Featured Article

Minimally invasive primary aortic valve surgery: the OLV Aalst experience

Johan van der Merwe, Filip Casselman, Bernard Stockman, Frank Van Praet, Roel Beelen, Lieven Maene, Yvette Vermeulen, Ivan Degrieck

The Department of Cardiovascular and Thoracic Surgery, OLV-Clinic, Aalst, Belgium

Correspondence to: Filip Casselman, MD, PhD, FETCS. Department of Cardiovascular and Thoracic Surgery, OLV-Clinic, Moorselbaan 164 9300, Aalst, Belgium. Email: Filip.Casselman@olvz-aalst.be.

Background: The purpose of this study was to evaluate our in-hospital outcomes with primary J-sternotomy aortic valve surgery since the initiation of our program in 1997.

Methods: Between October 1st 1997 and August 31st 2014, 768 patients (mean age: 69.1±11.2 years, 46.6% females, 15.6% aged greater than 80 years) underwent primary JS-AVS. Additional risk factors included diabetes mellitus (n=98, 12.2%), peripheral vascular disease (n=42, 5.5%) and body mass index greater than 30 (n=144, 18.8%). The mean logistical EuroSCORE I was 5.46%±4.5%.

Results: Aortic valve replacement and repair were performed in 758 (98.7%) and 10 (1.3%) patients respectively, for isolated valve stenosis (n=472, 61.8%), incompetence (n=56, 7.3%) and mixed valve disease (n=236, 30.9%). Valve pathology included sclerosis (n=516, 67.2%), rheumatic disease (n=110, 14.3%) and endocarditis (n=10, 1.3%). Reasons for conversion to full sternotomy (n=23, 3.0%) included porcelain ascending aorta (n=3, 0.4%), inadequate visualization (n=2, 0.3%) and intra-operative complications (n=18, 2.3%). Mean length of hospital stay was 11.0±7.4 days. Morbidity included stroke (n=15, 2.0%), revision or re-exploration (n=52, 6.8%), atrial fibrillation (n=201, 26.2%) and sternitis (n=5, 0.7%). In-hospital mortality was 1.6% (n=12). Overall survival at 30 days was 98.0%.

Conclusions: JS-AVS is safe and is our routine approach for isolated aortic valve disease. Procedure related mortality is lower than predicted, conversion rates limited and significant morbidity minimal.

Keywords: Aortic valve disease (AVD); minimally invasive cardiac surgery (MI-AVS); adult cardiac disease

Submitted Nov 05, 2014. Accepted for publication Jan 07, 2015.
doi: 10.3978/j.issn.2225-319X.2015.01.08
View this article at: http://dx.doi.org/10.3978/j.issn.2225-319X.2015.01.08

Introduction

Minimally invasive aortic valve surgery (MI-AVS) is now widely performed (1,2) and it appears that there is a gradual shift in the literature from comparing outcomes with conventional surgery, towards determining which of the various MI-AVS approaches are most beneficial in terms of clinical outcome and patient satisfaction (3-8).

We initiated our MI-AVS program in October 1997, shortly after the first description and pioneering study by Cosgrove and Sabik (9). We elected to establish partial upper J-sternotomy aortic valve surgery (JS-AVS) as our preferred and routine approach for isolated AVS. We reported our findings on the benefits of this technique compared with conventional surgery (10) and demonstrated the feasibility of this approach in more complex cases involving the aortic root and ascending aorta (11) as well as redo-operation modality (12).

This study provides an in-depth overview of our minimally invasive JS-AVS experience in 768 patients who underwent isolated primary aortic valve procedures over a 16-year period.

Methods

This is a retrospective review of a single-center prospective database. A total of 768 patients underwent primary isolated

Table 1 Patient characteristics and clinical data (N=768)

Variable	n (%)
Mean age (years)	69.1±11.2
<40	15 (2.0)
40-49	32 (4.2)
50-59	101 (13.2)
60-69	214 (27.9)
70-79	286 (37.2)
80-89	117 (15.2)
>90	3 (0.4)
Gender	
Male	410 (53.4)
Female	358 (46.6)
Co-morbidity	
Hypertension	408 (53.1)
Hyperlipidemia	386 (50.3)
NIDDM/IDDM	98 (12.8)
Previous CVA/TIA	49 (6.4)
Dialysis	4 (0.5)
Peripheral vascular disease	42 (5.5)
BMI ≥30	144 (18.8)
Smoking history	297 (38.7)
Left ventricle function	
Good (≥50%)	731 (95.2)
Moderate (31-49%)	31 (4.0)
Poor (≤30%)	6 (0.8)
Surgical urgency	
Elective	736 (95.8)
Emergency	32 (4.2)
EuroSCORE I logistical	5.5±4.5

BMI, body mass index.

Table 2 Pre-operative aortic valve characteristics: surgical indications and valve pathology (N=768)

Characteristics	n (%)
Surgical indications	
Stenosis	472 (61.8)
Incompetence	56 (7.3)
Mixed	236 (30.9)
Aortic valve pathology	
Congenital/bicuspid	101 (13.2)
Sclerosis	516 (67.2)
Rheumatic	110 (14.3)
Degenerative	16 (2.1)
Endocarditis	10 (1.3)
Acute	4 (0.5)
Chronic	6 (0.8)
Connective tissue disorder	5 (0.7)
Other	10 (1.3)

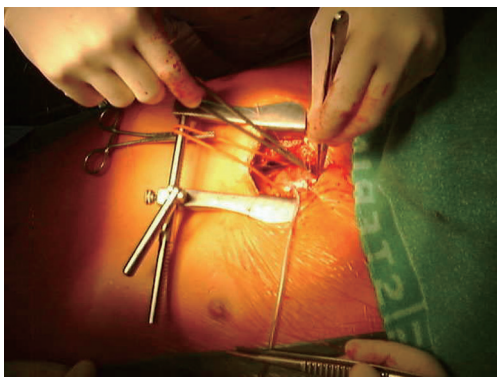

Figure 1 JS-AVS exposure. JS-AVS, J-sternotomy aortic valve surgery.

JS-AVS (excluding redo-, aortic root- and ascending aorta procedures) between 1 October 1997 and 31 August 2014. The relevant preoperative patient characteristics and clinical data are described in *Table 1*. The pre-operative aortic valve characteristics are detailed in *Table 2*.

Surgical technique and in-hospital treatment pathway

Our surgical technique for MI-AVS has been extensively described (3,13-16). We utilize a 4 to 8 cm midline skin incision starting at the manubrium-sternal joint and perform a partial upper JS-AVS with an oscillating saw down to either the 3rd or 4th right intercostal space depending on the patient body habitus (*Figure 1*).

We prefer direct antegrade ascending aortic cannulation and percutaneous femoral- and internal jugular venous cannulation via Seldinger technique (*Figure 2*). Combinations of femoral artery and vein cannulation through a 3 to 4 cm oblique incision in the groin may be used in selected patients with short aortas or impaired working space.

We use cold crystalloid cardioplegia in addition to mild systemic cooling (32 degrees) for myocardial protection. We induce cardioplegic arrest via the aortic root and maintain arrest by intermittent direct ostial cardioplegia delivery.

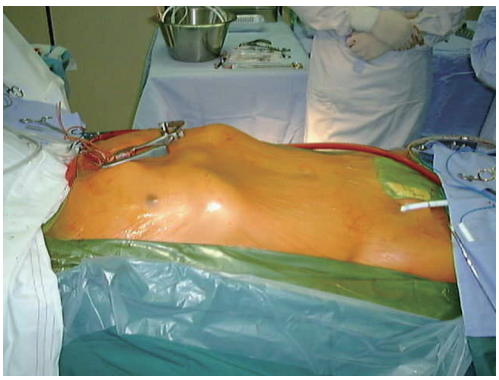

Figure 2 Cannulation setup for JS-AVS. Note the direct ascending aorta- and percutaneous right femoral vein cannulation. The right internal jugular vein for upper body drainage is not visible in this picture. JS-AVS, J-sternotomy aortic valve surgery.

Left ventricular distension is prevented by intermittent antegrade aortic root venting in cases of severe aortic valve incompetence.

Incision and closure of the aorta, valve excision and prosthetic implantation are all performed using standard instrumentation. Our de-airing strategy includes continuous CO_2 flooding of the operative field, antegrade aortic root vent and transesophageal echocardiography (TEE) confirmation of de-airing efficiency in all cases.

Cardio-respiratory support, sedation and analgesia are administered as indicated in intensive care. Post-operative chest tubes are routinely removed 48 hours post-operatively and all patients receive structured in-hospital- and post-discharge rehabilitation.

Anti-coagulated therapy with fenprocoumon (3M Health Care Ltd) is initiated and stabilized in-hospital and continued for three months, with conversion to acetyl salicylic acid in the absence of persistent post-operative AF or mechanical valve implantation.

Follow-up

All patients attend an outpatient clinic 6-8 weeks post-operatively. In-hospital and 30-day outcomes were assessed by the incidence of adverse events.

Data analysis

All in-hospital data are collected prospectively. However, this study design was retrospective as the post-discharge data was collected retrospectively. Data are expressed as the mean ± standard deviation. Analysis was performed with SPSS Statistics 20.0 (IBM, USA). The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the manuscript as written.

Results

Intra-operative outcome

A total of 768 patients underwent primary isolated JS-AVS. Aortic valve replacement and repair were performed in 758 (98.7%) and 10 (1.3%) patients respectively. The technical characteristics, cardiopulmonary bypass- and cross-clamp times are outlined in *Table 3*. Associated procedures performed are described in *Table 4*. There were no early revisions for implantation related valve dysfunction.

Early conversions occurred in five patients (0.7%) because of inadequate visualization or severely calcified aorta. Late intra-operative conversion occurred in 18 patients (2.3%) due to complications. The indications for early and late conversions are outlined in *Table 5*.

Post-operative course and outcome

Total in-hospital mortality was 1.6% (n=12). Non-cardiac causes accounted for 0.7% (n=5) of in-hospital deaths, which included sepsis related multi-organ failure (n=3), fatal intra-pulmonary hemorrhage (n=1) and respiratory failure (n=1). Mechanical ventilation longer than 48 hours was required in 25 patients (3.3%) and three patients (0.4%) required respiratory support longer than seven days. The mean length of hospital stay was 11.0±7.5 days.

Overall 30-day mortality was 2.0% (n=15), which included three discharged patients who died of sudden cardiac arrest on post-operative days 15, 24 and 28 respectively. In-hospital complications and morbidities are outlined in *Table 6*.

Discussion

The excellent outcomes of current conventional surgical techniques for valvular disease set high standards for the implementation and development of new approaches and strategies, especially in view of an aging population with increased co-morbidities, operative risks and quality of life expectations (2).

Various centers now perform MI-AVS and reports that compare the outcomes of the different techniques are emerging. Minimally invasive techniques currently under

Table 3 Valve replacement and repair characteristics (N=768)

Characteristics	n (%)
Valve profiles	
Mechanical	139 (18.3)
Biological	619 (81.7)
Implanted valves	
ATS	89 (81.7)
ST.Jude	50 (6.6)
CE-supra annular	65 (8.6)
CE-perimount	506 (66.8)
Mitroflow	32 (0.3)
Perceval	8 (1.1)
Trifecta	6 (0.8)
Implanted valve sizes	
18	3 (0.4)
19	50 (6.6)
20	5 (0.7)
21	237 (31.3)
22	3 (0.4)
23	247 (32.6)
25	146 (19.3)
27	60 (7.9)
29	6 (0.8)
Valve repair (n=10)	
Sub-valvular fibrous ring excision	1 (0.1)
Leaflet perforation/fenestration closure	3 (0.4)
Commisuroplasty	7 (0.9)
Raphe closure	5 (0.7)
Fibro-elastomectomy	1 (0.1)
Cardiopulmonary bypass time (CPBt) and cross-clamp time (CCt) (minutes)	CPBt/CCt
JS-AVS (n=744)	106.2±27.0/75.5±19.8
Conversions (n=24)	135.1±58.6/71.2±28.0

JS-AVS, J-sternotomy aortic valve surgery.

Table 4 Associated procedures performed

Surgery	n (%)
Carotid surgery	4 (0.5)
Dilatation	3 (0.4)
Endarterectomy	1 (0.1)
Cardiac surgery	16 (2.0)
Septal myomectomy	14 (1.8)
Radio frequency ablation	1 (0.1)
VSD closure	1 (0.1)
Elective hybrid PCI	14 (1.8)
Patent foramen ovale closure	1 (1.8)

Table 5 Planned JS-AVS (N=768): indications for early and late conversions

Indications	n (%)
Early conversions	5 (0.7)
Inadequate visualization	2 (0.3)
Severely calcified aorta	3 (0.4)
Late conversions	18 (2.3)
Type A dissection	1 (0.1)
Cannulation related bleeding	5 (0.7)
Iliac vein perforation	2 (0.3)
Coronary sinus perforation	2 (0.3)
Jugular vein cannula perforation	1 (0.1)
Non-cannulation related bleeding	6 (0.8)
Left atrium	4 (0.5)
Aorta	2 (0.3)
Other cannulation difficulties	2 (0.3)
Refractory ventricle fibrillation	3 (0.4)
Thrombus in left ventricle	1 (0.1)

JS-AVS, J-sternotomy aortic valve surgery.

investigation include right anterior thoracotomy (4,5,16), median mini-sternotomy with its variations (T-, J-, L-, reversed C-, S- and inverted V-shape) (3,6,8,11), off-pump implantation techniques through left anterior thoracotomy (17-23) and percutaneous aortic valve replacements (24,25).

We initiated our minimally invasive aortic valve program in October 1997 and established the partial upper JS-AVS approach as our preferred technique irrespective of body habitus, anatomical variation or risk profile. It offers circumferential access to the aorta and right atrium, even in obese patients. Indeed, 144 patients (18.8%) presented with body mass index (BMI) >30 and only five patients (0.7%) developed wound infection or sternal complications.

Early risk aversion conversion occurred in five patients (0.7%), whereas 18 patients (2.3%) required conversion due to an adverse intra-operative event. We consider the relative ease of conversion to full sternotomy an important advantage compared to other approaches.

Table 6 30-day complications other than mortality (N=768)

Complications	n (%)
Neurological events	
Stroke/TIA	15 (2.0)
Respiratory complications	
Mechanical ventilation >48 h	25 (3.3)
Pneumonia	23 (3.0)
Pneumothorax	22 (2.9)
Pleural collections requiring drainage	79(10.3)
Tracheostomy requirement for respiratory failure	3 (0.4)
Revision or re-exploration	52 (6.8)
Persistent bleeding	39 (5.0)
Tamponade	10 (1.3)
Early	7 (0.9)
Late	3 (0.4)
Acute cardiac arrest	3 (0.4)
Performed though JS incision	47 (6.1)
Renal failure requiring dialysis	3 (0.4)
Non-surgical cardiac complications	
Atrial fibrillation	201(26.2)
Permanent pacemaker	19 (2.5)
Urgent PCI	1 (0.8)
Other	
Sternitis/mediastinitis	5 (0.7)
Groin hematoma	2 (0.3)
Mean length of hospitalization (days)	11.0±7.4

Neurological events occurred in 15 patients (2.0%), with complete clinical recovery within 72 hours occurring in five patients (0.7%). This may be related to air embolism rather than organic micro-emboli. De-airing of the left ventricle is challenging and we strongly advocate continuous flooding of the operative field with CO_2, antegrade aortic root venting and meticulous air surveillance by TEE.

Revisions (n=52, 6.8%) can be performed using the same incision, which we were able to perform in 90.4% (n=47 of 52) of our re-explorations. We performed no early valve implantation related revisions and have shown that the risk of patient-prosthesis mismatch is low (26).

Post-operative pneumothoraces and pleural collections occurred in 23 (3.0%) and 79 (10.3%) patients respectively despite meticulous efforts to maintain pleural integrity. Mechanical ventilation longer than 48 hours was required in 25 patients (3.3%) and three patients (0.4%) required respiratory support longer than seven days.

New onset atrial fibrillation (AF) occurred in 201 patients (26.2%). We avoid manipulation of the right atrial appendage and superior vena cava as a general operative principle. Age is a risk factor (27) and 406 patients (53%) were older than 70 years. Cardioplegia type does not appear to influence the prevalence (28,29).

We initiate and stabilize anticoagulation- and rehabilitation regimens in-hospital, which accounts for our length of hospitalization (11.0±7.4 days). The in-hospital and 30-day mortality in our series were 1.6% and 2.0% respectively.

Conclusions

Any new techniques require experience and repetition before optimal results are achieved. We believe that JS-AVS is an acceptable alternative in MI-AVS, has many technical advantages and good clinical outcomes.

Acknowledgements

Disclosure: The authors declare no conflict of interest.

References

1. Rosengart TK, Feldman T, Borger MA, et al. Percutaneous and minimally invasive valve procedures: a scientific statement from the American Heart Association Council on Cardiovascular Surgery and Anesthesia, Council on Clinical Cardiology, Functional Genomics and Translational Biology Interdisciplinary Working Group, and Quality of Care and Outcomes Research Interdisciplinary Working Group. Circulation 2008;117:1750-67.
2. Phan K, Xie A, Di Eusanio M, et al. A meta-analysis of minimally invasive versus conventional sternotomy for aortic valve replacement. Ann Thorac Surg 2014;98:1499-511.
3. Svensson LG. Minimal-access "J" or "j" sternotomy for valvular, aortic and coronary operations or re-operations. Ann Thorac Surg 1997;64:1501-3.
4. Miceli A, Murzi M, Gilmanov D, et al. Minimally invasive aortic valve replacement using right minithoracotomy is associated with better outcomes than ministernotomy. J Thorac Cardiovasc Surg 2014;148:133-7.
5. Glauber M, Miceli A, Bevilacqua S, et al. Minimally invasive aortic valve replacement via right anterior

minithoracotomy: early outcomes and midterm follow-up. J Thorac Cardiovasc Surg 2011;142:1577-9.
6. Karimov JH, Santarelli F, Murzi M, et al. A technique of an upper V-type ministernotomy in the second intercostal space. Interact Cardiovasc Thorac Surg 2009;9:1021-2.
7. Schmitto JD, Mokashi SA, Cohn LH. Minimally-invasive valve surgery. J Am Coll Cardiol 2010;56:455-62.
8. Tabata M, Umakanthan R, Cohn LH, et al. Early and late outcomes of 1000 minimally invasive aortic valve operations. Eur J Cardiothorac Surg 2008;33:537-41.
9. Cosgrove DM III, Sabik JF. Minimally invasive approach for aortic valve operations. Ann Thorac Surg 1996;62:596-7.
10. Bakir I, Casselman FP, Wellens F, et al. Minimally invasive versus standard approach aortic valve replacement: a study in 506 patients. Ann Thorac Surg 2006;81:1599-604.
11. Bakir I, Casselman F, De Geest R, et al. Minimally invasive aortic root replacement: a bridge too far? J Cardiovasc Surg (Torino) 2007;48:85-91.
12. Bakir I, Casselman FP, De Geest R, et al. Should minimally invasive aortic valve replacement be restricted to primary interventions? Thorac Cardiovasc Surg 2007;55:304-9.
13. von Segesser LK, Westaby S, Pomar J, et al. Less invasive aortic valve surgery: rationale and technique. Eur J Cardiothorac Surg 1999;15:781-5.
14. Cohn LH, Adams DH, Couper GS, et al. Minimally invasive cardiac valve surgery improves patient satisfaction while reducing costs of cardiac valve replacement and repair. Ann Surg 1997;226:421-6; discussion 427-8.
15. Doll N, Borger MA, Hain J, et al. Minimal access aortic valve replacement: effects on morbidity and resource utilization. Ann Thorac Surg 2002;74:S1318-22.
16. Ruttmann E, Gilhofer TS, Ulmer H, et al. Propensity score-matched analysis of aortic valve replacement by mini-thoracotomy. J Heart Valve Dis 2010;19:606-14.
17. Walther T, Dewey T, Wimmer-Greinecker G, et al. Transapical approach for sutureless stent-fixed aortic valve implantation: experimental results. Eur J Cardiothorac Surg 2006;29:703-8.
18. Huber CH, Cohn LH, von Segesser LK. Direct-access valve replacement a novel approach for off-pump valve implantation using valved stents. J Am Coll Cardiol 2005;46:366-70.
19. Huber CH, von Segesser LK. Direct access valve replacement (DAVR) - are we entering a new era in cardiac surgery? Eur J Cardiothorac Surg 2006;29:380-5.
20. Walther T, Falk V, Borger MA, et al. Minimally invasive transapical beating heart aortic valve implantation--proof of concept. Eur J Cardiothorac Surg 2007;31:9-15.
21. Lichtenstein SV, Cheung A, Ye J, et al. Transapical transcatheter aortic valve implantation in humans: initial clinical experience. Circulation 2006;114:591-6.
22. Gammie JS, Brown JW, Brown JM, et al. Aortic valve bypass for the high-risk patient with aortic stenosis. Ann Thorac Surg 2006;81:1605-10.
23. Vassiliades TA Jr. Off-pump apicoaortic conduit insertion for high-risk patients with aortic stenosis. Eur J Cardiothorac Surg 2003;23:156-8.
24. Webb JG, Chandavimol M, Thompson CR, et al. Percutaneous aortic valve implantation retrograde from the femoral artery. Circulation 2006;113:842-50.
25. Miller DC, Blackstone EH, Mack MJ, et al. Transcatheter (TAVR) versus surgical (AVR) aortic valve replacement: occurrence, hazard, risk factors, and consequences of neurologic events in the PARTNER trial. J Thorac Cardiovasc Surg 2012;143:832-843.e13.
26. Hogue CW Jr, Hyder ML. Atrial fibrillation after cardiac operation: risks, mechanisms, and treatment. Ann Thorac Surg 2000;69:300-6.
27. Mathew JP, Parks R, Savino JS, et al. Atrial fibrillation following coronary artery bypass graft surgery: predictors, outcomes, and resource utilization. MultiCenter Study of Perioperative Ischemia Research Group. JAMA 1996;276:300-6.
28. Asher CR, DiMengo JM, Arheart KL, et al. Atrial fibrillation early postoperatively following minimally invasive cardiac valvular surgery. Am J Cardiol 1999;84:744-7, A9.
29. Bakir I, Casselman FP, Onan B, et al. Does a minimally invasive approach increase the incidence of patient-prosthesis mismatch in aortic valve replacement? J Heart Valve Dis 2014;23:161-7.

Cite this article as: van der Merwe J, Casselman F, Stockman B, Van Praet F, Beelen R, Maene L, Vermeulen Y, Degrieck I. Minimally invasive primary aortic valve surgery: the OLV Aalst experience. Ann Cardiothorac Surg 2015;4(2):154-159. doi: 10.3978/j.issn.2225-319X.2015.01.08

