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CENTRAL CANNULATION AN ALTERNATIVE TO PERIPHERAL VESSEL CANNULATION FORAORTIC VALVE REPLACEMENT THROUGH RIGHT THORACOTOMY AND ITS COMPARISON WITH CONVENTIONAL MIDLINE APPROACH

Dr Sunil Dixit , DrVikram Watti , Dr Mohit Sharma, Dr Anil Sharma, Dr Rajkumar Singh Jat

Associate Professor,Department of Cardiothoracic and vascular surgerySMS Medical College, Jaipur
drsunildixit@yahoo.com

1. (Corresponding Author)Assistan Professor,Department of Cardiothoracic Trauma and EmergencyAll India Institute of Medical Sciences, Bhopal
drvikramwatti@gmail.comPhone: (+91) 9755299995

Assistant Professor,Department of Cardiothoracic and Vascular surgerySMS Medical College, Jaipur
mohit@gmail.com

Professor and Head Department of Cardiothoracic and vascular surgerySMS Medical College, Jaipur
asharma.1961@yahoo.com

Assistant Professor Department of General surgery,Gandhi Medical College, Bhopal
drrajkumarjat01@gmail.com

ABSTRACT

Background

Midline sternotomy is consider as conventional approach for aortic valve replacement surgeries. However, sternum disruptions are responsible for increased rate of postoperative bleeding, pain and wound infection leading to longer hospital stay and patient discomfort. Right anterolateral thoracotomy with central cannulation is a minimal invasive approach can be used as an alternative over standard midline sternotomy procedure for aortic valve replacement (AVR) surgeries in developing or underdeveloped countries.

Objective

To compare and analyze the intraoperative and postoperative surgical outcomes of patients undergoing aortic valve replacement through right anterolateral thoracotomy by central cannulation with conventional midline sternotomy. To find out utility and cost effectiveness of thoracotomy for aortic valve replacement even in center's that are not dedicated for minimal invasive cardiac procedures. To find out advantage of limited anterolateral thoracotomy with central cannulation over midline sternotomy and other minimal invasive approaches which requires multiple incision with peripheral cannulation.

Methods

This is a facility based cross sectional study of 120 patients undergoing aortic valve replacement during the

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study period of 3 years in a tertiary care hospital. Patients with any co-morbidity or history of any previous surgery (mentioned in the main text) are excluded from the study. Very strict inclusion criteria are used in order to avoid any effect modifications. Based on the surgical approach, the study cohort was divided into right anterolateral thoracotomy group and midline sternotomy group with 60 patients in each respective group. A comparison of intraoperative and postoperative outcome was carried out.

Results

The mean age in the thoracotomy group was 26.03±6.014 years and in the midline sternotomy group was 56.07±10.03 years. The study cohort comprised of 92 (76.7%) males and 28 (23.3%) females. Mean body surface area in thoracotomy group and midline sternotomy group was 1.46±0.16 m2 and 1.62±0.27 m2 respectively. The mean bypass time, aortic cross clamp time and mean operating time in the midline sternotomy group was higher as compared to the thoracotomy group ($p<0.05$). Duration till mobilization, ICU stay and hospital stay was shorter in thoracotomy group ($p=0.000$). Wound infection, scar formation and readmission were observed to be higher among patients in the midline sternotomy group than the thoracotomy group ($p<0.05$).

Conclusion

Minimal invasive AVR by single incision such as right anterolateral thoracotomy with central cannulation is an excellent option when compared to conventional midline sternotomy approach. This not only exclude the issues related to midline sternotomy but also avoids multiple incisions and requirement of peripheral cannulation used currently for minimal invasive aortic valve replacement.

Keywords

Minimally invasive surgery, Aortic Valve replacement, Right mini thoracotomy, midline sternotomy, Central cannulation.

INTRODUCTION

Median sternotomy is routinely performed conventional method for aortic valve replacement (AVR) which allows good visualization, exposure and better working field. However, the development of post-sternotomy wound infections and scar formation remains a major disadvantage. In recent era, minimally invasive valve approach had made a breakthrough in terms of smaller incision and early recovery. However, they have been associated with an increased use of peripheral vessel cannulation and a separate incision for aortic cross clamp. Minimally invasive valve approach are associated with potential problems at the cannulation site, including perforation or rupture of the vessels and intimal tear with retrograde dissection. In this study we have avoided the groin incision for peripheral cannulation and used the single thoracotomy incision for aortic cross clamp and for central cannulation, it prevents the postoperative complications in the groin area as well as avoid the separate incision for aortic cross clamp usually used in patients undergoing AVR through minimal invasive approach.

Right anterolateral thoracotomy is superior over conventional midline sternotomy in terms of no sternal disruption or infection with significantly less wound burden, reduced ventilation time, reduced pulmonary complications, decreased use of blood and blood products comparable cross clamp and pump time, decrease postoperative pain, cosmetic satisfaction and cost effectiveness [1-4]. The objective of this study is to evaluate the intraoperative and postoperative surgical outcome of right anterolateral thoracotomy with central cannulation using conventional instruments in AVR and compare outcomes with standard midline sternotomy

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approach.

MATERIAL AND METHODS

This study was conducted in tertiary care hospital for 3 years in an effort to share and compare our institutional experience of minimal invasive approach for aortic valve replacement with conventional median sternotomy. Prior to study, ethical clearance was obtained from institutional Ethical committee and Research review board with certificate number 3465MC/EC/2017. A detailed preoperative assessment and high resolution computed tomography scan for anatomical evaluation of aortic valve and the ascending aorta is done in all patients required to undergo AVR. All the potential risks and benefits of available approaches were explained to patients and relatives and a written informed consent was obtained. Patients with ejection fraction >40 % were included in the study. Those patients with an associated lesion, complex ascending aortic pathology, atheromatous aorta, lung pathology, patients who were intubated pre-operatively due to any emergency condition, patients with any previous cardiac intervention or those undergoing redo surgery, previous thoracotomy procedure or those with an aortic stent, patients with preoperative ionotropic support, arrhythmia, cardiogenic shock, low ejection fraction, deranged renal and liver profile, diabetes mellitus, patients with infective endocarditis and immunocompromised patients were excluded from the study. After considering all the inclusion and exclusion criteria a total of 60 patients were recruited for the study, who were then divided into 2 groups based on the surgical approach into right anterolateral thoracotomy and midline sternotomy group having 60 patients in each group respectively. Baseline patient variables such as, age, sex, body surface area, type of pathology, New York Heart Association class III/IV functional status, left ventricular ejection fraction, were recorded.

Operative Procedure

Patient receiving an aortic valve replacement through midline sternotomy approach underwent direct arterial cannulation in the distal ascending aorta with a standard arterial cannula with bi-caval venous cannulation as a conventional method. The right anterolateral thoracotomy approach was performed with a 6-8 cm-long skin incision over the second or third intercostal space as per the exposure of ascending aorta and right atrium for arterial and venous cannulation respectively. Pericardium was opened 2-3 cm medial to left phrenic nerve. Arterial cannulation was performed with a straight shot (Edwards Life sciences) cannula, inserted through a double purse string suture placed in the aortic arch, while a two stage single venous cannula (Medtronic) was placed in the right atrium through right atrial appendage. A plane between the aorta and pulmonary artery is dissected for proper visualization of aortic valve and to facilitate the aortic closure. Aorta was cross-clamped at the origin of the innominate artery with a Chitwood-De Bakey clamp. Delnido cold cardioplegia 4°C was administered in an antegrade fashion in to the aortic root in to the coronary ostia following which cardiopulmonary bypass is initiated after systemic heparinization, the left ventricle is vented through the right upper pulmonary vein. A small transverse aortotomy is done and aortic valve is examined. If required reverse Trendelenburg position of operating table with slightly rotation towards patient left is done for further visualization of aortic valves. Traction sutures are placed through the top of each commissure and snapped to the surgical drape. Excision of aortic valve leaflets is done with scissors. A Rongeur instrument is then used to debride all the calcium from annulus and is flushed with normal saline to wash out any residual calcium debris.

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The annulus is then sized and horizontal pledgetted mattress sutures (Ethibond 2 -0 DARB) are placed in the aortic annulus. As an institutional protocol and unaffordability of patients for bioprosthetic valves all patients underwent mechanical prosthetic valve replacement. Mechanical prosthetic valve is then brought to the field and the sutures are passed through the valve sewing ring, the valve is then implanted to the aortic annulus and sutures are tied. The aortotomy is then closed in two layers (first layer with horizontal mattress and second in an over and over running fashion) with 5-0 polypropylene suture. Warm blood is then infused in retrograde manner in order to flush out any air from the coronary arteries. Aortic clamp is then removed and de-airing is performed under transesophageal echocardiogram (TEE) guidance by filling the heart in cardiopulmonary bypass and valsalva maneuvers are performed to wash our air out of the pulmonary veins. Once the de-airing completed left ventricular vent is removed from the right upper pulmonary vein and the patient is weaned off from cardiopulmonary bypass. In all cases of AVR through thoracotomy approach we have closed pericardium over aorta and right atrial appendage for possibility of any redo surgery in future. Pericardium should be kept opened at diaphragmatic level up to the right phrenic nerve to drain any pericardial collection in to the right pleural cavity. A single chest tube is placed at most dependent part of right pleural cavity for drainage and to avoid any possibility of pericardial tamponade. As an institutional protocol all patient were ventilated for some time and not rushed for early extubation. For immediate post-operative pain management we use a combine infusion of midazolam (0.03 mg/kg/hr) and fentanyl (1 mcg/kg/hr) till initiation of weaning. After extubation we give injection tramadol 50 mg 12 hourly slowly through intra venous route. While in the ward, we give tablet tramadol 50 mg.

Intra operative variables and postoperative variables were recorded and compared between the two groups. Intraoperative variables included, length of incision, valve size, intra operative arrhythmias, mean bypass time, aortic cross clamp time, mean operating time, pacemaker implantation, and intraoperative conversion to midline approach. Postoperative variables such as ventilation time, postoperative atrial fibrillation, drain, blood products used, requirement of intra-aortic balloon pump (IABP), low cardiac output syndrome, CO2 retention, mortality, pain score, mobilization, ICU stay wound infection and dehiscence, septicemia, intercostal drainage required, hospital stay, scar formation and readmission were recorded. The numeric pain rating scale with an ordinal value from 1 to 10 for patient self-reporting is used for assessment of postoperative pain. The data was entered in Microsoft excel and analyzed using SPSS version 22. The data was analyzed for Descriptive and Inferential Statistics. The Descriptive Statistics are expressed as Mean and Standard Deviation. Independent Sample t Test was performed to analyze the difference between the groups for Continuous variables and Chi Square Test was used to test for Differences in proportions between the groups. A difference was considered to be of statistical significance if the P value was ≤ 0.05.

RESULTS

The present study was conducted to evaluate the surgical outcome of AVR among patients using right anterolateral thoracotomy approach and compare it with the conventional midline sternotomy with 60 patients in each group. The study cohort comprised of 92 (76.7%) males and 28 (23.3%) females. Thoracotomy group had 42 males (70%) and 18 females (30%). Midline sternotomy group had 50 males (83.3%) and 10 females (16.7%).we have preferably choose young patients and patients with aortic regurgitation or mixed pathology for thoracotomy approach. The mean age in the thoracotomy group was 26.03 ± 6.014 years and in the midline

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sternotomy group it was 56.07±10.03 years. Mean body surface area in thoracotomy group and midline sternotomy group was 1.46±0.16 m2 and 1.62±0.27 m2 respectively. All patients in thoracotomy group belonged to class IV of NYHA classification, whereas in the midline sternotomy group, 4 (6.7%) patients belonged to class III of NYHA classification and 56 (93.3%) belonged to class IV. Amongst the thoracotomy group, 20 individuals (33.3%) exhibited a mixed pathology, 38 (63.3%) had aortic regurgitation and 2 patient (3.3%) exhibited aortic stenosis, all these lesions were rheumatic in nature. However in the midline sternotomy group majority (86.7%) exhibited aortic stenosis and 13.3% exhibited a mixed pathology. Although in 12 (20%) patients, the lesion was rheumatic in nature, 48 (80%) were degenerative in nature. The ejection fraction in the thoracotomy and midline sternotomy group was 56.4% and 47.4% respectively. Intraoperative and postoperative findings are summarized in table 1. The Mean incision length was 6.987±0.558 cm in the thoracotomy group and 22.97±1.83 cm in the midline sternotomy and this difference was statistically different (p=0.000). No statistically significant difference was found in the valve size between the 2 groups. The mean bypass time, aortic cross clamp time and mean operating time in the midline sternotomy group was 60±7.506, 44.97±7.242 and 122.47±10.744 minutes respectively which was significantly higher as compared to the thoracotomy group where the values were 53.10±5.921, 39.87±5.231 and 92.27±5.607 minutes respectively ($p<0.05$). The ventilation time was higher in the midline sternotomy group (6.592±0.647 hours) as compared to the thoracotomy group (4.991±0.625 hours) which was statistically different (p=0.000). The amount of drain blood, duration up to mobilization, ICU stay and hospital stay in the thoracotomy group was 125±43.052 ml, 42.10±5.985 hours, 25.77±2.596 hours, 4.03±0.183 days respectively and this was lower as compared to the conventional midline sternotomy group and this difference was statistically significant (p=0.000). The pain score was significantly higher in the midline sternotomy group than the thoracotomy Group (p=0.000) (Table 1) Intraoperative arrhythmia, requirement of cardiac pacing, post-operative arrhythmia, re-exploration due to bleeding, requirement of intra-aortic balloon pump (IABP), low cardiac output syndrome, CO_2 retention, mortality, wound dehiscence and septicemia was absent in both the approaches. Blood transfusion was done among 10 (16.7%) and 46 (76.7%) patients in the thoracotomy and midline sternotomy group respectively and this difference was statistically significant (p=0.000). No patient from thoracotomy group required conversion to midline sternotomy. Wound infection, scar formation and readmission were observed to be higher among patients in the midline sternotomy group than the thoracotomy group and this difference was statistically significant ($P \leq 0.05$). Intraoperative and postoperative complications are summarized in table 2.

DISCUSSION:

Midline sternotomy approach is the conventional standard approach for aortic valve replacement surgeries, however due to the risk of infections and scar formation, different approaches for minimally invasive AVR have been described as an alternative. With its advantages such as reduced surgical trauma, improved cosmetic acceptance, reduced hospitalization, minimally invasive aortic valve surgery are preferred by both the patients and treating surgeons [1-4]. In the present study, intraoperative and postoperative surgical outcomes and complications were compared between the right anterolateral thoracotomy group and standard midline sternotomy group in patients undergoing AVR surgery. The study cohort consisted of 28 (23.3%) females and 92 (76.7%) were males divided randomly into 2 groups. Mean length of incision for patient who underwent AVR through thoracotomy was approximately 6.987±0.558 cm which was much smaller than 22.97±1.83 cm in standard midline sternotomy approach. This smaller incision is consistent with the incisions used in previous

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studies. Carmine Minale and colleagues (1998) performed AVR via a mini-thoracotomy approach with 8 cm incision without rib resection in 50 patients [5]. The mean bypass time, aortic cross clamp time and mean operating time in the midline sternotomy group was 60±7.506, 44.97±7.242, 122.47±10.744 minutes respectively which was significantly higher as compared to the thoracotomy group where the values were 53.10±5.921, 39.87±5.231 and 92.27±5.607 minutes respectively ($p<0.05$).Pineda AM et al (2013) have reported longer bypass and aortic clamp time in the thoracotomy group [6].In our study we have used two stage single venous cannula (Medtronic) which is technically easy to use and save some time required for bi-caval venous cannulation. Also, in early stage of our study we have choose to operate relatively simple cases of either aortic regurgitation or mixed pathology through thoracotomy approach. Hence, overall reducing our bypass and aortic clamp time in the thoracotomy group. Elfriede Ruttmann and colleagues [7] reported significantly longer operating times with MIAVR through right anterior mini-thoracotomy. However in our study, the mean operating time was significantly less in thoracotomy approach as we have used single incision for both aortocaval cannulation and for aortic cross clamp avoiding multiple incisions for peripheral cannulation and a separate incision for aortic cross clamp resulting in early surgical site closure. Also, these surgeries are technique sensitive so mean operating time depends on the expertise and skills of operating surgeon and the assisting staff. Literature suggests less episodes of bleeding, shorter duration of mechanical ventilation, and reduced intensive care unit and hospital stay despite longer procedure times, together with an expected improved cosmetic result and a reduction in wound infections associated with minimal invasive surgeries [2, 4, 8, 9]. Walther et al believe that, early ambulation can be achieved in the patients undergoing cardiac surgeries through minimally invasive lateral mini-thoracotomy [10]. In our study, patients who underwent AVR through right anterolateral thoracotomy associated with less postoperative pain in terms of pain score and early mobilization as we have avoided vascular complications and discomfort related to peripheral cannulation. Past studies have also confirmed that right anterolateral thoracotomy is a less painful approach compared to the standard midline sternotomy approach [11, 12]. Glower et al found that quicker resolution of postoperative pain with a minimally invasive approach resulted in faster recovery of patients who returned to normal activity 5 weeks earlier than patients who underwent AVR through median sternotomy [13]. Similar results with shorter duration of ICU stay and early discharge associated with minimal invasive approaches have been reported in the literature [14, 15, 16]. Results of our study also confirm the fact that, compared to the standard approach, thoracotomy approach resulted in less postoperative pain, better mobilization which resulted in shorter duration of ICU stay resulting in early discharge from the hospital. Wound dehiscence was not observed in any patients of our study cohort. No intraoperative complications were recorded in both the groups. Whereas, the postoperative complications although observed, were much lower in the thoracotomy group. We observed 13.3% readmissions in midline sternotomy group compared to no readmissions in thoracotomy group. Grossi et al in their study have reported incidence of 0.9% incidence of mediastinitis in mini-thoracotomy and 5.7% in sternotomy group [17]. Andre Plass and colleagues have reported no wound infection (0%) in the patients who underwent AVR through right thoracotomy [18]. In our study wound infection was seen in 36.7% patients in midline sternotomy group compared to only 13.3% in thoracotomy group ($p=0.036$). Harjula et al [19] reported a sternal dehiscence rate of 0.56% in their patients. Sternal dehiscence is not reported in any of our patients. None of the patients in our study cohort underwent exploration due to surgical bleeding or tamponade, no mortality was observed. Compared to the conventional median sternotomy a greater number of patients were

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satisfied with the cosmesis in right anterolateral thoracotomy group. This is because, scar was observed in only 6.7% in thoracotomy group compared to 63.3% in midline sternotomy group. In a study by casselman et al [20], 99% patients had pleasant feeling regarding their scar. Compared with complete sternotomy, minimal invasive incisions are associated with less pain, discomfort and less post-operative analgesic use [21]. The cosmetic appearance of this approach particularly benefits the female patients in whom, the scar remains hidden in the inframammary fold.

CONCLUSION

Minimal invasive approach is a paradigm for the future in treatment of patients with valvular heart disease. But, due to limited dedicated centers for minimal invasive cardiac surgery and in terms of high expenses it is not easily available for patients of developing or underdeveloped countries. Also, with need of peripheral cannulation and a separate incision for aortic cross clamp this approach becomes comparatively difficult which requires excellent surgical skills, and precise preoperative planning. The objective of our study is to provide patients an alternative option for minimal invasive cardiac surgery in terms of limited single incision without peripheral vessel cannulation performed with conventional instruments even in center's where minimal invasive cardiac surgery facilities are not available. Right anterolateral thoracotomy approach with central cannulation is associated with fast recovery, less trauma and better cosmetic results also it avoids time consuming femoral bypass and associated complications like limb ischemia and gangrene. Nevertheless, when performed with conventional instruments right anterolateral thoracotomy approach is almost similar in cost effectiveness as compared to standard midline sternotomy. In our opinion, right anterolateral thoracotomy with central cannulation is an excellent single incision option for both patient and surgeon when compared to conventional midline approach in patients undergoing AVR in developing or underdeveloped countries.

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Table 1: comparison of intraoperative and postoperative variables between two groups

Variables	Approach	N	Mean	Std. Deviation	Std. Error Mean	Mean difference	95% Confidence Interval of the Difference		P value
							Lower	Upper	
Incision	TG	30	6.987	0.558	0.102	-15.990	-16.69	-15.28	0.000*
	MSG	30	22.977	1.837	0.335				
Valve Size	TG	30	21.57	2.269	0.414	0.367	-0.676	1.410	0.484
	MSG	30	21.20	1.730	0.316				
Mean Bypass Time	TG	30	53.10	5.921	1.081	-6.900	-10.39	-3.41	0.000*
	MSG	30	60.00	7.506	1.370				
Aortic Cross Clamp Time	TG	30	39.87	5.231	0.955	-5.100	-8.365	-1.835	0.003*
	MSG	60	44.97	7.242	1.322				
Mean Operating Time	TG	60	92.27	5.607	1.024	-30.200	-34.63	-25.77	0.000*
	MSG	60	122.47	10.744	1.962				
Ventilation Time	TG	60	4.991	0.625	0.114	-1.601	-1.929	-1.272	0.000*
	MSG	60	6.592	0.647	0.118				
Drain blood	TG	60	125.00	43.052	7.860	-260.833	-296.39	-225.27	0.000*
	MSG	60	385.83	87.268	15.933				
Pain	TG	60	2.17	0.648	0.118	-2.000	-2.409	-1.591	0.000*
	MSG	60	4.17	0.913	0.167				
Mobilization	TG	60	42.10	5.985	1.093	-20.767	-23.299	-18.235	0.000*
	MSG	60	62.87	3.491	0.637				
ICU Stay	TG	60	25.77	2.596	0.474	-23.833	-27.559	-20.107	0.000*
	MSG	60	49.60	9.860	1.800				
Hospital Stay	TG	60	4.03	0.183	0.033	-0.867	-1.118	-0.616	0.000*
	MSG	60	4.90	0.662	0.121				

TG- Thoracotomy Group-

MSG- Midline Sternotomy Group

*- Significant

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Table 2: compassion of intraoperative and postoperative complications

Observed Variables		Approach		X^2	P value
		Thoracotomy	Midline Sternotomy		
Blood product	No	50 (83.3%)	14 (23.3%)	21.696	0.000*
	Yes	10 (16.7%)	46 (76.7%)		
Wound infection	No	52 (86.7%)	38 (63.3%)	4.356	0.036*
	Yes	8 (13.3%)	22 (36.7%)		
Drainage	No	60 (100%)	52 (86.7%)	4.286	0.056
	Yes	0 (0%)	8 (13.3%)		
Scar	No	56 (93.3%)	22 (36.7%)	21.172	0.000*
	Yes	4 (6.7%)	38 (63.3%)		
Readmission	No	60 (100%)	52 (86.7%)	4.286	0.038*
	Yes	0 (0%	8 (13.3%)		