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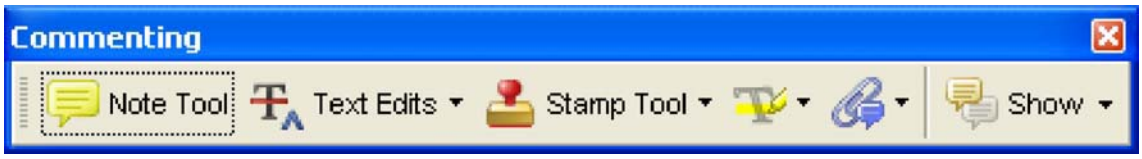

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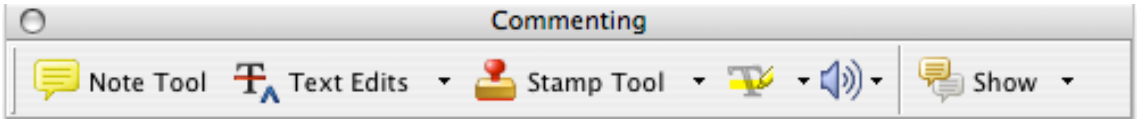

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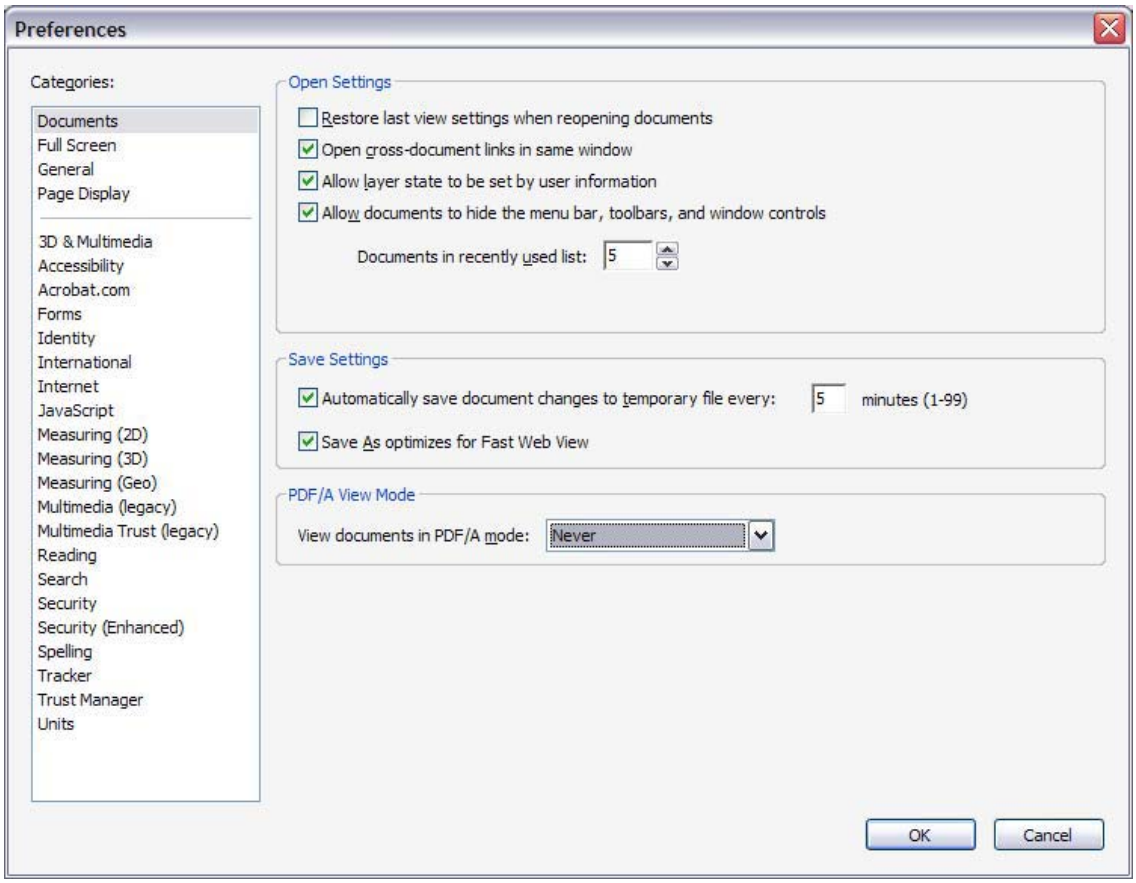

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Influence of Patient Age on Procedural Selection in Mitral Valve Surgery

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Background. **Previous studies suggest that mitral valve replacement is comparable to repair in the elderly, and a national trend exists toward tissue valves. However, few direct comparison data are available, and this study evaluated the effects of patient age on risk-adjusted survival after mitral procedures.**

Methods. **From 1986 to 2006, 2,064 patients underwent isolated primary mitral operations (±CABG). Maximal follow-up was 20 years with a median of 5 years. Valve disease etiology was the following: degenerative, 864; ischemic, 450; rheumatic, 416; endocarditis, 98; and "other," 236. Overall, 58% had repair and 39% had concomitant coronary artery bypass grafting. Survival differences were evaluated with a Cox proportional hazards model that included baseline characteristics, valve disease etiology, and choice of repair versus replacement with tissue or mechanical valves.**

Results. **Baseline risk profiles generally were better for mechanical valves, and age was the most significant multivariable predictor of late mortality [hazard ratio = 1.4 per 10-year increment, Wald $\chi^2 = 32.7$, $p < 0.0001$]. As compared with repair, risk-adjusted survival was inferior with either tissue valves [1.8, 27.6, <0.0001] or mechanical valves [1.3, 8.1, 0.0044], and no treatment interaction was observed with age ($p = 0.18$). At no patient age did tissue valves achieve equivalent survival to either repair or mechanical valves.**

Conclusions. **Mitral repair is associated with better survival than valve replacement across the spectrum of patient age. If replacement is required, mechanical valves achieve better outcomes, even in the elderly. These data suggest that tissue valves should be reserved only for patients with absolute contraindications to anticoagulation who are not amenable to repair.**

(Ann Thorac Surg 2010;xx:xxx)

Improvements in mitral repair have increased the number of valves amenable to autologous reconstruction, as compared with prosthetic valve replacement [1–22]. Nationally, repair rates for isolated mitral procedures have increased to almost 70% in the most recent National sample [23]. While newer analyses suggest that patients with ischemic or degenerative mitral regurgitation experience better survival after valve repair [24, 25], techniques and applicability of mitral repair, as well as the most effective approach for older patients, are controversial [5, 6, 24–35]. National data indicate that elderly patients more frequently receive tissue mitral valve replacement, and this trend seems to be increasing [23]. Unfortunately, few direct multivariable comparisons are available to document outcomes for mitral repair versus replacement in the elderly, as well as for contemporary bioprosthetic versus mechanical valves. The purpose of this study was to examine the influence of patient age on survival after mitral valve repair, and to compare repair survival with that observed with both mechanical and tissue valves.

Material and Methods

This study was performed with approval from the Duke Institutional Review Board and under a waiver of informed consent, but new late patient contact was not allowed. In the Duke Databank for Cardiovascular Disease, 2,064 consecutive patients with isolated mitral disease who underwent cardiac surgery from January 1, 1986 through December 31, 2006 were reviewed. Patients having concomitant coronary artery bypass grafting (CABG) or electrophysiologic procedures were included, but other major cardiac procedures were excluded (eg, aortic valves, tricuspid valves, postinfarct ventricular septal defects, ventricular aneurysm repair). While patients with previous CABG were included, those with previous mitral replacement were excluded, because they were not candidates for either procedure.

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Preoperative baseline and intraoperative characteristics for all patients were recorded prospectively over the entire 20 years, with consistent variables throughout. Late outcome data were collected prospectively on patients with significant concomitant coronary disease per Duke Databank protocols. A National Death Index search was conducted through 2006 to acquire mortality results for remaining patients. Patients were divided into two groups; the first was patients having mitral repair (n = 1,188), and the second was patients having prosthetic valve replacement (n = 876) with mechanical valves (n = AQ: 1 680 [78%]; predominantly St. Jude valves [St. Jude Medical, Inc, St. Paul, MN] or tissue valves (n = 196 [22%]; predominantly Carpentier Edwards [Edwards Lifesciences, Irvine, CA] porcine or pericardial bioprostheses). Operative notes of all 2,064 patients were audited to ensure proper categorization. Most repairs had full ring annuloplasty (usually Edwards Physio, Carpentier classic, or Séguin [St Jude Medical] rings) along with appropriate leaflet or chordal procedures. Innumerable different repair combinations were used, depending on surgeon preference, anatomy encountered, and evolution of techniques over time, and 18 different surgeons contributed patients. Partial or total chordal sparing valve replacement was performed frequently, but this variable was not documented well and was not assessed in the analysis. Follow-up for survival was 92% complete and only all-cause mortality was available consistently for analysis.

Baseline characteristics and clinical event rates were described using medians with 25th and 75th percentiles for continuous variables and frequencies and proportions for categoric variables. Descriptive data were compared using the Wilcoxon rank-sum test for continuous and ordinal variables, and a Pearson χ^2 or Fisher's exact test for categoric variables. Three propensity models were created to determine the propensity for repair versus mechanical replacement, repair versus tissue replacement, and mechanical versus tissue replacement [36]. A multivariable Cox proportional hazards regression model was employed with an analysis strategy that adjusted for the impact of baseline characteristics on survival [37]. To develop the risk-adjustment model, a pool of all known clinical covariates that have been shown to be important in previous analyses was developed [25]. Variables proving significant by stepwise univariable-multivariable procedures were included in the final Cox model and also used for risk adjustment. Propensity scores also were included in the Cox model, as were the valve repair-replacement variables of interest. Continuous and ordinal variables were tested for linearity over the log hazard and transformed as necessary. Adjusted survival estimates for each group were calculated by applying their baseline hazard functions, along with parameter estimates, to all patients in the entire cohort and then averaging over all patients at each time point. Statistical analyses were performed using SAS version 8.2 (SAS Institute, Cary, NC), and a p value of 0.05 or less was considered significant.

Results

Baseline characteristics of the entire population are detailed in Table 1. Among the groups, tissue replacement T1 patients were significantly older with less elective surgery. Mechanical replacement patients were younger, and repair patients were more predominantly male, had a higher incidence of concurrent 3-vessel disease and CABG, and lower ejection fractions. Procedural incidence over time is shown in Figure 1. F1

In an analysis subset 65 years of age or greater (n = 998 [data table available at jsrmd.com]), baseline characteristics were more similar, but mitral repair patients (n = 563) still had more 3-vessel disease, CABG, nonelective presentation, and lower ejection fractions. Mitral replacement patients (mechanical, n = 293; tissue, n = 142) were more predominantly female. Regardless of age and operative procedure, the most common etiology of mitral valve disease was degenerative followed by ischemic (Table 2). Rheumatic patients comprised 20% of the T2 population and more frequently underwent mitral replacement (88%), while ischemic and degenerative usually had repair.

Raw unadjusted 30-day mortality was 3.5% for mitral repair, 5.9% for mechanical replacement, and 8.2% for tissue replacement. Long-term unadjusted Kaplan-Meier survival was not significantly different between mitral valve repair and mechanical mitral valve replacement (Fig 2), and both groups had significantly better raw F2 survival as compared with tissue valve replacement. This finding was preserved in the unadjusted Kaplan-Meier survival comparison of patients 65 years or greater (Fig 3). F3

Final Cox model coefficients are shown in Table 2, and after adjusting for differences in baseline characteristics, risk-adjusted survival estimates are displayed in Figure 4. F4 Adjusted curves demonstrated better survival with mitral repair, and even after adjustment for adverse risk profiles, tissue replacement survival was still inferior. No treatment interaction was observed between procedural choice and age in the Cox model analysis ($p = 0.1781$). In other words, the hazard associated with each treatment was the same across all ages.

Another Cox model was generated for patients surviving 90 days after surgery (coefficients at jsrmd.com) in order to compare relative late mortalities. Conditional adjusted survival estimates demonstrated persistent superiority of repair and mechanical replacement as compared with tissue valve replacement (Fig 5). Finally, F5 adjusted survival probabilities at 10 years versus age at valve implant are shown in Figure 6. Regardless of F6 patient age, mitral repair was associated with better risk-adjusted 10-year survival compared with either mechanical or tissues. At no age did tissue valve replacement achieve equivalent results to either of the other two procedures.

Comment

An important issue in this analysis is the validity of comparing procedures that may not have been equally

AQ: 6

Table 1. Baseline Characteristics of Overall Population

	Total (n = 2,064)	Mitral Valve Repair (n = 1,188)	Tissue Mitral Valve Replacement (n = 196)	Mechanical Mitral Valve Replacement (n = 680)	Overall *p* Value
Age	64 (53, 72)	64 (53, 72)[a,b]	72 (63, 77)[c,b]	62 (52, 70)[c,a]	<0.0001
Gender					
% Male	46%	54%[a,b]	33.7%[c]	36%[c]	<0.0001
% Female	54%	46%[a,b]	66%[c]	64%	
Caucasian race	76%	76%	74%	77%	0.6581
History of diabetes	17%	19%[b]	16%	13%[c]	0.0020
Hypertension	50%	55%[b]	49%	44%[c]	<0.0001
Hyperlipidemia	34%	39%[a,b]	28%[c]	28%[c]	<0.0001
BMI	26 (23, 30)	26 (23, 30)[a]	25 (22, 28)[c,b]	26 (23, 30)[a]	0.0024
History of renal failure	4%	4%[a,b]	10%[c,b]	2%[c,a]	<0.0001
NYHA class					
I	32%	33%	29%	29%	0.0428
II	15%	16%	16%	14%	
III	31%	30%	26%	35%	
IV	22%	21%	29%	22%	
Chronic lung disease	10%	10%	9%	10%	0.8542
Infectious endocarditis	3%	2%[a]	7%[c,b]	3%[a]	<0.0001
History of CVA	10%	9%	9%	11%	0.1893
History of MI	24%	30%[a,b]	21%[c]	16%[c]	<0.0001
History of tobacco abuse	42%	41%	39%	44%	0.3539
Ejection fraction	0.50 (0.40, 0.60)	0.50 (0.34, 0.58)[a,b]	0.55 (0.45, 0.64)[c]	0.55 (0.45, 0.63)[c]	<0.0001
3-vessel disease	22%	29%[a,b]	19%[c,b]	11%[c,a]	<0.0001
Previous CABG	3%	3%	5%	2%	0.1366
Concomitant CABG	39%	46%[b]	39%[b]	29%[c,a]	<0.0001
Clinical status:					
Elective	70%	68%[a,b]	59%[c,b]	75%[c,a]	<0.0001
Nonelective	30%	32%[a,b]	41%[c,b]	25%[c,a]	

[a] $p < 0.05$ compared with tissue replacement; [b] $p < 0.05$ compared with mechanical replacement; [c] $p < 0.05$ compared with repair.

BMI = body mass index; CABG = coronary artery bypass grafting; CVA = cerebrovascular accident; MI = myocardial infarction; NYHA = New York Heart Association.

applicable to all patients or all mitral disease pathologies. This is an appropriate criticism, especially for the years included in this study. However, in the more recent era, repair techniques have evolved so that reconstruction can be performed in most patient categories [3, 38], and late outcome comparisons become useful to guide future patient management. Another concern regards possible undefined treatment selection biases or confounding variables, such that some patients might have been selected for one treatment or another who were at higher risk than defined by baseline variables. The potential for these types of problems exists with all observational studies. However, after 25 years of work with this data set, the determinants of mortality in mitral surgery are pretty well understood, and although minor factors may have been omitted, the major determinants are likely accounted for. With a large sample size, long follow-up, a comprehensive and consistent variable set, and meticulous multivariable modeling, this type of observational analysis has been shown to be quite accurate [39]. However, possibilities for confounders always exist, and the results need to be qualified and interpreted in this regard.

AQ: 2

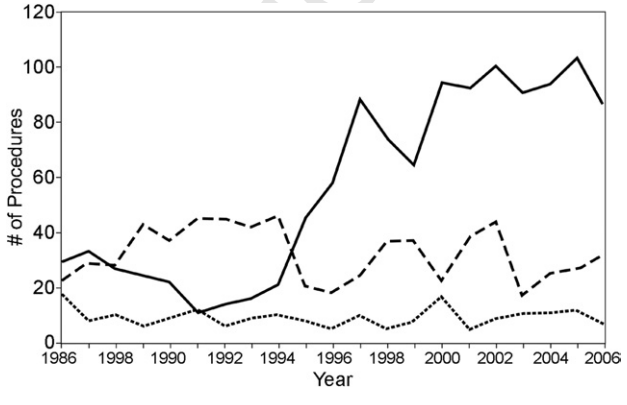

Fig 1. Incidence of mitral procedures over time. (— = repair; ●●● = replacement-tissue; --- = replacement-mechanical.)

Institutional selection biases also could exist. In the Duke practice, an early bias is evident against using

Table 2. Distribution of Valve Disease Etiology

Variable	Total (n = 2064)	Mitral Valve Repair (n = 1,188)	Tissue Mitral Valve Replacement (n = 196)	Mechanical Mitral Valve Replacement (n = 680)
Degenerative	42%	51%	32%	28%
Ischemic	22%	31%	12%	9%
Rheumatic	20%	4%	26%	47%
Other	11%	11%	12%	11%
Infectious	5%	3%	18%	5%

tissue valves in the mitral position because of higher failure rates with systolic closure stress. This factor probably accounts for the preponderance of mechanical versus tissue valves implanted over the entire experience. However, 18 different surgeons contributed patients over 20 years, so that significant variability in procedural selection philosophies existed. In studies of patient subgroups from this series [24, 25], propensity regressions showed that surgeon of record accounted for most of the procedural selection decisions, rather than any sort of systematic bias based on patient characteristics. Thus, most surgeons "believed" in one approach or the other, and practiced accordingly and in a consistent way. It is also likely that individual surgeon philosophies changed over time, and as stability of repair with autologous tissues became more apparent, the proportion of repair procedures increased dramatically (Fig 1) [25, 40]. While a general selection bias existed toward employing bioprostheses in the elderly, larger numbers of sick elderly patients received mechanical valves and repair in the greater than 65-year subgroup. In fact, the very sickest cohort, ischemic mitral regurgitation, was managed predominantly with repair [24]. Thus, a spectrum of procedural selection philosophies existed among the 18 surgeons, supporting the appropriateness of this comparison.

Several advantages existed with the approach used in this analysis. It was performed at a single institution with a relatively consistent technical and perioperative care philosophy. The sample size was good, and all patients had prospective recording of a consistent and complete set of baseline variables. Maximal follow-up was 20 years, and finally, the multivariable statistical approaches were state-of-the-art, adjusting for all known important baseline characteristics and propensity for procedural selection. The authors had no preconception of how the analysis would turn out, but after the National Death Index search, it became evident that unadjusted survival was best for mitral repair, followed by mechanical replacement, and then tissue valve replacement (Fig 2). This result with unadjusted data was not surprising as the tissue valve population was older on average, and age is a prominent predictor of survival. However, after adjustment for differences in preoperative baseline characteristics, mitral repair still had the best predicted survival, followed by mechanical valve replacement (Fig 4), and tissue valves seemed inferior to both of the other options. This relationship was maintained in the older mitral disease population and far into the advanced age group (Figs 3 and 6).

In order to minimize bias of operative mortality against tissue valve survival, adjusted survival conditional on

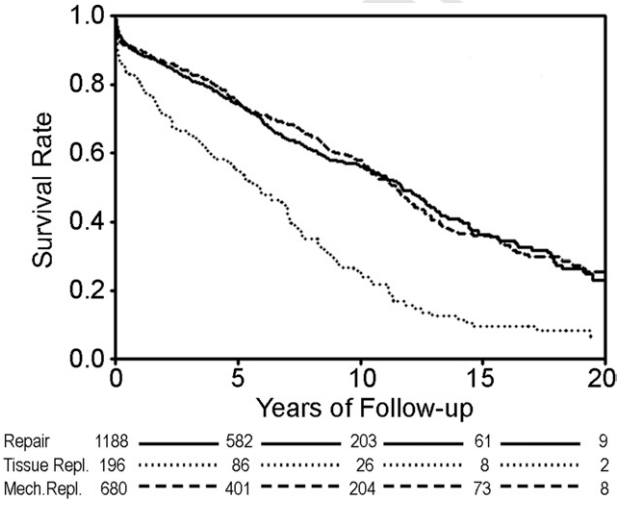

Fig 2. Unadjusted Kaplan-Meier survival analysis. Log-rank p value less than 0.0001 for tissue valves versus either mechanical valves or repair.

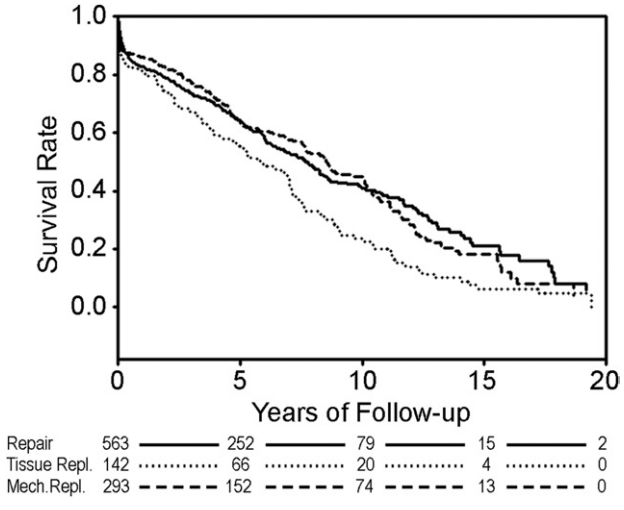

Fig 3. Unadjusted Kaplan-Meier survival analysis for patients greater than 65 years of age. Log-rank p value = 0.001 for tissue valves versus either mechanical valves or repair.

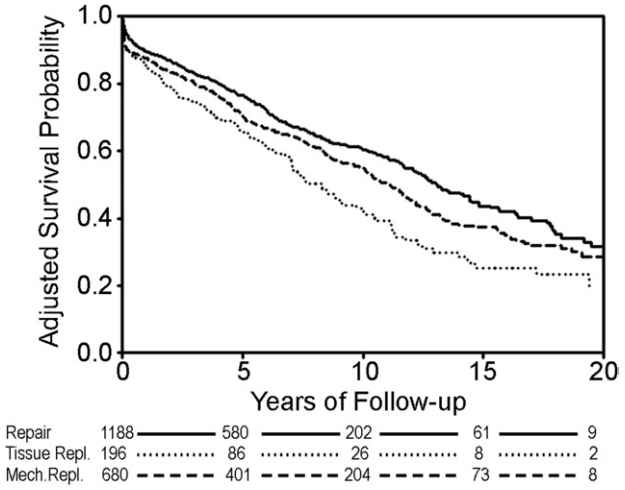

Fig 4. Long-term survival after adjusting for differences in baseline characteristics. Cox model p values. (Repair versus mechanical replacement = 0.0044; repair versus tissue replacement = <0.0001; mechanical versus tissue replacement = 0.0017.)

90-day survival was examined (Fig 5). Even in this cohort, mitral repair had better risk-adjusted outcomes, followed by mechanical then tissue valve replacement. Because nonfatal events were not available in this study the cause of this finding is unclear. However, it is likely related to worse valve-related complications, including valve degeneration which occurs at a higher rate for tissue valves in the mitral position. Somewhat surprising was the finding in the Cox model (Table 3) that tissue valve replacement had an associated hazard ratio of 1.8 (1.5, 2.3), second only to preoperative hemodialysis dependence. While the superiority of mitral repair relative to mechanical mitral replacement was definite but subtle, it seemed clear that tissue valve replacement was associated with inferior outcomes, independent of patient age (Fig 6).

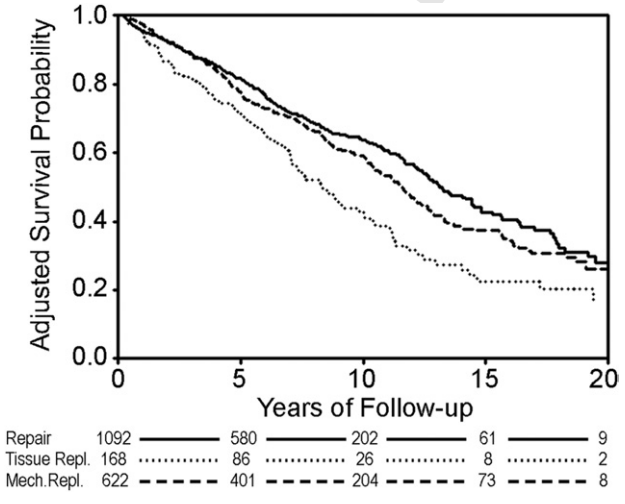

Fig 5. Adjusted survival estimates conditional on 90-day survival. Cox model p values. (Repair versus mechanical replacement = 0.0493; repair versus tissue replacement <0.0001; mechanical versus tissue replacement <0.0001.

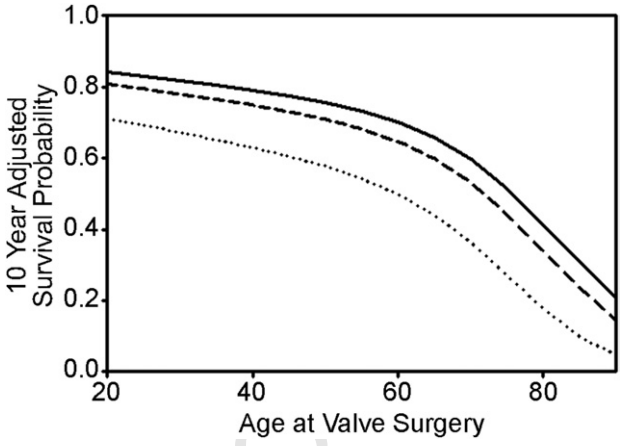

Fig 6. On the y axis is risk-adjusted survival at 10 years after valve surgery, and on the x axis is patient age at the original surgical procedure. Adjusted 10-year survival probability was best for patients receiving mitral valve repair, followed by mechanical valve replacement for all ages. Tissue mitral valve replacement was associated with decreased adjusted 10-year survival at all ages, even in the elderly. Thus, outcome differences for the 3 procedures were fairly constant across all patient ages. (— = repair; ●●● = tissue replacement; --- = mechanical replacement.)

How can these findings be reconciled with the currently accepted philosophy of adequate performance and broad application of tissue valves in the elderly? Perhaps some of the accepted concepts suffer from artifacts caused by using univariable "freedom from event" curves, an approach that is fraught with statistical inaccuracies due to the multivariable nature of outcomes and the competing risk of death in the elderly. The observed inferiority of tissue replacement is particularly concerning in light of the recent increased utilization of bioprostheses for elderly patients [23]. In the present analysis, however, it was clear that adjusted 10-year survival was inferior for tissue replacement patients of all ages (Fig 6), and the findings of this study suggest that valve repair should be the procedure of choice for most mitral valve disease.

The result of this analysis is dependent on the quality of the mitral repairs. While valve replacement was fairly standardized during this period, repair techniques evolved significantly, enhancing both the applicability and stability of repair procedures. Repair results steadily improved, with "year of surgery" yielding a χ^2 value of 11.3 in the Cox model (Table 3; $p = 0.0008$). Repair methods that have been shown to be less effective, such as pericardial bands, were avoided in the Duke practice, and utilization of inadequate repair techniques may account for some of the variability in the literature. In this series, full rings were used consistently, and management of chordal and leaflet abnormalities improved over time. Finally, it is probable that newer repair methods, such as artificial chordal replacement and autologous pericardial leaflet augmentation, will further enhance

Table 3. Overall Cox Model Parameters

Risk Factor	Wald χ^2	HR	95% CI		*p* Value
Dialysis	6.9	2.2	1.2	3.9	0.0088
Tissue valve replacement	28.9	1.8	1.5	2.3	<0.00001
History of peripheral vascular disease	24.5	1.7	1.4	2.1	<0.00001
History of CABG	10.2	1.7	1.2	2.3	0.0014
Full sternotomy	7.3	1.5	1.1	1.9	0.0069
History of cerebrovascular disease	12.4	1.4	1.2	1.8	0.0004
Age (HR per 10 years; truncated low end at 50)	32.7	1.4	1.3	1.6	<0.0001
History of diabetes	12.7	1.4	1.2	1.7	0.0004
Nonelective surgery	10.8	1.4	1.1	1.7	0.0010
Chronic lung disease	5.6	1.3	1.0	1.6	0.0180
Mechanical valve replacement	8.1	1.3	1.1	1.5	0.0044
Ischemic valve etiology	4.8	1.3	1.0	1.5	0.0287
GFR (HR per 5 unit decrease; truncated high end at 100)	27.6	1.2	1.1	1.4	<0.00001
Number of diseased vessels (HR per increase of 1)	2.3	1.1	1.0	1.1	0.1323
Ejection fraction (HR per 5% decrease)	0.112	1.0	1.0	1.1	0.0008
Year of surgery (HR per 1 year increase)	11.3	1.0	1.0	1.0	0.0008
Caucasian race	7.8	0.8	0.7	0.9	0.0052
Mechanical vs tissue replacement propensity	8.8				0.0031
Repair vs tissue replacement propensity	7.3				0.0070
Repair vs mechanical replacement propensity	7.2				0.0072

CABG = coronary artery bypass grafting; CI = confidence interval; GFR = glomerular filtration rates; HR = hazard ratio.

applicability and stability, and that repair outcomes will continue to improve into the future [1, 3, 4, 15, 35, 38].

Portions of this series have been analyzed in previous publications [24, 25, 33, 40]. Interestingly, the benefit of mitral repair on operative mortality seemed greater in acutely ill ischemic mitral regurgitation patients with adverse baseline characteristics [24]. In contrast, differences in 30-day outcome with repair versus replacement in patients with degenerative disease were smaller, perhaps because of the more elective nature of the population [25]. However, the long-term inferiority of valve replacement to repair was evident in both groups. Again, the reason for this difference will require further analysis of specific events, but it is now perhaps established that use of the body's own tissues to reconstruct heart valve function has significant long-term advantages. The tissue valve sample size in this study was marginal, and because of small numbers, comparison of early tissue valves with more recent designs was not possible. Therefore, further testing of the concluding hypothesis of this paper is suggested in other single institutional databases and potentially in the Society of Thoracic Surgeons data set.

In summary, the results of this study support the concept that diseased mitral valves should be repaired regardless of patient age. Based on these data, valves that are not amenable to repair should receive primarily mechanical mitral valve replacement. Utilization of tissue valves perhaps should be limited to irreparable patients who have contraindications to long-term systemic anticoagulation. From this analysis, advanced age seems neither to be an indicator for mitral valve replacement nor utilization of a bioprosthesis, although confirmation of these findings in other data sets is indicated.

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DISCUSSION

DR WALTER MERRILL (Cincinnati, OH): I have no disclosures. Dr Daneshmand and colleagues are to be congratulated for their efforts to bring to us important information concerning mitral valve repair and replacement. Their analysis of a 20-year experience at Duke will add to our understanding of many of the complex issues regarding mitral valve operations, particularly in older persons. Despite its many strong points, the study suffers from retrospective collections of some data, presumed changes in operative technique and patient or procedure selection over time, lack of complete follow-up information in all patients, and lack of information concerning causes of death and morbidities experienced in late survivors. The study employed rigorous statistical methodology in an effort to make appropriate adjustments for differences in baseline patient characteristics. While this is laudable, one has to question whether the goal was accomplished.

My first question. Is it possible that patients who received a tissue prosthesis were somehow fundamentally different in one or more important aspects from the other patients? They were older and less frequently underwent an elective operation. They had a higher incidence of renal dysfunction and endocarditis, as well as worse congestive heart failure preoperatively. Also, they had a much higher 30-day mortality. In the absence of late follow-up data concerning symptoms, performance status, assessment of ventricular function, adequacy of revascularization, and valve function, and given the absence of information regarding causes of late death, I am led to another question. Can the authors explain the reasons for their finding that patients with a tissue prosthesis had an inferior late survival?

DR DANESHMAND: Dr Merrill, thank you for agreeing to discuss our presentation and your kind comments and thought-

ful questions. This study needs to be interpreted within the context of an observational study to address your first point. We don't necessarily believe that randomized trials are inherently more valid than observational studies. They both have their limitations and their advantages. Earlier today we heard about some of the limitations of randomized trials. While they guarantee equality of baseline characteristics, they suffer from recruitment and cost issues. Observational studies like this one that use prospective data sets of well-validated variables and large sample sizes are more accurate but always have the possibility of unidentified treatment selection biases and unmeasured confounding variables. However, in the past 30 years the Duke data bank approach seems to be pretty accurate, and I would like to use the following slide as an example.

(Slide) The top curves represent raw unadjusted survival in this same population stratified by coronary disease and methods of bypass. All four groups have different baseline characteristics such as age, ejection fraction, et cetera. In the bottom panel we have utilized the same Cox model as we did in this study to adjust for differences in the baseline characteristics, and you can see that the adjustment technique brings the survival curves together. So we have a lot of confidence in the validity of the methodology.

Furthermore, in the final Cox model, tissue valve replacement is associated with a hazard ratio of 1.8. I think most statisticians would agree that such a high hazard is unlikely to be caused solely by confounding variables and deserves further consideration. So while it is likely that tissue valve replacement patients were different, I think we account for a majority of these differences with our statistical techniques.

To address your second issue, we don't currently understand the reasons for higher mortality in tissue valve replacement patients and we feel this does deserve further investigation.

DR EDWARD SAVAGE (Weston, FL): I have two questions for you. One is, do you have any data on how many of these valve replacements were chordal sparing or reimplantation of chords when they were done? And the second one, you had so much data and it went by quite quickly, there clearly was a difference in the number of patients in the valve replacement groups that had rheumatic disease, and rheumatic disease, as we know, is more than just valvular, it can impact on diastolic function, and I am curious to know if you had a way to evaluate how that may have impacted any of your outcomes?

DR DANESHMAND: Thank you for those questions. To address your first question regarding the utilization of chordal sparing or chordal replacement techniques in the replacement group, we don't have the specific numbers of this. This is data that was collected over the past 20 years, and the earlier patients obviously before the development of those techniques did not receive chordal sparing. The majority of the later patients did. I don't have the exact numbers of how many patients received chordal sparing.

DR SAVAGE: Could you have gotten that information from the operative notes?

DR DANESHMAND: That data, unfortunately, is not clear within our database right now, no.

DR SAVAGE: Unless you go back and look at the operative notes.

DR DANESHMAND: Well, the operative notes at Duke are actually generated straight from the database. Postoperatively you enter the data in the database and an automated operative report is created from that database.

Regarding the rheumatic patients, we looked at several echocardiographic variables within our Cox model. Those included parameters of diastolic dysfunction and ventricular size; none of them were statistically significant in predicting outcomes except for ejection fraction.

DR MARC R. MOON (St. Louis, MO): I just wanted to echo Dr Merrill's comments about the differences between the groups, because there are distinct differences in the patients that get a bioprosthetic versus a mechanical valve. For example, I do not think I have ever put a mechanical valve in an ischemic MR [mitral regurgitation] patient; they all get bioprosthetic valves. As a consequence, they are going to definitely be lower on the survival curve. In addition, the young endocarditis patient who is a drug user, they will get a bioprosthetic valve if they look like they are not [a] good candidate for anticoagulation, and they certainly will not, as a group, survive as long as a group of reliable mechanical recipients.