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# A Prospective Randomized Case-Control Study to Evaluate Mini Right Thoracotomy versus Conventional Sternotomy for Mitral Valve Repair in Rheumatic Heart Disease

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## Abstract

Purpose: Right mini thoracotomy has been evaluated in many studies for mitral valve repair mainly in degenerative valvular disease but not in rheumatic heart disease. Mitral valve repair is more challenging in rheumatic etiology due to complexity of lesions. This prospective randomized case control study was designed to evaluate repair through mini right thoracotomy and to compare the clinical and echocardiographic outcomes with sternotomy in rheumatic patients. Methods: 25 patients of rheumatic heart disease underwent mitral valve repair through mini right thoracotomy (group I). Various clinical and functional parameters were compared with 25 patients of mitral valve repair through sternotomy (group II). On follow up the results were compared in both groups for clinical and echocardiographic parameters. Results: The various pre-operative demographic parameters were comparable in two groups. Equal rate of mitral valve repair (group I-21/25, 84% and group II-21/25, 84%) was achieved in both groups. The various intra-operative and post-operative clinical parameters were better in group I .There were equivalent functional and valve related outcomes in both groups in term of NYHA class (1.28 ± 0.613 vs 1.08 ± 0.276, P = 0.144), post-operative mitral valve area (2.43 ± 0.891 vs 2.82 ± 0.662, P = 0.090), incidence of more than mild mitral regurgitation (0) and mean pressure gradient across mitral valve (4.98 ± 3.33 vs 4.23 ± 1.5, P = 0.309). Conclusion: Mitral valve repair through mini right thoracotomy approach in rheumatic etiology is feasible and safe with equivalent rate of successful repair as compared to median sternotomy. It is associated with lesser morbidity, cosmetic advantage and lesser resource utilization.

**Keywords**

Rheumatic Heart Disease, Mitral Valve Repair, Minimally Invasive Mitral Valve Repair, Right Anterolateral Thoracotomy

## 1. Introduction

There are various approaches and techniques for minimally invasive cardiac operations depending on the type of surgery, availability of equipments and technical expertise of the team. Minimally invasive mitral valve surgery can be performed either by direct vision approach or endoscopic and robotic technique [1].

There is ample literature on the safety, feasibility, better cosmetic and equivalent surgical outcome of minimally invasive mitral valve repair over conventional mitral valve repair mainly in degenerative mitral valve disease [2] [3] [4]. Mitral valve repair is challenging one in rheumatic heart disease due to complexity of lesions. The literature is sparse on the use of minimally invasive approach for mitral valve repair in rheumatic heart disease. This randomized prospective case-control study was designed to evaluate the feasibility, safety and rate of mitral valve repair through limited right anterolateral thoracotomy approach and to compare the various perioperative outcome with conventional mid sternotomy approach in the rheumatic heart disease patients.

## 2. Methods

Fifty consecutive patients with rheumatic mitral valve disease were selected by prospective simple randomization over a period of 1.5 years to undergo either minimally invasive mitral valve repair (MIMVR group 1, n = 25) or conventional mitral valve repair through median sternotomy (STMVR group II, n = 25). The procedure was performed through limited right anterolateral thoracotomy with peripheral femoral arterial cannulation in group I. The patients in group II were operated through median sternotomy and central cannulation for CPB. The exclusion criteria for the study were: 1) previous cardiac surgery, 2) significant coronary artery disease, 3) associated aortic valve disease needing intervention and calcified ascending aorta, 4) external iliac or femoral artery stenosis. This study was approved by ethics committee of our institute and prior written informed consent was taken from the patients. The study was completed after 1.5 year as this was a thesis project and time limited. The patients were followed up for clinical and echocardiographic parameters.

## 3. Surgical Techniques

The general anesthesia was provided according to the standard protocol by endotracheal intubation with both lung ventilations. Trans-esophageal echocardiography

(TEE) was done in both groups to assess mitral valve morphology and adequacy of repair. In the group 1 (MIMVR) patients were positioned supine with 30 degree elevation of right shoulder using a sand bag and right arm was slightly deviated from body. A 5 - 6 cm skin incision was given in right sub mammary crease and right thoracic cavity was entered through 4$^{th}$ intercostal space (**Figure 1(A)**). The pericardium was opened about 2 cm anterior to right phrenic nerve. Pericardial stay sutures were taken and right lung was retracted with a wet sponge under stay sutures. Normothermic cardiopulmonary bypass (CPB) was established with peripheral common femoral arterial cannulation by open Seldinger's technique (Fem flex II ™ Femoral arterial cannula, Edward life sciences, Irvine USA) (**Figure 1(B)**) and superior vena cava (SVC), inferior vena cava (IVC) cannulation with metal tip right angled cannulas (Medtronic DLP, Minneapolis, MN, USA) (**Figure 1(C)**). Aortic cross clamp was applied directly through thoracotomy

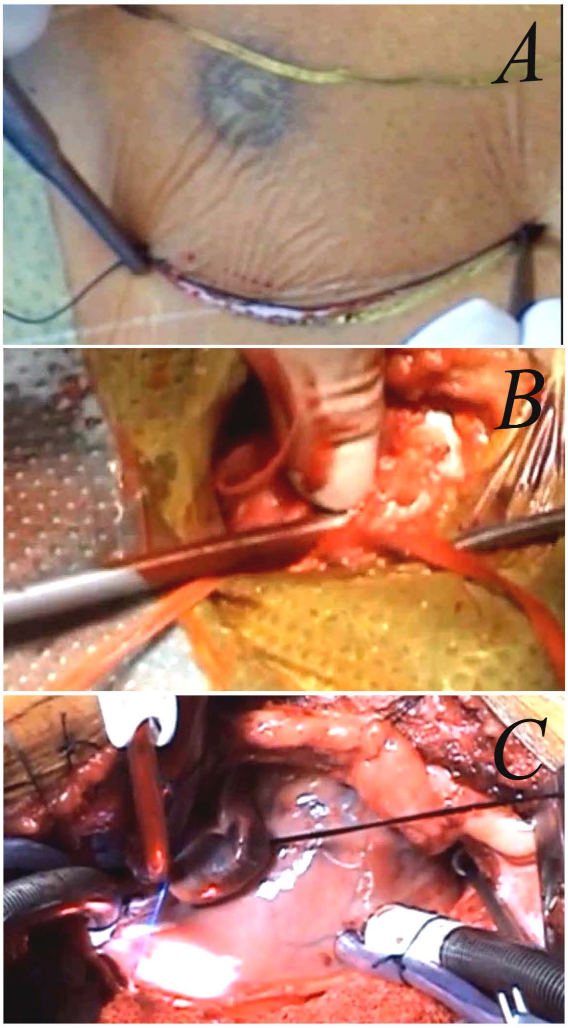


**Figure 1.** (A) Skin incision in sub-mammary crease. (B) Common femoral artery cannulation by open Seldinger's Technique. (C) Venous cannulation and cardioplegia needle insertion through thoracotomy incision.

incision with long curved clamp (KLS Martin De Bakey-24-418-28-07, Germany). Myocardial protection was achieved by antegrade hyperkalemic cold blood cardioplegia solution through aortic root every 20 minutes (Figure 1(C)). The left atrium was opened by developing Sondergaard's plane near the interatrial groove. Mitral valve was analyzed and suitability of repair was determined by degree of leaflets rigidity and subvalvular fusion (the criteria recommended by A Carpentier) [5]. Mitral valve repair was done by various repair techniques and ring annuloplasty. The steps of operative procedure are depicted in (Figures 2(A)-(F)). Left atrial appendage (LAA) was closed through

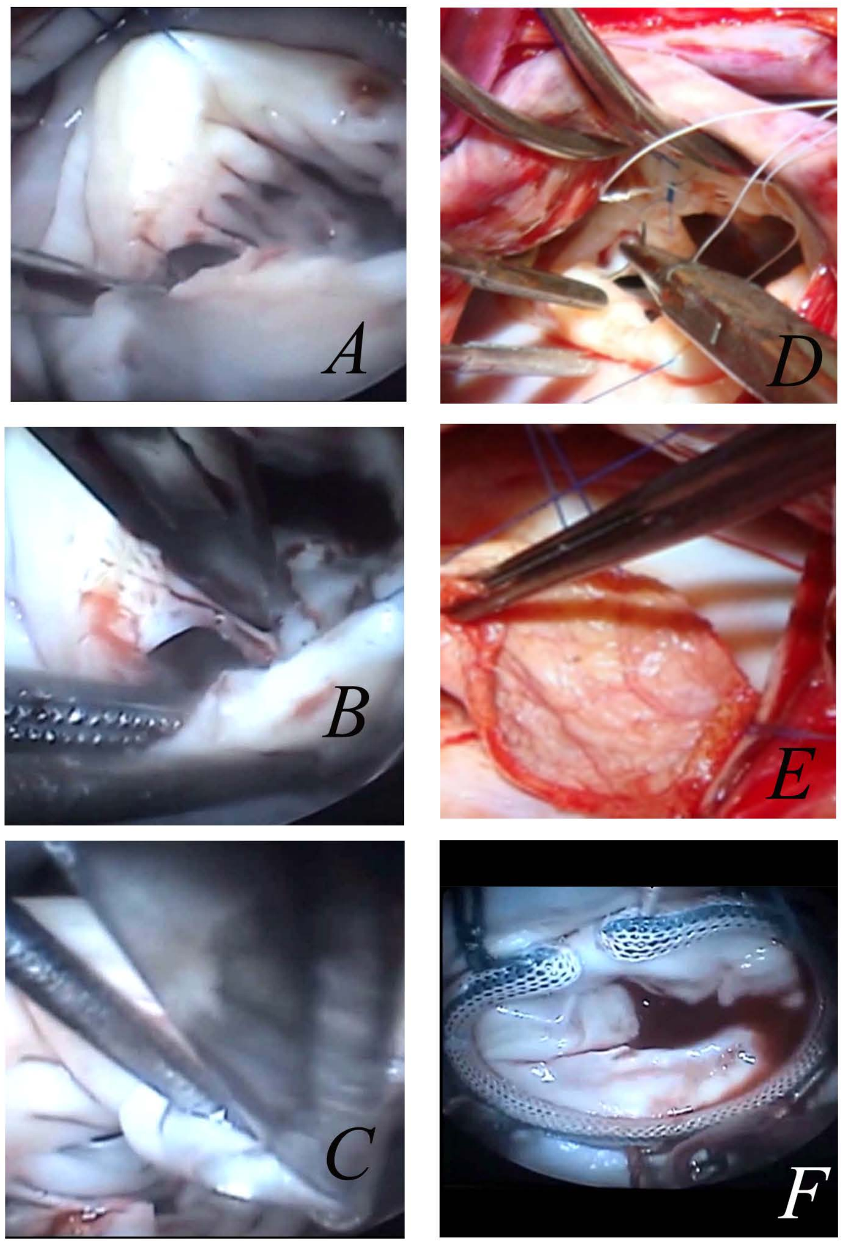


Figure 2. Different technique of mitral valve repair. (A) Commisurotomy, (B) papillotomy, (C) cutting of secondary level chordate, (D) artificial chordae implantation, (E) augmentation of posterior mitral leaflet with pericardial patch, (F) ring annuloplasty.

left atrium (LA) in two layers with 5 - 0 prolene. Left atriotomy was closed with 4 - 0 polypropylene suture. Right atriotomy was done where tricuspid valve repair was indicated. Cryocoxmaze III was done in patients having atrial fibrillation (AF). Pacing wire was fixed before removing cross clamp on still heart. Deairing and weaning off from CPB was done in standard fashion.

For the group II, a median sternotomy was done. CPB was established by aorto-bicaval cannulation after systemic heparinization. The other operative steps were same as in group 1. Left atrial appendage was closed through LA or externally in two layers with 5 - 0 prolene. The clinical and echocardiographic assessment was done on follow-up.

The results were analyzed as mean ± standard deviation. The continuous variables were compared using student's t-test. The categorical variables were reported as percentage and compared using chi square test. For all statistical analysis a p value of 0.05 or less was considered significant.

## 4. Results

The demographics and pre-operative clinical characteristics are comparable. All the patients were having rheumatic valvular heart disease (**Table 1**).

Equal rate of mitral valve repair was achieved in both groups. The incidence of mitral valve replacement was 16% in both groups. All the replacement was done when repair was not possible due to advanced disease and non favourable morphology of mitral valve except in 1 patient of test group. This was an obese female patient with BMI of 29. In this patient exposure was very difficult and incision was extended. Due to poor exposure mitral valve replacement was done in this patient. There was conversion to sternotomy in one patient due to severe pleural adhesions. Overall use of blood product was lesser in test group.

**Table 1.** Demographics and pre-operative clinical characteristics in group I and group II.

| Variable | MIMVR (Group I) | STMVR (Group II) | P-value |
|---|---|---|---|
| AGE (years) | 28.72 ± 11.07 | 31.12 ± 11.68 | 0.460 |
| Gender (male: female) | 6:19 | 7:18 | NS |
| Body Mass Index (Kg/$m^{2)}$ | 18.47 ± 3.00 | 18.34 ± 2.98 | 0.87. |
| New York Heart Association Class | 3.04 ± 0.61 | 3.12 ± 0.60 | 0.889 |
| Mitral Stenosis | 10 (40 %) | 7 (28%) | 0.370 |
| Mitral Insufficiency | 7 (28%) | 10 (40%) | 0.370 |
| Mixed Lesion | 8 (32%) | 8 (32%) | - |
| Pulmonary Artery Pressure (mm of Hg) | 55.76 ± 14.81 | 65.32 ± 20.07 | 0.061 |
| Left Ventricular Ejection Fraction (%) | 57.24 ± 5.35 | 56.32 ± 3.90 | 0.491 |
| Left Atrial size (mm) | 54.20 ± 15.12 | 55.84 ± 13.30 | 0.407 |
| Atrial Fibrillation | 10 (40%) | 9 (36%) | 0.770 |
| Tricuspid Regurgitation | 7 (28%) | 8 (32%) | 0.757 |

Left atrial appendage closure was done in all patients in both groups. In thoracotomy group it can be done only through left atrium. But in sternotomy group, it can be done both through left atrium and externally (Table 2).

All the techniques of mitral valve repair can be used easily through minimally invasive approach. The annular sutures were taken initially. It helped in better exposure of mitral valve. In few patients, we faced difficulty in taking annular sutures at anterior mitral annulus and cutting of 2˚ chordee at AML. These sutures were taken with long needle holder (Table 3).

**Table 2.** Intraoperative variables.

| Variable | MIMVR (N 25) | STMVR (N 25) | P value |
|---|---|---|---|
| Mitral valve repair | 21 (84%) | 21 (84%) | 1 |
| Mitral valve replacement | 4 (16%) | 4 (16%) | 1 |
| Tricuspid Valve Repair | 7 (28%) | 8 (32%) | 0.757 |
| Atrial Fibrillation Surgery | 10 | 9 | 0.770 |
| Left atrial appendage closure | 25 | 25 | - |
| Aortic cross clamp time (Minute) | 154.92 ± 45.53 | 158.48 ± 74.56 | 0.839 |
| Cardio pulmonary bypass time (Minute) | 171.48 ± 47.19 | 184.08 ± 83.83 | 0.516 |
| Packed cell (PCV) | 3.64 ± 1.11 | 4.48 ± 1.44 | 0.026 |
| Fresh frozen plasma (FFP) | 2.52 ± 0.871 | 3.68 ± 1.54 | 0.002 |
| Plateler rich plasma (PRP) | 2.04 ± 1.36 | 3.20 ± 2.04 | 0.022 |
| Conversion to sternotomy | 1 | - | - |

**Table 3.** Techniques used in mitral valve repair.

| Variable | MIMVR (N-21) | | STMVR (N-21) | | P value |
|---|---|---|---|---|---|
| Commisurotomy | 19 | (90.47%) | 14 | (66.66%) | 0.06 |
| Papillotomy | 14 | (66.66%) | 10 | (47.61%) | 0.212 |
| Fenestration of Chordae | 14 | (66.66%) | 10 | (47.61%) | 0.212 |
| Secondary Chordae Cutting | 19 | (90.47%) | 19 | (90.47%) | 1 |
| Chordal Transfer | 2 | (9.52%) | 3 | (14.28%) | 0.633. |
| Chordal Transposition | 2 | (9.52%) | 3 | (14.28%) | 0.633 |
| Neo Chordae implantation | 5 | (23.80%) | 6 | (28.57%) | 0.725 |
| Cusp Thinning/Peeling | 4 | (19.04%) | 7 | (33.33%) | 0.292. |
| Cleft Closure | 6 | (28.57%) | 4 | 19.04 | 0.468 |
| Leaflet Augmentation | 4 | (19.04%) | 5 | 23.80 | 0.706 |
| Magic Stich Commissural Closure | 4 | (19.04%) | 6 | 28.57 | 0.725 |

The details of type and size of annuloplasty ring used in mitral valve repair are described in Table 4. All type of rings can be implanted through minimally invasive approach.

The AF ablation surgery was done in both groups. In MIMVR group Cut and sew cox Maze III was not possible due to limited access. In Biatrial cryocoxmaze III the Left atrial lesions were developed for 2 minutes and right atrial lesions were developed for 1 minute. All lesions were created by applying the Cryo Maze Probe (ATS Medical) for 2 minutes directly to myocardial tissue with temperatures reaching −140˚C to −160˚C (Table 5).

The mean duration of ventilator support chest tube removal, ICU stay, hospital stay and volume of chest tube drainage was significantly less in test group. This resulted in lesser hospital resource utilization due to lesser ICU stay and early hospital discharge (Table 6).

**Table 4.** Prosthetic annuloplasty rings/bands implanted in mitral valve repair.

| Prosthetic Annuloplasty Rings/Bands Implanted (Size no.) | MIMVR (N-21) | STMVR (N-21) |
|---|---|---|
| Carpentier Edward classic Rigid Annuloplasty ring (Edward Life Sciences Irvine USA) | | |
| #26 | 1 | 0 |
| #28 | 11 | 4 |
| #30 | 1 | 4 |
| #32 | 0 | 4 |
| PROFILE 3D Rigid Annuloplasty Ring (Medtronic, Minneapolis, MN USA) | | |
| #28 | 1 | 1 |
| #30 | 4 | 2 |
| #32 | 1 | 2 |
| Saddle Ring St Jude #28 (St. Paul, Minnesota, USA) | 1 | 1 |
| Coosgrove-Edward Flexible Band #26 (Edward Life Sciences Irvine USA) | 1 | 3 |

**Table 5.** The details of atrial fibrillation ablation surgery.

| AF Surgery | MIMVR (N-10) | STMVR (N-9) | P value |
|---|---|---|---|
| Biatrial Cryocoxmaze III | 10(40%) | 4 (16%) | 0.058 |
| Cut and Sew Cox Maze III | 0 | 5 (20%) | 0.018 |

**Table 6.** Post-operative outcome.

| Variable | MIMVR (N-25) | STMVR (N 25) | P value |
|---|---|---|---|
| Ventilatory Support (Hrs) | 10.42 ± 4.74 | 18.92 ± 14.25 | 0.006 |
| Chest Tube Drainage (ml) | 371.20 ± 191.18 | 554.80 ± 205.59 | 0.002 |
| Chest Tube Removal (Hrs) | 54.84 ± 17.61 | 75.68 ± 30.04 | 0.004 |
| Intensive Care Unit Stay (Hrs) | 67.84 ± 28.33 | 115.76 ± 84.42 | 0.010 |
| Hospital Stay (Days) | 6.64 ± 2.09 | 9.12 ± 4.54 | 0.016 |

The overall incidence of various post-operative complications was lesser in MIMVR group. The mean no. of blood product use within 30 days was significantly less in MIMVR group. The dissatisfaction of patients with scar was significantly higher in STMVR group due to large externally visible scar than in MIMVR group (Figure 3(A)).

The mean length of scar was significantly less in MIMVR group. The small scar remains hidden under clothes and breast tissue (Figure 3(B), Figure 3(C) and Table 7).

Table 8 describes the clinical and echocardiographic outcome at follow-up. There are

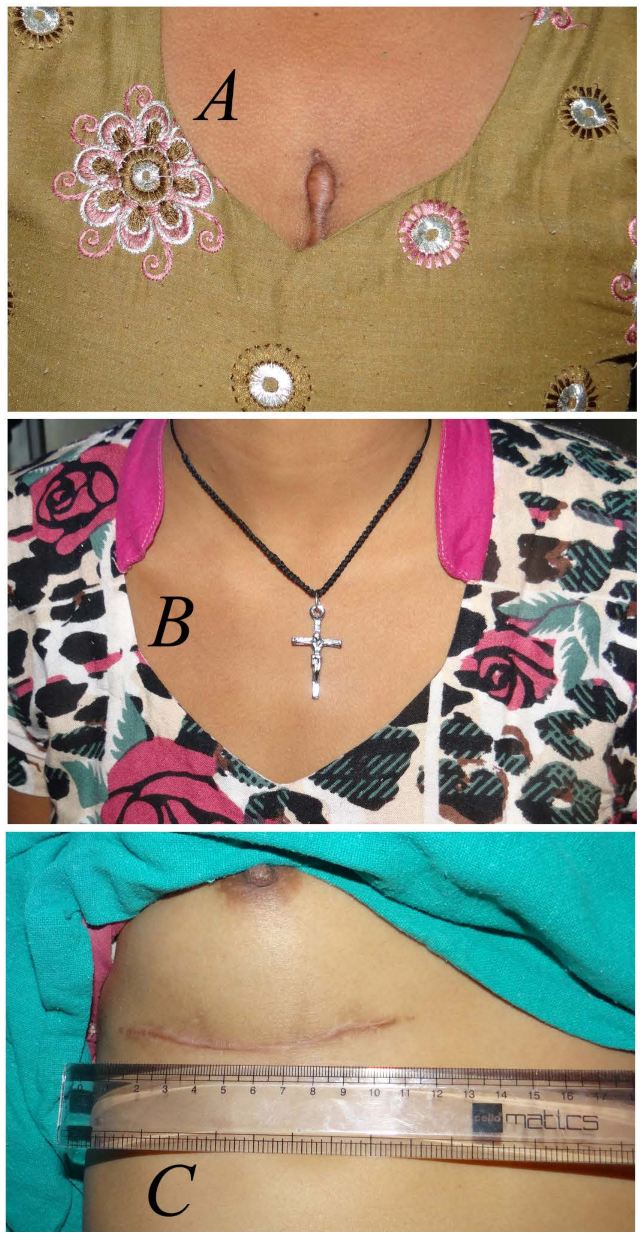


**Figure 3.** (A) Externally visible scar in sternotomy incision (cosmetic disadvantage). (B) Scar mark hidden under clothes in right mini thoracotomy incision. (C) Scar mark hidden under breast tissue (cosmetic advantage).

**Table 7.** The details of various post-operative complications.

| Variable | MIMVR (N-25) | STMVR (N 25) | P value |
|---|---|---|---|
| DEATH | 0 (0%) | 0 (0%) | - |
| Respiratory Complication. | 1 (4%) | 2 (8%) | 0.356 |
| Stroke | 0 (0%) | 1 (4%) | 0.312 |
| Myocardial Infarction | 0 (0%) | 0 (0%) | - |
| Bleeding. | 0 (0%) | 4 (16%) | 0.03 |
| Re-Exploration for Bleeding | 0 (0%) | 2 (8%) | 0.03 |
| Arrythmia | 1 (4%) | 3 (12%) | 0.297 |
| Renal Failure. | 0 (0%) | 0 (0%) | - |
| Gastrointestinal Events | 0 (0%) | 2 (8%) | 0.148 |
| Pericardial Effusion | 0 (0%) | 4 (16%) | 0.037 |
| Post-Pericardiotomy Syndrome | 0 (0%) | 4 (16%) | 0.037 |
| Aortic Dissection/Injury | 0 (0%) | 0 (0%) | - |
| Phrenic Nerve Palsy | 0 (0%) | 0 (0%) | - |
| 30 Days Readmission | 1 (4%) | 6 (16%) | 0.04 |
| Repeat Procedure | 0 (8%) | 4 (16%) | 0.037 |
| Repeat Blood in 30 daYs | | | |
| PCV | 0.52 ± 0.714 | 1.32 ± 1.31 | 0.010 |
| FFP | 0.36 ± 0.63 | 1.52 ± 1.68 | 0.002 |
| PRP | 0 | 1.36 ± 1.91 | (<0.001) |
| Superficial Wound Infection | 1 (4%) | 6 (24%) | 0.041 |
| Groin Wound Infection | 2 (8%) | 0 (0%) | 0.148 |
| Scar Length(cm) | 9.32 ± 1.97 | 17.64 ± 1.75 | (<0.05) |
| Hypertrophic Scar | 2 (4%) | 8 (32%) | 0.033 |
| Keloid | 0 (0%) | 2 (8%) | 0.148 |
| Scar Dissatisfaction | 1 (4%) | 10 (40%) | 0.002 |

**Table 8.** The clinical and echocardiographic outcomes at follow-up.

| Variable | MIMVR (N-25) | STMVR (N 25) | P value |
|---|---|---|---|
| NYHA Class | 1.28 ± 0.613 | 1.08 ± 0.276 | 0.144 |
| Mitral Valve Area ($cm^2$) | 2.43 ± 0.891 | 2.82 ± 0.662 | 0.090 |
| MILD Mitral Regurgitation | 4 (16%) | 3 (12%) | 0.683 |
| >MILD Mitral Regurgitation | 0 | 0 | - |
| Mean Pressure Gradient across Mitral Valve (mm of Hg) | 4.98 ± 3.33 | 4.23 ± 1.5 | 0.309 |
| Infective Endocarditis | 0 | 0 | - |
| Follow up (months) | 13.60 ± 5.42 | 12.12 ± 6.67 | 0.394 |

equivalent and good operative and functional outcome in term of NYHA class (1.28 ± 0.613 vs 1.08 ± 0.276), post-operative mitral valve area (2.43 ± 0.891 vs 2.82 ± 0.662), incidence of more than mild MR (0) and mean pressure gradient across mitral valve (4.98 ± 3.33 vs 4.23 ± 1.5) in two group .There was no incidence of infective endocarditis in both groups (Table 8).

## 5. Discussion

The objective of minimally invasive mitral valve surgery (MIMVS) is to provide a safe and effective approach for mitral valve surgery with benefits provided by minimally invasive approach. Surgical approach vary from centre to centre, depends on availability of resources and technical expertise of the surgical team.

We did MIMVR through direct vision mini right thoracotomy with peripheral femoral arterial cannulation in rheumatic patients. There is a potential concern about retrograde femoral/aortic dissection and acute limb ischaemia with peripheral arterial cannulation but its incidence is very low [6]. It did not occur in anyone of our patients. Femoral artery was closed at the site of cannulation by tying the purse string suture. There was no incidence of patch repair in our patients as described by other studies [7]. Direct SVC, IVC cannulation can be easily done which eliminates the risk of late venous thrombosis, thromboembolism and thrombophlebitis. Cardioplegia needle and aortic cross clamp can be easily placed through the thoracotomy with the aid of traction suture taken on aorta. TEE helps in effective deairing of heart and assessment of mitral valve repair postoperatively [8].

The base line demographic parameter and preoperative patient characteristic in the two groups were comparable (**Table 1**). Successful Mitral valve repair was possible in 84% of patients in each group. The various techniques of mitral valve repair were used in both groups with ease and accuracy. Annuloplasty ring of different sizes and character were used depending upon the disease and patient characteristics in both the groups. Various studies reported more than 90% rate of mitral valve repair by minimally invasive approach in degenerative mitral valve disease [2] [9] [10]. Our rate is slightly less but it is in rheumatic etiology. More over it is equal in both groups which show that it does not depend on approach but on etiology of disease. The post operative NYHA functional class and various surgical outcomes like mitral valve area, pressure gradient across mitral valve and incidence of residual mild MR was not statistically different in two groups. There was not more than mild MR in both groups (**Table 8**). These outcomes shows that equivalent and high rate of mitral valve repair can be achieved in rheumatic heart disease patients through minimally invasive approach. All the techniques of mitral valve repair can be used successfully and all kind of prosthesis can be inserted. Many studies had shown the good results of mitral valve repair through mini right thoracotomy approach in degenerative disease [3] [9] [10].

Concomitant tricuspid valve surgery, internal closure of left atrial appendage and AF ablation surgery (cryocoxmaze III) can be done through minimally invasive approach. Pfannmuller *et al.* also reported the feasibility of tricuspid valve repair through MICS approach [11]. Saint *et al.* and wolf et.al reported surgical ablation of AF by MICS approach [12] [13]. The adequate exposure for these procedures was achieved. In MIMVR group all the patients were free from AF at 1 year. Cut and sew coxmaze III procedure seemed impossible hence was not done in mini right thoracotomy group. It was done in five patients of mid sternotomy group. Left atrial appendage closure (LAA) is preferred in patients of mitral valve repair to avoid the risk of thromboembolism [14]. In mini right thoracotomy approach it can be achieved by internal closure of LAA through left atrium. In mid sternotomy group it can be done both ways internally or externally.

In our study the mean aortic cross clamp time and CPB time was lesser in test group than control group. This is in contrast to other studies where this is opposite [6] [15] [16] [17]. This may be due to the reason that number of concomitant procedure were higher in control group and in five patients cut and sew coxmaze III procedure was done leading to higher cross clamp and total bypass time.

As with other studies the mean unit of blood products used, post operative ventilatory need, chest tube drainage, total ICU and hospital stay was significantly less in MIMVR group [7] [15] [16] [17].

The rate of bleeding and re-exploration for bleeding were higher in STMVR group. Majority of patients who had bleeding complications (4) and reexploration (2/4) were, who had cut and sew coxmaze III procedure. There was stroke in one patient of control group and it was the patient in whom surgical cut and sew maze was done. Other studied also reported higher bleeding complications in sternotomy group [10] [15] [16] [17]. But in our study these complication in control group seems to be procedure related (Cut and Sew coxmaze III) and not approach related (**Table 7**).

There was no incidence of aortic dissection/injury and phrenic nerve palsy (**Table 7**). This is in contrast to metaanalysis by Cheng *et al.* [17]. This difference may be due to small no. of patients in this study.

Post pericardiotomy syndrome, 30-days readmission rate, rate of repeat procedure, were higher in STMVR group. In two patients surgical drainage of pericardial fluid was needed. The rate of 30-days blood product usage was significantly higher in STMVR group (**Table 7**). There are many studies and metaanalysis which have clearly shown the higher incidence of these complications in sternotomy patient [6] [7] [17].

There was no difference in mortality, myocardial infarction rate, arrthymias, renal failure, gastro-intestinal events and rate of phrenic nerve palsy between MIMVR and STMVR group. These events are variably reported by many studies [16] [18].

Overall wound related complications, hypertrophic scar and keloid formation was higher in STMVR group. MIMVS provided a clear cosmetic advantage to patients as externally visible scar was not present. A small submammary scar remains hidden under clothes and breast (**Figure 3(b)** and **Figure 3(c)**). They were more comfortable in their daily routine and professional life. They can comfortably attend cultural events and other functions. Ganie *et al.* also proved the less scar visibility and better cosmesis with limited thoracotomy approach [19]. The mean length of incision was significantly less in MIMVR group (9.32 ± 1.97 cm vs 17.64 ± 1.75 cm). In a meta analysis Cheng *et al.* reported mean incision length of 6.5 ± 1.3 cm in MIMVS group [17]. In most of these studies videoscopic assistance was taken with peripheral arterial and venous cannulation. Operations in our study were done under direct vision. Ganie *et al.* also reported mean incision length of 14.8 ± 2.3 cm [19]. Filky *et al.* reported incision length between 12 - 15 cm in their study [20]. The incision length can be reduced with the use of videoscopic and robotic assistance. But endoscopic and robotic techniques are very costly, require a significant learning curve, special instrument and resource utilization and still are not widely used. Surgery under direct vision can be done with routine instruments. Although length of incision is important but for cosmetic advantage location of incision also plays a role.

## 6. Conclusion

Mitral valve repair through mini right thoracotomy approach in rheumatic etiology is feasible and safe with equivalent and high rate of successful repair as compared to median sternotomy patients. Right mini thoracotomy approach is associated with lesser morbidity and lesser resource utilization in comparison to conventional sternotomy. Concomitant tricuspid valve repair and cryocoxmaze III procedure is possible through mini right thoracotomy. There are better cosmetic results with right mini thoracotomy in comparison to conventional sternotomy.

## Limitations

1) The number of patients in each group were small as the number of valve suitable for repair are very less due to complexity of lesions in rheumatic etiology and time limitation of this study.

2) There was initial learning curve with MIMVR.

3) MIMVR was done with use of routine instruments.

4) The cut and sew maze procedure were done in sternotomy group which may have overall impact on higher morbidity and complications in sternotomy group.

**Disclosure:** All authors declare that there is no conflict of interest in this article. The authors declare that the patient has given approval and consent to the publication of this article.

**Ethical Approval**: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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