

St Jude Medical Epic porcine bioprosthesis: Results of the regulatory evaluation


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Background: The St Jude Medical Epic heart valve (St Jude Medical, Inc, St Paul, Minn) is a tricomposite glutaraldehyde-preserved porcine bioprosthesis. The St Jude Medical Biocor porcine bioprosthesis is the precursor valve to the St Jude Medical Epic valve. The Epic valve is identical to the Biocor valve except that it is treated with Linx AC ethanol-based calcium mitigation therapy.

Methods: The St Jude Medical Epic valve was implanted in 761 patients (mean age 73.9 ± 9.2 years) between 2003 and 2006 in the US Food and Drug Administration regulatory study in 22 investigational centers. The position distribution was 557 aortic valve replacements, 175 mitral valve replacements, and 29 double valve replacements. Concomitant coronary artery bypass grafting was performed in 50.8% of patients undergoing aortic valve replacement and 36.6% of those undergoing mitral valve replacement.

Results: The early mortality was 3.6% in aortic and 2.3% in mitral valve replacement. The follow-up was 1675.5 patient-years with a mean of 2.2 ± 1.2 years/patient. Late mortality was 5.2%/patient-year in aortic and 6.6%/patient-year in mitral valve replacement. The late major thromboembolism rate was 0.98%/patient-year for aortic and 2.6%/patient-year for mitral valve replacement. There were 19 reoperations, including 2 for structural valve deterioration, 1 for thrombosis, 9 for nonstructural dysfunction, and 7 for prosthetic valve endocarditis. The actuarial freedom from reoperation owing to structural valve deterioration for aortic valve replacement at 4 years for age 60 years or less was $93.3\% \pm 6.4\%$; for ages 61 to 70 years, $98.1\% \pm 1.9\%$; and for older than 70 years, 100% ($P = .0006 > 70$ vs ≤ 60 years). There were no events of structural deterioration with mitral valve replacement. The actuarial freedom from major thromboembolism for all patients at 4 years was $93.6\% \pm 1.0\%$. The 2 cases of structural valve deterioration occurred in aortic valves that became perforated without calcification causing aortic regurgitation.

Conclusions: The performance of the St Jude Medical Epic porcine bioprosthesis is satisfactory at 4 years for both aortic and mitral valve replacement. This study establishes the early clinical performance including durability of this porcine bioprosthesis. (*J Thorac Cardiovasc Surg* 2011;141:1449-54)

 Supplemental material is available online.

The quest to establish a bioprosthesis for cardiac valve replacement that is durable for 20 to 25 years continues. There are current reports of 18- to 20-year valve durability experience with porcine and pericardial bioprostheses.¹⁻³ Of these, the St Jude Medical Biocor porcine bioprosthesis (St Jude Medical, Inc, St Paul, Minn) has a long-term durabil-

ity record.¹ The same valve, with an ethanol-based anticalcification treatment, Linx AC, is the St. Jude Medical Epic bioprosthesis. Both valves are tricomposite porcine bioprostheses formulated with 3 individual, independent porcine leaflets. Both include a low-profile flexible stent with a pericardial shield designed to aid in valve durability providing a tissue-to-tissue contact when the valve opens and closes.

The St Jude Medical Epic porcine bioprosthesis was evaluated in a Food and Drug Administration investigational device exemption study conducted between 2003 and 2006 at 22

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Disclosures: W. R. Eric Jamieson is a consultant to St Jude Medical Inc, as well as a consultant or member of the speakers' bureau for other prosthetic valve manufacturers, inclusive of Medtronic Inc, Sorin Group, Edwards Lifesciences, and OnX Life Technologies Inc. David S. Bach reports consulting fees for CVRx, Edwards Lifesciences, Medtronic, and St Jude Medical, as well as lecture fees from Edwards Lifesciences and Medtronic. Clifton T. P. Lewis reports consulting and proctoring fees from St Jude Medical, Intuitive Surgical, and St Jude medical.

Kent W. Jones reports consulting fees from St Jude Medical. Guy J. Fradet reports consulting fees from Medtronic and lecture fees from Sorin Medical. Tirone E. David, Marc P. Sakwa, John A. Sullivan, Denton A. Cooley, and Vibhu R. Kshetry have no commercial interests to disclose.

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Abbreviations and Acronyms

AVR	= aortic valve replacement
LV	= left ventricular
MVR	= mitral valve replacement
SVD	= structural valve deterioration

investigational centers in the United States and Canada. Since Biocor was introduced in 1981, multiple investigative groups have reported on extended experience in the past 4 years.^{1,4,5} Two reports on mitral replacement populations have identified remarkable durability performance in patients averaging just under 50 years of age.^{5,6} The durability performance of the Epic aortic and mitral bioprostheses has been reported in a large 5-year study in an elderly population over 75 years of age.⁷

This study establishes the early performance in a prospective evaluation of a large patient population and affords the opportunity for extended evaluation.

METHODS

This evaluation incorporated the methodology detailed in the “Guidelines for Reporting Morbidity and Mortality after Cardiac Valvular Operations (Valve Interventions)”^{8,9} and the requirements of the US Food and Drug Administration for an investigational device exemption study. Where there was variance, especially with regard to the definition of hemorrhage, only antithrombotic hemorrhage was reported in this study. Anticoagulation management was at the discretion of the standards of care of the respective institutions.

The bioprosthesis was implanted in 761 patients (women 43.9%, men 56.1%) from 2003 to 2006. The mean age of the population was 73.9 ± 9.2 years, with a range of 24 to 93 years. There were 557 aortic (AVR), 175 mitral (MVR), and 29 double valve replacements. Of the patients in the AVR group, 34 were less than 60 years of age, 101 were between 61 to 70 years, and 422 were older than 70 years. In the MVR population, 17 were younger than 60 years, 47 were between 61 and 70 years, and 111 were older than 70 years. The patient characteristics of the AVR and MVR populations are detailed in Table 1. The populations were distinguished for gender, left atrial enlargement, pulmonary hypertension, congestive heart failure, cardiac arrhythmias, left ventricular (LV) dysfunction, and mitral valve repair ($P < .0001$).

Previous surgery had been performed in 23.3% of AVR and 31.4% of MVR patients. Concomitant coronary artery bypass grafting was conducted in 50.8% of AVR and 36.6% of MVR patients. Concomitant atrial fibrillation ablation was performed in 5.4% of AVR and 23.4% of MVR patients; the procedures were performed with surgical, radiofrequency, or cryotherapy ablation.

Principal investigators from 8 of the study centers were selected to report on all data from the 22 investigational North American centers. The study centers and respective study principal investigators are shown in Appendix 1. These principal investigators were chosen on overall implant population of the various centers. The enrolment in the study closed in March 2006. The follow-up incorporated 1675.5 patient-years with a mean of 2.2 ± 1.2 years per patient. The completeness of follow-up was 97.2% at 2 years and 94.9% at 4 years for AVR and 96.6% at 2 years and 94.8% at 4 years for MVR. The echocardiographic evaluation was complete for AVR at 6 months, 1 year, and 2 years in 93.4%, 93.5%, and 89.1% of the patients, and for MVR at 6 months, 1 year, and 2 years in 91.4%, 94.2%, and 89.7% of the patients. The follow-up was conducted at the investigational cen-

ters by clinic evaluation, primary physician assessment or, if necessary, telephone interviews and attainment of appropriate documentation. The follow-up occurred at 6 months, 1 year, and annually. The evaluation included echocardiograms and blood assessment (inclusive of haptoglobin and serum lactate dehydrogenase), as well as New York Heart Association functional classification, medications, and documentation of any adverse events.

The statistical analyses were performed with SAS software (version 9.1.3; SAS Institute, Inc, Cary, NC). Descriptive summaries are expressed as mean values for continuous variables and as percentage for categorical variables; P values are from 2-sample t test or χ^2 test as appropriate. Late adverse event rates (percent per patient-year) are expressed as a linearized rate ([the number of late events occurring 31 or more days after implant/total late patient-years calculated for each subject from 31 days after implant to the last contact] · 100). Kaplan–Meier analyses are performed for survival or freedom from the event rates, and groups are compared using the log–rank static. Only Kaplan–Meier actuarial data analysis was reported because of the objective to report on prosthesis performance and not performance in a specific population subset (cumulative incidence, actual analysis).

RESULTS

The early mortality (30-day mortality) was 3.6% (20 events) for AVR and 2.3% (4 events) for MVR. The occurrence of the predominant valve-related complications presented as linearized occurrence rates (percent per patient-year) and actuarial freedom at 4 years for both AVR and MVR populations are detailed in Table 2 with the corresponding events. The valve-related mortality for AVR was 0.4%/patient-year and for MVR it was 1.1%/patient-year. The major thromboembolism rates, inclusive of major cerebrovascular accident and reversible ischemic neurologic deficit, were 0.98%/patient-year (12 events) and 2.6%/patient-year (9 events), respectively, for AVR and MVR. The antithrombotic hemorrhage rates were 1.3%/patient-year (16 events) for AVR and 1.7%/patient-year (6 events) for MVR.

There were 9 late valve-related deaths occurring between 83 and 1080 days after implantation (prosthetic valve endocarditis = 2; periprosthetic leak = 1; hemorrhage = 2; and sudden unexplained/unexpected = 4). There was only 1 reoperation (prosthetic valve endocarditis); the patient died during the reoperation for double valve replacement. There were 21 cases of cerebrovascular accident/reversible ischemic neurologic deficit (AVR = 12 and MVR = 9). Eight patients had documented accompanying atrial fibrillation. There were 2 cases of MVR thrombosis, only 1 requiring reoperation. The additional case was managed conservatively with anticoagulation.

Table 3 documents the actuarial performance of reoperation of the overall events, as well as the events in each valve-related complication category. There were 21 overall reoperative events including 1 heart transplantation and 1 early reoperation for atrioventricular groove disruption. All patients had successful surgery. Two patients required reoperation for structural valve deterioration (SVD). Both had had AVR, aged 47 and 61 years at implant, with the finding of perforation(s) not associated with calcification and presented with aortic regurgitation.

TABLE 1. Patient population and medical history*

Variables	AVR (n = 557)	MVR (n = 175)	P value
Age (y)	74.4 ± 9.3 (24.6,93.3)	72.2 ± 8.9 (44.5,91.4)	.0054
Gender (male)	61.0% (340)	44.0% (77)	<.0001
NYHA III/IV	55.5% (309)	61.7% (108)	.1459
Systemic hypertension	76.5% (426)	69.1% (121)	.0513
Left atrial enlargement	23.9% (133)	42.9% (75)	<.0001
Diabetes mellitus	26.2% (146)	20.0% (35)	.0966
TIA	6.3% (35)	3.4% (6)	.1519
Stroke/RIND/CVA	6.6% (37)	6.9% (12)	.9211
Pulmonary hypertension	14.2% (79)	34.9% (61)	<.0001
Myocardial infarction	13.1% (73)	16.6% (29)	.2482
Congestive heart failure	36.3% (202)	57.1% (100)	<.0001
Hyperlipidemia	59.8% (333)	45.7% (80)	.0011
Cancer	19.9% (111)	19.4% (34)	.8850
Lung disease	21.2% (118)	18.3% (32)	.4072
Coronary artery disease	65.0% (362)	49.7% (87)	.0003
Carotid artery disease	12.7% (71)	6.9% (12)	.0321
Peripheral vascular disease	14.0% (78)	7.4% (13)	.0215
Endocarditis	1.4% (8)	2.9% (5)	.2144
Cardiac arrhythmias	26.0% (145)	46.9% (82)	<.0001
Renal failure	3.8% (21)	4.0% (7)	.8900
LV dysfunction	66.8% (372)	46.9% (82)	<.0001
RV dysfunction	0.5% (3)	2.3% (4)	.0383
AV repair or replacement	0.9% (5)	0.0% (0)	.2085
MV repair	0.2% (1)	7.4% (13)	<.0001
Previous CABG	8.1% (45)	6.3% (11)	.4362
Previous carotid endarterectomy	4.3% (24)	2.9% (5)	.3905
Previous pacemaker	6.1% (34)	6.9% (12)	.7203
Balloon annuloplasty	2.7% (15)	2.3% (4)	.7675
Other surgery	7.5% (42)	16.0% (28)	.0009
Valve dysfunction			
Insufficiency	9.7% (54)	69.1% (121)	<.0001
Stenosis	62.7% (349)	8.6% (15)	<.0001
Mixed	27.6% (154)	21.7% (38)	.1196
Not reported	0.0% (0)	0.6% (1)	.2391

AVR, Aortic valve replacement; MVR, mitral valve replacement; NYHA, New York Heart Association; TIA, transient ischemic attack; RIND, reversible ischemic neurologic deficit; CVA, cerebrovascular accident; LV, left ventricular; RV, right ventricular; AV, aortic valve; MV, mitral valve; CABG, coronary artery bypass grafting. *A subject can be counted in multiple categories based on his or her individual medical history.

The pathologic evaluation of the 2 cases of SVD has identified abnormal findings of the native porcine leaflets, resulting in perforations and tears:

The examining pathologist in the initial case concluded that 2 of the cusps showed deterioration of the cuspal collagen and increasing permeability of the cusps with fibrin permeation resulting in cuspal perforation. One of the cusps

had an accompanying tear. The third cusp had focal areas of thinning of the cuspal fibrosa. There was no evidence of endocarditis or calcification.

The examining pathologist in the second case found that all 3 leaflets contained attenuation of the fibrosa and fibrin permeation of the spongiosa. Two leaflets had small perforations identical to each other near the free edges and the

TABLE 2. Valve-related late complications

	AVR		MVR	
	Late complications, %/pt-y (n)	KM freedom from the event, % at 4 y	Late complications, %/pt-y (n)	KM freedom from the event, % at 4 y
Valve-related mortality	0.4 (5)	98.7% ± 0.6%	1.1 (4)	96.6% ± 1.5%
Major TE (CVA + RIND)	0.98 (12)	94.5% ± 1.2%	2.6 (9)	91.0% ± 2.5%
Thrombosis	0.0 (0)	100% ± 0.0%	0.6 (2*)	97.9% ± 1.6%

AVR, Aortic valve replacement; MVR, mitral valve replacement; KM, Kaplan–Meier; TE, thromboembolism; CVA, cerebrovascular accident; RIND, reversible ischemic neurologic deficit. *One subject had echocardiographic evidence of possible small thrombosis that resolved on anticoagulant management.

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TABLE 3. Summary of freedom from reoperation for valve-related complications

Reoperation	Freedom	Events
Overall	92.3% ± 2.3%	21*
Valve related	92.6% ± 2.3%	19
SVD	99.4% ± 0.4%	2
NSD	97.2% ± 1.4%	9 (PPL 6)
PVE	96.2% ± 1.9%	7
Thrombosis	99.7% ± 0.3%	1

SVD, Structural valve deterioration; NSD, nonstructural dysfunction; PPL, periprosthetic leak; PVE, prosthetic valve endocarditis. *Heart transplantation, n = 1; atrioventricular disruption, n = 1.

other leaflet had a linear tear. There was no evidence of endocarditis or calcification.

Prosthetic valve endocarditis requiring reoperation occurred in 7 cases. One case of mitral valve thrombosis required reoperation in a patient with a history of endocarditis. The remainder of events were due to nonstructural dysfunction including 2 cases of pannus, 6 cases of paravalvular leaks, and 1 case of dehiscence of the aortomitral annular continuity requiring surgical repair.

The overall survival of the total population was 76.0% ± 2.7% at 4 years. Figures E1 and E2 illustrate survival by age groups (group A ≤ 60, group B 61–70, and group C > 70 years) for the AVR and MVR populations. For AVR, survival for group B (61–70 years) was greater than for group C (>70 years) (P = .013), and survival for group A (≤60 years) was greater than for group C (>70 years) (P = .011). There was no significant difference between groups A and B (<60 years and 61–70 years; P = .076). Survival after MVR was not different by age groups (P = .145), but the patient populations were small for the younger groups.

The actuarial freedom from valve-related mortality for the overall population was 98.1% ± 0.6% at 4 years and for all-cause reoperation, 92.3% ± 2.3% at 4 years (Table 3). The actuarial freedom from valve-related reoperation was 92.6% ± 2.3% at 4 years (Table 3).

The actuarial freedom from reoperation owing to SVD for the overall population at 4 years was 99.4% ± 0.4% (Table 3); for AVR 99.2% ± 0.6% and for MVR 100%. The actuarial freedom from reoperation owing to SVD for AVR age groups is illustrated in Figure 1. The freedom at 4 years for group A (≤60 years) was 93.3% ± 6.4%; for group B (61–70 years), 98.1% ± 1.9%; and for group C (>70 years), 100%. The actuarial freedom from reoperation owing to SVD for MVR age groups is presented in Figure 2. The freedom for each of the age groups (overall MVR range 44–91) is 100% at 4 years.

The actuarial freedom from overall thromboembolism at 4 years was 90.0% ± 1.7%. The freedom from major thromboembolism and reversible ischemic neurologic deficit at 4 years was 93.6% ± 1.0%. The freedom from antithrombotic hemorrhage at 4 years was 90.7% ± 1.2% and

Freedom (Actuarial) – Reoperation due to SVD ≤60, 61-70, >70yrs for AVR

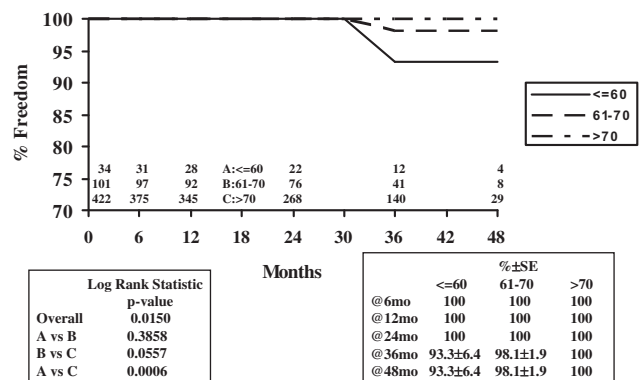


FIGURE 1. Freedom from reoperation owing to SVD for AVR by age groups (≤60, 61–70, >70 years). SVD, Structural valve deterioration; AVR, aortic valve replacement.

from thrombosis, 99.6% ± 0.3%. (The freedom from reoperation owing to thrombosis was 99.7% ± 0.3%.)

The actuarial freedom from overall reoperation for prosthetic valve endocarditis at 4 years was 96.2% ± 1.9% (Table 3). For the same time interval, the actuarial freedom from reoperation owing to nonstructural dysfunction, inclusive of periprosthetic leak, was 97.2% ± 1.4% (Table 3).

The hemodynamic performance at 6 months and 2 years for AVR and MVR is illustrated in Figures E3 and E4. The size distributions for AVR were as follows: 21 mm, 17.2%; 23 mm, 37.0%; 25 mm, 33.8%; 27 mm, 10.2%; and 29 mm, 1.7%. For the mitral valve they were as follows: 25 mm, 4.4%; 27 mm, 20.1%; 29 mm, 38.7%; 31 mm, 21.1%; and 33 mm, 15.7%. The mean gradients and effective orifice areas for both positions are documented. There was no occurrence greater than mild insufficiency observed for the reoperation subjects, and prosthesis insufficiency was not found to be an issue for these subjects.

Freedom (Actuarial) – Reoperation due to SVD ≤60, 61-70, >70yrs for MVR

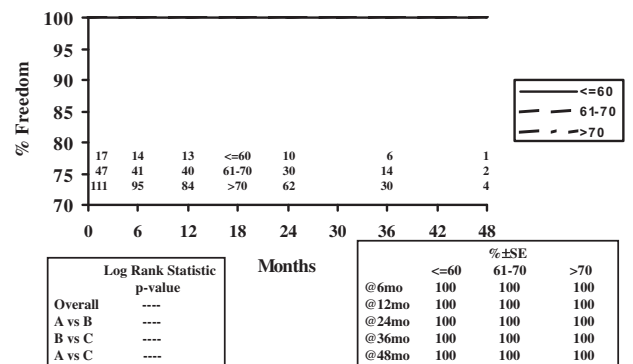


FIGURE 2. Freedom from reoperation owing to SVD for MVR by age groups (≤60, 61–70, >70 years). SVD, Structural valve deterioration; MVR, mitral valve replacement.

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A total of 334 subjects with AVR had complete time points (discharge, 6 month, 1 year, and 2 year). LV mass index data were available for the analysis. The mean (average) LV mass index was reduced by 23.9 g/m² ($P < .001$) from discharge to 6 months, 26.8 g/m² ($P = .0001$) from discharge to 1 year, and 27.6 g/m² ($P = .0001$) from discharge to 2 years (Figure E5).

DISCUSSION

The St Jude Medical porcine bioprostheses have been evaluated in 5 publications since 2000.^{1,4-7} The Biocor bioprosthesis was introduced in Brazil in 1981 and performance over 20 years has been documented in 4 of these publications. St Jude Medical markets the Biocor porcine bioprosthesis worldwide. Biocor and Epic are the same bioprostheses except that Biocor is formulated with no calcium mitigation therapy whereas Epic is treated with Linx AC, an ethanol-based therapy for calcium mitigation. Both valves are tricomposite porcine bioprostheses with glutaraldehyde preservation at low-pressure conditions of less than 1 mm Hg. Midterm results of the Epic bioprosthesis aortic and mitral performance have been reported in 1 large series.⁷

The Biocor bioprosthesis has been reported by Mykén and Bech-Hansen¹ in an AVR population of 70.8 years of age and an MVR population of 64.9 years. Eichinger and colleagues⁴ documented AVR performance in patients with a mean age of 72.5 years. Kirali,⁶ Pomerantzeff,⁵ and their coinvestigators documented MVR performance in populations with mean ages of 48 and 49.2 years, respectively. The reported experience on the Biocor and Epic prostheses have concentrated on freedom from valve-related mortality and freedom from SVD. They address durability of SVD primarily by explant reoperation. There are no comments on modes of failure in the reports on the Biocor bioprosthesis.

Before 2009, Mykén and colleagues reported on the Biocor bioprosthesis in 1994, 1995, 2000, and 2005. The recent report (2009) documented the 20-year performance of the Biocor valve in 1712 patients with 99.9% follow-up, mean follow-up of 6.0 years for AVR and 6.2 years for MVR.¹ The 20-year freedom from actuarial valve-related mortality was 84.3% for AVR and 88.0% for MVR. The actual/cumulative incidence of freedom from valve-related mortality was 92.5% for AVR and 92.8% for MVR. The 20-year freedom from reoperative SVD in AVR (1518 patients) was 61.1% (actual 85.6%) and for MVR (194 patients), 79.3% (actual 91.2%). The actuarial freedom in those older than 65 years and those 65 years or less for AVR was 92.1% and 44.5%, respectively, and for MVR, 88.0% and 75.2%, respectively. There were 77 subjects with SVD in the AVR by reoperative explant and 11 in the MVR group, for an overall rate of 0.9%/patient-year. The authors considered the durability of AVR and MVR to be comparable.

In 2008, Eichinger and coauthors⁴ reported on a cohort of 455 patients in whom the actuarial freedom from reoperative SVD after AVR was 86.5% at 20 years (mean of 8.2 years, completeness of 99.6%). Three other reports had documented 20-year experience with aortic porcine and pericardial bioprostheses, but none of these publications has adequate numbers at risk beyond 15 to 18 years to provide adequate assessment of 20-year durability.^{2,10,11}

The MVR durability, reported by Pomerantzeff and colleagues⁵ in 2006, in 546 patients (mean age 48 years) at 15 years was 51.8% for those younger than 50 years, 88.7% for those 51 to 60 years, and 84.0% for those 61 to 80 years for reoperative SVD. The freedom from valve-related mortality at 15 years was 80.7%. Kirali and coinvestigators⁶ documented performance in 2001 for 158 patients. There were 39 SVD cases and 16 came to reoperation. The overall freedom from SVD at 13 years was 64.8% and for SVD reoperation, 76.8%. The authors reported the 15-year freedom from valve-related mortality to be 98.6%.

The performance of 1168 AVR and 101 MVR Epic valves implanted between 2001 and 2006, mean age of 76 years, provided 5-year satisfactory results.⁷ In this report by Lehmann et al,⁷ the authors recommended long-term evaluation of the calcium-mitigation therapy.

In this current Epic study, we report on the regulatory population of 761 patients at 4 years: there were 2 AVR SVD cases of aortic insufficiency owing to cuspal perforations and actuarial freedom from reoperation owing to SVD for AVR at 4 years for ages 60 years and younger at 93.3% ± 6.4%; for ages 61 to 70 years at 98.1% ± 1.9%; and for older than 70 years at 100% ($P = .0006 > 70$ vs ≤ 60 years). There were no cases of MVR SVD. The mean follow-up was 2.2 years. The AVR SVD cases occurred in patients aged 47 and 61 years.

Hemodynamic performance was satisfactory for both MVR and AVR. All valves used were standard Epic aortic valves. The newer Epic Supra aortic valve is designed for supra-annular implantation and provides the potential for improved hemodynamic performance. For the same tissue annulus diameter, the Epic Supra incorporates a larger stent and therefore has a larger stent/annulus ratio than does the Epic aortic. Regardless, in the current study, LV mass regression significantly improved in patients with sufficient follow-up data.

This study can serve as the basis for long-term durability and performance evaluation of the St Jude Medical Epic porcine bioprosthesis in both the aortic and mitral positions. This will be important to confirm the favorable durability considerations specifically for the mitral bioprosthesis.

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APPENDIX 1. Site principal investigator list

Principal investigators	Investigational sites
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Kent Jones, MD	Intermountain Medical Center, Salt Lake City, Utah
John Puskas, MD	Emory University Hospital, Crawford Long Hospital, Atlanta, Ga
Valluvan Jeevanandam, MD	The University of Chicago, Chicago, Ill
Robert Mitchell, MD	Central Baptist Hospital, Lexington, Ky
Paul Corso, MD	Washington Hospital Center, Washington, DC
Marc Sakwa, MD	William Beaumont Hospital, Royal Oak, Mich
Denton Cooley, MD	Texas Heart Institute at St. Luke's Episcopal Hospital, Houston, Tex
John Oswalt, MD	Austin Heart Hospital, Seton Medical Center, Austin, Tex
Michael Ingram, MD	Sutter Memorial Hospital, Sacramento, Calif
A. Michael Borkon, MD	St Luke's Hospital, Kansas City, Mo
Robert Kramer, MD	Maine Medical Center, Portland, Maine
Ralph de la Torre, MD	Beth Israel Deaconess Medical Center, Boston, Mass
Tirone David, MD	Toronto General Hospital, Toronto, Ontario, Canada
John Sullivan, MD	Queen Elizabeth II Health Sciences Centre, Halifax, Nova Scotia, Canada
Guy Fradet, MD	Vancouver General Hospital, Vancouver, British Columbia, Canada
W. R. Eric Jamieson, MD	St. Paul's Hospital, Vancouver, British Columbia, Canada

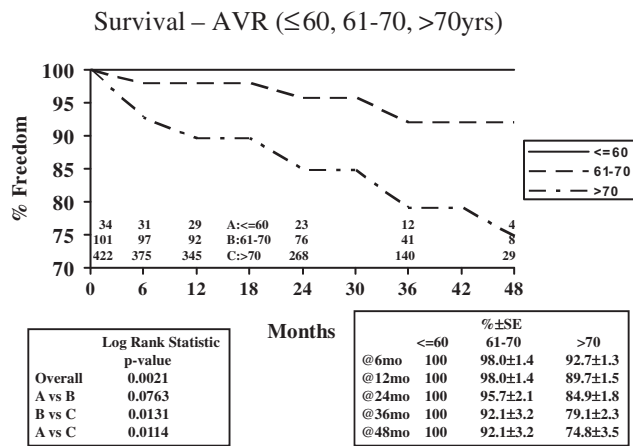


FIGURE E1. Patient survival AVR by age groups (≤60, 61–70, >70 years). AVR, Aortic valve replacement; SE, standard error.

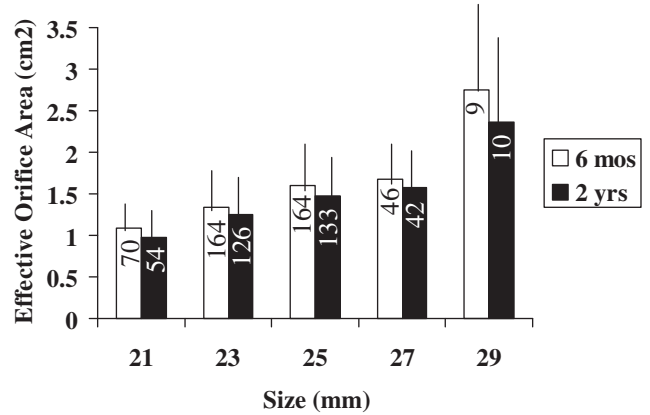
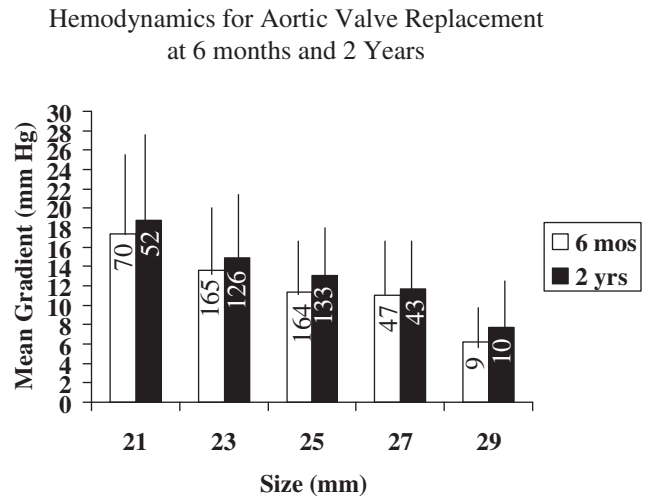


FIGURE E3. Hemodynamics—aortic valve replacement (mean gradients and effective orifice areas) at 6 months and 2 years.

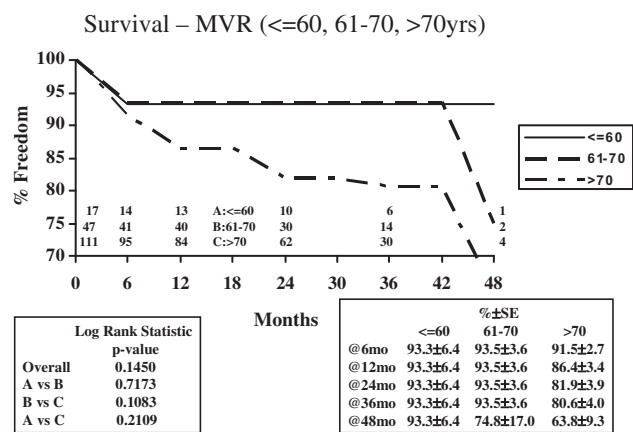


FIGURE E2. Patient survival MVR by age groups (≤60, 61–70, >70 years). MVR, Mitral valve replacement; SE, standard error.

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Hemodynamics for Mitral Valve Replacement at 6 months and 2 Years

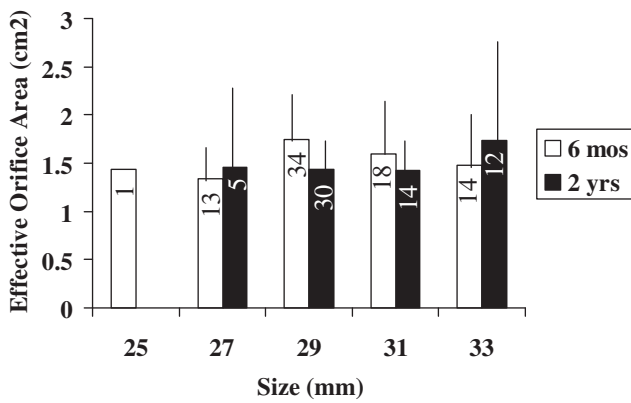
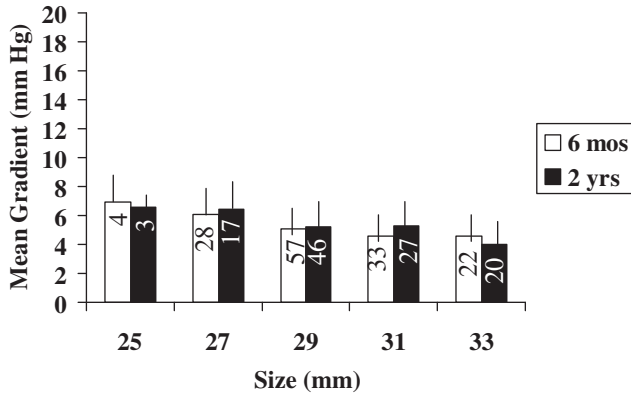
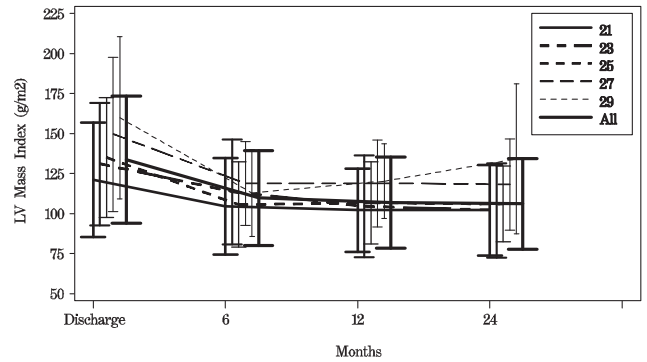


FIGURE E4. Hemodynamics—mitral valve replacement (mean gradients and effective orifice areas) at 6 months and 2 years.

LV Mass Index – Aortic



Aortic Valve Size (mm)	21	23	25	27	29
Number of Subjects	51	114	125	35	9

FIGURE E5. Left ventricular (LV) mass regression.