

Is a minimally invasive approach for re-operative aortic valve replacement superior to standard full re-sternotomy?

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Abstract

A best-evidence topic in cardiac surgery was written according to a structured protocol. The question addressed was 'is a minimally invasive approach for re-operative aortic valve replacement (AVR) superior to standard full re-sternotomy?' A total of 193 papers were found using the reported search of which 13 represented the best evidence to answer the clinical question. The authors, country, journal and date of publication, patient group studied, study type, relevant outcomes and results of these papers are tabulated. We conclude that minimally invasive re-operative AVR can be performed with an operative morbidity and mortality at least similar to the standard full sternotomy approach. A shorter hospital length of stay and less blood product requirements are the main advantages of this technique. The incidence of prolonged ventilation, bleeding requiring re-operation, sternal wound infections and in-hospital mortality may be reduced with a minimally invasive approach. Prospective studies are required to confirm the potential benefits of minimally invasive surgery and, up to date, conventional full re-sternotomy is still the standard approach for re-operative AVR.

Keywords: Aortic valve replacement • Minimally invasive cardiac surgery • Re-operative • Review

INTRODUCTION

A best-evidence topic was constructed according to a structured protocol fully described in the *Interactive CardioVascular and Thoracic Surgery* [1].

THREE PART QUESTION

In [patients undergoing re-operative aortic valve replacement (AVR)] is [a minimally invasive approach] superior to [standard median sternotomy] in terms of [morbidity and mortality]?

CLINICAL SCENARIO

A 76-year old woman with a history of AVR presented with worsening dyspnoea on exertion. Echocardiography revealed severe aortic insufficiency secondary to a paravalvular leak, and re-operative AVR is planned. Is a minimally invasive approach for a re-operative aortic valve worse, equal or better than a standard re-sternotomy?

SEARCH STRATEGY

Medline 1950 to May 2011 using Pubmed interface: [Heart valve prosthesis implantation OR aortic valve surgery OR aortic replacement OR AVR] AND [reoperative OR reoperation OR redo

OR re-operative OR re-operation OR re-do] AND [minimally invasive OR mini-thoracotomy OR partial sternotomy OR right mini-thoracotomy].

SEARCH OUTCOME

Using the reported search, 193 papers were found. Articles that did not include information on re-operative aortic valve procedures were excluded, as were review articles and letters to the editor. Finally, 12 papers were identified as the best evidence to answer the initial question (Table 1). Results from our institution, that were recently presented, were also included [2].

RESULTS

Right mini-thoracotomy approach

In 2000, Grossi *et al.* [3] reported a series of 127 patients undergoing re-operative procedures, which included mitral valve surgery ($n = 58$), aortic valve surgery ($n = 42$) and other complex procedures ($n = 27$). The mortality rate for re-operative AVR was 9.5%, and 5.6% of the patients developed postoperative bleeding requiring re-intervention.

Sharony *et al.* [4] compared the results of a right mini-thoracotomy with re-sternotomy in patients undergoing re-operative valve surgery. They included 498 patients of which 337 had a full re-sternotomy (160 AVRs) and 161 had minimally

Table 1: Best evidence papers

Author, Journal (country, year), study type, surgical approach	Patient group	Outcomes	Key results	Comments
Pineda et al. [2], <i>J Heart Dis</i> (USA, 2011) Case-control, right mini-thoracotomy	Outcomes of 28 patients with history of prior sternotomy who underwent re-operative AVR were compared with 40 patients who had full sternotomy	In-hospital mortality	0/28 (0%) vs. 4/40 (10%), $P = 0.09$	Retrospective nature of the study
		Conversion to full sternotomy	1/28 (3.6%)	Comparison with conventional sternotomy
		Bleeding requiring reoperation	0/28 (0%) vs. 4/40 (10%), $P = 0.09$	Right mini-thoracotomy was associated with lower composite postoperative complications, prolonged ventilation and PRBC's requirements. It also showed a trend towards less in-hospital mortality and bleeding requiring re-operation, and shorter total hospital length of stay
		Postoperative renal failure	1/28 (3.6%) vs. 4/40 (10%), $P = 0.32$	
		Postoperative stroke	3/28 (11%) vs. 1/40 (2.5%), $P = 0.16$	
		Deep wound infection	0/28 (0%) vs. 2/40 (5%), $P = 0.23$	
		Prolonged ventilation	4/28 (14%) vs. 17/40 (43%), $P = 0.01$	
		Postoperative complications	6/28 (21%) vs. 20/40 (50%), $P = 0.02$	
		PRBC's units transfused (median; IQR)	1 (0–2) vs. 5 (3–7), $P < 0.001$	
		PRBC's requirements	19/28 (68%) vs. 37/40 (93%), $P = 0.009$	
ICU length of stay (median; IQR)	49 h (43–109) vs. 70 (45–179), $P = 0.10$			
Total hospital length of stay (median; IQR)	8 days (5–10) vs. 9 (6–15), $P = 0.06$			
Gaeta et al. [14] <i>Ann Thorac Cardiovasc Surg</i> (Italy, 2010) Case series, 'J shape' or 'reverse T' partial upper hemisternotomy	16 patients underwent minimally invasive AVR after previous CABG (patent LIMA to left anterior descending coronary artery)	In-hospital mortality	No deaths	Retrospective nature of the study
		Conversion to full sternotomy	No conversions	No comparison with standard approach
		Postoperative complications	2/16 (12.5%)	
		Long-term mortality (median follow-up for 58 months)	4/16 (25%)	
		PRBC's requirements (mean \pm SD)	0.9 \pm 1.2 units	
		ICU length of stay (mean \pm SD)	1.6 \pm 1.1 days	
Totaro et al. [13] <i>Ann Thorac Surg</i> (Italy, 2009) Case series, 'Reverse T' or 'inverted L' partial upper hemisternotomy	Comparison between 77 patients who underwent redo AVR versus 695 patients who had primary AVR	In-hospital mortality	3.8% vs. 2.8%, $P = NS$	Retrospective nature of the study
		Conversion to full sternotomy	1.2% vs. 1.3%, $P = NS$	No comparison with standard approach
		Prolonged ventilation (>24 h)	8.6% vs. 6.6%, $P = 0.47$	Redo AVR had similar postoperative results when compared with primary AVR
		Bleeding requiring reoperation	2.8% vs. 2.7%, $P = 0.1$	
		ICU length of stay (days; mean \pm SD)	2.1 \pm 3.7 vs. 1.5 \pm 2.7, $P = NS$	
Tabata et al. [12], <i>J Thorac Cardiovasc Surg</i> (USA, 2008) Case-control, 'J-shape' partial upper hemisternotomy	Outcomes of 146 patients with prior sternotomy who underwent re-operative AVR, were compared with those of 150 patients who had full sternotomy approach	In-hospital mortality	6/146 (4.1%) vs. 7/150 (4.6%), $P = NS$	Retrospective nature of the study
		Conversion to full sternotomy	4/146 (2.7%)	Limited comparison with standard approach
		Bleeding requiring reoperation	1/146 (0.7%)	
		Deep wound infection	1/146 (0.7%)	
		Prolonged ventilation	21/146 (14.4%)	
		PRBC's units transfused	Median 3 units	
		PRBC's requirement	115/146 (78.8%) vs. 125/150 (83.3%), $P = 0.37$	
		Five-year actuarial survival	85%	
		Median hospital length of stay	8 days	

Continued

Table 1:: Continued

Author, Journal (country, year), study type, surgical approach	Patient group	Outcomes	Key results	Comments
Tabata et al. [11], <i>Eur J Cardiothorac Surg</i> (USA, 2008)	Comparison between 130 patients with previous sternotomy who underwent AVR versus 875 patients who had primary AVR	In-hospital mortality		Retrospective nature of the study
Case series, 'J shape' partial upper hemisternotomy		Blood transfusion	3.1% vs. 1.7%, $P = 0.29$ 83% vs. 49%, $P < 0.001$	No comparison with standard approach Redo AVR had more blood transfusion requirements but similar mortality when compared with primary AVR
Bakir et al. [10], <i>Thorac Cardiovasc Surg</i> (Belgium, 2007)	19 patients underwent minimally invasive isolated AVR after previous sternotomy	In-hospital mortality	1/19 (5.2%)	Retrospective nature of the study
Case series, 'J shape' partial upper hemisternotomy		Conversion to full sternotomy	No conversions	No comparison with standard approach
		Bleeding requiring reoperation	4/19 (21%)	
		Postoperative renal failure	3/19 (15.8%)	
		Postoperative stroke	1/19 (5.2%)	
		Sternal wound infection	1/19 (5.2%)	
		Long-term mortality (median follow up 24 months)	2/18 (11.1%)	
		PRBC's requirements (mean \pm SD)	2.4 \pm 3.7 units	
		ICU length of stay (days; mean \pm SD)	2.9 \pm 2.6, median 2 days (range 1-11)	
		Total hospital length of stay (days; mean \pm SD)	12.9 \pm 5.7, median 11 days (range 7-24)	
Sharony et al. [4], <i>J Card Surg</i> , (USA, 2006)	Outcomes of 161 (61 aortic; 100 mitral) patients with previous sternotomy who underwent	In-hospital mortality	5.6% vs. 11.3%, $P = 0.04$	Retrospective nature of the study
Case-control, right mini-thoracotomy	minimally invasive isolated valve surgery are compared with 337 patients (160 aortic; 177 mitral) via median sternotomy	Conversion to full sternotomy	No conversions	Outcomes of both aortic and mitral procedures were combined
		Bleeding requiring reoperation	5.0% vs. 3.3%, $P = 0.45$	Right mini-thoracotomy was associated with lower in-hospital mortality, fresh-frozen plasma requirements, deep wound infection, and shorter length of stay
		Postoperative renal failure	3.1% vs. 4.7%, $P = 0.48$	
		Postoperative stroke	2.5% vs. 2.4%, $P = 1.0$	
		Deep wound infection	0% vs. 2.4%, $P = 0.05$	
		Postoperative complications	23.6% vs. 22.3%, $P = 0.73$	
		Long-term mortality (median follow-up of 24 months)	38/161 (23.7%) vs. 114/337 (33.8%), $P = 0.08$	
		Fresh-frozen plasma requirements (median)	2.7 vs. 4.1 units, $P = 0.02$	
		Total hospital length of stay (median)	7 vs. 8 days, $P = 0.009$	
Mihaljevic et al. [9], <i>Ann Surg</i> (USA, 2004)	From 1042 patients undergoing AVR, 197 were re-operative procedures, 63 via a minimally invasive approach and 134 via full sternotomy	In-hospital mortality	5% vs. 1.4%, $P = 0.33$	Retrospective nature of the study
Case-control, 'J shape' (reversed L) partial upper hemisternotomy		Conversion to full sternotomy	Not available	Comparison with conventional full sternotomy available
		Bleeding requiring reoperation	0% vs. 2%, $P = 0.55$	Re-operative AVR by means of a partial upper hemisternotomy or full sternotomy had similar postoperative outcomes
		Postoperative stroke	6% vs. 5%, $P = 0.75$	
		Deep wound infection	2% vs. 0%, $P = 0.32$	
		Total hospital length of stay (days; median, range)	7 (3-44) vs. 7 (3-70), $P = 0.19$	

Continued

Table 1:: Continued

Author, Journal (country, year), study type, surgical approach	Patient group	Outcomes	Key results	Comments
Svensson <i>et al.</i> [8], <i>Eur J Cardiothorac Surg</i> (USA, 2001)	54 patients underwent aortic surgery (ascending aorta ± arch repair). From those, 41 had AVR and 18 (33%) were re-operations	In-hospital mortality	No deaths	Retrospective nature of the study
Case series, 'J shape' partial upper hemisternotomy		Conversion to full sternotomy	No conversions	Included patients undergoing ascending aorta and arch procedures. Limited information regarding re-operative AVR
		Postoperative stroke	1/18 (5.5%)	No comparison with standard approach
Grossi <i>et al.</i> [3], <i>Curr Cardiol Rep</i> (USA, 2000)	127 patients with prior cardiac surgery underwent a right mini-thoracotomy for different cardiac procedures, including AVR (42 patients)	In-hospital mortality (AVR, 42 patients)	4/42 (9.5%)	Retrospective nature of the study
Case series, right mini-thoracotomy		Bleeding requiring reoperation (127 patients)	5.6%	Included patients undergoing different cardiac re-operations No comparison with standard approach
		ICU length of stay (127 patients)	Median 25.6 h	
		Hospital total length of stay (127 patients)	Median 8 days	
Byrne <i>et al.</i> [7], <i>Eur J Cardiothorac Surg</i> (USA, 2000)	34 patients underwent re-operative (partial upper hemisternotomy for isolated AVR	In-hospital mortality	2/34 (5.9%)	Retrospective nature of the study
Case series, 'Inverted T' partial upper hemisternotomy		Conversion to full sternotomy	No conversions	No comparison with standard approach
		Postoperative complications	8/34 (25%)	
		Bleeding requiring reoperation	None	
		Postoperative stroke	1/34 (2.9%)	
		Sternal wound infection	2/34 (5.9%)	
		Long-term mortality (median follow-up of 19 months)	2/32 (6.2%)	
		PRBC's requirement (median, range)	2 units (0-9)	
		ICU length of stay (median, range)	1 day (1-8)	
Byrne <i>et al.</i> [6], <i>J Thorac Cardiovasc Surg</i> (USA, 1999)	Outcomes of 20 patients with prior sternotomy who underwent re-operative AVR were compared with 19 patients undergoing full sternotomy	In-hospital mortality	No deaths	Retrospective nature of the study
		Major complications	20 vs. 32, $P = 0.32$	Comparison with conventional full sternotomy available Re-operative AVR by means of a partial upper hemisternotomy had similar postoperative outcomes and a trend towards less blood loss and transfusion requirements when compared with full sternotomy
Blood loss during first 24 h (ml; mean ± SD)	458 ± 348 vs. 1071 ± 629, $P = 0.06$			
PRBC's requirement (units; median, range)	2 (0-9) vs. 5 (0-9), $P = 0.25$			
Total hospital length of stay (days; median, range)	6 (4-24) vs. 7 (3-13), $P = NS$			
Tam <i>et al.</i> [5], <i>J Thorac Cardiovasc Surg</i> (Australia, 1997)	Single case description of re-operative (prior AVR) isolated aortic valve surgery	In-hospital mortality	No	Single case report
		Conversion	No	No comparison with standard approach
Case report, partial upper hemisternotomy		Postoperative complications	None	
		ICU length of stay	1 day	
		Total hospital length of stay	5 days	

AVR: aortic valve replacement; ICU: intensive care unit; PRBC: packed red blood cells; CABG: coronary artery bypass graft surgery; LIMA: left internal mammary artery graft; SD: standard deviation; NS: not significant.

invasive surgery (61 AVRs). Mini-thoracotomy was associated with lower in-hospital mortality, less deep wound infections, less fresh-frozen plasma requirements and a shorter total hospital length of stay.

Our institution reported the outcomes of 28 patients with a history of cardiac surgery who underwent re-operative AVR compared with those of 40 patients who had a full re-sternotomy [2]. The minimally invasive approach was associated with a significantly reduced incidence of composite postoperative complications, prolonged ventilation and need for blood products.

Partial upper hemi-sternotomy approach

In 1997, Tam *et al* [5] reported a successful application of an upper hemi-sternotomy in one patient with a history of AVR undergoing re-operative AVR. This was followed by a study of 39 patients with previous cardiac surgery who underwent re-operative AVR through either a full re-sternotomy ($n = 20$), or an upper hemi-sternotomy ($n = 19$) [6]. The minimally invasive approach had similar outcomes, with less transfusion requirements. Another study of 34 patients undergoing re-operative AVR through an 'inverted T' upper hemi-sternotomy showed an in-hospital mortality of 5.9% and a postoperative complication rate of 25% [7].

Svensson *et al* [8] published a case series of 54 patients undergoing a 'J' upper hemi-sternotomy for aortic procedures, including ascending aorta and aortic arch repairs. Their study included 41 patients who underwent AVR, of which 18 (33%) were re-operations. There were no deaths, and the incidence of stroke was 5.5%. While Mihaljevic *et al.* [9] published a series of 1042 patients undergoing aortic valve surgery. Of those, 197 were re-operations, 63 done via the minimally invasive approach, and re-sternotomy in 134, and demonstrated similar outcomes between the two groups.

A case series of 19 patients who underwent re-operative AVR via a 'J' upper hemi-sternotomy demonstrated an incidence of postoperative renal failure of 15.8% and bleeding requiring re-intervention of 21% with an in-hospital mortality of 5.2% [10]. Another study of 130 patients, who underwent re-operative AVR through a 'J' upper hemi-sternotomy were compared with those of 875 patients undergoing primary AVR [11]. The patients who had re-operative surgery had similar mortality rates, but required more blood transfusions (83% vs. 49%, $P < 0.001$).

Tabata *et al* [12] published a retrospective study of 146 patients who underwent re-operative AVR via a 'J' partial upper sternotomy, and compared them with 150 patients who had a full sternotomy. There were no differences with regards to in-hospital mortality and units of blood transfused.

Totaro *et al* [13] performed AVR in a series of patients through a 'reverse T' or 'inverted L' upper hemi-sternotomy. The outcomes of 695 patients who had primary AVR were compared with those of 77 patients who had re-operative AVR. The re-operative AVR group had similar outcomes when compared with the primary procedure group.

Gaeta *et al.* [14] published a series of 16 patients with prior CABG who subsequently underwent AVR through a partial upper

hemi-sternotomy. There were no deaths, and postoperative complications occurred in 12.5% of the patients.

CONCLUSION

For patients with prior cardiac surgery undergoing re-operative AVR, minimally invasive surgery by means of a right mini-thoracotomy or a partial upper hemi-sternotomy is feasible and is at least as safe as a conventional full sternotomy. It appears to be associated with a shorter total hospital length of stay, less blood product requirements and may offer better postoperative outcomes, including less prolonged ventilation, sternal wound infection, bleeding requiring reoperation and in-hospital mortality. However, due to the limited number of studies and their retrospective design, the results of minimally invasive surgery for re-operative AVR should be confirmed by prospective studies with larger numbers of patients. Conventional full re-sternotomy is still considered the preferred choice of approach for these patients.

Conflict of interest: none declared.

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