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Early Outcome of Minimally Invasive Versus Conventional Mitral Valve Replacement Surgery

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ABSTRACT

Background: Recent justifications for minimally invasive techniques include the desire to reduce surgical trauma, enhance patient recovery, and lower costs without sacrificing the effectiveness of mitral valve repair or replacement. The objective of the current study is to ascertain whether minimally invasive mitral valve surgery using lower mini-sternotomies and mini-thoracotomies results in better postoperative outcomes than traditional surgery using a full sternotomy. **Patients and methods:** A total of 60 patients were included in this study, of which 30 cases were operated upon conventionally through full median sternotomy, 15 cases were operated upon through mini-sternotomy, and 15 cases were operated upon through right anterolateral mini-thoracotomy. Matched groups of patients were used.

Results: Statistical analysis of the basic data of patients before operations showed no statistical significance between the groups. Minimally invasive mitral valve surgery was statistically associated with a significantly better outcome regarding ventilation time, chest tube drainage, blood transfusion and postoperative pain in comparison to conventional mitral valve surgery. These better results were not accompanied by significant increase in ICU stay, duration of inotropic support, postoperative complications, hospital stay and in-hospital mortality. On the other hand, intra-operative time parameters were shorter in conventional cases with statistical significance in total operative time when compared with minimally invasive cases. Mini-thoracotomy as an approach showed superior results when compared with the mini-sternotomy approach regarding chest tube drainage, and blood transfusion. However, mini-sternotomy cases showed less intra-operative time parameters, ventilation time, duration of inotropic support and postoperative pain with statistical significance in total operative time.

Conclusion: Minimally invasive mitral valve surgery improved significantly the early outcome regarding ventilation time, chest tube drainage, blood transfusion and postoperative pain in comparison to conventional mitral valve surgery.

Keywords: Mitral valve replacement, Median sternotomy, minimally invasive mitral valve surgery, Mini-sternotomy, Mini-thoracotomy, Comparative study, Clinical Trial, Cairo University.

INTRODUCTION

Since the development of cardiac surgery in the 1950s, the full median sternotomy has been the accepted method for the majority of cardiac surgeries because it provides the best opportunity for exposing and treating the heart and surrounding structures. However, "surgical aggression" in the form of postoperative bleeding, wound infection, discomfort, and lengthy scars compromises this strategy [1,2].

The need for minimally invasive techniques stems in part from the need to reduce surgical trauma, enhance patient recovery, and lower costs without sacrificing the effectiveness of mitral valve repair or replacement. Access to all heart regions must be possible using a minimally invasive technique with little to no need for highly specialized equipment. Additionally, better cosmetic outcomes and reduced surgical discomfort should be offered. Additionally, it must offer the benefit of a patient's early recovery and quick return to work [2].

A lower mini-sternotomy uses a smaller incision and well-known tools to expose the heart as is customary. Additionally, it keeps the shoulder girdle continuous, which enhances postoperative breathing mechanics. In addition, if difficulties arise or the exposure is insufficient, it enables quick and simple conversion to a full sternotomy. Also, it is more prone to keloid formation than a full sternotomy and does not produce significantly superior cosmetic effects than a mini-thoracotomy [3]. Due to the preservation of the entire sternum in its entirety, mini-thoracotomies have the finest cosmetic outcomes and need the least amount of recuperation. However, this method has drawbacks, such as a longer learning curve required by the use of specialized long-shafted equipment and the non-standard approach to the mitral valve, as well as lengthier CBP, cross-clamp, and overall treatment times. Additionally, problems from peripheral cannulation are more likely when groyne vessels are cannulated [4].

The aim of the current study is to determine whether minimally invasive mitral valve surgery through lower mini-sternotomy and mini-thoracotomy improves postoperative outcome when compared to the conventional surgery through total sternotomy, including intra-operative time parameters, postoperative complications, intensive care unit and hospital stays, in-hospital mortality and postoperative pain.

PATIENTS AND METHODS

This is a comparative study, which included retrospective data. It included 60 patients underwent Mitral valve replacement (MVR) surgery, of which 30 cases were operated upon conventionally through full median sternotomy (*Group A*), 15 cases were operated upon through mini-sternotomy (*Group B*), and 15 cases were operated upon through right anterolateral mini-thoracotomy (*Group C*). Patients were operated upon in Kasr Al-Aini Hospitals in the period from June 2012 to June 2018.

Surgical techniques

A. Conventional mitral valve surgery:

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In the supine position, full median sternotomy was performed. Thereafter, via aorto-bicaval cannulation using cold blood cardioplegia and via left atriotomy incision in some cases and transseptal approach in others, mitral valve replacement was performed.

B. Mitral valve surgery through ministernotomy:

An oscillating saw was used to divide the sternum in the supine position vertically in the midline from the xiphoid process to the third intercostal space, and then transversely to the right at that point without damaging the internal mammary artery. The top sternum portion was unharmed (an inverted L-shaped partial sternotomy). Through bicaval cannulation, cardiopulmonary bypass was created using the right atrium and femoral artery. Through antegrade delivery of a cold blood cardioplegia solution to the aortic root and systemic chilling to 28°c, myocardial protection was achieved. A trans-septal technique was used to approach the mitral valve for replacement.

C. Mitral valve surgery through right anterolateral mini thoracotomy:

In a mild left lateral position with the right arm fixed above the head, a 5-7 cm incision was made in the 5th intercostal space. Both arterial and venous femoral cannulation was performed. Using cold blood cardioplegic arrest and through a transeptal approach, mitral valve was replaced

Study Tools

The 3 matched groups representing the 3 approaches were compared regarding preoperative patient characteristics and surgical risks; age, sex, functional status, co-morbidities, NYHA functional class (According to the New York Heart Association), ventricular function and mitral morphology. This was confirmed by the calculated mean Euro Score II of the groups. Intraoperative assessment was achieved including the total operative time, cardiopulmonary bypass (CPB) time and the cross-clamp time. All patients were evaluated post operatively regarding ventilation time, the need for inotropic support, Intercostal chest tube drainage, blood transfusion, duration of intensive care unit (ICU) stay, duration of hospital stay, pain score and morbidities (Re-exploration for bleeding new stroke, low cardiac output syndrome, new renal impairment, superficial wound infection and deep wound infection).

Ethical approval:

The Ethics Committees of Cairo University gave its approval to the study. Each study participant provided their signed consent after receiving full information. The Declaration of Helsinki, the World Medical Association's code of ethics for studies involving humans, guided the conduct of this work.

Statistical Analysis

The analysis of clinical records and diagnostic reports resulted in the abstraction of data. Following data coding, Statistical Package for the Social Sciences (SPSS) was used for statistical analysis. Quantitative data were described using mean and standard deviation, whereas categorical data were summarized using frequency (count) and relative frequency (%). One-way ANOVA was used to analyze the data between the study groups; Tukey HSD Post-hoc Test was used for multiple comparisons at confidence interval 95% to indicate the significance between each two groups. Chi-square statistical test was performed to compare the data % between different groups. P values were considered significant, if less than or equal to 0.05.

RESULTS

Preoperative Data

Demographic and clinical characteristics: The pre-operative patient characteristics are summarized in table 1.

Table (1): Pre-operative patients' demographic and clinical characteristics.

Variables	Conventional Surgery	Mini-sternotomy	Mini-thoracotomy	P-value	Significance
Age (years)	37.4 ± 10.7	37.0 ± 11.6	37.1 ± 11.4	0.994	Not significant
Sex **-** Male **-** Female	 12 (40%) 18 (60%)	 7 (46%) 8 (54%)	 6 (40%) 9 (60%)	0.833	Not significant
DM	4 (13%)	2 (13%)	3 (20%)	0.274	Not significant
COPD	3 (10%)	1 (6%)	2 (13%)	0.512	Not significant
Chronic renal impairment	2 (6%)	0	1 (6%)	0.596	Not significant
AF	9 (33.3%)	4 (26.67%)	3 (20%)	0.555	Not significant
NYHA class	2.80 ± 0.407	2.67 ± 0.488	2.87 ± 0.352	0.406	Not significant
Wilkin´s score	8.2±1.5	8.6 ± 1.3	9±1	0.078	Not significant
PAP (mmHg)	49.9 ± 9.70	49.0 ± 10.2	51.0 ± 9.67	0.856	Not significant
LVEF (%)	52.2 ± 7.03	51.7 ± 7.24	52.3 ± 7.53	0.965	Not significant
Euro Score II	1.22± 0.388	1.10 ± 0.228	1.25 ± 0.426	0.479	Not significant

DM: Diabetes mellitus, COPD: Chronic obstructive pulmonary disease, AF: atrial fibrillation, NYHA: New York heart association, PAP: Pulmonary artery pressure, LVEF: Left ventricular ejection fraction.

Operative data

The total operative time was longer (252.95 ± 26.05 min) in the minimally invasive groups (Groups B and C) than that of the conventional cases (Group A) which showed a total operative time of 187 (standard deviation SD= 24.1) min. The statistical difference between the groups was significant (p-value =0.01) (**Table 2**). It was longest (273 ± 32.0 min) in (Group C), followed by (Group B) (217 ± 16.1 min), while (Group A) showed the shortest mean total operative time (187 ± 24.1 min). The statistical difference between the groups was significant (p-value =0. 01) (**Table 3**). This difference was significant between all groups against each other was significant (p-value=0.02) (**Table 4**).

Table (2): Intra-operative time parameters in conventional and minimally invasive cases.

Variable	Conventional group	Minimally invasive groups	P-value
Operative time(min)	187 ± 24.1	252.95 ± 26.05	0.01 *
CPB time (min)	86.0 ± 7.0	102 ± 12.2	0.01 *
Cross clamp time (min)	57.7 ± 7.04	69.7 ± 11.6	0.02 *

* Significant difference - CPB: Cardiopulmonary bypass.

The cardiopulmonary bypass (CPB) time was longer also (102 ± 15.2 min) in the minimally invasive cases (Groups B and C), than that of (Group A) which showed a CBP time of 86 (SD= 7) min. The statistical difference between the groups was significant (p-value=0.001) (**Table 2**). It was longest in (Group C) (112 ± 14.7 min), followed by (Group B) (92.7 ± 7.29 min), while (Group A) showed the shortest CBP time (86.0 ± 7.0 min) (**Table 3**). The statistical difference between the groups was significant (p-value=0. 001). This difference was significant between (Group A) versus (Group C) and between the (Group B) versus (Group C). However, there was no statistically significant difference between *Group A* versus *Group B* (**Table 4**).

Table (3): Intra-operative time parameters between different groups.

Variable	Conventional	Mini-sternotomy	Mini-Thoracotomy	P-value
Operative time(min)	187 ± 24.1	217 ± 16.1	273 ± 32.0	0.01 *
CPB time (min)	86.0 ± 7.0	92.7 ± 7.29	112 ± 14.7	0.001 *
Cross clamp time(min)	57.7 ± 7.04	58.5 ± 7.58	81.7 ± 12.3	0.02 *

* Significant difference - CPB: Cardiopulmonary bypass.

Similarly, **the cross-clamp time** was longer (69.7 ± 15.6 min) in the minimally invasive patients (Groups B and C) than that of Group A, which showed a cross clamp time of 57.7 (SD=7.04) min (**Table 2**). It was longest in Group C (81.7 ± 12.3 min), followed by Group B (58.5 ± 7.58 min) while in Group A the cross-clamp time was the shortest (57.7 ± 7.04 min). The statistical difference between the groups was significant (p-value =0.01) (**Table 3**). This difference was significant between Group A versus Group C and between Group B versus Group C. However, there was no statistically significant difference between Group A versus Group B (**Table 4**).

Table (4): Operative times. Multiple comparisons between different groups.

Variable	Groups against each other	Mean Difference	P-value
Operative time (min)	Conventional /Mini-sternotomy	28.2800	0. 02*
	Conventional / Mini-thoracotomy	67.1600	0. 01*
	Mini-sternotomy/ Mini-thoracotomy	38.8800	0. 01*
CPB time (min)	Conventional/Mini-sternotomy	6.6700	0.077
	Conventional/Mini-thoracotomy	26.3300	0. 001*
	Mini-sternotomy/Mini-thoracotomy	19.6600	0. 001*
Cross clamp time (min)	Conventional/Mini-sternotomy	0.8700	0.967
	Conventional/Mini-thoracotomy	24.8700	0. 01*
	Mini-sternotomy/Mini-thoracotomy	24.0000	0. 01*

* Significant difference - CPB: Cardiopulmonary bypass.

Postoperative data:

The duration of mechanical ventilation was longer in Group A with a mean of 8.23 (SD= 1.85) hours, than that in the minimally invasive cases (Groups B and C) which showed a mean duration of mechanical ventilation of 6.43 (SD= 1.31) hours. The statistical difference between the groups was significant (p-value=0.002) (**Table 5**).

It was longest in Group A, followed by that in Group C (6.67 ± 1.42 hours). On the other hand Group B showed the shortest mean duration of mechanical ventilation (6.20 ± 1.31 hours). This was of statistically significant difference between the groups (p-value=0.011) (**Table 6**).

This difference was statistically significant between Group A against Group B and between Group A against Group C. In contrast there was no statistically significant difference between Group B against Group C (**Table 7**).

Table (5): Postoperative data and their statistical significance between the conventional group (Group A) and the minimally invasive cases (Group B and C).

Patient data	Conventional group	Minimally invasive cases	P- value	Significance
Ventilation time (hours)	8.23 ± 1.85	6.43 ± 1.31	0.002	Sig.
Inotropic support				
Number	7 (23%)	9 (30%)	0.559	Not sig.
Duration (hours)	9.85 ± 2.31	10.3 ± 2.41	0.590	
Drainage (cc)	587 ± 136	335 ± 81.11	0.001	Sig.
Transfusion (blood units	2.10 ± 0.43	0.75 ± 0.16	0.001	Sig.
ICU stay (days)	2.47 ± 0.51	2.02 ± 0.41	0.06	Not sig.
Hospital stay (days)	8.1 ± 1.8	8.07 ± 2.38	0.952	Not sig.
Pain score				
1st day after extubation	5.7 ± 1.17	4.40 ± 1.33	0.003	Sig.
5th day after extubation	4.70 ± 0.95	2.77 ± 0.33	0.001	
Morbidities				
Re-exploration for bleeding	1 (3.3%)	0	0.313	Not sig.
New stroke	1 (3.3%)	1 (3.3%)	1.000	Sig.
Low CO syndrome	0	1 (3.3%)	0.313	Not sig.
New renal impairment	0	1 (3.3%)	0.313	Not sig.
Superficial wound infection	3 (10%)	4 (13%)	0.688	Not sig.
Deep wound infection	1	0	0.559	Not sig.
Femoral wound **Complications**	0	5 1 Bleeding 2 Superficial infection 2 Lymphorrhea	0.020	Sig.
In-hospital mortality	1 (3.3%)	2 (6.6%)	0.554	Not sig.

ICU: Intensive care unit, CO: Cardiac output.

In a similar fashion, **the number of transfused blood units** was more in Group A which showed the higher mean (2.10 ± 0.41 unit), than that of the minimally invasive cases (Group B and C) (0.733 ± 0.141 unit). The statistical difference between the groups was significant (p-value=0.001) (**Table 5**).

It was more in Group A which showed the highest mean (2.10 ± 0.407 unit), followed by Group B (0.867 ± 0.640 unit), while Group C showed the least mean (0.737 ± 0.16 unit). The statistical difference between the groups was significant (p-value = 0.01) (**Table 6**).

This difference was statistically significant between Group A versus Group B and between Group A versus Group C. However, there was no statistically significant difference between Group B versus Group C (**Table 7**).

Table (6): Postoperative data and their statistical significance between different groups.

Variable	Conventional (Group A)	Mini-sternotomy (Group B)	Mini-thoracotomy (Group C)	P-value	Significance
Ventilation time (hours)	8.23 ± 1.95	6.20 ± 1.31	6.67 ± 1.42	0.011	Sig.
Inotropic support					
Number	7 (23%)	4 (26%)	5 (33%)	0.774	Not sig.
Duration (hours)	9.85 ± 2.44	9.9 ± 2.11	10.0 ± 2.40	0.891	Not sig.
Drainage (cc)	587 ± 136	370 ± 81.1	300 ± 71.2	0.001	Not sig.
Transfused (blood units	2.10 ± 0.41	0.867 ± 0.216	0.737 ± 0.16	0.01	Not sig.
ICU stay (days)	2.47 ± 0.41	2.10 ± 0.407	1.93 ± 0.417	0.061	Sig.
Hospital stay (days)	8.1 ± 1.81	8 ± 1.82	8.13 ± 1.59	0.984	Sig.
Pain score					
1st day after extubation	5.7 ± 1.17	3.26 ± 0.715	5.53 ± 1.35	0.001	Not sig.
5th day after extubation	4.70 ± 0.95	2.73 ± 0.44	2.80 ± 0.42	0.0001	Not sig.
Morbidities					
Re-exploration for bleeding	1 (3.3%)	0	0	0.601	Not sig.
New stroke	1 (3.3%)	1 (6%)	0	0.596	Not sig.
Low CO syndrome	0	1 (6%)	0	0.218	Not sig.
New renal impairment	0	1 (6%)	0	0.218	Not sig.
Superficial wound infection	3 (10%)	2 (13%)	2 (13%)	0.922	Not sig.
Deep wound infection	1	0	0	0.601	Not sig.
Femoral wound complications	non	3 1 bleeding 2 superficial infection	2 2 lymphorrhea	0.053	Not sig.
In-hospital mortality	1(3.3%)	1 (6%)	1(6%)	0.839	Not sig.

ICU: Intensive care unit, CO: Cardiac output

The amount of postoperative chest tube drainage was more in Group A with a mean of 587 (SD= 186) cc, than that in the minimally invasive patients (Group B and C) which showed a mean amount of postoperative chest tube drainage of 335 (SD= 81.11) cc. The statistical difference between the groups was significant (p-value=0.001) (**Table 5**). It was more in Group A with a mean of 587 (SD 136) cc, followed by 370 (SD 81.1) cc in Group B and finally 300 (SD= 71.2) cc in Group C. The statistical difference between the groups was significant (p-value=0.001) (**Table 6**). This difference was statistically significant between the different groups against each other (**Table 7**).

Table (7): postoperative parameters. Multiple comparisons between different groups.

Variable	Groups against each other	Mean Difference	P-value
Ventilation time (hours)	Conventional/Mini-sternotomy	2.0300	0.0085*
	Conventional/Mini-thoracotomy	1.6300	0.0415*
	Mini-sternotomy/Mini-thoracotomy	0.4000	0.8579
Amount of chest tube drainage (ml)	Conventional/Mini-sternotomy	195.3300	0. 016*
	Conventional/Mini-thoracotomy	343.3300	0. 001*
	Mini-sternotomy/Mini-thoracotomy	148.0000	0.005*
The amount of transfused blood units	Conventional/Mini-sternotomy	1.2330	0. 001*
	Conventional/Mini-thoracotomy	1.5000	0. 001*
	Mini-sternotomy/Mini-thoracotomy	0.2670	0.595

* Significant difference.

Upon assessing the degree of **postoperative pain on the 1st day after extubation** using the pain scale, Group A showed higher mean pain score (5.7 ± 1.17) than that in minimally invasive cases (Groups B and C) which showed a mean pain score of 4.40 (SD 1.33). This mean was 5.53 (SD= 1.35) in Group C and 3.26 (SD= 0.715) in Group B. The statistical difference between the groups was significant (p-value =0.003).

The difference was statistically significant between Group A versus Group B (p-value =0.001) and between Group B versus Group C (p-value=0.001). However, there was no statistically significant difference between Group A versus Group C (p-value =0.904) (**Figure 1A**).

The same finding was encountered when assessing **pain on the 5th day after extubation,** where Group A showed a higher mean pain score of 4.70 (SD= 0.95), while the minimally invasive cases (Groups B and C) showed a less mean pain scores of 2.77 (SD 0.33). This mean was 2.73 (SD= 0.44) in Group B and 2.80 (SD= 0.42) in Group C. The statistical difference between the groups was significant (p-value =0.001). The difference was statistically significant between Group A versus Group B (p-value =0.0001) and between Group A versus Group C (p-value =0.0001). However, there was no statistically significant difference between Group B versus Group C (p-value =0.9705) (**Figure 1**).

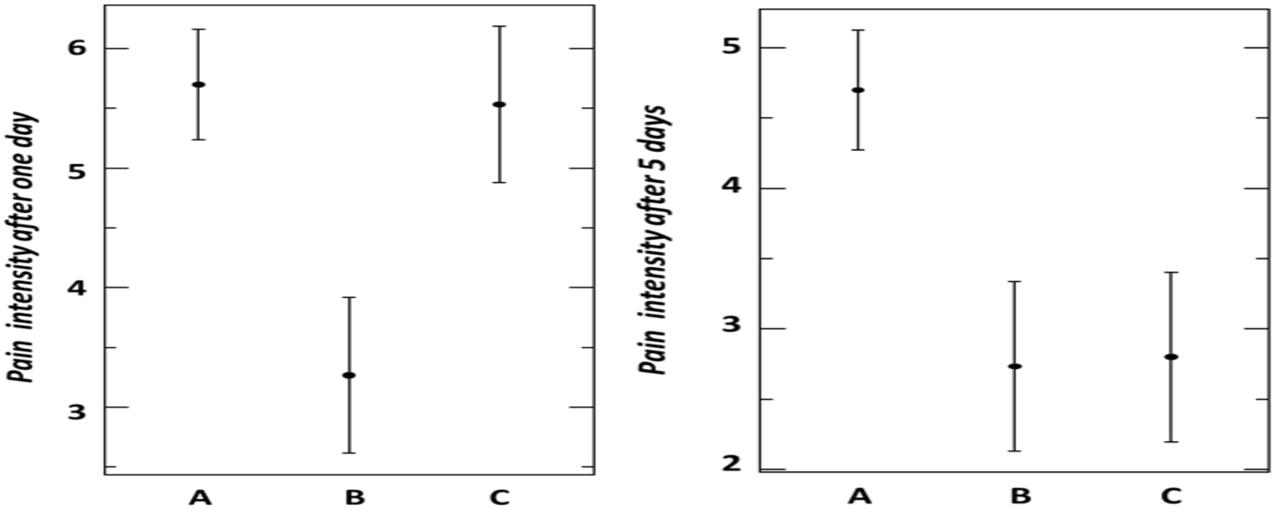

Figure (1): Pain score in the 1st day (A) and 5th day (B) after extubation between different groups. A= conventional B= mini-sternotomy C= mini-thoracotomy.

Complications

In the conventional group (Group A), one patient (3.33%) developed an embolic cerebro-vascular stroke with occipito-parietal infarction. This patient died later on the 8th postoperative day as a result of sepsis. One patient (3.33%) was re-explored for bleeding but no definite source was found for bleeding. One patient (3.33%) in this group developed deep sternal wound infection which was managed with debridement and rewiring. Three patients (10%) showed superficial wound infection which was managed conservatively with repeated dressings and antibiotics according to culture and sensitivity.

In the mini-sternotomy group, femoral artery injury occurred in one patient (6.66%) during cannulation which was managed through a vascular surgeon with an interposition tube graft. This patient was converted to a full sternotomy to go rapidly on bypass after occurrence of a retroperitoneal hematoma. Unfortunately, this patient developed cerebro-vascular insult and renal shutdown and died on the 4th postoperative day due to acute renal failure. In this group, 2 patient (13.3%) developed superficial femoral wound infection and 2 patients (13.3%) showed superficial sternal wound infection. All 4 patients were managed conservatively with dressings and antibiotics.

In the mini-thoracotomy group, one patient died on the 1st postoperative day as a result of severe refractory low cardiac output syndrome. 3 patients (20%) developed femoral lymphorrhea which was managed by repeated sterile compression bandages and 2 patients showed superficial thoracotomy wound infection which was managed conservatively. There were no statistically significant differences regarding in-hospital mortality and postoperative complications between the groups (P >0.05) (**Tables 5 and 6**).

All patients underwent post-operative echo before discharge from the hospital which showed no significant pericardial effusion, no paravalvular leak, well-functioning mitral valve prosthesis. Also, no significant reduction in LV systolic function was observed.

DISCUSSION

The minimally invasive mitral valve surgery (MIMVS) technique has gained popularity among cardiac surgeons all over the world, as well as among cardiologists and patients.

In the current study, the 3 compared groups were matched preoperatively as confirmed by the calculated mean Euro Score II of the groups which showed no statistically significant difference [7].

On reviewing the intra-operative time parameters, we find that the total operative time was significantly longer in the mini-sternotomy (217 ± 16.1 min) as well as the mini-thoracotomy (273 ± 32 min) techniques, compared to conventional cases (187 ± 24.1 min), which reflects the additional time needed for the femoral artery cannulation and preparing the operative field till the mitral valve is reached. In addition, this time was significantly longer in the mini-thoracotomy group than in the mini-sternotomy group representing the extra time needed for cannulating the femoral vein and confirming the position of the tip of the cannula in the SVC together with the learning curve of using special long-shafted instruments during the mini-thoracotomy approach.

On the other hand, the cardiopulmonary bypass (CPB) time was significantly longest in the mini-thoracotomy approach (112 ± 14.7 min) compared to conventional cases (86.0 ± 7 min) due to the time needed for preparing the operative field after going on bypass and the learning curve of using the long-shafted instruments. However, cardiopulmonary bypass (CPB) time was longer (92.7 ± 7.29 min) but not statistically significant in the mini-sternotomy due to additional few minutes needed for the trans-septal exposure of the mitral valve.

This was also true for the cross-clamp time which was longest in the mini-thoracotomy approach (81.7 ± 12.3 min) and insignificantly longer in the mini-sternotomy approach (58.5 ± 7.58 min) in comparison to the conventional cases (57.7 ± 7.04 min).

These figures are similar to those reported by earlier series comparing minimally invasive and conventional techniques like the study published by **Cohn and colleagues** [1] which compared two groups of 50 patients each, one undergone minimally invasive surgery while the other received conventional procedures. In their patients, operative time and cardiopulmonary bypass time increased by almost 40% in the minimally invasive group. **Fann and colleagues** [5] reported in 1997 a total operative time of 260 min, a cardiopulmonary bypass (CPB) time of 183 min and cross-clamp time of 136 min in Minimally Invasive cases. However, in later series like that of **Iribarne *et al.*** [1] and with growing experiences overcoming the learning curve, the cardiopulmonary bypass (CPB) time remained longer by 22.5 min (p =0.001) in the minimally invasive group compared to the conventional group (139.7 in minimal invasive and 117.1 in the median sternotomy). However, in the same study the cross-clamp time did not differ significantly between both the conventional and minimally invasive groups (83.7 versus 79.6) (p =0.106). This result was also reported in study performed (2017) in which mini-thoracotomy had longer cardiopulmonary bypass time (120 versus 99 min for the conventional) [7].

The duration of mechanical ventilation in our study was found to be more in conventional group, followed by the mini-thoracotomy group and then the mini-sternotomy group (8.23 hours, 6.67 hours, 6.20 hours respectively) with statistical significance between the conventional group versus each group of the minimally invasive techniques. On the other hand, there was no statistically significant difference between the mini-sternotomy and mini-thoracotomy groups. This is consistent with minimally invasive approaches where the integrity of the chest wall is preserved and thus the postoperative pulmonary functions are improved. Early postoperative pain is usually more after thoracotomy incisions than sternotomy incisions [8]. The superiority of minimally invasive incisions regarding postoperative ventilation time is confirmed by other studies like that of **Svensson and his colleagues** [8] in which they found that the minimal invasive approach significantly decreased the ventilation time. This was also true in another study including high risk patients as the study of **Santana** [9] on obese cases and the study performed by **Lamelas *et al.*** [10] in old (aged 75 years and more) patients.

In our study postoperative chest tube drainage was significantly less after minimally invasive surgeries with the least values in the mini-thoracotomy group. This is attributed to the less surface exposure and mediastinal dissection associated with smaller incisions, which is more obvious after avoiding total sternotomy in mini-thoracotomy cases. Our results go hand in hand with other previous reports including cases operated upon using the mini-sternotomy and/or mini-thoracotomy approaches [8,11,12,13,14]. In a similar fashion, transfusion of blood units postoperatively was more in the conventional group which showed the highest mean (2.10), followed by the mini-sternotomy group (0.867), while the mini-thoracotomy group showed the least mean (0.737). The difference was statistically significant between the conventional versus the mini-sternotomy groups, and between the conventional versus the mini-thoracotomy groups. However, there was no statistically significant difference between the mini-sternotomy versus the mini-thoracotomy groups. Many surgeons reported that transfusion of blood products in general was less frequent after minimally invasive surgery than after conventional surgery [2,11,15,16]. **Gillinov and Cosgrove** [12] reported in their mini-sternotomy operations that eighty-six percent of patients received no blood products at all. In a study done by **Santana *et al.*** [17]**,** cases operated upon through right anterior mini-thoracotomy received less packed red blood cells. **Mariscalco and Musumeci** [4] reported significantly lower postoperative blood loss in the MT group (481 ml versus 930 ml, p 0.01).

In our study pain scores were obtained routinely as part of clinical care from all patients after surgical intervention. Pain intensity, ranging from 0 (none) to 10 (most severe), was recorded at the 1st and 5th days of extubation for all patients. Pain was in general less in the minimally invasive groups than in the conventional one.

Cohn and Adams [1] in their study reported similar pain scores in the first day, and this proportion increased to about 60% by day 3. While **Svensson and D'Agostino** [13] reported that the mini-sternotomy technique required less postoperative morphine dosages than the conventional technique.

In our study we found that hospital stay didn't vary too much between the groups and the statistical difference between the groups was not significant. This was in accordance with another study done by **Svensson *et al.*** [8]**.**

In our study postoperative morbidity and in-hospital mortality was defined according to the Society of Thoracic Surgeons National Database [7]. Our patient's mortality rate was one patient from each group. This would be 3.33% in the conventional group (1/30) and 6.66% in each of the mini-sternotomy and the mini-thoracotomy groups (1/15). The increased percentage of mortality in our study is due to the small number of patients in each group as death of only one patient from 15 equals 6.66%. Some studies like that of **Svensson *et al.*** [8] found non-significant differences between the conventional and minimally invasive groups in concern with in-hospital mortality with an in-hospital mortality for propensity-matched patients of 0.17% (1/590) in those undergoing minimally invasive surgery and 0.85% (5/590) in those undergoing conventional surgery (P = 0.2).

In our study post-operative stoke was encountered in one patient in the conventional group (1/30) with no strokes in the minimally invasive operated cases and no statistical difference which confronts the concern postulated regarding de-airing and risk of strokes in minimally invasive surgery. This was the case also regarding the rate of wound infection whether superficial or deep and the rate of re-opening for bleeding which occurred in one patient in the conventional group (3.3%). Complications of the femoral cannulation were still acceptable as femoral artery injury occurred in one patient of the minimally invasive group (1/30). In the study of **Svensson *et al.*** [8] in-hospital complications occurred with similar frequency in both the mini-sternotomy and conventional groups. Occurrences of stroke (P =0.8), renal failure (P >0.9), myocardial infarction (P =0.7), and infection (P =0.8) were also similar. **Grossi *et al.*** [16] reported also similar rate of complications in the mini-thoracotomy and sternotomy cases.

In conclusion, minimally invasive mitral valve surgery improves significantly the early outcome regarding ventilation time, chest tube drainage, blood transfusion and postoperative pain in comparison to conventional mitral valve surgery. These better results were not accompanied by a significant increase in intensive care unit (ICU) stay, duration of inotropic support, postoperative complications, hospital stay and in-hospital mortality. However intra-operative time parameters especially total operative time were longer in minimally invasive techniques compared to the conventional one.

Mini-thoracotomy and mini-sternotomy incisions as minimally invasive techniques were associated with comparable results with superiority of the mini-thoracotomy approach regarding the amount of chest tube drainage and superiority of the mini-sternotomy approach regarding early postoperative pain on the 1st day which was reflected also on ventilation time.

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