Preoperative Clinical Features and High Pulmonary Wedge Pressure with a Discordant Pattern as Prognostic Factor in Hemodialysis Patients with Severe Aortic Valve Stenosis

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Summary

Hemodialysis (HD) is one of the important risks for the development of cardiovascular disease, including aortic valve stenosis (AS). Although aortic valve replacement (AVR) is a beneficial treatment for AS, HD patients are known to show a high rate of mortality after AVR than non-HD patients.

We retrospectively studied 109 patients who underwent AVR for severe AS, 18 of which were HD patients. Survival rate after AVR, preoperative clinical data, and surgical procedure were investigated.

In preoperative clinical features, left ventricular end-diastolic diameter was larger, intraventricular septum thickness (IVST) was thicker, left ventricular mass index (LVMI) was higher, left ventricular ejection fraction was lower, E/e' was higher, and pulmonary arterial wedge pressure (PAWP) was higher in the HD group than in the non-HD group. During a follow-up period of 3.2 ± 2.3 years after AVR, patients receiving HD had a worse prognosis than those without HD treatment: the 3-year survival rate after surgery in the HD group was 36.2% and that in the non-HD group was 84.9%. With regard to prognostic factors in the whole cohort, significant differences were found in IVST, LVMI, E/e', PAWP, and HD. In patients receiving HD, abnormally high PAWP for their right atrial pressure (RAP) was observed, suggesting that PAWP and RAP were discordant, and univariate analysis revealed that high PAWP was the only predictor of mortality in HD patients after surgery.

Preoperative PAWP with a discordant pattern in HD patients might be an important prognostic predictor after AVR.

Key words: Surgical AVR, Right heart catheterization, Prognosis

Due to the aging population in Japan, the number of elderly patients with critical aortic valve stenosis (AS) and of patients with end-stage renal disease requiring hemodialysis (HD) has been gradually increasing. The HD population in Japan is growing by about 30,000 patients annually due to the decrease in mortality rate among patients with end-stage renal disease.11 Patients undergoing HD have a high risk for the development of cardiovascular disease with calcification of cardiac valves and coronary arteries.23 AS is particularly common and has been found to be an independent risk factor for death in HD patients.230 Among HD patients with severe AS, the aortic valve replacement (AVR) strategy as compared with the conservative strategy was associated with significantly lower long-term mortality risk.23 However, regarding the clinical outcomes of HD patients with severe AS, some studies have shown that there are higher mortality and morbidity rates after surgical AVR.2,5-7 Although HD patients with severe AS are known to have a poor outcome, the prognostic factor after AVR is unclear in HD patients with severe AS.4,5,7-10

The purpose of this study was to evaluate preoperative clinical features and clarify the prognostic factors in HD patients with severe AS.

Methods

Subjects: We retrospectively investigated 109 consecutive patients with severe AS who underwent surgical AVR at Kochi Medical School Hospital between June 2007 and January 2016.

Clinical evaluation: Echocardiographic measurements were made in accordance with the American Society of Echocardiography guidelines.25 Left ventricular end-diastolic diameter (LVEDD), left ventricular end-systolic diameter, intraventricular septum thickness (IVST), and
left atrial diameter were assessed by two-dimensional measurements in the parasternal long axis view. Left ventricular ejection fraction (LVEF) was M-mode using the Teichholz formula or biplane volumetric Simpson method. LV mass index was calculated by the following formula: LV mass index (LVMi) = (0.8 × [1.04[(LVEDD + IVST + Posterior wall thickness)³ – LVEDD³] + 0.6]) / body surface area (BSA). Mitral inflow velocities were determined using pulsed-wave Doppler with the sample volume positioned at the tops of the mitral leaflets in the four chamber view. Peak early (E) transmitral filling velocities were measured. Tissue Doppler imaging was performed in the pulse-Doppler mode to allow for a spectral display and recording of mitral annulus velocities at septal corners. Peak early diastolic (e') velocity was measured, and the E/e' ratio was calculated.

Severe AS was defined as critical stenosis in the aortic valve area (AVA) ≤ 1.0 cm² (by the standard continuous equation), peak aortic velocity ≥ 4.0 m/second, or mean transaortic pressure gradient ≥ 40 mmHg measured by transthoracic echocardiography according to the American College of Cardiology/American Heart Association recommendations. Aortic regurgitation (AR), mitral regurgitation (MR), and tricuspid regurgitation (TR) were evaluated in accordance with the American College of Cardiology/ American Heart Association 2006 guidelines. AR, MR, TR were considered to be clinically significant when these degrees were moderate or severe.

The preoperative factors that were studied were age, gender, BSA, New York Heart Association (NYHA) functional class, comorbidities, medications, history of heart failure hospitalization, electrocardiographic and transthoracic echocardiographic findings, and right heart catheter data. We also investigated EuroSCORE II and surgical procedures, such as mechanical or bioprosthetic valve, isolated AVR, AVR + coronary artery bypass grafting, and AVR + mitral valve replacement (MVR) or plasty (MVP). The primary outcome was all cause mortality after surgery.

**Statistical analysis:** Data are expressed as mean ± standard deviation or frequency (percentage). Clinical characteristics in the HD and non-HD groups were compared by using Student’s t-test for normally distributed variables. Pearson’s chi-square test was used for comparisons of categorical variables, and Fisher’s exact test was used when the expected frequency was lower than five. The univariate Cox proportional hazards model was used to analyze the relationship between survival and prognostic indices. Event-free survival curves were also constructed with Kaplan-Meier estimates and compared by use of the log-rank test. The identification of the optimal cut off values for the survival was evaluated using the receiver operating characteristic (ROC) curves. A probability value of < 0.05 was considered significant. All statistical analyses were performed using SPSS version 21 (IBM Corporation, Armonk, NY).

**Results**

**Baseline characteristics in the HD and non-HD group:** Baseline characteristics are summarized in Table I. There were 18 HD patients and 91 non-HD patients. The duration of HD was 7.7 ± 4.6 years (range, 2-20 years). The overall mean age of the patients was 77.8 ± 7.5 years (range, 54-91 years), and 44 (40%) of the patients were male. Thirty-eight patients (35%) were preoperative NYHA class III or IV, and 23 patients (21%) had atrial fibrillation. Among comorbidities, old myocardial infarction was more frequently seen in the HD group than in the non-HD group. There were no significant differences

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**Table I. Characteristics of 109 Patients with Severe AS**

| Characteristic                        | Total (n = 109) | HD group (n = 18) | Non-HD group (n = 91) | P value |
|---------------------------------------|----------------|------------------|-----------------------|---------|
| Age, years                            | 77.8 ± 7.5     | 76.3 ± 5.9       | 78.1 ± 7.8            | 0.351   |
| Gender: male, n (%)                   | 44 (40%)       | 8 (44%)          | 36 (40%)              | 0.739   |
| BSA, m²                               | 1.47 ± 0.16    | 1.47 ± 0.14      | 1.48 ± 0.16           | 0.820   |
| eGFR, mL/minute/1.73 m²               | ***            | ***              | ***                   | ***     |
| Hypertension, n (%)                   | 85 (78%)       | 15 (83%)         | 70 (77%)              | 0.758   |
| Diabetes mellitus, n (%)              | 27 (25%)       | 8 (44%)          | 19 (21%)              | 0.069   |
| OMI, n (%)                            | 8 (7%)         | 4 (22%)          | 4 (4%)                | 0.024   |
| CVA, n (%)                            | 22 (20%)       | 6 (33%)          | 16 (18%)              | 0.194   |
| COPD, n (%)                           | 5 (5%)         | 0 (0%)           | 5 (5%)                | 0.588   |
| ACEI / ARB, n (%)                     | 54 (49%)       | 7 (39%)          | 47 (52%)              | 0.323   |
| Beta-blockers, n (%)                  | 20 (18%)       | 6 (33%)          | 14 (15%)              | 0.095   |
| Pre-operative NYHA class III or IV, n (%) | 38 (35%)   | 8 (44%)          | 30 (33%)              | 0.350   |
| Atrial fibrillation, n (%)            | 23 (21%)       | 7 (39%)          | 16 (18%)              | 0.058   |
| History of heart failure hospitalization, n (%) | 19 (17%) | 5 (28%) | 14 (15%) | 0.304 |
| Mechanical valve, n (%)               | 15 (14%)       | 2 (11%)          | 13 (14%)              | 1.000   |
| AVR + CABG, n (%)                     | 45 (41%)       | 10 (56%)         | 35 (38%)              | 0.178   |
| AVR + MVR or MVP, n (%)               | 4 (4%)         | 1 (6%)           | 3 (3%)                | 0.520   |
| EuroSCORE II, %                       | 5.28 ± 3.71    | 6.31 ± 4.18      | 5.08 ± 3.62           | 0.200   |

Data are shown as mean ± SD or number (percent). AS indicates aortic valve stenosis; HD, hemodialysis; BSA, body surface area; eGFR, estimated glomerular filtration rate; OMI, old myocardial infarction; CVA, cerebrovascular accidents; COPD, chronic obstructive pulmonary disease; ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin II receptor blocker; NYHA, New York Heart Association; AVR, aortic valve replacement; CABG, coronary artery bypass grafting; MVR, mitral valve replacement; and MVP, mitral valve plasty.
between the two groups in age, gender, BSA, other comorbidities, medications, preoperative NYHA class, heart rhythm, surgical procedure, valve selection, and EuroSCORE II.

In transthoracic echocardiographic data, AVA was not significantly different in the two groups as shown in Table II although peak aortic velocity and mean transaortic pressure gradient were significantly higher in the non-HD group. However, in the HD group, LVEDD was larger, LVEF was lower, IVST was thicker, left ventricular mass index (LVMI) was higher, E/e' (septal) was higher, and the proportion of significant MR was higher than those in the non-HD group.

Table II also shows right heart catheter data. With regard to the timing of right heart catheter study in the 18 HD patients, right heart catheterization was performed the day after HD in 15 patients and 2 days after dialysis in three patients. The mean time interval between the dates of right heart catheterization and echocardiography was 8.6 ± 11.6 days. Pulmonary arterial wedge pressure (PAWP) was higher in the HD group than in the non-HD group. On the other hand, right atrial pressure (RAP) was not significantly different in the two groups.

**Survival rate after aortic valve replacement and prognostic factors:** During a follow-up period of 3.2 ± 2.3 years after AVR, 10 of the 18 HD patients died: there were 7 cardiovascular deaths, 2 non-cardiovascular deaths (pneumonia and sepsis), and 1 unknown death. Patients receiving HD had a worse prognosis than patients without HD treatment: the postoperative 3-year survival rate in the HD group was 36.2% and that in the non-HD group was 84.9% (P < 0.001) (Figure 1). In the HD group, one patient underwent AVR + MVR among five patients with preoperative significant MR. In the resting four patients with significant MR, degree of MR improved to mild after isolated AVR.

When we divided all of the patients into two groups, a death group (n = 29) and a survival group (n = 80), there were several clinical determinants in the two groups (Table III). Significant differences were found in IVST, LVMI, E/e', PAWP, and presence of HD.

**Prognostic factors in HD patients after aortic valve replacement:** Four factors that were related to death in all of the patients were analyzed only for the HD group. The univariate Cox proportional hazard analysis showed that the independent determinant of death in HD patients after AVR was preoperative PAWP (Table IV). When we divided the HD patients into two groups according to each cut off value of IVST, LVMI, E/e' and PAWP determined using the ROC curves, only high PAWP was a risk factor in patients with HD (Figure 2). Compared with patients with preoperative PAWP ≤ 15 mmHg, patients with PAWP

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### Table II. Echocardiographic Parameters and Right Heart Catheter Data of 108 Patients with Severe AS

| Echocardiographic parameters | Total (n = 109) | HD group (n = 18) | Non-HD group (n = 91) | P value |
|-----------------------------|----------------|-----------------|----------------------|--------|
| LVEDD, mm                   | 46.5 ± 5.9     | 51.2 ± 6.8      | 45.6 ± 5.3           | <0.001 |
| LVEDD, mm                   | 29.7 ± 7.5     | 35.1 ± 9.0      | 28.6 ± 6.8           | 0.009  |
| LVEF, %                     | 62.6 ± 14.7    | 55.7 ± 14.7     | 63.9 ± 14.4          | 0.029  |
| AVA, cm²                    | 0.73 ± 0.17    | 0.72 ± 0.16     | 0.73 ± 0.18          | 0.686  |
| Peak aortic velocity, m/second | 4.69 ± 0.66 | 4.33 ± 0.56     | 4.77 ± 0.66          | 0.009  |
| Mean transaortic PG, mmHg   | 52.5 ± 15.7    | 42.8 ± 13.8     | 54.4 ± 15.4          | 0.003  |
| IVST, mm                    | 12.3 ± 1.9     | 13.2 ± 2.0      | 12.1 ± 1.8           | 0.021  |
| LVMI, g/m²                  | 190.3 ± 51.5   | 242.3 ± 60.5    | 180.0 ± 43.3         | <0.001 |
| LA, mm                      | 43.1 ± 7.4     | 46.8 ± 6.3      | 42.4 ± 7.4           | 0.020  |
| E/e'                        | 8.6 ± 11.6     | 28.2 ± 14.4     | 19.1 ± 7.3           | 0.017  |
| AR, n (%)                   | 10 (9%)        | 6 (3%)          | 6 (3%)               | 0.617  |
| MR, n (%)                   | 8 (7%)         | 2 (11%)         | 6 (7%)               | 0.617  |
| TR, n (%)                   | 7 (5%)         | 1 (6%)          | 4 (4%)               | 1.0    |

**Right heart catheter parameters**

| PAWP, mmHg                   | 11.7 ± 5.4     | 14.9 ± 5.5      | 11.0 ± 5.2           | 0.005  |
| SPAP, mmHg                   | 31.4 ± 10.1    | 35.2 ± 10.8     | 30.6 ± 9.9           | 0.082  |
| DPAP, mmHg                   | 11.9 ± 4.9     | 13.8 ± 5.1      | 11.5 ± 4.7           | 0.062  |
| MPAP, mmHg                   | 19.2 ± 7.2     | 21.9 ± 6.9      | 18.6 ± 7.2           | 0.079  |
| RAP, mmHg                    | 4.3 ± 2.3      | 3.7 ± 2.4       | 4.4 ± 2.2            | 0.220  |
| C.O, L/minutes               | 4.2 ± 1.0      | 4.5 ± 1.3       | 4.1 ± 1.0            | 0.147  |
| C.I, L/minute/m²             | 2.9 ± 0.7      | 3.1 ± 0.8       | 2.8 ± 0.6            | 0.121  |
| Ao SBP, mmHg                 | 126.8 ± 28.0   | 124.9 ± 24.6    | 127.2 ± 29.0         | 0.763  |
| DBP, mmHg                    | 61.8 ± 10.6    | 61.1 ± 8.9      | 61.9 ± 11.1          | 0.758  |
| HR, beat/minute              | 68.3 ± 12.6    | 70.3 ± 15.3     | 67.8 ± 12.0          | 0.457  |

Data are shown and mean ± SD. AS indicates aortic valve stenosis; HD, hemodialysis; LVEDD, left ventricular end-diastolic dimension; LVEDS, left ventricular end-systolic dimension; LVEF, left ventricular ejection fraction; AVA, aortic valve area; PG, pressure gradient; IVST, interventricular septum thickness; LVMI, left ventricular mass index; LA, left atrial; E/e', early transmitral flow velocity to early diastolic velocity; AR, aortic regurgitation; MR, mitral regurgitation; TR, tricuspid regurgitation; PAWP, pulmonary arterial wedge pressure; SPAP, systolic pulmonary arterial pressure; DPAP, diastolic pulmonary arterial pressure; MPAP, mean pulmonary arterial pressure; RAP, right atrial pressure; C.O, cardiac output; C.I, cardiac index; Ao, aorta; SBP, systolic blood pressure; and DBP, diastolic blood pressure.
> 15 mmHg showed worse survival rate. Furthermore, there was no significant difference of mortality rate between HD patients with PAWP ≤ 15 mmHg and non-HD patients (log rank \( P = 0.167 \)).

With regard to the relationship between left-sided and right-sided filling pressures, in this study, the relationship of mean PAWP = \( (2.3 \times \text{RAP} - 1.4) \) was almost applicable to the non-HD group (Figure 3). However, in the HD group, PAWP was higher than \( (2.3 \times \text{RAP} - 1.4) \) in many cases.

**Discussion**

The results of this retrospective study suggested that (1) HD patients with severe AS had a poor prognosis than non-HD patients after AVR and (2) the prognosis of HD patients was closely related to preoperative PAWP.

Kawase, et al. reported that HD patients with severe AS had a significantly poorer prognosis than non-HD patients with severe AS. Other previous studies also showed that HD patients had a poor prognosis after AVR. Those studies suggested that HD was an important prognostic factor, but the reason for HD being associated with poorer prognosis remains unclear. In this study, preoperative PAWP value seemed to be an important factor associated with the mortality of HD patients after AVR. High PAWP is commonly regarded as an indicator of left heart disease, and normal PAWP is usually less than 15 mmHg. With regard to the relationship between left-sided and right-sided filling pressures, Drazner, et al. found that PAWP could be estimated as \( (2.3 \times \text{RAP} - 1.4) \) in heart failure patients. This demonstrated that PAWP and RAP were significantly correlated and were often concordant (either both elevated or both not elevated). In this study, patients receiving HD showed abnormally high PAWP for their RAP, suggesting that PAWP and RAP were discordant.

In our study, preoperative PAWP > 15 mmHg was an important risk factor in HD patients with severe AS, and most of the patients receiving HD showed high PAWP with a discordant pattern. HD patients with PAWP > 15 mmHg may have irreversible left heart disease and that it may not be improved even if pressure load is released after AVR due to LV hypertrophy or diastolic dysfunction. As a result, HD patients with severe AS could have a poor postoperative prognosis. We also found that there was no significant difference of survival rate between HD patients with PAWP ≤ 15 mmHg and non-HD patients. From these results, if patients undergo surgery before PAWP elevation, there is a possibility that postoperative prognosis may be improved even if they are receiving HD. With regard to the mechanism of the discordant pattern in HD patients, it is not fully understood. We speculate that both more increased afterload due to harder blood vessels and more decreased LV function in patients with HD might lead to high PAWP with a discordant pattern than those in patients without HD treatment. In addition, water removal by HD might work more directly in the systemic congestion than in the pulmonary congestion.

There are several limitations to be acknowledged in the present study. First, the number of subjects was small and some of the statistical analyses might have been affected. Unfortunately, multivariate analysis was not used to evaluate the prognostic values of the clinical profiles due to the small sample number. However, to the best of our knowledge, this is the first report on evaluation of right heart catheter data, including PAWP in HD patients with severe AS. If the sample size was larger, other factors might have reached statistical significance. Non-invasive prognostic markers, such as echocardiographic indices, need to be identified to determine the appropriate timing of AVR for HD patients with severe AS. Second,
In conclusion, despite similar valve orifice areas, HD patients showed a poor clinical outcome after AVR than non-HD patients. Patients receiving HD showed higher the timing of right heart catheter study after dialysis in the HD group and the time interval between the dates of echocardiography and right heart catheterization were not at a fixed timing. These time differences might influence our results. Finally, due to the retrospective design of the study, it is possible that there is a selection bias, although the study population consisted of consecutive patients undergoing AVR.

In conclusion, despite similar valve orifice areas, HD patients showed a poor clinical outcome after AVR than non-HD patients. Patients receiving HD showed higher PAWP with a discordant pattern, and preoperative high PAWP was an important risk factor for the prognosis.

### Table III. Characteristics, Echocardiographic Parameters, Right Heart Catheter Data, and Surgical Procedure: Survival Versus Death Group

|                      | Survival group (n = 80) | Death group (n = 29) | P value |
|----------------------|------------------------|---------------------|---------|
| Age, years           | 77.6 ± 8.3             | 78.0 ± 5.0          | 0.870   |
| BSA, m²              | 1.48 ± 0.16            | 1.46 ± 0.17         | 0.670   |
| Hypertension, n (%)  | 60 (75%)               | 25 (86%)            | 0.212   |
| Diabetes mellitus, n (%) | 18 (23%)            | 9 (31%)             | 0.362   |
| OMI, n (%)           | 6 (8%)                 | 2 (7%)              | 1.0     |
| CVA, n (%)           | 15 (19%)               | 7 (24%)             | 0.536   |
| COPD, n (%)          | 4 (5%)                 | 1 (3%)              | 1.0     |
| ACEI / ARB, n (%)    | 43 (54%)               | 11 (38%)            | 0.144   |
| Beta-blockers, n (%) | 14 (18%)               | 6 (21%)             | 0.704   |
| LVEDD, mm            | 46.5 ± 5.5             | 46.5 ± 7.0          | 0.997   |
| LVEDD, mm            | 29.6 ± 7.7             | 29.9 ± 7.2          | 0.829   |
| LVEF, %              | 62.6 ± 15.4            | 62.3 ± 12.8         | 0.930   |
| AVA, cm²             | 0.73 ± 0.17            | 0.74 ± 0.19         | 0.770   |
| Peak aortic velocity, m/second | 4.74 ± 0.66      | 4.56 ± 0.72         | 0.212   |
| Mean transaortic PG, mmHg | 53.4 ± 14.7         | 50.0 ± 18.1         | 0.318   |
| IVST, mm             | 11.9 ± 1.9             | 13.4 ± 1.5          | <0.001  |
| LVMI, g/m²           | 182.8 ± 45.0           | 211.0 ± 63.5        | 0.034   |
| LA, mm               | 43.0 ± 6.7             | 43.3 ± 9.2          | 0.874   |
| E/e'                 | 19.5 ± 7.1             | 23.6 ± 13.7         | 0.048   |
| PAWP, mmHg           | 11.0 ± 3.6             | 13.7 ± 5.8          | 0.020   |
| MPAP, mmHg           | 18.4 ± 6.9             | 21.2 ± 7.7          | 0.080   |
| RAP, mmHg            | 4.3 ± 2.3              | 4.4 ± 2.1           | 0.872   |
| C.O, L/minutes       | 4.2 ± 1.0              | 4.3 ± 1.1           | 0.403   |
| C, I, L/minute/m²    | 2.8 ± 0.6              | 3.0 ± 0.7           | 0.257   |
| AR, n (%)            | 7 (9%)                 | 1 (3%)              | 0.679   |
| MR, n (%)            | 6 (8%)                 | 4 (14%)             | 0.452   |
| TR, n (%)            | 3 (4%)                 | 2 (7%)              | 0.607   |
| AVR + CAGB, n (%)    | 33 (41%)               | 12 (41%)            | 0.990   |
| EuroSCORE II, %      | 5.2 ± 3.9              | 5.4 ± 3.1           | 0.865   |
| HD, n (%)            | 8 (10%)                | 10 (34%)            | 0.006   |

Data are shown and mean ± SD. BSA indicates body surface area; OMI, old myocardial infarction; CVA, cerebrovascular accidents; COPD, chronic obstructive pulmonary disease; ACEI, angiotensin-converting-enzyme inhibitor; ARB, angiotensin II receptor blocker; LVEDD, left ventricular end-diastolic dimension; LVEDD, left ventricular end-systolic dimension; LVEF, left ventricular ejection fraction; AVA, aortic valve area (the standard continuity equation); PG, pressure gradient; IVST, interventricular septum thickness; LVMI, the left ventricular mass index; LA, left atrial: E/e', early transmural flow velocity to early diastolic velocity; PAWP, pulmonary arterial wedge pressure; MPAP, mean pulmonary arterial pressure; RAP, right atrial pressure; C.O, cardiac output; C.I, cardiac index; AR, aortic regurgitation; MR, mitral regurgitation; TR, tricuspid regurgitation; AVR, aortic valve replacement; CAGB, coronary artery bypass graft; MVR, mitral valve replacement; MVP, mitral valve plasty; and HD, hemodialysis.

### Table IV. Predictors of Death in HD Patients After AVR: Univariate Cox Proportional Hazard Analysis

| Hazard ratio (95% CI) | P value |
|-----------------------|---------|
| IVST                  | 1.190 (0.857—1.652) | 0.298 |
| LVMI                  | 0.999 (0.987—1.011) | 0.863 |
| E/e'                  | 1.018 (0.974—1.064) | 0.422 |
| PAWP                  | 1.134 (1.010—1.272) | 0.034 |

HD indicates hemodialysis; AVR, aortic valve replacement; IVST, interventricular septum thickness; LVMI, left ventricular mass index; and PAWP, pulmonary artery wedge pressure.
Figure 2. A: Kaplan-Meier curves of cumulative survival rate for HD patients with high IVST values (> 13 mm) versus patients with low IVST values (≤ 13 mm). B: Kaplan-Meier curves of cumulative survival rate for HD patients with high LVMI values (≥ 236 g/m²) versus patients with low LVMI values (< 236 g/m²). C: Kaplan-Meier curves of cumulative survival rate for HD patients with high E/e’ values (≥ 27) versus patients with low E/e’ values (< 27). D: Kaplan-Meier curves of cumulative survival rate for HD patients with high PAWP values (> 15 mmHg) versus patients with low PAWP values (≤ 15 mmHg).

HD indicates hemodialysis; IVST, interventricular septum thickness; LVMI, left ventricular mass index; and PAWP, pulmonary arterial wedge pressure.

Figure 3. Scatterplot showing PAWP and RAP. “PAWP = (2.3 × RAP - 1.4)” is the relationship between PAWP and RAP in heart failure patients (Drazner, et al. 14). PAWP indicates pulmonary arterial wedge pressure and RAP indicates right atrial pressure.

Disclosure

Conflicts of interest: None of the authors have conflict of interest to disclose in connection with our manuscript.

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