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Video-assisted mitral valve reoperation through a right minithoracotomy: a single-center experience

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ABSTRACT

Objective: The study aim was to determine our results of minimally invasive technique without aortic cross clamping for mitral valve surgery after previous cardiac surgery.

Material and Methods: We performed 24 consecutive mitral valve surgeries between January 2015 and December 2018 in patients with a history of previous cardiac surgery. The procedure was performed using video-assisted right minithoracotomy, femoro-femoral bypass, a temperature of 26 °C, and cardiopulmonary bypass without aortic cross-clamping.

Results: Mitral valve replacement was performed in 12 (50%) of these patients, and mitral valve repair was performed in the same number (50%). The mean ejection fraction was 46.08±6.52% and the mean age was 61.52±11.48 years. Eighteen patients (75%) had previous coronary artery bypass graft surgery, and six patients (25%) had previous mitral valve surgery. In terms of postoperative complication frequencies that patients have experienced, one of the patients (4.1%) had postoperative low cardiac output syndrome. Two patients (8.3%) had renal failure; 2 patients (8.3%) had pneumonia, and stroke was seen in one patient (4.1%) postoperatively, whereas 2 patients (8.3%) had reoperation for bleeding. The mean postoperative packed red blood cell transfusion requirement at 48 hours was 1.00±1.10 units. The mean length of hospital stay was 10.54±4.37 days.

Conclusion: Minimally invasive port access procedure via right thoracotomy may be a safe and effective option in selected patients who need mitral surgery and have a history of prior sternotomy.

Keywords: Reoperation, ventricular fibrillation, mitral valve surgery

INTRODUCTION

Redo cardiac surgeries are associated with a significantly higher risk of complications and death during the perioperative period, especially when involving reoperations on the mitral or tricuspid valves (1). Individuals with open or functioning coronary bypass grafts, with prior aortic valve replacements, or a heavily calcified aorta present additional technical challenges. Conventional median sternotomy in these cases is complicated by dense adhesions, heightened bleeding risk, potential graft injury, and suboptimal valve exposure-factors that collectively increase procedural complexity. In these cases, a right-sided thoracotomy serves as a viable alternative to the traditional median sternotomy approach (2). Minimally invasive mitral valve reoperation using video assistance offers a strategic alternative, mitigating many risks associated with repeat sternotomy. This approach minimizes trauma to mediastinal structures, reducing the likelihood of damage to the heart, major blood vessels, phrenic nerve, and existing bypass grafts. Enhanced visualization and controlled dissection decrease intraoperative hemorrhage and postoperative complications (3). Furthermore, the technique provides superior visualization of the mitral valve anatomy achieved with minimal to moderate retraction, facilitating precise surgical repair while preserving thoracic stability. In most cases, the mitral valve is readily accessible through the right side of the chest. Although the distance to the valve is considerable, it can be managed effectively with the use of extended surgical instruments. This approach also allows access to the superior and inferior vena cava, as well as entry into the right atrium, enabling the performance of additional procedures on the right side of the heart.

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For many years, hypothermia-induced ventricular fibrillation has been utilized as a method of myocardial protection during coronary surgery. This technique is grounded in the understanding that a decompressed heart in ventricular fibrillation at a temperature of 26 °C requires significantly less energy. In this study, we aimed to share our experience of minimally invasive mitral valve surgery without aortic cross clamping after previous cardiac surgery.

MATERIAL and METHODS

A total of 24 consecutive redo minimally invasive mitral valve surgeries with insignificant or minimal aortic insufficiency, performed between January 2015 and December 2018, were retrospectively analyzed. The study protocol was approved by the İstanbul Bilim University Ethics Committee (date: 07.06.2017, no: 44140529/2017-66). Preoperative computed tomography (CT) angiography was routinely performed in all patients to evaluate the suitability of femoral arterial and venous cannulation for cardiopulmonary bypass (CPB). Imaging assessment focused on aortoiliac patency, vascular caliber, and anatomic variations that could preclude safe peripheral cannulation.

The presence of significant aortic insufficiency (grade 2+ or more) was an exclusion criterion as it limits the visibility of the surgical field and may cause coronary malperfusion. If coronary artery disease cannot be effectively treated with percutaneous coronary intervention (PCI), a sternotomy may still be necessary to provide surgical access. The presence of pectus excavatum would also be an exclusion criterion, because of the difficulty of mitral valve exposure due to displacement of the cardiac chambers by the malformed sternum. Also, individuals with pleural adhesions and thickening were excluded from the study. Antithrombotic drugs were discontinued in patients undergoing PCI one week before the procedure, and the surgery was postponed 3 months after PCI. The EuroSCORE risk model provides standardized preoperative risk quantification for in-hospital mortality and severe morbidity following cardiac surgery, supporting surgical decision-making and patient counseling. The EuroSCORE algorithm incorporates multiple preoperative variables including patient demographics (age, gender), cardiovascular history, and significant comorbidities to generate individualized risk estimates for postoperative mortality and major adverse cardiac events. The updated EuroSCORE II version enhances predictive accuracy through the inclusion of additional clinical parameters and the application of contemporary statistical modeling techniques.

Surgical Procedure Description

The patients were placed in the 30-degree lateral decubitus position following the induction of general anesthesia and single-lumen endotracheal intubation. Intraoperative transesophageal echocardiography (TEE) was systematically performed in all cases, with comprehensive assessment of biventricular function, valvular morphology/hemodynamics, and exclusion of intracardiac pathology prior to cannulation. The surgical technique utilized two thoracic ports along the anterior axillary line for the video camera, cardiotomy vent, and CO_2 insufflation (2 L/min), in addition to a 4-6 cm incision made in the right fourth intercostal space.

A 4-cm longitudinal skin incision was performed on all patients in the femoral region, centered medial to the femoral pulse at the inguinal crease. The direct arterial cannulation method was used. The femoral artery was encircled with a snare proximally, positioned over the cannula, and secured with a clamp distally.

Cannulation and CPB Establishment

Femoro-femoral CPB was achieved through percutaneous insertion of a 17 Fr arterial cannula (Medtronic, MN, USA) and a 30/33 Fr multistage venous cannula (Medtronic) via the femoral vessels. Venous drainage was augmented with a 17 Fr bicaval cannula (Medtronic) placed percutaneously in the right internal jugular vein under ultrasound guidance. All procedures incorporated an intraoperative cell salvage system (Cell Saver Elite+, Haemonetics, MA, USA) for autologous blood recovery.

Minimally Invasive Access

Surgical access was obtained through:

1. Two 5-mm thoracic ports placed along the anterior axillary line (3rd and 5th intercostal spaces) for:

- 3D videoscope (Stryker 1688, 4K resolution)
- CO_2 insufflation (2 L/min flow rate)
- Cardiotomy vent

2. A 4-6 cm right anterolateral thoracotomy at the 4th intercostal space, utilizing a soft-tissue retractor (Estech Flex A) and specialized rib spreader (Estech Riblift II).

Surgical Technique

Following systemic cooling to 26 °C nasopharyngeal temperature:

1. The pericardium was opened 2 cm superior and running alongside to the phrenic nerve

2. Left atriotomy was performed via Sondergaard's groove

3. Mitral valve exposure was achieved using a dynamic atrial retractor (Estech MitraFlex).

Physiological Management

CPB parameters were maintained at:

- Mean arterial pressure: 70-80 mmHg
- Pump flow: 2.4-2.8 L/min/m^2
- Mixed venous saturation >70%

Patient positioning included:

- 15° trendelenburg
- 20° right lateral decubitus tilt

Ventricular fibrillation was permitted during cooling, with electric cardioversion reserved for persistent fibrillation after rewarming. Air was carefully expelled from the left ventricle, and a catheter was inserted through the valve under increased CO_2 insufflation (8 L/min).

Closure and Rewarming Protocol

Following completion of the mitral valve procedure, the left atriotomy was closed in two layers using a continuous 4-0 polypropylene suture (Prolene, Ethicon). A final TEE assessment confirmed:

- Absence of atrial air
- Competent valve function
- Normal ventricular filling

Systemic rewarming was initiated with a graded protocol:

1. Temperature gradient maintained at ≤10 °C between blood and core temperature

2. Rewarming rate of 0.25-0.5 °C/min to prevent microbubble formation

3. Target nasopharyngeal temperature of 36.5 °C before weaning CPB

After confirming the absence of left ventricular air during the TEE, patients were weaned off CPB.

Post-CPB Resuscitation and Closure Protocol

1. Defibrillation and Rhythm Management

- External defibrillation was performed using 30-50 J biphasic shocks (ZOLL M-Series) to achieve sinus rhythm
- Two temporary epicardial pacing wires (Medtronic 6500) were secured to the right ventricular anterior wall.

· Unipolar ventricular lead for backup pacing

· Atrial lead available for sequential pacing if needed.

2. Drainage and Hemostasis

- Two 28 Fr straight chest tubes (Atrium Medical) were placed under direct vision:

· Pericardial tube positioned posterior to the heart

· Right pleural tube placed along the diaphragmatic surface

- Meticulous hemostasis was verified with Valsalva maneuver at 30 cm H_2O.

3. Structured Chest Closure

- Pericardium was loosely reapproximated with interrupted 2-0 Vicryl sutures
- Ribs were reapproximated using #5 FiberWire pericostal sutures
- Layered soft tissue closure:

· Muscle: Continuous 0 Vicryl

· Subcutaneous: 2-0 Vicryl

· Skin: Staples or subcuticular 4-0 Monocryl.

Statistical Analysis

The distribution of continuous variables was formally evaluated for normality using the Shapiro-Wilk test (W statistic) with $\alpha=0.05$ threshold for significance. Continuous variables were expressed as mean ± standard deviation when normally distributed, and as median with interquartile range, when the distribution was non-normal. Categorical variables were summarized using counts and percentages. All data are reported accordingly.

RESULTS

A total of twenty-four patients, 14 males and 10 females, were evaluated. Patients had a mean age of 61.52±11.48. Fifteen patients (62.5%) had hypertension, 5 patients (20.8%) were diabetic, 12 patients (50%) had hyperlipidemia, and 2 patients (8.3%) had chronic renal failure. Six patients (25%) were in functional class II, fourteen (58.3%) were in functional class III, and four (16.7%) were in class IV. Twenty patients (83.3%) had a mild level of tricuspid regurgitation (TR) whereas 4 patients (16.7%) had a severe level of TR (Table 1).

Eighteen patients (75%) had previous coronary artery bypass graft (CABG) surgery and 6 patients (25%) had previous mitral valve surgery. Mitral valve replacement was performed in 12 (50%) of these patients and mitral valve repair was performed in 12 (50%) of them. Neochordae replacement and annuloplasty ring were used for all mitral repair patients. There was no residual mitral regurgitation before discharge, at early and midterm follow-up, for repair patients.

The mean interval between the initial surgery and subsequent reoperations was 7.16±4.93 years. The mean EuroSCORE was 8.4±1.67. The mean durations of ventricular fibrillation and CPB were respectively, 82.95±12.08 minutes and 142.91±30.60 minutes. Mean hospital stay was 10.54±4.37 days, whereas intensive care unit stay was 2.70±3.40 days (Table 2). We did not convert the surgery to sternotomy in any patient.

In terms of postoperative complication frequencies that patients have experienced, one of the patients (4.1%) had postoperative low cardiac out syndrome. Two patients (8.3%) had renal failure, two patients (8.3%) had pneumonia postoperatively, and two patients (8.3%) underwent reoperation for bleeding. Postoperative stroke was observed in one patient. There were two deaths in our study due to multi-organ failure.

The average packed red blood cell transfusions 24 hours postoperatively were 0.87±0.99, and 48 hours postoperatively were 1.00±1.10 units.

Table 1. Patients instead of patient

		Mean ± SD
Age (years)		61.52±11.48
EF (%) **EuroSCORE**		4.08±6.52 8.4±1.67
		n (%)
Gender	**Female**	10 (41.7)
	Male	14 (58.3)
HT		15 (62.5)
DM		5 (20.8)
HL		12 (50)
CRF		2 (8.3)
PAD		2 (8.3)
COPD		6 (25)
NYHA	2	6 (25)
	3	14 (58.3)
	4	4 (16.7)
TR	Mild	20 (83.3)
	Severe	4 (16.7)

SD: Standard deviation, EF: Ejection fraction, HT: Hypertension, DM: Diabetes mellitus, HL: Hyperlipidemia, CRF: Chronic renal failure, PAD: Peripheral arterial disease, COPD: Chronic obstructive pulmonary disease, NYHA: New York Heart Association, TR: Tricuspid regurgitation

Table 2. Operative data of patients

	Mean ± SD/n (%)
Operation interval (year)	7.16±4.93
Fibrilatory arrest (min)	82.95±12.08
CPB (min)	142.91±30.60
ICU stays (day)	2.70±3.40
Hospital stays (day)	10.54±4.37
Packed RBC transfusions-24 h post-op. (U)	0.87±0.99
Packed RBC transfusions-48 h post-op. (U)	1.00±1.10
Stroke	1 (4.1%)
Renal failure	2 (8.3%)
LCOS	1 (4.1%)
Pneumonia	2 (8.3%)
Reoperation for bleeding	2 (8.3%)

SD: Standard deviation, CPB: Cardiopulmonary bypass, ICU: Intensive care unit, RBC: Red blood cell, LCOS: Low Cardiac Output Syndrome

DISCUSSION

Redo surgeries performed via median sternotomy pose a heightened risk for patients with patent coronary bypass grafts. Injury to a patent graft can be life-threatening. To reduce complications, enhance recovery time, and improve cosmetic results, various alternatives to traditional sternotomy have been developed. These include partial sternotomy, mini right anterolateral thoracotomy—conducted either with direct visualization or video assistance—and robotic approaches to mitral valve surgery. Such procedures often utilize extended conventional instruments along with compact retractors. The right anterolateral thoracotomy approach helps avoid manipulation of patent grafts, thereby lowering surgical risk. Myocardial protection during these operations can be maintained without aortic cross-clamping by employing hypothermia and inducing ventricular fibrillation.

This method has also been used for reoperative mitral valve surgery in the presence of a patent left internal mammarian artery (LIMA)-left anterior descending artery (LAD) graft (4,5). In our study, 18 patients (75%) had previous CABG surgery with patent LIMA-LAD graft.

The presence of concomitant coronary artery disease, which would normally require concurrent coronary artery bypass surgery, would be a contraindication for minimally invasive valve surgery. However, the use of PCI could advantageous in such scenarios, by circumventing the need for CABG and allowing the minimally invasive valve procedure to be performed. Concurrent PCI was successfully utilized in 8.3% of the present patients. Performing PCI in a diseased graft or native coronary artery avoids the necessity for reoperative coronary artery bypass surgery. To perform concurrent coronary bypass surgery, the entire heart must be exposed, placing any patent grafts at risk.

Repair can be carried out under fibrillatory arrest or with the beating heart in such circumstances. Both beating heart and fibrillatory-arrested heart procedures have been confirmed to be safe in several studies (6,7).

Umakanthan et al. (8) highlighted the safety of using ventricular fibrillation combined with hypothermia and without aortic clamping during minimally invasive mitral valve surgeries. The study involved 195 patients who underwent this myocardial protection technique in cardiac surgery procedures. In patients with prior cardiac surgery, dense pericardial and mediastinal adhesions pose a significant obstacle to minimally invasive approaches. These adhesions not only complicate dissection but also critically limit access to key structures, particularly the aorta, making safe cross-clamping extremely challenging. Our findings indicated a 30-day mortality rate of 8.4%, with low output syndrome and stroke occurring in 4.1% of cases, which aligns with the outcomes reported by other studies utilizing myocardial protection with aortic clamping (9,10). The low incidence of inotropic support in our cohort supports the literature, which suggests that this technique offers effective myocardial protection (11). Limited surgical dissection reduces the risk of excessive bleeding and the need for transfusions. Furthermore, this minimally invasive approach causes less tissue damage and is associated with lower postoperative pain levels (12). Patients also experience the benefit of earlier mobilization due to the enhanced stability of the bony thorax. The observed reductions in postoperative ventilation duration, intensive care unit stay, and overall hospitalization period may be attributed to the less invasive surgical approach. This correlation suggests that minimally invasive techniques enhance recovery kinetics in this patient cohort, potentially due to reduced surgical trauma, diminished systemic inflammatory response, and preserved respiratory mechanics compared to conventional sternotomy approaches. Bolotin et al. (13) however, observed no significant difference in mortality or CPB times, though their study showed notable reductions in postoperative intubation duration, blood transfusion requirements, and hospital stay. Onnasch et al. (14) reported their experience with 39 patients undergoing redo mitral valve surgery through port access. They concluded that this technique is safe for use in reoperations. The practical advantages of this approach include avoiding sternal reentry, minimizing cardiac dissection, and preventing dissection of patent grafts. Additionally, it leads to lower transfusion rates, fewer wound complications, reduced overall morbidity, and shorter hospital stays. Our findings are consistent with those of other studies regarding postoperative blood loss, the lengths of stay in both the intensive care unit and the hospital, and the amount of red blood cells transfused (14).

Svensson et al. (15) documented a 7.5% incidence of stroke in patients undergoing right thoracotomy. The elevated stroke rate noted in our cohort may be attributed to several contributing factors. In cases of repeat surgery, mediastinal adhesions can displace the left ventricular apex toward the outflow tract, which may increase the risk of complications, including the entrapment of air emboli. To mitigate this risk, we utilize intraoperative strategies such as manually agitating and compressing the chest and employing TEE to ensure effective de-airing of the left ventricle. We believe our comparatively low stroke rate is a result of maintaining arterial pressure above 40 mmHg during CPB, using a cannula for continuous aspiration from the left ventricle, and delivering a steady flow of carbon dioxide into the operative field throughout the procedure. In our research, postoperative stroke occurred in one patient (4.1%).

A comprehensive preoperative evaluation of the aorta, iliac, and femoral arteries using imaging modalities such as CT or angiography is crucial to minimize the potential for dislodging thrombi or atheromatous plaques during retrograde perfusion. Importantly, we observed no complications related to cannulation in our series.

Our observed in-hospital mortality rate was 8.4%, which aligns with outcomes reported in other studies involving mitral valve reoperations performed via either right thoracotomy or median sternotomy (15,16).

In right minithoracotomy approaches, fibrillatory arrest is generally favored, as operating on a beating heart can compromise mitral valve visualization—particularly when aortic regurgitation is present—and may heighten the risk of air embolism (17). Additional research would be valuable to further assess the comparative outcomes of fibrillatory arrest versus beating heart techniques in redo mitral valve surgery.

The beating heart method is typically reserved for situations where aortic clamping is not feasible, such as in cases of porcelain aorta or prior proximal aortic surgery. Moreover, the presence of mild or greater aortic regurgitation precludes the use of this technique, in which case an aortic endo-balloon becomes a suitable alternative.

CONCLUSION

In summary, minimally invasive mitral valve reoperations performed under hypothermia and ventricular fibrillation without aortic cross-clamping can be conducted safely in carefully selected patients, with a low rate of associated complications.

Ethics

Ethics Committee Approval: The study protocol was approved by the İstanbul Bilim University Ethics Committee (date: 07.06.2017, no: 44140529/2017-66).

Informed Consent: A written informed consent was obtained from the parents and/or legal guardians of the patients.

Footnotes

Author Contributions

Surgical and Medical Practices - M.E., K.O., A.S., K.T.S., B.A.; Concept - M.E., K.O., A.S.; Design - M.E., K.T.S., B.A.; Data Collection or Processing - M.E., K.O., A.S.; Analysis or Interpretation - M.E., A.S., K.T.S.; Literature Search - M.E., K.T.S.; Writing - M.E., K.O., A.S., K.T.S., B.A.

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