Albanian Journal of Trauma and Emergency Surgery (2025) 9/1:1691-1697
DOI: https://doi.org/10.32391/ajtes.v9i1.413

REVIEW ARTICLES

Minimally Invasive Mitral Valve Surgery: Initial One-team Experience and Short Review

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Received: 24 July 2024 / *Accepted:* 12 August 2024 / *Published online:* 20 January 2025
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Abstract

Introduction: Minimally invasive mitral valve surgery (MIMVS) is now a widely accepted and more frequently utilized method for patients needing mitral valve surgery. The promoted advantages are less trauma, less bleeding, less pain, and fewer wound infections, allowing faster postoperative and decreased healthcare costs.

Material and Methods: This is a single-center retrospective study. We have collected the records of patients who underwent MIMVS by one team at the Cardiac Surgery Service, UHC" Mother Theresa" Hospital. The patients' data regarding demographic, preoperative, operative, and postoperative variables were collected from the medical records in the hospital. All statistical analyses were performed using IBM SPSS version 24.0 software (SPSS, Inc., Chicago, IL, USA).

Results: Surgical technique includes mitral valve repair or replacement through right lateral mini-thoracotomy, through a small 5-7cm incision in the 4th–5th right intercostal space under direct vision Seldinger technique under transesophageal echocardiogram guidance is used for cannulation, first 3 cases of MIMVS was performed with two venous cannulas – one percutaneous jugular cannula and femoral one, 8 cases underwent single two-stage femoral venous cannulation for venous drainage, femoral arterial cannulation and vacuum assisted cardiopulmonary bypass (CPB).

Conclusion: Minimal-invasive mitral valve surgery is as safe as the standard approach and allows faster recovery with a shorter length of hospitalization, resulting in decreased healthcare costs. We need a more extensive study to confirm the other advantages, but minimal-invasive should be pushed to become a standard approach for mitral valve surgery. An adequate learning curve is mandatory for all the operative teams to achieve all the benefits for the patients.

Keywords: Mitral valve surgery, minimally invasive mitral valve procedures, right lateral Mini thoracotomy.

Introduction:

Since 1996, when Carpentier performed the first video-assisted minimally invasive mitral valve surgery (MIMVS) through a mini-thoracotomy [1], a minimally invasive approach for mitral valve surgery has become an increasing trend. In the past decades, right mini-thoracotomy became a standard mitral valve repair and replacement approach in many centers. Approximately 1 in 3 isolated mitral operations in North America are performed via a less invasive, sternal-sparing approach.[2] Compared to traditional approaches, the potential advantages of MIMVS include decreased postoperative pain levels, faster recovery time, reduced necessity for blood product transfusions, and better cosmetic outcomes compared to mitral valve surgery performed via sternotomy. There were numerous technological developments, such as the methodology of canulation, clamps, and port access, to achieve the best results today [3, 4, 5]. Despite the mentioned benefits, minimally invasive mitral valve surgery was criticized mainly because it is technically more complex and requires a long learning curve that may negatively affect the results of standard surgery. We will present the initial experience of one team using the right mini-thoracotomy with the primary

Original article, no submission or publication in advance or in parallel

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goal of making the mini-thoracotomy approach a standard technique. In addition, we will provide a short overview of MIMVS based on recent literature.

Surgical technique: The right mini-thoracotomy (RMT) approach is performed through a small 5-7cm right lateral sub-mammary incision, usually on the 4th or 5th intercostal space. The installation of CPB is realized through percutaneous jugular vein cannulation and open right femoral vein, both under trans-esophageal echocardiography (TEE). The arterial route of canulation used was the open right femoral artery.

There are different techniques to occlude the aorta and protect the heart. We use a transthoracic clamp (TTC). Using the TTC technique, the aorta is occluded through a transthoracic direct clamp inserted through an additional port or the working incision. The antegrade warm blood cardioplegia is delivered through a standard cardioplegia cannula secured with purse-string sutures in the ascending aorta. With the heart arrested on cardiopulmonary bypass, the left atrium is opened adjacent to the interatrial groove. The view of the left atrium and mitral valve is generally sufficient to repair or replace the mitral valve. Upon completion of the mitral procedure, the left atrium is closed in a standard fashion. De-airing of the heart is achieved. Any residual air on the echo can be aspirated through the aortic root vent. The aortic cross-clamp is removed once the heart is well de-aired on echo. The patient is gradually weaned from cardiopulmonary bypass after the placement of pacemaker wires on the anterior surface of the heart. Only one pleural drain is placed. The wound is closed as usual. (fig.1)

Figure 1. Dumani S: Photos before incision and after intervention

Materials and Methods:

This is a single-center retrospective study. We reviewed the records of all patients who underwent MIMVS by one team at the Cardiac Surgery Service of UHC "Mother Theresa" between May 2022 and April 2024. The patients' information regarding demographic, preoperative, operative, and postoperative variables was collected from the medical records in the hospital. All statistical analyses were performed using IBM SPSS version 24.0 software (SPSS, Inc., Chicago, IL, USA). Categorical variables are summarized with frequencies and percentages. Normally distributed variables were reported as mean ±standard deviation, and non-normally distributed variables were reported as median with range. The endpoints of our study include early mortality, significant postoperative complications, and postoperative time-related outcomes and recovery. We also will provide an overview of the recent literature about MIMVS.

Results:

The mean age (±SD) of cases is 61 years (±8), with a minimum age of 46 and a maximum age of 73.

Among 11 patients, 54.4% are male, 45.5% are female, 54.5% were diagnosed with severe mitral regurgitation, and 18.2% had mixed pathology mitral valve.

The majority of patients, precisely 90.9% (10), correspond to the class I of heart failure, while only 9.1% (1) belong to the class II of heart failure.

The echocardiographic data are presented in Table 2, which lists the risk factors for the patient's conditions, such as hypertension, diabetes mellitus, dyslipidemia, and smoking. Hypertension is the most common risk factor, followed by dyslipidemia and smoking. Almost all patients had preserved left ventricular function, with an average value of EF 60% (±6), a minimum of 47%, and a maximum of 65%.

Most patients (54.5%) underwent minimally invasive mitral valve replacement (MIMVR). Mitral valve repair, including annuloplasty, P2 resection, and "Alfieri suture," is performed in 5 patients. Regarding the CPB and aortic clamp time, the mean (±SD) time of CPB is 128 (±32) minutes with a minimum of 87 minutes and a maximum of 212 minutes. The mean (±SD) time of the aortic clamp is

Demographic data		Count	%	Mean(±SD)	Minimum	Maximum
Sex	Female	5	45.5 %			
	Male	6	54.5 %			
Age				61(±8)	46	73

Table 1: Demographic data of the patients. (Sex and age)

Preoperative data		**Count**	**%**	**Mean(±SD)**	**Min.**	**Max.**
Diagnosis	Mitral regurgitation	6	54.5%			
	Mitral stenosis	1	9.1%			
	Rheumatic mitral disease	1	9.1%			
	Mitral endocarditis	1	9.1%			
	Steno-insufficiency mitral valve	2	18.2%			
NYHA	I	1	9.1%			
	II	10	90.9%			
EF %				60(±6)	47	65
Left Atrium(mm)				45(±6)	39	54
Pulmonary systolic Pressure(mmHg)				37(±8)	23	45
Thickness Posterior Wall(mm)				10(±1)	8	11
Thickness Septum (mm)				11(±1)	9	13
Tele diastolic Diameter(mm)				51(±7)	39	68
Tele systolic Diameter(mm)				38(±3)	32	44
Mitral annulus Calcification	No	7	63.6%			
	Yes	4	36.4%			
Euroscore				1.27(±1)	1.04	1.41
Risk factors	Hypertension	10	91%			
	Diabetes Mellitus	1	9%			
	Dyslipidemia	6	55%			
	Smoking	4	36%			

Table 2: Preoperative data of the patients presented as number/ percentage or mean(±SD) and echo graphic data.

Operative data		**Count**	**%**	**Mean(±SD)**	**Min.**	**Max.**
CPB time, min				128(±32)	87	212
Aortic clamp time(min)				95(±24)	62	142
Intervention	Annuloplasty with Edwards ring and P2 resection	4	36.4%			
	Mitral repair, according to Alfieri	1	9.1%			
	Mitral replacement (MIMVR)	6	54.5%			
P2 Resection	No	7	63.6%			
	Yes	4	36.4%			
	None	5	45.5%			
Prosthetic Valve type	Bioprosthetic (SJM Epic Supra Valve)	1	9.1%			
	Mechanical valves (SJM Masters)	5	45.5%			

Table 3: Operative data of the patients presented as number/ percentage (type of intervention, p2 resection, prosthetic valve type) or mean(±SD) (CPB time, AC). CPB time- cardiopulmonary bypass time; AC- aortic clamp; MIMVR- minimally invasive mitral valve replacement.

Postoperative data		Count	%	Mean(±SD)	Min.	Max.
ICU(hours)				30(±11)	27	46
Hospitalization (days)				12 (±8)	7	30
Postoperative hospitalization (days)				8(±5)	5	18
Respiratory Assistance time (hours)				8(±4)	6	14
Postoperative complications	Pulmonary dysfunction	1	6.7%			
	Renal insufficiency	1	6.7%			
	Hemorrhage	2	13.3%			
	New Atrial fibrillation	2	22.3%			
	Infection	1	6.7%			
	Perceptual disorders	2	13.3%			
	Exitus	1	9.1%			

Table 4: Postoperative data of the patients presented as number/ percentage (postoperative complications) or mean (±SD), ICU- intensive care unit

95(±24) minutes, with a minimum of 62 and a maximum of 142 minutes.

One patient died due to a massive hemorrhage because of an atrioventricular sulcus rupture. The remaining patients received intensive care in the ICU for an average of 30 hours (±11). They stayed hospitalized for 5 to 18 days after the intervention, with an average hospital stay of 8 days (±5), and the respiratory assistance time ranged from 6 to 14 hours, averaging 8(±4) hours. The recovery early after the intervention, two to three days after the intervention, was notably much easier than the patient who underwent a standard sternotomy. Based on the analyzed data, the average overall hospitalization time was 12 (±8) days.

Discussion

Minimally invasive mitral valve surgery (MIMVS) was initiated in the middle 1990s, but systematic adoption of the technique has been limited. MIMVS has become a treatment for many patients with MV surgery: in the United States, its use has increased from 11.9% in 2004 to 20.1% in 2008, and in Germany, from 13.1% in 2004 to 45.2% in 2013 and more than 50% in 2017[6].

Skepticism about using MIMVS, even the increasing trend, derives from the fact that this approach is technically more complex, requires a long learning curve, and may negatively influence the standard approach results. We will represent some of the studies and meta-analyses according to the results, polemics, and complications of MIMVS.

The most challenging aspect of the surgical complexity is the possible development of serious complications associated with peripheral cannulation: retrograde aortic dissection is a rare but life-threatening complication that may arise from this cannulation method. Heart-Port World Wide Registry reported aortic dissection in 11 of 610 patients undergoing Port-Access surgery, which was superior to the incidence of aortic dissection after conventional cardiac surgeries [7].

Safety of the surgical technique: In 1998, Mohr et al. [4] published a preliminary study revealing severe complications in a series of 51 patients who underwent minimally invasive surgeries. The hospital mortality rate was 9.8%, the transient ischemic attack rate was 7%, acute retrograde aortic dissection was reported in 3.9% of patients, and 5.8% of patients required reoperation for para-valvular leakage. Aortic dissection events were probably caused by the guide wire transit that created an intimal tear, increased by the retrograde flow that led to a complete vessel dissection. The rate of these complications at the early stage of their experience was related to the limited surgeon and team expertise. The same team published several reports in the following years with excellent long-term results, a low rate of complications, and drastically decreased conversion to sternotomy [8]. After these initial studies, the efficacy and safety of the minimally invasive approach were evaluated with a few randomized trials and several meta-analyses or propensity score-matched investigations.

In 2005, Dogan and colleagues [9] published the first prospective randomized study about the video-assisted Port-Access technique, comparing it to standard surgery: in this study, the Port-Access technique was reported to be more time-consuming, even if the differences were not statistically relevant. The CPB and cross-clamp time were similar. A significant result was that no patient demonstrated clinical evidence of myocardial ischemia, indicating a similar quality of myocardial protection in both techniques. Furthermore, no permanent neurologic deficit was described. Before this study, Schneider and colleagues [10] had reported a similar experience, not observing significant differences in the stroke rates between patients undergoing Port Access or conventional surgery. It is essential to point out that before randomization, the surgical team had minimal experience with the minimally invasive port access technique, and some of the technical problems reported in these series may be attributed to the learning curve.

Neurological events: Gammie and coauthors [11], with their analysis of the STS database, reported a markedly higher rate of permanent perioperative stroke in patients who underwent minimally invasive surgeries compared to the conventional sternotomy group. Supplementary analyses demonstrated that patients who underwent MIVS without aortic occlusion were at higher risk of stroke (on beating- or fibrillating-heart); meanwhile, femoral cannulation was not independently related to increased risk of stroke. In addition, in 2011, a meta-analysis (Cheng et al.) including [12] comparative studies compared MIMVS clinical outcomes and resource utilization to conventional open mitral valve surgery. They reported that the 30-day risk of stroke (2.1% vs. 1.2%) and aortic dissection/injury (0.2% vs. 0%) were significantly increased for MIMVS compared to the standard procedure. The minimally invasive method increased cross-clamp, cardiopulmonary bypass, and procedure times. Still, ventilation time and length of stay in the intensive care unit and hospital were reduced.

In 2014, a systematic review and meta-analysis [13] by Sunderman et al. investigated more than 20.000 patients who underwent MV surgery from 45 different studies. An important outcome was that stroke rate (1.7% vs 1.6%) and all-cause mortality up to 30 days were similar in MIMVS and classic MV surgery. In contrast to the precedent-cited studies, specifically the meta-analysis by Grammie and Cheng and colleagues, [11, 12] this report showed that the MIMVS group of patients did not have an increased stroke rate compared with the conventional surgery. The initial negative results probably resulted from the learning curve in the centers involved in the earliest reports. In our study group, we did not have stroke events, but we had longer operative time, which is logically related to the fact that it is just the beginning of the experience. Nevertheless, this does not give the impression of predicting a negative clinical impact.

Bleeding, Transfusion, and revision for hemorrhage: A reduction in postoperative hemorrhage and transfusion requirements has been suggested as a potential advantage of minimally invasive valve surgery. This benefit is essential given the significant morbidity and mortality associated with transfusions. Smaller incisions should theoretically reduce postoperative bleeding, and transfusion requirements should be revised for bleeding. There is no significant difference in blood losses, blood product transfusions, or chest tube drainage [8, 14, 15, 16] despite longer CPB times that disfavor MIMVS. In a prospective, randomized trial, Dogan et al. [9] found a significant decrease in postoperative chest tube output in the mini group compared with the entire sternotomy group.

The right mini-thoracotomy was associated with 51% fewer blood products than a conventional sternotomy [17]. In addition, Cohn et al. confirm that patients undergoing minimally invasive valve surgery are transfused 1.8 units less than a traditional cohort [18]. In our group, we had two revisions for bleeding. One of them was the disruption of the atrioventricular sulcus, which resulted in fatalities, and we think that is unrelated to the approach. The group is small, and we will focus more on this topic in the future.

Atrial Fibrillation: It has been suggested that a less traumatic surgical approach would be a less potent trigger of postoperative AF. Meta-analysis of four eligible studies showed no significant difference between minimally invasive and sternotomy approaches. Asher et al. [19] addressed this question in a cohort of 100 patients having elective primary minimally invasive MV surgery compared with a control group undergoing conventional sternotomy. They found a similar prevalence of postoperative AF using either method. There are lots of reports that support a lower incidence of AF related to MIMVS. Some clinical outcomes, including atrial fibrillation, were significantly improved with MIMVS [12]. Postoperative new AF was inferior in the MIMVS group, probably related to reduced right atrial manipulation [13]. The PAIR registry reported a 10% incidence of new-onset AF with the port access technique, which is lower than expected for sternotomy [19]. In our group, we had only two patients who had a new onset of atrial fibrillation.

Wound infections: The incidence of wound infections and septic complications is lower with a thoracotomy than with a median sternotomy. Grossi et al., in a case-control study, reported a decreased incidence of wound complications [17]. Thirty-five studies, two randomized controlled trials, and 33 nonrandomized studies suggest that mini-MVS may be associated with decreased bleeding, blood product transfusion, atrial fibrillation, and sternal wound infection [12].

Pain, quality of life, and recovery time: Compared with a complete sternotomy, thoracotomy incisions are associated with less pain, discomfort, and postoperative analgesics [15]. Cohn's data show less pain in the hospital and after discharge, less analgesic usage, greater patient satisfaction, and a return to regular activity 4.8 weeks ahead of sternotomy patients [18]. Cheng et al., in an extensive review, reported that between several clinical outcomes, the time of postoperative recovery was significantly improved with MIMVS in terms of time to return to regular activity and scar cosmetic results [12]. Even though our group was small, almost all patients were more satisfied than those with standard sternotomy, and the postoperative activation was much more accessible.

Hospital Stay and Costs: The minimally invasive approach significantly reduced mean and median hospitalization costs, consistent with the observed difference in hospitalization duration between the groups. In addition, patients undergoing MIMVS had faster rates for independent ambulation and time to independent sit-to-stand activity [15,17,20]. Some reported benefits of MIMVS include decreased intensive care unit and total hospital length of stay, faster physical rehabilitation, and decreased overall hospital resource use [21].

Mortality: Several comparative mini vs complete sternotomy studies evaluating mortality showed no significant difference between minimally invasive and conventional approaches [15, 19, 21, 22, 23, 24]. Mihaljevic et al. compared 474 minimally invasive mitral operations (mostly lower sternotomy and right parasternal) with 337 median sternotomy procedures. The perioperative mortality was 0.2% for the minimally invasive group, and this is compared favorably with 0.3% in the sternotomy patients. However, the MIMVS patients were found to be a lower-risk group (better ejection fraction, more repairs, less symptomatic), and no attempt was made to adjust for these differences [23].

Furthermore, Grossi et al. matched 100 consecutive patients undergoing minimal invasive aortic and mitral valve surgery over a 2.5-year period (through either a 3rd or 4th interspace incision) to patients having the same valve surgery via a sternotomy [24]. They demonstrated no significant difference in hospital mortality (3.7% versus 3.4%) between groups, even though mean CPB times were 30 min longer in the minimally invasive group.

It is essential to remember that adopting a new surgical technique requires a learning curve, so if this point is not considered, the results are only partially realistic. Casselman et al. [25] defined the learning curve at 50 consecutive MIVS cases, finding favorable outcome data associated with MIMVS. The 30-day mortality rate of a series of 500 patients was 1.4%, the primary stroke rate was only 0.8%, and no aortic dissections occurred. These results significantly contrast with the precedent literature, and the main reason for these differences is that only in this study were surgeons fully experienced with minimally invasive mitral valve surgery (at least 100 patients operated with this technique). Later, in 2018, a multicenter propensity-matched study [26] of 1278 patients from England proved no difference between MIVS and sternotomy regarding early and late outcomes out to 8 years.

Conclusions:

MIMVS has been proven to be a safe alternative to the conventional complete sternotomy approach with low perioperative morbidity and short-term mortality. Reported benefits of MIMVS include decreased postoperative pain, improved postoperative respiratory function, reduced surgical trauma, and greater patient satisfaction. The operative team must have An adequate learning curve to achieve all patient benefits.

COI Statement: This paper has yet to be submitted in parallel, presented fully or partially at a meeting, podium, or congress, published, or submitted for consideration beforehand.

This research received no specific funding from public, commercial, or non-profit sectors. The authors declare that they, their relatives, or next of kin have no financial relationships with external companies that could be considered relevant or minor.

Disclosure: The authors declared no conflict of interest. No funding was received for this study.

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