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Right Anterior Thoracotomy Minimally Invasive Aortic Valve Replacement vs. Conventional Mediastinotomy: Propensity Score Matching Analysis

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1. Abstract

1.1. Background: This research aims to compare intraoperative and postoperative outcomes of Right Anterior Thoracotomy minimally invasive aortic valve replacement (RAT-MIAVR) surgery with conventional aortic valve replacement (C-AVR) surgery and analyze the results.

1.2. Methods: A total number of 230 patients, of which 50 (21.7%) patients of isolated aortic valve replacement treated with right anterior thoracotomy minimally invasive aortic valve replacement surgery (RAT-MIAVR) and 180 (78.3%) patients of the same disease treated with conventional isolated aortic valve replacement (C-AVR) surgery in the period between January of 2016 to March of 2021. Propensity score matching (PSM) and retrospective cohort study elements (Chi-square and T-test) were conducted. The data was then analyzed.

1.3. Results: From 230 patients in our study, 117 patients were included from both RAT-MIAVR and C-AVR during PSM, of which 39 (33.3%) patients matched in the RAT-MIAVR group and 78 (66.6%) patients matched in the C-AVR group. The mean age of patients treated with C-AVR surgery was 47.44±13.54 (p=0.962), 71.79% were males, and 28.21% were female, while the mean age was 47.56±14.37 (p=0.962) for RAT-MIAVR group, of which 74.36% were male, and 25.64% were female. Longer Cardiopulmonary Bypass time (CPB) (130.77±34.86 minutes) was found in RAT-MIAVR compared with C-AVR (111.59±36.82 minutes) (p=0.008). We also found that Aortic Cross Clamping time (ACC) was longer in RAT-MIAVR (77.00±20.50 minutes) versus (65.97±20.08 minutes) in the C-AVR group (p=0.006). Operative Time (OPT) time was also increased in RAT-MIAVR (357.15±69.16 minutes) compared with (308.41±60.65 minutes) in the C-AVR group (p=0.000). We observed that estimated blood loss postoperatively is increased in the C-AVR group (1056.38±330.63 mL) compared to the RAT-MIAVR group (891.95±261.47) (p = 0.008). 12h drainage was significantly increased in C-AVR (481.41±394.40 mL) compared with (308.21±324.42) in the RAT-MIAVR (p= 0.019). A significant increase is also observed in total drainage in C-AVR (814.29±523.07 mL, p= 0.020) comparing to (586.41±418.83 mL) in RAT-MIAVR (p= 0.020). Pacemaker was frequently used after surgery in the C-AVR group (25(32.05%)) compared to (5(12.82%)) (p=0.025) in the RAT-MIAVR group. No significant change was observed in other intraoperative and postoperative characteristics.

1.4. Conclusion: Compared with C-AVR, RAT-MIAVR does not have any significant difference in mortality and early follow-up. Postoperative complications such as blood loss, drainage fluid, and postoperative pacemaker use were significantly decreased in RAT-MIAVR surgery. Despite longer CPB, ACC, and OPT, RAT-MIAVR did not show any significant complication related to prolonged CPB time.

2. Introduction

Ever since doctors Harken and Starr introduced Aortic Valve Replacement surgery (AVR) in 1960 with conventional mediastinotomy [1], aortic valve disease prognosis has significantly increased from 60% to 80% in patients undergoing aortic valve replacement surgery [2]. The median sternotomy aortic valve replacement is still the first choice in most cardiac surgical centers. Over time, surgeons worldwide never stop pursuing a minimally invasive way to improve the overall surgical method and the quality of life postoperatively with less injury. In 1996, Minimally Invasive Aortic Valve Replacement (MIAVR) approaches were first reported, which were revolutionary and more accepted by patients due to their cosmetic advantage [3-5]. Minimally Invasive Aortic Valve Replacement (MIAVR) has been enormously researched [6]. Relevant ongoing observational studies focusing on comparing conventional sternotomy and several minimally invasive aortic valve replacement techniques showed variations in post-operation results [7-9]. However, according to recent systematic reviews and meta-analyses, existing MIAVR trials are still limited to support the current shreds of evidence [10, 11]. Our research aims to compare Right Anterior Thoracotomy-Minimally Invasive Aortic Valve Replacement (RAT-MIAVR) with Conventional mediastinotomy Aortic Valve Replacement (C-AVR) in surgical techniques, pre-operative characteristics, intra-operative characteristics, and, most importantly, postoperative complications.

3. Methods

3.1. Patients Selection and General Methods

We collected 230 adult records of patients of Asian descent (average age 47 years old) diagnosed with isolated aortic valve disease in the period between January 2016 to March 2022; 50 patients underwent Right Anterior Thoracotomy MIAVR, while 180 underwent conventional mediastinotomy. A propensity score matching was conducted. Matched patients underwent a retrospective cohort study, and appropriate statistical methods were used to conclude the results. During collection, we used basic mathematical calculations to determine unrecorded data, such as the number of days in hospital after surgery. Our patient groups were enclosed to only one surgeon's work to eliminate performance bias in both C-AVR and RAT-MIAVR groups.

3.2. Statistical Analysis

We collected the following twenty-eight Pre-operative characteristics and plotted them in an excel file: age, sex, weight and height, BMI, obesity, diabetes, hypertension, smoking and alcohol history, Chronic Kidney disease, history of recent dialysis, urgent operation, previous cardiac surgery, history of transient ischemic attack, history of coronary artery disease, history of Bioabsorbable polymerase stent surgery, history of atrial fibrillation, pre-operative ejection fraction, presence of mild mitral valve regurgitation associated with aortic valve disease, NYHA classification, Eurooscore II for cardiac operative risk, aortic valve size under ultrasound, presence of pre-operative chronic obstructive pulmonary disease, pre-operative neurological problems (any type), pre-operative anemia and presence of endocarditis. We used the python-based program R commander (Version 1.78) [12, 13] to conduct propensity score matching and logistic regression and to plot ROCs using the previously introduced pre-operative characteristics. After logistic regression, we calculated the variables of propensity score and matched the data using the optimal caliper width (0.2) according to the latest studies [14]. Pair matching was adjusted to fit the 1:2 pairs rate; hence the C-AVR group includes more patients. The matched variables showed a total sample number of 117 (n=117), of which 39 were MIAVR (33.33%) and 78 were CSAVR (66.67%). After PSM calculation and matching, logistic regression was conducted again to plot ROC (Figure 1). To validate propensity score matching, we plotted ROC, Standardized differences, and covariant balance related to study groups after PSM. Results showed matched pre-operative groups shown in Figure 1-3, confirming PSM validity and eliminating confounding characteristics. We then performed Chi-square (χ^2), Student's test (independent t-test), and Fisher's Exact Test (P-value) on binary and numerical data. P-value is used here to determine whether or not there is a significant association between the two categorical variables. We used the online Statistical Products and Service Software Automatically (SPSSAU) (version 22.0) in this step. Pre-operative characteristics, intraoperative, and postoperative factors were plotted on tables separately, as shown in Table 1-3, and the previous statistical method was used on each. The above characteristics were selected according to data availability in the hospital database. Particular characteristics chosen in the initial study design were excluded from the final study due to data missing; no significant missing data were reported during data collection in the final study design.

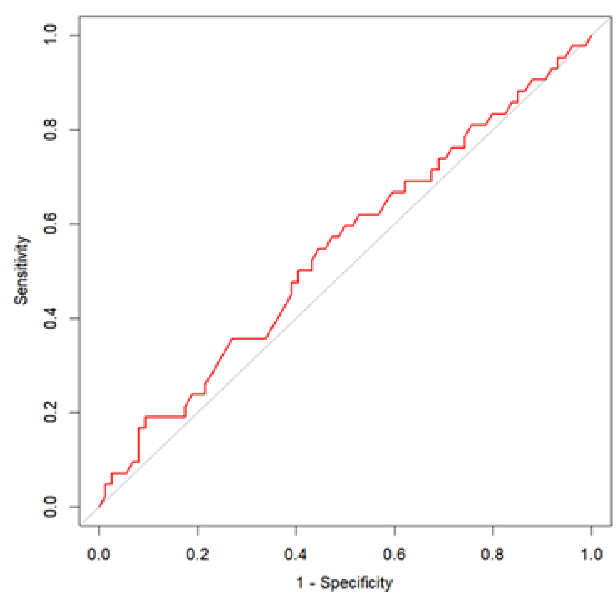

Figure 1: ROC

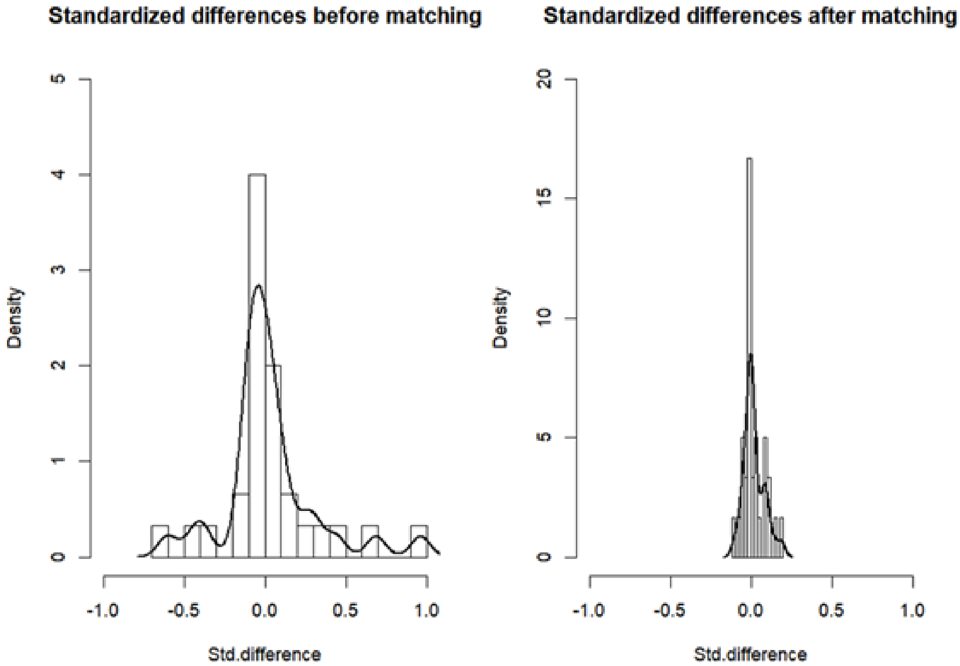

Figure 2: Standardized Differences Chart

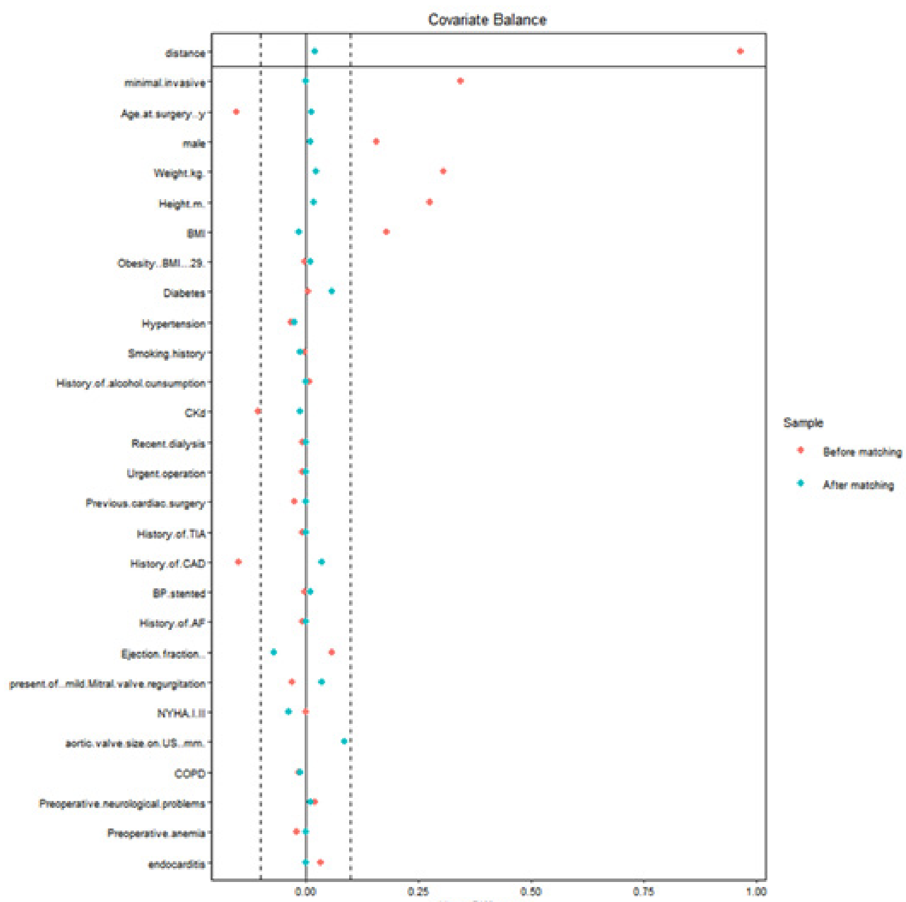

Figure 3: Covariate Balance Table

3.3. Operative Technique

After general anesthesia and relevant procedures, the patient was placed in a supine position with the upper right-back cushion of the chest region slightly elevated by 3-7 cm off the supine position by a small pillow. Proper disinfection was performed, and draping was installed. A right inguinal incision (5-7cm) was established to isolate the femoral artery and femoral vein. After heparinization, the femoral artery and vein were catheterized along with the right internal jugular vein with large vesicular catheters to initiate cardiopulmonary bypass. After the installment of the CPB machine, a right anterior intercostal skin incision (5 cm) was made as an operation opening (Figure 4). The lung was observed and moved to prevent any intercoastal adhesion. A wound protector set was placed to keep the surgical wound open, followed by a rip spreader to increase the operation's vision. A right lateral intercostal opening was made as a bridge to the thoracic endoscope. After deflation of the right lung (not the left lung), the pericardium was carefully opened to expose the aortic root. With a 4-0 Monofilanmnt polypropylene line, two sealing sutures are made on the top of the ascending aorta near the aortic arch. The aorta was clamped at the arch above the seal after the CPB cooled the body to 30C degrees. The ascending aorta was spirally cut 2 cm above the coronary opening. Anterograde Histidine-tryptophan-ketoglutarate (HTK) cardioplegia was perfused directly through the left and right coronary arteries to induce cardiac arrest and protect cardiac cells. The diseased valve was observed and removed. The aortic orifice was measured via valvumeter, and a particular valve was replaced according to the specific medical case (mechanical or biosynthetic valve). 16-20 needles with 2-0 double-needle polyester thread were used to make Interrupted suturing to connect the annulus with the artificial valve cushion using evert suturing technique, with needle insertion from the inner annular surface passing through the artificial valve suturing cushion. The valve was then pushed smoothly into the annulus along the suturing line. 7-10 sliding knots were performed and ended with one surgical knot. Two interrupted sutures were performed at the edges of the aortic spiral cut using a 4-0 Monofilanmnt polypropylene line, followed by a continuous suture at both ends of the aortic incision, which then was tied and fixed in the middle of the incision. A small 50 ml needle was inserted through the ascending aorta between the pre-made sealing to remove tiny air bubbles and prevent reperfusion injury. The aortic clamp was removed, and an AED was used if the heart had not automatically rebounded. The circulation was assisted gradually to wean the body out of the cardiopulmonary bypass machine. Hemostasis was checked, and a right thoracic drainage tube was installed with a 1-2 cm incision. Finally, the surgical opening was closed layer by layer and ended with a subcuticular skin suture. It is worth referring that our surgical approach was initially introduced by Rao P.N et al. [15] in 1993 and has been in clinical trials since then (Figure 4).

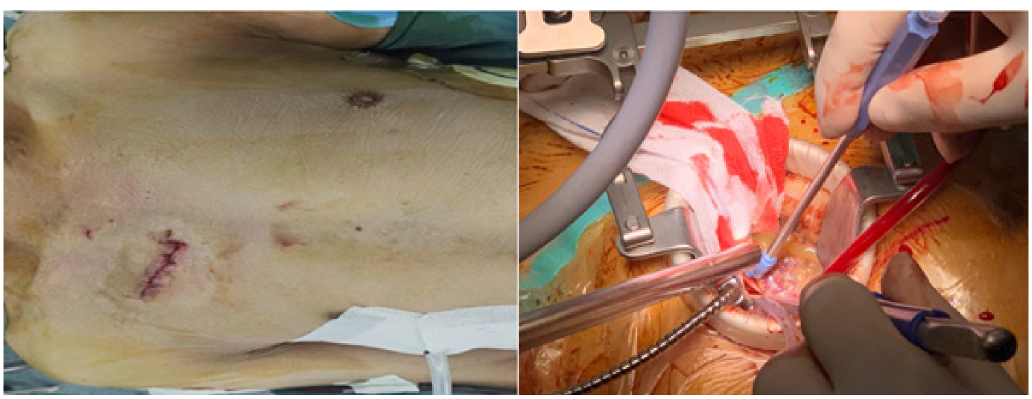

Figure 4: surgical opening length and MIAVR surgical setup.

4. Results

4.1. Pre-Operative Results

Our sample included 230 patients, of which 50 (21.7%) underwent RAT-MIAVR and 180 (78.3%) C-AVR surgery. After PSM was performed, the number of patients matched to propensity criteria was 117, of which 39 (33.3%) was in the RAT-MIAVR group and 78 (66.7%) was in the C-AVR group. As illustrated in Table 1, the mean age of patients who underwent C-AVR surgery was higher in the unmatched group (50.53±12.48) vs. (47.54±14.48) in the RAT-MIAVR (p= 0.149) than in the matched group (47.44±13.54) vs. (47.56±14.37) (p = 0.962), which was a confounding in the sample before PSM. Older patients were mainly subjected to elective transcatheter aortic valve replacement (TAVR) surgery. On the other hand, pre-operative endocarditis was a statistically significant characteristic before PSM, which could be confounding in our study. The number of patients diagnosed with endocarditis in the unmatched C-MAIVR group (n = 21 (11.67%)) vs. (n=21(11.67)) in the RAT-MIAVR group (p= 0.040) was significantly higher than the matched C-MAIVR group (n = 1 (1.28%)) vs. (n= 1(1.28)) in the RAT-MIAVR group (p= 0.614), which remained the same before and after PSM. The presence of preoperative neurological problems is also considered a confounding in this study, which could affect the final results in our study (unmatched group: C-MAIVR (n= 2(1.11%)), RAT-MAIVR (n= 3(6.00%) p =0.036), matched group: C-MAIVR (n= 0(0.00%)), T-MAIVR (n= 1(2.56%), p = 0.156). Another interesting pre-operative result was recent dialysis, in which cases existed in the unmatched group (C-MAIVR n= 0(0.00%), RAT-MAIVR n= 1(2.00%) p =0.036) while no cases appeared in the matched group. BMI should also be considered as a possible confounding; hence the P-value in both samples was too close to the significance standard (unmatched group: C-MAIVR mean = 23.07±3.10, RAT-MAIVR mean= 23.99±2.95 p =0.062, matched group: C-MAIVR mean = 23.54±2.88, RAT-MAIVR mean = 23.83±3.03, p = 0.62).

Table 1: Preoperative Characteristics

Variables	Before PSM			After PSM		
	RAT-MIAVR (N=50)	C-AVR (N=180)	P-value	RAT-MIAVR (N=39)	C-AVR (N=78)	P-value
	Mean (SD +-)/ N (%)			Mean (SD +-)/ (%)		
Age at surgery (years)	47.54±14.48	50.53±12.48	0.149	47.56±14.37	47.44±13.54	0.962
Female	11(22.00)	52(28.89)	0.334	10(25.64)	22(28.21)	0.769
Male	39(78.00)	128(71.11)		29(74.36)	56(71.79)	
Weight (Kg)	67.42±11.85	64.56±11.03	0.113	65.97±10.31	67.14±10.81	0.574
Height (m)	1.68±0.09	1.68±0.08	0.786	1.67±0.08	1.68±0.08	0.809
BMI	23.99±2.95	23.07±3.10	0.062	23.54±2.88	23.83±3.03	0.62
Obesity (BMI > 29)	1(2.00)	4(2.22)	0.924	0(0.00)	1(1.28)	0.478
Diabetes	4(8.00)	24(13.33)	0.308	3(7.69)	7(8.97)	0.815
Hypertension	15(30.00)	64(35.56)	0.464	14(35.90)	26(33.33)	0.783
Smoking history	14(28.00)	47(26.11)	0.789	10(25.64)	21(26.92)	0.882
Alcohol consumption	12(24.00)	35(19.44)	0.48	9(23.08)	18(23.08)	1
CKD	7(14.00)	34(18.89)	0.424	5(12.82)	10(12.82)	1
Recent dialysis	1(2.00)	0(0.00)	0.057	0 (0.00)	0 (0.00)	N/A
Urgent operation	0(0.00)	1(0.56)	0.597	0 (0.00)	0 (0.00)	N/A
Previous cardiac surgery	3(6.00)	11(6.11)	0.977	2(5.13)	3(3.85)	0.747
History of TIA	0(0.00)	1(0.56)	0.597	0 (0.00)	0 (0.00)	N/A
History of CAD	6(12.00)	37(20.56)	0.17	5(12.82)	8(10.26)	0.677
BP stented	1(2.00)	3(1.67)	0.873	1(2.56)	2(2.56)	1
LVEF (%)	59.90±8.55	59.85±9.52	0.973	59.21±8.32	60.53±9.41	0.459
the presence of functional MVR	5(10.00)	30(16.67)	0.246	5(12.82)	10(12.82)	1
NYHA I/II	42(84.00)	154(85.56)	0.784	32(82.05)	66(84.62)	0.723
NYHAII/IV	8(16.00)	26(14.44)	0.784	12(15.38)	7(17.95)	0.723
Euroscore II	2.00±1.00	2.00±1.00	0.374	2.00±1.00	2.00±1.00	0.512
AV size on US (mm)	25.56±3.66	25.33±3.92	0.708	25.67±3.79	25.82±4.45	0.854
COPD	6(12.00)	16(8.89)	0.508	3(7.69)	4(5.13)	0.581
neurological problems	3(6.00)	2(1.11)	0.036*	1(2.56)	0(0.00)	0.156
Preoperative anemia	3(6.00)	18(10.00)	0.385	2(5.13)	5(6.41)	0.783
endocarditis	1(2.00)	21(11.67)	0.040*	1(2.56)	1(1.28)	0.614

BMI: Body Mass Index, CKD: Chronic Kidney Disease, TIA: Transit Ischemic Attack, CAD: Coronary Artery Disease, BP: Bioabsorbable Polymer, LVEF: Left Ventricular Ejection Fraction, MVR: Material Valve Regurgitation, NYHA: New York Heart Association, AV: Aortic Valve, US: Ultrasound, COPD: Chronic Obstructive Pulmonary Disease * p<0.05 ** p<0.01

4.2. Intraoperative Results

Intraoperative results illustrated in (Table 2) characterized by CPB time, ACC time, and total operative time, which were significantly increased in the RAT-MAIVR group (mean=130.77±34.86 minutes, mean=77.00±20.50 minutes, mean=357.15±69.16 minutes respectively) comparing to C-MAIVR (mean= 111.59±36.82 minutes, mean=65.97±20.08 minutes, mean=308.41±60.65 minutes respectively) with P-value of 0.008 for CPB time, 0.006 for ACC time and 0.000 for total operative time.

Table 2: Intraoperative Characteristics

Variables	Before PSM			After PSM		
	RAT-MIAVR (N=50)	C-AVR (N=180)	P-value	RAT-MIAVR (N=39)	C-AVR (N=78)	P-value
	Mean (SD +-)/ (%)			Mean (SD +-)/ (%)		
CPB Time (min)	113.23±35.39	129.80±33.30	0.003**	130.77±34.86	111.59±36.82	0.008**
ACC Time (min)	76.00±18.92	66.63±21.96	0.007**	77.00±20.50	65.97±20.08	0.006**
Operation time (min)	353.08±72.68	313.20±63.08	0.000**	357.15±69.16	308.41±60.65	0.000**
Valve diameter (CM)	22.56±2.04	22.63±1.81	0.82	22.56±1.98	22.82±1.77	0.48
Mechanical valve	44(88.00)	152(84.44)	0.531	35(89.74)	68(87.18)	0.687
Biosynthetic valve	6(12.00)	28(15.56)		4(10.26)	10(12.82)	

CPD: Cardio-Pulmonary Bypass, ACC: Aortic Cross-Clamping * p<0.05 ** p<0.01

4.3. Postoperative Results

As for the post-operative characteristics (Table 3), the matched results showed a significant increase in blood loss after surgery in the C-AVR group (mean= 1056.38±330.63 mL, p= 0.008) and as well as an increase in 12h drainage (mean= 481.41±394.40 mL, p= 0.019) and total drainage (mean= 586.41±418.83 mL, p= 0.020). conversion to full sternotomy was increased statistically (C-AVR n= 0 (00%), RAT-MIAVR n=2 (5.13%), p= 0.044) since no patients in the C-AVR group could be enrolled into this characteristic. The need for a pacemaker after surgery was significantly increased in the C-AVR group (C-AVR n 25(32.05%), RAT-MIAVR (n=5(12.82%)) (p= 0.025) than in the RAT-MIAVR group.

Table 3: match postoperative characteristics

Variables	RAT-MIAVR (N=39)	C-AVR (N=78)	P value
	Mean (SD +-)/ (%)		
in-hospital stay after surgery (Days)	14.85±8.50	16.42±5.76	0.239
length of ICU stay (Days)	4.51±5.23	3.77±2.55	0.303
length of hospital stay (Total/ Days)	14.85±8.50	16.42±5.76	0.239
discharged to other departments	2(5.13)	2(2.56)	0.472
RBC total (1st day) *10^12/L	3.53±0.42	3.55±0.59	0.798
Platelets total (1st day) *10^9/L	125.23±33.83	129.42±49.17	0.59
Packed cells transfused (Units)	7.55±5.14	9.17±5.44	0.125
Estimated Blood loss during operation (mL)	891.95±261.47	1056.38±330.63	0.008**
12h Drainage (mL)	308.21±324.42	481.41±394.40	0.019*
24h Drainage (mL)	296.92±274.09	314.68±227.91	0.711
Total Drainage (mL)	586.41±418.83	814.29±523.07	0.020*
Re-exploration from potential bleeding or tamponade	3(7.69)	5(6.41)	0.796
readmission due to reasons related to surgery	4(10.26)	3(3.85)	0.168
Conversion to full sternotomy	2(5.13)	0(0.00)	0.044*
reintubation	4(10.26)	4(5.13)	0.3
Mechanical Ventilation for more than 24 hours	7(17.95)	12(15.38)	0.723
Mediastinitis	1(2.56)	6(7.69)	0.27
Pacemaker	5(12.82)	25(32.05)	0.025*
any postoperative Aki	10(25.64)	19(24.36)	0.88
Hemodialysis	1(2.56)	0(0.00)	0.345
Postoperative renal failure	1(2.56)	0(0.00)	0.307
Pleural effusion requested Drainage	5(12.82)	7(8.97)	0.518
EF after surgery (%)	58.87±9.50	57.42±11.24	0.491
Postoperative arrhythmia	15(38.46)	24(30.77)	0.405
in-hospital/30-day mortality	2(5.13)	1(1.28)	0.215

ICU: Intensive Care Unit, RBC: Red Blood Cells, EF: ejection Fraction

5. Discussion

The main finding of our research is that RAT-AVR does not show any significant difference in mortality and morbidity compared with C-AVR. RAT-AVR is as feasible and safe as C-AVR. However, RAT-MIAVR is more acceptable and demanded by patients generally due to better cosmetic results.

Usually, prolonged CPB time could lead to challenging complications [16, 17]. Although prolonged CPB, ACC, and total operative time were found in our RAT-MIAVR group, we still did not observe any significant prolongation in mechanical ventilation, ICU, and total hospitalization time between the two groups. Similar studies also support that MIAVR with increased CPB timing does not result in severe prolonged CPB time complications [18-22]. To explain this, we went through several recent pieces of research. Michael Robich et al. [23] suggested that the prolonged use of CPB leads to increased serum soluble syndecan-1 indicating endothelial shedding, which mobilizes neutrophils out of the bone marrow leading to leukocytosis, amplifying inflammation and tissue damage. However, a study by Nicole A.M et al. [24] indicates that using heparin biocompatible coating during the CPB time may prevent the increase of syndecan-1 in serum blood, which may be the case in our study. Another possibility is the use of HTK cardioplegia in MIAVR, Alexander C Reynolds et al [25], in a recent meta-analysis pointed out that HTK cardioplegia could decrease intraoperative time and the need for Spontaneous defibrillation following aortic cross-clamp removal. Konstadinos Plestis et al., in their study, pointed out that the use of HTK and Cor-Knot titanium fastener could significantly improve postoperative complications, such as prolonged mechanical ventilator and renal failure, and decrease intraoperative time[26].Anyhow, Mauro Del Giglio et al.[19] pointed out that there was no significant increase in CPB timing in their RAT-MIAVR; their observation could be due to using three running sutures during prosthetic valve fixation or/and sutureless valves (SU-AVR) in their RAT module (RAT+SU-MIAVR). Those two factors make replacing the valve easier and faster than conventional mechanical valves. Their results also showed no significant development in postoperative complications suggested by prolonged CPB. Yet, SU-AVR is still a relatively new technique, long term life quality and valve life expectancy are still to be determined.

Mediastinitis is one of the most severe complications of C-AVR, with mortality rates of postoperative mediastinitis could range from 12% to 47% [27]. Compared to MIAVR, studies showed that mediastinitis is rare or not present in RAT-MIAVR [28]. In our study, one patient in the RAT-MIAVR was diagnosed with postoperative mediastinitis in 2016. This issue could be due to insufficient opening in the pericardium for the fluid to drain into the chest tube at the end of the operation, which in roll led to pericardial effusion and mediastinitis. We fixed this complication by enlarging the pericardial opening to avoid the retention of the fluid inside the pericardium after surgery.

In most cases, the RAT approach comes with high costs, limited operational visualization, and smaller space between the aorta and mediastinal could lead to misreading the valvulometer and choosing smaller valves. In our experience, the proper pericardial suspension gives a clear view and enhances visualization, which is good enough to onset a proper prosthetic valve and shows a large orifice.

Some centers advise ligating the right interior thoracic artery to avoid unexpected rupture resulting in bleeding during surgery. This approach can be a disadvantage of RAT-MIAVR for patients with coronary artery disease who may require future surgical coronary revascularization since visualization of the coronary arteries is impaired during RT-AVR surgery. This issue could be fixed by making the incision 3cm away from the mediastinum without overextending intercostal space, which gives us a clear and sufficient surgical view.

Nevertheless, the estimated blood loss and postoperative Drainage were significant findings in this study. In our MIAVR approach, the significant decrease in blood loss provides remarkable evidence of a significant reduction in cellular injury and improved recovery. Emiliano A et al. compared the Quality of Life (QOL) after one month in a randomized cohort study that included mini-sternotomy and full sternotomy AVR groups. They found faster recovery with improved QOL and satisfaction in the first month and a significant reduction in 24 postoperative bleeding in the semi-sternotomy group [29]. However, our study also observed a significant decrease in postoperative drainage fluid in the RAT-MIAVR group, indicating minor cellular damage. This result does not indicate that RAT is better than semi-sternotomy in terms of postoperative bleeding; hence some semi-sternotomy studies also indicated a reduction in postoperative bleeding [20]. Interestingly, RBC count, platelets count, and packed cells transfused had no significant difference between both groups, even after the significantly improved Drainage in the MIAVR group, which is not well understood.

The frequent use of pacemakers in the C-AVR group suggests the presence of severe arrhythmia or heart block in the C-AVR group. However, our findings do not show any significant differences in the presence of overall arrhythmia between the two groups; further detailed studies in this field should be performed to show clear evidence of the relationship between severing, moderate or mild arrhythmia in RAT-MIAVR and C-AVR.

Although RAT-MIAVR tends to have minor surgical wounds and improved cosmetics, the use of this technique is still limited. Since aortic valve disease (AVD) tends to occur in older patients, the rates of vascular disease (such as atherosclerotic plaques/thrombosis in the femoral vesicles, inflammatory vesicular disease…Etc.) are higher [30-32]. To avoid vascular injury from retrograde CPB perfusion, our center examines patients with Multidetector CT (MDCT) scans of the whole aorta, femoral arteries, and internal carotid artery to check if there is any aortic condition such as ulcer, aortic dissection, aneurysm, severe calcification, and to check the diameter of the peripheral vesicles.

Overall, our matched groups were not very severe. As we observed in our pre-operative results, our patients' age did not exceed 61 in both groups. Older patients were subjected to elective Trans-endothelial Aortic Valve Replacement (TAVR) Surgery, the LVEF in both groups was near 60%, and functional aortic regurgitation was present with no significant difference in both groups. This fact may explain the relatively good postoperative LVEF results.

6. Conclusion

Despite prolonged ACC, CPB, and operative time, Right Anterior Thoracotomy Minimally invasive aortic valve replacement surgery showed significant postoperative improvements compared with Conventional Aortic valve replacement in patients with isolated aortic valve disease. Cosmetic surgical wound, decreased cellular damage, and decreased postoperative pacemaker use were the main benefits of RAT- MIAVR.

7. Study Limitations

This study is a retrospective cohort study of our single institute experience, which does not plot the overall results of MIAVR surgery alone. Other institutes' experiences should be considered to prove or disapprove of our results. Only a few patients could be followed up over 30 days after surgery, which does not conclude the long-term impact on our MIAVR patients. Our study groups only included one racial group (Asian), which could not evaluate any racial-related postoperative complication.

8. Conflicts of Interest

The authors have no conflicts of interest to declare.

9. Ethical Statement

All data were collected by signed consent from the patients to process their data, and all names, ID numbers, and other personal information were blinded to the researcher with strict monitoring by the institute and the relative authorities.

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