Comparative Outcome of Different Types of Redo Surgery in Malfunction of Mechanical Prosthetic Mitral Valve

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Abstract
Objectives: Redo mitral valve replacement (MVR) is an important therapeutic approach in patients with the malfunction of the prosthetic mitral valve, especially in patients with severe dyspnea or a large thrombus burden. Redo replacement (MVR) and thrombectomy are different surgical approaches in these patients. This study evaluated the outcome of the second mitral valve surgery including mechanical MVR (M-MVR), biologic MVR (B-MVR), and surgical thrombectomy.
Materials and Methods: To this end, 71 patients were included in this study, who underwent second mitral valve surgery following the malfunction of the prosthetic mitral valve in the last 10 years. These patients were divided into M-MVR, B-MVR, and surgical thrombectomy groups and their demographic, clinical, echocardiographic, and laboratory findings were gathered as well. Then, the patients were evaluated for their third MV surgery if it was performed, followed by evaluating the pump time and cross-clamp time
Results: Fifty-seven, 8, and 6 patients underwent M-MVR, B-MVR, and thrombectomy, respectively. Based on the results, the mortality rate was not significantly different between the 3 groups ($P=0.059$). In addition, 12 patients underwent the third surgery with the highest (100%) and lowest (0%) rates at thrombectomy and B-MVR groups, respectively. Higher pump time and cross-clamp time were significantly associated with an increased mortality rate ($P=0.014$ and $P=0.026$, respectively).
Conclusions: In the malfunction of the prosthetic mitral valve, mortality rate failed to significantly differ between the patients undergoing M-MVR, B-MVR, and thrombectomy but third surgery is often needed after thrombectomy. It seems that the replacement of previous prosthetic valve with a new mechanical or biological valve yields better results in the case of prosthetic valve malfunction.
Keywords: Cardiac valve prosthesis, Heart valve prosthesis implantation, Bioprostheses

Introduction

Malfunction is a serious complication of prosthetic mitral valves. In this condition, redo surgery is regarded as an important therapeutic approach, especially in patients with severe dyspnea or a large thrombus burden. However, there is a controversy between different surgical techniques in patients with malfunction (1-4). Three surgical approaches are now available to the malfunction of the prosthetic mitral valve, including mitral valve replacement (MVR) with mechanical valves (M-MVR) or biologic valves (B-MVR) or surgical thrombectomy alone without valve replacement. MVR may be associated with significant risks and complications despite remarkable advances in Redo MVR techniques and postoperative cares (5-8). The type of prosthetic valve is implanted during redo MVR including mechanical or biologic valves and some simpler surgical techniques such as thrombectomy

technique are between different surgical approaches in these patients. Right thoracotomy or mini-thoracotomy also are noticed in redo-MV surgery to decrease the rate of complication in redo-sternotomy (9-11). Various studies reported some other factors which could be effective in the outcome of Redo MVR, including the time interval between the primary and redo operation, the patient's age during redo operation, gender, regular warfarin use, prothrombin time and international normalized ratio level, renal failure (creatinine [Cr] ≥1.5 mg/dL), atrial fibrillation, and left ventricular ejection fraction (9-16).

Given the high mortality and the adverse event rate of redo MVR, the present study was performed on patients with the malfunction of prosthetic mitral valve aiming at evaluating the outcome of different surgical approaches including redo MVR with mechanical and biologic valves, as well as redo MV surgery with thrombectomy alone.

Materials and Methods

The participants of this cross-sectional study included all patients who underwent redo-MV surgery in our tertiary heart center following the malfunction of prosthetic MVR including B-MVR and M-MVR during the past 10 years. Next, patients' information was collected and analyzed using the retrograde approach. The study patients were categorized into 3 groups according to the type of second (redo) surgery including redo M-MVR, redo B-MVR, or thrombectomy. In addition, patients' demographic information, along with other variables was collected by a checklist. Such variables were as follows.

- The time interval between the primary and redo operation;
- The type of valve implanted in the primary and redo surgeries, as well as the third surgery for patients undergoing surgery for the third time;
- Patient's age in primary and redo operations;
- The type of illness causing the primary surgery, including valve stenosis, valve insufficiency, endocarditis, and thrombus;
- The type of complication leading to redo and third surgeries such as degeneration, endocarditis, thrombus, paravalvular leakage, and pannus;
- The type of symptoms during hospital admission;
- The length of hospital stay;
- Prothrombin time and international normalized ratio levels during hospital admission;
- Renal failure based on Cr ≥1.5 mg/dL;
- Atrial fibrillation through an electrocardiogram;
- Left ventricular function evaluated by the eyeball estimation of ejection fraction before and after the surgery;
- Valve function and pathology examination by transthoracic echocardiography;
- Aortic cross-clamp time;
- Pump time;
- Hemodynamic instability (systolic blood pressure <90 mm Hg);
- A need for inotrope after the surgery;
- Acute respiratory distress syndrome based on respiratory failure and chest X-ray (CXR) findings;
- Postoperative pulmonary edema based on clinical and CXR findings;
- Stroke based on clinical findings and brain CT scan results;
- Pulmonary embolism based on the computed tomography angiography of pulmonary arteries;
- Patient's weight;
- A need for urgent surgery in the first 24 hours;
- Preoperative NYHA (New York Heart Association) functional class;
- The times of operation, valve type, and position;
- The type of concomitant surgery;
- Mortality;
- A need for permanent pacemaker;

- Massive bleeding (the need for blood transfusion).

Patients' follow-up information was collected by their medical file and telephone call. Further, categorical variables, as a percentage, were compared by χ^2 or Fisher exact test and continuous data, as mean ± SD, were compared by independent t test and the Mann-Whitney U test. $P < 0.05$ was considered as statistically significant. The information was imported to SPSS software (version 17) as the statistical data.

Results

From a total of 71 patients, 57, 8, and 6 cases underwent mechanical mitral valve surgery (M-MVR), biologic (B)-MVR, and thrombectomy alone, respectively. Some patients had simultaneous multivalvular surgery, generally, aortic valve surgery (AVR), the details of which are presented in Table 1. The mean follow-up time was 7.7 ± 5.6 years.

During redo surgery, the majority of patients had M-MVR instead of B-MVR or thrombectomy (Table 2) and the most common symptom during hospitalization was dyspnea in all groups. Most patients had dyspnea NYHA FC III-IV during admission as well. Other less frequent symptoms included syncope, angina, dizziness, and palpitation.

Totally, twelve patients underwent the third surgery from whom, 3 cases died but the mortality rate was not significantly different in terms of the type of valve in the third surgery (Fisher exact test, $P = 0.52$). The mean age was also 59.1 ± 5.7 years.

Likewise, higher ages were related to the need for permanent pacemaker implantation but the difference was not significant ($P = 0.12$). Further, age had no significant impact on mortality, massive bleeding,

Table 1. Type of Multivalvular Surgery in All Groups

Groups/Type of Surgery	MVR	MVR, AVR	MVR, TVR, AVR	Total
M-MVR	51	5	1	57
B- MVR	7	1	0	8
Thrombectomy	6	0	0	6
Total	64	6	1	71

Abbreviations: M-MVR, Mechanical mitral valve replacement; B-MVR, Biologic mitral valve replacement; TVR, Tricuspid valve replacement; AVR, Aortic valve surgery.

Table 2. Patients' Number in All Groups

Groups	Sex		Total
	Male	Female	
M-MVR	21	36	57
B-MVR	4	4	8
Thrombectomy	2	4	6
Total	27	44	71

Abbreviations: M-MVR, Mechanical mitral valve replacement; B-MVR, Biologic mitral valve replacement.

hypotension, myocardial infarction, pulmonary edema, acute respiratory distress syndrome, the need for long time ventilation, and ejection fraction (EF) rate before and after the surgery. The comparison of the types of redo surgery indicated that patients who received M-MVR showed more hemorrhage ($P = 0.007$) than those with B-MVR or thrombectomy (5.35%).

Similarly, the need for long time ventilation was higher in B-MVR ($P = 0.02$) compared to other surgeries (25%). Furthermore, preoperative EF represented a higher rate (46.21 ± 7.15) in M-MVR group ($P < 0.001$) in comparison to thrombectomy (39.00 ± 14.74), and B-MVR (45.00 ± 6.45) groups. Moreover, the hemodynamic instability was significantly higher in B-MVR group (50%) while it was 16.07% and 33% in M-MVR and thrombectomy groups, respectively ($P = 0.035$). Higher pump time was also significantly related to increased mortality rate ($P = 0.014$). In patients who died, the average pump time was 167 minutes (± 44.9 SD) as compared to 123 minutes (± 52.86 SD) in those without mortality. Additionally, higher cross-clamp time was significantly associated with increased mortality rate ($P = 0.026$). The average cross-clamp time in patients who died was extremely higher compared to patients without mortality, indicating 117 minutes (± 18.7 SD) compared to 83 minutes (± 38.9 SD), respectively.

The findings related to pump time, cross-clamp time, EF, and prothrombin time (PT) in all groups are provided in Table 3.

The average PT level in all groups was lower than the therapeutic goal and the difference between PT levels was not significant in no groups. In addition, the rate of surgery-related complications was not significantly different between different surgery types (Table 4).

Table 3. Surgical, Laboratory, and Echocardiographic Findings in All Groups

	Min	Max	Mean±SD
PT (M-MVR group)	12.50	43.40	19.19±5.59
Clamp time (M-MVR group)	17.00	210.00	84.49±42.20
Pump time (M -MVR group)	34.00	300.00	128.71±54.23
LV EF before surgery (M-MVR group)	30.00	60.00	46.25±7.15
LV EF after surgery (M-MVR group)	25.00	60.00	44.22±7.53
Clamp time (B-MVR group)	53.00	174.00	118.25±46.69
Pump time (B-MVR group)	24.00	223.00	137.00±70.68
PT (B-MVR group)	13.00	39.00	21.93±11.61
LV EF before surgery (B-MVR group)	35.00	55.00	45.00±6.45
LV EF after surgery (B-MVR group)	30.00	45.00	40.00±7.07
Clamp time (Thrombectomy group)	16.00	117.00	84.00±23.46
Pump time (Thrombectomy group)	64.00	191.00	133.83±39.58
PT (Thrombectomy group)	13.00	22.40	19.13±2.47
LVEF before surgery (Thrombectomy group)	25.00	50.00	39.00±14.74
LVEF after surgery (Thrombectomy group)	35.00	50.00	43.75±7.50

Abbreviations: M-MVR, Mechanical mitral valve replacement; B-MVR, Biologic mitral valve replacement; PT, Prothrombin time; LV EF, Left ventricle ejection fraction; SD, Standard deviation.

As shown in Table 5, the mortality rate also demonstrated no significant difference between the 3 groups ($P = 0.059$). The mortality rate of patients with B-MVR was 25%, 14%, and 16.6% during redo surgery, M-MVR, and thrombectomy, respectively. Higher pump time and cross-clamp time were both significantly related to an increased mortality rate ($P = 0.014$ & $P = 0.026$, respectively).

M-MVR Group
This group included 57 patients encompassing twenty patients with a history of B-MVR and 36 patients with M-MVR from their first surgeries. Similarly, the patients' mean age was 56.66 ± 11.24 ranging from 21 to 84 years and the most common symptom during the hospital admission was dyspnea (49 patients, 85.9%). Twenty-one patients were males (36.8%) and 36 of them were females (63.1%). Further, all the patients (100%) were on warfarin and death occurred in 7 patients (12.2%) including 3 men and 4 women.

Furthermore, valve stenosis was the most common cause of the first surgery in this group, which affected 34 patients (61.8%). The other causes included valve insufficiency, endocarditis, as well as simultaneous valve stenosis and insufficiency which were observed in 14 (25.5%), 2 (3.5%), and 6 (10.7%) patients, respectively. Likewise, the most prevalent cause of second surgery was valve thrombosis, which was found in 22 patients (39.3%), followed by degeneration in 15 (26.8%), endocarditis in 8 (14.3%), paravalvular leakage in 7 (12.5%), and simultaneous pannus and thrombus in 4 patients (7.1%).

The time interval between the first and second operations in this group was 8.12 ± 6.64 years ranging from 10 months to 24 years. Moreover, the time interval between the second and third operations in this group was equal to 9.00 ± 6.67 years and ranged from 3 to 20 years. Six patients needed a third surgery in this group where, finally, 4 patients underwent prosthetic valve implantation and 2 experienced biological valve implantations.

B-MVR Group
Eight patients were included in this group, containing 3 cases with B-MVR and 5 cases with M-MVR from their first surgeries. The mean age of the patients was 63.12 ± 14.78 years and the mortality rate was 25% (2 patients). The patients underwent isolated MVR surgery (n = 6), MVR accompanied by AVR (n = 1), and MVR with tricuspid valve replacement surgery (n = 1). Additionally, all the patients were on warfarin while no patient needed the third surgery after redo surgery with biologic valve implantation.

The valve stenosis was considered as the most common cause of the first surgery in this group, which was detected in 5 patients (62.5%). Similarly, valve insufficiency was observed in one patient (12.5%) and the mixed pathology of valve stenosis and insufficiency was found in 2 patients (25%). In addition, degenerative changes were the main

Table 4. Complications Associated With Redo Surgery in All Groups

Variables	M-MVR Group (n=57)	B-MVR Group (n=8)	Thrombectomy Group (n=6)
Unstable hemodynamic	9 (16%)	4 (50%)	2 (33.3%)
Inotrope administration	9 (group 16%)	4 (50%)	2 (33.3%)
Long time ventilation	1 (1.8%)	2 (25%)	0
Pulmonary edema	3 (5.4%)	0	1 (16.7%)
ARDS	5 (8.9%)	1 (12.5%)	1 (16.7%)
Renal failure	5 (8.9%)	1 (12.5%)	0
Post operation infection	1 (1.8%)	0	0
Need to pacemaker	1 (1.8%)	1 (12.5%)	0
Atrial fibrillation	8 (14.3%)	1 (12.5%)	0
Stroke	1 (1.8%)	0	0
Massive bleeding	3 (5.4%)	1 (12.5%)	1 (16.7%)
Function class after operation	NYHA FC I, 22 (39.2%)	0	1 (16.6%)
	NYHA FC II, 18 (32.1%)	3 (37.5%)	2 (33.3%)
Paravalvular leakage after surgery	Mild, 1 (1.8%)	0	0
	Moderate, 2 (3.5%)	0	1 (16.7%)
	Severe, 1 (1.8%)	0	0
MI	0	0	0
Pulmonary thromboembolism	0	0	0

Abbreviations: M-MVR, Mechanical mitral valve replacement; B-MVR, Biologic mitral valve replacement; ARDS, Acute respiratory distress syndrome; HF, Heart failure; NYHA FC, New York Heart Association function capacity; MI, Myocardial infarction.

Table 5. Mortality Rate in All Groups

Groups	Mortality				Total
	Yes		No		
	Female	Male	Female	Male	
M-MVR	4	3	32	18	57
B-MVR	1	1	3	3	8
Thrombectomy	0	1	4	1	6
Total	5	5	39	22	71

Abbreviations: M-MVR, Mechanical mitral valve replacement; B-MVR, Biologic mitral valve replacement.

cause of redo surgery in patients with biologic valves, which involved 3 patients (37.5%). The malfunction caused by thrombus was observed in 3 patients (37.5%) and endocarditis involved 2 patients in prosthetic valve (25%). The time interval between the first and second surgeries was 8.78 ± 5.95 years and ranged from 1 month up to 27 years.

Mechanical Valve Thrombectomy Group
This group included 6 patients who all had M-MVR from their first surgeries. The mean age was 61.16 ± 7.19 ranging from 50 to 70 years and all the patients of this group needed a third surgery, and finally, underwent MVR surgery. The valves, implanted during third surgery, encompassed M-MVR in 4 and B-MVR in 2 cases. The time interval between the first and second surgeries was 3.33 ± 1.75 years within the range of one month to 6 years. The time interval between the second and third surgeries was also 0.83 ± 0.67 years ranging from 1 month to 2 years. In general, patients needed third surgery in less than 2 years. The etiologic cause of the first surgery included valve stenosis (3 patients), valve insufficiency (1 patient), and the mixed pathology of valve stenosis and insufficiency (2 patients). The most prevalent cause of redo surgery was related to pannus ingrowth which was found in 5 patients and degenerative changes were detected in one patient. Eventually, all patients were on warfarin.

Discussion
The findings of this study showed that all patients who underwent surgical thrombectomy (100% of thrombectomy group), needed a third surgery with MVR within 2 years after the second surgery. However, the number of patients undergoing the third surgery, following redo MVR (both M-MVR and B-MVR) in the second surgery, was only 5 cases (7.8%) which was proportionally lower than the number of patients who underwent thrombectomy alone. This suggests that thrombectomy alone was not an appropriate procedure in the thrombotic malfunction of M-MVR, and MVR (including M-MVR and B-MVR) may yield better results. Despite the results of another research (1-4), the mortality rate was not significantly different between M-MVR, B-MVR, and thrombectomy groups but patients in B-MVR group had relatively higher but statistically insignificant mortality rate (25%) when compared to M-MVR (12.2%) and thrombectomy (16.6%) groups. This higher mortality in B-MVR group can be attributed to more hemodynamic instability or endocarditis in these patients. Like the other studies (1,9-11), there was no significant association between gender and mortality ($P = 0.059$). Gender was not significantly related to hemodynamic instability as well ($P = 0.41$).

This different result is probably related to our patient's lower ages. Likewise, age and gender were not the

predictors of mortality, which is in line with the findings of Fukunaga et al (1).

Based on the results, higher pump time and cross-clamp time were significantly associated with an increased mortality rate ($P = 0.014$ and $P = 0.026$, respectively). Given the significant associations of pump time and cross-clamp time with mortality, reducing the time of these measures may lead to a decline in mortality. Three out of 12 patients, who underwent the third surgery due to valve dysfunction, died, which had no significant relationship (Fisher exact test, $P = 0.52$) with the type of previous surgery (M-MVR or B-MVR) and therefore, it suggests that the type of valve has no significant impact on mortality.

Subtherapeutic average prothrombin time level was observed in all groups, which is probably the main cause of mechanical valve dysfunction. The results further revealed that the patient's age was not significantly associated with the other postoperative complications except for pacemaker implantations, indicating that patients' age was not a determinant factor in terms of the type of the second surgery procedure which was selected for these patients. One out of all the patients who underwent multiple valve replacement including AVR with MVR died (14.28%) and the third surgery was only conducted in one of these patients (14.28%). This was not significantly different from the patients undergoing only one valve replacement (Fisher exact test, $P = 0.69$).

A significant percentage of patients were women, which is related to a higher prevalence of valvular heart diseases, especially the rheumatic ones among women in this region (64.3%).

Further, the common causes of MVR dysfunction in the order of their prevalence were thrombus, valve degeneration, endocarditis, paravalvular leakage, and pannus.

Twelve patients underwent the third surgery with the highest rate among those who underwent thrombectomy while the lowest rate was found among those who received B-MVR in the second surgery.

The most common symptoms of patients with valve dysfunction were dyspnea, followed by syncope and angina to lesser extents. Furthermore, postoperative symptoms showed a significant improvement over the time before the surgery, suggesting the efficacy of surgeries on these patients. Moreover, degenerative changes were regarded as the major cause of biologic valve dysfunction in addition to thrombus and endocarditis as the other recognized causes. All these patients received mechanical valves following valve dysfunction and none of them needed a third surgery. On the other hand, those patients who underwent mechanical valve thrombectomy, finally, needed a third surgery with MVR, which represented that the mechanical valve thrombectomy surgery was insufficient in patients with valve dysfunction. The average time interval between the second and third surgeries in this group was 0.83 year, which indicates that this type of surgery had no necessary efficacy.

The comparison of different types of redo surgeries demonstrated that patients who received M-MVR had more hemorrhage than those who experienced biological valves or thrombectomy surgeries ($P = 0.007$). The need for long time ventilation was also higher in patients with biological valve implantation ($P = 0.022$), which may be related to their hemodynamic instability in the post-operation period.

Vohra et al showed that in-hospital mortality was 12% and was mainly due to cardiac causes, multi-organ dysfunction, stroke, and respiratory failure in Redo MVR. In-hospital mortality was related to preoperative LVEF ≤50% while age, gender, the indication of surgery, the type of the previous prosthesis, and concomitant procedures had no effect on in-hospital mortality. The overall survival was significantly lower in patients with preoperative LVEF ≤50%, concomitant AVR, and urgent surgery ($P = 0.001$). Based on the findings of the above-mentioned, early mortality was associated with older age, female gender, advanced NYHA class, low ejection fraction (<35%), LVEDD>50 mm, pulmonary edema, urgent surgery, concomitant valvular surgeries, and previous myocardial infarction (9).

Additionally, Jamieson et al highlighted several predictive factors such as age, concomitant coronary artery bypass graft, urgency status, NYHA class, and reoperation time. The overall mortality, as well as mortality for elective status and urgency/emergent status was 11.9%, 6%, and 17.8%, respectively. In general, redo MVR mortality rate may be low in elective status with low to medium NYHA function class. The routine evaluation of patients can lead to a lower risk of redo surgery as well (5). In a study by Jones et al (12) on 671 patients, primary redo-surgery mortality, the mortality of redo-surgery due to unsuccessful repair, in redo-surgery for prosthetic valve dysfunction or periprosthetic leakage, and in redo-surgery for endocarditis or valve thrombosis were 8.6%, 3%, 10.6%, and 29.4%, respectively. Concomitant coronary artery bypass graft was related to a mortality of 15.4% compared to when it was unnecessary (8.2%). Similarly, the mortality was 6.4%, 7.4%, 2.2%, 25.6%, and 9.1% for AVR, mitral valve, isolated valve repair, tricuspid valve replacement, and periprosthetic leakage repair, respectively. Among the 336 patients who required the replacement of the prosthetic valve, the mortality for redo-surgery in the prosthetic valve was 26% compared to 8.6% for tissue valve replacement ($P < 0005$). In addition, the mortality was higher for redo heart valve surgery when compared to primary valve surgery. The causes of mortality included heart failure (51.7%), hemorrhage (15.5%), endocarditis (10.3%), bronchopneumonia (6.9%), myocardial infarction (5.2%), multi-organ failure (3.5%), renal failure (3.5%), CVA (1.7%), and acute abdomen (7%).

Moreover, Akay et al evaluated the risk factors of in-

hospital mortality, short-term (5 years) and mid-term (10 years) survival rate in patients who underwent MVR. In-hospital mortality was 6.4%, 1-, 5-, and 10-year survival rates were 94% ± 2%, 89% ± 6%, and 81 ± 9%, respectively. Further, short-term survival risk factors encompassed NYHA function class (IV), lower left ventricular ejection fraction (EF<35%), increased left ventricle end-diastolic dimension (LVEDD)>50 mm, female gender, pulmonary edema, and urgent surgeries. Likewise, mid-term survival risk factors included NYHA function class (IV), low LVEF, increased LVEDD, and left atrial diameter more than 60 mm. Finally, short- and mid-term mortality decreased in redo M-MVR (13).

Conclusions
In general, mortality rate failed to significantly vary between the patients undergoing thrombectomy or redo MVR in patients with a history of M-MVR and malfunction, but third surgery was often needed after thrombectomy. It seems that redo MVR (M-MVR or B-MVR) yields better results in the case of prosthetic valve malfunction as compared to thrombectomy. Eventually, reducing the pump time and cross-clamp time may have an important role in decreasing mortality and adverse events.

Limitations
The major limitation of this research was the small number of patients; therefore, the confirmation of the results requires further research with a larger population. Moreover, given the retrograde nature of this study, some of the variables were not fully recorded in patients' files and were thus eliminated from analyses. Accordingly, prospective studies may resolve these issues.

Conflict of Interests
The authors declare that there is no conflict of interests.

Ethical Issues
This study was approved by the Ethics Committee of Tabriz University of Medical Sciences (IR.TBZMED. REC. 1394.397).

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