseph's Health Hospital, Department of Cardiac Surgery, 104 Union Ave, Ste 806, Syracuse, NY 13203; email: zhandong@yahoo.com.

incisions, reduced blood loss, shorter hospital stays, faster recovery times, and improved cosmetic outcomes.^{1,2} Robot-assisted MIDCAB is an attractive option allowing precise intrathoracic maneuvers through robotic instrumentation while avoiding the need for cardiopulmonary bypass and aortic manipulation.³ Robotic technology offers improved dexterity, visualization, and instrument articulation, leading to better outcomes.⁴

The hybrid approach combines the advantages of surgical and percutaneous interventions to optimize revascularization in patients with complex multivessel coronary artery disease.⁵ This approach involves a combination of minimally invasive surgical bypass of the left anterior descending coronary artery (LAD) using the left internal mammary artery (LIMA), followed by subsequent PCI to non-LAD vessels, offering a comprehensive treatment option.⁶ By tailoring the revascularization strategy to the patient's anatomy and disease complexity, the hybrid approach potentially leads to improved outcomes.⁷

There is a scarcity of literature directly comparing the 2 techniques; most are single-center experiences and retrospective analyses like our study. Comparing the outcomes of multivessel robotic MIDCAB and the hybrid approach in patients with multivessel coronary artery disease will facilitate informed decision-making and help optimize selection of patients for the most appropriate revascularization strategy.

PATIENTS AND METHODS

STUDY DESIGN AND PATIENT SELECTION. A retrospective review of all cases that underwent robotic MIDCAB at our institution between 2012 and 2022 was conducted. Two groups of patients were selected: the surgery group and the hybrid group. The surgery group consisted of patients with multivessel disease who underwent robotic multivessel MIDCAB as the primary revascularization strategy. The hybrid group included patients who underwent a hybrid approach, with a single-vessel robotic MIDCAB followed by PCI within 30 days. The selection of patients for each group was based on clinical presentation, coronary anatomy, and suitability for either revascularization approach.

SURGICAL TECHNIQUE. All patients in both groups underwent robot-assisted LIMA harvest by the standard 3-port technique. The camera port, located at the fourth intercostal space, was enlarged to approximately 6 cm in both groups to allow better visualization and manipulation.

In the surgery group, the LIMA was harvested by robotic assist as in the hybrid group, and multivessel anastomoses were performed by hand suturing, either with or without cardiopulmonary bypass. The use of cardiopulmonary bypass in the surgery group was

without aortic cross-clamping and cardioplegic arrest to provide hemodynamic support while grafting. In the hybrid group, the LIMA was anastomosed to the LAD or sequentially to both the LAD and diagonal artery. Following the surgical procedure, PCI was performed within 30 days to complete the revascularization.

DATA COLLECTION AND ANALYSIS. A comprehensive analysis of patients' demographic characteristics, comorbidities, and perioperative variables was performed. Variables included age, sex distribution, body mass index, left ventricular ejection fraction, history of atrial fibrillation, cerebrovascular disease, peripheral vascular disease, previous PCI, diabetes mellitus, congestive heart failure, and renal disease. Procedural details, such as the number of bypass grafts performed, elective vs urgent cases, and the use of off-pump procedures, were recorded. Postoperative outcomes, including length of stay, ventilation times, postoperative atrial fibrillation rates, and other complications, were assessed.

STATISTICAL ANALYSIS. Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. Continuous variables were expressed as mean $\pm$ SD or median (interquartile range), depending on their distribution. Categorical variables were presented as frequencies and percentages. To compare the differences between the groups, statistical tests were used, such as the *t*-test for continuous variables and the χ^2 test or Fisher exact test for categorical variables. A *P* value $< .05$ was considered statistically significant.

ETHICAL CONSIDERATIONS. This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The study protocol was approved by the institutional review board. Patient confidentiality and data protection were strictly adhered to during data collection and analysis.

RESULTS

A total of 186 patients were included in this retrospective study, with 105 patients in the surgery group and 81 patients in the hybrid group. The demographic and clinical characteristics of the 2 groups were comparable, except for age. The surgery group had significantly older patients, with a mean age of 70.05 years compared with 65.35 years in the hybrid group ($P = .004$). There was no significant difference in sex distribution, body mass index, left ventricular ejection fraction, or prevalence of comorbidities between the groups.

In the hybrid group, most (80%) underwent coronary artery bypass grafting (CABG) 1 time, with the LIMA anastomosed to the LAD. The remaining 20% of patients underwent CABG 2 times, with the LIMA anastomosed to both the LAD and diagonal artery. In the surgery group, the patients had 2 to 5 coronary grafts (Table).

TABLE Hybrid Coronary Revascularization vs Robotic Multivessel MIDCAB

Variable	Hybrid (n = 81)	Surgical Multivessel (n = 105)	P Value
Age, y	65.35 ± 12.15	70.05 ± 9.27	.004
Sex, male	60 (74)	79 (75)	.856
Body mass index, kg/m ²	29.52 ± 6.022	30.37 ± 5.902	.339
Diabetes mellitus	33 (41)	48 (46)	.498
Peripheral vascular disease	11 (14)	16 (15)	.75
Cerebrovascular disease	20 (25)	37 (35)	.122
Renal disease	5 (6)	3 (3)	.269
Previous PCI	40 (49)	49 (47)	.713
History of congestive heart failure	21 (26)	23 (22)	.522
LVEF, %	50.6 ± 11.583	53.25 ± 11.043	.13
Status			
Elective	39 (48)	52 (49.5)	.852
Urgent	42 (52)	53 (50.5)	
CABG			
CABG × 1	65 (80)	0 (0)	
CABG × 2	16 (20)	60 (57)	
CABG × 3	0 (0)	40 (38)	
CABG × 4	0 (0)	4 (4)	
CABG × 5	0 (0)	1 (1)	
Off-pump procedure	72 (89)	31 (30)	<.001
30-day mortality—alive	81 (100)	105 (100)	
Extubated <6 h	70 (86)	28 (27)	<.001
Reoperation for bleeding	0 (0)	2 (1.9)	.212
Postoperative renal failure	1 (1.23)	0 (0)	.254
Postoperative atrial fibrillation	12 (14.81)	29 (27.62)	.037
Postprocedure length of stay, d	5.84 ± 2.87	6.32 ± 3.52	.307

Categorical variables are presented as number (percentage). Continuous variables are presented as mean ± SD. Boldface P values represent statistical significance. CABG, coronary artery bypass grafting; LVEF, left ventricular ejection fraction; PCI, percutaneous coronary intervention.

Off-pump procedures were performed in 89% of the hybrid group and in 30% of the surgery group. The remaining 70% of cases in the surgery group underwent revascularization on the beating heart with cardiopulmonary bypass providing hemodynamic support. Nine patients in the hybrid group (11%) had grafts to the LAD plus non-LAD/diagonal vessels with cardiopulmonary bypass support.

There were no mortalities in either group during the study period. The length of stay did not differ significantly between the groups. The surgery group had longer ventilation times ($P < .001$). The incidence of postoperative atrial fibrillation was significantly higher in the surgery group (27.62%) compared with the hybrid group (14.81%; $P = .037$).

Other postoperative complications did not show significant differences between the groups. The overall rates of complications were low, indicating the safety of both approaches.

COMMENT

Minimally invasive approaches for coronary revascularization have currently gained attention as alternatives to

traditional procedures. This study aimed to explore and to compare the outcomes of multivessel robotic MIDCAB and the hybrid approach.

The results of this study demonstrated that both multivessel robotic MIDCAB and the hybrid approach can be performed with comparable safety and efficacy in selected patients with multivessel coronary artery disease. Importantly, there were no mortalities in either group, suggesting that these minimally invasive approaches are associated with favorable outcomes. These findings align with existing literature.^{1,2}

The absence of significant differences in length of stay and postoperative complications between the surgery and hybrid groups supports the feasibility and safety of these approaches. The similar distribution of comorbidities and baseline characteristics between the groups strengthens the validity of the comparative analysis. This is consistent with previous studies that have reported comparable postoperative outcomes.^{3,8}

Multivessel surgical MIDCAB represents another strategy for minimally invasive coronary revascularization. Although less common and typically performed in technically advanced centers, multivessel surgical MIDCAB offers the potential for complete revascularization

and longer lasting results compared with hybrid techniques.

Complete revascularization has been associated with improved long-term outcomes and reduced rates of future cardiac events.^{9,10} Multivessel surgical MIDCAB allows the direct bypass grafting of multiple coronary vessels while avoiding sternotomy.

Whereas the hybrid approach offers the advantage of combining surgical and percutaneous interventions, it may not always achieve complete revascularization, particularly in cases with complex lesions in non-LAD territories. Multivessel surgical MIDCAB provides the opportunity for complete revascularization by directly grafting multiple vessels, including those in non-LAD territories.

Multivessel surgical MIDCAB can be particularly advantageous in patients who are not ideal candidates for percutaneous interventions, such as those with heavily calcified vessels, diffuse disease, or small-caliber vessels. In such cases, direct bypass grafting through surgical MIDCAB allows effective revascularization without relying on the feasibility and success of percutaneous interventions.

Bakaeen and coworkers² reported their experience with >1000 cases of robot-assisted CABG and demonstrated positive surgical outcomes but in mostly single-vessel grafts. Falk and colleagues¹ described the successful implementation of total endoscopic off-pump CABG.

The hybrid approach, with its ability to combine surgical and percutaneous interventions, offers flexibility and may be the preferred option in many cases. However, the unique advantages of multivessel surgical MIDCAB, including the potential for complete revascularization and potentially more durable results, make it

an important alternative that can be considered in selected patients.

LIMITATIONS. This study has several limitations inherent to its retrospective design and single-center experience. The absence of randomization and the potential for selection bias could affect the generalizability of the findings. In addition, the relatively small sample size might limit the statistical power to detect significant differences between the groups. Despite these limitations, this study provides valuable insights into the outcomes and feasibility of multivessel robotic MIDCAB and the hybrid approach in our population of patients.

Whereas this study demonstrates feasibility of these 2 techniques, we plan to present medium- and long-term follow-up in subsequent studies.

CONCLUSION. Multivessel surgical MIDCAB and the hybrid approach both represent valuable options for minimally invasive coronary revascularization. Whereas the hybrid approach offers flexibility and the ability to tailor the treatment plan to each patient, multivessel surgical MIDCAB provides the potential for complete revascularization and potentially more durable results. The choice between these techniques should be made on the basis of the individual patient's characteristics, anatomic considerations, and expertise available. Ultimately, the goal of both approaches is to improve patient outcomes and quality of life by providing effective and lasting revascularization for patients with multivessel coronary artery disease.

FUNDING SOURCES

The authors have no funding sources to disclose.

DISCLOSURES

The authors have no conflicts of interest to disclose.

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