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Research Article

Comparison between Minimally Invasive Approach and Conventional Sternotomy in Mitral Valve Surgery: Critical Analysis of a Daily Practice

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Abstract

Objective: To assess our strategy of treatment allocation between minimally invasive approach (MIMVS) and conventional sternotomy (CS) in mitral valve surgery.

Methods: During a 16-months period, all patients who underwent a mitral valve surgery were prospectively included in the study. All procedures were consecutively performed by the same operator as an intention-to-treat surgery.

Results: The treatment allocation was MIMVS in 20 patients and CS in 20 patients. The comparison of preoperative data between the two groups confirmed higher-risk patients in the CS group, who underwent also more frequently an associated procedure. Ischemic and cardiopulmonary bypass times were significantly longer in those undergoing MIMVS. In the sub-group of patients who underwent isolated mitral surgery (MIMVS, 18; CS, 12), the same pre and per-operative differences were observed, there was no death or stroke in both groups and their postoperative outcome was similar.

Conclusion: The analysis of our practice was consistent with the literature; it has confirmed the non-inferiority of MIMVS in comparison with CS, in selected patients with low or intermediate risk profile. High-risk patient were naturally referred to CS, and there is no evidence to modify this strategy in treatment allocation.

Keywords: *Mitral Valve Surgery; Minimally Invasive Surgery; Mitral Valve Repair; Video-Assisted Surgery*

Introduction

The concept of minimally invasive mitral valve surgery (MIMVS) has been well established for two decades. In addition to benefits of improved cosmetic, MIMVS was pioneered with the intent of reducing morbidity, postoperative pain, blood loss, hospital length of stay, and time to return to normal activity. Although clinical studies support many of the theoretical advantages of less-invasive approaches to mitral [1-3], there is still ongoing debate about the benefits of MIMVS because no definitive randomized trial has been conducted to date [4]. Several meta-analyses, based on retrospective and/or propensity score studies, showed that perioperative outcome is similar for MIMVS performed via a right lateral thoracotomy and conventional mitral valve surgery performed via median sternotomy [5-7].

However, treatment allocation biases inherent in retrospective studies beget significant differences in baseline risk profile of minimally invasive and sternotomy groups, often with the higher-risk patients in the sternotomy cohort. Propensity score analyses help to control for such bias, but matched groups were similar with regard to the low/intermediate risk MIMVS population because patients on either end of the probability spectrum are typically unmatchable. Therefore, the limitations of such studies are not always emphasized, and generalizability from them is open to criticism.

Nowadays, there is a discrepancy between the message from literature and experts, promoting MIMVS as a new standard for all patients, and the real world of MIMVS where this technique is mainly dedicated for low or intermediate risk population. According to the recommendations and the guidelines, patients are identified earlier in the disease course and there is a growing advocacy for referral of asymptomatic or paucisymptomatic patients for surgery, specially in degenerative mitral valve disease. Concurrently, there is an increasing demand from patients and referring physicians for less-invasive mitral valve surgery.

Despite a paucity of objective evidence to demonstrate therapeutic equivalence, in our surgical strategy, MIMVS is indicated as first choice and sternotomy approach is the second choice when there is a probability of potential higher surgical risk with MIMVS, according to empiric treatment paradigms, and in case of absolute contraindications of MIMVS including severe peripheral arterial disease, high-grade atheroma of the descending aorta, and previous right thoracic surgery [8].

Aim of the Study

The aim of this study is a critical analysis of our daily practice in the real world of mitral valve disease and to establish where we are, according to the treatment allocation described above.

Material and Methods

Population

During a 16-months period, 40 patients underwent a mitral valve surgery, consecutively performed by the same operator. All procedures were performed as an intention-to-treat surgery. The treatment allocation was a MIMVS in 20 patients and a sternotomy approach in 20 patients; the non-MIMVS allocation was documented. Baseline demographics, comorbidity profiles, echocardiographic details, operative data, and in-hospital outcomes were stratified by operative approach and compared. To avoid the bias of associated procedure, a subgroup analysis of patients who underwent isolated mitral valve surgery was done.

Operative technique

MIMVS was performed using standardized technique [9,10]. Standard monitoring lines are placed and the patient is intubated with a double-lumen endotracheal tube. Thoracic access is achieved via a 5-cm lateral incision in the fourth intercostal space (Figure 1). A soft tissue retractor is used and rib spreading with retractor is limited. Before cannulation, a complete echocardiographic assessment is performed and cannulation is done under TEE guidance. A 16F femoral cannula is used for the right internal jugular; femoral venous cannulation is performed with a 25F cannula; femoral arterial cannulation is performed with a 19F to 21F cannula depending of the body size. Cardiopulmonary bypass is initiated with moderate hypothermia (34°C); aortic occlusion is accomplished with transthoracic clamping and crystalloid cardioplegia solution (Custodiol) is used for cardiac arrest. Video-assistance is used systematically (Figure 2).

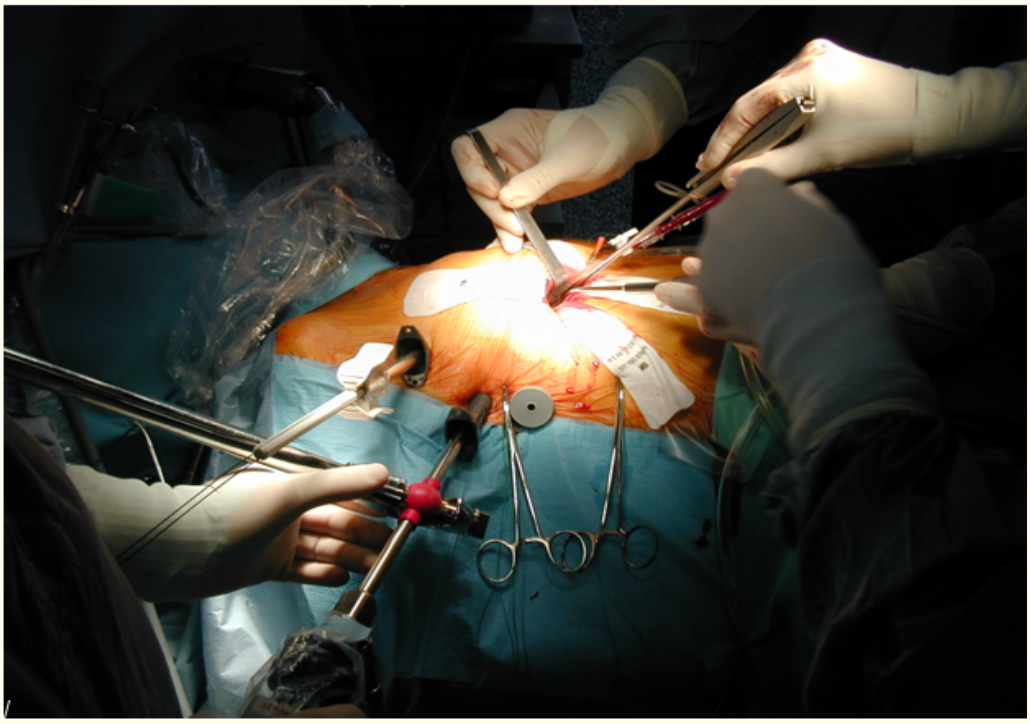

Figure 1: *Operative view of minimally invasive mitral valve surgery using right mini-thoracotomy approach and video-assistance.*

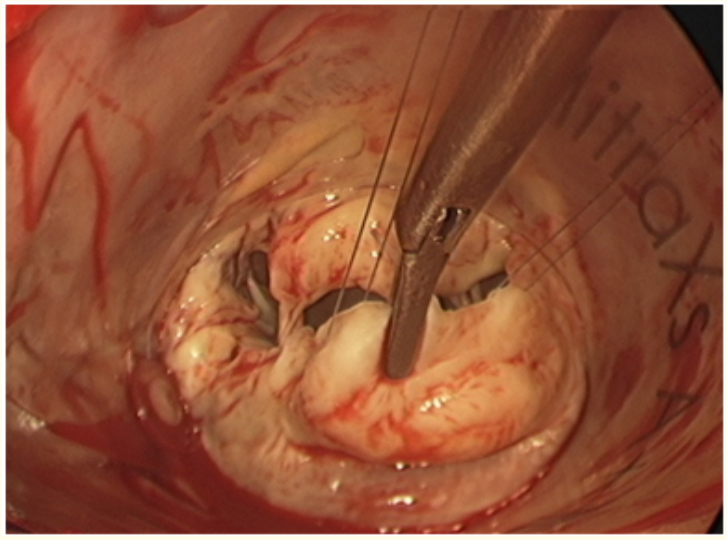

Figure 2: *Video-assisted view of the mitral valve during minimally invasive mitral valve repair surgery.*

In sternotomy approach, central cannulation is performed and cold blood cardioplegia is used. Mitral valve surgery itself is standardized regardless the surgical approach. In isolated mitral valve procedure, the left atrium is entered along the inter-atrial groove; in case of associated tricuspid procedure, a trans-septal approach of the mitral valve is used; when associated, left appendage exclusion is done from the atrial side, with running suture. Valve repair and valve replacement are performed using standardized techniques. CO_2 insufflation and TEE de-airing techniques are routinely used. After weaning of cardiopulmonary bypass, a TEE assessment of the valve is done and a repeat bypass run with re-exploration of the mitral valve is indicated in case of persistent significant mitral valve dysfunction.

Statistical analysis

Continuous variables are expressed as the mean ± standard deviation, and categorical variables are presented as proportions. Differences between groups were assessed using Fisher exact test for categorical variables and the Student t test for normally distributed continuous variables.

Results

The treatment allocation of the surgical approach in this population of mitral patient is summarized in table 1. In 7 patients, the sternotomy approach was imposed by the anatomic condition: previous right thoracotomy, aortic regurgitation, coronary disease. In 5 patients, the sternotomy approach was preferred because of the advance stage of the mitral disease with severe pulmonary hypertension. In the other 8 patients, the sternotomy approach was decided because of significant co-morbidity: age, COPD, renal failure, obesity. The comparison of preoperative data between the two groups of patients confirmed higher-risk patients in the sternotomy cohort (Table 2): Patients were significantly older, with higher BMI and higher pulmonary pressure; there were also significantly more females in this group. However, regarding the functional status of the patients, the etiology of the mitral valve disease, the lesion of the mitral valve and the LV function, there was no difference between MIMVS and sternotomy cohorts. Incidence of atrial fibrillation and tricuspid regurgitation were higher in sternotomy group but not significant. In MIMVS cohort, in 3 patients, the procedure was a reoperation of a previous mitral surgery (2 secondary failures of mitral valve repair, 1 degenerative bioprosthesis); in sternotomy cohort, 2 patients had a non-mitral previous cardiac operation (1 ASD, 1 tricuspid valve repair). In both groups, half of patients had valve repair and half of patients had valve replacement; the distributions between mechanical prosthesis/bioprosthesis and between leaflet resection/neochordae were the same in both group. The rate of associated procedure was significantly higher in sternotomy group, mainly a tricuspid valve surgery and/or a left atrial appendage closure (Table 3). During the procedure, ischemic and cardiopulmonary bypass times were significantly longer in those undergoing the minimally invasive procedure (Table 4). In MIMVS cohort, 3 patients had a repeat bypass run because of a significant residual MR after repair: 2 patients had conversion to mitral valve replacement and 1 patient had a successful repeat mitral valve repair. In sternotomy cohort, 1 patient had a repeat bypass run because of mitral annulus rupture after mitral valve replacement with bioprosthesis and tricuspid annuloplasty: a patch repair of the LV and a new mitral valve replacement with mechanical valve allowed to fix the situation. Unfortunately, this 83-year old female, despite an initial good outcome with early extubation, died of multiple organ failure on PO day 13. In MIMVS cohort, an aortic dissection due to retrograde perfusion occurred in 1 patient at the end of the procedure during the left atrium closure: immediate diagnosis was done and aortic root replacement was performed through sternotomy approach and the outcome of the patient was favorable after a 90-day ICU stay. There was no stroke event in both cohorts and there was no significant difference in postoperative complications between the two groups of patients (Table 5); however, re-exploration for bleeding was higher after MIMVS and low cardiac output was higher after sternotomy. After exclusion of the patient who had a prolonged stay in ICU related to aortic dissection event during MIMVS, the postoperative hospital length of stay was significantly longer after sternotomy approach (9 ± 4 days vs 6.9 ± 3.6 days, $p < 0.05$) with a higher rate of readmission in the 30 PO days (20% vs 0%, ns). The postoperative follow-up was short in both groups, even if significantly higher in MIMVS cohort (6.6 ± 4.5 months vs 2.6 ± 1.9 months) and the occurrence of new cardiovascular events was a bite higher after sternotomy approach (Table 6).

Indication of Sternotomy Approach	All Procedures (n = 20)	Isolated procedure (n = 12)
Moderate to severe PHT	5	3
Moderate aortic regurgitation	4	2
COPD	3	2
Age > 70 y	3	1
Previous right thoracotomy	2	2
Renal failure / Dialysis	1	1
Obesity	1	1
Coronary disease	1	0

Table 1: *Indications for treatment allocation to sternotomy approach.*

PHT: Pulmonary Hypertension; COPD: Chronic Obstructive Pulmonary Disease.

	All Patients			Isolated MV procedures		
Variable	**Median Sternotomy (n = 20)**	**Minimally Invasive (n = 20)**	**P value**	**Median Sternotomy (n = 12)**	**Minimally Invasive (n = 18)**	**P value**
Demographics						
Age (y)	52.1 ± 13.9	42.3 ± 13.3	0.01	48.7 ± 11.1	42.1 ± 13.3	0.08
Gender (%female)	17 (85%)	9 (45%)	0.008	10 (83%)	8 (44.4%)	0.03
BMI (kg/m^2)	28.9 ± 5.5	25.3 ± 4.8	0.01	29.6 ± 6.8	24.3 ± 3.9	0.03
Comorbidities	8 (40%)	4 (20%)		5 (42%)	4 (22.2%)	
Chronic kidney disease	1	0	NS	1	0	NS
Chronic lung disease	3	0		2	0	
Peripheral vascular disease	1	0		0	0	
Cerebrovascular disease	1	1		0	1	
Previous cardiac surgery	2	3		2	3	
NYHA functional class						
I-II	3 (15%)	8 (40%)	NS	2 (17%)	8 (44.4%)	NS
III-IV	17 (85%)	12 (60%)		10 (83%)	10 (55.6%)	
Atrial fibrillation	8 (40%)	5 (25%)	NS	3 (25%)	3 (16.6%)	NS
Cause mitral disease						
Degenerative	11 (55%)	13 (65%)	NS	7 (58%)	13 (72.2%)	NS
Rheumatic	8 (40%)	5 (25%)		4 (33%)	3 (16.6%)	
Other	1 (5%)	2 (10%)		1 (9%)	2 (11.2%)	
Echocardiography						
Ejection fraction (%)	61.8 ± 6	61.1 ± 6	NS	63.2 ± 5.8	62 ± 5.6	NS
Mean PAP (mmHg)	38.9 ± 5.5	27.1 ± 4.7	0.01	33.6 ± 6.8	26.3 ± 10	NS
Severe Mitral regurgitation	13 (65%)	15 (75%)	NS	10 (83%)	14 (77.7%)	NS
Severe Mitral stenosis	7 (35%)	5 (25%)	NS	2 (17%)	4 (22.2%)	NS
Mild or greater TR	9 (45%)	4 (20%)	NS	3 (25%)	3 (16.6%)	NS
Mild AR	4 (20%)	0	NS	2 (17%)	0	NS

Table 2: *Demographics and clinical characteristics.*

MV: Mitral Valve; BMI: Body Mass Index; NYHA: New York Heart Association; PAP: Pulmonary Arterial Pressure; TR: Tricuspid Regurgitation; AR: Aortic Regurgitation.

Variable	Median Sternotomy (n = 20)	Minimally Invasive (n = 20)
Previous cardiac surgery	ASD closure TV repair	MV repair MV repair MV bioprosthesis
Associated procedure		
Left atrial appendage closure	5	1
TV repair	4	1
TV replacement	1	
Maze procedure	1	
LIMA to LAD bypass	1	
Aortic valve assessment	1	
Repeat bypass run	Mitral annulus rupture (n = 1, 5%)	Failure of MV repair (n = 3, 15%)
Conversion to replacement	0	2 (10%)

Table 3: *Surgical details.*

ASD: Atrial Septal Defect; TV: Tricuspid Valve; MV: Mitral Valve; LIMA: Left Internal Mammary Artery; LAD: Left Anterior Descending Artery.

	All Patients			Isolated Procedure		
Variable	**Median Sternotomy (n = 20)**	**Minimally Invasive (n = 20)**	**P value**	**Median Sternotomy (n = 12)**	**Minimally Invasive (n = 18)**	**P value**
Mitral valve replacement	10 (50%)	10 (50%)		3 (25%)	9 (50%)	
Mechanical prosthesis	4	3	NS	1	2	NS
Bioprosthesis	6	7		2	7	
Mitral valve repair	10 (50%)	10 (50%)		9 (75%)	9 (50%)	
Leaflet resection	3	5	NS	2	5	NS
Neochordae	3	5		3	4	
Leaflet remodeling	4	0		4	0	
Crossclamp time (min)	87.6 ± 34.2	106 ± 52.5	0.099	75.3 ± 21	108 ± 55	0.03
Bypass time (min)	126.8 ± 51.1	166.1 ± 72	0.028	110.5 ± 30	170 ± 75	0.002
Repeat bypass run	1 (5%)	3 (15%)	NS	0	3 (16.6%)	NS
Associated procedure	8 (40%)	2 (10%)	0.02	0	0	NS

Table 4: *Operative data.*

	All Patients		Isolated Procedures	
Outcome	**Median Sternotomy (n = 20)**	**Minimally Invasive (n = 20)**	**Median Sternotomy (n = 12)**	**Minimally Invasive (n = 18)**
Death	1 (5%)	0 (0%)	0 (0%)	0 (0%)
Exploration for hemorrhage	1 (5%)	2 (10%)	0 (0%)	2 (11%)
Low cardiac output	2 (10%)	0 (0%)	2 (16.6%)	0 (0%)
Dissection aorta	0 (0%)	1 (5%)	0 (0%)	1 (5.5%)
Atrial fibrillation	1 (5%)	1 (5%)	1 (8.3%)	1 (5.5%)
AVB	2 (10%)	1 (5%)	0 (0%)	1 (5.5%)
Stroke	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Time to discharge (d)	9 ± 4 *	6.9 ± 3.6	8.4 ± 3.7	6.8 ± 3.7
Readmission within 30 d	4 (20%) *	0 (0%)	1 (8.3%)	0 (0%)

Table 5: *In hospital outcome.*

**p < 0.05; AVB: Atrio-Ventricular Block.*

	All Patients		Isolated procedures	
Follow-up	**Median Sternotomy (n = 19)**	**Minimally Invasive (n = 20)**	**Median sternotomy (n = 12)**	**Minimally Invasive (n = 18)**
Mean follow-up (m)	2.6 ± 1.9	6.6 ± 4.5 *	2.5 ± 2.1	6.4 ± 4.7 *
Death	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Stroke	1 (5.2%)	0 (0%)	0 (0%)	0 (0%)
New AF	1 (5.2%)	0 (0%)	0 (0%)	0 (0%)
Ejection fraction (%)	55.9 ± 8.4	55.5 ± 6.9	55.1 ± 9.1	56 ± 5.9
Mild to moderate MR	1 (5.2%)	0 (0%)	1 (8.3%)	0 (0%)
Moderate to severe TR	1 (5.2%)	0 (0%)	0 (0%)	0 (0%)

Table 6: *Follow-up results.*

**p = 0.003; AF: Atrial Fibrillation; MR: Mitral Regurgitation; TR: Tricuspid Regurgitation.*

In the sub-group of patients who underwent isolated mitral procedure with sternotomy approach, the severity of hemodynamic condition is less because patients with significant tricuspid regurgitation, pulmonary hypertension, needing an associated tricuspid valve annuloplasty, were excluded. The comparative analysis between the two cohorts who underwent isolated mitral valve procedure, showed the same difference in demographics and in non-cardiac co-morbidity, with higher-risk patients in the sternotomy cohort (Table 2): patients were significantly older, with higher BMI; there were also significantly more females in this group. The comparative analysis in operative data confirmed that operative time were significantly longer in MIMVS cohort with 3 cases of repeat bypass run related to repair failure and 1 case of aortic dissection (Table 3). After the exclusion of these 4 critical operative situations, the clamping time of MIMVS procedure could be normalized (82 ± 13 minutes vs 75.3 ± 21 minutes, ns), but difference in CPB time remained significant (136 ± 26 minutes vs 110.5 ± 30 minutes, p = 0.014).

In sub-group analysis, there was no death and no stroke in both cohorts; postoperative complications occurred without significant difference between the two groups: re-exploration for bleeding higher was in MIMVS group and low cardiac output was higher in sternotomy group. The hospital stay was longer in sternotomy cohort but no more significantly, and readmission rate in the 30 PO days was the same in both groups (Table 5). And finally, the postoperative follow-up was the same in both groups with a same low rate of new cardiovascular event (Table 6).

Discussion

Minimally invasive mitral valve surgery (MIMVS) has become the preferred access for mitral valve surgery in a growing number of centers. Several studies have proved feasibility, safety and benefits [11,12], such as reduction of surgical trauma, faster postoperative recovery and mobilization, and improved cosmetic results with high patient satisfaction (Figure 3). The consensus statement from the International Society of Minimally Invasive Coronary Surgery assigned a class IIb recommendation for minimally invasive surgery for mitral valve disease [13]. However, there is still ongoing debate about the benefits of MIMVS because no definitive randomized trial has been conducted to date. Theoretically, MIMVS and conventional mitral valve surgery are considered having a similar perioperative outcome; in the real world of mitral valve surgery, there is a treatment allocation according to the risk profile of the patients, with the higher-risk patients referred to sternotomy approach. This strategy is based on the experience of the center, the information from previous meta-analyses comparing conventional surgery (CS) and MIMVS, and the common sense of the surgical team. In other words, because nowadays a large randomized controlled trail is may be ethically infeasible, in many centers, MIMVS is becoming the first option as the reference standard, but CS with sternotomy approach remains a safer alternative in case of risk factors due to co-morbidity or advanced cardiac condition. The aim of our study was to assess such empiric treatment paradigms.

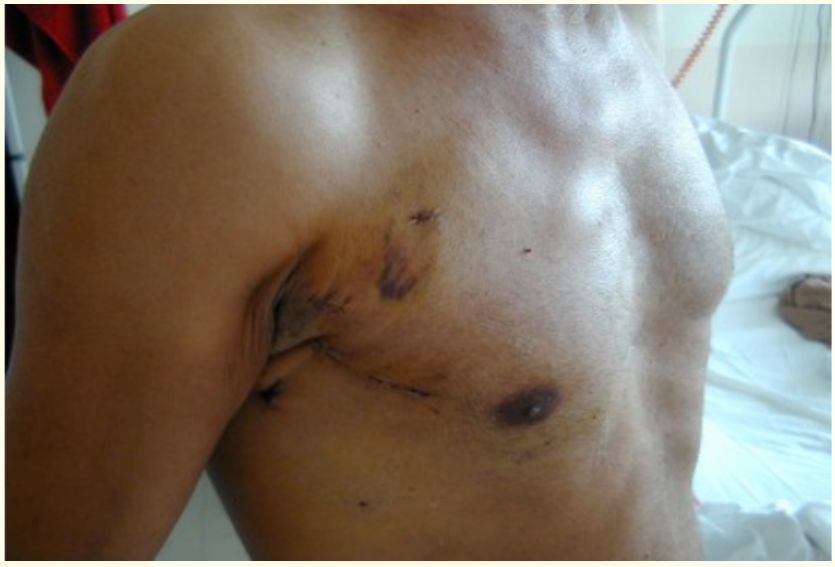

Figure 3: *Lateral mini-thoracotomy wound after minimally invasive mitral valve repair.*

In our study, the analysis of the treatment allocation has confirmed that the sternotomy approach was mainly reserved to higher-risk patients because of co-morbidity, advance stage of the mitral disease or inappropriate anatomic condition, and when an associated procedure is indicated; mainly because in all these situations it is well established that longer operative times could have a bad impact on the postoperative outcome of the patients and may increase the morbi-mortality of the procedure.

Several meta-analyses have examined key outcomes after MIMVS in comparison with CS. Modi and colleagues [5] included 2827 patients from 1 RCT and 10 case-control studies published between 1998 and 2005. This meta-analysis quantified the effects of MIMVS compared with CS and demonstrated equivalent perioperative mortality, reduced need for reoperation for bleeding, and a trend towards shorter hospital stays. These benefits were evident despite longer cardiopulmonary bypass and cross-clamp times in MIMVS. Cheng and colleagues [6] examined the results of 35 studies, 2 RCT and 33 non-RCT published between 1997 and 2010. MIMVS was associated with decreased bleeding, blood product transfusion, atrial fibrillation, sternal wound infection, scar dissatisfaction, ventilation time, ICU stay, hospital length of stay, and reduced time to return to normal activity, without detected adverse impact on results beyond 1 year. However, these potential benefits for MIMVS came with an increased risk of stroke, aortic dissection or aortic injury, phrenic nerve palsy, groin infection/complications, and increased cross-clamp, CPB, and procedure time. Sundermann and colleagues [7] included 20,342 patients from 3 RCT and 42 non-RCT published between 1997 and 2013. They found that CPB time, cross clamp time, and procedure time were increased in the MIMVS group. In contrast, blood drainage volume, blood transfusions, length of ICU stay, respiratory dependence, and length of hospital stay were significantly reduced. Stroke rate, re-exploration rate and all-cause mortality were similar in both groups. Despite significant biases, these meta-analyses became benchmarks in the treatment allocation decision.

Four propensity matched comparisons have been published in order to offset the biases of retrospectives studies: Svensson and colleagues [14] matched 1,047 patients after conventional sternotomy and 2,124 after MIMVS and compared 590 matched patients in each cohort; Holzhey and associates [15] analysed 143 matched patients in each group, from 1,028 patients more than 70 years of age receiving isolated MV repair or replacement through a right minitoracotomy and through a median sternotomy; Goldstone and colleagues [16] identified 201 well-matched patient pairs from 1011 isolated mitral valve repairs; Lange and associated [17] identified 97 matched patient pairs from 745 patients who underwent isolated MV repair. The results of these four studies were clear and consistent. First, in unmatched analyses, the higher risk patients were referred to sternotomy approach and matched cohorts consolidated low risk patients. Second, all the potential benefits of MIMVS, expected from the different meta-analyses, were not confirmed or found with a marginal impact. Third, cross-clamp time, cardiopulmonary bypass time and procedure time were significantly longer in MIMVS. Fourth, operative mortality, long-term survival and durability of valve repair were similar in both cohorts. These studies confirmed the noninferiority of minimally invasive mitral valve surgery despite longer operative times, and the conclusion from the last study published in 2017 by Lange and colleagues is very explicit: "Mitral valve surgery through a right minithoracotomy is a safe procedure associated with a very low operative mortality comparable to the standard sternotomy approach. In addition to improved cosmetics, minimally invasive MV surgery provides equally durable results as the standard sternotomy approach" [17].

Speziale and associates [18] have published a randomized trial between both techniques in the very specific group of patients having Barlow disease with bileaflet prolapse. The study was based on 70 patients in each group and the analysis confirmed that both techniques were similar concerning the feasibility profile, and the operative and follow-up results.

Our experience in MIMVS started twenty years ago, in 1997, and we have followed the different evolutions and techniques applied in this specific field of cardiac surgery [19,20]: we started with the endoaortic ballon clamp and we have moved to the Chitwood clamp; we started with the 2D vision and we have adopted the 3D new technology. For us it was interesting to make the point and to analyze our

practice in a short and recent period. There has been no change over the time regarding the treatment allocation and high risk patients remain referred to conventional sternotomy approach: the patients undergoing a median sternotomy were older, more likely to be female, with more comorbidities and the need of an associated procedure. There is no convincing data from literature to modify or influence this strategy. Despite experience and simplification of the technique with the use of more dedicated instruments [20], the operative times remain longer in MIMVS approach which may have an impact of the operative risk, but probably less in low risk patients. It could explain that finally despite higher operative times, early mortality remains similar in MIMVS and CS; the influence of these factors being offset in propensity scoring because these studies consolidate low risk patients. Our sub-group analysis in isolated MV surgery showed that in case of non-complicated valve surgery, it is possible to normalize the cross clamp time in MIMVS, but the difference in CPB time remains significant. Our experience confirms that all the techniques of MV repair are accessible in MIMVS, from the simple P2 resection to more complex repair as bileaflet prolapses corrected by neochordae or patch enlargement of the leaflet in rheumatic disease. However, we had three cases of failure of the MV repair during a MIMVS procedure: one could be fixed with additional neochordae, the two others leaded to conversion to valve replacement. In these two cases, there was no evidence that the cause of the failure was related to the approach or the exposure; there were a discrepancy between a good water test at the end of the repair and a significant residual MR on TEE assessment after the weaning from CPB and a non-understanding of its mechanism which leaded to replace the mitral valve. In their randomized study, Speziale and associates [18] have demonstrated that minimally invasive approach does not compromise the feasibility, the quality, and the durability of complex valve repair. However, in their series, the rate of conversion of the procedure to mitral replacement due to failed repair was higher in the MIMVS group.

In our short series, we observed two rare per-operative complications: one rupture of mitral annulus in CS group and one retrograde aortic dissection in MIMVS group; both were fixed surgically but one leaded to the death of the patient and the other to a very long stay in ICU. There was no difference in postoperative complications between both groups; there was no stroke event and the rates of re-exploration for bleeding were similar. Hospital length of stay was significantly shorter in MIMVS group with a lower rate of readmission in the 30 days. However, in the sub-group analysis done in patient who underwent isolated mitral valve surgery, these differences were no more significant and there was no early death in both groups. In both groups, mean postoperative follow-up time is limited, even if significantly longer in MIMVS group (6.6 ± 4.5 months versus 2.6 ± 1.9 months, $p = 0.03$) and there was no difference between the two cohorts which confirms that both approaches provide equally durable results when properly indicated.

The main limitation of our study is the lack of randomization but it was not the objective. The aim was to have a snapshot of our practice. Some parameters were not assessed as blood looses, blood transfusion, ventilator support, or ICU stay, because there are too dependent of the preoperative patient condition and the population was not homogeneous enough.

Our strategy and the results observed are consistent with the literature. In the real world of mitral valve surgery, MIMVS is mainly indicated in low risk or intermediate risk patients; there is no evidence that MIMVS provide better results, the best the noninferiority of MIMVS is demonstrate in low risk patients; the benefit of MIMVS is mainly cosmetic and operative times are definitively longer; the risk of severe complication as retrograde aortic dissection remains a concern.

Consequently, the selection of patients for MIMVS remains relevant. There are obvious contraindications as severe peripheral arterial disease, high-grade atheroma of the descending aorta, and previous right thoracic surgery, but for each patient the ratio risk/benefit has to be evaluated regarding cardiac risk factors and non-cardiac risk factors with the idea to detect and to avoid the potential negative impact of the longer operative times and to offset the influence of these factors on the early outcome. High risk patients, emergency situations must be avoided; chronic lung disease, renal failure, obesity or broad patient are comorbidity risk factors in disfavor of MIMVS; LV dysfunction, pulmonary hypertension, combined surgery, mitral calcifications, complex repair could be the cardiac limits of the technique

in order to stay on the safe side. More than specific criteria, the association of these risks factors must be taken in consideration in the process of treatment allocation [21].

Finally the worst situation during or after a MIMVS procedure, is the finding of a difficult situation or outcome that could have been probably avoided if a conventional procedure had been done. The anticipation of such situation is the key of success of MIMVS, specially in a population of patients with mitral regurgitation, who are more and more referred to surgery before the development of adverse sequels of the disease, and when an optimal result is expected.

Conclusion

The analysis of our practice was consistent with the literature; it has confirmed the non-inferiority of MIMVS in comparison with CS, in selected patients with low or intermediate risk profile. Nowadays, these surgical strategy and treatment allocation remain relevant. In addition, the results of MIMVS should be used as the reference standard against which future percutaneous platforms for mitral valve surgery are compared.

Disclosure

The authors declare no conflict of interest.

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