Comparative study of outcomes of different approaches in redo mitral valve surgery

Mohaned M.M. Radwan, Mohamed I. Sewielam, Hisham A.F. Shawky

Department of Cardiothoracic Surgery, Faculty of Medicine, Cairo University, Cairo, Egypt

Correspondence to Mohaned M.M. Radwan, MD, Department of Cardiothoracic Surgery, Faculty of Medicine, Cairo University, Cairo, Egypt. Tel: 01279255833;
e-mail: mohanedradwan@gmail.com

Received: 7 November 2023
Revised: 12 November 2023
Accepted: 27 November 2023
Published: 31 January 2024

The Egyptian Journal of Surgery 2024, 43:280–289

Background
Redo mitral valve replacement surgery is a challenging procedure as the access of the mitral valve mandates good exposure yet mitral visualization may not be sufficient as previous cardiac operations may complicate mitral valve exposure, as adhesions and loss of mobility in the surrounding tissues may be present. In such cases, the conventional left atrial incision may not offer satisfactory visualization in the surgical site of the valve. Therefore, several alternative approaches have been proposed, such as superior trans-septal approach, for satisfactory visualization of the mitral valve intra-operatively.
Patients and methods
Between January 2017 and November 2021, 100 patients were enrolled and with 50 patients randomly assigned in each group. Group one on patients undergoing redo surgery via a superior trans-septal approach and group two undergoing redo surgery via left atrial approach.
Results
Transeptal approach provides same results like left atrial approach in redo mitral valve surgery.
Conclusion
We conclude that the transseptal approach when compared to left atrial in redo patients provides comparable results in the intraoperative as well as postoperative outcomes

Keywords:
cardiac surgery, left atrial, mitral valve, redo surgery, transseptal

Egyptian J Surgery 43:280–289

1110-1121

Background

Many patients with mitral valve diseases need surgical procedures for the replacement of their mitral valve, the exposure of the mitral valve is done by either a superior trans-septal approach which involves opening the right atrium then the atrial septum and extending the incision into the left atrial dome or a left atrial approach involving opening the left atrium directly visualizing the mitral valve [1]. There is a great deal of controversy over the outcomes of the trans-septal (TS) and left atrial (LA) approaches to the mitral valve [1].

Redo mitral valve replacement surgery is a challenging procedure as the access of the mitral valve mandates good exposure yet mitral visualization may not be sufficient as previous cardiac operations may complicate mitral valve exposure, as adhesions and loss of mobility in the surrounding tissues may be present. In such cases, the conventional left atrial incision may not offer satisfactory visualization in the surgical site of the valve. Therefore, several alternative approaches have been proposed for satisfactory visualization of the mitral valve intra-operatively [2].

Patients and Methods

This study was a Prospective Cohort Study. 100 patients were enrolled in this study with 50 patients randomly assigned in each group. Group one on patients undergoing redo mitral valve surgery via a superior trans-septal approach and group two undergoing redo mitral valve surgery via left atrial approach. This research was performed at the Department of General Surgery, Cairo University Hospitals. Ethical Committee approval and written, informed consent were obtained from all participants.

Inclusion criteria

(1) Patients with history of previous cardiac surgery

Exclusion criteria

(1) Patients with Low EF (<30%),
(2) Patients with tricuspid valve disease

(3) Uncontrolled diabetes
(4) Uncontrolled hypertension
(5) Bleeding disorder
(6) Obese patients (BMI >30)

Patients for this study were selected from those admitted to the cardiothoracic surgery department in Cairo University hospital scheduled for redo mitral valve surgery.

They were divided randomly into two groups, 50 patients in each. Group one is the superior trans-septal group and group two was the left atrial group.

Recording of age, sex, cross-clamp time, ischemia time, pre- and postoperative electrocardiographic (ECG) findings, CPB time,. The amount of bleeding, length of hospital and intensive care unit (ICU) stay, postoperative ECHO and postoperative complications including pacemaker implantation, bleeding and arrhythmias were be recorded.

The surgical techniques and approaches to the mitral valve were assigned randomly to each group.

Details of procedures

Preoperative prophylactic broad spectrum antibiotics were administered to the patients 30 minutes before induction of anaesthsisa

Skin sterilization is done using betadine 10% and sterile drapes are used for preoperative preparation.

In cases where distal cannulation for CPB was planned ahead, preparation of femoral cannulation site was carried out simultaneously at the same time as opening the sternum were another surgeon would expose the femoral vessels and place purse string sutures in both the femoral artery and vein using 5/0 or 4/0 prolene suture. The cannulation technique that was used by our team is the seldinger gradual technique where introduction of dilators of increasing size was done until the cannulae were possible to introduce in both vessels. The position of both cannulae was checked using TEE.

Access for both groups was via an open median sternotomy, the sternum was divided using rotating semicircular sternal saw for the anterior tablet of the sternum and the main body of the sternum. In most cases however division of the posterior sternal tablet was done using a heavy scissors after clearing as much adhesions as possible from the upper and lower ends of the sternum. At the point of division of the posterior sternal tablet the anterior chest wall was retracted by application of 2 to the periosteum of sternum and pulling upward.

The adhesions lying posterior to the sternum were then very carefully divided as this stage is considered to be the most dangerous during reopening of cardiac surgery patients, first because the adhesions are very dense behind the sternum and second because there adhesions may contain and obscure important vital structures such as the aorta, innominate vein or previous grafts that were done in the first cardiac surgery, dissection was done using both sharp and blunt methods until a space enough to apply sternal retractor was developed and the sternal retractor was applied and very slowly opened.

The right side of the pericardium is suspended high on to the sternum and allow the left sided pericardium to fall deep into the left chest.

Dissecting out pericardial adhesions around SVC and inferior vena cava (IVC) to aid with exposure of the mitral valve, to enable placement of tape snares around both vessels for complete (bicaval) CPB and make retraction of the left atrium upwards easier.

Total cardiopulmonary bypass through aortic and bicaval venous cannulation is instituted.

Antegrade cardioplegia was instituted using either cold crystalloid cardioplegic solution or HTK solution for maximal cardiac protection when the procedure was anticipated to be of long time.

Intrapericardial caval attachments are dissected around 3 cm to avoid injury to azygos or hepatic veins.After cardioplegic arrest caval snares are tightened up.

Group 1 via a superior transeptal atrial approach

In this technique exposure was obtained by extending the septal incision across the RA and the dome of the LA thus making a rather large incision allowing excellent exposure of the mitral valve. We were aware of the SA nodal artery and its anatomical variations to avoid injury.

The SVC cannula was placed lateral to the right atrial appendage or in the SVC directly. A longitudinal (vertical) right atriotomy was done anterior to the sulcus terminalis. The incision was cephalad around the superior base of the atrial appendage, or sometimes directly through the appendage, to reach the atrial septum. We kept the incision 1 to 2 cm from the

right ventricle to allow safe closure and to avoid the sino-atrial node. The septum was incised vertically through the fossa ovalis, directly under and parallel to the right atriotomy, extended superiorly to the superior apex of the right atriotomy. The confluence of these two incisions was continued superiorly into the dome of the left atrium and kept this incision away from the thin tissue at the base of the left atrium near the aorta and left ventricle, away from the right pulmonary artery, and away from the posterior side of the ascending aorta near the left coronary artery. Marking the junction of these three incisions facilitates subsequent re-approximation and closure. The atrial septum is retracted gently to avoid atrioventricular nodal injury. Closure of the wound and incision is done in multiple layers.

This approach allows adequate exposure of the mitral valve, with minimal to moderate retraction of the aorta and SVC. It also allows a view of the mitral annulus more perpendicular to its plane than do other approaches.

Group 2 via a left atrial approach

In the left atriotomy group it was important to adequately expose the right border of the heart down to interatrial groove (Sondergaard), which was a challenging step in itself and sometimes resulted in inadverant entry into the right atrium which was rapidly dealt with using 3/0 prolene suture. Anterior and leftward traction on the inferior vena caval tourniquet further improves exposure. Initiation of vertical left atriotomy anterior to the right superior pulmonary vein and posterior to the interatrial sulcus (Sondergaard's groove). Extend it in a "C" fashion superiorly behind the superior vena cava (SVC), avoiding injury to the right pulmonary artery, and inferiorly into the oblique fissure behind the inferior vena cava (IVC).

The site of the vertical left atriotomy may be at the fatty interatrial junction or may be located closer to the mitral valve by dissecting the Sondergaard's groove, separating the left atrium from the right, and allowing the surgeon to perform left atriotomy 2 to 4 cm medially.

This latter incision requires closure where the left atrium is thinner and may carry a greater risk of suture line bleeding.

Transaction of the SVC also allows extension of the cephalad limb of the atriotomy onto the superior roof and permits further rotation of the right atrium and atrial septum to the left and away from the surgeon. The transection should leave at least a 1- to 2-cm cuff on the right atrium and may require moving the SVC cannulation site from the right atrium to the SVC or innominate vein.

Air lock or compromised venous drainage may occur during this transfer. SVC stenosis or thrombosis and sinoatrial node injury have been described with this technique.

Statistical analysis

Data were coded and entered using the statistical package for the Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA) 3. Data was summarized using mean and standard deviation for quantitative variables and frequencies (number of cases) and relative frequencies (percentages) for categorical variables. Comparisons between groups were done using unpaired t test. For comparing categorical data, Chi square (χ 2) test was performed. Exact test was used instead when the expected frequency is less than 5. P-values less than 0.05 were considered as statistically significant.

Results

In the interval between January 2017 and November 2021, 100 patients were enrolled and assigned 50 to each group randomly, In group 1, 29 patients were females (58%) and 21 patients were males (42%) as compared to group 2 were 26 patients were females (52%) and 24 were males (48%). (see Table 1)

Intraoperatively, the mean ischemia time in group 1 was 78.84 minutes +/– 37.07 minutes as compared to group 2 which was 79.3 minutes +/– 28.83 minutes . (see table 1)

The mean cardiopulmonary bypass time had a mean of 90.64 +/– 36.27 minutes in group 1 and had a mean of 91.1 +/– 24.88 minutes in group 2. (see table 1)

In group 1 bleeding occurred in 12% of the patients (6 patients) as compared to group 2 it occurred in 14%

Table 1 Comparison between both groups regarding age, ischemia time, cardiopulmonary bypass time and blood loss at 12 hours

	Group 1 Mean	Group 2 Mean	*P* value
Age	55.82	57.82	0.079
Ischemia time	78.84	79.3	0.445
CPB time	90.64	91.1	0.736
Blood loss at 12 hrs	312.4	318.6	0.244

CPB, cardiopulmonary bypass.

Table 2 Comparison between both groups regarding occurrence of arrhythmias (atrial fibrillation and heart block)

	Groups				
	Group 1		Group 2		
	Count	%	Count	%	*P* value
Arrhythmia atrial fibrillation					
Yes	5	10.0	7	14.0	0.538
No	45	90.0	43	86.0	
	Groups				
	Group 1	Group 2			
	Count	%	Count	%	*P* value
Arrhythmia heart block					
Yes	11	22.0	3	6.0	0.021
No	39	78.0	47	94.0	

of the patients (7 patients) with a p – value 0.766, meaning that the difference between groups is statistically insignificant. (See Table 1).

Post-operatively concerning arrhythmias, in group 1 atrial fibrillation occurred in 10% of the patients(5 patients) as compared to group 2 it occurred in 14% of the patients (7 patients) with a p – value 0.538, meaning that it is statistically insignificant. (see Table 2). In group 1 heart block occurred in 22% of the patients (11 patients) as compared to group 2 it occurred in 6% of the patients (3 patients) with a p – value 0.021, meaning that the difference between groups is statistically significant. (see Table 2).

In group 1, 12% of the patients(6 patients) required implantation of pacemaker as compared to group 2 were 0% of the patients (no patients) with a p – value 0.027, meaning that the difference between groups is statistically significant. (see Table 3)

In group 1 the mean hospital stay was 5.94 days± 0.77 and in group 2 was 5.82 days± 0.75. P value was 0.43 denoting that this is statistically insignificant. Figures 1–7

In all groups patients who underwent previous cardiac surgery either underwent redo mitral valve replacement (35 patients), failed mitral valve repair(20 patients), aortic valve replacement (15 patients) or coronary artery bypass surgery(CABG) (30 patients).

In group 1 44% of the patients(22 patients) had a previous mitral valve replacement, 8% underwent failed mitral valve repair(4 patients), 10% underwent previous aortic valve replacement(5 patients) and 38% underwent previous coronary artery bypass surgery (19 patients) . In group 2 26% of the patients(13 patients) had a previous mitral valve replacement, 32% underwent failed mitral valve repair(16 patients), 20% underwent previous aortic valve replacement(10 patients) and 22% underwent previous coronary artery bypass surgery (11 patients).

Discussion

Mitral valve diseases are the most common valvular diseases that need surgical intervention in our country. This is primarily due to prevalence of rheumatic heart disease which affect the left sided heart valves in the majority of cases leading to valve dysfunction in the form of stenosis and / or incompetence. In many cases this necessitates surgical intervention at an early age, in the form of mitral valve repair or replacement. This means that some of these patients will need reoperation at some point later in their lives due to failure of primary prosthesis/repair [4].

While surgical intervention has vastly improved in outcomes over the past two decades, redo surgery still has a higher overall rates of morbidity and mortality. The ideal surgical exposure still has much debate specifically in cases of reoperations where adhesions may limit accessibility to the heart [5].

While left atriotomy is the standard and most widely used incision, the trans septal approach has been gaining increased popularity specifically in reoperation cases due to easier access through the anterior surface of the right atrium and less need for dissection around the right boarder of the heart [6].

Another factor of the controversy is the intraoperative as well as postoperative course, which mainly revolves around the cross clamp and total bypass times as well as incidence of bleeding and arrhythmias such as new onset AF or heart block that might need permanent

Table 3 Comparison between both groups regarding need for implantation of pacemaker

	Group				
	Group 1		Group 2		
	Count	%	Count	%	*P* value
Pacemaker implantation					
Yes	6	12.0%	0	0%	0.027
No	44	88 .0%	50	100%	

pacemaker (PPM) insertion in the post operative period [7,8].

It is for such reasons that this study was carried out with the aim of evaluating the prevalence of such complication in patients who undergo reoperation for mitral valve in Cairo University and comparing those results with that of other studies done internationally to determine where we stand in terms of outcomes among the international practice.

On reviewing publications and studies done in the past five years we found only one study carried out in Egypt but with a smaller number of patients that was carried out in redo patients that is Hitawy et al. (2020) study which was done in Al azhar university. This will be handled later in this discussion [6].

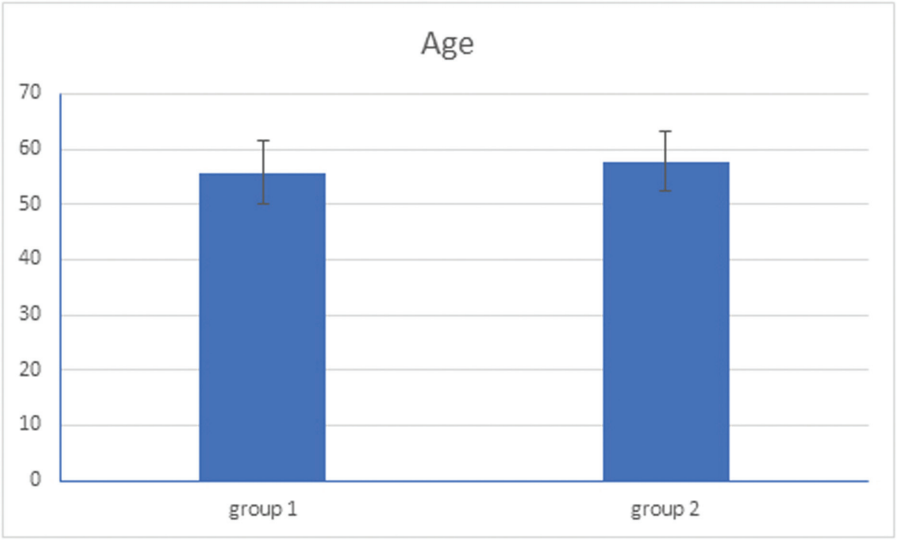
The largest study found to date and the only meta-analysis carried out comparing patients who underwent mitral valve surgery via standard left atriotomy versus those who did it through trans-septal approach is Harky et al. (2021). This analysis used pooled data from 16 studies that compared both techniques with a total of 4537 patients, making it the largest reported cohort to date [6].

In this meta-analysis the total number of patients who had surgery using trans septal approach (both superior trans septal and conventional trans septal) were 1472 while those who underwent surgery via left atriotomy approach was 3065 patients. Naturally this is a very large sample size being a meta-analysis which contrasts our small sample size of 100 patients with 50 patients in each group. The authors of this study also reported that four of the included studies reported patients with previous cardiac surgeries amounting for 54.1% (1655 patients) of patients in left atrial group and 40% (588 patients) of transseptal group [6].

Regarding the intra-operative data in the above mentioned study (Harky *et al.*, 2021) the aortic cross clamp time was significantly longer in the TS cohort than the LA cohort (74+/– 22 minutes vs 87+/– 23 minutes). Similarly the total bypass time was also significantly longer in the TS group than the LA group (110+/–29 minutes vs 127+/–31 minutes). However it is reported by the author that the TS cohort had a significantly higher rates of tricuspid valve repair carried out than the LA cohort (26.8% vs 13.1%) which means that the combined procedures is a confounding factor in this case. Which might contribute to the increased timed difference between both cohorts.

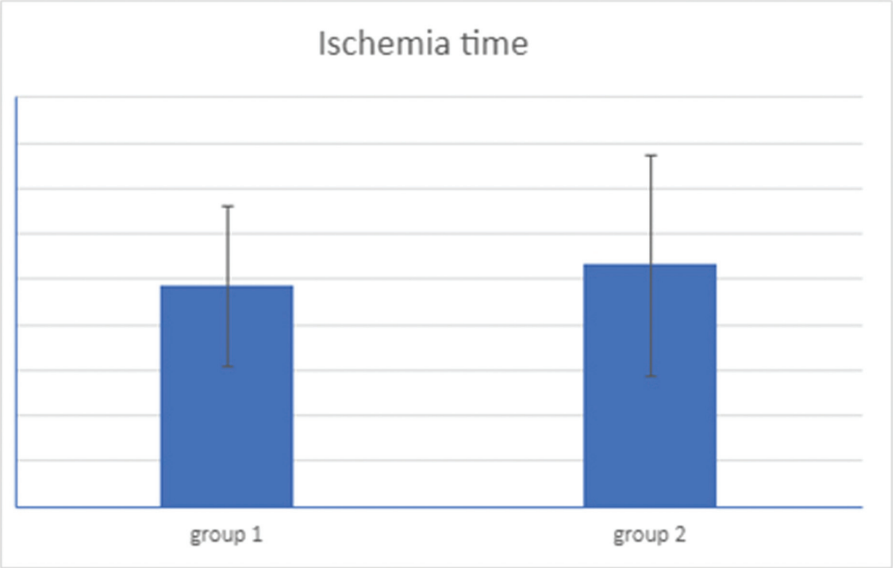
On subgroup analysis of isolated mitral valve procedures (in 5 studies that reported isolated MV cases with a total of 1513 patients, LA 1111 vs TS 402 patients) in both TS and LA groups there was no difference between both groups in aortic cross clamp time (73+/–21 minutes vs 77+/– 21 minutes) or in total bypass time (98+/– 27 minutes vs 101+/– 26 minutes) [3,6,9]. This concurs with our results where there were no differences in aortic cross clamp time between both TS and LA (78.8 +/– 28.83 minutes vs 79.3 +\- 37.07 minutes). Also total bypass time in our study did not show differences that were statistically significant between both TS and LA (90.64 +/– 36.27 minutes vs 91.1 +/– 24.88).

Figure 1



Comparison between both groups regarding age.

Figure 2

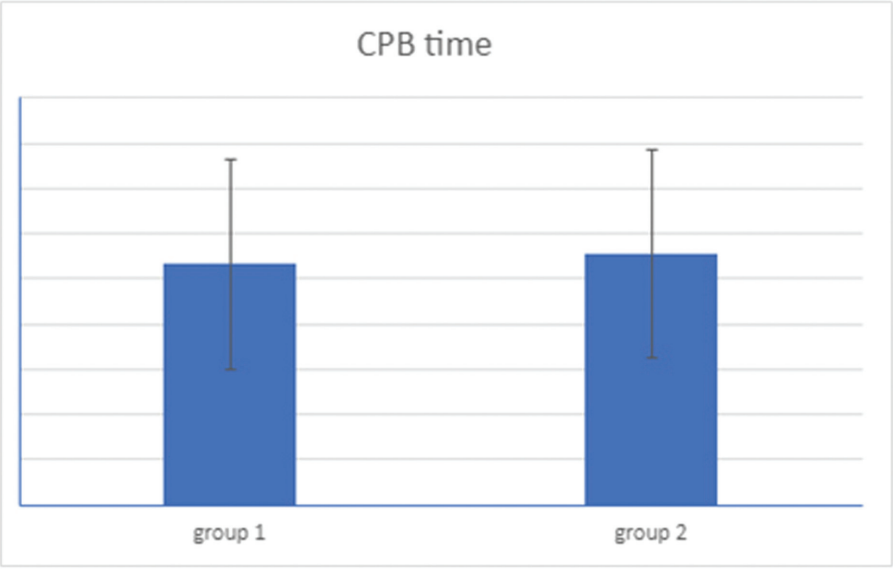


Comparison between both groups regarding ischemia time.

Regarding post-operative outcomes, Harky *et al.* (2021) found that there was no significant difference between both transseptal and left atrial cohorts in terms of postoperative bleeding rates at 12 hours (488 +/−232ml in TS cohort vs 446+/−214ml in LA cohort). Furthermore there was no significant difference between both cohorts when it came to reoperation for bleeding findings where there were no statistically significant difference between both groups in rates of postoperative blood loss at 12 hours (312.4ml+/− 25ml in TS group vs 318.6ml +/− 27.6ml in LA group) [6].

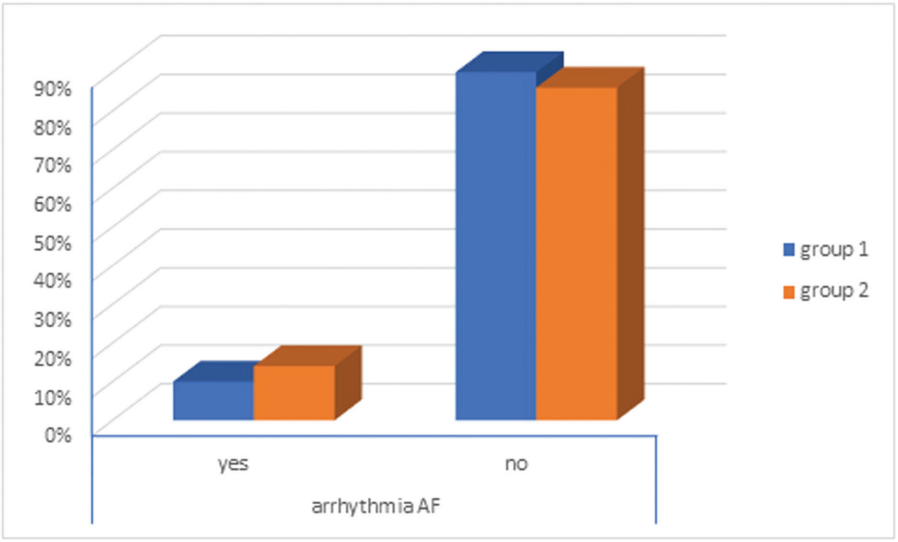
When it came to arrhythmia Harky et al. (2021) found that there was an increased rate of new onset AF in TS cohort than LA cohort (26% vs 25%). The rate of PPM implantation was higher in TS cohort than LA cohort as well (5% vs 3%). Strangely the authors report that in the subgroup analysis there was no difference in both the rates of new onset AF or PPM insertion between

Figure 3



Comparison between both groups regarding cardio-pulmonary bypass time.

Figure 4



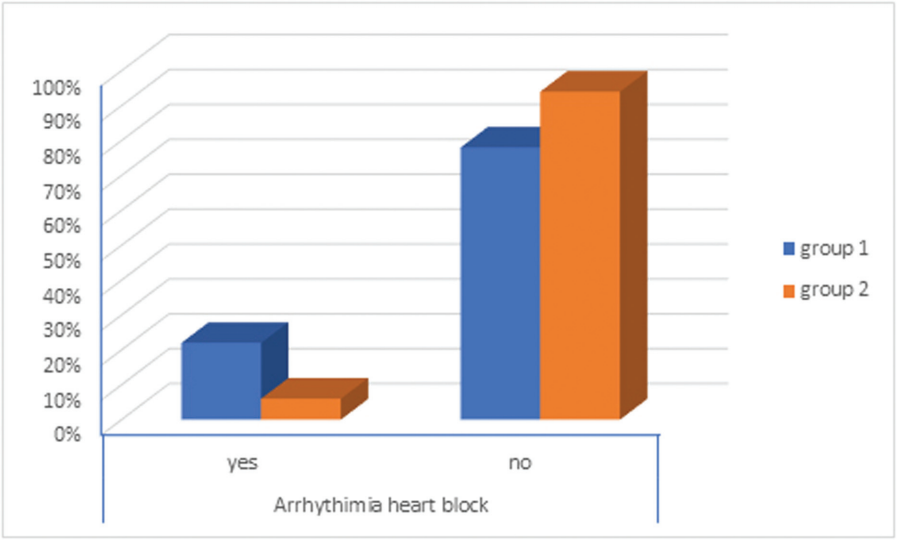
Comparison between both groups regarding occurence of atrial fibrillation.

both cohorts. The results of this subgroup analysis resembles our findings as we found that the rate of new onset AF was 10% in the TS group vs 14% in the LA group which is statistically insignificant. Also the rate of PPM insertion was 8% in TS group whereas it was 10% in the LA group which was statistically significant [6].

The next study that is of interest here is that by Mujtaba and Clark in which a total of 1017 patients who underwent isolated mitral valve surgeries were compared between the years 2000 and 2015. In this study 135 of patients had surgery through TS approach while 882 had it by left atrial approach as compared to our small sample size of 100 patients with 50 patients in each group [9].

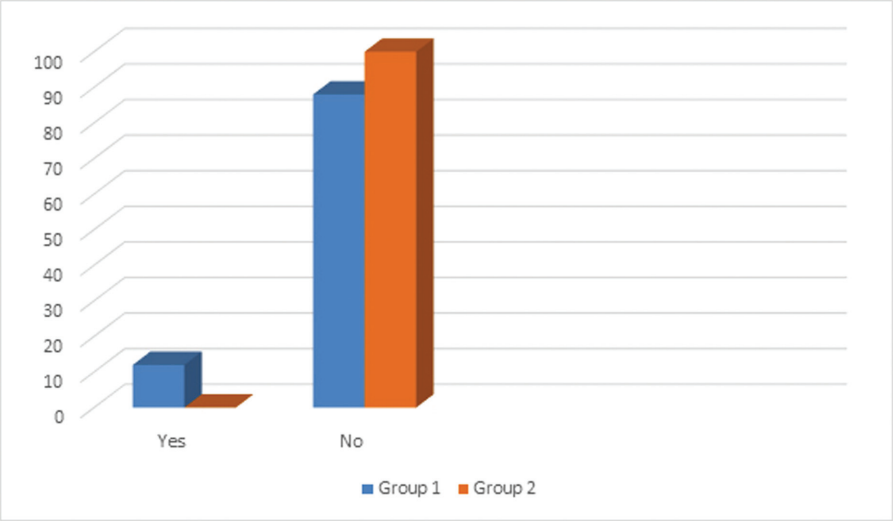
When looking at their intra-operative data the aortic cross clamp time was significantly longer in the TS cohort than the LA cohort (82 minutes vs 78 minutes). By nature the total bypass time was also significantly longer in the TS group than the LA group (107 minutes vs 114 minutes). This agrees with our results where there were no differences in aortic cross clamp times between both TS and LA (mean 78.84 minutes +/− 37.07 minutes vs 79.3 minutes +/−

Figure 5



Comparison between both groups regarding occurrence of heart block.

Figure 6



Comparison between both groups regarding need for implantation of pacemaker.

28.83 minutes).[10] Also cardiopulmonary bypass time in our study did not show differences that were statistically significant between both TS and LA (90.64 +/− 36.27 minutes vs 91.1 minutes +/− 24.88 minutes). Yet the cardiopulmonary bypass time was longer in the study because they had higher percentage of combined procedures including tricuspid repair, aortic valve procedures as well as coronary artery bypass whereas in our study the patients had isolated mitral valve procedures [10].

As for the post-operative outcomes the authors found that there was no difference of statistical significance between both TS and LA cohorts in terms of postoperative bleeding rates at 12 hours (415ml in TS cohort vs 427ml in LA cohort). Also there was no significant difference between both cohorts when it came to reoperation for bleeding (5% or 7 patients in TS vs 6% or 56 patients in LA cohort).

Regarding arrhythmia Mujtaba et al. (2018) found that there was an increased rate of new onset AF in TS cohort than LA cohort (42% or thirty seven patients vs 35% or one hundred sixty five patients). The rate of PPM implantation was higher in TS cohort than LA cohort as well (5.93% or eight patients vs 3.35% 29 patients). These results are similar with our own findings where there were no statistically significant

Figure 7

Comparison between both groups regarding blood loss in the first 12 hours post operative.

difference between both groups in rates of postoperative blood loss at 12 hours (312.4ml+/– 25ml in TS group vs 318.6ml +/– 27.6ml in LA group) [10]. Similarly there was no difference in our study between both groups when it came to rate of re-exploration for bleeding. Concerning arrythmias we found that the rate of new onset AF was 10% in the TS group vs 14% in the LA group which is statistically insignificant whilst the incidence of heart block was in trans-septal group 22% and in left atrial group 6% which was statistically significant. (p value 0.021). Also the rate of PPM insertion was12% in TS group whereas it was 0% in the LA group which was statistically significant [10].

Lastly a study that was carried out in Egypt in al Azhar university by Hitawy et al. (2020) This included 30 patients who had redo mitral valve surgery 15 had surgery through LA and the same number through TS compared to our sample size of 100 patients with 50 patients in each group.This study was included in our discussion as it is the only study done Egypt and the only study done in redo cardiac patients [11].

Regarding the intra-operative data from this study the aortic cross clamp time did not show significant differences in the TS cohort than the LA cohort (83.4+/– 6.6minutes vs 81.8+/–8.7minutes). Similarly the total bypass time was also significantly longer in the TS group than the LA group (99.2+/– 7.6 minutes vs 96.4+/– 10 minutes) [11]. This also is similar with our results where there were no differences in aortic cross clamp sizes between both TS and LA (78.8 minimum and maximum 69.74-98.57 minutes vs 79.3 minimum and maximum 56.81-93.88 minutes). Also total bypass time in our study did not show differences that were statistically significant between both TS and LA (90.64 minimum and maximum of 71.4-107.67 minutes vs 91.1 minimum and maximum 75.44-100.32 minutes) [11].

Regarding post-operative outcomes Hitawy et al. [11] found that there was no significant difference between both TS and LA cohorts in terms of postoperative bleeding rates at 12 hours (330ml +/– 50ml in TS cohort vs 300ml +/– 70 in LA cohort). Furthermore there was no significant difference between both cohorts when it came to reoperation for bleeding (6.7% or 1 patients in TS vs 6.7 % or 1 patients in LA cohort). These results are in line with our own findings where there were no statistically significant difference between both groups in rates of postoperative blood loss at 12 hours (312.4ml+/– 25ml in TS group vs 318.6ml +/– 27.6ml in LA group). Similarly there was no difference in our study between both groups when it came to rate of re-exploration for bleeding [11].

When it came to arrhythmia Hitawy et al. (2020) found that there was an increased rate of PPM implantation was higher in TS cohort than LA cohort as well (6.7% or one patients vs 0%). Similarly we found that the rate of new onset AF was 10% in the TS group vs 14% in the LA group which is statistically insignificant. Also the rate of PPM insertion was 8% in TS group whereas it was 10% in the LA group which was statistically significant [11].

It is important to mention that in our study patients with tricuspid valve disease were excluded to eliminate any factor of right ventricular compromise that may affect the outcome and act as confounding factor hence all cases selected were for isolated mitral valve intervention.

Conclusion

We conclude that the TS approach when compared to LA in redo cardiac patients provides comparable results in the intraoperative as well as postoperative outcomes in terms of cross clamp time, total CPB, bleeding during first 12 hours, re-exploration and new onset AF yet incomparable in heart block and pacemaker insertions. That while TS approach has the added benefit of providing better visualization of the mitral valve without the need for use of any special equipment or retractors. Therefore we advise to further implement TS approach and generalize its use specifically among young and training surgeons as it provide better educational opportunity for them, specially in redo patients.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1 Agarwal S, Choi SW, Fletcher SN, Klein AA, Gill R, Contributors Anderson L, *et al.* The incidence and effect of resternotomy following cardiac surgery on morbidity and mortality: a 1-year national audit on behalf of the Association of Cardiothoracic Anaesthesia and Critical Care. Anaesthesia. 2021; 76 (1):19–26.

2 Aydin E, Arslan A, Ozkokeli M. Comparison of superior septal approach with left atriotomy in mitral valve surgery, Rev Bras Cir Cardiovasc 2014; 29 (3):367–735.

3 Chan YH. Qualitative Data – Tests of Independence. Singapore Med J. 2003; 44 (10):498–503.

4 Maganti K, Rigolin VH, Sarano ME, Bonow RO. Valvular heart disease: diagnosis and management. InMayo Clinic Proceedings 2010 May 1 (Vol. 85, No. 5, pp. 483–500). Elsevier.

5 Fatehi Hassanabad A, Zarzycki AN, Jeon K, Deniset JF, Fedak PWM. Post-Operative Adhesions: A Comprehensive Review of Mechanisms. Biomedicines. 2021; 9 (8):867.

6 Harky A, Kusu-Orkar TE, Chan JS, Noshirwani A, Savarimuthu S, Pousios D, Muir AD. Left atrial or transeptal approach for mitral valve surgery: a systematic review and meta- analysis. Current Problems in Cardiology. 2021; 46 (3):100602.

7 Sultan I, Trivedi DP, Machiraju VR. Surgical approaches to the mitral valve: variable paths to the same destination. Indian Journal of Thoracic and Cardiovascular Surgery. 2018; 34 (2):105–12.

8 Turkyilmaz S, Kavala AA. Comparison of left atriotomy and superior transseptal approaches in mitral valve surgery. Heart Surg Forum 2018; 21:E318–21.

9 Garcia-Villarreal OA, Gonzalez-Oviedo R, Rodriguez-Gonzalez H, Martinez-Chapa HD. Superior septal approach for mitral valve surgery: a word of caution. Eur J Cardiothorac Surg 2003; 24: 862–7.

10 Mujtaba SS, Clark SC. Extended trans-septal versus left atrial approach in mitral valve surgery: 1017 patients' experience. Heart Asia 2018; 10.

11 Hitawy MA, Hassan MS, Abdelwahab FI, Mousa ME. Comparative study: Transseptal approach versus Transatrial approach in mitral valve replacement in redo patients. International Journal of Medical Arts. 2020; 2 (3):619–24.