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Percutaneous cannulation for cardiopulmonary bypass in robotic mitral valve surgery with zero groin complications

Murat Bastopcu MD[1] | Sahin Senay MD[2] | Ahmet Ü. Güllü MD[2] | Muharrem Kocyigit MD[3] | Cem Alhan MD[2]

[1]Department of Cardiovascular Surgery, Tatvan State Hospital, Bitlis, Turkey

[2]Department of Cardiovascular Surgery, Acıbadem Mehmet Ali Aydınlar University, Istanbul, Turkey

[3]Department of Anesthesiology, Acıbadem Mehmet Ali Aydınlar University, Istanbul, Turkey

Correspondence
Murat Bastopcu, MD, Department of Cardiovascular Surgery, Tatvan State Hospital, Bitlis, Karşıyaka Mah, Hastane Cad. No:1 Tatvan/Bitlis, Turkey.
Email: muratbastop@gmail.com

Abstract

Introduction: Robotic valve surgery utilizes the femoral vessels to set up cardiopulmonary bypass (CPB) which translates to groin wound and lower extremity vascular complications. A less invasive technique is a totally percutaneous bypass using vascular closure devices (VCDs) with concerns for lower limb ischemia and arterial stenosis. Since April 2018, we have adopted the standard use of total percutaneous CPB in our robotic mitral cases. We report our institutional results with this technique.

Methods: All consecutive patients who underwent robotic mitral valve surgery between April 2018 and December 2020 in our institution were included in our study. Hospital database data on demographics, operative variables, and surgical outcomes were recorded and analyzed.

Results: Robotic mitral valve surgeries were performed on 32 consecutive patients (mean age 57.2 ± 14.8) between April 2018 and December 2020. None of our patients developed an infection at any site. Seroma, hematoma, or pseudoaneurysm were not observed at puncture sites. Surgical repair of the femoral vessels or an additional VCD was not necessary for any of our patients. Patients were followed up for a mean duration of 23.5 months. Our patients did not present with a late wound infection, a seroma, or a pseudoaneurysm, nor had complaints of limb ischemia or claudication.

Conclusion: Total percutaneous bypass is the least invasive method of establishing extracorporeal circulation for cardiac surgery and can be performed with excellent results. The benefits of robotic surgery can be expanded with better results in groin cannulation by the adoption of total percutaneous CPB.

KEYWORDS

cardiopulmonary bypass, mitral valve, postoperative complications, robot-assisted surgery

1 | INTRODUCTION

Minimally invasive surgery has received increased attention from cardiac surgeons and patients over the last three decades. Minimal invasive approaches to valve surgery offer patients lower rates of complications, earlier ambulation, as well as better cosmesis.[1] Robotic mitral surgery, although technically more demanding, is the least invasive approach to valve operations.[2]

Robotic valve surgery utilizes the femoral vessels for cannulation to set up cardiopulmonary bypass (CPB). The shift from central vessels to the femoral vessels translates to possible groin wounds and lower extremity vascular complications that valve surgery patients would not be exposed to with the traditional sternotomy approach. A less invasive technique for groin cannulation is a totally percutaneous technique with the use of vascular closure devices (VCDs). Initially used to achieve hemostasis following percutaneous

interventions, VCDs have gained popularity for their advantages in easy hemostasis and improved postoperative comfort.[3] They have recently found broader applications with extracorporeal membrane oxygenation and CPB cannulations.[4–6]

With percutaneous cannulations in cardiac surgery, reduced wound and vessel-related complications are reported.[7] The patients benefit from avoidance of possible wound infections or seromas that occur with surgical cut-down of the femoral region. The trade-off for using VCDs to achieve total percutaneous CPB are concerns for lower limb ischemia and arterial stenosis. In our institution since April 2018, we have adopted the standard use of the Preclose technique with two Proglide (Abbott Vascular) devices for total percutaneous CPB in all of our robotic mitral cases. We, herein, report our institutional results with this technique.

2 | METHODS

All consecutive patients who underwent robotic mitral valve surgery between April 2018 and December 2020 in our institution were included in our analysis. Hospital database data on demographics, operative variables, and surgical outcomes were recorded. Categorical parameters are presented as count and percentage while continuous parameters are presented as mean ± standard deviation.

2.1 | Surgical technique

Robotic surgery was carried out using the Davinci XI or SI systems. Patients with mitral valve disease, tricuspid valve disease, atrial septal defects, and cardiac myxoma who required surgical treatment were included. Patients with concomitant aortic valve or coronary artery disease that required surgical intervention were excluded. Patients over 70 years of age and with concomitant coronary artery disease or peripheral arterial disease underwent routine preoperative computed tomography to ensure safe peripheral cannulation.

Our set-up for robotic mitral valve surgery was described earlier.[8] After anesthetic preparation, a mini-thoracotomy at the right 4th intercostal space is performed. The second and fifth intercostal spaces are used for the working ports and insertion of the Chitwood clamp, respectively. The mini-thoracotomy incision is used for the placement of the camera port. After completion of the robotic set-up, CPB is initiated.

2.2 | Percutaneous CPB

We have used an intraoperative ultrasound (US) for needle guidance and assessment of the arterial wall at the puncture site in all our cannulations. After systemic heparinization, the anterior surface of the common femoral artery is punctured with a 5-French micro-puncture needle and a 6-French sheath is placed under US guidance. The 0.035 guidewire is advanced through the sheath which is then removed, leaving the wire in the femoral vessel. The correct placement of this guidewire, over which the device is progressed, is ensured with the US and transesophageal echocardiography (TEE). With the preclose technique, two Proglide devices are deployed on the femoral artery at 10 o'clock and 2 o'clock positions. The sutures are clamped without tightening the knots. The guidewire for the arterial cannula is then advanced under TEE guidance. The puncture site is dilated to allow placement of 15–22-French arterial cannulae according to the patient's body surface area. For venous cannulation, the right jugular and left femoral veins are utilized. The stiff guidewires for the venous cannulae are advanced under TEE guidance. A 17-Fr venous cannula is introduced in the jugular vein; 18–24-Fr venous cannulae were used for left femoral vein cannulation. CPB is initiated with vacuum-assisted venous drainage.

After completion of valve surgery and administration of protamine, the femoral venous cannula is removed. A deep suture followed by slight compression achieves hemostasis for the femoral vein. The jugular cannula is removed and a purse suture is tied at the insertion site. The arterial cannula is removed and the Proglide sutures are pulled, lowering the knots onto the arterial wall. With US-guided compression on the femoral artery, adequate hemostasis is achieved and femoral artery flow is checked for any stenosis or obstruction.

3 | RESULTS

We performed robotic mitral valve surgeries on 32 consecutive patients between April 2018 and December 2020. The mean age of our patients was 57.2 ± 14.8. The demographic and operative data are presented in Table 1. Eighteen operations were isolated mitral valve procedures while fourteen operations included additional interventions for left atrial appendix ligation, patent foramen ovale closure, tricuspid valve repair, or myxoma excision. Three operations were performed urgently for precipitating shock and CPB was established percutaneously in these patients without difficulty. Seven (21.9%) of our patients had a BMI ≥30 and one patient had extreme obesity with a BMI of 45.54.

Postoperative outcomes concerning mortality and morbidity are presented in Table 2. None of our patients developed an infection at any site including the groin region. Seroma, hematoma, or pseudoaneurysm were not observed at puncture sites. Surgical repair of the femoral vessels was not necessary for any of our patients. Two Proglide sutures were sufficient for hemostasis with cannula size up to 22-Fr in our experience and no patient required the insertion of an additional device.

Our robotic mitral patients were followed up for a mean duration of 23.5 months. Our patients did not present with a late wound infection, a seroma, or a pseudoaneurysm during this period. None of our patients had complaints of limb ischemia or claudication in their follow-up.

4 | DISCUSSION

Our experience with the use of total percutaneous bypass shows that it can be performed with excellent results for robotic mitral surgery patients. Total percutaneous cannulation with the use of two Proglide VCDs for hemostasis has resulted in minimal complications in our institution.

TABLE 1 Demographic and operative data

	(*n* = 32)
Age	57.2 ± 14.8
Female gender	20 (62.5%)
NYHA grading	
Class 3	9 (28.1%)
Class 4	3 (9.4%)
Previous myocardial infarction	2 (6.3%)
Myocardial infarction within 90 days	2 (6.3%)
Congestive heart failure	3 (9.4%)
Previous cardiac surgery	4 (12.5%)
CABG	0 (0%)
Valve	4 (12.5%)
Other	1 (3.1%)
BMI	27.83 ± 5.73
Obesity (BMI ≥ 30)	7 (21.9%)
Diabetes mellitus	6 (18.8%)
Hypertension	9 (28.1%)
Hyperlipidemia	6 (18.8%)
Renal disease	0 (0%)
Preoperative creatinine (mg/dl)	1.08 ± 0.44
Preoperative hematocrit	39.75 ± 5.63
Chronic obstructive pulmonary disease	1 (3.1%)
Peripheral artery disease	3 (9.4%)
Cerebrovascular disease	3 (9.4%)
Neurological dysfunction	0 (0%)
Atrial fibrillation	8 (25.0%)
LVEF ≤ 50	4 (12.5%)
Preoperative medications	
Aspirin	2 (6.3%)
Clopidogrel	0 (0%)
Thrombin Inhibitors	0 (0%)
Euroscore II	9.21 ± 18.97
Urgent surgery	3 (9.4%)
Cardiac procedure	
Valve	18 (56.3%)
Valve + other	14 (43.8%)
CPB duration	118.94 ± 38.05
CC time	68.56 ± 25.67
Transfusion	4 (17.4%)
Erythrocyte suspension	1.30 ± 3.88
Fresh frozen plasma	0.61 ± 1.64
Thrombocytes	0.61 ± 2.52

Abbreviations: BMI, body mass index; CABG, coronary artery bypass surgery; CC, cross-clamp; CPB, cardiopulmonary bypass; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association.

TABLE 2 Postoperative outcomes

	(*n* = 32)
Chest tube output (ml)	227.45 ± 168.76
Reoperation	0 (0%)
Postoperative stroke	0 (0%)
Postoperative dialysis	1 (3.1%)
Reintubation	1 (3.1%)
Infection	0 (0%)
Pneumonia	0 (0%)
Endocarditis	0 (0%)
Superficial sternal	0 (0%)
Deep sternal	0 (0%)
Groin complications	
Infection	0 (0%)
Seroma	0 (0%)
Hematoma	0 (0%)
Pseudoaneurysm	0 (0%)
Surgical conversion	0 (0%)
Need for an additional vascular closure device	0 (0%)
GIS complication	0 (0%)
Multiorgan failure	0 (0%)
30-day mortality	0 (0%)

The total percutaneous approach has been beneficial in interventions with lower transfusions and shorter length of stay[9] and can also be beneficial in minimally invasive surgery.

In an era where cardiac operations are performed less and less invasively, total percutaneous bypass avoids a wound in the groin region that is associated with undesirable infections and wound complications.[10] The open-Seldinger method for femoral cannulation has been associated with fewer vascular complications but wound complications remain possible due to cut-down access of femoral vessels.[11] Total percutaneous bypass removes the need for surgical exploration, thereby resulting in fewer groin complications and better cosmetic results. With sheaths up to 24-Fr in transcatheter aortic valve replacement procedures, two Proglide sutures have been safely used for adequate hemostasis.[12] The risk of Proglide failure increases with cannula size,[13] however, we have used arterial cannula with sizes up to 22-Fr with no case requiring a third device or surgical conversion. While endoaortic

balloon occlusion was not required in our cases, this technique for total percutaneous CPB can be performed using an arterial cannula with a side-port for placement of the endoaortic balloon occlusion device.

Total percutaneous bypass relies on VCDs for arterial closure. The use of VCDs has been associated with an increased rate of vascular complications counterbalancing fewer wound infections and seromas.[7,14] The possible vascular complications during placement of VCDs and the cannulas can be prevented with the routine use of US and TEE. The routine utilization of US during placement of the Proglide sutures is crucial for correct orientation and placement that could otherwise result in femoral artery stenosis. The US-guided puncture has been shown to reduce complications for percutaneous access in transcatheter aortic valve implantation procedures.[15] TEE guidance is also important to prevent vascular complications during the advancement of the guidewires or the cannulae. Obesity should not be a contraindication for total percutaneous CPB as these patients can benefit most from the avoidance of a groin wound and the technical challenges of percutaneous cannulation in the obese patient can be mitigated with US and TEE assistance. No preoperative angiography was performed in our patients to assess for the peripheral arterial disease but no short-term vascular complications were seen relying on routine operative US and TEE guidance. Late complications of femoral artery dissection or pseudoaneurysm have been described with the Proglide Perclose technique after percutaneous EVAR procedures.[16] Routine postoperative evaluations of the femoral vessels were not performed for our patients but none had claudication or ischemia during long-term follow-up that would warrant a radiological examination of the vascular system.

Because CPB in adult patients requires cannula of >8-Fr sizes, two Proglide sutures are necessary for arterial closure. There is a learning curve with the use of VCDs.[17,18] Our institution has used VCDs for other interventions and we have transferred our know-how to total percutaneous CPB which enabled us to use the devices without complications in robotic surgery. Centers without a background in the use of VCDs may opt to perform percutaneous procedures that require smaller-sized catheters for their initial experience.

There are certain limitations to our study. Our results are reported from a single center with a single group of operating surgeons. The number of included patients is limited which makes generalizing our results difficult. Our study did not compare the results of total percutaneous CPB against other methods of establishing CPB in robotic surgery and other studies designed for this purpose are needed to show the true benefit of this technique. All patients were assessed at the end of the operation with the US for vascular complications but not with postoperative imaging. We have opted for the same VCD for all our percutaneous cannulations and experiences with other devices may produce different results.

5 | CONCLUSION

Total percutaneous bypass is the least invasive method of establishing extracorporeal circulation for cardiac surgery. It can be performed with excellent results. The benefits of robotic surgery can be expanded with better results in groin cannulation by the adoption of total percutaneous CPB.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

ORCID

Murat Bastopcu http://orcid.org/0000-0002-0402-1453
Sahin Senay http://orcid.org/0000-0001-5692-6927
Ahmet Ü. Güllü http://orcid.org/0000-0002-7160-6427
Muharrem Kocyigit http://orcid.org/0000-0003-0615-6025
Cem Alhan http://orcid.org/0000-0001-9052-8121

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