RESEARCH ARTICLE

Preoperative Heart Failure Influences Cardiac Functional Outcome in Patients with Prosthetic Valve Endocarditis

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ABSTRACT

Background: Heart Failure (HF) is an indication for surgical intervention in cases of Prosthetic Valve Endocarditis (PVE). We reviewed outcomes of redo surgery for PVE to evaluate the influence of preoperative HF on late-phase postoperative cardiac function.

Methods: Nineteen patients underwent redo surgery for PVE. The patients were divided into 2 groups according to the presence or absence of acute preoperative heart failure (HF group *vs.* non-HF group).

Results: We found that time from diagnosis of PVE to the redo surgery was significantly shorter and postoperative hospital stay was significantly longer for the HF group patients. In the non-HF group, changes in key echocardiographic variables from the preoperative to late postoperative period were as follows: left ventricular end-diastolic dimension, from 52.5 mm ± 6.9 mm to 43.8 mm ± 7.9 mm in (p=0.0025); left ventricular end-systolic dimension, from 35.4 mm ± 5.5 mm to 27.8 ± 2.6 mm (p=0.0098), and systolic volume, from 81.3 ml ± 26.3 ml to 60.7 ml ± 31.4 ml in (p=0.0384). In the HF group, there was no significant improvement in these echocardiographic variables.

Conclusion: Acute preoperative HF appears to negatively influence cardiac contractility and thus cardiac functional outcome in patients with PVE.

Introduction

Infective Endocarditis (IE) is a rare condition that can be fatal in the absence of appropriate treatment. In-hospital mortality ranges from 15% to 20%, and 1-year mortality is close to 40% [1]. Prosthetic Valve Endocarditis (PVE), a major complication, especially after valve replacement surgery, occurs at a rate of 0.3%-1% per year per patient who has undergone prosthetic valve replacement and accounts for 16%-34% of all cases of IE [2,3]. The reported 10-year survival rate for patients with PVE is about 60%, with a late-stage mortality rate of 16% and a reoperation rate of 20% [3]. Early surgical intervention is recommended for patients with PVE in whom complications, such as Heart Failure (HF), valve dysfunction, and/or abscess, develop [1]. However, data are lacking regarding the timing of surgical intervention and cardiac functional outcome. Predictors of early mortality associated with PVE include a high New York Heart Association functional class and preoperative pulmonary edema, both of which have been associated with shock and poor Left Ventricular (LV) function [2-4]. However, few studies have evaluated improvement in cardiac function in the late period following surgical intervention for PVE. We conducted a single-center, retrospective cohort study to review perioperative morbidity and mortality associated with PVE, and to assess the influence of preoperative HF on long-term cardiac functional outcome after redo surgery for PVE.

Materials and Methods

Patient selection and data collection

The study was approved by the Institutional Review Board of Jichi Medical University (Approval No. S22-102). Informed consent was secured through an opt-out system available to patients on the institution's website. Patients included in the study (10 men and 9 women, aged 20 years or more) were identified from among a total of 279 patients who had undergone surgery for IE between April 1990 and December 2022. The 19 study patients were those who had undergone redo surgery for PVE, which had been diagnosed according to the modified Duke criteria [5]. Preoperative and postoperative outcome variables were extracted from our institutions' adult cardiac surgery database. Mean age of the study patients was

69.3 ± 12.5 years. PVE was defined as an intravascular microbial infection occurring in part of a prosthetic valve or in a reconstructed native valve [6]. Comorbidities present or developing in patients preoperatively, perioperatively, or postoperatively were documented. Renal failure was defined as an increase in serum creatinine to more than 1.5 mg/dl. In-hospital mortality was defined as death occurring within 30 days of the redo surgery, and late mortality was defined as death occurring beyond 30 days. On the basis of the European Society of Cardiology guidelines, PVE occurring within 1 year of the primary valve surgery was classified as "early-onset PVE" and after 1 year as "late-onset PVE" [7]. Pertinent perioperative variables were compared between patients with acute preoperative HF (HF group) and patients without preoperative HF (non-HF group). In addition, changes between preoperative and postoperative cardiac function were evaluated in each group.

Surgical re-intervention criteria

In cases of PVE, a determination must be made whether medical therapy should be continued or urgent surgical intervention is needed. If medical therapy does not promptly improve congestion, redo surgery is indicated.6 According to the 2020 American College of Cardiology/American Heart Association guidelines, surgery is recommended for patients with recurrent PVE in whom no other source of infection can be identified (with recurrent PVE defined as recurrent bacteremia after completion of a full course of appropriate antibiotics and subsequent negative blood culture results) (Class I), and early surgery (surgery performed during initial hospitalization and before completion of a full course of antibiotics) is recommended for patients with PVE who have recurrent emboli or persistent verrucae despite having received appropriate antibiotic therapy (Class IIa) [1]. Cerebral embolization is not a contraindication for surgery if there is no cerebral hemorrhage, if the time between embolization and surgery would be short (preferably no more than 72 hours), and the integrity of the blood-brain barrier is not significantly compromised [8]. Surgical intervention in all 19 cases was based on the above criteria.

Echocardiography

Transthoracic two-dimensional echocardiography at rest was performed preoperatively, in the early postoperative period (up to 4 weeks after the surgery), and in the late postoperative period, as previously described [9,10]. Regional myocardial contractile function was evaluated in the left lateral decubitus position. Left Atrial Diameter (LAD) was measured on the long-axis image. Left ventricular volume was determined by means of M-mode echocardiography, with the maximum minor axis of the Left Ventricular End-Diastolic Dimension (LVDd) and Left Ventricular End-Systolic Dimension (LVDs) measured in the parasternal long-or short-axis view, on the assumption that the left ventricle was spheroid. Left ventricular volume was usually calculated by the formula of Teichholz, as follows: Volume=$7.0 \times$ Dimension^3/(2.4+Dimension) [9]. Left ventricular Stroke Volume (SV) was obtained by subtracting Left Ventricular End-Systolic Volume (LVESV) from Left Ventricular End-Diastolic Volume (LVEDV). Left Ventricular Ejection Fraction (LVEF) was calculated as follows: LVEF=SV $\times$ 100/LVEDV (%) [9].The Tricuspid Regurgitation Pressure Gradient (TR-PG) was recorded, taken as the Doppler-estimated peak systolic tricuspid pressure gradient.

Statistical analysis

Continuous variables are shown as mean ± standard deviation values. Categorical variables are expressed as the number and percentage of patients. Differences between the 2 study groups were analyzed by Student t-test or Mann-Whitney U-test (for normally and non-normally distributed continuous variables, respectively). Differences in group proportions were evaluated by means of χ^2 test or Fisher's exact test, as appropriate. Differences in mean values of paired observations in a single group were analyzed by paired samples t-test. GraphPad Prism software, version 8 (GraphPad Software, San Diego, CA, USA) was used for all statistical analyses, and p less than or equal to 0.05 was considered significant

Results

Patients' preoperative characteristics are shown for the HF group and non-HF group in Table 1. There was no between-group difference in mean age (67.3 ± 12.7 *vs.* 72.1 ± 12.6 years, p=0.4197) or the proportion of male patients (6 (54.5%) *vs.* 4 (50.0%), p=0.8447). There was no difference in whether the initial surgery was due to IE (4 (36.4%) *vs.* 3 (37.5%), p=0.9596) or to valve dysfunction without infection (7 (63.7%) *vs.* 5 (62.5%), p=0.9596). There was no difference in the incidence of pre-existing hypertension (5 (45.5%) *vs.* 4 (50.0%), p=0.8447), dyslipidemia (3 (27.3%) *vs.* 4 (50.0%), p=0.3106), diabetes (1 (9.1%) *vs.* 1 (12.5%), p=0.8111), or renal failure (4 (36.4%) *vs.* 2 (25.0%), p=0.5988). The total 13 cases for which the initial surgery was Aortic Valve Replacement (AVR)(6 (54.5%) *vs.* 7 (87.5%), p=0.1271) involved 3 mechanical valves (1 (16.7%) *vs.* 2 (28.6%), p =0.6115) and 10 biological valves (5 (83.3%) *vs.* 5 (71.4%), p=0.6115). The 5 cases for which the initial surgery was Mitral Valve Replacement (MVR) (4 (36.4%) *vs.* 1 (12.5%), p=0.2435) involved 4 mechanical valves (3 (75.0%) *vs.* 1 (100.0%), p=0.5762) and 1 biological valve (1 (25.0%) *vs.* 0 (0.0%), p=0.5762). A single patient in the HF group un-

derwent AVR+MVR (1 (9.1%) *vs.* 0 (0.0%), p=0.3809). Replacement of the aortic valve with a bioprosthesis accounted for more than half of all cases of PVE in both groups. Mean time from diagnosis to the surgery for all 19 patients was 21.1 days. Time to surgical intervention, which was 5.3 ± 4.3 days in the HF group, was significantly (p=0.0127) less than the 40.4 ± 41.9 days in the non-HF group. There were 10 early reoperation cases (7 (63.6%) *vs.* 3 (37.5%), p=0.3698) and 9 late reoperation cases (4 (36.4%) *vs.* 5 (62.5%), p=0.0.3698) with a mean time to surgery of 2225 (636.4 ± 959.1 *vs.* 1625.6 ± 1997.5, p=0.1847) days. Genus *Staphylococcus* was the most common responsible organism (present in 8 cases) (4 (36.4%) *vs.* 4 (50.0%), p=0.5522), followed by Genus *Staphylococcus* (present in 3 cases) (1 (9.1%) *vs.* 2 (25.0%), p=0.3478), Genus *Enterococcus,* (also present in 3 cases (2 (25.0%) *vs.* 1 (12.5%), p=0.7374), and other species in 5 cases (4 (36.4%) *vs.* 1 (12.5%), p=0.2435). Eight patients had suffered cerebral infarction (5 (45.5%) *vs.* 3 (37.5%), p=0.7288), and 3 had suffered cerebral hemorrhage (1 (9.1%) *vs.* 2 (25.0%), p=0.3478). Thus, over 60% of the study patients had suffered a preoperative central nervous system complication. Preoperative anticoagulation therapy was performed in 15 patients (10 (90.9%) *vs.* 5 (62.5%), p=0.2621).

Preoperative echocardiographic variables are shown in Table 2. There was no significant between-group difference in LAD (46.9 ± 9.4 *vs.* 52.3 ± 6.9, p=0.2037), LVDd (48.0 ± 1.9 *vs.* 52.5 ± 6.9, p=0.0859), LVDs (31.5 ± 4.3 *vs.* 35.4 ± 5.5, p=0.2285), LVEDV (107.8 ± 9.7 *vs.* 135.2 ± 39.7, p=0.0689), LVESV (40.4 ± 14.0 *vs.* 53.9 ± 19.7, p=0.2183), SV (67.5 ± 12.3 *vs.* 81.3 ± 26.3, p=0.1164), LVEF (63.1 ± 10.3 *vs.* 60.1 ± 8.7, p=0.7489), or TR-PG (28.8 ± 13.1 *vs.* 31.2 ± 16.6, p=0.4197).

Perioperative variables are shown in Table 3. There was no difference in operation time (411.3 ± 108.0 *vs.* 518.5 ± 129.3 min, p=0.0656). AVR (including root reconstruction in 2 cases) was performed in 9 cases (5 (45.5%) *vs.* 4 (50.0%), p=0.8447), with a mechanical valve in 2 cases (1 (20.0%) *vs.* 1 (25.0%), p=0.8577) and a biological valve in 7 (4 (80.0%) *vs.* 3 (75.0%), p=0.8577). MVR was performed in 7 cases (5 (45.5%) *vs.* 2 (25.0%), p=0.3651), with a mechanical valve in 4 cases (3 (60.0%) *vs.* 1 (50.0%), p=0.8091) and a biological valve in 3 (2 (40.0%) *vs.* 1 (50.0%), p=0.8091). Both AVR and MVR (including 1 case of root reconstruction) were performed in 3 cases (1 (9.1%) *vs.* 2 (25.0%), p=0.3478), with a mechanical valve in 1 case (1 (100.0%) *vs.* 0 (0.0%), p=0.0833) and a biological valve in 2 (0 (0.0%) *vs.* 2 (100.0%), p=0.0833). Thus, there was no between-group difference in surgical procedures. Postoperative hospital stay was significantly (p=0.0053) longer for the HF group (56.5 ± 14.0 days) than for the non-HF group (29.0 ± 23.6 days). There were 2 in-hospital deaths (10.5%), one due to heart failure caused by prosthetic valve failure resulting from difficulty in infection control (HF group) and the other due to intestinal necrosis caused by thrombosis of the superior mesenteric artery (non-HF group). Late mortality occurred in 3 patients (15.8%), resulting from submural hemorrhage at 1.2 years (HF group), heart failure at 1.6 years (HF group), and HF at 2.3 years (non-HF group).

Echocardiography (preoperative *vs.* early postoperative *vs.* late postoperative period) was performed to evaluate cardiac function in all 19 patients (Tables 4 and 5).

Table 1. Patients' preoperative characteristics, per study group.

Characteristics	HF group	Non-HF group	p Value
	(n=11)	(n=8)	
Age (years)	67.3 ± 12.7	72.1 ± 12.6	0.4197
Sex, male, n (%)	6 (54.5)	4 (50.0)	0.8447
Indication for initial surgery			
Infective endocarditis, n (%)	4 (36.4)	3 (37.5)	0.9596
Other, n (%)	7 (63.7)	5 (62.5)	0.9596
Medical history			
Hypertension, n (%)	5 (45.5)	4 (50.0)	0.8447
Dyslipidemia, n (%)	3 (27.3)	4 (50.0)	0.3106
Diabetes mellitus, n (%)	1 (9.1)	1 (12.5)	0.8111
Renal dysfunction (Cr>1.5 mg/dl), m (%)	4 (36.4)	2 (25.0)	0.5988
Initial surgery			
AVR (includes aortic root reconstruction)	6 (54.5)	7 (87.5)	0.1271

Mechanical valve, n (%)	1 (16.7)	2 (28.6)	0.6115
Bioprosthetic valve, n (%)	5 (83.3)	5 (71.4)	0.6115
MVR	4 (36.4)	1 (12.5)	0.2435
Mechanical valve, n (%)	3 (75.0)	1 (100.0)	0.5762
Bioprosthetic valve, n (%)	1 (25.0)	0 (0.0)	0.5762
AVR+MVR	1 (9.1)	0 (0.0)	0.3809
Mechanical valve, n (%)	1 (100.0)	0 (0.0)	0.8859
Bioprosthetic valve, n (%)	0 (0.0)	0 (0.0)	0.8859
Time from diagnosis to surgical procedure (days)	5.3 ± 4.3	40.4 ± 41.9	0.0127
Early reoperation, n (%)	7 (63.6)	3 (37.5)	0.3698
Late reoperation, n (%)	4 (36.4)	5 (62.5)	0.3698
Time since previous surgery (days)	636.4 ± 959.1	1625.6 ± 1997.5	0.1847
Causative organisms of PVE			
Genus *Staphylococcus*, n (%)	1 (9.1)	2 (25.0)	0.3478
Genus *Staphylococcus*, n (%)	4 (36.4)	4 (50.0)	0.5522
Genus *Enterococcus,* n (%)	2 (25.0)	1 (12.5)	0.7374
Other, n (%)	4 (36.4)	1 (12.5)	0.2435
Pre-operative inflammatory response			
WBC count (/µl)	11373.6 ± 7790.7	6707.5 ± 2610.0	0.124
CRP (mg/dl)	8.7 ± 8.3	2.4 ± 2.1	0.0531
Preoperative cerebral complications			
Cerebral infarction, n (%)	5 (45.5)	3 (37.5)	0.7288
Cerebral hemorrhage, n (%)	1 (9.1)	2 (25.0)	0.3478
Preoperative anticoagulation therapy, n (%)	10 (90.9)	5 (62.5)	0.2621

Note: Mean ± SD values are shown unless otherwise indicated.

Abbreviations: AVR: Aortic Valve Replacement; Cr: Serum Creatinine; CRP: C-Reactive Protein; MVR: Mitral Valve Replacement; WBC: White Blood Cell.

Table 2. Preoperative echocardiographic variables, per study group.

	HF group (n=11)	Non-HF group (n=8)	p Value
LAD (mm)	46.9 ± 9.4	52.3 ± 6.9	0.2037
LVDd (mm)	48.0 ± 1.9	52.5 ± 6.9	0.0859
LVDs (mm)	31.5 ± 4.3	35.4 ± 5.5	0.2285
LVEDV (ml)	107.8 ± 9.7	135.2 ± 39.7	0.0689
LVESV (ml)	40.4 ± 14.0	53.9 ± 19.7	0.2183
SV (ml)	67.5 ± 12.3	81.3 ± 26.3	0.1164
LVEF (%)	63.1 ± 10.3	60.1 ± 8.7	0.8555
TR-PG (mmHg)	28.8 ± 13.1	31.2 ± 16.6	0.7489

Note: Mean ± SD values are shown.

Abbreviations: LAD: Left Atrial Dimension; LVDd: Left Ventricular end-Diastolic dimension; LVDs: Left Ventricular end-Systolic Dimension; LVEDV: Left Ventricular End-Diastolic Volume; LVEF: Left Ventricular Ejection Fraction; LVESV: Left Ventricular End-Systolic Volume; SV: Systolic Volume; TR-PG: Tricuspid Regurgitation Pressure Gradient.

Table 3. Operative and post-operative variables, per study group.

	HF group (n=11)	Non-HF group (n=8)	p Value
Operation time (minutes)	411.3 ± 108.0	518.5 ± 129.3	0.0656
Surgical procedure			
AVR (incl. aortic root reconstruction)	5 (45.5)	4 (50.0)	0.8447
Mechanical valve, n (%)	1 (20.0)	1 (25.0)	0.8577
Bioprosthetic valve, n (%)	4 (80.0)	3 (75.0)	0.8577
MVR	5 (45.5)	2 (25.0)	0.3651
Mechanical valve, n (%)	3 (60.0)	1 (50.0)	0.8091
Bioprosthetic valve, n (%)	2 (40.0)	1 (50.0)	0.8091
AVR+MVR	1 (9.1)	2 (25.0)	0.3478
Mechanical valve, n (%)	1 (100.0)	0 (0.0)	0.0833
Bioprosthetic valve, n (%)	0 (0.0)	2 (100.0)	0.0833
Postoperative hospital stay (days)	56.5 ± 14.0	29.0 ± 23.6	0.0053
In-hospital mortality, n (%)	1 (9.1)	1 (12.5)	0.8111
Late mortality, n (%)	2 (40.0)	1 (12.5)	>0.9999

Note: Mean ± SD values are shown unless otherwise indicated.
Abbreviations: AVR: Aortic Valve Replacement; MVR: Mitral Valve Replacement.

Table 4. Pre-and post-operative echocardiographic variables in the HF group.

	Pre-operative period	Early post-operative period	Late post-operative period	p Value		
				Pre- *vs.* Early	Early *vs.* Late	Pre- *vs.* Late
LAD (mm)	46.9 ± 9.4	40.2 ± 9.0	46.2 ± 10.4	0.0294	0.0826	0.7137
LVDd (mm)	48.0 ± 1.9	46.5 ± 5.2	46.8 ± 6.3	0.1049	0.3704	0.533
LVDs (mm)	31.5 ± 4.3	32.5 ± 4.3	31.8 ± 9.2	0.5881	0.7654	0.8976
LVEDV (ml)	107.8 ± 9.7	101.2 ± 26.2	103.6 ± 34.6	0.1194	0.3603	0.6992
LVESV (ml)	40.4 ± 14.0	43.7 ± 14.5	45.2 ± 34.7	0.6199	0.811	0.632
SV (ml)	67.5 ± 12.3	57.5 ± 18.0	58.4 ± 7.2	0.0504	0.1605	0.0999
LVEF (%)	63.1 ± 10.3	57.5 ± 7.3	60.3 ± 16.0	0.1208	0.3156	0.5218
TR-PG (mmHg)	28.8 ± 13.1	22.4 ± 4.3	23.6 ± 7.7	0.3494	0.7861	0.2199

Note: Mean ± SD variables are shown unless otherwise indicated.
Abbreviations: LAD: Left Atrial Dimension; LVDd: Left Ventricular end-Diastolic dimension; LVDs: Left Ventricular end-Systolic Dimension; LVEDV: Left Ventricular End-Diastolic Volume; LVEF: Left Ventricular Ejection Fraction; LVESV: Left Ventricular End-Systolic Volume; SV: Systolic Volume; TR-PG: Tricuspid Regurgitation Pressure Gradient.

Table 5. Pre and post-operative echocardiographic variables in the non-HF group.

	Pre-operative period	Early post-operative period	Late post-operative period	p Value		
				Pre- *vs.* Early	Early *vs.* Late	Pre- *vs.* Late
LAD (mm)	52.3 ± 6.9	42.7 ± 8.8	45.6 ± 10.9	0.1093	0.6194	0.081
LVDd (mm)	52.5 ± 6.9	49.5 ± 6.4	43.8 ± 7.9	0.4511	0.2212	0.0025
LVDs (mm)	35.4 ± 5.5	32.5 ± 3.8	27.8 ± 2.6	0.2465	0.0288	0.0098
LVEDV (ml)	135.2 ± 39.7	117.8 ± 35.9	90.1 ± 35.9	0.4125	0.1856	0.0039
LVESV (ml)	53.9 ± 19.7	43.3 ± 11.9	29.4 ± 6.8	0.2446	0.0272	0.0183
SV (ml)	81.3 ± 26.3	74.5 ± 32.5	60.7 ± 31.4	0.7657	0.32	0.0384
LVEF (%)	60.1 ± 8.7	62.1 ± 9.5	63.7 ± 14.4	0.3708	0.855	0.3784
TR-PG (mmHg)	31.2 ± 16.6	23.8 ± 8.0	25.9 ± 14.2	0.1242	0.6858	0.4817

Note: Mean ± SD variables are shown unless otherwise indicated.
Abbreviations: LAD: Left Atrial Dimension; LVDd: Left Ventricular end-Diastolic dimension; LVDs: Left Ventricular end-Systolic dimension; LVEDV: Left Ventricular End-Diastolic Volume; LVEF: Left Ventricular Ejection Fraction; LVESV: Left Ventricular End-Systolic Volume; SV: Systolic Volume; TR-PG-Tricuspid Regurgitation Pressure Gradient.

In the HF group, echocardiographic variables did not change significantly between the preoperative period and late postoperative period: LAD, from 46.9 ± 9.4 mm to 46.2 ± 10.4 mm (p=0.7137); LVDd, from 48.0 ± 1.9 mm to 46.8 ± 6.3 mm (p=0.5330); LVDs, from 31.5 ± 4.3 mm to 31.8 ± 9.2 mm (p=0.8976); LVEDV, from 107.8 ± 9.7 ml to 103.6 ± 34.6 ml (p=0.6992); LVESV, from 40.4 ± 14.0 mL to 45.2 ± 34.7 mL (p=0.632); SV from 67.5 ± 12.3 ml to 58.4 ± 7.2 ml (p = 0.0999); LVEF, from 63.1 ± 10.3% to 60.3 ± 16.0% (p=0.5218); and TR-PG, from 28.8 ± 13.1 mmHg to 23.6 ± 7.7 mmHg (p=0.2199). In the non-HF group, LVDd, LVDs, LVEDV, LVESV, and SV improved significantly from 52.5 ± 6.9 mm to 43.8 ± 7.9 mm (p=0.0025), 35.4 ± 5.5 mm to 27.8 ± 2.6 mm (p=0.0098), 135.2 ± 39.7 ml to 90.1 ± 35.9 ml (p=0.0039), 53.9 ± 19.7 ml to 29.4 ± 6.8 ml (p=0.0183), and 81.3 ± 26.3 ml to 60.7 ± 31.4 mL (p=0.0384), respectively. However, LAD, LVEF, and TR-PG did not change significantly in this group (from 52.3 ± 6.9 mm to 45.6 ± 10.9 mm (p=0.0810), 60.1 ± 8.7 % to 63.7 ± 14.4% (p=0.3784), and 31.2 ± 16.6 mmHg to 25.9 ± 14.2 mmHg (p=0.4817), respectively.

Discussion

Studies conducted in the 1980s and early 1990s doc-umented mortality rates following surgery for PVE ranging from 20% to 60% [11]. A fairly recent report documented an improvement in 30 day mortality to less than 15% [3]. Despite improvements in surgical techniques for PVE, careful management of infection, central nervous system complications, and HF are re-quired because of patients' increased risk of mortality and morbidity compared with that faced by primary IE patients. Hence, when considering reoperation for PVE, it is important to identify the timing of surgical inter-vention as it relates to outcomes.

PVE observed within the first postoperative year is classified as early-onset PVE, and that observed later is classified as late-onset PVE. Whether PVE occurs early or late depends on differences in microbiolog-ical characteristics [6]. Early-onset PVE is typically caused by methicillin-resistant *Staphylococcus epi-dermidis*, gram-negative bacteria, or fungi, suggest-ing nosocomial infection. Late-onset PVE, however, is typically caused by bacteremia attributed to skin, oral, or abdominal infection or an invasive medical or den-tal procedure, with streptococci and *Staphylococcus epidermidis* as common causative pathogens [2,12]. Among our study patients, however, the most common causative microorganism for early-onset PVE was of the genus *Streptococcus* (50% incidence rate), and this

was followed by *Staphylococcus* as the most common causative microorganism in cases of both early- and late-onset PVE. Also, there was no significant difference between our HF group and our non-HF group with respect to the causative organisms. Patients who underwent valve replacement for active IE, patients for whom the causative organism was unknown, and patients for whom antibiotic therapy is inadequate appeared to be at particularly high risk for early-onset PVE. Early-onset PVE developed in 10 patients (52.6%), and in 6 of these patients, the initial surgery was valve replacement (for IE). Preoperative HF was not associated with early- or late-onset PVE among our study patients. Although early-onset PVE is associated with extremely high mortality [12], among our study patients there was no in-hospital death in cases of early-onset PVE and only 1 late death, which was due to subarachnoid hemorrhage. Endocarditis developed in the late postoperative period in 9 of our study patients, 6 of whom had received a bioprosthetic valve. The incidence of late-onset PVE has been reported to be higher among patients with a bioprosthetic valve than among those with a mechanical valve [6], but among our study patients the incidences were equivalent.

Strong predictors of IE-related mortality include persistent bacteremia, HF, intracardiac abscess, and stroke, all of which are common indications for surgical intervention [13]. HF is known to be one of the strongest predictors of in-hospital mortality among patients with PVE, remaining at around 15% [3]. At our institution, the criteria for surgical intervention in cases of PVE are based on published guidelines, and in-hospital mortality associated with preoperative HF was limited to only 1 case (9.1%). Our surgical outcomes were comparable to or better than those reported elsewhere for PVE [2,12,14]. Possible reasons for the favorable surgical outcomes include prompt surgical intervention at the appropriate time. For our study patients without HF, average time from diagnosis of the PVE to surgery was 40.4 days, but for those with HF average time was 3 days. Thus, surgical intervention was performed significantly sooner in our patients with HF. It is crucial to accurately evaluate HF status in patients with PVE and to perform the requisite surgery promptly.

We sought to perform a concrete functional analysis to evaluate the outcomes of our redo surgery for PVE. One of the main purposes of our study was to clarify the influence of preoperative HF on cardiac function in the early and late postoperative periods. LVEDV, LVESV, and LVEF are commonly used as clinical markers reflecting global LV systolic performance or LV remodeling [15,16]. In patients with HF, LVEF and LV volumes reflect global LV systolic performance or are associated with LV remodeling [10,15,16]. Of note, previous re-

ports have emphasized the superiority of LVESV over LVEF or LVEDV in predicting poor prognosis in patients with cardiac disease [10,17,18]. Therefore, LVEF, LVEDV, and especially LVESV may accurately reflect the status of patients with HF and their risks for morbidity and mortality [10,19]. Both LVEDV and LVESV were found to be markedly improved after surgery in our non-HF group. Improvement in cardiac contractility in patients without preoperative HF could forecast a favorable cardiac outcome. Conversely, in our HF group, there was no significant improvement in cardiac contractility in the late postoperative period. Such a lack of improvement in the late postoperative period and may point to an unfavorable cardiac functional outcome.

Conclusion

Appropriate timing of surgical intervention for PVE reduced in-hospital mortality by 10.5%. Preoperative HF appears to negatively influence cardiac contractility and thus cardiac functional outcome in patients with PVE. In patients with PVE, acute preoperative HF appears to have a deleterious effect on cardiac contractility and, consequently, cardiac functional outcome. In patients without preoperative HF, an increase in ventricular contractility may indicate a positive cardiac prognosis.

Limitations

Limitations of our study include the following: First, only a small number of patients were included. Second, echocardiographic variables were assessed in patients collectively, rather than separately, depending on whether patients had undergone AVR, MVR, or both. Third, echocardiographic variables were found to have improved significantly after redo surgery in the non-HF group. However, it is unclear whether improvement in these variables can be directly linked to long-term symptomatic relief. Therefore, further objective tests, such as exercise tolerance tests, are needed to uncover any association between improved echocardiographic values and favorable clinical outcomes.

Disclosure Statement

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