Original Investigation

Survival and Long-term Outcomes Following Bioprosthetic vs Mechanical Aortic Valve Replacement in Patients Aged 50 to 69 Years

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IMPORTANCE The choice between bioprosthetic and mechanical aortic valve replacement in younger patients is controversial because long-term survival and major morbidity are poorly characterized.

OBJECTIVE To quantify survival and major morbidity in patients aged 50 to 69 years undergoing aortic valve replacement.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort analysis of 4253 patients aged 50 to 69 years who underwent primary isolated aortic valve replacement using bioprosthetic vs mechanical valves in New York State from 1997 through 2004, identified using the Statewide Planning and Research Cooperative System. Median follow-up time was 10.8 years (range, 0 to 16.9 years); the last follow-up date for mortality was November 30, 2013. Propensity matching yielded 1001 patient pairs.

MAIN OUTCOMES AND MEASURES Primary outcome was all-cause mortality; secondary outcomes were stroke, reoperation, and major bleeding.

RESULTS No differences in survival or stroke rates were observed in patients with bioprosthetic compared with mechanical valves. Actuarial 15-year survival was 60.6% (95% CI, 56.3%-64.9%) in the bioprosthesis group compared with 62.1% (95% CI, 58.2%-66.0%) in the mechanical prosthesis group (hazard ratio, 0.97 [95% CI, 0.83-1.14]). The 15-year cumulative incidence of stroke was 7.7% (95% CI, 5.7%-9.7%) in the bioprosthesis group and 8.6% (95% CI, 6.2%-11.0%) in the mechanical prosthesis group (hazard ratio, 1.04 [95% CI, 0.75-1.43). The 15-year cumulative incidence of reoperation was higher in the bioprosthesis group (12.1% [95% CI, 8.8%-15.4%] vs 6.9% [95% CI, 4.2%-9.6%]; hazard ratio, 0.52 [95% CI, 0.36-0.75]). The 15-year cumulative incidence of major bleeding was higher in the mechanical prosthesis group (13.0% [95% CI, 9.9%-16.1%] vs 6.6% [95% CI, 4.8%-8.4%]; hazard ratio, 1.75 [95% CI, 1.27-2.43]). The 30-day mortality rate was 18.7% after stroke, 9.0% after reoperation, and 13.2% after major bleeding.

CONCLUSIONS AND RELEVANCE Among propensity-matched patients aged 50 to 69 years who underwent aortic valve replacement with bioprosthetic compared with mechanical valves, there was no significant difference in 15-year survival or stroke. Patients in the bioprosthetic valve group had a greater likelihood of reoperation but a lower likelihood of major bleeding. These findings suggest that bioprosthetic valves may be a reasonable choice in patients aged 50 to 69 years.

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Aortic valve replacement is indicated for survival benefit, symptom relief, and preservation of left ventricular function in patients with severe aortic valve disease.[1,2] Approximately 50 000 patients undergo aortic valve replacement annually in the United States alone.[3] In older patients, bioprosthetic valves pose a low lifetime risk of reoperation for structural degeneration and avoid many of the major thrombotic and hemorrhagic complications associated with mechanical prostheses: bioprosthetic valves are therefore recommended in patients older than 70 years.[1,2] The optimal prosthesis type for younger patients is less clear.[1,2,4-7] This is primarily because structural valve degeneration of bioprostheses occurs earlier and progresses more rapidly in younger patients, resulting in a higher lifetime risk of reoperation.[7] Prospective studies have been underpowered to detect differences in long-term mortality and major morbidity in this age group,[8-10] and larger retrospective analyses are limited to single-center studies with follow-up dependent on patients returning to the same institution.[11-13] We therefore analyzed a statewide administrative database to quantify differences in long-term survival, stroke, reoperation, and major bleeding episodes after aortic valve replacement according to prosthesis type among patients aged 50 to 69 years.

Methods

Study Design

This was a retrospective cohort analysis comparing long-term outcomes after primary, isolated aortic valve replacement in New York State from January 1, 1997, through December 31, 2004, in patients aged 50 to 69 years, according to whether they received a bioprosthetic or mechanical prosthetic valve. Patients were identified using the *International Classification of Diseases, Ninth Revision, Clinical Modification* procedure code of bioprosthetic (35.21) or mechanical prosthetic (35.22) aortic valve replacement. The cohort was identified using the Statewide Planning and Research Cooperative System (SPARCS), an all-payer, administrative database that prospectively collects patient-level data on every hospital discharge, ambulatory surgery visit, and emergency department visit in New York State. SPARCS allocates each patient a unique identifier linking all such encounters, permitting longitudinal analysis. We also examined trends in prosthesis types implanted between 1997 and 2010.

Exclusion criteria were out-of-state residency, prior replacement of any valve, concomitant valve replacement, concomitant valve repair, coronary artery bypass graft surgery, or thoracic aortic surgery (see eTable 1 in the Supplement for definitions). Baseline comorbidities were identified using diagnosis codes from the index hospitalization and all hospitalizations up to 2 years prior to the index hospitalization (eTable 2 in the Supplement).

The study was approved by the data protection review board of the New York State Department of Health as well as the Program for Protection of Human Subjects at the Icahn School of Medicine at Mount Sinai. The approval included a waiver of informed consent.

Study End Points

The primary outcome measure was all-cause mortality. Secondary outcomes were stroke, reoperation, and major bleeding events. Deaths were identified using the Social Security Death Master File (current as of November 30, 2013) and by searching all hospital admissions and ambulatory or emergency department visits for patient deaths. Stroke was defined as cerebrovascular accident occurring during the index hospital admission as well as any subsequent hospital admission for which the primary diagnosis was recorded as a hemorrhagic or ischemic cerebrovascular event; transient ischemic attacks were excluded. Reoperation was defined as any repeat aortic valve replacement; subsequent cardiac surgical operations not involving the aortic valve were not included for the purposes of this analysis. Major bleeding events were defined as any subsequent hospitalization for which the primary diagnosis was intracerebral hemorrhage, hemopericardium, cardiac tamponade, gastrointestinal hemorrhage (including bleeding peptic ulcer), hematuria, hemarthrosis, or hemoptysis. The *International Classification of Diseases, Ninth Revision, Clinical Modification* codes used are listed in eTable 3 in the Supplement. Patients for whom no stroke, reoperation, or major bleeding event and no date of death were found were censored on December 31, 2012 (last date of follow-up by SPARCS).

Statistical Analysis

Continuous variables are reported as mean (SD). Categorical variables are expressed as proportions. Baseline differences between patients receiving bioprosthetic or mechanical prosthetic valves were detected using *t* test for normally distributed continuous variables and Pearson χ^2 test for categorical variables as well as standardized differences for both continuous and categorical variables.

To adjust for differences in baseline characteristics, propensity score matching was performed.[14] To account for variation in practice between surgeons, a hierarchical logistic regression model was fit with bioprosthesis implantation as the outcome and with patients specified as being clustered within surgeons. For each patient, the proportion of aortic valve replacement operations performed by their surgeon using a bioprosthesis in the past year was entered as a covariate into the propensity score model. All baseline characteristics (which included year of surgery, age, sex, race/ethnicity (self-reported; assessed as a confounding variable), admission urgency, active endocarditis, coagulation or platelet disorders, hypertension, diabetes, coronary artery disease, peripheral vascular disease, cerebrovascular disease, congestive heart failure, atrial fibrillation, chronic obstructive pulmonary disease, chronic kidney disease, liver disease, and cancer) were also included as covariates in the propensity score model. The area under the receiver operating curve for the model was 0.83. Patients were then matched on a 1:1 basis using a caliper width of 0.10 of the logit of the propensity score. After propensity score matching, differences in baseline characteristics and the incidence of 30-day complications between patients in each group were detected using paired *t* test for normally distributed continuous variables and McNemar test for categorical

variables (see eTable 4 in the Supplement for definitions of 30-day complications) as well as standardized differences.

Survival curves for the primary end point of survival were constructed for the entire study population as well as the propensity-matched groups. Survival estimates at 15 years after surgery were derived from the life table. The difference in survival was assessed using a marginal Cox model with a robust sandwich variance estimator. Competing risk analysis of the secondary end points of stroke, reoperation, and major bleeding was performed by constructing cumulative incidence curves for the propensity-matched groups and comparing them using Gray test. Additionally, for each end point, Cox proportional hazards models with only prosthesis type entered as a covariate were fit to calculate hazard ratios. The proportional hazards assumption was valid in all models.

The baseline characteristics of patients in the bioprosthesis group who were not matched are listed in eTable 5 in the Supplement. To assess the validity of our results, analyses of all end points were repeated using all patients by fitting Cox models with prosthesis type, age, and sex entered as covariates (eFigure 1 in the Supplement) and then again with prosthesis type, propensity score, and all baseline characteristics entered as covariates (eTable 6 in the Supplement). There were no significant differences between the results obtained using these alternative analyses.

All tests were 2-tailed; an α level of .05 was considered statistically significant. All statistical analyses were performed using SAS version 9.3 (SAS Institute Inc).

Results

Study Population

A total of 10 981 patients aged 50 to 69 years were identified. Patients with 1 or more of the following characteristics were excluded: out-of-state residents (893 [8.1%]), prior replacement of any valve (587 [5.3%]), and concomitant valve replacement (1353 [12.3%]), valve repair (263 [2.4%]), coronary artery bypass graft surgery (4077 [37.1%]), or thoracic aortic surgery (1009 [9.2%]). After applying exclusion criteria, 4253 patients remained. Of these patients, 1466 (34.5%) received bioprosthetic valves and 2787 (65.5%) received mechanical prosthetic valves. Overall median follow-up time was 10.8 years (range, 0-16.9 years). Median follow-up times were 10.6 years (range, 0-16.9 years) in the bioprosthesis group and 10.9 years (range, 0-16.9 years) in the mechanical prosthesis group. Propensity score matching produced 1001 patient pairs.

Patient Characteristics

The proportion of patients who underwent bioprosthetic aortic valve replacement increased from 15% in 1997 to 74% in 2012 ($P < .001$ [eFigure 2 in the Supplement]). In the study cohort of patients who underwent aortic valve replacement between 1997 and 2004, those who received a bioprosthetic valve were older (mean, 62.3 [SD, 5.4] vs 60.2 [SD, 5.6] years; $P < .001$) and more likely to have a history of diabetes (21% vs 18%, $P = .01$), cerebrovascular disease (7% vs 5%, $P = .05$), coagulation or platelet disorders (4% vs 3%, $P = .01$), liver disease (4% vs 2%, $P = .01$), and cancer (4% vs 3%, $P = .03$) (**Table 1**). After propensity score matching, age and all baseline comorbidities were balanced between the 2 groups (**Table 2**). There was no significant difference in 30-day mortality (3% in the bioprosthesis group vs 3% in the mechanical prosthesis group, $P = .49$) or other short-term outcomes (**Table 3**).

Mortality

No difference in long-term survival was observed ($P = .74$). **Figure 1** displays the survival curves for overall survival in the propensity-matched cohort (survival curves for the unmatched patients are shown in eFigure 2 in the Supplement). There were 322 deaths in the bioprosthesis group and 318 deaths in the mechanical prosthesis group during a maximum of 16.9 years of follow-up. Actuarial 15-year survival was 60.6% (95% CI, 56.3%-64.9%) in the bioprosthesis group compared with 62.1% (95% CI, 58.2%-66.0%) in the mechanical prosthesis group. The hazard ratio for death for mechanical prostheses vs bioprostheses was 0.97 (95% CI, 0.83-1.14).

Stroke

No difference in stroke rates was observed ($P = .84$) (**Figure 2**). A total of 68 strokes in the bioprosthesis group and 71 strokes in the mechanical prosthesis group occurred during a maximum follow-up of 16.9 years. The cumulative incidence of stroke at 15 years was 7.7% (95% CI, 5.7%-9.7%) for patients who received a bioprosthetic valve, compared with 8.6% (95% CI, 6.2%-11.0%) for those who received a mechanical prosthetic valve. The hazard ratio for stroke for mechanical prostheses vs bioprostheses was 1.04 (95% CI, 0.75-1.43). The 30-day mortality after stroke was 18.7%.

Reoperation

Bioprostheses were associated with a significantly higher rate of aortic valve reoperation than mechanical prostheses ($P = .001$) (Figure 2). During a maximum follow-up time of 16.9 years, 79 patients in the bioprosthesis group and 43 patients in the mechanical prosthesis group underwent reoperation. The cumulative incidence of aortic valve reoperation at 15 years was 12.1% (95% CI, 8.8%-15.4%) in the bioprosthesis group compared with 6.9% (95% CI, 4.2%-9.6%) in the mechanical prosthesis group. The hazard ratio for aortic valve reoperation for mechanical prostheses vs bioprostheses was 0.52 (95% CI, 0.36-0.75). The 30-day mortality after aortic valve reoperation was 9.0%.

Major Bleeding

Mechanical prostheses were associated with a significantly higher rate of major bleeding compared with bioprostheses ($P = .001$) (Figure 2). There were 58 major bleeding events in the bioprosthesis group vs 101 in the mechanical prosthesis group during a maximum of 16.9 years of follow-up. The cumulative incidence of major bleeding events at 15 years was 6.6% (95% CI, 4.8%-8.4%) for the bioprosthesis group compared with 13.0% (95% CI, 9.9%-16.1%) for the mechanical prosthesis group. The hazard ratio for major bleeding in the mechanical prosthesis group was 1.75 (95% CI, 1.27-2.43). The 30-day mortality after a major bleeding event was 13.2%.

Table 1. Patient Baseline Characteristics in the Overall Cohort, According to Type of Prosthesis

Baseline Characteristics	No. (%)			Standardized Difference, %	*P* Value
	All Patients (N = 4253)	Prosthesis Type			
		Bioprosthetic (n = 1466)	Mechanical (n = 2787)		
Demographics					
Age, mean (SD), y	60.9 (5.6)	62.3 (5.4)	60.2 (5.6)	38.2	<.001
Men	2677 (63)	908 (62)	1769 (63)	3.2	.32
Race/ethnicity					
White (non-Hispanic)	2784 (65)	984 (67)	1800 (65)	7.7	.001
African American (non-Hispanic)	300 (7)	101 (7)	199 (7)	1.0	
Hispanic	236 (6)	102 (7)	134 (5)	9.1	
Other/unknown	933 (22)	279 (19)	654 (23)	10.8	
Emergent/urgent admission	1525 (36)	540 (37)	985 (35)	3.1	.33
Comorbidities					
Endocarditis	31 (1)	11 (1)	20 (1)	0.4	.91
Coagulation/platelet disorders	132 (3)	59 (4)	73 (3)	7.8	.01
Hypertension	2410 (57)	859 (59)	1551 (56)	5.9	.07
Diabetes mellitus	802 (19)	313 (21)	489 (18)	9.6	.003
Coronary artery disease					
Without prior revascularization	1095 (26)	394 (27)	701 (25)	3.9	.48
Prior percutaneous coronary intervention	71 (2)	28 (2)	43 (2)	2.8	
Prior CABG surgery	177 (4)	61 (4)	116 (4)	0.0	
Peripheral vascular disease	144 (3)	57 (4)	87 (3)	4.2	.19
Cerebrovascular disease	243 (6)	98 (7)	145 (5)	6.3	.05
Congestive heart failure	1334 (31)	458 (31)	876 (31)	0.4	.90
Atrial fibrillation	747 (18)	245 (17)	502 (18)	3.4	.29
Chronic obstructive pulmonary disease	737 (17)	271 (18)	466 (17)	4.6	.15
Chronic kidney disease	204 (5)	62 (4)	142 (5)	4.1	.15
Liver disease	126 (3)	58 (4)	68 (2)	8.6	.01
Cancer	141 (3)	61 (4)	80 (3)	7.0	.03
Year of surgery					
1997	516 (12)	75 (5)	441 (16)	35.3	<.001
1998	486 (11)	99 (7)	387 (14)	22.7	
1999	491 (12)	134 (9)	357 (13)	12.8	
2000	583 (14)	164 (11)	419 (15)	11.9	
2001	508 (10)	180 (12)	328 (12)	0.0	
2002	527 (12)	242 (17)	285 (10)	20.4	
2003	530 (12)	248 (17)	282 (10)	20.4	
2004	612 (14)	324 (22)	288 (10)	32.3	

Abbreviation: CABG, coronary artery bypass graft.

Discussion

Current consensus guidelines state that choice of either a bioprosthetic or mechanical prosthetic aortic valve is reasonable in patients aged 60 to 70 years, and that a mechanical valve replacement is reasonable in patients younger than 60 years without contraindications to coumadin.[1,2] These class IIa recommendations are based on the results of 3 randomized clinical trials,[8-10] 2 of which enrolled patients nearly 4 decades ago and evaluated prostheses since superseded by more durable and less thrombogenic models.[8,9] Consequently, the findings of these studies may no longer reflect outcomes in current clinical practice. Our analysis of a large, contemporary patient cohort supports the view that either prosthesis type is a reasonable choice in patients aged 60 to 69 years and suggests that this recommendation could reasonably be extended to include patients aged 50 to 59 years.

There are conflicting data from recent single-center retrospective studies comparing long-term outcomes in this age group. Brown et al[11] reported a 10-year survival benefit in 250 matched pairs aged 50 to 70 years favoring mechanical prostheses. This may reflect the authors' inability to control for a systematic treatment bias arising from the tendency to

implant mechanical prosthetic valves in healthier patients with better life expectancy: even after propensity matching, the patients who received bioprosthetic valves in their study were older, more symptomatic, more likely to have major comorbidities such as lung disease and peripheral vascular disease, and had a significantly higher 30-day mortality.

Table 2. Baseline Characteristics After Propensity Score Matching

Baseline Characteristics	Prosthesis Type, No. (%)		Standardized Difference, %	*P* Value
	Bioprosthetic (n = 1001)	Mechanical (n = 1001)		
Demographics				
Age, mean (SD), y	61.5 (5.7)	61.5 (5.3)	0.0	.94
Men	634 (63)	645 (64)	2.3	.60
Race/ethnicity				
White (non-Hispanic)	673 (67)	680 (68)	1.5	.75
African American (non-Hispanic)	65 (7)	63 (6)	0.8	
Hispanic	61 (6)	52 (5)	3.9	
Other/unknown	202 (20)	206 (21)	1.0	
Emergent/urgent admission	351 (35)	364 (36)	2.7	.54
Comorbidities				
Endocarditis	7 (1)	9 (1)	2.2	.62
Coagulation/platelet disorders	36 (4)	41 (4)	2.6	.56
Hypertension	569 (57)	566 (57)	0.6	.89
Diabetes mellitus	197 (20)	194 (19)	0.8	.87
Coronary artery disease				
Without prior revascularization	272 (27)	269 (27)	0.7	.65
Prior percutaneous coronary intervention	19 (2)	21 (2)	1.4	
Prior CABG surgery	41 (4)	43 (4)	1.0	
Peripheral vascular disease	35 (4)	34 (3)	0.5	.90
Cerebrovascular disease	59 (6)	57 (6)	0.9	.85
Congestive heart failure	313 (31)	320 (32)	1.5	.73
Atrial fibrillation	182 (18)	187 (19)	1.3	.77
Chronic obstructive pulmonary disease	167 (17)	184 (18)	4.5	.32
Chronic kidney disease	47 (5)	49 (5)	0.9	.83
Liver disease	32 (3)	35 (4)	1.7	.71
Cancer	40 (4)	40 (4)	0.0	.99
Year of surgery				
1997	70 (7)	76 (8)	3.8	.41
1998	92 (9)	79 (8)	3.6	
1999	117 (12)	109 (11)	3.1	
2000	126 (13)	138 (14)	2.9	
2001	138 (14)	152 (15)	2.8	
2002	162 (16)	134 (13)	8.5	
2003	132 (13)	154 (15)	5.8	
2004	164 (16)	159 (16)	0.0	

Abbreviation: CABG, coronary artery bypass graft.

Table 3. Outcomes Within 30 Days of Aortic Valve Replacement in Propensity Score–Matched Patients

Outcome	Prosthesis Type, No. (%)		*P* Value
	Bioprosthetic (n = 1001)	Mechanical (n = 1001)	
Mortality	25 (3)	30 (3)	.49
Stroke	18 (2)	12 (1)	.26
Atrial fibrillation	129 (12)	135 (13)	.69
Acute kidney injury	18 (2)	16 (2)	.73
Respiratory failure	101 (10)	86 (9)	.26
Readmission	173 (17)	172 (17)	.95

McClure et al[13] compared groups that were more closely matched (30-day mortality was the same) and in their single-center analysis of 310 propensity matched pairs younger than 65 years saw no significant survival difference up to 18 years following surgery.

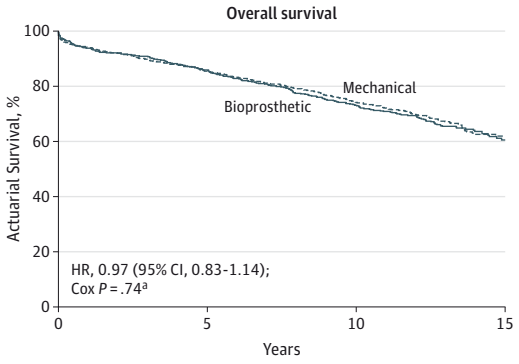
The absence of a significant survival benefit associated with one prosthesis type over another focuses decision making on lifestyle considerations, including the burden of anticoagulation medication and monitoring, and the relative risks of major morbidity—primarily stroke, reoperation, and major bleeding events. In our study cohort, long-term stroke risk did not appear to be affected by choice of prosthesis, which is consistent with the findings of previous studies.[11,13] We observed significant differences in reoperation and major bleeding rates according to prosthesis type. By 15 years after surgery, 12.1% of patients with bioprostheses had undergone aortic valve reoperation, compared with 6.9% with mechanical prostheses. The observed 30-day mortality after reoperation (9.0%) could perhaps be reduced. High-volume valve centers report mortality of 2% to 5% for reoperative aortic valve replacement,[15-17] and there may consequently be a case for targeted referrals of selected patients requiring reoperation to reference centers. In a small number of high-risk patients with an aortic bioprosthesis requiring reoperation, transcatheter valve-in-valve implantation has been used[18]: this technique may eventually represent a reasonable alternative to open reoperation.

Mechanical prostheses were associated with a lower reoperation rate, but this was at the expense of more major bleeding events, experienced by 6.6% of patients with bioprostheses compared with 13.0% of patients with mechanical prostheses by 15 years after surgery. The 30-day mortality after a major bleeding event in this cohort was 13.2%. Two randomized trials comparing low-intensity, self-monitored anticoagulation regimens with standard anticoagulation in patients with mechanical valves have not shown a significant reduction in major bleeding or thromboembolic events.[19,20] These outcomes, together with the well-recognized patient dissatisfaction with the prospect of a lifetime of anticoagulation,[21] may partially explain the increasing use of bioprostheses that we observed during the last decade, which follows national trends previously reported in an analysis of the Society of Thoracic Surgeons cardiac surgery database.[22]

Limitations

SPARCS is a prospectively collected statewide, mandatory database containing detailed demographic, diagnostic, and procedural information. Despite the use of statistical methods to reduce imbalance, several potential confounding variables could not be included in the model, including frailty, etiology of aortic valve dysfunction, severity of other valve lesions, extent of coronary artery disease, and ventricular dysfunction. This potentially introduces a bias in favor of mechanical valves because surgeons tend to implant biopros-

Figure 1. Overall Survival Among Propensity-Matched Patients Aged 50 to 69 Years After Bioprosthetic vs Mechanical Aortic Valve Replacement



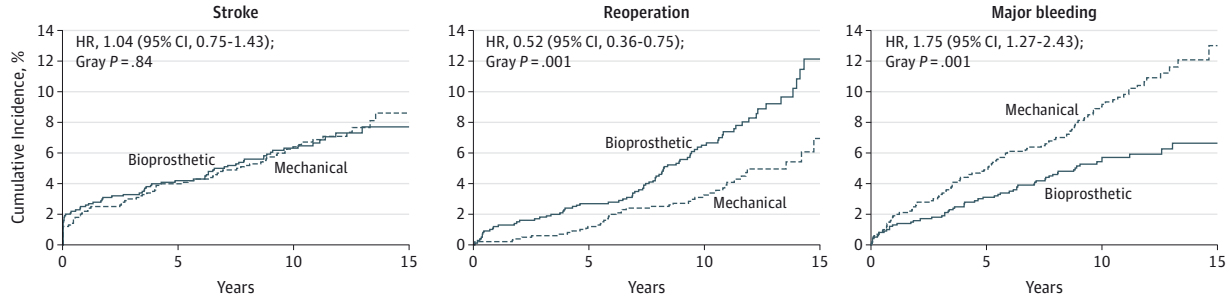
No. at risk

Bioprosthetic	1001	860	589	91
Mechanical	1001	856	611	89

There were 322 all-cause deaths in the bioprosthesis group vs 318 in the mechanical prosthesis group.

[a] *P* value calculated using a marginal Cox model with a robust sandwich variance estimator.

Figure 2. Cumulative Incidence of Major Morbidity (Stroke, Reoperation, Major Bleeding) Among Propensity-Matched Patients Aged 50 to 69 Years After Bioprosthetic vs Mechanical Aortic Valve Replacement



No. at risk

Bioprosthetic	1001	836	466	43	1001	845	456	37	1001	838	463	39
Mechanical	1001	827	480	48	1001	847	487	49	1001	819	468	46

There were 68 strokes in the bioprosthesis group vs 71 in the mechanical prosthesis group; 79 reoperations in the bioprosthesis group vs 43 in the mechanical prosthesis group; and 58 major bleeding events in the bioprosthesis group vs 101 in the mechanical prosthesis group.

thetic valves in patients that they consider to have reduced life expectancy based on these and other factors. If this bias were significant, one would expect a survival difference between the 2 groups in the overall study population after adjusting for age and sex and no other comorbidities; however, this was not the case (eFigure 2 in the Supplement). A second potential bias in favor of mechanical prostheses is the greater tendency for deaths to be missing in the Social Security Death Master File for younger patients, who were more likely to receive mechanical prostheses. Last, we were unable to determine when patients were hospitalized out of state, potentially causing us to underestimate the rate of the secondary end points: we believe that movement out of state would affect both groups equally and note that the rates of stroke, reoperation, and major bleeding we observed were similar to those reported in other series.[7,23]

Conclusions

Among propensity-matched patients aged 50 to 69 years who underwent aortic valve replacement with bioprosthetic compared with mechanical prosthetic valves, there was no significant difference in 15-year survival or stroke. Patients in the bioprosthetic valve group had a greater likelihood of reoperation but a lower likelihood of major bleeding. These findings suggest that bioprosthetic valves may be a reasonable choice in patients aged 50 to 69 years.

ARTICLE INFORMATION

Author Contributions: Mr Chiang had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Chiang, Chikwe, Moskowitz, Adams, Egorova.
Acquisition, analysis, or interpretation of data: Chiang, Chikwe, Itagaki, Adams, Egorova.
Drafting of the manuscript: Chiang, Chikwe.
Critical revision of the manuscript for important intellectual content: Chiang, Chikwe, Moskowitz, Itagaki, Adams, Egorova.
Statistical analysis: Chiang, Itagaki, Egorova.
Administrative, technical, or material support: Chikwe.
Study supervision: Chikwe, Moskowitz, Adams, Egorova.

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REFERENCES

1. Nishimura RA, Otto CM, Bonow RO, et al; ACC/AHA Task Force Members. 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014; 129(23):e521-e643.

2. Vahanian A, Alfieri O, Andreotti F, et al; Joint Task Force on the Management of Valvular Heart Disease of the European Society of Cardiology (ESC); European Association for Cardio-Thoracic Surgery (EACTS). Guidelines on the management of valvular heart disease (version 2012). *Eur Heart J*. 2012;33(19):2451-2496.

3. Buie VC, Owings MF, DeFrances CJ, Golosinskiy A. National Hospital Discharge Survey: 2006 Annual Summary. *Vital Health Stat 13*. 2010;13(168): 1-70. http://www.cdc.gov/nchs/data/series/sr_13/sr13_168.pdf. Accessed September 5, 2014.

4. Chikwe J, Filsoufi F, Carpentier AF. Prosthetic valve selection for middle-aged patients with aortic stenosis. *Nat Rev Cardiol*. 2010;7(12):711-719.

5. Kaneko T, Cohn LH, Aranki SF. Tissue valve is the preferred option for patients aged 60 and older. *Circulation*. 2013;128(12):1365-1371.

6. Suri RM, Schaff HV. Selection of aortic valve prostheses: contemporary reappraisal of mechanical versus biologic valve substitutes. *Circulation*. 2013;128(12):1372-1380.

7. Grunkemeier GL, Li HH, Naftel DC, Starr A, Rahimtoola SH. Long-term performance of heart valve prostheses. *Curr Probl Cardiol*. 2000;25(2): 73-154.

8. Hammermeister K, Sethi GK, Henderson WG, Grover FL, Oprian C, Rahimtoola SH. Outcomes 15 years after valve replacement with a mechanical versus a bioprosthetic valve: final report of the Veterans Affairs randomized trial. *J Am Coll Cardiol*. 2000;36(4):1152-1158.

9. Oxenham H, Bloomfield P, Wheatley DJ, et al. Twenty year comparison of a Bjork-Shiley mechanical heart valve with porcine bioprostheses. *Heart*. 2003;89(7):715-721.

10. Stassano P, Di Tommaso L, Monaco M, et al. Aortic valve replacement: a prospective randomized evaluation of mechanical versus biological valves in patients ages 55 to 70 years. *J Am Coll Cardiol*. 2009;54(20):1862-1868.

11. Brown ML, Schaff HV, Lahr BD, et al. Aortic valve replacement in patients aged 50 to 70 years: improved outcome with mechanical versus biologic prostheses. *J Thorac Cardiovasc Surg*. 2008;135(4): 878-884.

12. Ruel M, Masters RG, Rubens FD, et al. Late incidence and determinants of stroke after aortic and mitral valve replacement. *Ann Thorac Surg*. 2004;78(1):77-84.

13. McClure RS, McGurk S, Cevasco M, et al. Late outcomes comparison of nonelderly patients with stented bioprosthetic and mechanical valves in the aortic position: a propensity-matched analysis [published online January 15, 2014]. *J Thorac Cardiovasc Surg*. doi:10.1016/jtcvs.2013.12.042.

14. Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika*. 1983;70(1):41-55.

15. Davierwala PM, Borger MA, David TE, Rao V, Maganti M, Yau TM. Reoperation is not an independent predictor of mortality during aortic valve surgery. *J Thorac Cardiovasc Surg*. 2006;131 (2):329-335.

16. Potter DD, Sundt TM III, Zehr KJ, et al. Operative risk of reoperative aortic valve replacement. *J Thorac Cardiovasc Surg*. 2005;129 (1):94-103.

17. Breglio A, Anyanwu A, Itagaki S, Polanco A, Adams DH, Chikwe J. Does prior coronary bypass surgery present a unique risk for reoperative valve surgery? *Ann Thorac Surg*. 2013;95(5):1603-1608.

18. Dvir D, Webb J, Brecker S, et al. Transcatheter aortic valve replacement for degenerative bioprosthetic surgical valves: results from the global valve-in-valve registry. *Circulation*. 2012;126 (19):2335-2344.

19. Koertke H, Zittermann A, Wagner O, et al. Efficacy and safety of very low-dose self-management of oral anticoagulation in patients with mechanical heart valve replacement. *Ann Thorac Surg*. 2010;90(5):1487-1493.

20. Hering D, Piper C, Bergemann R, et al. Thromboembolic and bleeding complications following St. Jude Medical valve replacement: results of the German Experience With Low-Intensity Anticoagulation study. *Chest*. 2005; 127(1):53-59.

21. Ruel M, Kulik A, Lam BK, et al. Long-term outcomes of valve replacement with modern prostheses in young adults. *Eur J Cardiothorac Surg*. 2005;27(3):425-433.

22. Brown JM, O'Brien SM, Wu C, Sikora JA, Griffith BP, Gammie JS. Isolated aortic valve replacement in North America comprising 108,687 patients in 10 years: changes in risks, valve types, and outcomes in the Society of Thoracic Surgeons National Database. *J Thorac Cardiovasc Surg*. 2009;137(1): 82-90.

23. Kulik A, Bédard P, Lam BK, et al. Mechanical versus bioprosthetic valve replacement in middle-aged patients. *Eur J Cardiothorac Surg*. 2006;30(3):485-491.