Original Article

Minimally Invasive Aortic Valve Replacement Does Not Reduce the Incidence of Postoperative Atrial Fibrillation

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Abstract

Objective: Due to an aging population needing aortic valve replacements (AVR), there is a growing need for minimally invasive cardiac surgery aimed at reducing operative trauma and peri-operative morbidity. Large case series have reported minimally invasive (MI) AVR to be a good alternative to median sternotomy AVR with faster recovery and reduced morbidity. Our aim is to review our early experiences with MI AVR and compared that to full sternotomy (FS) AVR.

Methods: We performed 35 cases of MI AVR and 62 cases of FS AVR from January 2012 to September 2014. Prospectively collected perioperative data was analysed retrospectively. MI AVR consisted of 7 right anterior thoracotomy and 28 partial sternotomy cases. All patients were followed up in accordance with the Australian and New Zealand Society of Cardiac and Thoracic Surgeons (ANZSCTS) database requirements.

Results: The mean age for FS and MI was 70 and69 years respectively. FS cohort had a shorter mean cardiopulmonary bypass time (86 vs. 104 minutes; p=0.003) and aortic cross clamp time (70 vs. 84; p=0.002). Mean ventilation time favoured the MI group at 8.6 hours compared to 12 for the FS group (p=0.03.4). MI patients trended towards less postoperative inotrope requirements, lower postoperative creatinine, and lower postoperative atrial fibrillation rates. There have been no wound breakdowns to date. There were no operative mortalities.

Conclusion: MI AVR can be performed safely and with equivocal results compared with FS AVR. MI AVR is a good alternative to the traditional median sternotomy approach with potential for improved post-operative recovery.

Key Words: Aortic Valve Replacement, Minimally invasive

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Introduction

In the western world, the commonest acquired heart valve disease is Aortic stenosis (AS). It is generally a result of a myriad of degenerative changes associated with native annular and leaflet calcification. The Gold Standard for treatment of AS remains a surgical aortic valve replacement (AVR). Prior to the first report of minimally invasive (MI) cardiac surgery for AVR in the 1993 by Rao et al[1], all AVR procedures were performed via a median sternotomy with direct arterial cannulation of the distal ascending aorta and right atrial venous cannulation for cardiopulmonary bypass (CPB). Enthusiasm and popularity for MI AVR grew in the late 1990s as an alternative to a traditional full sternotomy (FS) for patients with isolated aortic valve disease. Various techniques have been described including: parasternal, infra-axillary, lower hemi-sternotomy, transverse sternotomy, upper hemi-sternotomy, and right anterior thoracotomy. Today, the vast majority of MI AVR cases globally are performed using either an upper partial sternotomy extending into the 2nd, 3rd, or 4th intercostal spaces (referred to as a "J", "L", or inverted "T") or a right anterior (parasternal) thora cotomy (RAT) at the 2nd intercostal space[2-5].

Benefits of MI AVR, which include improved cosmesis, reduced pain, reduced surgical trauma, reduced blood loss, reduced transfusion requirements, shorter ventilation times, earlier functional recovery, shorter ICU and inpatient hospital stay, have been shown in numerous reports[6-9]. As such, many large cardiac surgical institutions have adopted MI AVR as the preferred approach for all isolated AVR procedures. As experience in MI AVR has developed over the past decade, there are growing reports of extending the scope of MI AVR to include redo patients, concomitant mitral and/or tricuspid valve, or aortic procedures[10,11]. Despite this, widespread acceptance of MI AVR has been slow in Australia. There are concerns of increased

CPB and aortic cross-lamp times due to limited access, which are predictive of worse outcomes in cardiac surgery. Other concerns include the significant learning curve required to adopt a new surgical technique and uncertainty in the "real world" benefits of MI techniques.

In this paper, we report outcomes of MI AVR cases performed at our institution from January 2012 to September 2014 and compare that to conventional FS AVR cases during this same time period.

Methods

This is a retrospective observational cohort study of all isolated aortic valve replacement procedures. Data is collected prospectively for all patients undergoing cardiac surgery at our institution in accordance with the Australian and New Zealand Society of Cardiac and Thoracic Surgery (ANZSCTS) database. Follow-up is obtained by phone call at 30 days after the date of operation.

All AVR cases from January 2012 to September 2014 were identified from our database retrospectively. Cases where concomitant procedures such as coronary artery bypass grafting, mitral or other valve surgery, replacement of the ascending aorta, or atrial fibrillation ablation had been performed were excluded for analysis. Patients who had previous surgery or had a history of postoperative atrial fibrillation were also excluded from the analysis.

Surgical Technique

Partial Sternotomy (PS)

We used an upper partial sternotomy from the jugular notch through a 7-9 cm skin incision. The sternum was divided in the midline and subsequently transected horizontally into the 2nd to 4th intercostal spaces, either unilaterally to the right or bilaterally. The right internal mammary artery was divided if necessary. Thymic fat was dissected as via FS, pericardiotomy performed and pericardial sutures are placed and retracted. The patient was fully heparinized and the ascending aorta was palpated for safe cannulation sites. Venous drainage was achieved with either venous cannula inserted into the right atrial appendage or by inserting a long multi-stage right atrial venous cannula through the right femoral vein. Cardiopulmonary bypass was initiated and the aorta was directly cross-clamped. Antegrade and retrograde cold blood cardio plegia was given and, if aortic insufficiency is present, direct ostial cardioplegia was given after performing the aortotomy.

Right Anterior Thoracotomy (RAT)

We created a 5 cm parasternal incision over the 2nd or 3rd intercostal space and entered the pleural cavity. The costalchondral cartilage may be divided at the sternal edge to allow a larger operative field. The pericardiotomy was performed, sutures placed, and pericardium is retracted. The patient was fully heparinized and was then cannulated via the femoral artery and veins with continuous guidance with Transoesophageal echocardiography. Cardiopulmonary bypass was initiated, the aorta was then clamped and antegrade cold blood cardioplegia is given. If aortic insufficiency was of concern, direct ostial cardioplegia was given after performing the aortotomy.

Patient Selection

The decision of whether patients undergoes a MI AVR or a FS was at the sole decision of the surgeon and patient. We performed an additional non-contrast CT scan for patients who are being considered for a RAT approach.

Statistical Analysis

Categorical variables were analysed using chi-squared or fisher exact tests where appropriate. Continuous variables were conducted using a t-test and are presented as means ± standard error of the mean (SEM) or medians and inter-quartile ranges as appropriate. All analyses were performed using STATA v13.1.

Results

We identified 97 AVR cases that matched our criteria for this analysis. There were 62 AVR cases performed via a full sternotomy (FS) and 35 performed with a minimally invasive (MI) approach. The MI AVR cases were comprised of 28 PS and 7 RAT. Preoperative characteristics for the FS and MI cohorts were generally well balanced for heterogeneity as shown in Table 1. The only baseline characteristic that was statistically significant was BMI where the MI group had a mean BMI of 22 kg/m^2 as compared with 32 kg/m^2 for the FS group ($P=0.013$). The MI group had a higher proportion of males (71% vs. 52%), however this was not statistically significant.

The mean age for the FS and MI AVR groups were 70 and 69, respectively. Infective Endocarditis represented 8% of patients in the FS group but none in the MI group. In addition, the FS group had a higher proportion of peripheral vascular disease (8% vs. 3%), previous cerebrovascular accident (5% vs. 0%), lung disease (13% vs. 6%), and patients with a NYHA class of 3 or 4 (34% vs. 20%). Preoperative diabetes, hypercholesterolemia, eGFR and BSA were all well balanced between the 2 cohorts.

Mean intraoperative cardiopulmonary bypass times in the FS and MI groups were 86 and 104 minutes, respectively ($p=0.003$). Similarly mean cross clamp times for FS and MI cohorts were 70 and 84 minutes ($p=0.002$), respectively, shown in Table 2. Only 1 patient required an intra-aortic balloon pump, which was in the FS group. In the intensive care unit, patients in the MI group were significantly quicker to wean off ventilation with a mean ventilation time of 8.6 hours compared to FS where mean ventilation was 12 hours ($p=0.034$). Although it was not statistically significant, mean ICU length of stay was also shorter in the MI group compared to the FS group, being 28 hours and 41 hours respectively ($p=0.187$). In addition, MI group had a slightly reduced incidence of red blood cell and non-red blood cell products transfusion. However, drainage output were significantly higher in the MI group with average 4-hour drainage output of 217 ml compared with 146 ml in the FS group ($p=0.047$). Three patients were required to return to theatre for bleeding, comprising of 2 in the FS group and 1 in the MI group. MI patients showed lower incidence of inotrope use of more than 4 hours for low cardiac output compared at 11% compared to 27% for FS patients (p=0.066). Similarly, other postoperative outcomes were also not statistically different between the FS and MI group (Table 3). However, there was a trend towards lower postoperative creatinine in the MI group (mean: 105 umol/L vs. 126 umol/L). The incidence of postoperative atrial fibrillation was 37% in the FS and slightly less at 29% in the MI group, however this was not statistically significant (p=0.395).

Table 1 : Baseline characteristics

Baseline Characteristics	**FS (n=62)**	**MI (n=35)**	**P value (≤)**
Age (years)	70±1.4	69±1.8	0.848
Male sex	32	25	0.057
Smoking (current)	38 (5)	24 (7)	0.473 (0.086)
Family History of CAD	21	9	0.629
Diabetes	14	9	0.727
Hypercholesterolemia	30	19	0.577
CVD	3	0	0.186
PVD	5	1	0.307
Lung Disease	8	2	0.263
Infective Endocarditis	5	0	0.085
Heart Failure (at time of surgery)	11 (4)	7 (1)	0.784 (0.442)
HYHA 3 or 4	21	7	0.148
eGFR (ml/kg/min)	85±4.7	80±5.7	0.556
Preoperative Creatinine(umol/L)	92±4.3	92±4.9	0.999
BMI (kg/m^2)	32±0.84	28±1.0	**0.013**
BSA (m^2)	1.94±0.028	1.93±.0.43	

Continuous variables are reported as mean±stand error of the mean (SEM) and discrete/categorical variables are reported as whole numbers where statistically significant results are those with p<0.05

FS = Full sternotomy; MI = Minimally Invasive; BMI = Body mass index; BSA = Body surface area; CVD = Cerebrovascular disease; PVD = Peripheral vascular disease; CAD = Coronary artery disease; HYHA = New York Heart Association; eGFR = estimated Glomerular Filtration Rate

Table 2 : Intraoperative& ICU Characteristics

Intraoperative & ICU Characteristics	**FS (n=62)**	**MI (n=35)**	**P value (≤)**
Cardiopulmonary Bypass Time (minutes)	86±3.0	104±5.3	**0.003**
Cross Clamp Time (minutes)	70±2.5	84±4.4	**0.002**
ICU stay (hours)	41±7.1	28±3.6	0.187
Ventilation (hours)	12±1.1	8.6±0.96	**0.034**
Prolonged ventilation > 24 hours	6	1	0.213
4-hour drain output	146±17	217±20	0.470
Red Blood Cell Transfusion (incidence)	16	5	0.186
Non-Red Blood Cell Transfusion (incidence)	13	9	0.592
Return to Operating Theatre	2	1	0.920
Re-intubation	1	1	0.679
Perioperative Cardiogenic Shock	1	0	0.450
Inotropes longer than 4 hours post-op	20	8	0.326
- For low cardiac output	17	4	0.066
- For low SVR	13	6	0.649
IABP requirement	1	0	0.570

Continuous variables are reported as mean ± stand error of the mean (SEM) and discrete/categorical variables are reported as whole numbers where statistically significant results are those with p<0.05

FS = Full sternotomy; MI = Minimally Invasive; ICU = Intensive care unit; IABP = Intra-aortic Balloon Pump

Table 3 : Postoperative Outcomes

Postoperative Outcomes	FS (n=62)	MI (n=35)	P value (≤)
New renal failure	3	1	0.637
- Dialysis	3	1	0.637
- Post-operative Creatinine (umol/L)	126±7.1	108±4.2	0.077
New PPM requirement	5	2	0.885
Cardiac Arrest	1	0	0.450
CVA/TIA	0	0	-
Pulmonary Embolism	0	1	0.181
Pneumonia	1	0	0.450
Deep sternal wound infection	0	0	-
Post-operative Atrial Fibrillation	23	10	0.395
Postoperative length of stay (days)	7.7±0.6	6.8±0.3	0.168
Readmission	3	3	0.440
Mortality at 30 days	1	1	0.637

Continuous variables are reported as mean ± stand error of the mean (SEM) and discrete/categorical variables are reported as whole numbers where statistically significant results are those with $p<0.05$

FS = Full sternotomy; MI = Minimally Invasive; SVR = Systemic vascular resistance; CVA = Cerebrovascular accident; TIA = Transient ischaemic attack;

Discussion

Minimally invasive cardiac surgery represents a significant change in the approach to traditional procedures. Benefits of MI AVR have been reported widely after increasing popularity in the past decade. This is often without increases in mortality or serious morbidity. Despite this, skepticism of MI techniques remains and some require further evidence of reported benefits.

We have described a local experience after introducing MI AVR techniques with the associated learning curve at a regional tertiary cardiac referral centre in Australia. Although our series is small in comparison to many European and North American reports, our progression through the MI learning curve is undoubtedly comparable[12].

The major finding of our study is a reduction in ventilation time, which has essentially been a universal result from contemporary papers in MI AVR. This has been widely attributed to reduced postoperative pain resulting in faster recovery in breathing mechanics and mobilization. We also noticed trends in reduced ICU length of stay, and RBC transfusion rates in MI AVR patients, although these did not achieve statistical significance, most likely due to a small sample have also reported reduced RBC transfusion rates base on the principle of reduced dissection in MICS leading to less bleeding.

Our MI cases resulted in longer cardiopulmonary bypass and cross-clamp times when compared with the FS counterparts. This is most likely due to restricted access and increased surgeon caution present for all new techniques. Specifically for our cohort, the majority of MI patients would have been part of the learning curve inherent in all new procedures. Our results are consistent with current literature, albeit a much smaller series of MI AVR cases[3,4,13,14].

It was surprising that we did not show a trend towards reducing POAF, which had been reported other series[15]. However, a recent meta-analysis by Phan et al also did not yield a difference in POAF between FS and MI AVR cases[16]. Postoperative atrial fibrillation is a complex multifactorial entity, however studies showing reduced POAF rates is certainly based on improvements on other patients' perioperative parameters. Although we have not seen differences in POAF rates, as the most common adverse event after cardiac surgery, it is a potential for additional benefits of MI AVR.

Partial sternotomy offers the surgeon with a familiar view and access, albeit smaller, and almost universally regarded as a technique with an easier learning curve when compared with a RAT. In addition, there are no further investigations necessary for patient selection with PS MI AVR.

From our experience to date, we believe a PS access is a safe approach to the introduction of MI AVR to a cardiac surgical unit. With increased experience and familiarity with MI access, RAT can be introduced safely and seamlessly.

Study Limitations

This study is subject to all the limitations of a single center experience retrospective observational cohort study. Relatively small numbers of our study may bring into question its generalizability. Reported cases are inclusive of all our MI AVR experience and include cases which were part of our learning curve. Therefore, our results may underestimate the benefits of MI AVR, which larger series and meta-analysis have shown.

Conclusion

MI AVR is more technically demanding when compared with traditional sternotomy AVR, especially during the initial learning curve. Despite this learning curve MI AVR via a partial sternotomy or RAT can be performed safely and effectively. Peri-operative outcomes in these patients are at least similar to FS AVR. MI AVR is becoming increasingly accepted and with our aging population. MI AVR should be considered for all patients requiring an AVR.

The authors declare no conflict of interest.

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