

Is Port-Access Applicable To Complex Mitral Valve Repair?

(#2001-6751 ... June 27, 2001)

Donald D. Glower, MD, Kevin P. Landolfo, MD, Alan P. Kypson, MD, Thomas M. Bashore, MD, J. Kevin Harrison, MD, Andrew Wang, MD, John J. Warner, MD

Duke University Medical Center, Durham, NC

Presented at the Fourth Annual Scientific Meeting of the International Society for Minimally Invasive Cardiac Surgery, June 27-30, 2001, Munich, Germany.

Address correspondence and print requests to: Dr. Donald D. Glower, Box 3851, Duke Univ. Med. Ctr., Durham, NC 27710, Phone: 919-681-5789, FAX 919-681-8912, Email: Glowe001@mc.duke.edu

ABSTRACT

Background: The suitability of the Port-Access approach to complex mitral valve repair remains controversial and has not been documented.

Methods: Retrospective analysis was performed of 161 consecutive patients undergoing mitral repair for mitral regurgitation (MR) using Port-Access at a single institution from 1996-2001 using direct visualization of the mitral valve through a 6 cm right anterolateral thoracotomy. Repair was classed as annuloplasty alone (ANN, N=39), complex valvuloplasty (CX, N=25) requiring chordal repair of the anterior leaflet, or any other valvuloplasty (VAL, N=97).

Results: CX patients were similar to VAL patients but differed from ANN patients in being more male (17/25(68%) vs 15/39(38%)), having less ischemic disease (1/25(4%) vs 9/39(23%)), less prior procedures (1/25(4%) vs 8/39(21%)), and higher ejection fraction ($50\pm 7\%$ vs $39\pm 12\%$). CX patients had clamp times and pump times longer than ANN but not different from VAL. Mortality was 0/25(0%) for CX and 1/161 overall. Intraoperative echo showed no difference in grade of residual MR ($p=0.6$ CX vs ANN or VAL)(none > 1+). At a median follow-up of 12 months, CX patients did not differ from VAL or ANN in degree of late MR ($p=0.7$) or need for late mitral reoperation ($p=0.14$). Two CX patients were reoperated, 1 for endocarditis, 1 for recurrent mitral regurgitation.

Conclusions: This single institution experience demonstrates that complex mitral repair using Port-Access can achieve excellent short term results comparable to those from less complex repairs. Although longer follow-up is needed, Port-Access or other limited access techniques need not be withheld from patients requiring complex repair once the surgical team becomes comfortable with limited access.

INTRODUCTION

Port-Access via a small right thoracotomy is one of several minimally invasive approaches to the mitral valve. Port-Access is defined as an operation on the mitral

valve through a small right thoracotomy using percutaneous access to the right atrium, aorta, or coronary sinus using catheters manufactured by Heartport, Inc. (Redwood City, CA)[Pompili 1996]. Port-Access has been shown to have potential advantages of improved cosmesis, earlier return to normal activity, avoidance of sternotomy, less bleeding, less transfusion, less pain, and less sepsis or wound infection relative to standard median sternotomy [Glower 1998, Walther 1999, Grossi 2001]. Disadvantages to Port-Access include longer operating times, limited exposure, greater degree of difficulty, and longer learning curve than standard sternotomy [Glower 1998, Glower 2001, Grossi 2001]. As a result, a general consensus has existed that Port-Access is not advisable for complex mitral repairs (defined as repairs involving anterior leaflet chordae) where clamp times and procedure difficulty are already greater than most mitral procedures.

The purpose of this report was to critically examine the results of complex mitral valve repair using Port-Access relative to those from standard mitral repair with Port-Access. This study was intended to confirm or deny the applicability of Port-Access to complex mitral valve repair.

MATERIALS AND METHODS

A retrospective analysis was performed of all 166 consecutive patients undergoing isolated mitral valve repair by a single surgeon at Duke University from 1996 through 2001. Of these 166 patients, 5 patients underwent median sternotomy because of other aortic valve disease, coronary disease, or hemodynamic instability which were felt to preclude Port-Access. These 5 sternotomy patients were excluded from analysis, and the remaining 161 Port-Access mitral repair patients constitute the population for this study. Data were collected prospectively, through retrospective chart review, and through patient contact after approval of the institutional review board. Intra-operative transesophageal echocardiograms were examined, as were reports from all post-operative echocardiograms obtained during follow-up at Duke University.

Port-Access procedures were performed as previously reported for mitral valve operations [Glower 1998]. Patients were positioned supine with a roll behind the right shoulder. Lung isolation was achieved in all patients with a dual lumen endotracheal tube or an endobronchial blocker. A 6-cm right anterolateral thoracotomy was performed through the 4th intercostal space. In most patients, the fourth rib was divided medially and then repaired with a single figure-of-eight No. 4 sternal wire at the end of the case. The pericardium was incised vertically from the diaphragm to the innominate vein. A 25 Fr. venous catheter (Heartport, Inc., Redwood City, CA) was percutaneously introduced into the right femoral vein over a wire and directed into the right atrium using palpation and echocardiography [Boova 1998]. The ascending aorta was cannulated through the first intercostal space as previously described [Glower 1999], or alternatively, the right femoral artery was cannulated through a small groin incision.

Once on cardiopulmonary bypass using centrifugal or vacuum assisted venous return, the heart was arrested using antegrade and retrograde cardioplegia. The aorta was occluded in most cases using an endoclamp as previously described [Glower 1999], or using an external aortic clamp when the aortic diameter exceeded 3.5 cm [Chitwood 1999]. Ventricular fibrillation was used instead of cardioplegic arrest in several cases where the ability to occlude the aorta and deliver

cardioplegia was limited by previous patent coronary bypass grafts. The coronary sinus catheter was placed either percutaneously or directly in the right atrium through the operative field. The mitral operation was performed using mitral repair techniques standard for median sternotomy and using direct vision of the mitral valve via a left atriotomy and the thoracotomy incision. Laparoscopic instruments were used to conduct the mitral repair (Heartport, Inc., Redwood City, CA).

Statistical analysis was performed using the NCSS statistical program [Hintze 1988]. Continuous variables were analyzed by analysis of variance and categorical variables by the Chi-squared test or Fisher's exact test. Non-parametric testing was performed with the Mann-Whitney test. A p value of less than 0.05 was considered significant.

RESULTS

Of the 161 consecutive Port-Access mitral valve repair patients, 39 underwent annuloplasty alone, 97 underwent standard valvuloplasty, and 25 underwent complex mitral repair. The baseline demographics for each of the three patient groups did not differ significantly (Table 1), except that annuloplasty patients were more likely to be female than VAL or CX patients, annuloplasty patients were more likely to have had previous heart procedures than VAL or CX, and annuloplasty patients had lower ejection fraction than did VAL or CX. No apparent demographic difference was found between VAL and CX patients.

Mitral valve disease etiology was more likely to be prolapse and less likely to be ischemic or other degenerative disease in CX patients than in ANN patients (Table 2). CX and VAL patients did not differ in mitral disease etiology, except that CX patients were less likely than VAL to have prolapse other than Barlow's disease.

The types of procedures that were performed in each group included quadrangular resection of the posterior leaflet in 78% of VAL and only 28% of CX patients (Table 3). Anterior leaflet procedures were artificial polytetrafluoroethylene chord placement in 18/25(72%) CX patients and chordal transfer in 6/25(24%) CX patients (Table 4). An annuloplasty ring was used in all patients, and the ring size was significantly smaller for ANN patients but did not differ significantly between VAL and CX patients. The median ring size was 32 mm for VAL and CX (Figure 1).

Femoral arterial cannulation, the use of an endoclamp, and the use of ventricular fibrillation did not differ significantly between groups (Table 5). ANN patients had significantly shorter clamp and pump times than did VAL or CX patients. CX patients did not differ significantly in clamp or pump time from VAL patients (Table 5).

Hospital morbidity did not differ significantly between patient groups (Table 6). Although 2 CX patients and 1 ANN patient had perioperative strokes (related to postoperative atrial fibrillation), CX did not differ from ANN or VAL in the incidence of stroke ($p=0.1$). One death occurred in the ANN group due to liver failure in a patient with viral cardiomyopathy.

Residual mitral regurgitation in the operating room using transesophageal echocardiography after weaning from cardiopulmonary bypass did not differ significantly between the three groups ($p=0.6$). No patient had more than mild regurgitation, other than 1 VAL patient with mild to moderate residual mitral regurgitation (Figure 2). Follow-up echocardiograms at Duke University were

available in 79/161(49%) patients with a median time from operation of 12±12 months. Residual mitral regurgitation on follow-up echocardiogram did not differ significantly between groups (p=0.7)(Figure 3). One ANN patient developed ring dehiscence 3 months postoperatively and was reoperated successfully using Port-Access and repeat mitral repair. This repair failure was felt to result not from port access but from massive annular dilation in the setting of a fixed mediastinum (prior sternotomy). The authors have subsequently avoided this problem by using pledgeted mattress sutures instead of unpledgeted mattress sutures in patients with significant annular dilation and prior sternotomy. One VAL patient required reoperation 4 months postoperatively for endocarditis. Two CX patients required reoperation, 1 for enterococcal endocarditis 2 months postoperatively and 1 for elongation of a congenital single papillary muscle at 1 month. The incidence of reoperation was not significantly different between groups (p=0.14).

DISCUSSION

This study demonstrates that acceptable short-term results can be obtained using Port-Access in patients requiring complex mitral valve repair. The results of complex mitral repair using Port-Access are comparable and not significantly different from results in patients undergoing less complex mitral repair using Port-Access. In sternotomy patients, some authors have observed that anterior leaflet repairs were less durable than other mitral repairs [Fukui 1996, Gillinov 1998]. Yet, recent studies have agreed with the findings of the present study that anterior leaflet repairs are not significantly less durable if more mature techniques of chordal transfer, artificial chordal replacement, and ring annuloplasty are used [Grossi 1995, David 1998, Phillips 2000].

Several factors may contribute to acceptable results from complex mitral repair using Port-Access. First, all patients underwent mitral valve repair using direct vision without video directed surgery [Vanerman 1999] and without the use of robotics [Chitwood 1999, Reichenspurner 1999], each of which could increase difficulty of a complex procedure. Second, these results were obtained at an institution with a relatively large experience using Port-Access for mitral valve repair.

As with sternotomy, mitral valve repair using port access can involve a range of technical difficulty, varying from simple annuloplasty alone to more complex repairs involving both mitral leaflets. Excellent results were obtained at this institution by starting with more simple mitral annuloplasty and mitral valve replacement, then gradually increasing the complexity of patients as the operating team gathered experience. Previous studies have suggested that the initial learning curve with port access requires about 10-20 cases over a period of 3-6 months [Glower 2001], and this is the time period when complex mitral repairs using port access might be avoided. All mitral valve operations require more time and patience with port access relative to sternotomy [Glower 1998, Grossi 2001], primarily due to the limited field of view. Yet, the actual ease of *visualizing* the valve and subvalvular apparatus is in fact *better* with port access than with sternotomy, due to the more lateral angle of view using port access (versus a more medial view of the laterally directed mitral valve using sternotomy). As a consequence, no particular mitral repair maneuvers are contraindicated or even need modification to be applied to the port access approach. Because longer operating time is the only essential difference between port access and sternotomy, the only relative contraindication to port access

might be a repair of such complexity that the expected aortic clamp time would be under 4 hours with sternotomy (acceptable) but potentially over 4 hours with port access (unacceptable).

This study does have several limitations. First, the conclusions of this report may not be applicable to video directed complex mitral repair or to robotic mitral repair which were not examined. Second, the results might not apply to an operating team still in the early learning curve of Port-Access techniques. Multi-institutional registry data suggest that some degree of learning is still ongoing after 100 cases with Port-Access, although the initial learning curve appears to be 10 to 20 cases [Glower 2001]. Third, this study did not compare results of complex mitral repair in Port-Access to those of complex repair with standard sternotomy. Nonetheless, the results of complex repair reported here did not significantly differ from recent larger series of complex mitral repairs using sternotomy where reoperation rates at 1 year were 1% to 5% [Grossi 1995, David 1998, Totaro 1999, Kobayashi 2000, Phillips 2000].

Finally, patient selection bias may have favored more routine complex repairs in this study. However, it should be noted that the primary surgeon in this case performed 161/166(97%) isolated mitral repairs using Port-Access during the study period. In 5/166(3%) patients, sternotomy was used instead of Port-Access because of concurrent aortic valve or coronary disease which ultimately were not treated, or because of hemodynamic instability. Only one of these 5 patients underwent complex mitral repair using sternotomy for papillary muscle rupture. Thus, relative contraindications for Port-Access approach to complex mitral repair are the same as for Port-Access mitral procedures in general, including: need for concurrent coronary or aortic valve procedures, inability to obtain either single lung ventilation or femoral arterial cannulation, significant pectus excavatum, or hemodynamic instability.

CONCLUSION

These data therefore suggest that Port-Access (or other minimally invasive right thoracotomy approaches) need not be withheld from patients requiring complex mitral valve repair. Complex mitral repair using Port-Access is, however, reasonable only if the patients are candidates for Port-Access and if the operating team is sufficiently experienced to apply Port-Access comfortably to complex mitral repair. It is conceivable that complex mitral patients inappropriate for Port-Access exist, either because of mitral repair complexity beyond that undertaken in this study, because of predicted clamp times already close to 4 hours using sternotomy, or because of needed access to the external ventricular wall for transmural suture placement. These patients, however, should be relatively unusual.

As with any other evolving technology, increased experience with Port-Access should improve results and generally broaden application as technology advances. Future studies will need to evaluate results using video directed and robotic techniques in complex mitral repair patients as these techniques mature.

REFERENCES

1. Boova RS. A method of percutaneous venous access for minimally invasive cardiac surgery. [unpublished video] 1998.

2. Chitwood WR Jr. Video-assisted and robotic mitral valve surgery: toward an endoscopic surgery. *Sem Thor Cardiovasc Surg* 11: 191-205, 1999.
3. David TE, Omran A, Armstrong S, Sun Z, and Ivanov J. Long-term results of mitral repair for myxomatous disease with and without chordal replacement with expanded polytetrafluoroethylene sutures. *J Thorac Cardiovasc Surg* 115: 1279-85, 1998.
4. Fukui T, Yoshida K, Akasaka T, Hozumi T, Yamaura Y, Izumi C, et al. Serial change of mitral regurgitation after mitral valve repair: comparison of anterior with posterior leaflet lesions. *J Cardiol* 27: 73-76, 1996.
5. Gillinov AM, Cosgrove DM, Blackstone EH, Diaz R, Arnold JH, Lytle BW, et al. Durability of mitral valve repair for degenerative disease. *J Thorac Cardiovasc Surg* 116: 734-43, 1998.
6. Glower DD, Landolfo KP, Clements F, Debruijn NP, Stafford-Smith M, Smith PK, et al. Mitral valve operation via Port Access versus median sternotomy. *Eur J Cardio-thorac Surg* 14: S143-7, 1998.
7. Glower DD, Komtebedde J, Clements FM, Debruijn NP, Stafford-Smith M, and Newman MF. Direct aortic cannulation for Port-Access mitral or coronary bypass operations. *Ann Thorac Surg* 65:1529-31, 1999.
8. Glower DD, Siegel LC, Galloway AC, Ribakove G, Grossi E, Robinson N, et al. Predictors of operative time in multicenter Port-Access valve registry: institutional differences in learning. *Heart Surgery Forum* #2000-43030 4: 40-46. 2001.
9. Grossi EA, Galloway AC, LeBoutillier M3rd, Steinberg B, Baumann FG, Delainides J, et al. Anterior leaflet procedures during mitral valve repair do not adversely influence long-term outcome. *J Am Coll Cardiol* 25: 134-6, 1995.
10. Grossi EA, LaPietra A, Ribakove GH, Delianides J, Esposito R, Culliford AT, et al. Minimally invasive versus sternotomy approaches for mitral reconstruction: comparison of intermediate-term results. *J Thorac Cardiovasc Surg* 1221: 708-13, 2001.
11. Hintze JL. Number Cruncher Statistical System. Version 5.5. Survival Analysis. Kaysville, UT, Dr. Jerry L. Hintze. 1988.
12. Kobayashi J, Sasako Y, Bando K, Minatova K, Niwaya K, and Kitamura S. Ten-year experience of chordal replacement with expanded polytetrafluoroethylene in mitral valve repair. *Circulation* 102: III-30-4, 2000.
13. Phillips MR, Daly RC, Schaff HV, Dearani JA, Mullany CJ, and Orszulak TA. Repair of anterior mitral valve prolapse: chordal replacement versus chordal shortening. *Ann Thorac Surg* 69: 25-9, 2000.
14. Pompili MF, Yakub A, Siegel LC, Stevens JH, Awang Y, and Burdon TA. Port-access mitral valve replacement: initial clinical experience. [abstract] *Circulation* 94: I-533, 1996.
15. Reichenspurner H, Boehm D, and Reichart B. Minimally invasive mitral valve surgery using three-dimensional video and robotic assistance. *Sem Thorac Cardiovasc Surg* 11: 235-43, 1999.
16. Totaro P, Tulumello E, Fellini P, Rambaldini M, L Canna G, Coletti G, et al. Mitral valve repair for isolated prolapse of the anterior leaflet: an 11-year follow-up. *Eur J Cardio-thorac Surg* 15: 119-26, 1999.

17. Vanermen H, Wellens F, DeGeest R, Degrieck I, and VanPraet F. Video-assisted port-access mitral valve surgery: from debut to routine surgery. Will trocar-port-access cardiac surgery ultimately lead to robotic cardiac surgery? *Sem Thorac Cardiovasc Surg* 11: 223-34, 1999.
18. Walther T, Falk V, Metz S, Diegler A, Battellini R, Autschbach R, et al. Pain and quality of life after minimally invasive versus conventional cardiac surgery. *Ann Thorac Surg* 67: 1643-7, 1999.

FIGURE LEGENDS

Figure 1. Mitral ring size for patients undergoing Port-Access mitral repair.

Figure 1

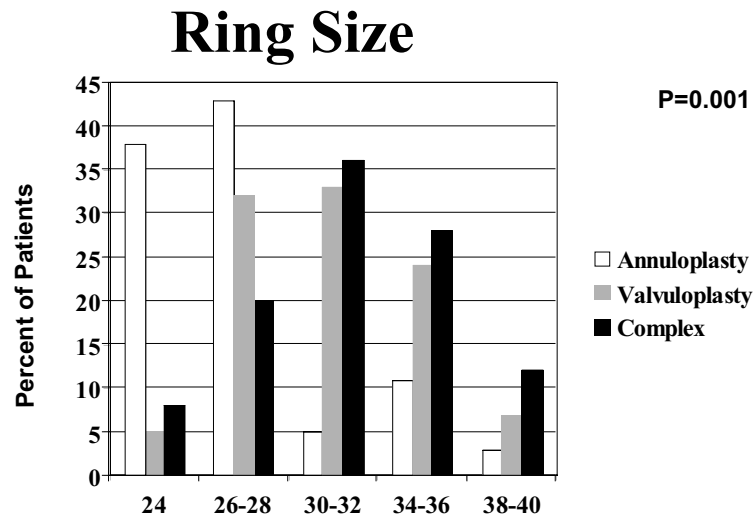


Figure 2. Degree of residual mitral regurgitation by intraoperative transesophageal echocardiography after Port-Access mitral repair.

Figure 2

Intraoperative Residual MR

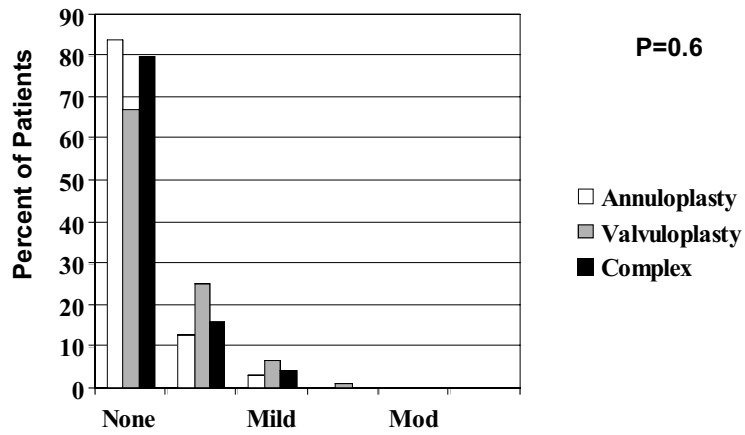


Figure 3. Degree of residual mitral regurgitation by postoperative follow-up echocardiography after Port-Access mitral repair.

Figure 3

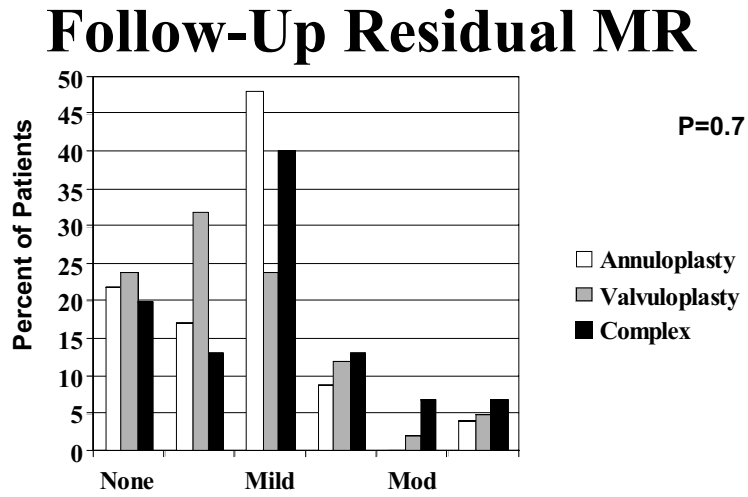


Table 1. Demographic characteristics of patients who underwent Port-Access mitral annuloplasty ANN, standard valvuloplasty VAL, or complex repair CX. Data are mean±SD. (*p<0.05 vs CX)

	ANN	VAL	CX
N	39	97	25
Age(yrs)	59±16	58±14	54±16
Female	24(62%)*	34(35%)	8(32%)
Redo	8(21%)*	5(5%)	1(4%)
EF(%)	39±12*	52±10	50±7

Table 2. Mitral valve disease etiology of patients who underwent Port-Access mitral annuloplasty ANN, standard valvuloplasty VAL, or complex repair CX. (*p<0.05 vs CX)

	ANN	VAL	CX
Barlow's disease	2(5%)	7(7%)	5(20%)
Prolapse	1(3%)*	73(75%)*	12(48%)
Degenerative	25(64%)*	9(9%)	5(20%)
Ischemic	9(23%)*	2(2%)	1(4%)
Endocarditis	0(0%)	4(4%)	2(8%)
Congenital	2(5%)	2(2%)	0(0%)

Table 3. Posterior leaflet procedure for patients who underwent Port-Access mitral annuloplasty ANN, standard valvuloplasty VAL, or complex repair CX. (*p<0.05 vs CX)

	ANN	VAL	CX
None	39(100%)*	4(4%)*	6(33%)
Cleft closure	0(0%)*	17(18%)	6(34%)
Quad resection	0(0%)	36(39%)*	3(17%)
Quad resection, sliding leaflet plasty	0(0%)	36(39%)*	2(11%)

Table 4. Anterior leaflet procedure for patients who underwent Port-Access mitral annuloplasty ANN, standard valvuloplasty VAL, or complex repair CX. (*p<0.05 vs CX)

	ANN	VAL	CX
None	39(100%)*	87(94%)*	0(0%)
Cleft closure	0(0%)	6(6%)	0(0%)
Chordal transfer	0(0%)*	0(0%)*	7(28%)
Artificial chord	0(0%)*	0(0%)*	18(72%)

Table 5. Intraoperative results for patients who underwent Port-Access mitral annuloplasty ANN, standard valvuloplasty VAL, or complex repair CX. Data are mean \pm SD. (p<0.05 vs CX)

	ANN	VAL	CX
Femoral arterial cannulation	8(21%)	33(34%)	11(44%)
Endoclamp	30(77%)	83(86%)	21(84%)
Fibrillation	9(23%)	9(9%)	2(8%)
Clamp time(min)	49 \pm 34*	116 \pm 54	128 \pm 68
Pump time(min)	143 \pm 56*	188 \pm 51	192 \pm 70

Table 6. Postoperative morbidity for patients who underwent Port-Access mitral annuloplasty ANN, standard valvuloplasty VAL, or complex repair CX. (p<0.05 vs CX)

	ANN	VAL	CX	P
Stroke	0(0%)	1(1%)	2(8%)	0.04
Reop for bleed	5(12%)	3(3%)	1(4%)	0.08
New pacer	0(0%)	2(2%)	0(0%)	0.5
Sternotomy	1(2%)	1(1%)	1(4%)	0.6
Operative death	1(2%)	0(0%)	0(0%)	0.2