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Early Outcomes of Minimally Invasive Mitral Valve Surgery versus Standard Median Sternotomy Technique

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Abstract

Background: Mitral Valve Surgery (MVS) performed through a Standard Median Sternotomy can be particularly technically challenging and is known to carry a potential risk of injuries to patent coronary artery bypass grafts and vascular structures that lie directly substernally and can adhere to the sternum.

Postoperative complications after cardiac surgery, particularly when occurring in combination, have a profound impact on long-term early, survival and postoperative deaths.

Aim of Study: To evaluate the early outcomes of minimally invasive mitral valve surgery versus standard median sternotomy technique in patients undergoing mitral valve surgery.

Patients and Methods: A retrospective comparative study that is conducted on cases candidate minimally invasive mitral valve surgery versus standard median sternotomy technique.

Results: This study was conducted on 40 patients; 18 of them (45%) having isolated mitral valve disease, 22 (55%) having mitral plus tricuspid valve disease. All the patients completed the study. There was no mortality among the patients. The patients were classified into 2 groups:

- Group A: minimally invasive group. This group includes 20 patients requiring mitral valve surgery, and was approached through right anterolateral minithoracotomy.
- Group B: Sternotomy group. This group includes 20 patients requiring mitral valve surgery, and was approached through conventional median sternotomy.

Conclusion: According to the findings in the current study, minimally invasive mitral valve surgery is a safe procedure, associated with a low incidence of intraoperative complications and excellent postoperative outcomes. However, the cost-effectiveness remains controversial. Therefore, additional multicenter studies are needed to make econometric analysis for any future evaluation of novel cardiovascular therapies.

Key Words: *Mitral Valve Surgery – Minimally Invasive – Standard Median Sternotomy Technique.*

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Introduction

MITRAL Valve Surgery (MVS) performed through a Standard Median Sternotomy MST (MST-MVS) can be particularly technically challenging and is known to carry a potential risk of injuries to patent coronary artery bypass grafts and vascular structures that lie directly substernally and can adhere to the sternum **[1].**

Postoperative complications after cardiac surgery, particularly when occurring in combination, have a profound impact on long-term early, survival and postoperative deaths **[2].**

Valid alternative to repeated conventional ST-MVS would be a minimally invasive approach (MIV-MVS) through a right anterolateral minithoracotomy (MT) **[3].**

An incision of <10cm is made in the 4^{th} or 5^{th} intercostal space, the goal being to minimize surgical trauma compared to that of a full ST or thoracotomy (20cm) **[4].**

List of Abbreviations:

CPB : Cardiopulmonary bypass.
EF : Ejection fraction.
FVC : Forced vital capacity.
HRQoL : Health-related quality of life.
ICU : Intensive care unit.
MIMVS : Minimally invasive mitral valve surgery.
MS : Median sternotomy.
MT : Minithoracotomy.
MVS : Mitral Valve Surgery.
NRS : Numerical rating scale.
SCAR : Scar Cosmesis Assessment and Rating.

MIV-MVS can be performed either under direct or video-assisted vision, with the use of long-shafted instruments in both situations. Primary MIV-MVS is, besides being associated with less surgical trauma, believed to result in diminished pain, blood loss and need for transfusions, which translates into reduced length of hospital stay **[5]**.

Minimally invasive mitral valve surgery was associated with good short-term outcomes comparable to those with procedures performed through a sternotomy **[6]**.

In a recent study of Mohamed et al. **[7]**, they reported that, Minimally invasive mitral valve surgery is a safe alternative to a conventional approach and is associated with less morbidity especially with expert surgeon in simple mitral valve surgery **[7]**.

Initiating a minimally invasive mitral valve programme with a limited number of surgeons and a well-executed institutional selection strategy did not confer an increased risk for adverse events **[6]**.

Aim of the work:

This study aims to evaluate the early outcomes of minimally invasive mitral valve surgery versus standard median sternotomy technique in patients undergoing mitral valve surgery.

Patients and Methods

A retrospective comparative study that is conducted on cases candidate minimally invasive mitral valve surgery versus standard median sternotomy technique in Ain Shams University Hospital and Maadi Military Hospital (Cardiothoracic Surgery Department). Study period 1 year (between March 2019 and February 2020). Patients Aged >18 years and Forty adult patients who underwent isolated mitral valve surgery at Ain Shams and Maadi Military Hospital (Cardiothoracic Surgery Department) between March 2019 and December 2020 were included in the study. While, patients who undergoing combined procedures (e.g. double valve replacement), Patients who required perioperative renal replacement therapy and Redo patients were excluded from the study.

Statistical analysis: Prior data indicate that the average ICU stay among controls is 3.0±1.7 days, and the average ICU stay for experimental subjects is 1.8±0.6 days Hiraoka et al., **[8]**. Then, proper statistical analyses were used. In All tests, *p*-value less than 0.05 considered significant.

Results

This study is a retrospective comparative study conducted on 40 mitral valve surgery patients; to evaluate the early outcomes of minimally invasive mitral valve surgery versus Standard median sternotomy technique in patients undergoing mitral valve surgery.

This study was conducted on 40 patients; 18 of them (45%) having isolated mitral valve disease, 22 (55%) having mitral plus tricuspid valve disease. All the patients completed the study.

There was no mortality among the patients. The patients were classified into 2 groups:

- Group A: Minimally invasive group. This group includes 20 patients requiring mitral valve surgery, and was approached through right anterolateral minithoracotomy.
- Group B: Sternotomy group. This group includes 20 patients requiring mitral valve surgery, and was approached through conventional median sternotomy.

Preoperative assessment:

Demographic data and clinical characteristics of the patients in group “A”, age ranged from 18-61 years with a mean of 42.73±12.96,while in group “B” age ranged from 29-65 years with a mean of 49.8±12.47, and there was no statistical significance (*p*-valve >0.05). In group “A”, there was 3 males (15%) and 17 females (85%), while in group “B” there was 4 males (25%) and 16 females (75%) with no statistical significance (*p*-value >0.05). The mean BMI in group “A” was 28.66±5, and in group “B” it was 27.9±4.57 and a *p*-value >0.05. These data are shown in Table (1).

A- Clinical classification:

Patients were classified according to the NYHA classification, in group “A” 4 patients (20%) were in class I, 6 patients (30%) were in class II, 9 patients (45%) were in class III and 1 patient (5%) was in class IV. In group “B” 3 patients (15%) were in class I, 7 patients (35%) were in class II, 10 patients (50%) were in class III and no patient was in class IV.

The mean NYHA classification was 3.75±2.75 in group “A”, while it was 3.75±2.98 in group “B” with no statistical significance as shown in Table (2).

B- Preoperative echocardiographic assessment:

Preoperative assessment in group “A” showed that 12 patients (60%) suffered from isolated mitral

valve disease, 8 patients (40%) had mitral and tricuspid valve disease. In group "B", there was 13 patients (65%) suffered from isolated mitral valve disease, 7 patients (35%) had mitral and tricuspid valve disease with no statistical significance between the two groups (*p*-value >0.05) as shown in Table (3).

Table (4) shows that the ejection fraction (EF) in group "A" was 61.68±9%, while in group "B" it was 61.6±6.7% with a *p*-value >0.05. The left atrial dimension in group "A" was 5.18±0.9, and in group "B" it was 5.52±0.82, pulmonary artery pressure in group "A" was 46±14.2, while in group "B" it was 50.2±12.5 with a *p*-value >0.05 with no statistical difference between the 2 groups.

D- *Preoperative spirometric study:*

Preoperative mean forced vital capacity (FVC) in group "A" was 2.74±0.8 (Liters) while the mean percentage of predicted FVC was 65.84±13.4. The mean forced expiratory volume at one second (FEV1) in group "A" was 2.5±0.7L and the percentage of the predicted FEV1 was 72.4±11.4%. The FEV 1 to FVC ratio (FEV1 / FVC) was 90.9±6.99. In group "B", the mean FVC was 2.88±0.7L, while the mean percentage of predicted FVC (FVC %) was 65.4±7.9%. The mean FEV1 in group "B" was 2.7±0.7L and the percentage of the predicted FEV1 was 75.95±10.5% And the FEV1 / FVC was 95.7±4.9%. These data are shown in Table (5).

Intra-operative course:

The intra-operative surgical data e.g. cross-clamp time and total bypass time were comparable in both study groups. There was no statistical significance between the two groups as regards the cross clamp time and the total bypass time. with a *p*-value more than 0.05 denoting no statistical significance yet minimally invasive group needed more time for cross camp and so total bypass time as shown in Table (6).

The surgical procedure in group "A" included 15 patients (75%) of mitral valve replacement, 4 patients (20%) of mitral valve replacement plus tricuspid valve repair, 1 patient (5%) of mitral valve repair. In group "B", there was 15 patients (75%) of mitral valve replacement, 5 patients (25%) of mitral valve replacement plus tricuspid valve repair, no patient of mitral valve repair. There was no statistical significance as regards the surgical procedure done, as shown in Table (7).

The length of the incision was compared in the two groups. The mean length of incision in group "A" was 8.2±1.85cm. While in group "B" the mean length was 19.66±2.46cm which is statistically higher than that of group "A" (*p*-value <0.01), as shown in Table (8).

The mean total operation time in group "A" was 229.7±83.6minutes, while in group "B" the mean operation time was 173.66±65.99cm, with a *p*-value <0.05, denoting statistical significance as regards the operation time. This difference may be due to the new experiences in this MIMVS, and the instrumentation also narrow the field of MIMVS. These data are shown in Table (9).

Weaning from cardiopulmonary bypass was done without difficulty in both groups. 2 patients (10%) required inotropic support during weaning in group "A", while in group "B" one patient (5%) required DC shock to weaning from bypass. One patient (5%) required inotropic support during weaning in group "A", while in group "B" 3 patients (15%) In both groups the inotropic support weaned during the first 24 hours. The *p*-value was >0.05, denoting that there was no statistically significant difference as regards the use of DC shock, inotropic. These data are shown in Table (10).

Intensive care course:

All patients in both groups required post-operative mechanical ventilation no patients were extubated in the operating theatre. The ventilation time for group "A" ranged from 4-10 hours, with a mean±SD of 6-1.85 hours. In group "B" the ventilation time ranged from 6-24 hours with a mean±SD of 10.5-4.98 hours. This shows that there is a statistically significant difference between the two groups as regards post-operative mechanical ventilation time (Table 11).

The blood drainage and blood transfusion required to keep a hematocrite above 25-30 % was comparable in both groups. In group "A", blood drainage ranged from 125-400ml during the first 24 hour, with a mean±SD of 265±78.5 / 24 hour. In group "B", the blood loss ranged from 175-1150ml during the first 24 hour, with a mean±SD of 460±260ml / first 24 hour, this shows that there is a highly statistically significant difference between the two groups as regards the blood drainage as shown in Table (11).

The amount of blood units transfused to group "A" ranged from 0 to 2 units with a mean of 0.2±0.56 units, while in group "B" it ranged from 0 to 3 units with a mean of 0.87±1 units. This shows that group "B" required much more blood transfusion than group "A" with statistically significant difference as shown in Table (11).

The total intensive care unit (ICU) stay was comparable in both groups. In group "A", the ICU stay ranged from 1-7 days, with a mean of 3±1.92 days, while in group "B" the range was 2-10 days with a mean of 3.86±2 days, which shows that the ICU stay in the minimally invasive group is less than the sternotomy group, with statistically significant difference (Table 11).

Post-operative course:

After discharge from the intensive care unit, all patients were subjected to do pulmonary functions 1 month later.

Post-operative spirometric study:

There was a highly statistically significant difference in the FVC, FEV1%, FEV1, FVC% between the two groups, and no significant change in FEV1/FVC between both group denoting better post operative pulmonary function of minimally invasive (group A) patients. So Postoperative pulmonary functions showed that group "B" had more deterioration in their functions than group "A" (Table 12).

A comparison between the pre and post-operative pulmonary functions showed that in group (A) there is mild deterioration in all functions except FEV1/FVC, with no statistically significant (Table 13).

A comparison between the pre and post-operative pulmonary functions showed that in group (B) there is marked deterioration in all functions except FEV1/FVC, this deterioration is highly significant statistically (Table 14).

Post-operative pain:

Post-operative pain score using the visual analogue scale was compared in the two groups.

In group "A", the mean pain score in the fifth post-operative day was 11.2±3.7, Pain score in group "B" during the fifth post-operative day was 17.4±5.22.

This data shows that pain was less in group "A", with highly statistically significant difference as shown in Table (15).

Post-operative complications:

In group "A", there was 5 patients with complications (25%). Three patients (15%) developed postoperative arrhythmias, one of them (5%) six weeks post-discharge recovered. One patient (5%) right ARDS with total lung collapse, which responded to medical and physiotherapy and totally resolved on the 5^{th} day postoperative. One patient (5%) had superficial wound infection involving only the skin and responded to frequent dressing and antibiotics. One patient (5%) had dehiscent femoral wound due to excessive dissection which closed by 2ry prolen sutures (Table 16).

In group "B", 5 patients (25%) suffered from post operative complications. three patients (15%) developed postoperative arrhythmias. This complication disappeared four weeks later for 2 of them.

Two patients (10%) had superficial wound infection involving only the skin and responded to frequent dressing and antibiotics.

There was no statistical significant difference as regards postoperative complications in both groups as shown in Table (17).

The total hospital stay was comparable in the two groups, the range of hospital stay in group "A" was 4-10 days with a mean of 6±1.85 days, while in group "B" the range was 6-24 days with a mean of 10.5±4.5 days. This shows that the total hospital stay in the minimally invasive group was less than sternotomy group, and this difference has statistical significance as shown in Table (17).

Operative cost:

This data shows that group (A) more operative cost than group (B) with highly statistically significant difference as shown in Table (18).

Cost effectiveness:

Minimally invasive surgeries have the superiority of the cost. But in our center the different in between the MIMVS, median sternotomy does not exceed 3.50 thousand L.E which consider not a lot as regard the above statistical consideration that show MIMVS had lower total hospital stay, post-operative complications, pain, blood need, ventilation stay, better cosmetic appearance, respiratory function, more patient satisfaction especially between the females of both group which give better quality of life and outcome.

So we can say that minimally invasive mitral valve surgery is considered more cost effective than full sternotomy.

Our finding infers that cardiac surgery remains controversial from a cost-effectiveness standpoint, making econometric analysis an important component for any future evaluation of novel cardiovascular therapies. Our findings need to be confirmed by additional multicenter studies.

Table (1): Demographic data and clinical characteristics of the patients.

Demographic data	Group A (n=20)	Group B (n=20)	Test value	*p*-value	Sig.
Age (years):					
Range	18-60	29-65	1.758	0.087	NS
Mean ± SD	42.73±12.96	49.8±12.47			
Sex:					
Male	3 (15.0%)	5 (25.0%)	0.156	0.693	NS
Female	17 (85.0%)	15 (75.0%)			
BMI:					
Mean ± SD	28.66±5	27.9±4.57	–0.502	0.619	NS

Using: *t*-Independent Sample *t*-test for Mean ± SD.
x2 : Chi-square test for Number (%) or Fisher's exact test, when appropriate.
NS : Non significant. S: Significant. HS: Highly significant.

Table (2): Preoperative NYHA classification (Number & percentage).

NYHA classification	Group A	Group B	Test value	*p*-value	Sig.
I	4 (20%)	3 (15%)	1.272	0.736	NS
II	6 (30%)	7 (35%)	–0.815	0.420	
III	9 (45%)	10 (50%)			
IV	1 (5%)	0 (0.0%)			
Mean ± SD	2.47±0.83	2.26±0.8			NS

Using: *t*-Independent Sample *t*-test for Mean ± SD.
x2 : Chi-square test for Number (%) or Fisher's exact test, when appropriate.
NS : Non significant. S: Significant. HS: Highly significant.

Table (3): Preoperative mitral valve pathology.

	Group A	Group B	Test value	*p*-value	Sig.
Single miral disease	12 (60%)	13 (65%)	1.758	0.185	NS
Double mitral + tricuspid	8 (40%)	7 (35%)	2.500	0.114	NS

x2 : Chi-square test for Number (%) or Fisher's exact test, when appropriate.
NS : Non significant. S: Significant. HS: Highly significant.

Table (4): Preoperative echocardiographic data.

	Group A	Group B	Test value	*p*-value	Sig.
Ejection fraction %	61.68±9	61.6±6.7	–0.032	0.975	NS
Left atrial dimension	5.18±0.9	5.52±0.82	1.249	0.219	NS
Pulmonary artery pressure	46±14.2	50.2±12.6	0.989	0.329	NS

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (5): Preoperative spirometric study in both groups.

	Group A	Group B	Test value	*p*-value	Sig.
FVC (liters)	2.74±0.8	2.88±0.7	0.589	0.559	NS
FVC %	65.84±13.4	65.4±7.9	–0.126	0.900	NS
FEV1 (liters)	2.5±0.7	2.7±0.7	0.904	0.372	NS
FEC1%	72.4±11.4	75.95±10.5	1.024	0.312	NS
FEV1/FVC	90.9±6.99	95.7±4.9	2.515	0.016	S

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (6): Cross clamp & total bypass time in both groups.

	Group A	Group B	Test value	*p*-value	Sig.
Cross clamp (min.)	106.2±27.3	94.66±45.5	–0.973	0.337	NS
Total bypass time	157±47.9	128.3±63.25	–1.618	0.114	NS

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (7): Procedure done in both groups (number & percentage).

	Group A	Group B	Test value	*p*-value	Sig.
Mitral valve replacement	15 (75%)	15 (75%)	0.000	1.000	NS
Mitral valve replacement + tricuspid valve repair	4 (20%)	5 (25%)	0.140	0.709	NS
Mitral valve repair	1 (5%)	0	1.000	0.317	NS

x2 : Chi-square test for Number (%) or Fisher's exact test, when appropriate.
NS : Non significant. S: Significant. HS: Highly significant.

Table (8): Length of skin incision in both groups.

Length of skin incision	Group A	Group B	Test value	*p*-value	Sig.
Range (cm)	6-12	16-24	16.651	0.001	HS
Mean ± SD (cm)	8.2±1.85	19.66±2.46			

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (9): Total operation time in both groups.

Total operation time (min)	Group A	Group B	Test value	*p*-value	Sig.
Mean ± SD	229.7±83.6	173.66±65.99	–2.353	0.024	S

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (10): Patients requiring inotropic, DC shock during weaning from cardiopulmonary bypass.

	Group A	Group B	Test value	*p*-value	Sig.
DC shock (number & %)	2 (10%)	1 (5%)	0.351	0.553	NS
Inotropic support (number & %)	1 (5%)	3 (15%)	1.083	0.298	NS

x2 : Chi-square test for Number (%) or Fisher's exact test, when appropriate.
NS : Non significant. S: Significant. HS: Highly significant.

Table (11): Ventilation, blood loss, blood transfusion and total ICU stay.

	Group A	Group B	Test value	*p*-value	Sig.
Ventilation (hours):					
Range	4-10	6-24	4.136	0.003	S
Mean ± SD	6±1.85	10.5±4.5			
Blood loss (ml):					
Range	125-400	175-1150	3.211	0.003	S
Mean ± SD	265±78.5	460±260			
Blood transfusion (unit):					
Range	0-2	0-3	2.614	0.013	S
Mean ± SD	0.2±0.56	0.87±1			
ICU stay (day):					
Range	1-7	2-10	1.387	0.174	NS
Mean ± SD	3±1.92	3.86±2			

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (12): Post-operative pulmonary functions in both groups (Mean±SD).

	Group A	Group B	Test value	*p*-value	Sig.
FVC (liters)	2.26±0.75	1.6±0.53	–3.214	0.003	HS
FEV1 (liters)	2.12±0.77	1.5±0.5	–2.532	0.016	S
FEV1/FVC	93.5±9.26	95.18±6.8	0.654	0.517	NS
FVC%	58.7±12.3	41.6±12.7	–4.325	0.001	HS
FEV1%	66.8±14.8	48.9±14.9	–3.812	0.001	HS

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (13): Comparison between pre and post-operative pulmonary functions in group "A".

	Pre-operative	Post-operative	Test value	*p*-value	Sig.
FVC (liters)	2.74±0.8	2.26±0.75	–1.958	0.058	NS
FEV1 (liters)	2.5±0.7	2.12±0.77	–1.633	0.111	NS
FEV1/FVC	90.9±6.99	93.5±9.26	1.002	0.323	NS
FVC%	65.84±13.4	58.7±12.3	–1.76	0.087	NS
FEV1%	72.4±11.4	66.8±14.8	–1.341	0.188	NS

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (14): Comparison between pre and post-operative ulmonary functions in group "B".

	Pre-operative	Post-operative	Test value	*p*-value	Sig.
FVC (liters)	2.88±0.7	1.6±0.53	–6.520	0.001	HS
FEV1 (liters)	2.7±0.7	1.5±0.5	–6.239	0.001	HS
FEV1/FVC	95.7±4.9	95.18±6.8	–0.277	0.783	NS
FVC%	65.4±7.9	41.6±12.7	–7.116	0.001	HS
FEV1%	75.95	48.9±14.9	–6.637	0.001	HS

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (15): Pain score among the two groups (mean±SD).

	Pre-operative	Post-operative	Test value	*p*-value	Sig.
5th day postoperative pain (mm)	11.2±3.7	17.4±5.22	4.334	0.001	HS

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (16): Post-operative complications of both approaches.

	Pre-operative	Post-operative	Test value	*p*-value	Sig.
No complications	15 (75%)	15 (75%)	0.000	1.000	NS
Developed arrhythmias	3 (15%)	3 (15%)	0.000	1.000	NS
ARDS	1 (5%)	–	1.000	0.317	NS
Superficial wound infection	1 (5%)	2 (10%)	0.351	0.553	NS

x2 : Chi-square test for Number (%) or Fisher's exact test, when appropriate.
NS : Non significant. S: Significant. HS: Highly significant.

Table (17): Total hospital stay of both groups.

Total hospital stay "days"	Group A	Group B	Test value	*p*-value	Sig.
Range	4-10	6-24	4.136	0.001	HS
Mean ± SD	6±1.85	10.5±4.5			

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (18): Operative cost among the two groups (mean±SD).

	Group A	Group B	Test value	*p*-value	Sig.
Cost by thousband L.E	18±0.7	14.88±1.1	–10.702	0.001	HS

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Table (19): Operative and Post-operative parameters in both groups that shows the upper hand of minimally invasive surgery.

	Group A	Group B	Test value	*p*-value	Sig.
Length of skin incision (cm)	8.2±1.85	19.66±2.46	16.651	0.001	HS
Ventilation (hour)	6±1.85	10.5±4.5	4.136	0.002	S
Blood loss (ml)	265±78.5	460±260	3.911	0.001	HS
Blood transfusion (unit)	0.2±0.56	0.87±1	2.614	0.013	S
5th day postoperative pain (mm)	11.2±3.7	17.4±5.22	4.334	0.001	HS
Postoperative FVC (liter)	2.26±0.75	1.6±0.53	–3.714	0.001	HS
Postoperative FEV1 (liter)	2.12±0.77	1.5±0.5	–3.020	0.005	S
Postoperative FVC%	58.7±12.3	41.6±12.7	–4.325	0.001	HS
Postoperative FEV1%	66.8±14.8	48.9±14.9	–3.812	0.001	HS

Using: *t*-Independent Sample *t*-test for Mean ± SD.
NS : Non significant. S: Significant. HS: Highly significant.

Discussion

The adoption of minimally invasive mitral valve surgery (MIMVS) has become a prominent trend in mitral valve procedures *[9]*.

This retrospective study compared the early outcomes of minimally invasive mitral valve surgery (MIMVS) with the standard median sternotomy (MS) technique in 40 patients undergoing mitral valve surgery.

As demonstrated by our results, the two groups had similar baseline characteristics. The age of the included patients showed a non-significant difference between the MIMVS group and the MS group in the present study; however, the MIMVS group was a little younger (42.73±12.96) than the MS group (49.8±12.47).

In agreement with our study, patients in the MIMVS group were more likely to be younger (64.1±9.1 versus 65.6±10.4 in the MS group; p= 0.02) in Pojar et al. *[10]* study.

Similarly, patients who underwent minimally invasive mitral valve surgery (MIMVS) were younger than those who underwent sternotomy in Yaşar et al. *[11]* study. The preference for MIMVS among younger patients may be attributed to several factors. Initially, younger people frequently choose less intrusive procedures since they typically yield better aesthetic results and require shorter recovery periods. Younger patients can also have higher expectations for their quality of life following surgery. A speedier return to normalcy is possible with minimally invasive mitral valve surgery. In addition, younger people are often lower-risk and have fewer comorbidities, which makes them good candidates for minimally invasive operations.

In the current study, there was a non-significant difference between the two groups regarding gender; however, there was a female predominance among the included patients in the MIMVS group (85%), and the MS group (75%). Our result agreed with Pojar et al. *[10]* study which showed female predominance among the included patients in the MIMVS group (55%), and the MS group (57%).

Contrary to our result, there was male predominance (57.9%) in Ntinopoulos et al. *[12]* study which assessed the outcomes of mitral valve surgery via right MIMVS in octogenarians. Similar result was reported in Olsthoorn et al. *[13]* and Kofler et al. *[14]* studies.

Although the present study reported a non-significant difference between the MIMVS group and MS group regarding the preoperative spirometric study, the post-operative spirometric study showed a significant difference regarding FVC, FEV1%, FEV1, and FVC% and no significant change in FEV1/FVC between both groups, denoting better postoperative pulmonary function in MIMVS group patients. When comparing preoperative and postoperative results, the spirometric study of the MIMVS group revealed a slight, non-significant decline in all lung functions, with the exception of FEV1/FVC. However, a spirometric study of the MS group revealed a high significant decline in all lung functions, with the exception of FEV1/FVC.

Regarding the intra-operative surgical outcomes in the current study, there was a nonsignificant increase in cross-clamp time in the MIMVS group (106.2±27.3) compared with the MS group (94.66±45.5). Likewise, the total bypass time was non-significantly longer in the MIMVS group (157±47.9) compared with the MS group (128.3±63.25). However, there was a significant increase in total operation time in the MIMVS group (229.7±83.6 min) compared with the MS group (173.66±65.99 min).

In agreement with our findings, Yaşar et al. *[11]* study showed that operation, and cross-clamp times were higher in MIMVS than in the conventional MS approach. While, in the propensity score-matched analysis conducted by Kastengren et al., *[6]* study, patients who had MIMVS had significantly longer aortic cross-clamp time (105±40 vs 97±36 min; p=0.030).

Likewise, Mkalaluh et al. **[15]** in a retrospective propensity-score-matched analysis, demonstrated that minimally invasive surgery has prolonged operation, cardiopulmonary bypass, and aortic cross-clamp times compared to the conventional approach. These findings were consistent with those of Moscarelli et al. **[16]** and Pojar et al. **[10]** studies.

The increase in the time required for MIMVS compared with MS may attributed to the limited access and restricted field of view may require meticulous maneuvers to achieve optimal surgical outcomes.

By contrast, the total operation time did not differ in both MIMVS and MS groups ($p>0.05$) in Chernov et al. **[17]** study, while the cardiopulmonary bypass (CPB) time was lower in the MS group than in the MIMVS group ($p\leq0.001$).

The required time for cross-clamp in MIMVS group in the current study was comparable to Barbero et al. **[18]** study which revealed that the required time for cross-clamp was 105±27 minutes. By contrast, our result was higher than Radwan et al. **[19]** study result which reported that the median (IQR) cross-clamp time in the MIMVS patients was 97.5 (11.2) minutes.

In the present study, the incision length was significantly longer in MS group (19.66±2.46cm) compared with MIMVS group (8.2±1.85cm).

Our result agreed with Huang et al. **[20]** study which compared the aesthetic appearance of the surgical incision among patients who had undergone mitral valve surgery using either MIMVS or median sternotomy approach. The patients were followed up using the Scar Cosmesis Assessment and Rating (SCAR) scale and numerical rating scale (NRS). The difference in the SCAR scores between the two groups was significant, with the MIMVS group being more satisfied with the aesthetic appearance of the incision ($p<0.05$).

Regarding the intra-operative surgical outcomes in the current study, the process of weaning off cardiopulmonary bypass was uneventful for both groups. Inotropic support during weaning showed a non-significant difference between the MIMVS group (5%) and the MS group (15%). Similarly, the required DC shock for weaning from bypass showed a non-significant difference between the MIMVS group (10%) and the MS group (5%).

Inotropic support usage during weaning among the MIMVS in the current study was lower than reported in Xu et al. **[21]** study where inotropic support beyond 4 hours after MIMVS operation was required in seven patients (28%).

In the present study, even though patients in both groups required post-operative mechanical ventilation without extubating in the operating theatre, the MIMVS group required significantly shorter postoperative mechanical ventilation time (6±1.85 hours) compared with the MS group (10.5±4.5 hours).

Conceding with our results, Kofler et al. **[14]** study showed that MIMVS was associated with a significant shorter ventilation time [708 min (429–1236)] compared with MS [1440 min (659–4411)]. Likewise, prolonged artificial ventilation (>24h) was less frequent in the MIMVS group (6% versus 13% in the MS group; $p=0.02$) in Pojar et al. **[10]** study.

In the present study, the MIMVS group had a highly significant lower blood loss (265±78.5ml) in the first 24 hours compared with the MS group (460±260ml). Therefore, the requirement for blood transfusions was significantly lower in the MIMVS group (0.2±0.56 units) than the MS group (0.87±1 units).

In agreement with our study, Pojar et al. **[10]** study revealed that a minimally invasive approach was associated with a significantly lower postoperative blood loss. Transfusion was less frequent after minimally invasive surgery than sternotomy. Comparable result was reported in Kofler et al. **[14]** study.

In line with our study, Kastengren et al. **[6]** study showed the MIMVS was associated with a lower need for transfusions compared with sternotomy procedures.

Surprisingly, there was no blood transfusion among the octogenarian patients who underwent MIMVS in Ntinopoulos et al. **[12]** study.

In contrary to our results, blood loss among our MIMVS group were lower than the reported median (IQR) blood loss during the ICU among the MIMVS (450 [363]ml) in Radwan et al. **[19]** study.

In the current study, the MIMVS group showed a non-significantly shorter total intensive care unit (ICU) stay (3±1.92 days) compared with the MS group (3.86±2 days). Conceding with our results, Moscarelli et al. **[16]** study have reported a shorter hospital and ICU stay in patients undergoing MIMVS compared to the conventional approach. Similar result was reported in Yaşar et al. **[11]** study. By contrast, intensive care unit stays were comparable

in both groups [MIMVS: 1 day (1–4), MS: 3 days (1–9); $p = 0.061$] in Kofler et al. *[14]* study.

In a systematic review and meta-analysis study conducted by Shirke et al. *[22]*, seven studies reported the length of ICU stay for patients of MIMVS and MS groups. The difference was not statistically significant between the two groups.

In the present study, the MIMVS group had a significantly lower post-operative pain score (11.2±3.7) on the fifth post-operative day than the MS group (17.4±5.2).

Our result agreed with Huang et al. *[20]* study which compared the pain intensity among patients who had undergone mitral valve surgery using either MIMVS or median sternotomy approach. The patients were followed-up to the 3rd month after the operation, and health-related quality of life (HRQoL) assessment demonstrated significant differences in the scores for the bodily pain. There were significantly fewer complaints of postoperative pain in the MIMVS group than in the MS group.

In the current study, there were non-significant differences between the two groups regarding complications, with a comparable distribution of postoperative arrhythmias (15%), while there was a higher distribution of total lung collapse (5%) in MIMVS group and a higher distribution of superficial wound infection (10%) in MS group. There was no mortality among the patients.

The mortality rate among patients in our study was consistent with Kastengren et al. *[6]* study which reported low mortality rates ranging from 0.3% in the MIMVS group to 0.7% in the MS group. Likewise, Ntinopoulos et al. *[12]* study reported that there was no mortality among 38 octogenarian patients with severe mitral regurgitation who underwent isolated mitral valve surgery via MIMVS.

The present study agreed with Olsthoorn et al. *[13]* study regarding the nonsignificant difference in mortality results; however, our study disagreed with the mentioned study regarding new-onset arrythmia, where there was a significant difference between the MIMVS group (21%) and the MS group (41%).

In addition, there was a statistically non-significant difference in mortality results between minimally invasive and standard sternotomy methods, according to Olsthoorn et al. *[13]* and Liu et al. *[23]* studies.

Moreover, there was a statistically non-significant difference in mortality results between minimally invasive and standard sternotomy methods, according to Liu et al. *[23]* study.

Similarly, Pojar et al. *[10]* study reported that patients treated with a minimally invasive approach had a lower rate of hospital-related mortality than patients undergoing sternotomy (1% versus 5%, respectively) and a non-significantly lower incidence of wound infection (1% versus 2%, respectively).

According to systematic review and meta-analysis conducted by Tariq et al. *[24]*, surgical site infection showed a non-significant difference between the MIMVS and MS group. Six studies, with a total of 796 participants (264 for MIMVS and 532 for redo MS), reported on surgical site infection. The indicated infection rate was 0.39% in the minimally invasive group and 2.06% in the sternotomy group.

Contrary to our results, Yaşar et al. *[11]* study showed that the MIMVS group brought significantly fewer incidents of postoperative new-onset atrial fibrillation than the MS group, suggesting that the minimally invasive method had a positive outcome. However, there was no mortality in the MIMVS group, whereas there was all the mortality (2.7%) in the MS group.

In the present study, the total hospital stay in the MIMVS group (14.2±6.25 days) was significantly shorter than in the MS group (27.5±13 days). Our result agreed with Yaşar et al. *[11]* study which reported a significantly shorter hospital stay among the MIMVS group compared with the MS group. A similar result was reported in Pojar et al. *[10]* study.

Conceding with our results, Kastengren et al. *[6]* study revealed that MIMVS was associated with a shorter hospital stay compared with sternotomy procedures. While Grant et al. *[25]* study analyzed data from 3 UK hospitals from 2008 to 2016 and performed a propensity matched analysis on 639 pairs of patients demonstrating a reduced postoperative length of stay in minimally invasive patients.

In a systematic review and meta-analysis study conducted by Shirke et al. *[22]*, only nine studies specified the average length of stay for each of the groups. The pooled analysis suggested that the length of hospital stay for patients that underwent MIMVS was significantly lower than the sternotomy group.

Although there was a shorter median hospital stay among the MIMVS group (7 [5–12]) and the MS group (7 [4–14]) in Olsthoorn et al. *[13]* study compared to our study, there was a non-significant difference between the two group.

In the current study, the MIMVS group had a significantly higher operative cost than the MS group; however, the MIMVS group had the superiority of the cost because it had a low total hospital stay, post-operative complications, pain, blood need, ventilation stay, better cosmetic appearance, respiratory function, and more patient satisfaction, especially between the females of both groups which gave better life quality and outcome.

Our results corroborate Pojar et al. **[10]** study which evaluated the healthcare costs associated with a minimally invasive approach relative to a traditional surgery. Analysis of total hospital cost demonstrated equivalent values between the MIMVS and MS cohorts (p=0.48).

There was a higher operative cost associated with minimally invasive approach than with full median sternotomy (p<0.001). However, MIMVS approach was associated with significantly lower blood product costs (p<0.001). Higher operative cost of MIMVS approach was offset by significantly lower postoperative costs for the minimally invasive cohort (p=0.004). In general, minimally invasive approaches are considered to be more expensive than traditional approaches.

This study has several limitations. The retrospective study design with inherent bias in data collection. In addition, minimal invasive procedures were performed by multiple surgeons, each with varying experience levels in this technique. While some surgeons were highly experienced, others were still in the early stages of their learning curve. Lastly, this study focused on early outcomes and did not investigate long-term clinical outcomes. Understanding the long-term durability and efficacy of MIMVS is essential for evaluating its overall benefits. Future research should consider conducting follow-up studies to assess long-term outcomes.

Conclusion:

According to the findings in the current study, minimally invasive mitral valve surgery is a safe procedure, associated with a low incidence of intraoperative complications and excellent postoperative outcomes. However, the cost-effectiveness remains controversial. Therefore, additional multicenter studies are needed to make econometric analysis for any future evaluation of novel cardiovascular therapies.

Declarations:

- Ethical approval and consent to participate: The study protocol by the research ethics committee of faculty of medicine of Ain Shams University.
- Consent for publication: All patients gave consent for publication.
- Availability of data and materials: The data will be available on demand
- Competing interests: Authors declare that there is no competing of interest.
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النتائج المبكرة لجراحة الصمام الميترالى طفيفة التوغل مقابل تقنية شق القص الوسطى القياسى

يمكن أن تشكل جراحة الصمام الميترالى التى يتم إجراؤها من خلال جراحة الشق الكامل لعظمة القص (MST-MVS) تحديا تقنيا من الناحية الفنية ومن المعروف أنها تحمل مخاطر محتملة لإصابات الشرايين التاجية والهياكل الوعائية التى تقع مباشرة تحت عظمة القص ويمكن أن تلتصق بها. مضاعفات ما بعد الجراحة القلبية لاسيما عندما تحدث لها تأثير عميق على البقاء على قيد الحياة على المدى الطويل والوفيات المبكرة بعد العملية الجراحية ١. تعد جراحة الصمام الميترالى ذات التدخل الجراحى المحدود إجراءً آمنًا، ويرتبط بانخفاض معدل حدوث المضاعفات أثناء الجراحة ونتائج ممتازة بعد الجراحة.

تهدف هذه الدراسة إلى تقييم النتائج المبكرة لجراحة الصمام الميترالى ذات التدخل الجراحى المحدود مقابل تقنية الشق الكامل لعظمة القص فى المرضى الذين يخضعون لجراحة الصمام الميترالى. قارنت هذه الدراسة بأثر رجعى النتائج المبكرة لجراحة الصمام الميترالى ذات التدخل الجراحى المحدود (MIMVS) مع تقنية الشق الكامل لعظمة القص (MS) فى ٤٠ مريضًا يخضعون لجراحة الصمام الميترالى.

فى هذه الدراسة كان لمجموعة MIMVS التفوق فى التكلفة لأنها كانت تتمتع بإجمالى إقامة منخفض فى المستشفى وانخفاض معدل مضاعفات ما بعد الجراحة، والألم، والحاجة إلى الدم، ومظهر تجميلى أفضل، ووظيفة الجهاز التنفسى، ورضا أكبر للمرضى، خاصة بين إناث المجموعة. مما أعطى نوعية حياة ونتائج أفضل.