

# The Valve of Choice in Elderly Patients and its Influence on Quality of Life: A Long-Term Comparative Study

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## Disclosure

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**Background and aim of the study:** Mechanical heart valves are preferred for younger patients in order to avoid valve structural deterioration, but bioprosthetic valves are favored for older patients to avoid long-term anticoagulation. With increasing patient longevity, controversy persists regarding the valve of choice in the 65- to 75-year-old population. With improving patient survival, long-term quality of life (QOL) is a critical element in helping to resolve this controversy.

**Methods:** A retrospective analysis was conducted of 1,104 consecutive patients, aged 65-75 years, who underwent valve replacement between July 1976 and December 1999. Valves implanted were either a Carpentier-Edwards (CE) porcine bioprosthesis (596 patients) or a St. Jude Medical (SJM) mechanical valve (508 patients), with and without concomitant coronary artery bypass grafting. QOL was assessed using the Short Form (SF-36) Health Survey for both groups at the time of follow up, which was 98.2% complete. Comparable patient groups were analyzed within quintiles by propensity score analysis.

Mechanical heart valves are preferred for younger patients in order to avoid valve structural deterioration and a subsequent need for reoperation. In contrast, bioprosthetic valves are favored for older patients in order to avoid long-term anticoagulation and its attendant complications, particularly hemorrhage. For these reasons, the current American Heart Association/American College of Cardiology (AHA/ACC) valve guidelines recommend that a bioprosthesis be used for patients without risk factors for

**Results:** Operative mortality was 9.4% (n = 56) for CE patients, and 5.3% (n = 27) for SJM patients (p = 0.014). Propensity score analysis revealed no significant difference in operative mortality between groups in any of the five quintiles. Actuarial survival for hospital survivors favored SJM patients (p = 0.005). However, when compared within quintiles, there was no significant difference between groups. QOL summary scores were significantly higher for physical health (p = 0.007) for SJM patients, but similar between valve groups for mental health. Comparison within quintiles revealed no significant difference between the groups in either area.

**Conclusion:** When comparing the outcomes of mechanical versus bioprosthetic valve replacement, considerable care must be exercised to ensure the clinically relevant similarity of groups. When evaluating comparable patient groups, there was no advantage in either survival or QOL for patients aged 65-75 years receiving a CE or SJM valve.

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thromboembolism who are aged over 65 years and undergoing aortic valve replacement (AVR), or aged over 70 years and undergoing mitral valve replacement (MVR) (1). However, practice patterns vary widely, with many centers shifting the threshold toward 70-75 years (2,3). This controversy has recently been raised as a quality issue (4), suggesting - without clinical validation - that the 'overuse' of mechanical valves in patients aged over 65 years "...represents problems in decision making" (5).

Nonetheless, the clinical reality remains that as the population ages (6) the risk of reoperation at an elderly age increases. Meta-analyses have shown the life expectancy of a 65-year-old male undergoing bioprosthetic AVR to be 11.3 years, and the risk of reoperation within that time to be 28% (7). As cardiac surgeons operate on increasingly elderly patients, even this assessment may underestimate the true risk.

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Interestingly enough, between 26% and 40% of patients receiving a bioprosthesis are found to be receiving anticoagulation at subsequent follow up examinations (8,9). Moreover, both advanced age and reoperation are powerful predictors of operative mortality (10-13). Therefore, the risk of implanting a bioprosthesis may be higher and the benefit lower than generally assumed by the current recommendations.

Given the considerable uncertainty surrounding these current recommendations, which is reflected by clinical behavior, it becomes increasingly important to evaluate the impact of prosthesis choice on both short- and long-term outcomes in patients aged 65-75 years.

## Definitions

### *Preoperative variables*

Hypertension was defined as a patient having high blood pressure ( $\geq 140$  mmHg systolic or  $\geq 90$  mmHg diastolic) on two occasions, or currently receiving anti-hypertensive medication. Hypercholesterolemia was defined as a serum cholesterol level  $> 200$  mg/dl on admission to hospital. Renal insufficiency was defined as a patient having a documented history of renal failure, with a serum creatinine level  $\geq 2.0$  mg/dl, or undergoing dialysis.

Elective surgery was defined as an operation, which could be deferred without increased risk of compromised cardiac outcome. Urgent surgery was defined as being required within 48 h in an effort to prevent further clinical deterioration. Emergent surgery was defined as those instances when the patient had intractable angina or heart failure that did not respond to aggressive clinical measures or had impending infarction, or when decompensation occurred in the cardiac catheterization laboratory and measures such as defibrillation, extended cardiac massage, balloon counterpulsation, or inotropic support were required.

### *Postoperative variables*

Respiratory insufficiency was defined as a patient requiring ventilatory support for more than 48 h or tracheostomy (or both). Cerebrovascular accident (CVA) was defined as a neurological deficit that remained unresolved and presented for more than 24 h. Perioperative myocardial infarction (MI) was defined as a new onset of Q waves with or without elevation of myocardial enzymes, or a substantial elevation of myocardial enzymes alone. Low cardiac output syndrome was defined as clinical evidence of hypotension, oliguria, and peripheral vascular constriction with normal or supranormal left ventricular filling pressure or a measured cardiac index  $< 2$  l/min/m<sup>2</sup>, necessitating the administration of catecholamines or use of the intra-aortic balloon pump (IABP), or both.

Hospital mortality was defined as death occurring

during the operation or the hospitalization in which the procedure was performed, or death occurring after discharge from the hospital but within 30 days of the surgical procedure, unless the cause was clearly unrelated to the operation.

## Clinical material and methods

### **Patient population**

Between July 1976 and December 1999, a total of 1,104 patients aged 65-75 years underwent valve replacement with and without concomitant coronary artery bypass grafting (CABG) with at least one Carpentier-Edwards (CE;  $n = 596$ ) porcine bioprosthesis (Edwards Lifesciences, Irvine, CA, USA) or one St. Jude Medical (SJM;  $n = 508$ ) mechanical valve (St. Jude Medical®, Saint Paul, MN, USA). These two groups of patients represent the clinical material for this report. The patient clinical characteristics for the two groups are listed in Table I.

The groups were fairly comparable, with several notable differences. CE patients were older, more likely to be male, and to have renal insufficiency and three-vessel coronary artery disease (CAD); in contrast, SJM patients were more likely to be smokers, have a history of congestive heart failure (CHF), unstable angina and previous valve surgery. The duration of cardiopulmonary bypass (CPB) was significantly ( $p = 0.001$ ) longer for CE patients, but the aortic cross-clamp time was comparable for the two groups.

In order to better understand factors influencing the surgeon's choice of valve type, a logistic regression was used to calculate propensity scores. This analysis corroborates the above observations. Those factors which significantly influenced valve choice included: age ( $p = 0.001$ ), renal insufficiency ( $p = 0.020$ ), gender ( $p = 0.001$ ), surgical history ( $p = 0.010$ ), date of surgery ( $p = 0.006$ ), perfusion time ( $p = 0.001$ ), and unstable angina ( $p = 0.028$ ).

### **Operative technique**

Details of the operative technique applied in the current series, including CABG, have been discussed previously (14). All operations were performed with the assistance of CPB. Since 1989, combined antegrade and retrograde methods of cardioplegia have been used to enhance myocardial protection. Anticoagulation was initiated with warfarin on the first or second postoperative day depending on the patient's condition. Mechanical valve patients remained in hospital until such time as an acceptable therapeutic level of anticoagulation was achieved. Porcine bioprosthesis patients were anticoagulated for six weeks post-discharge from the hospital.

**Operative data**

A total of 636 valves was implanted in CE patients: these included 371 valves (58.3%) in the aortic position, 260 (40.9%) in the mitral position, four (0.6%) in the tricuspid position, and one valve (0.2%) in the pulmonic position. Among CE patients, 40 (6.7%) underwent multiple valve replacements. There were 205 valves (32.2%) with pure stenosis, 290 (45.6%) with pure insufficiency, and 141 (22.8%) with mixed dysfunction (stenosis and insufficiency). Of the CE patients, 250 (49.9%) received a total of 597 coronary artery grafts (mean 2.39 per patient; range: one to five grafts).

A total of 561 valves was implanted in SJM patients: these included 332 valves (59.2%) in the aortic position, 228 (40.6%) in the mitral position, and one valve (0.2%) in the tricuspid position. Among SJM patients, 53 (10.4%) underwent multiple valve replacements. There

were 210 valves (37.4%) with pure stenosis, 258 (46.0%) with pure insufficiency, and 93 (16.6%) with mixed dysfunction. Of the SJM patients, 182 (35.8%) received a total of 399 coronary artery grafts (mean 2.19 per patient; range: one to five grafts). The distribution of procedures by patient group is presented in Table II.

The mean CPB time was 106.8 ± 51.4 min (range: 36 to 411 min) in CE patients, and 93.6 ± 38.4 min (range: 37 to 384 min) in SJM patients (p = 0.001). The mean aortic cross-clamp time was 70.4 ± 30.5 min (range: 18 to 229 min) in CE patients and 68.3 ± 31.1 min (range: 13 to 366 min) in SJM patients (p = 0.259).

**Quality of life (QOL) measurement**

QOL assessment was conducted with the Short Form-36 (SF-36) developed by Ware (15) and associates. The SF-36 is a standardized instrument com-

*Table I: Comparison of preoperative clinical variables by patient group.*

Variable	CE valve	SJM valve	p-value
No. of patients	596	508	-
<i>Preoperative risk factor</i>			
Mean age (years)*	71.3 ± 3.0	69.3 ± 2.9	0.001
Male gender	341 (57.2)	259 (51.0)	0.038
Family history of CAD	137 (23.0)	108 (21.3)	0.419
Hypertension	273 (45.8)	234 (46.1)	0.932
Hyperlipidemia	107 (18.0)	94 (18.5)	0.813
Smoking history	208 (34.9)	208 (40.9)	0.039
Diabetes mellitus	126 (21.1)	98 (19.3)	0.446
Renal insufficiency	63 (10.6)	36 (7.1)	0.044
Cerebral vascular disease	60 (10.1)	51 (10.0)	0.932
Peripheral vascular disease	58 (9.7)	64 (13.6)	0.130
Prior MI	150 (25.2)	119 (23.4)	0.501
History of CHF	302 (50.7)	294 (57.9)	0.017
Arrhythmia	178 (29.9)	158 (31.1)	0.656
Angina (unstable)	171 (28.7)	208 (40.9)	0.001
Prior PCI	56 (9.4)	47 (9.3)	0.935
NYHA class IV	177 (29.7)	176 (34.7)	0.059
Three-vessel CAD	154 (32.2)	103 (22.2)	0.001
Ejection fraction (%)			
>50	227 (38.1)	233 (45.2)	0.482
30-50	191 (34.5)	181 (36.7)	0.699
<30	86 (15.5)	79 (16.0)	0.659
Urgent/emergent surgery	144 (24.2)	135 (26.6)	0.358
Reoperation	137 (23.0)	147 (28.9)	0.024
Intra-aortic balloon pump	17 (2.9)	16 (3.1)	0.773
<i>Intraoperative risk factor</i>			
Intra-aortic balloon pump	21 (3.5)	16 (3.1)	0.731
CPB time (min)*	106.8 ± 51.4	93.6 ± 38.4	0.001
Aortic cross-clamp time (min)*	70.4 ± 30.5	68.3 ± 31.1	0.259

\*Values are mean ± SD.

Values in parentheses are percentages.

CAD: Coronary artery disease; CHF: Congestive heart failure; CPB: Cardiopulmonary bypass; MI: Myocardial infarction; PCI: Percutaneous coronary intervention.

prised of 36 items, which are designed to measure eight dimensions of overall health. These included: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional, and mental health. For each dimension, item scores are computed, totaled and converted into a scale, which ranges from 0 for worst health to 100 representing best health.

Two summary components - a physical and mental health score - are also computed. A high score in the Physical Health Summary component indicates no physical limitations, disabilities, decrements in well-being and/or high energy levels. A low score indicates substantial limitations in self-care, physical, social and role activities, severe bodily pain, or persistent tiredness. In the Mental Health Summary component, a high score demonstrates recurring positive affect, an absence of psychological distress, and a sense of emotional well-being. A low score is indicative of the presence of psychological disturbance and substantial social and role dysfunction due to emotional instability. The Physical and Mental Health Summary scores are scaled to have a mean of 50 and a standard deviation of 10 in the general population (16). The SF-36 has been used in a number of public health studies, and is generally completed by patients in approximately 10-15 min. It may be administered in person, by telephone, or by mail.

#### Data collection and management

Perioperative data were obtained by prospective

review of the patient's hospital record, catheterization reports, cineangiograms and echocardiography, applying a standardized methodology and definition of terms. A Patient Registration Form was completed for each patient in the study at the time of operation. Data were entered into a Cardiac Surgery Clinical Database and subsequently retrieved for analysis. Follow up information was obtained between March 1999 and April 2001 through comprehensive questionnaires and by telephone interview with surviving patients, family members, or the patient's personal physician, and a Patient Follow Up Form was completed.

The use of these data collection instruments provided for standardized reporting of each patient's clinical status before and after the operation. A 97.2% follow up was obtained in the CE group, with 15 patients being lost to follow up after discharge from the hospital. Follow up in the SJM group was 98.8%, with six patients lost to follow up.

#### Statistical analysis

Data were presented as frequency distributions and simple percentages. Values of continuous variables were expressed as mean  $\pm$  SD. Analysis of discrete variables was accomplished by chi-square, the continuity-adjusted chi-square analysis, or a two-tailed Fisher's exact test. Comparison of means for continuous variables was conducted using an unpaired Student's *t*-test.

Logistic regression was used to calculate the probability or propensity score of each patient chosen to

Table II: Operative procedure: distribution by patient group.

Procedure	CE valve	SJM valve
No. of patients	596	508
AVR	181 (30.4)	167 (32.9)
MVR	106 (17.8)	102 (20.1)
TVR	4 (0.7)	1 (0.2)
PVR	1 (0.2)	0 (0.0)
AVR + MVR	31 (5.2)	46 (9.1)
AVR + CABG	141 (23.7)	103 (20.3)
MVR + CABG	101 (16.9)	68 (13.4)
AVR + MVR + CABG	7 (1.2)	7 (1.4)
AVR + mitral valve repair	8 (1.3)	7 (1.4)
AVR + MVR + tricuspid repair	2 (0.3)	0 (0.0)
AVR + mitral + tricuspid repair	1 (0.2)	0 (0.0)
MVR + tricuspid valve repair	12 (2.0)	3 (0.6)
AVR + mitral valve repair + CABG	0 (0.0)	2 (0.4)
MVR + tricuspid valve repair + CABG	1 (0.2)	2 (0.4)

Values in parentheses are percentages.

AVR: Aortic valve replacement; CABG: Coronary artery bypass grafting; MVR: Mitral valve replacement; PVR: Pulmonic valve replacement; TVR: Tricuspid valve replacement.

receive a SJM mechanical valve, based on 27 preoperative and intraoperative risk factors. The application of propensity score technology reduced the influence of preoperative risk factors to a single score that summarized a collection of covariates. The probability or propensity score for each patient was then ranked in ascending order and divided into five quintiles for further analysis (17). By applying this technique, it was possible to achieve a balanced distribution between the two valve groups within each of the quintiles. It was estimated that >90% of the bias produced by each covariate could be removed by applying this approach (18).

In order to identify predictors of hospital mortality, a multivariable analysis by forward stepwise logistic regression of 24 preoperative and intraoperative variables (see Appendix I) was performed. A Cox proportional hazards regression model was developed to identify preoperative and intraoperative factors associated with late death (>30-day mortality) (19).

Patient survival was expressed by actuarial analysis according to the method of Kaplan and Meier (20) using time zero as the date of operation and late death as the end point (with variability expressed as the SEM). The equality of survival distribution for the two patient groups was computed using the Log Rank algorithm (21). Data collected were subjected to both quantitative and qualitative analysis using the biostatistical capabilities of the Patient Analysis and Tracking System (PATS; Axis Clinical Software, Inc., Portland, OR, USA) and the Number Cruncher Statistical Systems (NCSS; Kaysville, UT, USA).

A significant difference between measurements was defined as a p-value  $\leq 0.05$ .

## Results

### Hospital mortality

Hospital mortality was 9.4% (n = 56) for CE patients, and 5.3% (n = 27) for SJM patients (p = 0.010). The mortality rate for isolated AVR was 5.0% (9/181) in CE patients and 4.8% (8/167) in SJM patients (p = 0.937); rates for isolated MVR were 11.3% (12/106) in CE patients and 3.9% (4/102) in SJM patients (p = 0.045). The mortality rate for double valve replacement (aortic and mitral) was 9.7% (3/31) in CE patients and 8.7% (4/46) in SJM patients (p = 0.883). The mortality rate for all other procedures was 11.7% (32/278) in CE patients and 5.7% (11/193) in SJM patients (p = 0.031).

The mortality rate after elective surgery was 8.1% (34/452) for CE patients and 4.3% (16/373) for SJM patients. This difference approached statistical significance (p = 0.053). The mortality rate after non-elective surgery in CE patients was 17.4% (25/144) and 8.9% (12/135) for SJM patients (p = 0.037). The mortality

Table III: Comparison of hospital mortality by quintile by patient groups.

Quintile	CE valve	SJM valve	p-value
1	27/178 (15.2)	3/31 (9.7)	0.421
2	8/140 (5.7)	4/69 (5.8)	0.981
3	7/100 (7.0)	2/108 (1.9)	0.091
4	5/87 (5.7)	6/121 (5.0)	0.802
5	4/44 (9.1)	10/164 (6.1)	0.501

Values in parentheses are percentages.

rate for first operation was 7.8% (36/459) for CE patients and 3.6% (13/361) for SJM patients (p = 0.011). The mortality rate for reoperation was 14.6% (20/137) in CE patients and 9.5% (14/147) in SJM patients (p = 0.188).

The information in Table III provides a comparison of the hospital mortality rates for the two patient cohorts after grouping of the total study population into five quintiles using propensity score analysis. The distribution of cases into quintiles was based on the calculated propensity of receiving a SJM mechanical valve. Patients who received the SJM valve only were then compared with those who had a CE porcine bioprosthesis within each quintile. The hospital mortality rate was higher in CE than SJM patients in four of the five quintiles. However, these differences did not achieve statistical significance.

In order to identify independent correlates of hospital mortality for the two groups combined, 24 preoperative and intraoperative variables were entered into a stepwise logistic regression model. Of the variables entered into the multivariate model, two preoperative variables (renal insufficiency (p = 0.005), and IABP inserted preoperatively (p = 0.001)) and two intraoperative variables (IABP inserted intraoperatively (p = 0.001) and perfusion time (p = 0.001) were found to be predictors of increased hospital mortality. Because the IABP is a surrogate for the most critically ill patients, it was felt that this predictor might mask more subtle associations in the model. Therefore, the analysis was repeated removing IABP from the model, which led CHF to emerge as a significant predictor. Two preoperative variables (renal insufficiency (p = 0.004) and CHF (p = 0.007)), and one intraoperative variable (perfusion time (p = 0.001)) were found to be predictors of increased hospital mortality (Table IV).

### Hospital morbidity

The overall incidence of postoperative morbidity for the two groups was low, with a majority of the CE patients (66.9%; n = 399) and SJM patients (73.4%; n = 373) experiencing no hospital complications. The

occurrence rate of postoperative morbidities was significantly lower in CE patients ( $p = 0.019$ ). The hospital complication rates for the two groups are listed in Table V. A between-group comparison of each of the reported hospital complications revealed no significant difference, except for reoperation for bleeding ( $p = 0.003$ ).

The average postoperative length of stay was  $15.3 \pm 13.0$  days for CE patients and  $13.5 \pm 15.0$  days for SJM patients. This difference between the groups achieved statistical significance ( $p = 0.044$ ).

### Long-term follow up

Follow up data were collected for 540 CE patients and 481 SJM patients discharged from the hospital. The mean follow up for CE patients was 5.3 years (range: 1.5 months to 22.8 years), and was 5.33 years (range: 1.8 months to 15.5 years) for SJM patients. The cumulative follow up was 2,862.9 patient-years (pt-yr) for CE patients, and 2,564.6 for SJM patients.

In order to identify predictors of late mortality, 25 preoperative and intraoperative variables (see Appendix I) with the addition of date of surgery were entered into a Cox proportional hazards regression model to determine their relationship to late death (>30-day mortality). Cox regression analysis identified the independent influence of eight covariates: arrhythmia ( $p = 0.005$ ), CHF ( $p = 0.001$ ), cerebral vascular disease ( $p = 0.021$ ), diabetes mellitus ( $p = 0.001$ ), date of surgery ( $p = 0.001$ ), surgical history (0.030), surgical urgency (0.023), and perfusion time (0.001). The complete results of this analysis are presented in Table VI.

On completion of follow up, 45.9% (248/540) of the CE hospital survivors and 63.8% (307/481) of the SJM patients were alive. The actuarial survival data for CE and SJM patients are shown in Figure 1. At seven years, mean ( $\pm$  SEM) survival was  $57.0 \pm 2.5\%$  for CE patients, and  $66.0 \pm 2.5\%$  for SJM patients. At 15 years, survival was  $19.1 \pm 2.9\%$  for CE patients and  $26.6 \pm$

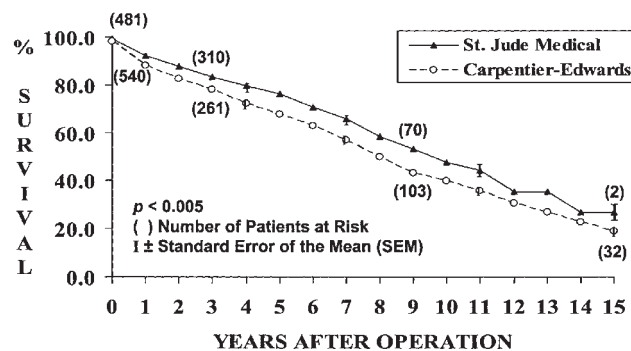


Figure 1: Comparison of actuarial survival of Carpentier-Edwards porcine bioprosthesis and St. Jude Medical mechanical valve patients.

8.8% for SJM patients. The equality of survival distribution for the two groups of patients was tested, and a significant difference found ( $p = 0.005$ ). However, when the total patient population was grouped into five quintiles using propensity score analysis, there was no significant difference in the equality of survival distribution in any of the quintiles.

On completion of the follow up, many current survivors were clinically and functionally improved. Among CE patients, 85.5% were in NYHA classes I or II, compared to 90.2% among SJM patients.

### QOL assessment

The patient's perception of their health status following valvular heart surgery represents an important end-point in assessing outcomes. At follow up, QOL assessment was conducted for all surviving CE patients (96.4%; 239/248) and SJM patients (96.1%; 295/307) willing and capable of completing the SF-36 Health Survey. Mean ( $\pm$  SD) values for each of the eight health scale scores, as well as the Physical and Mental Health Summary component scores for the two patient groups are listed in Table VII. Between-group compar-

Table IV: Multivariate analysis of preoperative and intraoperative variables associated with hospital mortality in patients aged 65-75 years.

Predictor	Beta estimate	Standard error	$\chi^2$	p-value*	Odds ratio	Confidence limits (95%)
Preoperative						
Renal insufficiency+	0.9958	0.3297	8.11	0.004	2.7	1.4-5.2
CHF	0.7330	0.2816	7.25	0.007	2.1	1.2-3.6
Intraoperative						
Perfusion time	0.0152	0.0022	47.43	0.001	1.0	1.0-1.0

\*Only significant variables ( $p < 0.05$ ) listed.

+Serum creatinine  $\geq 2.0$  mg/dl.

CHF: Congestive heart failure.

Table V: Comparison of hospital complications by patient group.

Complication	CE valve	SJM valve	p-value
No. of patients	596	508	
Reoperation for bleeding	34 (5.7)	11 (2.2)	0.003
Respiratory insufficiency	82 (13.8)	63 (12.4)	0.506
Cerebral vascular accident	20 (3.4)	14 (2.8)	0.565
Postoperative MI	8 (1.3)	4 (0.8)	0.404
Renal insufficiency	60 (10.1)	43 (8.5)	0.362
Low cardiac output	95 (15.9)	71 (14.0)	0.363
Cardiac arrest	53 (8.9)	32 (6.3)	0.107

Values in parentheses are percentages.

MI: Myocardial infarction.

isons on the eight health status scale scores showed that SJM patients scored significantly higher on physical functioning ( $p = 0.013$ ), role-physical ( $p = 0.044$ ), general health ( $p = 0.006$ ) and mental health (0.012). Of the two summary components, SJM patients scored significantly higher than CE patients on physical health ( $p = 0.011$ ). A comparison of the Physical and Mental Summary scores of CE patients with age-adjusted norms demonstrated a significant difference in the Physical Health Summary score (CE = 41.0 versus norms = 43.3;  $p = 0.013$ ), but comparable scores in mental health (CE = 51.0 versus norms = 52.7). In SJM patients, no significant difference was observed in the Physical Health Summary score (SJM = 43.5 versus norms = 43.3) or the Mental Health score (SJM = 52.2 versus norms = 52.7). However, when the total patient population was grouped into quintiles using propensity score analysis, there was no significant difference in the patients' Physical and Mental Health Summary scores in any of the five quintiles between groups. These findings show that CE and SJM patients undergoing valvular heart surgery have a comparable QOL, similar to that of the general population when correct-

ed for age and gender.

## Discussion

The relative advantages and disadvantages of bioprosthetic and mechanical valves have been well described (22,23). Nonetheless, clinical practice is far from uniform, with controversy centering on patients aged 65 to 75 years. Despite AHA/ACC guidelines advising the use of bioprostheses in this age group (1), improvements in the medical care of an aging population has left surgeons with a realistic concern that a bioprosthesis inserted at 65-75 years of age may represent an increased risk and a technically demanding reoperation at age 75 to 85 years. Numerous encouraging reports have documented the relatively low risk of valve reoperation (24,25), these having focused primarily on patients in their mid-60s, but not on those in their 80s. Even though valve surgery is becoming increasingly common in octogenarians, with corresponding improvements in outcome (26), the challenge of reoperation in this age group remains formidable (10).

Table VI: Variables influencing late mortality as evidenced by Cox regression analysis for patients aged 65-75 years.

Variable	Regression coefficient	SE	Relative hazard	p-value*
<b>Preoperative</b>				
Arrhythmia	0.2915	0.1026	1.3385	0.005
Congestive heart failure	0.2927	0.0994	1.6282	0.001
Cerebral vascular disease	0.3576	0.1546	1.4299	0.021
Diabetes mellitus	0.4350	0.1168	1.5450	0.001
Date of surgery	0.0001	0.0000	1.0001	0.001
Surgical history	0.2398	0.1103	1.2709	0.030
Surgical urgency	0.2408	0.1058	1.2723	0.023
<b>Intraoperative</b>				
Perfusion time (min)	0.0047	0.0011	1.0047	0.001

\*Only significant variables ( $p < 0.05$ ) listed.

Table VII: Health Status Scale Scores (mean  $\pm$  SD) at follow up for patients aged 65-75 years undergoing valve replacement with Carpentier-Edwards porcine bioprosthesis (CE) and St. Jude Medical mechanical valve (SJM).

Scale score	CE valve (n = 239)	SJM valve (n = 295)	p-value
Physical functioning	54.5 $\pm$ 29.8	60.7 $\pm$ 27.8	0.013
Role-physical	60.6 $\pm$ 44.3	68.2 $\pm$ 42.5	0.044
Bodily pain	71.8 $\pm$ 29.2	76.1 $\pm$ 27.4	0.081
General health	60.1 $\pm$ 25.6	65.9 $\pm$ 23.3	0.006
Vitality (energy/fatigue)	54.4 $\pm$ 21.8	56.2 $\pm$ 21.3	0.337
Social functioning	78.3 $\pm$ 26.7	81.7 $\pm$ 27.1	0.147
Role-emotional	72.0 $\pm$ 41.5	76.9 $\pm$ 37.5	0.153
Mental Health	72.9 $\pm$ 19.5	77.1 $\pm$ 19.0	0.012
Physical Health Summary	41.0 $\pm$ 11.7	43.5 $\pm$ 10.9	0.011
Mental Health Summary	51.0 $\pm$ 10.5	52.2 $\pm$ 10.0	0.178

Balancing these risks are concerns regarding the morbidity of anticoagulation in the elderly. Even though thromboembolic complications are similar for bioprosthetic and mechanical valve patients (27), bleeding is more common with a mechanical valve, and the risk and severity increases with age (22). However, recent experience has demonstrated that carefully managed home anticoagulation can reduce target international normalized ratios (INRs) for mechanical valve patients, and significantly reduce both thromboembolic and bleeding complications (28). Moreover, nearly one-half of patients with bioprosthetic valves may ultimately require chronic anticoagulation (9). Therefore, clinicians have become increasingly willing to consider a mechanical valve in patients aged 65 years and over.

The aim of the present study was to focus on the clinical practice of valve replacement at a single surgical center (with a relatively consistent decision-making algorithm) in patients aged 65-75 years. In this cohort, patients were more likely to receive a porcine bioprosthesis if they were older, male, had renal insufficiency or triple-vessel disease - all of which have been associated with diminished long-term survival in valve patients (29,30). The preference for tissue valves in more recent years most likely reflects the demonstration of freedom from valve structural deterioration with increasing patient age (31).

Patients with a history of previous valve replacement were more likely to receive a mechanical valve. Given the potential for facing a third operation within the patient's life expectancy at an advanced age, with its predictably high morbidity and mortality, this preference is not surprising. The predilection for a mechanical valve in those with a history of CHF, even in the absence of a low ejection fraction, may in fact represent a group of patients many of whom had a prior requirement for anticoagulation. Unfortunately, this specific question was not addressed by the present cardiac sur-

gery clinical database; neither was atrial fibrillation addressed independently of other arrhythmias. Therefore, although it is certain that the need for anticoagulation affected the decision to use a mechanical valve in the present study, the interplay of this with other risk factors cannot be clearly defined. The impact of patient preference on the decision-making process cannot be assessed with currently available data.

In the present study, there was an apparent survival advantage - both postoperatively and in the long term - associated with the use of mechanical valves. However, propensity score analysis, which permits a more careful evaluation of comparable patients groups, revealed no significant difference in either operative or long-term survival in any of the five quintiles. Although the reduction in the sample size of patient groups might certainly raise concern regarding the potential for a Type II error, these findings were corroborated by multivariable analyses. Valve selection was not found to be a significant predictor of either perioperative or long-term survival. These outcomes are supported by careful analyses performed elsewhere on patients of all ages (29,32). The findings of the present study further confirm the results among the controversial 65- to 75-year-old patient group. Moreover, they reinforce the need for the careful evaluation of all studies to ensure that what is being compared is sufficiently similar to validate the findings.

Similarly, the QOL of late survivors, as assessed by the SF-36, seemed to favor the use of mechanical valves, especially in the domains related to patient-perceived physical well-being. Given the comparability of survival and functional status reported herein, patient QOL could potentially assume an increasingly important role in clinical decision-making. Despite the difference in patient characteristics, as well as patient risk and burdens (risk of reoperation with bioprosthesis versus need for continuous monitoring and risk of bleeding from anticoagulation required by mechanical

valves), propensity score analysis failed to reveal any significant difference in the patient perception of QOL between long-term survivors of bioprosthetic versus mechanical valves. Moreover, when properly adjusted, both patient groups achieved a QOL comparable to that of age-matched controls.

### Limitations of the study

The present study included some limitations which, in addition to those mentioned above, deserve consideration. Clearly, the study's retrospective nature imposed some limitations on comparability of the groups. Propensity score analysis was used in an attempt to correct for this, but it is not certain that factors unaccounted for in the analysis may have affected outcome. It should be noted, however, that prospective randomized control studies, of necessity, make exclusion decisions at the point of study entry, and may thus have much more limited clinical applicability than all-inclusive retrospective reviews.

Although the present study was conducted within a single surgical practice, several surgeons participated over time, and varied somewhat in their approach to valve selection. No effort was made to control for this variable in the analysis. Nonetheless, fairly consistent patterns of choosing a bioprosthesis for those patients with a relatively shorter anticipated life expectancy could be identified.

Because the study represented a cross-sectional follow up, data on valve-related complications were not harvested on an ongoing basis. The arduous task of carefully validating patient reports of the presence or absence of these events is ongoing, and not included in this analysis. However, by focusing on mortality as well as the reliable results of the SF-36 conducted at the time of follow up, the study was limited to the most reliable end-points currently available, as reported elsewhere (29,32).

The aim of the present study was not merely to mimic the well-documented differences in morbidity between valve types (22,23), but rather to assess the cumulative effect of these morbidities on survival and QOL. The question remains as to which is more disabling - a transient gastrointestinal bleed which resolves in two days and is almost forgotten years later, or a devastating intracerebral hemorrhage? Or an uneventful reoperation with a benign postoperative course or a prolonged reoperation with multiple transfusions, prolonged intensive care unit stay, multisystem organ failure and life-long impairment? All of these scenarios fall within the parameters of current definitions, but the resulting cumulative impact on patient perception of QOL remains obscure. This global effect was the focus of this initial investigation. Future studies can now be directed toward discerning

specifically which factors contribute to QOL, and what is the nature and degree of their effect. However, this important area of future exploration is beyond the scope of this initial report.

One strength of the present study was the consistent use of one mechanical and one bioprosthetic valve. Clearly, improved bioprostheses with longer longevity are now available. However, the advantages of newer mechanical valves remain to be proven, and hence it is not surprising that the use of tissue valves has increased dramatically over the past decade. The critical point of the present study was not the specific valves used, but rather the elements of decision-making, and how they influence patient outcome.

*In conclusion*, an analysis of patients in the controversial 65- to 75-year age group with regard to the selection of a bioprosthetic versus mechanical heart valve reveals that the choice of prosthetic valve is not a predictor of either perioperative mortality, long-term survival, or patient perception of QOL. Considerable caution should be exercised in evaluating the results of comparisons between devices to ensure that only truly comparable groups are being evaluated. Age alone is clearly inadequate as a sole criterion for valve selection in this age group, and should not by itself be used as a surrogate for quality. Current research has successfully addressed the issues of valve survival and complications. Future investigations must focus on better predictive models of patient survival (30,33), so that ever-complex art and science can be used to match the patient to the most appropriate valve available for their specific clinical scenario.

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## Meeting discussion

**MR. J. PEPPER** (London, UK): You observed patients for quite a long period within the quality of life study, but did you consider those who underwent other operations, such as orthopedic procedures? Did you compare the ease with which those operations were conducted, and the recovery from surgery for mechanical versus bioprosthetic valves? That might be an interesting subgroup.

**DR. PAUL KURLANSKY** (Miami, Florida, USA): This was a cross-sectional follow up, and it is very difficult to obtain good information in that way. I did not examine the valve-related complications because the data cannot be totally trusted. When patients are eventually contacted to complete the SF-36 form, there is no indication as to what has happened to them during the intervening years - there may be many other factors involved. One point identified in other groups of patients at late follow up was that the choice of valve at the time of surgery had very little to do with the patient's current quality of life. This was probably because other factors such as intercurrent illnesses or other operations can affect the quality of life that the patient perceives at the time.

**DR. W. ERIC JAMIESON** (Vancouver, Canada): But there must be an issue of elderly patients who require other operations. What is the morbidity of that situation? In a study such as this I feel it's critical that this point be considered.

**DR. KURLANSKY**: I agree, because if the patients require other operations and are receiving anticoagulation, then they will need to stop the anticoagulation. Whether or not there was any associated morbidity is a very powerful issue.

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## Appendix I: Covariates used to predict hospital mortality.

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### Preoperative variables

- 1 Age
- 2 Female gender
- 3 Diabetes
- 4 Dyslipidemia
- 5 Family history of coronary artery disease
- 6 Smoking history
- 7 Hypertension
- 8 Renal insufficiency
- 9 Congestive heart failure
- 10 Cerebral vascular disease
- 11 Peripheral vascular disease
- 12 Arrhythmia
- 13 New York Heart Association class IV
- 14 Unstable angina
- 15 Prior percutaneous coronary intervention
- 16 Ejection fraction
- 17 Left main disease
- 18 Surgical history
- 19 Surgical urgency
- 20 Diseased vessels

### Intraoperative variables

- 21 Perfusion time (min)
  - 22 Cross-clamp time (min)
  - 23 Valve type
  - 24 Coronary artery bypass grafting
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