The Heart Surgery Forum #2004-1104
7 (6), 2004 [Epub November 2004]
doi:10.1532/HSF98.20041104

Online address: www.hsforum.com/vol7/issue6/2004-1104.html

Port-Access Aortic Valve Surgery: A Technique in Evolution

Dr. Wheatley

Grayson H. Wheatley III, MD,[1] Syma L. Prince, RN,[1] Morley A. Herbert, PhD,[1] William H. Ryan, MD[2]

[1]Cardiopulmonary Research Science and Technology Institute, [2]Presbyterian Hospital of Dallas, Dallas, Texas, USA

ABSTRACT

Background: Innovative minimally invasive surgical techniques have been developed for treating many cardiac diseases. We reviewed our experience with port-access aortic valve replacement (PAVR) surgery.

Methods: We retrospectively reviewed the charts of patients with aortic valve disease who underwent surgical correction using the Heartport System and minithoracotomy (PAVR) from January 1998 to December 2002 (n = 58) and matched them 1:1 with a cohort of patients who underwent AVR with conventional sternotomy.

Results: No preoperative statistical differences existed between the groups, including age, sex, New York Heart Association class, and ejection fraction. Perioperatively, there was a statistically significant difference between the AVR and PAVR groups with regard to aortic cross-clamp time (74.0 ± 22.9 minutes versus 92.7 ± 20.4 minutes, $P < .01$). Average operative times improved in the PAVR group by almost 83 minutes from the first 10 patients to patients 21 to 31 ($P = .05$). PAVR patients also averaged shorter stays in the intensive care unit (ICU) (1.5 days less) and hospital (1.8 days less) and were extubated sooner (4.9 hours). Mortality (1/58, 1.7%) and morbidity (reoperation for bleeding, infection, and stroke) were similar for both groups.

Conclusions: This minimally invasive approach to aortic valve surgery allows patients to be extubated earlier and promotes shorter stays in the ICU and hospital. These data suggest that the PA approach is an attractive alternative for patients requiring aortic valve surgery. There also appears to be a rapid surgeon learning curve.

INTRODUCTION

Port access (PA) surgery has been established as safe and effective for both cardiac revascularization and mitral valve surgery [Schwartz 1997, Mohr 1998, Ribakove 1998]. It can be performed through a minithoracotomy incision with accompanying endovascular placement of cardiopulmonary bypass catheters, PA vents, and cardioplegia delivery catheters [Reichenspurner 1999]. Aortic valve surgery using a PA approach, although not as common, has been shown to be safe and effective [Kaur 1998, Christiansen 1999, Kort 2001]. The objective of this study is to review our experience with PA aortic valve surgery and compare those results with a computer-matched control group of patients who underwent aortic valve replacement (AVR) with standard median sternotomy.

MATERIALS AND METHODS

After Institutional Review Board approval, the medical records of patients who underwent aortic valve surgery between January 1998 and December 2002 were reviewed. We retrospectively reviewed the charts of consecutive patients who underwent isolated AVR using the Heartport System (Redwood City, CA, USA) combined with a right third-interspace minithoracotomy (PAVR) (n = 58) and matched them 1:1 according to age ±7 years, presence of cardiovascular disease, New York Heart Association (NYHA) class, presence of aortic insufficiency, and preoperative inotrope requirements with a cohort of patients who underwent conventional sternotomy (AVR). Patients requiring redo aortic valve surgery were excluded from this study.

Using the Society of Thoracic Surgeons database and medical records of both groups, we collected preoperative data such as patient age and sex; presence of diabetes mellitus, renal disease, arrhythmia, peripheral vascular disease or congestive heart failure; history of previous coronary artery bypass grafting; NYHA class; and ejection fraction. Perioperative variables such as total operative time, aortic cross-clamp time, total cardiopulmonary bypass time, and number of patients requiring blood transfusion were also collected. Postoperative variables were compared and included time on the ventilator, length of stay in the intensive care unit (ICU), total length of stay in the hospital, morbidities, and 30-day mortality.

After induction of general anesthesia, patients receiving PAVR underwent endovascular cardiopulmonary catheter placement with the assistance of transesophageal echocardiography (TEE) and intraoperative fluoroscopy. A venous bypass catheter (Cardiovations, Somerville, NJ, USA) was placed into the right atrium and superior vena cava via the femoral vein while an arterial bypass catheter (Cardiovations)

Presented at the Seventh Annual Meeting of the International Society for Minimally Invasive Cardiothoracic Surgery, London, UK, June 23-26, 2004.

Received July 5, 2004; accepted August 13, 2004.

Address correspondence and reprint requests to: William H. Ryan, MD, 7777 Forest Lane C-742, Dallas, TX 75230, USA; 1-972-566-6820; fax: 1-972-566-8524 (e-mail: wbryanmd@yahoo.com).

Table 1. Clinical Characteristics of the Study Patients*

	AVR (n = 58)		PAVR (n = 58)		
	n	%	n	%	*P*
Female	20	(34.5)	21	(36.2)	NS
Diabetes mellitus	14	(24.1)	14	(24.1)	NS
Renal failure	2	(3.5)	3	(5.2)	NS
Hypertension	31	(53.5)	36	(62.1)	NS
Cerebral vascular accident	1	(1.7)	6	(10.3)	NS
Peripheral vascular disease	4	(6.9)	4	(6.9)	NS
Previous bypass grafting	6	(10.3)	8	(13.8)	NS
Congestive heart failure	23	(39.7)	14	(24.1)	NS
Myocardial infarction	4	(6.9)	4	(6.9)	NS
Preoperative arrhythmia	11	(19.0)	12	(20.7)	NS
Aortic stenosis	45	(77.5)	48	(82.7)	NS
Aortic insufficiency					NS
0	37	(63.8)	37	(63.8)	
1+	3	(5.2)	3	(5.2)	
2+	1	(1.7)	1	(1.7)	
3+	7	(12.1)	7	(12.1)	
4+	10	(17.2)	10	(17.2)	
Operative status					NS
Elective	38	(65.5)	43	(74.1)	
Urgent	20	(34.5)	15	(25.9)	
Emergent	0	(0)	0	(0)	

*AVR indicates conventional aortic valve replacement; PAVR, port-access aortic valve replacement.

was placed into the femoral artery. Retrograde cardioplegia was administered through a coronary sinus catheter (Cardiovations) placed percutaneously through the right internal jugular vein. The aorta was cross-clamped using a Cosgrove flexible aortic cross-clamp. Access to the aortic valve was obtained using a 4- to 5-cm right third-interspace minithoracotomy incision and a standard transverse aortotomy. In the AVR group, aortic valve surgery was performed using a conventional median-sternotomy approach with direct cannulation of the aorta and right atrium.

RESULTS

Patient Demographics

Average patient age was nearly identical in the AVR and PAVR groups (70.4 ± 10.4 years versus 70.1 ± 10.2 years). No preoperative statistical differences existed between the groups in regard to sex and history of diabetes mellitus, hypertension, renal disease, cerebral vascular accidents, previous myocardial infarction, congestive heart failure, arrhythmia, aortic stenosis, aortic insufficiency, or previous coronary artery bypass grafting.

Preoperative ejection fraction was 51.6% ± 13.2% in the AVR group and 49.5% ± 13.4% in the PAVR group and was not statistically significant. In addition, the predicted rate of mortalities was identical for both groups (0.04 ± 0.03, *P* = NS).

Table 1 lists the demographic comparison between the 2 groups.

Table 2. Perioperative Variables*

	AVR (n = 58)	PAVR (n = 58)	*P*
Aortic cross-clamp time, min	74.0 ± 22.9	92.7 ± 20.4	<.01
Cardiopulmonary bypass (perfusion) time, min	107.0 ± 34.8	113.4 ± 24.9	NS
Time on ventilator (to extubation), h	8.5 ± 14.5	3.6 ± 8.4	.03
Length of ICU stay (days)	4.1 ± 9.9	2.6 ± 3.6	.05
Length of hospital stay (days)	9.1 ± 11.1	7.3 ± 5.8	.03

*AVR indicates conventional aortic valve replacement; PAVR, port-access aortic valve replacement.

Perioperative Variables

Although average perfusion times were similar for the PAVR and AVR groups (113.4 ± 24.9 minutes versus 107 ± 34.8 minutes, *P* = NS), average aortic cross-clamp times were longer in the PAVR group (92.7 ± 20.4 minutes versus 74.0 ± 22.9 minutes) and reached statistical significance (*P* < .01). However, duration of ventilation following surgery (4.9 hours less) and ICU length of stay (1.5 days less) were shorter for the PAVR group, and both variables were statistically significant compared to the AVR group (*P* = .03, *P* = .05, respectively). In addition to a shorter length of stay in the ICU, PAVR patients had a statistically significant shorter total length of stay in the hospital compared to the AVR group (7.3 ± 5.8 days versus 9.1 ± 11.1 days, *P* = .03).

Table 2 summarizes the differences between the 2 groups regarding perioperative variables.

Total operative times for the first 31 consecutive PAVR patients are individually plotted in Figure 1. A best-fit line demonstrates that total operative times, as a whole, steadily declined from the first PAVR patient (490 minutes) to the 31st PAVR patient (255 minutes). When total operative times were subdivided into consecutive groups of 10 patients and averaged, the average operative times improved in the PAVR group by almost 83 minutes from the first 10 patients (333.0 minutes) to patients 21 to 31 (251.36 minutes), and this difference was statistically significant (*P* < .03).

Figure 2 shows the differences in average operative times.

Postoperative Variables

There were no statistical differences between the groups in postoperative complications including development of atrial fibrillation, renal failure, myocardial infarction, stroke, prolonged ventilation, pneumonia, or deep sternal wound infections. Additionally, the incidence of surgically related complications was similar in the PAVR and AVR groups with regard to the number of patients who required blood transfusion, developed cardiac tamponade, or needed reoperation for bleeding or for valvular dysfunction. There were also no significant differences between the PAVR and AVR groups with regard to the number of readmissions to the hospital within 30 days postoperatively, and in both groups only 1 death occurred (1.7%, *P* = NS) in the first 30 days following surgery.

Table 3 compares the PAVR and AVR groups in relation to postoperative morbidity and mortality.

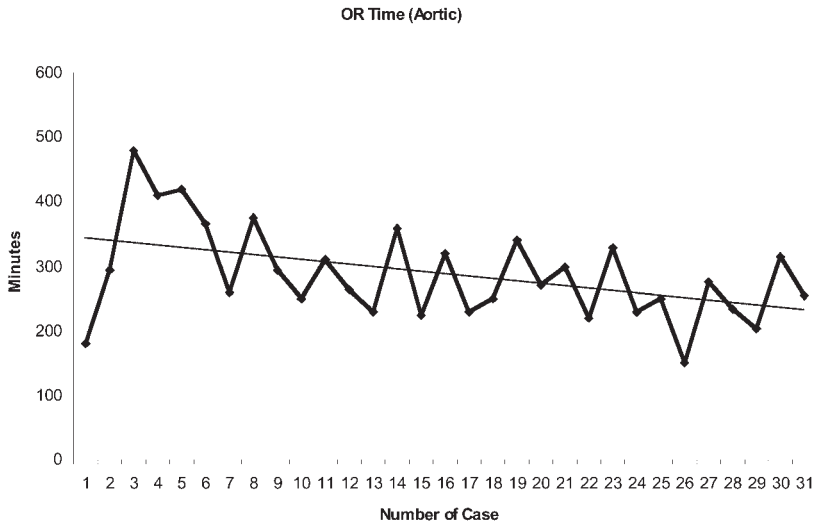

Figure 1. Total operative times (minutes) of the first 31 consecutive cases of port-access aortic valve replacement, with associated best-fit line. OR indicates operating room.

There was 1 groin complication in the PAVR group. A 75-year-old male patient experienced a deep vein thrombosis (DVT) following femoral vein cannulation and required long-term anticoagulation. No arterial insufficiency or embolic phenomena were noted related to femoral artery cannulation for PAVR.

DISCUSSION

A number of different surgical approaches exist for minimally invasive aortic valve surgery: (1) right parasternal from the second to the fifth costal cartilages, (2) inverse-T partial sternotomy, (3) transverse sternotomy, and (4) minithoracotomy in the second or third interspaces [Cohn 1999, Cohn 2001]. Each of the different exposure techniques possesses inherent advantages and disadvantages. The right third interspace minithoracotomy approach, combined with PA technology, is the minimally invasive technique favored by our group because of the small incision size, avoidance of sternotomy, and excellent exposure to the proximal aorta and root.

Procedures using the PA approach for mitral valve surgery, coronary artery bypass grafting, and atrial-septal defect closure using both femoral and direct aortic cannulation have been shown to be safe and effective [Galloway 1999]. However, despite easier access for aortic cannulation and a less complex de-airing procedure, the adoption of minithoracotomy AVR has been less widespread. This study demonstrates a safe, short learning curve for PAVR with morbidity and

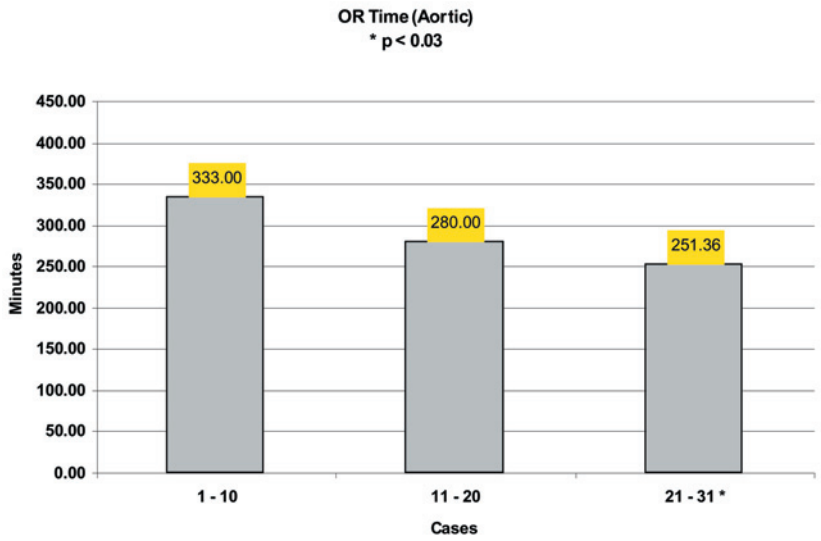

Figure 2. Total operative times (minutes) of the first 31 consecutive port-access aortic valve cases separated into groups of 10 cases, with associated group average operative times. OR indicates operating room.

Table 3. Postoperative Comparison (30 Day)*

	AVR (n = 58)		PAVR (n = 58)		
	n	%	n	%	*P*
Atrial fibrillation	20	(34.5)	25	(43.1)	NS
Renal failure	8	(13.8)	2	(3.5)	NS (.09)
Myocardial infarction	0	(0)	0	(0)	NS
Pneumonia	2	(3.5)	0	(0)	NS
Reoperation for bleeding	7	(12.1)	6	(10.3)	NS
Reoperation for valve dysfunction	0	(0)	0	(0)	NS
Deep sternal wound infection	1	(1.7)	0	(0)	NS
Stroke	0	(0)	0	(0)	NS
Cardiac tamponade	1	(1.7)	4	(6.9)	NS
Blood transfusion	32	(55.2)	39	(67.2)	NS
Prolonged ventilation (>24 h)	8	(13.8)	6	(10.3)	NS
Readmission within 30 days	5	(10.6)	2	(5.3)	NS
Death	1	(1.7)	1	(1.7)	NS

*AVR indicates conventional aortic valve replacement; PAVR, port-access aortic valve replacement.

mortality rates comparable to those of a conventional approach for aortic valve disease. Until either percutaneous transcatheter AVR or transapical transcatheter AVR become available, the PA approach, using percutaneous femoral vessel cannulation and minithoracotomy, offers the least invasive alternative to conventional AVR.

There are limitations to the PAVR procedure. It requires familiarity with TEE anatomy for catheter placement. If significant ascending aortic atherosclerosis is present, an open procedure, with wider exposure for aortic cross-clamp placement or aortic replacement, is necessary. A previous diagnosis of DVT is a relative contraindication to femoral vein cannulation, unless venography or ultrasound demonstrates normal vein patency and no residual lower leg vein thrombi exist. If femoral artery cannulation is employed, magnetic resonance imaging or computed tomography should confirm the absence of significant atherosclerotic disease in the aorta or iliac vessels. All of these constraints may limit use of this procedure in older patients, yet these are the very patients who could be expected to benefit most from the procedure.

This study also has drawbacks. It is retrospective and computer matched, and as such enjoys the benefits of surgical selection. A more realistic approach would include prospective randomization of all isolated AVRs. This strategy would identify the percent of patients with aortic valve disease who were screened but were deemed not suitable candidates for a PA approach. In addition, a prospectively randomized study would perhaps better define the subset of patients who may benefit most from PAVR.

PAVR patients were, on average, extubated sooner and discharged from the ICU earlier than AVR patients. The earlier extubation and more rapid discharge from the ICU also translated into a shorter average length of stay in the hospital compared to patients receiving AVR. This result suggests that PAVR patients are perhaps more likely to regain mobility earlier after surgery and may not be adversely limited by the minithoracotomy incision.

In addition to being statistically significant compared to the AVR group, decreases in both the time on the ventilator and lengths of stay in the ICU and hospital for PAVR patients could potentially decrease overall hospital costs. Additional studies are needed to evaluate the total cost benefit of decreased use of hospital resources versus the increased intraoperative costs associated with PA technology and catheters. Perhaps enrolling more patients in the PAVR group could amplify the differences between these 2 groups.

In conclusion, our study suggests that PAVR can be performed safely. These patients have minimal postoperative complications, are extubated sooner, have shorter ICU stays, and are discharged home sooner. Additional studies are necessary to evaluate cost utilization of this new technology. There is also a need to assess quality of life several months to years postoperatively in relation to the smaller size and favorable location of the surgical incision in PAVR patients. A rapid surgeon learning curve allows for early adoption of PAVR. The potential benefits of PA technology may become more apparent as more patients undergo PAVR and more surgeons gain experience with PA techniques.

REFERENCES

Christiansen S, Stypmann J, Tjan TDT, et al. 1999. Minimally-invasive versus conventional aortic valve replacement—perioperative course and mid-term results. European J Cardiothorac Surg 16:647-52.

Cohn LH. 2001. Minimally invasive valve surgery. J Card Surg 16:260-5.

Cohn LH, Adams DH, Couper GS, Bichell DP. 1997. Minimally invasive aortic valve replacement. Semin Thorac Cardiovasc Surg 9:331-6.

Galloway AC, Shemin RJ, Glower DD, et al. 1999. First report of the Port Access International Registry. Ann Thorac Surg 67:51-8.

Glower DD, Siegel LC, Frischmeyer KJ, et al. 2000. Predictors of outcome in a multicenter port-access valve registry. Ann Thorac Surg 70:1054-9.

Grossi EA, Galloway AC, Ribakove GH, et al. 2001. Impact of minimally invasive valvular heart surgery: a case-control study. Ann Thorac Surg 71:807-10.

Kaur S, Balaguer J, Vander Salm TJ. 1998. Improved myocardial protection in minimally invasive aortic valve surgery with the assistance of port-access technology. J Thorac Cardiovasc Surg 116:874-5.

Kort S, Applebaum RM, Grossi EA, et al. 2001. Minimally invasive aortic valve replacement: echocardiographic and clinical results. Am Heart J 142:476-81.

Mohr FW, Falk V, Diegeler A, et al. 1998. Minimally invasive port-access mitral valve surgery. J Thorac Cardiovasc Surg 115:567-74.

Reichenspurner H, Weltz A, Gulielmos V, Boehm DH, Reichart B. 1999. Port-access cardiac surgery using endovascular cardiopulmonary bypass: theory, practice, and results. J Card Surg 14:275-80.

Ribakove GH, Miller JS, Anderson RV, et al. 1998. Minimally invasive port-access coronary artery bypass grafting with early angiographic follow-up: initial clinical experience. J Thorac Cardiovasc Surg 115:1101-10.

Schwartz DS, Ribakove GH, Grossi EA, et al. 1997. Minimally invasive mitral valve replacement: port-access technique, feasibility, and myocardial functional preservation. J Thorac Cardiovasc Surg 113:1022-31.