Long Term Outcomes and Durability of Bioprosthetic Valve for Valve Replacement at Siriraj Hospital

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ABSTRACT

Objective: Bioprosthesis has been used in cardiac valve replacement for a long time. However, structural valve deterioration is still a major cause of failure. There are several risk factors for valve deterioration. This study evaluates the risk factors of valve deterioration in the long term (10 years) at Siriraj Hospital.

Materials and Methods: We retrospectively reviewed the medical records of 249 patients who underwent mitral or aortic valve replacement between January 2006 and December 2012 using various tissue valves, comprising Carpentier–Edwards porcine, Carpentier–Edwards Perimount bovine pericardial, Carpentier–Edwards Perimount Magna bovine pericardial, and St Jude Trifecta bovine pericardial types. The information from each patient was entered into a database at the time of the operation and followed up regularly, with a mean follow-up of 10 years.

Results: After 10 years follow-up time, the incidence of valve deterioration events were 1.2% and 8.43% in the first five and ten years, respectively. The overall death rate during follow-up was 2.41%. There were three statistically significant risk factors ($p < 0.05$) of valve deterioration: gender (female) ($p = 0.042$), age ≤ 60 years old ($p = 0.010$) and St Jude Trifecta bovine pericardial valve ($p = 0.004$).

Conclusion: In the surgical populations who underwent valve replacement at Siriraj Hospital with tissue valves, we found an acceptable long-term durability of the tissue valve. The risk factors of valve deterioration were female gender, age ≤ 60 years old, and St Jude Trifecta bovine pericardial valve.

Keywords: Tissue valve; bioprosthesis valve; structural valve deterioration (Siriraj Med J 2022; 74: 211-216)

INTRODUCTION

There are two types of prosthetic heart valves: the mechanical heart valve and the bioprosthetic tissue valve. The mechanical valve is recommended for young patients because of its durability, but the patient is required to take anticoagulants for life to prevent thromboembolism events; whereas the tissue valve is less durable than the mechanical valve, but the patient is not required to take anticoagulants for life; thus leading to a lower risk of bleeding events associated with the use of anticoagulants.

In 1966, Dr. Alain Carpentier invented the stented porcine valve and used glutaraldehyde solution as the chemical preservative for porcine valves by creating collagen cross-links. This preservation protected the denaturation of tissue leaflets and made the tissue immunologically inactive.[1]

Since 1980s, tissue valves have been improved through the use of low-pressure fixation to maintain a normal leaflet morphology. Anti-calcification and anti-mineralization treatment methodologies were developed to obtain longer durable leaflets.[2]

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Porcine and pericardial tissue valves have been used for cardiac valve replacement surgery for 20 years at Siriraj Hospital. However, it is known that these may suffer structural valve deterioration over time, which is the major cause of tissue valve failure worldwide. Data collected from 1970 to 2000 revealed that 30% - 40% of tissue valves at the mitral or aortic position require replacement within 15 years following implantation because of structural valve deterioration.[3] There are several risk factors for structural valve deterioration, such as a younger patient, renal insufficiency, hyperparathyroidism, hypertension, tissue valve at the mitral position, and an older generation of tissue valve.

Calcification is accelerated in younger patients, renal insufficiency, or hyperparathyroidism patients. Systemic hypertension damages tissue valves at the mitral and aortic positions due to the increased systolic and diastolic closing pressure. Older generations of tissue valves are less durable than the newer generation of tissue valves. Pericardial valves are more durable than porcine valves.[4,5]

The primary objective of this study was durability of tissue valve and secondary objective was the risk factors of long-term (10-year) structural valve deterioration in patients at Siriraj Hospital, which are essential to have a better understanding of in order to support selection of the proper tissue valve types for patients in terms of the position and timing of tissue valve replacement.

MATERIALS AND METHODS

This research was approved by the Ethical Committee on Research Involving Human Subjects, Faculty of Medicine Siriraj Hospital, Mahidol University on March 24, 2021.

We retrospectively reviewed the medical records of 249 patients who underwent mitral or aortic valve replacement since January 2006 to December 2012 using the Carpentier–Edwards porcine (porcine) (24 cases), Carpentier–Edwards Perimount bovine pericardial (PM) (165 cases), Carpentier–Edwards Perimount Magna bovine pericardial (PM magna) (57 cases), and St Jude Trifecta bovine pericardial (trifecta) (3 cases) tissue valves types and who survived the operation. The types of tissue valve were selected by the individual surgeon's preference and the valves available at that time. The case of structural valve deterioration was defined by clinical presentation, echocardiographic finding results and reoperation event.

Statistical analysis

The baseline demographic continuous data were presented as number or percentage, mean and standard deviation were carried out as normal distribution. Categorical data was presented as percentage or ratio/ In inferential statistic, 95%CI was used. In case of time to deterioration in univariate analysis, deterioration was obtained from Kaplan-Meier survival curves and log-rank test for compared each group. For multivariate analysis using Cox (Proportional Hazards) regression analysis was performed after adjusted controlling confounding factors with p-value < 0.2 from univariate analysis using backward elimination for variable selection. The statistical significance was accepted if the p-value was < 0.05.

Table 1 summarizes the preoperative clinical characteristics of all the patients. The male gender represented 48.2% of cases and the female gender 51.8%. The mean age was 69.2 years old (range 15–98 years old), with 203 patients (81.5%) being more than 60 years old. Overall, 148 patients underwent aortic valve replacement (AVR) (59.4%), 84 patients underwent mitral valve replacement (MVR) (33.7%), and 17 patients underwent double valve replacement (DVR) (6.8%).

Also, 79 patients (31.7%) with significant coronary artery disease who received preoperative angiography underwent concomitant coronary artery bypass graft surgery were included in this study. The data obtained from all the patients were entered into a database at the time of the operation and then those patients were followed up regularly.

TABLE 1. Preoperative clinical characteristics.

Variables (n=249)	Number (%) or Mean ± SD
Gender; Male	120 (48.2%)
Female	129 (51.8%)
Age (years)	69.2 ± 11.4
≤ 60 years	46 (18.5%)
> 60 years	203 (81.5%)
Follow-up time (years)	10.0 (4.0-15.0)
Diagnosis	
Regurgitation	153 (61.4%)
Stenosis	79 (31.7%)
Mixed	17 (6.8%)
Operation	
AVR	148 (59.4%)
MVR	84 (33.7%)
DVR	17 (6.8%)
Type of tissue valve	
PM	165 (66.3%)
PM magna	57 (22.9%)
Porcine	24 (9.6%)
Trifecta	3 (1.2%)
Concomitant CABG	79 (31.7%)

RESULTS

After 10 years (range 4-15 years) follow-up time, the incident of structural valve deterioration events was 1.2% (95%CI: 0.25-3.47) and 8.43% (95%CI: 5.27-12.56) in the first five and ten years, respectively (Fig 1). The overall death rate during follow-up was 2.41% (95%CI: 0.97-5.66). A summary of the incidence of structural valve deterioration is shown in Table 2.

According to Table 3, there were three statistically significant risk factors ($p < 0.05$) of structural valve deterioration, i.e., female gender, age ≤ 60 years old, and St Jude Trifecta bovine pericardial valve. The risk of structural valve deterioration was 2.75 times (95%Cl: 1.04 to 7.28 times) higher significant ($p = 0.042$) in females compared to males, and the risk of structural valve deterioration is 3.33 times (95%Cl: 1.34 to 8.29 times) more significant ($p = 0.010$) in the adult group (age ≤ 60 years old) compared with the elderly group (age > 60 years old). The St Jude Trifecta valve was also found to be a significant risk factor of structural valve deterioration ($p = 0.004$)

DISCUSSION

The expanding use of tissue valves for valve replacement has been supported by evidence of their long term durability and freedom from structural valve deterioration. In this present study at Siriraj Hospital, we followed 249 cases of tissue valve replacement in the aortic and mitral valve positions. During the early years of our experience, the main reasons for using a tissue valve were patients having a contraindication to taking anticoagulants, elderly patients, and women of reproductive age. Nowadays, patient preference has become one of the most important factors for choosing the proper valve. In our series, the freedom from structural valve deterioration at 10 years was 91.57% (Fig 1). There were three statistically significant risk factors ($p < 0.05$) of structural valve deterioration identified in our study: female gender, age ≤ 60 years old and St Jude Trifecta bovine pericardial valve (Table 3, Fig 2, Fig 3).

The risk of structural valve deterioration in the mitral position has been considered to be higher than in the aortic position because the systolic closing pressure at the mitral position is higher than the diastolic closing pressure at the aortic position. In an Edinburgh study[6], after 15 year tissue valve follow-up, a reoperation rate of 29% due to structural valve deterioration was observed in the AVR group and 44% in the MVR group. In our series, after 10 year tissue valve follow-up, we found a rate of structural valve deterioration of 6.8% in the AVR group and 10.7% in the MVR group. However, the statistical difference was insignificant ($p = 0.183$).

Regarding gender, as far as we know there has been no report about the effects of gender associated with structural valve deterioration after tissue valve replacement, but we found a structural valve deterioration rate of 11.6% in females and 5.0% in males. The risk of structural valve deterioration was 2.75 times (95%Cl: 1.04-7.28) more significant ($p = 0.042$) in female compared to male. The suggested reason behind this result might be the use of a smaller valve in female patients, which carries a higher risk of structural valve deterioration.[4]

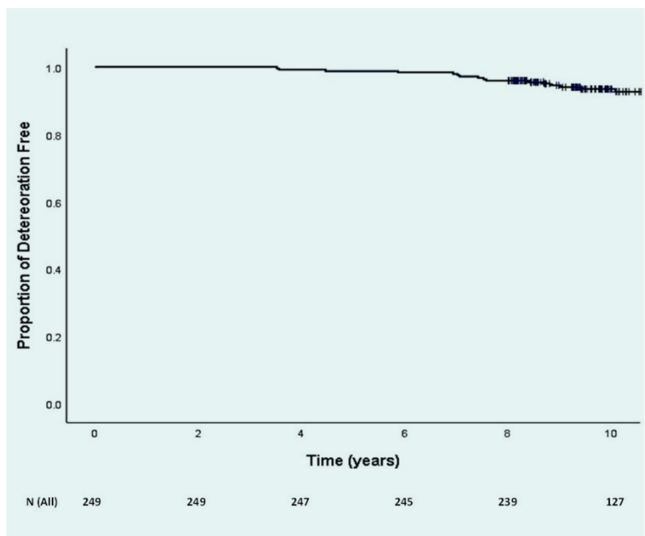

Fig 1. Freedom from structural valve deterioration for all tissue valves.

TABLE 2. Incidence of structural valve deterioration.

Variables (n=249)	Number of Deterioration	Incident of Deterioration (95%CI)
Deterioration		
at 5 years	3	1.20% (0.25-3.47)
at 10 years	21	8.43 % (5.27-12.56)
Died during follow-up	6	2.41% (0.97-5.66)

TABLE 3. Risk factors of structural valve deterioration.

Variable	Number (%) or Mean ± SD Non-deterioration (n=228)	Deterioration (n=21)	Log-rank test (p-value)	Multivariate Adjusted HR (95%CI)	Cox regression (p-value)
Gender					
Male (n=120)	114 (95.0)	6 (5.0)	0.069	1	
Female (n=129)	114 (88.4)	15 (11.6)		2.75 (1.04-7.28)	0.042 *
Age (year)	69.8 ± 10.7	63.05±15.7			
Adult group; age ≤ 60 year (n=46)	38 (82.6)	8 (17.4)	0.021	3.33 (1.34-8.29)	0.010 *
Elderly group; age > 60 year (n=203)	190 (93.6)	13 (6.4)		1	
Diagnosis					
Regurgitation (n = 153)	137 (89.5)	16 (10.5)	0.930		
Stenosis (n = 79)	75 (94.9)	4 (5.1)			
Mixed (n = 17)	16 (94.1)	1 (5.9)			
Operation					
AVR (n=148)	138 (93.2)	10 (6.8)	0.183		
MVR (n=84)	75 (89.3)	9 (10.7)			
DVR (n=17)	15 (88.2)	2 (11.8)			
Type					
PM (n=165)	153 (92.7)	12 (7.3)	0.052	1	
PM magna (n=57)	53 (93.0)	4 (7.0)		1.53 (0.47-5.00)	0.479
Porcine (n=24)	20 (83.3)	4 (16.7)		2.22 (0.70-7.01)	0.173
Trifecta (n=3)	2 (66.7)	1 (33.3)		23.71 (2.69-209.09)	0.004 *
CABG					
yes (n=79)	75 (94.9)	4 (5.1)	0.176		
no (n=170)	153 (90.0)	17 (10.0)			

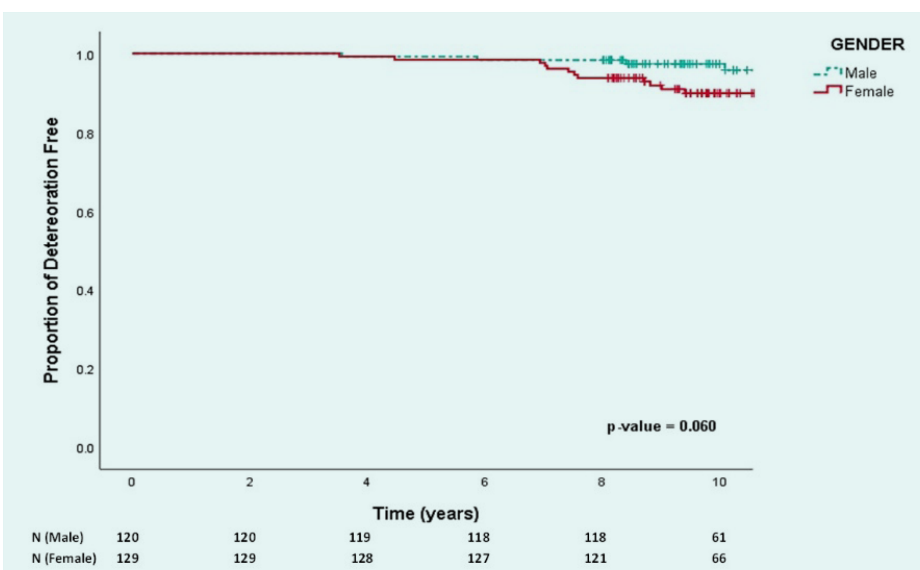

Fig 2. Freedom from structural valve deterioration for male and female patients.

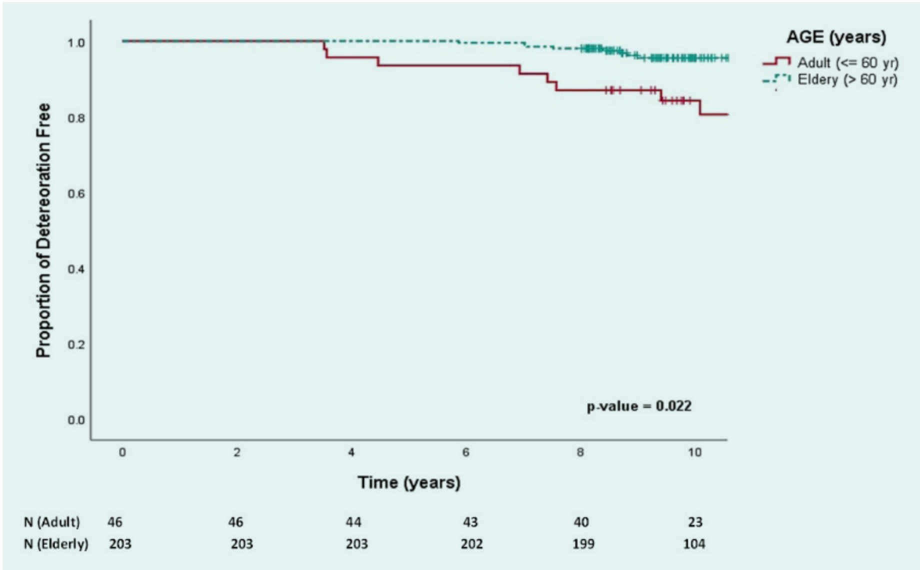

Fig 3. Freedom from structural valve deterioration for adult and elderly patients.

Elderly patients have been shown to be the most powerful determinants of tissue valve longevity.[7] Rizzoli et al.[3] reported the actual freedom from structural valve deterioration in patients younger than 65 years old was less than that seen in older patients (84.5% vs. 95%). Similarly, we found the rate of structural valve deterioration was 17.4% in the adult group (age ≤ 60 years old) and 6.4% in the elderly group (age > 60 years old). The risk of structural valve deterioration was 3.33 times (95%Cl: 1.34-8.29) more significant (p = 0.010) in the adult group (age ≤ 60 years old) compared to the elderly group (age > 60 years old).

The newer generations of tissue valves are more durable than older generations of tissue valves. Likewise, pericardial valves are more durable than porcine valves.[5] Bourguignon et al.[8,9] reported the long-term outcomes of patients fitted with a Carpentier–Edwards Perimount valve in the aortic or mitral position. They found that the expected valve durability was 19.7 years in the aortic position and 14.2 years in the mitral position.

In our series, after 10 year tissue valve follow-up, we found structural valve deterioration in 7.3% of cases in the Perimount group, 7.0% in the Perimount Magna group, 16.7% in the porcine group, and 33.3% in the Trifecta group. However, the statistical difference was insignificant for the Carpentier–Edwards porcine compared to the Carpentier-Edwards Perimount bovine pericardial type (p = 0.173, 95%Cl: 0.70-7.01). Conversely, the St Jude Trifecta bovine pericardial type was found to be a significant risk factor of structural valve deterioration (p = 0.004, 95%Cl: 2.69-209.09), but it should be noted that the total number of cases in the Trifecta group was very small (n = 3) compared to in the other groups. So, we cloud not conclude that they were more likely to deteriorate than other types.

When reoperation is required, reoperative AVR or MVR can be done safely. The recent mortality outcomes were 5%-7% in reoperative AVR or reoperative MVR.[10,11] Besides, in the future, valve in valve transcatheter aortic valve replacement (TAVR) and transcatheter mitral valve replacement (TMVR) may be the second optional treatments for patients who develop structural tissue valve deterioration. In our series, there were 7 cases who underwent reoperative AVR or reoperative MVR without mortality and 2 cases who underwent TAVR without mortality, while 12 structural valve deterioration cases were still waiting for their definitive treatment soon.

CONCLUSION

In surgical populations that underwent valve replacement at Siriraj Hospital with tissue valves, we found an acceptable long-term durability of the new tissue valve. The risk factors of structural valve deterioration were the female gender and age ≤ 60 years. The freedom from reoperation was not significantly different in terms of the valve position. However, we need to further re-evaluate the data in the next 5-10 years to obtain longer term results.

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