

Extended trans-septal versus left atrial approach in mitral valve surgery: 1017 patients' experience

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ABSTRACT

Objective The mitral valve may be accessed directly through the left atrium but visualisation can sometimes be challenging. A trans-septal interatrial approach provides better exposure and easy access for concomitant tricuspid procedures especially in difficult cases. This retrospective study evaluates the safety and effectiveness of the extended vertical trans-septal approach (EVTSA) for routine mitral valve exposure.

Method 1017 consecutive patients undergoing an isolated primary mitral valve procedure (repair/replacement) through a median sternotomy were retrospectively studied between 2000 and 2015. Up to 135 patients were operated by EVTSA (group A) while 882 patients underwent a traditional left atrial (LA, group B) approach.

Results There were 135 patients (M/F=56/79) in group A and 882 patients (M/F=398/484) in group B. Logistic EuroSCORE was significantly lower in EVTSA group (0.61 vs 0.90, $p=0.000001$). In the LA group there were more patients with preoperative transient ischaemic attack or stroke (94 vs 6, $p=0.005$). Cumulative cross-clamp time was 82 (44–212) min (EVTSA group) and 78 (30–360) min (LA group) ($p=0.271$) while cardiopulmonary bypass time was 107 (58–290) and 114 (43–602) min, respectively ($p=0.121$). Postoperative blood loss was 415 mL (EVTSA) vs 427 mL (LA) ($p=0.273$). No significant difference was found in the incidence of postoperative atrial fibrillation ($p=0.22$) or heart block requiring permanent pacemaker ($p=0.14$).

Conclusion In our opinion, EVTSA to the mitral valve is safe and reproducible. It gives excellent exposure of the mitral valve under all circumstances without any significant increase in cross-clamp or bypass time, postoperative arrhythmia, heart block/pacemaker rate or bleeding.

INTRODUCTION

The mitral valve may be accessed directly via the left atrium after development of Sondergaard's groove or through the interatrial septum after incising the right atrium. While the left atrial (LA) approach has traditionally been most popular among surgeons, visualisation and access to the mitral valve can sometimes be difficult and challenging especially with regard to the anterior leaflet and annulus. The interatrial trans-septal (TS) approach affords superior access and can be transverse or vertical.

Lillehei *et al*¹ exposed the valve by means of a left atriotomy posterior to the interatrial groove from the right thorax. Effler *et al*² modified this approach by operating on the mitral valve through the interatrial septum from the right chest.

Dubost and colleagues³ used a TS incision which extended medially from right superior pulmonary

vein to right atrium and through the interatrial septum. Guiraudon *et al*⁴ alternatively described a superior septal or extended vertical TS incision through the right atrium superiorly into left atrium along with an interatrial septostomy to the inferior pole of fossa ovalis.

The risks of transecting the sinus node artery and the internodal pathways and the need to reconstruct the wall of the atria and the interatrial septum have been considered important limitations. Because the incisions are longer, closing time is prolonged and there may be more risk of bleeding. There are concerns regarding postoperative atrial fibrillation and complete heart block requiring permanent pacemaker which may be of greater incidence than for conventional approaches despite the superior access to the mitral valve which is afforded.

To address the concerns raised in the literature regarding the extended vertical trans-septal approach (EVTSA), this paper presents our experience with more than 1000 mitral valve procedures utilising either the traditional LA or EVTSA.

Surgical technique

After midline sternotomy is performed and heparin given, the superior vena cava is cannulated directly. The inferior vena cava is similarly cannulated at the inferior, lateral portion of the right atrium. Both cavae are encircled with tapes. After cardiopulmonary bypass (CPB) is instituted with aortic return, cardioplegia is delivered through the ascending aorta after cross-clamping and is repeated every 45 min. For the extended TS approach the right atrium was opened along its anterolateral aspect extending it across the base of the right atrial appendage to the superior aspect of the interatrial septum (figure 1). A 3 cm incision was then made in the roof of the left atrium extending beneath the ascending aorta and then continued inferiorly along the interatrial septum and ending at the inferior end of the fossa ovalis (figure 2). No special retractors are required and the mitral valve is simply exposed with stay sutures or with simple retraction on the septal edge by an assistant (figure 3). Closure was performed using 4-0 polypropylene running sutures, first closing the roof of the left atrium and then the septal incision. The two sutures were tied where they met, and the right atrial incision was closed.

METHODS

The patient population studied was a consecutive series of 1017 patients undergoing an isolated primary mitral valve procedure (repair/replacement) through a median sternotomy between the



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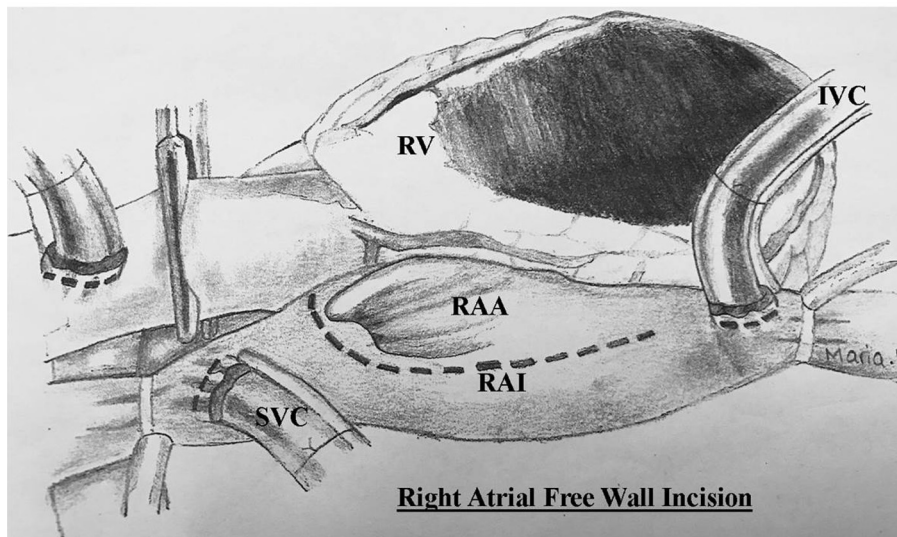


Figure 1 Right atrial free wall incision. IVC, inferior vena cava cannula; RAA, right atrial appendage; RAI, right atrial free wall incision; RV, right ventricle; SVC, superior vena cava cannula.

years 2000 and 2015 by a total of eight surgeons. Combined or redo operations were excluded.

The data used in this analysis were extracted from local National Adult Cardiac Surgery Audit data collected contemporaneously and managed nationally by the National Institute for Cardiovascular Outcomes Research, with clinical direction and strategy provided by the Society for Cardiothoracic Surgeons and its Project Board.

Group A included patients who underwent an operation through EVTSA performed by two surgeons while group B included six surgeon's traditional approach operations through left atrium. Preoperative patient characteristics, comorbidity, preoperative ejection fraction, cross-clamp time, total bypass time, postoperative complications and mortality and type of mitral procedure (repair or replacement) were recorded (table 1). Patients with current or past episodes of atrial fibrillation were designated as having preoperative rather than new-onset atrial

fibrillation. All patients had continuous electrocardiographic telemetry during their postoperative stay. Patients who received a permanent pacemaker during the same hospitalisation for any reason were designated as having a new pacemaker.

Statistical analysis

Analysis was performed using Microsoft Excel. Numerical values were compared using a Student's paired t-test, with a two-tailed distribution assuming unequal variances. Box and whisker plots were used as a comparator for range and quartiles of the data. Categorical variables were compared using χ^2 analysis.

RESULTS

Of the 1017 patients, 135 (M/F=56/79) were in EVTSA group while 882 (M/F=398/484) were in LA group. Gender, procedure type, preoperative angina and dyspnoea status, presence

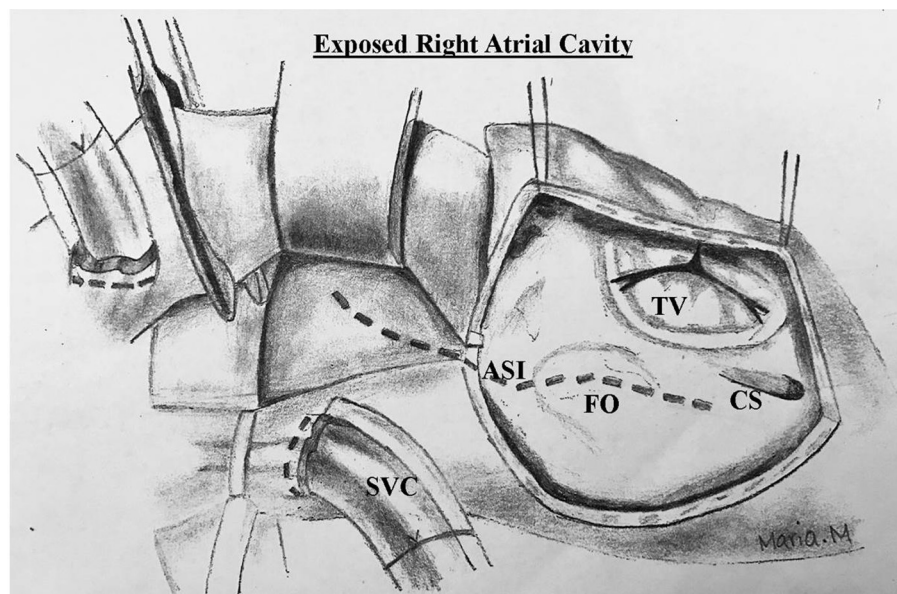


Figure 2 Exposed right atrial cavity. ASI, atrial septal incision extending to roof of left atrium; CS, coronary sinus; FO, fossa ovalis; SVC, superior vena cava cannula; TV, tricuspid valve.

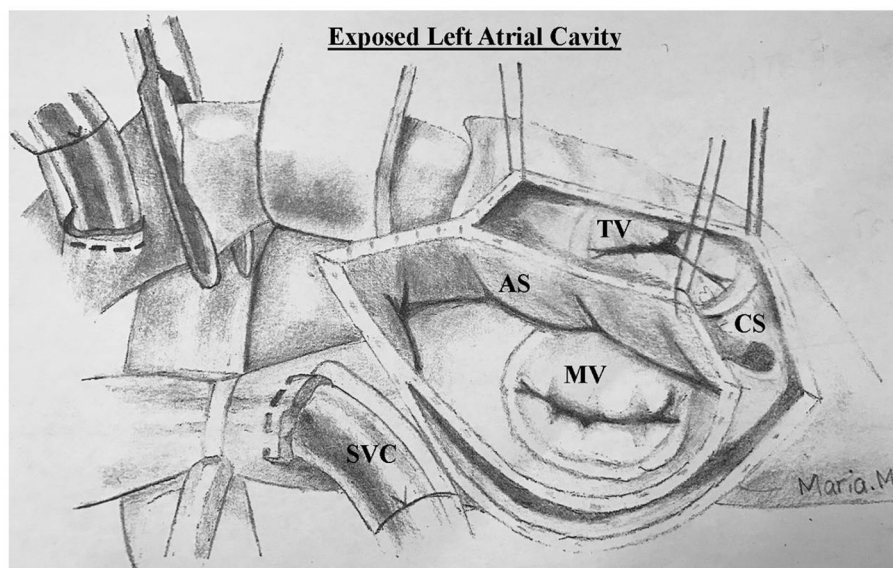


Figure 3 Exposed left atrial cavity. AS, atrial septum; CS, coronary sinus; MV, mitral valve; SVC, superior vena cava cannula; TV, tricuspid valve.

of diabetes mellitus or hypertension, cigarette smoking status, presence of renal and pulmonary disease and preoperative ejection fraction in the two groups were compared using χ^2 test, and there was no significant difference (table 2).

Age, height and weight between two groups also showed no significant difference.

The logistic EuroSCORE was significantly lower in EVTSA group (0.61 vs 0.90, $p=0.000001$). In the LA group there were more patients with preoperative transient ischaemic attack or stroke (94 vs 6, $p=0.05$) and this difference was statistically significant. Preoperatively in the EVTSA group 52 (39%) were in atrial fibrillation while in the LA group, this incidence was in 389 (44%) patients. Six (1.8%) patients were also in complete heart block in the LA group ($p=0.13$).

In the EVTSA group the cumulative cross-clamp time was 82 (44–212) min, and 78 (30–360) min in the LA group ($p=0.271$), while CPB time was 107 (58–290) and 114 (43–602) min ($p=0.121$), respectively.

Seven (5%) EVTSA patients vs 56 (6%) LA patients were reopened for bleeding ($p=0.54$). Postoperative incidences of sternal wound infection, neurological and renal dysfunction and inotropes/vasoconstrictor usage showed no significant differences between the groups.

Thirty day mortality was 3.7% in the EVTSA group while it was 4.3% in the LA group ($p=0.75$). Postoperative blood loss was 415 mL (EVTSA) vs 427 mL (LA) ($p=0.273$).

No significant difference was found in the incidence of postoperative atrial fibrillation or heart block. Thirty-five (42%) patients had new-onset atrial fibrillation in the EVTSA group and 165 (35%) in the LA group ($p=0.22$). Eight (5.93%) patients required permanent pacemaker in the EVTSA group while 29 (3.35%) patients needed pacing in the LA group ($p=0.14$).

Intensive care unit stay was 2.9 days in the EVTSA group and 3.7 days in the LA group ($p=0.098$).

DISCUSSION

There are several potential advantages of the EVTSA over the LA approach.

Depending on chest anatomy, visualisation of the valve is vastly improved because the valve can be seen clearly and in its entirety

looking straight down through the sternotomy rather than from the right lateral position with minimal distortion of the heart. This encourages the highest quality of mitral intervention with clear visualisation of all aspects of the mitral valve achieved effortlessly. No additional or special retractors are required. The approach can be used with either small or large atria and should a tricuspid valve procedure need to be done concomitantly there is no need for a second incision since the tricuspid valve can be readily visualised through the right atriotomy.

The TS approach is also well suited for ablation procedures for concomitant atrial fibrillation. Benussi *et al*⁵ described their experience with bipolar radiofrequency modification of the Maze procedure through a TS incision. Importantly, they achieved an 80% freedom from atrial fibrillation without a single patient requiring a permanent pacemaker.

Finally, the extended TS approach makes valvular surgery easier to learn for trainees and easier to teach, because both the surgeon and the assistant have an excellent view of the valve from either side of the operating table. In fact, with this approach, most mitral procedures could be done entirely with the surgeon standing on either the right or left side of the patient.

The retrospective nature of this study has obvious limitations despite the large data set. The study only included in-hospital data and did not assess for potential long-term complications such as late arrhythmias. Prior studies suggest that most new atrial arrhythmias declare themselves prior to discharge however.⁶ Thus, the current study focused on the period during which arrhythmias are most likely to develop and during which any gross differences between the two approaches are most likely to be observed.

This approach to the mitral valve is not new but has enjoyed a recent resurgence.

Eng⁷ compared the TS ($n=40$) and LA ($n=37$) approaches in a far smaller study than ours. He found no difference in permanent pacemaker placement and New York Heart Association class after 18 months. Other smaller series including that by Alfieri *et al*⁸ studied 111 patients with an extended TS approach and found no difference in cross-clamp and CPB time. Masiello *et al*⁹ retrospectively studied 172 patients. Although the TS extended atriotomy provided excellent exposure for mitral valve

Table 1 Preoperative summary

	Group A n=135			Group B n=882			
Preoperative summary	n	%		n	%		P values
Gender (M/F)	56/79	41/59		398/484	45/55		0.43
Procedure types							
Mitral valve replacement	99	73.34		622	70.50		0.12
Annuloplasty ring	36	26.66		260	29.48		0.15
Cigarette smoking history	66	48.88		490	55.55		0.26
History of hypertension	53	39.26		380	43.08		0.37
Renal disease at time of surgery	0	0		16	1.81		0.73
History of pulmonary disease	16	11.85		151	17.12		0.12
History of neurological disease (ie, TIA, CVA)	6	4.44		94	10.66		0.05
Angina status presurgery							0.6
0. No angina	88	65.19		565	64.06		
1. No limitation of physical activity	27	20.00		193	21.88		
2. Slight limitation of ordinary activity	10	7.41		63	7.14		
3. Marked limitation of ordinary physical activity	5	3.70		39	4.42		
4. Symptoms at rest or minimal activity	5	3.70		22	2.49		
Dyspnoea status presurgery							
1. No limitation of physical activity	22	16.30		135	15.31		0.14%
2. Slight limitation of ordinary physical activity	45	33.33		232	26.30		
3. Marked limitation of ordinary physical activity	51	37.78		344	39.00		
4. Symptoms at rest or minimal activity	17	12.59		171	19.39		
H/O diabetes mellitus	9	6.66		93	10.54		0.38
Preoperative heart rhythm							
0. Sinus rhythm	83	61.48		470	53.29		0.13
1. Atrial fibrillation/flutter	52	38.52		389	44.10		
2. Complete heart block/pacing	0	0.00		16	1.81		
3. Ventricular fibrillation or ventricular tachycardia	0	0.00		1	0.11		
4. Other abnormal rhythm	0	0.00		6	0.68		
Ejection fraction category							
1. Good (LVEF>50%)	115	85.19		687	77.89		0.18
2. Fair (LVEF 30%–50%)	19	14.07		158	17.91		
3. Poor (LVEF<30%)	1	0.74		35	3.97		
9. Not measured		0.00		2	0.23		
	Group A n=135			Group B n=882			
	Range	Mean	Median	Range	Mean	Median	P values
Age of patients at time of procedure	27–84	62.5	65.0	18–81	63.2	65.0	0.156
Logistic EuroSCORE comparison	0.015–0.312	0.061	0.042	0.015–0.834	0.090	0.056	0.000001
Height (cm)	144–189	166	164	143–185	165	165	0.586
Weight (kg)	45.5–171	75	75	35–104	71	70	0.061

CVA, cerebrovascular accident; H/O, haem oxygenase; LVEF, left ventricular ejection fraction; TIA, transient ischaemic attack.

surgery, the incidence of ischaemia time and total postoperative bleeding ($p=0.004$), and postoperative junctional arrhythmia in those with preoperative sinus rhythm ($p<0.001$) were greater than in the conventional LA approach group.

Rezahassemi *et al*¹⁰ retrospectively compared 163 TS and 652 LA incision cases.

They concluded that the TS approach was associated with higher pump and cross-clamp times as well as a higher risk of postoperative atrial fibrillation, but it did not increase the rates of permanent pacemaker placement, reoperations and mortality.

Frapiet *et al*¹¹ reported 55 patients with superior TS approach. They concluded that it gives better exposure at the expense of transient atrial arrhythmias. Cheema and Jalal¹² examined 25

patients with TS approach and showed that no patients developed iatrogenic arrhythmia, conduction defects or residual atrial septal defect.

Borracci *et al*¹³ studied the TS approach in 62 patients undergoing mitral valve replacement. Mortality at 60 days was of 8.1% (five patients) and 4.8% needed a permanent pacemaker due to atrioventricular (AV) block or persistent nodal rhythm. Guiraudon *et al*² published their series of 34 patients with EVTSA. There were no complications with closure of atriotomy, that is, no retroaortic LA bleeding, atrial septal defects, atrial fibrillation or heart block postoperatively.

Gaudino *et al*¹⁴ discussed 146 consecutive patients undergoing mitral valve replacement using either the conventional left

Table 2 Postoperative summary

Postoperative summary	Group A n=135			Group B n=882			P values
	Range	Mean	Median	Range	Mean	Median	
Cumulative cross-clamp time (min)	44–212	82	70.5	30–360	78	68	0.271
Cross-clamp time (MV repair)	54–212	84	72	50–360	81	71	0.284
Cross-clamp time (MV replace)	44–180	79	67	30–320	75	66	0.261
Cumulative bypass time (min)	58–290	107.5	92.5	43–602	114.4	98	0.121
Bypass time (MV repair)	70–290	112	95	57–602	118	101	0.135
Bypass time (MV replace)	58–240	105	90	43–560	111	95	0.115
Post-op blood loss at 12 hours (mL)	50–3200	415.4	300.0	50–4217	426.7	325	0.773
ITU stay in days	1–43	2.9	1	1–90	3.8	1	0.098

	Group A n=135		Group B n=882		P values
	n	%	n	%	
Reoperation for bleeding or tamponade	7	5.19	56	6.35	0.54
Sternal wound infection (Y/N)	1	0.74	5	0.57	0.81
New post-op neurological dysfunction (Y/N)	5	3.7	34	3.85	0.93
New HF/dialysis postoperatively (Y/N)	8	5.93	69	7.82	0.44
Patient status at discharge (mortality) (Y/N)	5	3.7	38	4.31	0.75
SIRS (low SVR)	16	11.85	160	18.14	0.07
Sinus rhythm preoperatively, but AF/flutter postoperatively (new-onset atrial fibrillation)	35	42.17	165	35.11	0.22
Patients requiring new pacemaker (Y/N)	8	5.93	29	3.35	0.14
ITU readmission (Y/N)	12	8.89	52	5.9	0.18

AF, atrial fibrillation; HF, haemofiltration; ITU, intensive therapy unit; MV, mitral valve; N, No; SIRS, systemic inflammatory response syndrome; SVR, systemic vascular resistance; Y, Yes.

atriotomy or the superior TS approach. The CPB and cross-clamp times were significantly higher in the superior TS group. No significant difference was found in blood loss and residual atrial septal defect. The maintenance of sinus rhythm at late follow-up, the incidences of postoperative arrhythmias and newly developed AV block were not significantly different between the two groups. Nienaber and Glower¹⁵ presented a comparison of the LA approach (n=273) to mini TS (n=258) approach, where a 6 cm long incision was made in the interatrial septum without incising the roof of left or right atrium. This provided excellent exposure without any significant increase in junctional rhythm, atrial fibrillation or new pacemaker requirement.

Yüksel *et al*¹⁶ presented a retrospective study, which compared biatrial approach (n=34) with unilateral approach (n=8) and right atriotomy and right ventriculotomy (n=1) in patients with LA myxoma. They preferred biatrial approach for wide resection of the tumour and to avoid residual tumour.

Our experience presents the largest published series of more than 1000 patients undergoing isolated mitral valve repair or replacement operated on through either EVTSA or LA incisions^{17 18}. Contrary to previous studies, we did not find EVTSA to have statistically significant long cross-clamp or bypass times. Although logistic EuroSCORE was significantly lower in the EVTSA group, it was not arrhythmogenic and did not lead to significantly more permanent pacemaker implants. Postoperative blood loss was not significantly different.

CONCLUSION

It is our opinion that EVTSA is safe and reproducible. It gives excellent exposure of the mitral valve for best visualisation of the mitral valve even in challenging circumstances. It is ideal for teaching and training with both surgeons able to fully appreciate the mitral valve in its entirety during surgery. There are

no adverse effects on patient outcomes in this largest published series of cases.

Adapted/hand-drawn from A. Thomas Pezzella, Joe R. Utley, Thomas J. Vander Salm. Operative approaches to the left atrium and mitral valve: an update. Operative Techniques in Thoracic and Cardiovascular Surgery, May 1998, Volume 3, Issue 2, pp 74–94.

Key messages

What is already known about this subject?

- Extended vertical trans-septal approach to the mitral valve is associated with adequate exposure and no inherent complications.

What does this study add?

- There are no adverse effects on patient outcomes in this largest published series of cases.
- It does not cause significant increase in cross-clamp or bypass time, postoperative arrhythmia, heart block/pacemaker rate or bleeding.

How might this impact on clinical practice?

- The extended vertical trans-septal approach provides excellent exposure and visualisation of the mitral valve and lends itself to surgical training.
- Since it does not incur excess morbidity compared with the conventional left atrial approach, the technique may become more widely accepted.

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