Is Mitral Valve Repair Superior to Replacement in Elderly Patients?

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Background. **Mitral valve replacement is more frequently performed and perceived to be equivalent to repair in elderly patients, despite the superiority of repair in younger patients. Our objective was to compare mitral repair to replacement in elderly patients age 75 years or older. Patients younger than 75 years undergoing mitral valve surgery served as a reference population.**

Methods. **Consecutive elderly patients undergoing operation for mitral regurgitation at our institution from 1998 to 2006 were reviewed. Elderly patients (mean age, 78.0 ± 2.8 years) who underwent mitral repair (n = 70) or replacement (n = 47) were compared with cohorts of young patients (mean age, 58.9 ± 9.3 years) who underwent repair (n = 100) or replacement (n = 98) during the same period. Patient details and outcomes were compared using univariate, multivariate, and Kaplan–Meier analyses.**

Results. **Mitral replacement in elderly patients had higher mortality than repair (23.4%, 11 of 47 versus 7.1%, 5 of 70; $p = 0.01$) or as compared with either operation in the reference group ($p < 0.0001$). Postoperative stroke was higher in elderly replacement patients compared with repair (12.8%, 6 of 47 versus 0%; $p = 0.003$) or compared with either young cohort ($p = 0.02$). Compared with elderly repair patients, elderly replacement patients had more cerebrovascular disease (21.3%, 10 of 47 versus 4.3%, 3 of 70; $p = 0.005$) and rheumatic mitral valves (21.3%, 10 of 47 versus 0%; $p = 0.0001$). In the young group, overall complication and mortality were no different between replacement and repair. Long-term survival favored repair over replacement in elderly patients ($p = 0.04$). One elderly repair patient experienced late recurrence of persistent mitral regurgitation.**

Conclusions. **In patients age 75 years or older, mitral repair is associated with a lower risk of mortality, postoperative stroke, and prolonged intensive care unit and hospital stay compared with mitral replacement. Mitral repair can be performed in preference over replacement even in patients older than the age of 75.**

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Mitral valve (MV) repair is preferred over replacement to treat mitral insufficiency with improved short-term and long-term survival [1–5]. Patients with degenerative mitral regurgitation (MR) have superior outcomes with repair over replacement [1–4]. Good-risk patients with ischemic mitral regurgitation also benefit from MV repair compared with replacement, with better early and late (5-year) survival, in part because of preservation of the subvalvar apparatus [5]. Older patients, however, are often not considered appropriate candidates for MV repair because of comorbidities [6] and the perception that they may not tolerate a return to cardiopulmonary bypass for an inadequate MV repair. Furthermore, older patients are professed to benefit least from repair owing to short life expectancy. Because of these factors, most surgeons perform MV replacement in elderly patients. The Society of Thoracic Surgeons (STS) database indicates that MV repair is performed in only 36.1% of MV operations in patients older than 70 years nationally, significantly less than in younger age populations [7]. There is discrepancy in the literature regarding the benefit of repair in elderly patients. Some authors cite improved in-hospital and long-term survival in elderly patients age 70 years or older undergoing isolated MV repair [6], whereas others suggest MV repair provides no benefit in patients older than the age of 60 years [8].

The purpose of this investigation was to review our experience of MV repair versus MV replacement in elderly patients age 75 years or older who underwent isolated and concomitant cardiac procedures to determine what differences, if any, exist in regard to morbidity and mortality. In addition, long-term mortality after repair and replacement in elderly patients was compared. Finally, elderly patients were also compared with patients younger than 75 years undergoing MV repair or replacement.

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Patients and Methods

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Table 1. Demographics for Repair Versus Replacement Stratified by Age Group

	≥75 Years Old			<75 Years Old		
Variable	Replacement (n = 47)	Repair (n = 70)	*p* Value	Replacement (n = 98)	Repair (n = 100)	*p* Value
Age (y)[a]	78.9 ± 3.5	78.3 ± 2.9	0.34	58.6 ± 9.5	59.4 ± 10.7	0.61
Female[b]	29 (61.7%)	34 (48.6%)	0.16	55 (56.1%)	38 (38%)	0.01
Preoperative comorbidities						
Diabetes mellitus	9 (19.1%)	12 (17.1%)	0.78	22 (22.4%)	26 (26%)	0.56
Peripheral vascular disease	6 (12.8%)	12 (17.1%)	0.53	7 (7.1%)	9 (9%)	0.63
Tobacco use	8 (17.0%)	16 (22.9%)	0.48	23 (23.5%)	33 (33%)	0.16
COPD	8 (17.0%)	12 (17.1%)	0.99	11 (11.2%)	13 (13%)	0.68
Hypertension	21 (44.7%)	39 (55.7%)	0.24	49 (50%)	59 (59%)	0.20
Chronic renal insufficiency	7 (14.9%)	13 (18.6%)	0.60	14 (14.3%)	13 (13%)	0.79
Atrial fibrillation	24 (51.1%)	25 (35.7%)	0.14	37 (37.8%)	23 (23%)	0.03
Cerebral vascular disease	10 (21.3%)	3 (4.3%)	0.005	18 (18.4%)	7 (7%)	0.02
Coronary artery disease	16 (34.0%)	40 (57.1%)	0.02	21 (21.4%)	41 (41%)	0.003
Inpatient status	31 (47.0%)	25 (44.4%)	0.44			
Reoperative surgery	8 (17.0%)	5 (7.1%)	0.10	15 (15.3%)	8 (8%)	0.11
NYHA class	2.10 ± 0.64	2.22 ± 0.68	0.32	2.22 ± 0.81	2.16 ± 0.61	0.54
Preoperative LV function						
Normal	27 (57.4%)	38 (54.2%)	0.99	48 (49%)	46 (46%)	0.05
Mild dysfunction	8 (17.0%)	12 (17.1%)		24 (24.5%)	18 (18%)	
Moderate dysfunction	8 (17.0%)	12 (17.1%)		15 (15.3%)	10 (10%)	
Severe dysfunction	4 (8.5%)	7 (10.0%)		11 (11.2%)	26 (26%)	
Etiology of MR						
Degenerative	15 (31.9%)	39 (56.5%)	0.0001	27 (27.6%)	48 (48%)	0.0001
IMR	14 (29.7%)	30 (42.9%)		10 (10.2%)	46 (46%)	
MAC	6 (12.8%)	1 (1.5%)		4 (4.1%)	0 (0%)	
Rheumatic	10 (21.3%)	0 (0%)		43 (43.9%)	2 (2%)	
Endocarditis	2 (4.3%)	0 (0%)		14 (14.3%)	4 (4%)	

[a] Continuous variables are reported as mean ± standard deviation; *p* values derived from Student's *t* test. [b] Categorical variables are reported as N (%); *p* values derived from χ^2 test or Fisher's exact test.

COPD = chronic obstructive pulmonary disease; IMR = ischemic mitral regurgitation; LV = left ventricular; MAC = mitral annular calcification; MR = mitral regurgitation; NYHA = New York Heart Association.

Virginia Health System, including a waiver for the need to obtain patient consent. All patients undergoing MV operations are entered into a database. A retrospective review was performed of all MV operations for mitral regurgitation in elderly patients (age ≥75 years) during a 9-year period (January 1, 1998, to December 31, 2006) at the University of Virginia. Patients with emergency operation, previous mitral prosthesis, and mitral stenosis were excluded from this study. A total of 117 elderly patients (mean age, 78.0 ± 2.8 years) who underwent MV repair (n = 70) or MV replacement (n = 47) were compared with each other as well as with a cohort of young patients (age <75 years). This reference group (mean age, 58.9 ± 9.3 years) included patients who underwent MV repair (n = 100) and MV replacement (n = 98) during the same period. Demographic and preoperative comorbidities were compared between age groups and between MV operations.

Elderly Patients

No differences in age or preoperative risk variables including diabetes, peripheral vascular disease, or chronic obstructive pulmonary disease were identified between elderly patients undergoing MV repair or replacement (Table 1). Twenty-nine (61.7%) elderly MV replacement patients were female, although this was not significantly different from elderly repair patients (48.6%; $p = 0.16$). New York Heart Association class was similar between elderly MV repair and replacement patients (2.22 ± 0.68 versus 2.10 ± 0.63; $p = 0.32$). Preoperative cerebrovascular disease was more common in elderly MV replacement patients (21.3%) than in elderly MV repair patients (4.3%; $p = 0.005$). Preoperative atrial fibrillation was not different. Indications for MV surgery were different between groups. Elderly repair patients were more likely to have degenerative (56.5%) or ischemic (42.9%) mitral regurgitation compared with elderly replacement patients, who had more rheumatic disease (21.3%), mitral annular calcification (12.8%), and endocarditis (4.3%; $p = 0.0001$). Coronary artery disease was less common in elderly MV replacement patients (34.8%) versus repair patients (57.1%; $p = 0.02$).

Young Patients

Differences between patients undergoing MV repair and replacement identified in the elderly group were also confirmed in young patients (Table 1). Young MV replacement patients had more cerebrovascular disease than the young repair patients (18.4% versus 7.0%; p = 0.02). As in the elderly group, young MV repair patients were more likely to have degenerative (48%) or ischemic mitral regurgitation (46%) compared with young replacement patients, who more often had rheumatic valves (43.9%) and endocarditis (14.3%; p = 0.0001). Coronary artery disease was more common in young repair patients than in young replacement patients (41% versus 21.4%; p = 0.003). Young replacement patients were more often female compared with repair patients (56.1% versus 38%; p = 0.01). Preoperative atrial arrhythmias were more common in young replacement patients than in repair patients (37.8% versus 23.0%; p = 0.03).

Definitions

All patients had at least 3+ MR, and the degree of MR was determined by preoperative transthoracic echocardiogram. Mechanism of MV disease was diagnosed by direct surgical inspection, pathologic reports, and echocardiograms. Ischemic disease was further characterized by patients with at least one previous myocardial infarction, associated regional wall motion abnormality, normal valve leaflets and chordae, and the absence of other MV disease. Rheumatic disease and mitral annular calcification was identified by preoperative imaging, including echocardiography and cardiac catheterization, and confirmed at operation.

Operative Techniques

All procedures were performed through full or partial sternotomy by 6 surgeons during the study period. Patients were placed on cardiopulmonary bypass using standard techniques. Dual venous cannulation was performed either percutaneously or directly. Antegrade with or without retrograde cardioplegia was used, dependent on surgeon preference. When performed, coronary artery bypass grafting (CABG) or atrial ablation procedure was done before the mitral procedure. Tricuspid and aortic valve procedures were done after the mitral procedure. Transesophageal echocardiogram was used in all patients before MV surgery to help characterize the mechanism of MR and then after MV repair or replacement to evaluate the adequacy of MV surgery. All patients were considered for MV repair. Standard repair techniques including triangular leaflet resection (as described previously) [9], artificial neochord insertion, and semirigid or rigid annuloplasty ring insertion were used in MV repair patients. Subvalvar sparing technique for MV replacement patients was used in all patients when-

Table 2. Operative Details and Associated Procedures for Elderly and Young Patients

	≥75 Years Old			<75 Years Old		
Variable	Replacement (n = 47)	Repair (n = 70)	p Value	Replacement (n = 98)	Repair (n = 100)	p Value
Valve repair technique[a]	N/A			N/A		
Triangular resection		25 (35.7%)			47 (47%)	
Quadrangular resection		9 (12.9%)			4 (4%)	
Neochord insertion		1 (1.4%)			3 (3%)	
Edge-to-edge repair		1 (1.4%)			1 (1%)	
Annuloplasty ring		70 (100%)			97 (97%)	
Valve replacement		N/A			N/A	
Hancock porcine	21 (44.7%)			59 (60.2%)		
Carpentier-Edwards pericardial	16 (34.0%)			14 (14.2%)		
St. Jude mechanical	10 (21.2%)			16 (16.3%)		
Onyx mechanical				9 (9.2%)		
Chordal preservation	32 (71.1%)					
LV reconstruction	1 (2.1%)	1 (1.4%)	1	2 (2.0%)	4 (4%)	0.68
Atrial ablation/appendage ligation	3 (6.4%)	9 (13.2%)	0.35			
Other valve surgery	11 (23.4%)	7 (10.0%)	0.05	25 (25.5%)	12 (12%)	0.02
Aortic valve replacement	5 (10.6%)	2 (2.9%)	0.12	12 (12.2%)	8 (8%)	0.30
Tricuspid annuloplasty	7 (14.9%)	5 (7.1%)	0.22	16 (16.3%)	4 (4%)	0.003
Coronary artery bypass grafting	15 (31.9%)	32 (45.7%)	0.14	24 (24.5%)	44 (44%)	0.005
Number of bypassed vessels[b]	1.9 ± 1.0	2.6 ± 1.1	0.08	2.0 ± 1.0	2.4 ± 1.2	0.15
Cross-clamp time (min)	120 ± 50	86 ± 36	0.005	120 ± 58	94 ± 46	0.005
CPB time (min)	158 ± 50	119 ± 41	0.003	160 ± 64	128 ± 49	0.002

[a] Categorical variables are reported as N (%); p values derived from χ^2 test or Fisher's exact test. [b] Continuous variables are reported as mean ± standard deviation; p values derived from Student's t test.

CPB = cardiopulmonary bypass; LV = left ventricular; N/A = not available.

ever possible, and performed in 71.1% of valve replacements.

Follow-Up

Follow-up information was obtained during outpatient appointments and by phone interviews with the referring or primary care physicians. Additional data were also obtained from Social Security death registries. Follow-up data on survival and reoperation were available on 97.4% of all elderly patients. The mean duration of follow-up was 45.1 ± 32.9 months and 59.0 ± 34.6 months in elderly patients undergoing MV repair and replacement, respectively.

Statistical Analysis

Patient data were tabulated and stratified by age group for repair versus replacement. Continuous variables were compared using Student's *t* test or Wilcoxon rank-sum tests, and categorical variables were compared using χ^2 analysis or Fisher's exact test, as appropriate. Logistic regression analysis of clinically relevant risk factors was used to identify independent predictors of 30-day mortality. Kaplan–Meier survival curve estimates were used to compare long-term survival between mitral repair and replacement in elderly patients. Statistical tests were performed with SAS 9.1.3 (SAS Institute, Inc, Cary, NC).

Results

Operative Details—Elderly Patients

Techniques used for elderly patients undergoing MV repair (70 patients) included 25 patients with triangular leaflet resection (35.7%), 9 patients with quadrangular leaflet resection (12.9%), and 1 patient each with artificial neochord insertion and with edge-to-edge repair (1.4%). A semirigid or rigid annuloplasty ring was inserted in every elderly patient undergoing MV repair. Elderly patients undergoing MV replacement had the following prostheses inserted: 21 patients with Hancock porcine valve (44.7%), 10 patients with Carpentier-Edwards bovine pericardial valve (34.0%), and 16 patients with St. Jude mechanical valve (21.2%; Table 2). Atrial ablation and ligation of the appendage was not different between groups. Concomitant valve operations, including either aortic valve or tricuspid valve operation, were more commonly performed in elderly replacement compared with elderly repair patients (23.4% versus 10%; $p = 0.05$). Conversely, CABG was less commonly performed in elderly replacement patients (31.9%) compared with repair patients (45.7%), but this was not significantly different ($p = 0.14$). Differences in the number of bypassed vessels approached significance with more bypasses being performed in elderly repair patients compared with replacement patients (2.6 ± 1.1 versus 1.9 ± 1.0 bypasses; $p = 0.08$). Elderly patients undergoing MV replacement had longer cardiopulmonary bypass times than those undergoing repair (156 ± 60 versus 128 ± 49 minutes; $p = 0.003$). Similarly, cross-clamp times were longer in elderly MV replacement patients compared with repair patients (117 ± 55 versus 94 ± 46 minutes; $p = 0.01$).

Operative Details—Young Patients

Repair techniques used for young patients undergoing MV repair included 47 patients with triangular leaflet resection (47%), 4 patients with quadrangular leaflet resection (4%), 3 patients with artificial neochord insertion, and 1 patient with edge-to-edge repair (1%; Table 2). In addition, 1 patient had bovine pericardial patch repair of leaflet perforation (1%). A semirigid or rigid annuloplasty ring was inserted in all but 3 young patients

Table 3. Operative and Mortality Outcomes for Repair Versus Replacement, Stratified by Patient Age Group

Variable	≥75 Years Old Replacement (n = 47)	≥75 Years Old Repair (n = 70)	*p* Value	<75 Years Old Replacement (n = 98)	<75 Years Old Repair (n = 100)	*p* Value
Conversion to MV replacement/return to CPB for MR[a]	0 (0%)	1 (2.8%)	0.40	0 (0%)	1 (1.0%)	1
30-day mortality	11 (23.4%)	5 (7.1%)	0.01	5 (5.1%)	2 (2%)	0.27
Postoperative complications	15 (31.9%)	13 (18.6%)	0.10	17 (17.3%)	13 (13%)	0.39
Stroke	6 (12.8%)	0 (0%)	0.003	7 (7.1%)	5 (5%)	0.55
Acute renal failure	8 (17.0%)	3 (4.3%)	0.03	6 (6.1%)	2 (2%)	0.17
Infectious complication	8 (17.0%)	4 (5.7%)	0.06	7 (7.1%)	6 (6%)	0.68
Pneumonia	4 (8.5%)	8 (11.4%)	0.76	4 (4.1%)	2 (2%)	0.44
Myocardial infarction	0 (0%)	0 (0%)		1 (1.0%)	0 (0%)	1
Prolonged course on ventilator (>3 days)	10 (21.3%)	2 (2.9%)	0.001	7 (7.1%)	7 (7%)	0.97
Prolonged ICU stay (>3 days)	10 (21.3%)	3 (4.3%)	0.004	13 (13.3%)	7 (7%)	0.14
Postoperative hospital stay (days)[b]	14.0 ± 13.2	8.6 ± 3.5	0.01	11.4 ± 9.2	8.5 ± 7.1	0.02

[a] Categorical variables are reported as N (%); *p* values derived from χ^2 test or Fisher's exact test. [b] Continuous variables are reported as mean ± standard deviation; *p* values derived from Student's *t* test.

CPB = cardiopulmonary bypass; ICU = intensive care unit; MR = mitral regurgitation; MV = mitral valve.

undergoing repair (97%). Young patients undergoing MV replacement had the following prostheses inserted: 59 patients with St. Jude mechanical valve (60.2%), 16 patients with Hancock porcine valve (16.2%), 14 patients with Carpentier-Edwards pericardial valve (14.2%), and 9 patients with Onyx mechanical valve (9.2%). Young patients undergoing MV replacement more commonly had concomitant valve surgery compared with repair patients (25.8% versus 12%; $p = 0.02$; Table 2). Although the incidence of aortic valve replacement was similar between groups, tricuspid annuloplasty was more commonly performed in young patients with MV replacement compared with repair patients (16.3% versus 4.0%; $p = 0.003$). Consistent with the group of elderly patients, the incidence of CABG was less common in young MV replacement compared with repair patients (24.5%versus 44%; $p = 0.005$). The number of bypassed vessels was not significantly different between young MV repair patients (2.4 ± 1.2 bypasses) and young replacement patients (2.0 ± 1.0 bypasses; $p = 0.15$).

Table 4. Demographics and Perioperative Details Related to Stroke and Mortality of Young and Elderly Patients[a]

Variable	No Stroke (n = 291)	Stroke (n = 18)	*p* Value	Lived (n = 292)	Died (n = 23)	*p* Value
Age (y)	68 (59–77)[b]	66.5 (62–75)	0.86	66 (57–76)[b]	76 (74–78)	0.003
Female	145 (49.8%)[c]	9 (50.0%)	0.99	142 (48.6%)[c]	14 (60.9%)	0.25
MV replacement	131 (45.0%)	13 (72.2%)	0.03	129 (44.2%)	16 (69.6%)	0.02
Preoperative comorbidities						
Diabetes mellitus	65 (22.4%)	3 (17.7%)	0.77	63 (21.7%)	6 (26.1%)	0.63
Peripheral vascular disease	30 (10.4%)	2 (11.1%)	1	31 (10.7%)	3 (13.0%)	0.73
Tobacco use	75 (26.2%)	3 (3.9%)	0.58	75 (26.1%)	5 (21.7%)	0.64
COPD	43 (14.9%)	0 (0%)	0.09	40 (13.8%)	4 (17.4%)	0.55
Hypertension	155 (53.3%)	9 (50.0%)	0.79	154 (52.7%)	14 (60.9%)	0.45
Chronic renal insufficiency	44 (15.2%)	3 (16.7%)	0.74	41 (14.1%)	6 (26.1%)	0.13
Cardiac arrhythmia	99 (34.4%)	8 (44.4%)	0.38	102 (35.4%)	7 (30.4%)	0.63
Cerebral vascular disease	34 (11.8%)	4 (25.0%)	0.12	34 (11.9%)	4 (17.4%)	0.50
Coronary artery disease	110 (38.2%)	7 (41.2%)	0.81	108 (37.2%)	10 (47.6%)	0.34
Reoperative Surgery	33 (11.3%)	4 (22.2%)	0.25	34 (11.7%)	3 (13.0%)	0.74
NYHA class			0.42			0.20
I	29 (11.2%)	1 (7.4%)		29 (11.3%)	1 (5.3%)	
II	170 (65.6%)	8 (57.1%)		170 (66.4%)	10 (52.6%)	
III	46 (17.8%)	3 (21.4%)		43 (16.8%)	6 (31.6%)	
IV	14 (5.4%)	2 (14.3%)		14 (5.5%)	2 (10.5%)	
Preoperative LV function			0.86			0.02
Normal	149 (51.2%)	9 (50.0%)		152 (52.1%)	7 (30.4%)	
Mild dysfunction	55 (18.9%)	3 (16.7%)		56 (19.2%)	6 (26.1%)	
Moderate dysfunction	43 (14.8%)	2 (11.1%)		38 (13.0%)	8 (34.8%)	
Severe dysfunction	44 (15.1%)	4 (22.2%)		46 (15.8%)	2 (8.7%)	
Etiology of MR			0.67			0.03
Degenerative	51 (47.2%)	2 (33.3%)		121 (41.4%)	8 (34.8%)	
IMR	38 (35.2%)	4 (66.7%)		88 (30.1%)	12 (52.2%)	
MAC	7 (6.5%)	0 (0%)		10 (3.4%)	1 (4.4%)	
Rheumatic	10 (9.3%)	0 (0%)		55 (18.8%)	0 (0%)	
Endocarditis	2 (1.9%)	0 (0%		18 (6.2%)	2 (8.7%)	
LV reconstruction procedure	7 (2.4%)	1 (5.6%)	0.38	7 (2.4%)	1 (4.4%)	0.46
Other valve surgery	49 (16.8%)	4 (22.2%)	0.52	50 (17.1%)	5 (21.7%)	0.57
Aortic valve replacement	23 (7.9%)	3 (16.7%)	0.18	24 (8.3%)	3 (13.0%)	0.43
Tricuspid annuloplasty	29 (10.0%)	2 (11.1%)	0.70	29 (10.0%)	3 (13.0%)	0.72
Coronary artery bypass grafting	104 (35.9%)	8 (44.4%)	0.46	105 (36.1%)	10 (43.5%)	0.48
Number of bypassed vessels	2 (1–3)	2 (1–3)	0.71	2 (1–3)	2 (2–3)	0.66
Cross-clamp time (min)	88 (67–123)	156 (60–198)	0.13	88.5 (64–123)	115.5 (83–165)	0.06
CPB time (min)	125 (96–166)	210 (97–250)	0.06	125 (96–166)	155 (122–210)	0.04

[a] Stroke data available only for 309 patients. [b] Continuous variables are reported as median (interquartile range); *p* values derived from Wilcoxon two-sample test. [c] Categorical variables are reported as N (%); *p* values derived from χ^2 test or Fisher's exact test.

COPD = chronic obstructive pulmonary disease; CPB = cardiopulmonary bypass; IMR = ischemic mitral regurgitation; LV = left ventricular; MAC = mitral annular calcification; MR = mitral regurgitation; MV = mitral valve; NYHA = New York Heart Association.

Outcomes

One elderly and 1 young patient each required return to cardiopulmonary bypass with replacement of their MV after attempted repair. No patient who underwent MV replacement required return to cardiopulmonary bypass for issues with their prosthetic valve. Elderly patients undergoing MV surgery collectively had higher 30-day hospital mortality than young patients (13.7%, 16 of 117 patients, versus 3.6%, 7 of 197 patients; $p = 0.001$). Elderly MV replacement patients had higher 30-day mortality (23.4%) than elderly repair patients (7.1%; $p = 0.01$; Table 3). In young patients, mortality differences were not evident between patients undergoing repair or replacement (2.0% versus 5.1%; $p = 0.27$).

Although the overall complication rate in elderly MV replacement patients compared with elderly repair patients was similar (31.9% versus 18.6%; $p = 0.10$; Table 3), postoperative stroke was higher in elderly replacement patients (12.8%, 6 of 47 patients), whereas no strokes occurred in elderly repair patients ($p = 0.003$). The stroke rate in elderly replacement patients was also significantly higher than in young patients independent of MV operation ($p = 0.02$). Acute renal failure was more common in elderly replacement patients than in elderly repair patients (17.0% versus 4.3%; $p = 0.03$). The difference in infectious complications in elderly replacement patients approached significance compared with repair patients (17.0% versus 5.7%; $p = 0.06$). In young patients, differences in renal failure, stroke, infections, and respiratory failure were not observed between patients undergoing repair and replacement.

Prolonged ventilator course occurred more often in elderly replacement versus repair patients (21.3% versus 2.9%; $p = 0.001$). Prolonged stay in the intensive care unit occurred in 21.3% of elderly replacement patients and was significantly higher than in elderly repair patients (4.3%; $p = 0.004$). Young patients had equivalent intensive care unit and ventilator course independent of type of MV operation. Hospital length of stay was longer in elderly replacement patients than in elderly repair patients (14.0 ± 13.2 versus 8.6 ± 3.5 days; $p = 0.01$). Similarly, young replacement patients (11.3 ± 9.3 days) had longer lengths of stay than patients undergoing repair (8.5 ± 7.1 days; $p = 0.02$).

Univariate analysis was performed on young and old (315) patients to identify risk factors correlated with stroke and mortality (Table 4). The only risk factor associated with stroke was MV replacement ($p = 0.03$). Age, type of concomitant operation, and preoperative cerebrovascular disease were not associated with stroke. Univariate analysis of all patients documented that mortality was highly associated with age as patients who died were on average 10 years older (range, 42 to 83 years) than survivors ($p = 0.003$). Mitral valve replacement was significantly associated with mortality ($p = 0.02$). Other variables associated with mortality by univariate analysis included preoperative left ventricular dysfunction ($p = 0.02$), cause of MR ($p = 0.03$), and cardiopulmonary bypass time ($p = 0.04$). Other risk factors, including concomitant operation (whether CABG or other valve procedure) as well as New York Heart Association class, did not correlate with mortality. Operating surgeon did not correlate with mortality ($p = 0.16$).

Table 5. Multivariate Analysis of Mortality of All Patients Undergoing Mitral Surgery

Risk Factor	Odds Ratio	95% Confidence Interval	p Value
Elderly age (≥75 y)	3.6	1.4–9.6	0.01
Mitral valve replacement	5.6	1.9–16.7	0.001
Female	1.5	0.6–3.9	0.44
Severe LV dysfunction	0.4	0.1–2.2	0.31
Concomitant procedure			
CABG	1.2	0.4–3.4	0.80
Aortic valve	1.2	0.2–6.3	0.86
Tricuspid valve	1.0	0.3–4.0	0.98
Reoperative procedure	0.9	0.3–3.4	0.92
Ischemic regurgitation as indication	3.9	1.3–11.5	0.01

CABG = coronary artery bypass grafting; LV = left ventricular.

Multivariate analysis on all patients was performed to account for confounding factors and included clinically relevant risk factors of elderly age, MV replacement, concomitant operations, reoperation, and cause of MR (Table 5). After logistic regression, mortality was associated with age of 75 years or older (odds ratio, 3.6; $p = 0.01$) and highly associated with MV replacement (odds ratio, 5.6; $p = 0.001$). Concomitant operation and reoperative status were not associated with mortality. The cause of MR was also associated with mortality by multivariate analysis. Ischemic MR was highly associated with mortality (odds ratio, 3.9; $p = 0.01$). Operation for rheumatic disease was not associated with mortality as none of these patients died (Table 4) and thus was not included in multivariate analysis. The risk factor left ventricular dysfunction, although associated by univariate analysis, was not associated with mortality after accounting for other variables ($p = 0.31$). Cardiopulmonary bypass time was associated with mortality by univariate analysis but was not included in the logistic regression model because longer cardiopulmonary bypass times were highly associated with MV replacement (Table 2), and the inclusion of this variable would be a surrogate variable for MV replacement.

The diagnosis of ischemic MR was a predictor of mortality. There were no differences in mortality in young patients with ischemic MR who underwent repair or replacement (repair, 4%, 2 of 46 patients; replacement, 0%, 0 of 10 patients; $p = 1.0$). Mortality of elderly patients with ischemic MR was significantly better with mitral repair (13%, 4 of 30 patients) than for replacement (42%, 6 of 14 patients; $p = 0.05$).

Long-Term Outcomes

Long-term survival curves indicate improved survival after MV repair over replacement in elderly patients ($p =$

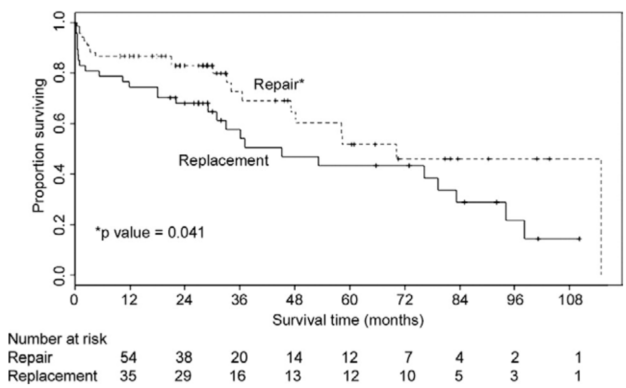

Fig 1. Long-term survival with mitral valve repair (dashed line) versus replacement (solid line) in elderly patients.

0.041; Fig 1). After accounting for postoperative deaths, survival between repair and replacement in elderly patients was similar ($p = 0.21$). During the follow-up period, 1 elderly patient required eventual replacement 7 months after initial repair (1.4%). No elderly patient who underwent MV replacement required reoperation for his or her MV. After accounting for early postoperative mortality, long-term survival was equivalent in elderly patients undergoing repair (88.2%) versus replacement (91.5%; $p = 0.76$).

Comment

Mitral valve repair for MR was performed in nearly 60% of patients age 75 years or older at our institution, in contrast to reports from the Society of Thoracic Surgeons database (36%) [7]. Major centers have documented an increase in the ability to repair valves in more recent times [10]. Older patients are often not considered to be candidates for mitral repair because of (1) concerns of poor tolerance with return to cardiopulmonary bypass, (2) unclear benefit of repair in elderly patients, and (3) the fact that valve repair can be difficult [11]. In our series, elderly patients fared better with MV repair compared with replacement with better 30-day and late survival. The improved late survival in elderly repair patients was admittedly in large part attributable to better operative mortality compared with replacement. Stroke, complication rate, and length of stay were improved in elderly patients undergoing repair. By multivariate analysis, mortality was independently and highly associated with MV replacement. Mortality was also independently associated with elderly age and ischemic MR. Only 2 deaths occurred in young patients with ischemic MR, suggesting low mortality independent of operation in young patients. Elderly patients with ischemic MR, however, had significantly worse outcome with replacement. Rheumatic disease was not identified as an independent variable associated with mortality as all rheumatic patients survived. Our mortality rate for elderly patients undergoing repair (7.1%) and replacement (23.4%) compares favorably with reports in the literature indicating operative mortality of 0.7% to 12.6% for elderly patients undergoing MV repair [6, 12] and 14.3% to 27% for elderly patients undergoing MV replacement [12–14]. A surprisingly large number of elderly patients received mechanical valves. The choice for mechanical valve in elderly patients was based on a number of reasons. Elderly patients with preoperative atrial fibrillation or a previously placed mechanical aortic valve who were tolerating anticoagulation therapy were offered the choice of a mechanical valve. A smaller proportion of patients with small left ventricles were thought to better tolerate the lower-profile mechanical MV when their valve needed replacement.

Mitral valve repair has become the preferred approach for most causes of MR in young patients. In-hospital and long-term survival advantages exist for valve repair over replacement for degenerative MV disease [1–4]. En-

Table 6. Selected Literature Examining Valvular Surgery in the Elderly

Author, Year	Number of Patients	Age (y)	Type of Procedure	Mortality	Conclusions
Alexander, 2000 [17]	92	≥80	MVR + CABG	19.6%	Mortality highest for MVR/CABG compared to other valve operations
Nagendran, 2005 [18]	58	≥80	MVR (56%)/MVP (44%)	15.5%	Mitral replacement risk factor for mortality
Tsai, 1994 [19]	73	≥80	MVR ± CABG (58%)/ MVP ± CABG (42%)	28.6% versus 22.6% (NS)	Mitral procedure in elderly has high mortality
Fremes, 1989 [20]	188	≥70	MVR (82%)/MVP (18%)	14.7% vs 16.2% (NS)	Good risk patients should be offered surgery
Goldsmith, 1999 [21]	43	≥75	MVR (49%)/MVP (51%)	38.0% versus 22.7% (NS)	Longer cross clamp times for repair than replacement
Gogbashian, 2006 [6]	292	≥70	MVR (25%)/MVP (75%)	13.9% versus 0.7% (p = 0.002) favoring repair	Benefit of repair lost with concomitant CABG
Enriquez-Sarano, 1995 [3]	83	≥75	MVR (39)/MVP (44)	30.8% versus 6.8% (p = 0.0005) favoring repair	Valve repair significantly improves outcome

CABG = coronary artery bypass grafting; MVP = mitral valve repair; MVR = mitral valve replacement; NS = not significant.

riquez-Sarano and associates [3] reported significantly less hospital mortality with MV repair over replacement for degenerative MV disease (2.6% versus 10.3%). Ten-year survival rate was better for repair than replacement (68% ± 6% versus 52% ± 4%; $p = 0.0001$). A report from Gillinov and colleagues [2] supported long-term durability of MV repair for degenerative disease with 10-year freedom from reoperation of 93%. Patients with ischemic MR have also seen benefit to valve repair although this has been less well studied in part because of intrinsic disease that is inseparable from the process causing MR [15]. Good-risk patients with ischemic MR who undergo repair have 1- and 5-year survivals of 82% and 58% compared with 56% and 36% survival, respectively, in replacement patients [5]. Our group previously reported no reoperation for recurrent MR at 5 years after valve repair in patients with ischemic MR, supporting the longevity for repair in this group of patients [15]. In a study evaluating patients with degenerative or ischemic MR, Akins and coworkers [16] found a shorter length of stay (10 versus 12 days) and less hospital mortality (3% versus 12%) in patients who underwent MV repair versus replacement. The mean age of patients in the majority of these large series indicating superiority of MV repair over replacement is between 55 and 65 years of age [1–5, 16].

Mortality risk in elderly patients undergoing valve surgery is understandably higher than in younger patients. Our series confirmed higher mortality in all elderly patients undergoing mitral surgery compared with younger patients.

Mitral Repair Versus Replacement in Elderly

Few studies have evaluated MV repair and replacement in elderly patients (Table 6). Older reports contrast more recent reports indicating the lower operative mortality in elderly patients undergoing MV repair compared with replacement. Gogbashian and associates [6] compared MV repair with replacement in 292 patients aged 70 years or older and showed that in-hospital mortality for isolated MV repair (0.7%) was significantly better than for replacement (13.9%). Five-year survival also favored MV repair over replacement (MV repair, 81% ± 3%; MV replacement, 63% ± 3%). In the subset of patients age 70 years or older in the report by Enriquez-Sarano and coworkers [3], operative mortality for repair patients was 6.8% compared with 30.8% in replacement patients, and is remarkably similar to our results. Thourani and colleagues [8] demonstrated that MV replacement and age were both independent predictors of in-hospital and long-term mortality. Despite documented superior outcomes with MV repair in elderly patients in these recent series, authors have concluded that MV repair does not provide long-term benefit in patients older than the age of 60 [8]. In our series, we documented improved survival in elderly patients with ischemic MR undergoing repair, a finding that has been seen in other large series independent of age [5].

Mitral Repair With Concomitant Coronary Artery Bypass Grafting

The concept of benefit of MV repair over replacement in patients who require concomitant CABG is controversial. The report by Thourani and associates [8] documented equivalent survival with MV repair and replacement in patients requiring CABG. This finding is also supported by Gogbashian and colleagues [6] who documented in-hospital mortality for CABG with MV repair of 1.4% compared with CABG with MV replacement of 5.3% (not significant). Perhaps unexpectedly in that report, isolated MV replacement patients had higher mortality (13.9%) than concomitant MV replacement with CABG (5.3%). In contrast, Enriquez-Sarano and associates [3] documented a survival benefit at 6 years with MV repair over replacement in patients with concomitant CABG (74% ± 6% versus 34% ± 8%). In a multivariate analysis, Nagendra and coworkers [18] documented concomitant CABG as an independent risk factor for mortality in octogenarians undergoing MV surgery. Our report did not identify worse mortality with concomitant CABG by multivariate analysis.

Potential Explanations for Improved Outcomes

Lower mortality documented in our study in elderly patients undergoing repair can be attributable to several reasons. Preservation of the subvalvar apparatus improves long-term left ventricular function and survival [22–24]. Although techniques to preserve the subvalvar apparatus were used in the majority of patients undergoing replacement (71%) in our series, valve repair is still considered superior to replacement [6, 25]. Our experience describes shorter cardiopulmonary bypass times with valve repair, which may also be linked with lower mortality. Importantly, our experience of shorter cross-clamp and bypass times during mitral repair was seen in both elderly and young patients. Unrepairable valves that require replacement may be a harbinger of more-advanced heart disease and thus may bode worse outcomes.

Limitations

This is a single-institution retrospective review, a limitation to most of the literature comparing MV repair to replacement. As such, there may be a selection bias for valves that are able to be repaired. The repairability of a valve including the complexity of valve disease and degree of annular calcification is difficult to assess by reviewing operative notes of patients who underwent mitral replacement and is a clear limitation to the potential bias in our report. A standardized intraoperative assessment model would be helpful in this and future multicenter studies. Some baseline characteristics, including preoperative cerebrovascular disease origin of MR, and concomitant operations are different between repair versus replacement in our elderly patients. Importantly, concomitant valve operations were more common in replacement patients although this was not linked to mortality by multivariate analysis. Rheumatic valves were more commonly replaced, although we documented no mortality or stroke in those patients. Thus, the higher mortality in elderly replacement patients was not explained by the higher preponderance of patients with rheumatic disease. Although excellent early and midterm outcomes after repair of rheumatic mitral disease have been reported, mortality is not as favorable as in patients with degenerative disease [26, 27]. In our report, operations for ischemic MR were associated with higher mortality. These findings are consistent with the literature, suggesting that elderly patients with ischemic origin have the highest mortality of any subgroup [11]. These differences between our repair and replacement patients can only be accounted for through a multicenter randomized trial. Finally, there is a relatively small sample size of elderly patients (n = 117). Further differences between repair and replacement in elderly patients may become apparent given more patients.

Conclusions

There is a perception that MV repair does not provide benefit in elderly patients. Despite shorter life expectancy in elderly patients, we document improved operative and long-term survival as well as lower stroke rates in patients age 75 years or older with mitral repair over replacement. The rate of return to cardiopulmonary bypass or reoperation for persistent MR is low. No differences in outcomes were identified when concomitant CABG or valve operation was required. Mitral repair can be performed over replacement when feasible even in patients older than the age of 75.

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DISCUSSION

DR JENNIFER SUE LAWTON (St. Louis, MO): Thank you for your manuscript and also thank you for such a thought-provoking investigation. It is important to stress, and you did in your presentation, that these are all patients with mitral regurgitation and that you excluded stenosis. And if we are going to focus on the elderly population, because I think that is where you would like to make a statement in that the elderly don't do as well with mitral replacement, I think it is important to note that there are significant differences in the elderly replacement group and the elderly repair group, both preoperatively and intraoperatively. The elderly replacement group had a higher incidence of cerebrovascular disease before surgery. You also had a higher percentage of women in the replacement group, although that was not statistically significant. You had a higher percentage of rheumatic patients, annular calcification patients, and also endocarditis patients in the replacement group. You also had longer cardiopulmonary bypass time and cross-clamp time, which could also lead to higher mortality and stroke, and you also had an increased percentage of concomitant valve surgery, both aortic and tricuspid, at the same operation, as well as a higher percentage of reoperations in the replacement group, although that was not statistically significant. So if you could comment, perhaps if we had a larger group of patients we could match them better preoperatively, would you see the same finding, do you think?

And my second question is, I was curious as to why 21% of your elderly replacement patients, these are patients older than 75, got a St. Jude valve?

Thank you.

DR AILAWADI: Thank you for your questions. The first question related to whether we could have matched it differently or if it was a larger sample size if we expect to see the same outcomes. Given the sample size that we had, we attempted to account for all these differences that you mentioned using multivariate analysis. So if we believe statistical methods, we would anticipate with larger sample sizes we would see a similar outcome.

With respect to your second question?

DR LAWTON: Twenty-one percent of your elderly replacement patients actually got a St. Jude valve. These are people older than 75.

DR AILAWADI: There were different reasons depending on the patient. A patient, for example, who is already on Coumadin (sodium warfarin) for A-fib (atrial fibrillation) who did very well with Coumadin may have gotten a St. Jude valve or patients that already had a mechanical valve in another position may have gotten a mechanical valve.

DR LAWTON: So would you say that you placed it because of ease?

DR AILAWADI: We know that repairing patients with mitral regurgitation when possible, even in the face of other valve prostheses, still has a better outcome. The Cleveland Clinic group has shown that very nicely.

DR LAWTON: Thank you.

DR JOHN M. KRATZ (Charleston, SC): Your replacement group had a fairly daunting 12% stroke rate, which probably contributed a good bit to your increased mortality in that group 2. A lot of us have been getting away from even short-term anticoagulation for a bioprostheses. Could you comment on that stroke group of 12% and your anticoagulation protocol? What do you think that had to do with your stroke rate?

DR AILAWADI: The anticoagulation protocols depended on the surgeon's choice. Some surgeons at our institution anticoagulate all mitral valves for a period of 3 months, others use the AHA (American Heart Association) guidelines to anticoagulate only patients that are considered high risk that have had a previous thromboembolism, A-fib patients. So we did not look at that specifically if there was a difference based on whether they were on anticoagulation or not. We did note that even though there were differences in preoperative cerebrovascular disease, this did not bear out in way of the outcome of stroke.

DR TARA KARAMLOU (Portland, OR): You first showed that patients were statistically much more likely when they are elderly to undergo replacement. I wonder then if your results actually just are reflecting your institutional bias toward repairs since you had only 47 patients who actually underwent replacement with a preponderance of repairs. So could you comment on that?

DR AILAWADI: The STS database takes all-comers. There are no provisions for patients that have mitral stenosis with a previous mitral prosthesis. I quoted the STS database reports a 36% repair rate for all mitral surgery. Our repair rate for mitral regurgitation is over 60%. Certainly we prefer to repair any valve in which it is possible despite their age. We feel that repair even in elderly provides a better long-term outcome.