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Mitral Valve Operations through Standard and Smaller Incisions

Vincent A. Gaudiani,[1] Gary L. Grunkemeier,[2] Luis J. Castro,[1] Audrey L. Fisher,[1] YingXing Wu[2]

[1]Pacific Coast Cardiac & Vascular Surgeons, Sequoia Hospital, Redwood City, California; [2]Medical Data Research Center, Providence Health System, Portland, Oregon USA

ABSTRACT

Objective: Evaluate the operative results of mitral valve repair (MVV) and mitral valve replacement (MVR) performed through standard and smaller incisions.

Methods: From January 1997 through December 2002, 821 consecutive patients underwent mitral valve operation. Of these procedures, 475 were MVV and 346 were MVR. A logistic regression model was developed to identify the risk factors for early mortality and to evaluate the effect of replacement versus repair and standard versus small incision.

Results: Replacement patients were older, more likely New York Heart Association (NYHA) class III or IV, more likely female, and had more frequent previous median sternotomy and stroke (all $P < .05$). The mitral diagnoses in the 2 groups were markedly different. Prolapse and ischemia dominated the repairs, whereas calcific and rheumatic diagnoses required replacement. There were 667 concomitant procedures performed on these patients, most commonly coronary artery bypass graft (229), aortic valve replacement (170), maze (79), and tricuspid valve (TV) repair/replacement (73). Thirty-three patients (4.0%) died in the postoperative period, 2.3% after repair and 6.4% after replacement ($P < .01$). Endocarditis (4/17), calcific disease (7/73), and ischemic disease (9/121) accounted for 26% of patients and 60% of deaths. Multivariate regression analysis identified NYHA class, emergent status, concomitant TV operation, and history of renal failure, but not repair versus replacement, as independent risk factors predicting mortality. We estimated that 356 of the 821 patients (43%) were candidates for small-incision operations, the others were excluded by the need for concomitant procedure or other cause. A total of 205/356 (57%) actually underwent small-incision operations, all with central cannulation and standard techniques. From 1997-1999, 32% of eligible patients were so treated, but from 2000-2002, with increasing surgeon experience, this percentage rose significantly to 71% ($P < .01$). Eligible patients who underwent small-incision operation were younger and had lower NYHA classifications, lower preoperative creatinine, and shorter length of stay (all $P < .01$) than those who had standard incisions. Cross-clamp time, perfusion time, and mortality rate were not significantly different.

Conclusions: The mortality rate for MV operations is concentrated among a few diagnoses. In some patients surgery may be approached safely through smaller incisions without introducing new elements of operative risk.

INTRODUCTION

The development of operative interventions for mitral valve (MV) disorders provides a rich chapter in the history of cardiac surgery. That history began with closed operations before the advent of cardiopulmonary bypass, followed by the development of reasonably safe and durable mitral prostheses. As the incidence of rheumatic disease declined in the developed world and the limitations of prostheses became more evident, mitral valve repair techniques improved substantially and became the standard approach to correct prolapse [Carpentier 1980, Carpentier 1983]. At present, smaller-incision techniques using conventional cardiopulmonary bypass are widely available, and the future holds the promise, or perhaps the threat, of robotic techniques [Cosgrove 1998, Gundry 1998, Chitwood 2000, Grossi 2002]. In this paper, we present results from 821 consecutive, unselected patients referred to our practice for MV operation during the past 6 years. This review emphasizes the differences in preoperative characteristics, diagnoses, and outcomes between the MV repair (MVV) and MV replacement (MVR) populations, and it stresses the advantages and limitations of small-incision approaches as we have used them. We hope this review will provide some basis for assessing developing MV technologies.

MATERIALS AND METHODS

We reviewed the records of all 821 patients referred for mitral valve operation during the 6-year period from January 1, 1997, through December 31, 2002. We excluded 2 patients with perivalvular leaks around prosthetic valves that were repaired. Neither of those 2 patients died or had any major complications. Analysts using the Society of Thoracic Surgeons algorithms recorded all data concurrently. We estimated that 356 of the 821 patients (43%) were candidates for small-incision operations, the others were excluded by the

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Address correspondence and reprint requests to: Vincent A. Gaudiani, MD, Sequoia Hospital, 2900 Whipple Ave, Suite 210, Redwood City, CA 94062; 1-650-366-0225; fax: 1-650-364-3728 (e-mail: vgaudiani@pccvs.com).

Table 1. Demographic Characteristics of Mitral Valve Replacement (MVR) versus Repair (MVV) Patients

Risk Factor	All MVR (n = 346)	All MVV (n = 475)	*P*
Average age, y	69.2	64.2	<.001
Female	59%	35%	<.001
History of renal failure	11%	7%	.059
Emergent status	3%	2%	.085
Cardiogenic shock	6%	4%	.131
New York Heart Association class 4	50%	22%	<.001
Tricuspid valve disease requiring surgery	15%	4%	<.001

need for concomitant procedure or other cause. A total of 205/356 (57%) actually underwent small-incision operations.

SURGICAL TECHNIQUE

By 1997, we had begun exploring techniques to reduce incision size without fundamentally changing our standard of care. Working in a community setting without specific research protocols, we felt obligated to minimize additional risks such as groin cannulation and limit standard risks such as cardiopulmonary bypass time to our own current standard. When we did not use a standard sternotomy, we chose upper ministernotomy as our default small incision. Although this incision lacks some cosmetic appeal, all men and most women readily accept it as a substitute for complete sternotomy. Upper ministernotomy provides excellent exposure of both the aortic and mitral valves, and it facilitates central cannulation. We also offered right inframammary thoracotomy with central cannulation to women who wanted the optimal cosmetic result; we used the lower ministernotomy for the same purpose in a few women who required double valve replacement. Early on we decided to avoid all techniques that used elective groin cannulation until we could recognize a benefit to the patient worth the small, but catastrophic, risk of dissection. We used normothermic cardiopulmonary bypass (34.5°C-37°C) in all patients. During the last 3 years of the study, we used vacuum-assisted venous drainage in all cases to reduce venous cannula size. We used both antegrade and retrograde cardioplegia, as we deemed necessary. We used standard repair techniques and pursued chordal-sparing replacement in a large majority of those cases. We performed all cardiac cases with transesophageal echocardiography, and we used it to facilitate placing the retrograde cardioplegia catheter in the small-incision cases.

DIAGNOSTIC NOMENCLATURE

Most categories are self explanatory, but 3 of them can be confusing. Central mitral regurgitation was categorized as ischemic if it appeared to result from severe coronary artery disease and/or infarction. It was considered annular dilatation if it resulted from valvular or other myopathy not related to coronary disease. A valve was considered calcified if that was the most important pathoanatomic finding. If we recognized rheumatic features, we made that diagnosis regardless of calcium. The diagnoses categorized as repairable were failure of prior repair, prolapse, ischemic, annular dilatation, and other.

Table 2. Primary Mitral Diagnoses

Primary Diagnosis	All Mitral Valve Replacements (n = 346)	All Mitral Valve Repairs (n = 475)	Total (n = 821)
Endocarditis	12 (3%)	5 (1%)	17 (2%)
Calcific	72 (21%)	1 (0%)	73 (9%)
Ischemic	35 (10%)	86 (18%)	121 (15%)
Prosthetic valve dysfunction	56 (16%)	0 (0%)	56 (7%)
Failure of prior repair	21 (6%)	10 (2%)	31 (4%)
Annular dilatation	5 (1%)	55 (12%)	60 (7%)
Rheumatic	105 (30%)	3 (1%)	108 (13%)
Prolapse	18 (5%)	303 (64%)	321 (39%)
Paravalvular leak	11 (3%)	0 (0%)	11 (1%)
Other	11 (3%)	12 (3%)	23 (3%)

STATISTICAL METHODS

The chi-square test was used to do univariate comparison for categorical variables, and the Student *t* test was used for continuous variables. Logistic regression was used to estimate the impact of risk factors on early death, which was defined as death occurring before hospital discharge or within 30 days postoperation, whichever was longer. The C-statistic (area under the receiver operating characteristic curve) was used to measure model discrimination [Grunkemeier 2001]. The Hosmer-Lemeshow test was used to measure model calibration [Lemeshow 1982]. Observed mortality (O)/expected mortality (E) ratio and the associated 95% confidence interval were used to do risk-adjusted comparison. Statistical analysis was done using SPSS 10 (SPSS, Chicago, IL, USA).

RESULTS

Table 1 compares the demographics of those who underwent repair to those who underwent replacement, and Table 2 compares their diagnoses. As others have shown [Galloway 1989, Gillinov 2003, Savage 2003], repair patients are younger, less ill, more likely male, and less likely to have tricuspid involvement. This finding is largely the result of younger, healthier patients with prolapse in the repair group. Table 2 shows that most patients with repairable diagnoses do in fact undergo repair, with MV replacement reserved for irreversible structural deterioration of the valve.

Table 3 compares concomitant procedures in the 2 groups. Coronary bypass is more common in the repair group because it contains those with ischemic regurgitation who are most likely to have operable coronary disease. Aortic valve disease is more common in the replacement group because calcific and rheumatic diagnoses predominate. We had just begun surgical treatment of atrial fibrillation in

Table 3. Concomitant Procedures

Concomitant Procedure	All Mitral Valve Replacements (n = 346)	All Mitral Valve Repairs (n = 475)	Total (n = 821)
Coronary artery bypass	96	133	229
Aortic valve replacement	106	64	170
Maze	30	49	79
Tricuspid valve procedure	54	19	73
Aortic root enlargement	17	4	21
Aortic root reconstruction	11	5	16
Left ventricular aneurysm resection	10	9	19
Ascending aortic reconstruction	6	5	11
Other	22	27	49
Total concomitant procedures	352	315	667

Table 5. Mortality by Diagnosis

Primary Diagnosis	No. of Patients (n = 821)	No. of Operative Mortalities	% Operative Mortality
Endocarditis	17	4	24%
Calcific	73	7	10%
Ischemic	121	9	7%
Prosthetic valve dysfunction	56	3	5%
Failure of prior repair	31	1	3%
Annular dilatation	60	1	2%
Rheumatic	108	2	2%
Prolapse	321	4	1%
Paravalvular leak	11	0	0%
Other	23	2	9%

1997, so the maze cases have rapidly increased in number in the past 2 or 3 years.

We evaluated operative risk in several ways. First, as Table 4 demonstrates, 3 diagnostic categories, which account for approximately 25% of the patients, account for 60% of the deaths. In contrast, there were only 4 deaths among 321 prolapse patients, and no deaths occurred in the 271 patients who were under the age of 70. Second, we evaluated risk by univariate and multivariate analysis. The C-statistic was 0.839 and the Hosmer-Lemeshow test was 0.463 for the model. Among the patients eligible for MVV, the O/E ratio was 0.94 (0.47, 1.98) for MVR and 0.87 (0.52, 1.57) for MVV. For both MVR and MVV, the observed mortality was not significantly different from the expected mortality after adjustment for the risk factors in the regression model. MV replacement (22 deaths; mortality rate, 6.4%) was a significant univariate predictor of mortality compared to MV repair (11 deaths; mortality rate, 2.3%; $P < .001$) but did not remain a factor in multivariate analysis. This fact and the results of multiple logistic regression analysis are

Table 4. Factors Predicting Mortality by Multivariate Logistic Regression

	Coefficient	*P*	Odds Ratio (95% Confidence Interval)
Age (decades)	.264	.146	1.30 (0.91, 1.86)
Female	.631	.112	1.88 (0.86, 4.10)
History of renal failure	1.029	.018	2.80 (1.19, 6.57)
Emergent/cardiac shock	1.526	.001	4.60 (1.89, 11.2)
New York Heart Association 4	1.507	.002	5.51 (1.71, 11.9)
Concomitant tricuspid valve surgery	1.108	.018	3.03 (1.21, 7.58)
Mitral valve replacement*		.431	
Small incision*		.575	

*Mitral valve replacement and small incision were not found to be significant risk factors.

shown in Table IV. The model shows that severity of illness (NYHA class IV, chronic renal failure), acuteness of illness (emergent/cardiogenic shock), and the necessity for tricuspid valve operation account for most of the operative risk in this series.

Mortality by diagnosis, regardless of procedure, is shown in Table 5. More than half of the deaths occurred in that 25% of the population with endocarditis, calcific disease, or ischemic disease. There were 4 deaths among 321 prolapse patients. One 70-year-old man died of cerebral injury. The other 3 deaths occurred in patients older than 80 years who were probably not well selected for intervention. In 271 prolapse patients younger than 70 years, there were no deaths.

Figure 1 shows the categories of patients excluded from consideration for smaller-incision approaches. Although we know that some colleagues would disagree, we prefer to reoperate through the previous median sternotomy [Tribble 1987, Cohn 1989]. We also excluded maze cases as well as those requiring coronary bypass or tricuspid valve repair or replacement because we routinely perform these operations through a median sternotomy. We did not exclude those patients who also required aortic valve replacement because we commonly perform this operation and double valve replacement via ministernotomy.

Figure 2 shows the percentage of patients who received smaller-incision procedures by year of the study. We interpret this graph to show that by 2000 we crossed a threshold of familiarity and technique that allowed us to comfortably and safely approach approximately 75% of eligible cases with smaller incisions. Table 6 compares preoperative characteristics of eligible patients who did and did not receive small-incision operations. For both the repair and the replacement groups, those who received a small-incision operation were significantly younger and healthier and had somewhat better renal function. Length of stay was significantly shorter for the repair patients (Table 7), but operative times and outcomes were similar for both groups. Among the patients eligible for small incision, the O/E ratio was 0.74 (0.23, 3.53) for small incision and 1.18 (0.47,

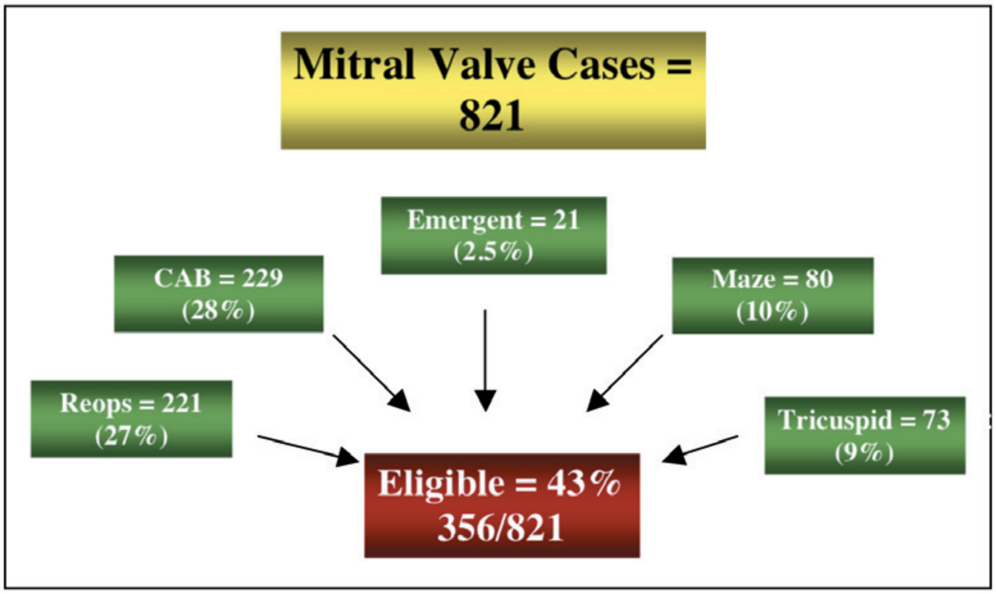

Figure 1. List of criteria excluding patient from eligibility for limited-incision valve surgery.

2.54) for full incision. For both small incision and full incision, the observed mortality was not significantly different from the expected mortality after adjustment for the risk factors in the regression model.

DISCUSSION

For the past decade or so the literature on mitral valve surgery has rightly focused on specific problems and has arrived at important areas of consensus. Our literature suggests that repair is preferable to replacement in patients with prolapse, that anatomic repair for prolapse is durable, that chordal sparing replacement helps to preserve left ventricular function, and that repair often provides better results in ischemic disease despite some troubling failures [Carpentier 1980, Sarris 1989, David 1994, Bolling 1995, Gillinov 2001]. During the period of this study, we have employed all of these ideas.

In contrast to these specific studies, ours is an overview of a current practice of mitral valve surgery, and we hope it will provide a benchmark for operative results using the current consensus. We found that mortality after mitral valve operations is concentrated among a few diagnostic categories and that the results of repair for prolapse are likely to be as good as those obtained with any open-heart operation. These

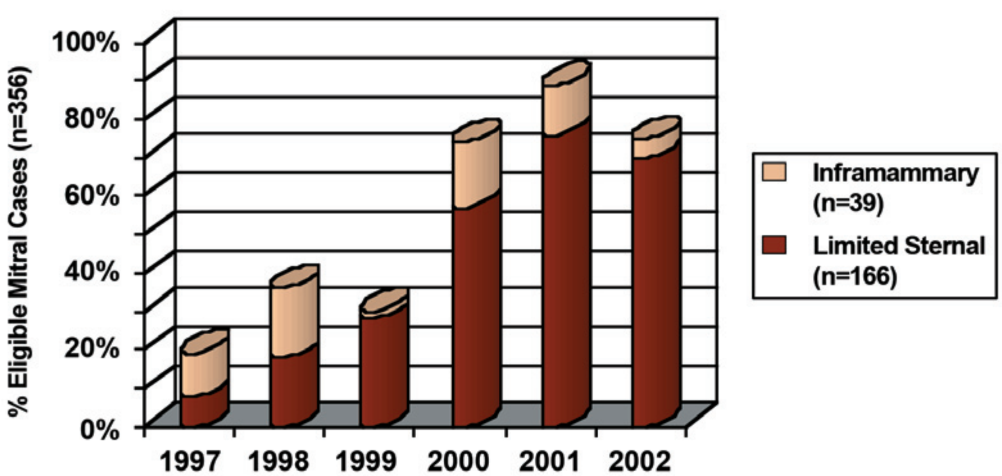

Figure 2. Percentage of small-incision mitral valve cases by year for both limited sternal and inframammary incisions.

Table 6. Demographic Characteristics of Limited-Incision Patients*

Factor	Mitral Valve Replacement			Mitral Valve Repair		
	Full (n = 59)	Limited (n = 36)	*P*	Full (n = 92)	Limited (n = 169)	*P*
Average age, y	72.1	65.7	.023	64.5	57.4	<.001
NYHA class 3+	86%	67%	.035	61%	25%	<.001
Female	63%	75%	NS	34%	42%	NS
Preoperative creatinine	1.5	1.0	.015	1.2	1.0	<.001

*NYHA indicates New York Heart Association.

Table 7. Intraoperative Factors and Postoperative Outcomes of Limited-Incision Patients

Factor	Mitral Valve Replacement			Mitral Valve Repair		
	Full (n = 59)	Limited (n = 36)	*P*	Full (n = 92)	Limited (n = 169)	*P*
Cross-clamp time, min	71	69	NS	54	55	NS
Perfusion time, min	85	84	NS	68	67	NS
Operative death	3.4%	2.8%	NS	3.3%	0.6%	NS
Stroke	6.8%	0%	.045	2.2%	0%	NS
Average total length of stay, d	10.8	9.0	NS	7.3	5.8	.006

findings support the idea of early repair for those with severe prolapse [Mohty 2001].

In addition we extended the current consensus to mitral valve operations performed through smaller incisions. We avoided modifying repair or replacement techniques to suit the smaller incisions because we did not want choice of incision to influence our standard of care. We also avoided introducing new risks, such as peripheral cannulation and balloon aortic occlusion, for the same reason. This approach allows us to compare our results in standard- versus smaller-incision operations knowing that the size of the incision is the only substantial technical difference. Of course we used smaller incisions only when we thought it safe to do so, and this practice is reflected in the lower-risk profile of the small-incision groups.

We found that approximately 43% of our mitral valve population could theoretically be operated upon through a limited incision. During the last year of the study, we actually used smaller incisions in 70% of those eligible. Patients' body habitus, severity of illness, and awareness of our technical limits inhibited us in the other 30%. When we compared the outcomes of standard versus smaller incision approaches, we found that operating time, cross-clamp time, and mortality were virtually identical in the 2 groups. Length of stay was shorter among those who had smaller incisions, most likely because they were the better risk group. We infer from these results that we can perform smaller-incision operations in some patients without degrading the standard of care.

This conclusion may seem rather unheroic, but in the current practice environment, we think it is significant. Most patients who require operations naturally prefer smaller incisions, but virtually none would accept either additional risk to life or limb or a less effective operation to achieve that goal. The Heartport technique (Port-Access) is a case in point. Although it is skillfully applied at New York University (NYU) and other institutions [Colvin 1998, Glower 1998, Reichensprunger 1998], it has generally failed in most operating rooms because it is evidently too difficult and time-consuming for most of us. Even its masters at NYU experience cross-clamp times nearly twice as long as those presented here. This does not imply that new techniques should be shunned. In fact Heartport ideas stimulated all of us to consider how to perform smaller-incision cardiac operations, but it does mean that new techniques should be thoroughly investigated before being widely marketed. Now robotic techniques are being evaluated, and they may prove to be a boon to some patients with mitral valve disease. At present, however, they require changes in the incision as well as changes in repair technique. They are likely to be used most frequently in the lowest risk group, prolapse patients, for whom, as we have seen, results are already very good. These techniques require peripheral cannulation and will be more costly in time and equipment than the techniques described here. We believe that they should not be widely adopted until they demonstrate results as good as those obtained by the conventional techniques we used. We hope that this study will provide some basis on which to judge the efficacy of this next generation of technical changes in mitral valve surgery.

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