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Comparative study between minimally invasive right anterior mini-thoracotomy versus conventional median sternotomy in isolated aortic valve replacement: early outcome

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Abstract

Background

In cardiac surgery, minimally invasive surgical procedures have recently been adopted. These innovative procedures have a number of benefits, including less postoperative discomfort, fewer morbidity and mortality, faster recovery, and shorter hospital stays at lower costs.

Patients and methods

Outcomes of 30 patients who underwent isolated aortic valve replacement, were subjected to a prospective comparative study, were compared. In group A (n = 15) minimally invasive right anterior mini-thoracotomy approach and in group B (n = 15) conventional median sternotomy approach had been used.

Results

The second group had much higher total morbidity than the first. In group A, blood loss was 335.3 ± 174.5, while in group B, it was 633.3 ± 179.9. In group B, postoperative discomfort was much higher. In both groups, inotropes were determined to be negligible. Group B had a longer total hospital stay (101.7 days) than group A (5.60.6 days).

Conclusion

In patients undergoing isolated aortic valve replacement, a right anterior mini-thoracotomy lowers postoperative pain, the requirement for blood transfusions, assisted ventilation time, and hospital stay.

Keywords: Aortic valve replacement, minimally invasive, right mini-thoracotomy

Introduction

For many years, median sternotomy has been the conventional method for all forms of open heart surgery, as it affords excellent access to the heart. However, it is linked to a high rate of morbidity such as severe pain due to traction of the ribs and thoracic ligaments. Also, it is associated with high risk of bleeding and sternal wound infection, which frequently necessitates debridement and cosmetic surgery reconstruction and can result in mortality [1].

As new technologies and instrumentation become available, minimally invasive heart valve operations are becoming more popular. Several procedures and techniques have already been proposed, but most of them are geared to primary valve surgery.

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Because of the diffuse mediastinal and pericardial adhesions, reoperative procedures are more difficult, but they also present an opportunity. Procedures that are 'minimally intrusive' may be the most beneficial [2]. A big incision expands the surgeon's operative field, but it comes at the cost of increased morbidity and death. The unbroken sternum, on the other hand, will maintain

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the chest wall's integrity, improving sternal stability, and allowing for earlier extubation, especially in obese patients [3].

The morbidity associated with the midline technique can be reduced with minimal access aortic valve surgery. Despite the reduced surgical field, the aortic valve is remarkably well exposed [4].

Aim

The aim of this study is to compare the early outcome (6 months postoperatively) of traditional sternotomy versus the less invasive right anterior mini-thoracotomy technique in patients with isolated aortic valve disease requiring aortic valve replacement (AVR) according to inclusion criteria.

Patients and methods

A prospective comparative study included 30 patients who underwent aortic valve surgery in between March 2019 and June 2021 at the National Heart Institute. They were divided into two groups:

(1) Group A: included 15 patients who underwent aortic valve surgery through right anterior mini-thoracotomy via cardiopulmonary bypass using femoral artery and femoral vein cannulation.
(2) Group B: included 15 patients who underwent aortic valve surgery through conventional median sternotomy.

The patients were followed up for 6 months. Approved in ethical committee on 10th of February, 2019.

Inclusion criteria

Patients with isolated aortic valve disease requiring AVR surgery.

Exclusion criteria

(1) Patients with other valvular diseases other than isolated aortic surgery.
(2) Combined cardiac disease (valvular, congenital, or ischemic heart disease).
(3) Emergency cases.
(4) Redo cases.
(5) Patients have significant pulmonary hypertension.
(6) Preoperative comorbidities (hepatic, renal, pulmonary, etc.).

Preoperative evaluation

(1) Informed consent, history taking, clinical examination.
(2) Routine investigations:
    (a) Routine preoperative laboratory investigations, ECG, radiological examination, echocardiography, preoperative transesophageal echocardiogram (TEE), coronary angiography for patients above 40 years.
    (b) Respiratory function tests.

Operative procedures

Anesthesia: the patient is prepared for AVR as usual. The procedure is carried out under general anesthesia. The patient is sedated and intubated. For single (left) lung ventilation, a double-lumen endotracheal tube can be utilized in group A. A probe for transesophageal echocardiography is inserted.

In group A, the patients are positioned supine and an air sack is put under the right scapulae to allow the surgeon to shift the patient's right chest upward or lower throughout the surgery as needed for a greater working field exposure. The patient's anterior and right lateral chest walls, as well as both groin areas, are draped.

Surgical approach

The surgery is carried out in group A through an incision in the right second or third intercostal region. The medial angle of the incision is positioned lateral to the right internal mammary artery, which is 1.5–2 cm laterally to the sternal border, and lateral angle considering the other mean length of incision of 6–10 cm, which varies in various patients.

The pericardium is incised, and stay sutures are put on the incised pericardium's lateral edge. The workplace environment is well lit.

Preparation is started on the groin. Both femoral vein and femoral artery were exposed and cannulated guided by TEE.

The intervention will proceed as usual. The cannula for the aortic root has been inserted. To ensure a bloodless field, a venting cannula is inserted into the right superior pulmonary vein.

The cardioplegia is administrated in a conventional manner.

Myocardial protection is originally provided through a flexible angulated cross-clamp. Cardioplegia is administered as a single dose/shot of crystalloid solution (Custodiol) into both coronary ostia antegradely.

In group B: conventional aortocaval cannulation was done.

Data recorded

(1) Operative time.
(2) Time of aortic cross-clamp and extracorporeal circulation.
(3) Demographic data and clinical characteristics.
(4) Inotropes.
(5) Echocardiographic finding.
(6) Pulmonary function test.

Postoperative data

ICU stay, ventilation, inotropic agents when indicated and postoperative echocardiography.

Judgment criteria

(1) The main judgment criteria will be:
(a) Vital signs (blood pressure, temperature, pulse, urine output, and oxygen saturation).
(b) ECG first day, 48 h, and end of the first week.
(c) Echocardiography.
(d) Pulmonary function test.

The postoperative echocardiography

An echocardiography was done before discharge to monitor:

(1) Left ventricular end-diastolic dimension (LVEDD) and left ventricular end-systolic dimension (LVESD).
(2) Postoperative ejection fraction (EF).

Results

This study was to compare the procedure and early postoperative outcome (6 months postoperatively) of the standard sternotomy approach versus the minimally invasive approach through the right anterior mini-thoracotomy technique.

Demographic data

Table 1.

Preoperative data analysis

Tables 2 and 3.

Operative analysis

Tables 4–6.

Postoperative data analysis

Tables 7 and 8.

There were four (26.7%) individuals in group 'A' who had problems. Two (13.3%) patients experienced postoperative arrhythmias, although both were able to recover and return to normal sinus rhythm. One (6.7%) patient had right-sided acute respiratory distress syndrome (ARDS) with right-sided entire lung collapse, which responded to medical and physiotherapy and resolved completely on the fifth day after surgery. One (6.7%) patient had a skin-only superficial wound infection that was treated with regular dressings and medicines (Table 8).

Two (13.4%) instances in group 'B' had postoperative problems. One (6.7%) patient experienced atrial arrhythmias after surgery, which went away 4 weeks later. One (6.7%) patient had superficial wound infection involving only the skin and responded to frequent dressing and antibiotics (Tables 9 and 10).

Table 1: Age and sex of both groups

	Group A (mean±SD)	Group B (mean±SD)	*P*
Age (years)	53.88±17.80	51.36±18.05	NS
Male	6	7	NS
Females	9	8	NS

P value less than 0.05 is considered significant.

Table 2: Preoperative echocardiography in both groups

Pre-echocardiography	Group A (mean±SD)	Group B (mean±SD)	*P*
EF%	57.92±10.45	54.64±12.87	NS
EDD	5.3±0.56	5.49±0.71	NS
ESD	3.58±0.68	3.75±0.7	NS
Left atrial dimension	4.3±0.7	3.9±0.6	NS
Pulmonary artery pressure	42.7±7.7	32.6±4.7	NS

EDD, end diastolic dimension; EF%, ejection fraction %; ESD, end systolic dimension. *P* value less than 0.05 is considered significant.

Table 3: Preoperative NYHA classification

Preoperative NYHA classification	Group A	Group B	*P*
I	3	1	NS
II	8	9	NS
III	4	5	NS
IV	0	0	NS

Discussion

Our findings suggest that minimally invasive AVR using the right anterior mini-thoracotomy method is a safe and reproducible operation with low postoperative mortality and morbidity, as well as good midterm survival. Patients who underwent AVR by a right anterior mini-thoracotomy had a lower rate of postoperative blood transfusions, as well as a shorter ventilation time and postoperative length of stay than those who underwent AVR using a normal median sternotomy.

Despite an increase in the number of older patients and individuals with major comorbidities, AVR mortality and postoperative complications have significantly improved over the last decade [5]. However, as new technologies as surgical and anesthetic techniques have improved, minimally invasive surgery has become a safe and effective treatment option with higher patient satisfaction [6].

Minimally invasive AVR has been found to reduce postoperative complications, resulting in a speedier recovery, a shorter hospital stay, less pain, better cosmetic results, and, as a result, fewer hospital resources being used. Bonacchi *et al*. [7] reported that minimally invasive AVR reduced blood transfusions, mechanical ventilation, and hospital stay in small randomized experiments.

In a meta-analysis of 4667 patients undergoing isolated AVR, the study found that those who received any minimally invasive procedure benefited in terms of perioperative mortality, ICU and hospital stay, and ventilation time, despite the fact that the cross-clamp and cardiopulmonary bypass times were longer [8]. Brown *et al*. [9] have also recently verified these findings after a comprehensive review and meta-analysis of 26 studies with a total of 4586 patients receiving mini-sternotomy or conventional approach. The researchers concluded that mini-sternotomy was linked to shorter ventilation times, critical

Table 4: Difference of total operative time, cross-clamp, and total bypass time in both groups

	Group A (mean±SD)	Group B (mean±SD)	*P*	
Cross-clamp (min)	73.3±28.5	51.7±12.5	0.007*	Significant
Total bypass time (min)	115.7±30.2	73.7±14.7	<0.001*	Highly significant
Total operation time (mean±SD) (min)	249±22.7	210±38.4	0.023*	Significant

*Statistically significant, *P* value less than 0.05 is considered significant.

care unit and hospital stays, and reduced blood loss within 24 h, according to the findings [9].

Despite these encouraging findings, the majority of these studies' findings have centered on mini-sternotomy. The potential benefits of minimally invasive AVR using the right anterior mini-thoracotomy method have only been studied in a few trials. Several case series have reported minimal rates of AF and favorable results in terms of mortality and postoperative sequelae, blood transfusions, artificial ventilation, and the length of time spent in the hospital after surgery [6]. However, as compared with traditional surgery, these advantages were not as obvious.

Ruttmann *et al*. [10] observed no difference in postoperative early outcomes in a propensity score matched study, but did find a longer postoperative ventilation time and a trend toward a higher prevalence of renal insufficiency in patients undergoing RT mini-thoracotomy. The absence of benefits of minimally invasive AVR was most likely due to the fact that the matched minimally invasive AVR group had a higher number of older patients. It is widely recognized that getting older increases the risk of postoperative AF, as well as renal and pulmonary problems [10].

In contrast, Sharony *et al*. [11] discovered that patients undergoing minimally invasive AVR through RT mini-thoracotomy (90% of total) or mini-sternotomy had a shorter postoperative length of stay and a higher proportion of patients discharged directly home than those undergoing conventional sternotomy in a larger and well-propensity matched cohort [11].

Furthermore, patients in the RT group were extubated sooner and required fewer blood transfusions, according to our findings. The smaller incision, preservation of the sternum, and integrity of the costal cartilages would lessen postoperative pain, improve respiratory function, and cause less AF. De Smet *et al*. [12] discovered that minimally invasive AVR was linked to a decreased rate of AF after AVR. Furthermore, reduced dissection of other places might lower the risk of bleeding and blood transfusions, albeit no change in chest reopening was seen.

Our results regarding the length of operative time were different from that of the study of Olds *et al*. [13]. The study included 503 patients which claimed that the mini-thoracotomy approach showed decreased operative times besides other benefits in decreasing lengths of stay, decreased incidence of prolonged ventilator time, and a trend toward lower mortality when compared with mini-sternotomy and conventional sternotomy [13].

Our data were similar to that of the Alassal *et al*. [8] study regarding the superiority of right mini-thoracotomy approach in decreasing postoperative pain and hospital stay.

Also, our results agree with the Mohammed *et al*. [14] study regarding that the right mini-thoracotomy approach not only has better cosmetic outcome, but also minimize harm to patients by reducing blood loss, amount of blood transfusion, postoperative infection by minimizing wound dimensions, and shortening the patient's ICU and hospital stay.

The introduction of sutureless devices is likely to shorten operative times, making this treatment even easier and more consistent. The RT mini-thoracotomy technique may be considered an alternative to Trans Aortic Valve Insertion (TAVI) for high-risk patients due to the excellent postoperative outcomes associated with the least invasive approach. Zierer *et al*. [15] reported similar early mortality and morbidity among patients following TAVI and minimally invasive AVR procedures in a retrospective investigation.

The Placement of Aortic Transcatheter Valve (PARTNER) trial (Smith, CR, Leon, MB) found that transcatheter AVR is not inferior to conventional surgery in terms of early mortality and 1-year survival. TAVI operations, on the other hand, were linked to a higher rate of vascular complications, as well as an increased risk of embolic stroke and paravalvular leakage. There were no vascular problems in our series, and the lower risk of postoperative stroke and paravalvular leakage make right anterior mini-thoracotomy a safe technique and a feasible alternative to TAVI [16].

Finally, individuals who had less invasive AVR took longer cardiopulmonary bypass and aortic cross-clamping time than

Table 5: Patients requiring inotropic, DC shock during weaning from cardiopulmonary bypass

	Group A [*n* (%)]	Group B [*n* (%)]	*P*
DC shock	5 (33.3)	6 (40)	NS
Inotropic support	10 (60)	11 (73.3)	NS

NS, non significant; *P* value less than 0.05 is considered significant.

Table 6: Operative and postoperative parameters in both groups that show the superiority of minimally invasive surgery

	Group A (mean±SD)	Group B (mean±SD)	*P*	
Length of skin incision (cm)	7.1±2.4	21.1±2.2	>0.001*	Highly significant
Ventilation (h)	2.6±0.5	6.3±2.2	>0.001*	Highly significant
Blood loss (ml)	335.3±174.5	633.3±179.9	0.001*	Highly significant
Blood transfusion (unit)	0.7±0.8	1.6±0.6	0.002*	Highly significant
5th day postoperative pain	2.5±0.6	5.6±0.7	>0.001*	Highly significant
Total hospital stay (day)	5.6±0.6	10±1.7	>0.001*	Highly significant

*Statistically significant, *P* value less than 0.05 is considered significant.

Table 7: Inotropic need in both groups

	Group A	Group B	*P*
Inotropes	7	6	NS

Inotropes were found to be nonsignificant in both groups. NS, non significant; *P* value less than 0.05 is considered significant.

Table 8: Postoperative complications of both approaches

Postoperative complications	Group A [*n* (%)]	Group B [*n* (%)]	*P*
No complications	11 (73)	13 (86)	NS
Arrhythmias	2 (13.3)	1 (6.7)	NS
ARDS	1 (6.7)	0	NS
Superficial wound infection	1 (6.7)	1 (6.7)	NS
Mortality	0	0	NS

There was no statistically significant difference as regards postoperative complications in both groups.

Table 9: Postoperative echocardiography in both groups after 3 months

Postoperative echocardiography	Group A (mean±SD)	Group B (mean±SD)	*P*
EF%	55.8±8.8	52.64±10.65	NS
EDD (cm)	5.21±0.70	5.2±0.88	NS
ESD (cm)	3.6±0,749	3.64±0.829	NS
Left atrial dimension	4.1±0.5	3.8±0.6	NS
Pulmonary artery pressure	37.6±7.3	31.6±3.5	NS

EDD, end diastolic dimension; EF%, ejection fraction %; ESD, end systolic dimension. *P* value less than 0.05 is considered significant.

Table 10: Postoperative echocardiography in both groups after 6 months

Postoperative echocardiography	Group A (mean±SD)	Group B (mean±SD)	*P*
EF%	57.8±6.8	54.54±9.45	NS
EDD (cm)	4.51±0.30	5.1±0.28	NS
ESD (cm)	3.3±0.5	3.4±0.6	NS
Left atrial dimension	4.0±0.2	3.7±0.4	NS
Pulmonary artery pressure	36.6±6.3	30.4±3.3	NS

EDD, end diastolic dimension; EF%, ejection fraction %; ESD, end systolic dimension. *P* value less than 0.05 is considered significant.

those who had a full sternotomy. This was a limitation of our approach, implying that exposing and implanting the prosthetic valves is more difficult than the standard method. However, we identified no problems as a result of the prolonged operational periods, and our findings are consistent with earlier researches.

Conclusion and recommendation

To conclude, in patients undergoing isolated AVR, a right anterior mini-thoracotomy lowers postoperative pain, the requirement for blood transfusions, assisted ventilation time, and hospital stay. Our findings suggest that cardiac surgery is still debatable in terms of cost-effectiveness, making econometric analysis a critical component of any future assessment of innovative cardiovascular therapy. Additional multicenter investigations are needed to corroborate our findings.

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Conflicts of interest

There are no conflicts of interest.

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