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ORIGINAL ARTICLE

Artificial Valve

Heart valve surgery in hemodialysis-dependent patients: nutrition status impact on surgical outcome

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Abstract Valve surgery in hemodialysis-dependent patients is associated with postoperative complications and a high mortality rate, and such patients frequently suffer cachexia. This study aimed to determine pre- and intraoperative risk factors associated with in-hospital mortality and long-term survival in hemodialysis-dependent patients undergoing heart valve surgery from the viewpoint of nutrition status. Eighty-seven hemodialysis-dependent patients who underwent valve surgery between January 1998 and October 2015 were retrospectively reviewed. Thirty-seven potential perioperative risk factors were evaluated. The in-hospital mortality rate was 12.6 % (11 patients). Univariate analysis identified New York Heart Association Functional Classification III or IV, emaciation (body mass index <17.6 kg/m^2), total cholesterol <120 mg/dl, serum albumin <3.0 mg/dl, emergent/urgent surgery, and intraoperative blood transfusion >3000 ml as predictors of in-hospital death. Multivariate logistic regression analysis confirmed low serum albumin <3.0 mg/dl (hazard ratio 7.22; $p = 0.032$) and emergent/urgent operation (hazard ratio 43.57; $p = 0.035$) as independent predictors of in-hospital death. The 1- and 3-year actuarial survival rates were 64.9 ± 5.4 and 51.8 ± 5.8 %, respectively. Long-term survival estimated by log-rank test was negatively impacted by anemia (hemoglobin <10 mg/dl), low serum albumin, emergent/urgent operation, and infective endocarditis. Multivariate analysis using Cox proportional hazards modeling indicated low serum albumin (hazard ratio 2.12; $p = 0.047$) and emergent/urgent operation (hazard ratio 8.97; $p = 0.0002$) as independent predictors of remote death. Hypoalbuminemia and emergent/urgent operation are strong predictors of in-hospital and remote death. Malnutrition before surgery should be considered for operative risk estimation, and adequate preoperative nutrition management may improve surgical outcomes for hemodialysis-dependent patients.

Keywords Heart valve replacement · Kidney · Renal function failure · Nutrition

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Introduction

Metabolic imbalance of calcium and phosphate caused by hemodialysis (HD) promotes severe calcification of heart valves and surrounding tissues leading to valvular diseases [1–3], and a main cause of death of HD-dependent patients is cardiovascular events. End-stage renal disease prevalence is increasing rapidly, with approximately 314,000 HD patients in Japan [4]. Accordingly, HD-dependent patients are increasingly referred for cardiac surgery owing to cardiac symptoms and hemodynamic instability during HD. However, cardiac surgery in HD patients is associated with high mortality and morbidity. In HD-dependent patients, severe atherosclerosis, immune system suppression, and delayed wound healing are commonly observed and affect surgical outcomes. The use of cardiopulmonary bypass amplifies these adverse effects. Although off-pump coronary artery bypass grafting, which avoids adverse effects of cardiopulmonary bypass, has improved the surgical outcomes for coronary surgery in HD-dependent patients [5, 6], valvular surgery outcome in HD-dependent patients remains poor [7–13].

Malnutrition is common in chronic kidney disease (CKD) patients. In HD-dependent patients requiring heart valve surgeries, cachexia is frequently observed and associated with several comorbidities [3]. Although malnutrition may be associated with increased surgical mortality in HD-dependent patients, surgical risk analysis from the viewpoint of patients' nutritional status has not been performed. The aim of this study was to determine the impact of preoperative nutrition status on in-hospital mortality and long-term survival.

Patients and methods

The institutional review board approved this retrospective observational study, and the approval included a waiver of informed consent.

Among 1454 consecutive patients who underwent valvular surgery at Jichi Medical University Hospital between January 1998 and October 2015, 87 patients (6.0 %, 58 men and 29 women) were chronic HD-dependent patients (peritoneal dialysis patients were excluded from this study). The mean age of these patients was 66 ± 10 years (range 33–82 years). Mean body surface area was 1.5 ± 0.2 m^2 (range 1.17–1.88 m^2). Mean body mass index (BMI) was 20.3 ± 3.2 kg/m^2 (range 15.5–31.5 kg/m^2). According to the New York Heart Association (NYHA) Functional Classification, 6 patients were class I, 54 class II, 18 class III, and 9 class IV. Left ventricular ejection fraction was 54 ± 15 % (range 15–86 %), and left ventricular end-systolic volume index was 67 ± 43 ml/m^2 (range 18–220 ml/m^2).

In 33 patients (38 %), renal failure was primarily due to diabetes. Non-diabetic nephropathy was observed in 54 patients (62 %), including chronic glomerulonephritis in 18, nephrosclerosis in 10, systemic lupus erythematosus in 3, polycystic kidney in 3, IgA nephropathy in 2, others in 4, and unknown in 14. Preoperatively, all patients were maintained on HD. The mean dialysis duration was 104 ± 85 months (range 1–432 months) prior to undergoing valvular surgery.

Among nutrition parameters, mean total cholesterol was 158 ± 38 (62–245) mg/dl, mean total protein was 6.7 ± 0.7 (5.0–8.9) g/ml, and mean serum albumin was 3.4 ± 0.5 (1.9–4.4) g/ml. Mean hemoglobin was 10.2 ± 1.4 mg/dl, and calcium phosphate product was 45 ± 13 (13–77). Risk evaluation by EuroSCORE II ranged from 0.95 to 61.88 (mean 6.01 ± 8.23).

Surgical procedures

The surgical procedures are listed in Table 1. Single-valve surgery with or without tricuspid annuloplasty was performed in 39 patients (aortic valve in 32, mitral in 6, and tricuspid in 1), double-valve surgery in 11, apico-aortic bypass in 4, and root replacement in 2. Combined surgeries were performed in 31 patients (coronary artery bypass grafting in 27, aortic surgery in 2, and congenital surgery in 2). Surgical indications in this series were identical to those for non-HD patients. Mechanical heart valves were mainly selected: mechanical prostheses for 75 patients, bioprostheses for 8, and annular ring for annuloplasty for 4. Operation time was 359 ± 111 (191–705) min, cardiopulmonary bypass time was 205 ± 74 (103–447) min, and aortic cross-clamp time was 133 ± 57 (32–327) min.

Table 1 Surgical procedures

Procedures	No. of patients (repeat surgery)	No. of hospital deaths (repeat surgery)
AVR (+TAP)	32 (1)	3 (0)
+CABG	15	3 (0)
+Ascending aorta (arch) replacement	2	
+PDA closure	1	
MVR (+TAP)	6	1 (0)
+CABG	4	1 (0)
MVP	0	
+CABG	2	
+VSD closure	1	
AVR + MVR (+TAP)	11 (1)	
+CABG	6 (1)	1 (0)
Root replacement	2	
TAP	1	
Apico-aortic bypass	4 (1)	2 (0)

AVR aortic valve replacement, *TAP* tricuspid annuloplasty, *CABG* coronary artery bypass grafting, *PDA* patent ductus arteriosus, *MVR* mitral valve replacement, *VSD* ventricular septal defect

Surgical techniques

Surgery was performed through a median sternotomy, except for four cases of apico-aortic bypass procedure performed through a left anterolateral thoracotomy. Patients underwent surgery under moderate to mild hypothermic cardiac arrest with standard cardiopulmonary bypass (apico-aortic bypass was performed under ventricular fibrillation). Cold blood cardioplegic solution was administered in an antegrade or retrograde manner. To deal with severe calcification of the valve, we used ultrasonic surgical device. For severe calcification extended to the aorta (porcine aorta), we performed apico-aortic bypass procedure in four patients. HD was performed on the day before surgery by the standard method. We performed hemofiltration using hemoconcentrator incorporated with the circuit to deal with excess hemodilution during cardiopulmonary bypass. Washed red blood cells treated with Cell Saver® autotransfusion system (Haemonetics Corporation, Braintree, MA, USA) were used to avoid hyperkalemia associated with blood transfusion during surgery. Intraoperative HD was not performed routinely. After surgery, most patients resumed routine intermittent HD in the intensive care unit on the first postoperative day, except for those with hemodynamic instability or advanced hyperkalemia, who alternatively underwent continuous venovenous hemofiltration/hemodiafiltration.

Data collection and follow-up

Mortality was defined as death for any reason during follow-up. Outcome data were obtained through patient follow-up. Patients were either examined at our outpatient clinic or contacted by telephone. Seventy-six patients were followed up (follow-up rate 97 %). The time between operation and examination or other contact ranged from 0 to 126 months (mean 27 ± 29 months).

Statistical analysis

Preoperative and operative data were gathered from clinical records, and 37 perioperative variables were selected for the determination of risk factors for in-hospital mortality (Tables 2, 3). Emergent/urgent operation was defined

Table 2 Preoperative patient characteristics (results of univariate analysis)

Variables	Early			Late		
	Survived ($n = 76$)	Died ($n = 11$)	p value[a]	Alive ($n = 37$)	Died ($n = 48$)[b]	p value
Age >70 years	28 (37 %)	6 (55 %)	0.327	15 (41 %)	18 (38 %)	0.792
Male sex	51 (67 %)	7 (63 %)	>0.999	24 (65 %)	33 (69 %)	0.567
BSA >1.5	47 (61 %)	5 (46 %)	0.338	25 (68 %)	27 (56 %)	0.527
HD duration >100 months	36 (47 %)	2 (18 %)	0.104	18 (49 %)	19 (40 %)	0.684
Diabetes nephropathy	29 (38 %)	4 (36 %)	>0.999	17 (46 %)	14 (29 %)	0.456
Smoking	25 (33 %)	4 (36 %)	>0.999	8 (22 %)	20 (42 %)	0.496
Severe calcified ascending aorta	6 (8 %)	3 (27 %)	0.083	1 (3 %)	8 (17 %)	0.170
Atrial fibrillation	8 (11 %)	0 (0 %)	0.589	3 (8 %)	5 (10 %)	0.359
LV ejection fraction <30 %	4 (5 %)	2 (18 %)	0.165	3 (8 %)	3 (6 %)	0.950
LV ESVI >70 ml/m^2	19 (25 %)	3 (27 %)	>0.999	8 (22 %)	13 (27 %)	0.799
NYHA functional class III, IV	19 (25 %)	8 (73 %)	0.003*	12 (32 %)	15 (31 %)	0.400
Associated disease						
Ischemic heart disease	32 (42 %)	7 (63 %)	0.209	16 (43 %)	22 (46 %)	0.593
Hypertension	60 (79 %)	9 (82 %)	>0.999	30 (81 %)	38 (79 %)	0.551
Hyperlipidemia	22 (29 %)	1 (9 %)	0.275	9 (24 %)	13 (27 %)	0.615
Cerebrovascular accident	15 (20 %)	4 (36 %)	0.246	5 (14 %)	13 (27 %)	0.224
PAD	19 (25 %)	2 (10 %)	>0.999	9 (24 %)	11 (23 %)	0.333
Chronic lung disease[c]	3 (4 %)	2 (18 %)	0.118	1 (3 %)	4 (8 %)	0.592
Liver dysfunction[d]	6 (9 %)	1 (9 %)	>0.999	2 (5 %)	4 (8 %)	0.931
Nutrition status						
Obesity (BMI >24 kg/m^2)	11 (15 %)	2 (18 %)	0.667	6 (16 %)	7 (15 %)	0.578
Emaciation (BMI <17.6 kg/m^2)	12 (16 %)	5 (45 %)	0.035*	7 (19 %)	9 (19 %)	0.366
Anemia (Hb <10.0 mg/dl)	44 (58 %)	4 (36 %)	0.209	8 (22 %)	31 (65 %)	0.006*
Total cholesterol <120 mg/dl	10 (13 %)	6 (55 %)	0.004*	6 (16 %)	10 (21 %)	0.327
Total protein <6.0 g/ml	8 (11 %)	3 (27 %)	0.141	5 (14 %)	6 (13 %)	0.829
Serum albumin <3.0 g/ml	10 (13 %)	7 (64 %)	0.001*	1 (3 %)	16 (33 %)	<0.001*
Ca × Pi >60	11 (14 %)	0 (0 %)	0.345	7 (19 %)	4 (8 %)	0.117

BSA body surface area, *HD* hemodialysis, *LV* left ventricular, *ESVI* end-systolic volume index, *NYHA* New York Heart Association, *PAD* peripheral artery disease, *COPD* chronic obstructive pulmonary disease, *BMI* body mass index, *Hb* hemoglobin, *Ca × Pi* calcium phosphate product

* $p < 0.05$

[a] p values for each variable with regard to hospital mortality

[b] Including in-hospital mortality. Two patients fall from the follow-up survey (follow-up rate 97 %)

[c] Defined by long-term use of bronchodilators or steroids for lung disease

[d] Defined by serum aspartate transaminase and alanine aminotransaminase >35 IU/l

Table 3 Operative variables (results of univariate analysis)

Variables	Early			Late		
	Survived ($n = 76$)	Died ($n = 11$)	p value[a]	Alive ($n = 37$)	Died ($n = 48$)[b]	p value
Emergent/urgent operation	1 (1 %)	3 (27 %)	0.006*	0 (0 %)	4 (8 %)	<0.0001*
Infective endocarditis	4 (5 %)	2 (18 %)	0.165	1 (3 %)	5 (10 %)	0.003*
Repeat surgery	4 (5 %)	0 (0 %)	>0.999	2 (5 %)	2 (4 %)	0.769
Mechanical valve replacement	68 (89 %)	8 (73 %)	0.141	33 (89 %)	41 (85 %)	0.083
Concomitant procedure	26 (34 %)	6 (54 %)	0.203	15 (41 %)	16 (33 %)	0.966
Double-valve surgery	15 (20 %)	1 (9 %)	0.681	5 (14 %)	11 (23 %)	0.711
Mitral valve surgery	26 (34 %)	3 (27 %)	0.745	7 (19 %)	21 (44 %)	0.272
Intraoperative BTF >3000 ml	13 (17 %)	6 (55 %)	0.012*	9 (24 %)	10 (21 %)	0.487
Operation time >360 m	26 (34 %)	7 (64 %)	0.094	9 (24 %)	10 (21 %)	0.487
CPB time >240 m	16 (21 %)	5 (45 %)	0.125	7 (19 %)	13 (27 %)	0.346
ACC time >180 m	13 (17 %)	2 (18 %)	>0.999	5 (14 %)	10 (21 %)	0.753
Intraoperative fluid balance >3000 ml	34 (45 %)	5 (45 %)	>0.999	12 (32 %)	25 (52 %)	0.669

BTF blood transfusion, *CPB* cardiopulmonary bypass, *ACC* aortic cross-clamp

* $p < 0.05$

[a] p values for each variable with regard to hospital mortality

[b] Including in-hospital mortality. Two patients fall from the follow-up survey (follow-up rate 97 %)

as cases of an operation performed within 24 h after the consultation.

In-hospital mortality of survivors ($n = 76$) and non-survivors ($n = 11$) was compared with univariate analysis. Categorical variables are presented as counts, and differences between groups were assessed by Fisher's exact test. P value <0.05 was used to identify the variables for inclusion in multivariate logistic regression analysis to predict in-hospital mortality. Overall survival was defined as the time from surgery to death from any cause. Time-related survival was estimated using the Kaplan–Meier method and compared by log-rank test, with the hazard ratio (HR) and 95 % confidence interval (CI) estimated using a multivariate Cox proportional hazards regression model. Long-term mortality prediction included in-hospital mortality. Statistical analysis was performed with StatView 5.0 (Abacus Concepts Inc., Berkeley, CA). P values <0.05 were considered statistically significant.

Results

Short-term results

The in-hospital mortality rate including operative death was 12.6 % (11 patients). The causes of in-hospital mortality were heart failure ($n = 3$ patients), aspiration pneumonia ($n = 2$), myocardial infarction ($n = 2$), mediastinitis ($n = 1$), sepsis ($n = 1$), left ventricular rupture after mitral valve replacement ($n = 1$), and cardiac tamponade ($n = 1$). The patients underwent each cardiac surgery, and the numbers of hospital deaths were enumerated in Table 1.

Twenty-nine postoperative complications occurred in 26 patients, including heart failure ($n = 5$ patients), cerebral infarction ($n = 4$), surgical wound infection ($n = 4$), pneumonia/respiratory failure ($n = 4$), myocardial infarction ($n = 2$), sepsis ($n = 2$), left ventricular rupture ($n = 2$), cardiac tamponade ($n = 2$), gastrointestinal bleeding ($n = 1$), ileus ($n = 1$), lower leg ischemia ($n = 1$), and complete atrioventricular block which required pacemaker implantation ($n = 1$).

The preoperative and operative risk factors for in-hospital death are described in Tables 2 and 3. Of the 37 variables assessed, 6 were significantly related to in-hospital death on univariate analysis: New York Heart Association Functional Classification class III or IV, emaciation (BMI <17.6 kg/m^2), total cholesterol <120 mg/dl, serum albumin (<3.0 mg/dl), emergent/urgent surgery, and massive blood transfusion during surgery (>3000 ml). Multiple logistic regression analysis confirmed low serum albumin <3.0 mg/dl (hazard ratio 7.22; $p = 0.032$) and emergent/urgent operation (hazard ratio 43.57; $p = 0.035$) as statistically significant independent risk factors for in-hospital death (Table 4).

Long-term results

Thirty-seven patients died after hospital discharge. The causes of death were withdrawal from dialysis ($n = 7$ patients), cerebral hemorrhage/infarction ($n = 6$), pneumonia ($n = 5$), heart failure ($n = 3$), myocardial infarction ($n = 2$), multiple organ failure ($n = 2$), arrhythmia

Table 4 Multivariate analysis of in-hospital mortality prediction

Variable	p value	Hazard ratio	95 % confidence interval
NYHA class III, IV	0428	2.14	0.33–13.97
Emaciation (BMI <17.6 kg/m^2)	0.102	5.71	0.71–46.14
Total cholesterol <120 mg/dl	0.119	0.19	0.02–1.54
Serum albumin <3.0 g/ml	0.032*	7.22	1.18–44.08
Emergent/urgent operation	0.035*	43.57	1.29–1467.53
Intraoperative BTF >3000 ml	0.483	0.50	0.07–3.47

NYHA New York Heart Association, *BMI* body mass index

* $p < 0.05$

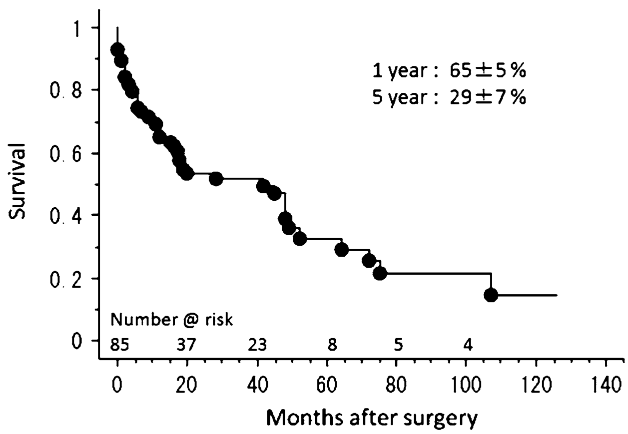

Fig. 1 Kaplan–Meier curves for long-term survival in hemodialysis-dependent patients undergoing heart valve surgery

($n = 1$), rupture of abdominal aortic aneurysm ($n = 1$), malignancy ($n = 1$), peritonitis ($n = 1$), ileus ($n = 1$), lower leg ischemia ($n = 1$), blood access trouble ($n = 1$), prosthetic valve endocarditis ($n = 1$), and unknown ($n = 4$). The 1- and 3-year actuarial survival rates including in-hospital death were 64.9 ± 5.4 and 51.8 ± 5.8 %, respectively (Fig. 1).

The preoperative and operative risk factors for late death are described in Tables 2 and 3. Univariate analysis (including hospital mortality) identified the following four risk factors as statistically significant predictors of remote death: anemia (hemoglobin <10 mg/dl), low serum albumin, emergent/urgent operation, and infective endocarditis. Multivariate analysis using Cox proportional hazards modeling confirmed low serum albumin (hazard ratio 2.12; $p = 0.047$) and emergent/urgent operation (hazard ratio 8.97; $p = 0.0002$) as statistically significant risk factors for remote death (Table 5).

Discussion

In spite of recent advances in cardiac surgery, heart valve surgery in HD-dependent patients remains associated with high mortality and morbidity on short- and long-term follow-up. Early surgical mortality rates are estimated to range from 6.7 to 29.0 % [7–13], with 3-year survival rates of approximately 28–48 % [7, 9, 10, 12]. In this series, the in-hospital mortality rate was 12.8 %, and actuarial survival rates were 66.7 and 52.5 % at 1 and 3 years, which are comparable to previous reports. The principal finding of this study is that low serum albumin concentration, usually used as an index of malnutrition, was highly associated with increased in-hospital and long-term mortality risk in HD-dependent patients. Besides hypoalbuminemia, univariate analysis indicated that emaciation (BMI <17.6 kg/m^2) and low total cholesterol (<120 mg/dl), which contribute to malnutrition status, are predictors for early death in addition to the previously reported risk factors for severe NYHA class, massive blood transfusion, and emergent surgery [6, 11, 14–16]. Furthermore, multivariate analysis identified low serum albumin as a strong risk factor, as well as emergent/urgent surgery. Regarding long-term mortality, univariate analysis also identified malnutrition factors such as low serum albumin and anemia as risk factors; moreover, multivariate analysis confirmed low serum albumin as a strong predictor.

Table 5 Multivariate analysis of long-term mortality prediction

Variable	p value	Hazard ratio	95 % confidence interval
Anemia (Hb <10.0 mg/dl)	0.214	1.52	0.79–2.95
Serum albumin <3.0 g/ml	0.047*	2.12	1.01–4.44
Emergent/urgent operation	<0.001*	8.97	2.82–28.56
Infective endocarditis	0.161	2.20	0.73–6.60

Hb hemoglobin

* $p < 0.05$

Malnutrition is believed to be common in patients with chronic renal failure [3, 17–21]. The etiology of malnutrition in chronic renal failure is complex and may include many factors including poor food intake caused by uremic toxicity-related anorexia and nausea, hormonal derangements, acidosis, and increased resting energy expenditure [20]. The coexistence of heart valve diseases and renal failure may further worsen nutritional condition because associated heart failure frequently causes digestion and absorption disorder. The combination of chronic renal failure and valvular disease may amplify deteriorated nutrition status and increase surgical risk; however, this matter has not been investigated in detail.

The current study identified hypoalbuminemia as a strong predictor for in-hospital and long-term mortality. Lowrie et al. [20] reported that low serum albumin concentration indicates malnutrition and poor prognosis in patients with renal replacement therapy. Malnutrition has also been reported to increase oxidative stress in combination with chronic inflammation, and it is possible that increased cytokine production during oxidative stress could result in an acute phase response [21, 22]. Conversely, inflammation can cause hypoalbuminemia by suppressing albumin synthesis and promoting albumin transfer from the vascular to the extravascular space in combination with reduced protein intake in CKD patients [20, 22]. Furthermore, low serum albumin levels were found to increase the risk of cardiovascular disease by the presence of an acute phase response [23]. These findings suggest a strong interaction between malnutrition and inflammation in chronic renal failure patients. Stenvinkel et al. suggested the existence of a syndrome consisting of malnutrition, inflammation, and atherosclerosis (MIA syndrome) in patients with chronic renal failure [20], pointing out that malnutrition, inflammation, and atherosclerotic cardiovascular diseases cause a vicious cycle, resulting in poor prognosis of this patient category. Indeed, chronic inflammation is more common in malnourished HD-dependent patients, and malnutrition and inflammatory response are independent predictors of hospitalization and cardiovascular mortality [3, 20]. In heart valve surgeries on HD-dependent patients, surgical insults including cardiopulmonary bypass may boost the vicious cycle of MIA syndrome and affect surgical outcomes. From the perspective of control for systemic inflammation, aggressive perioperative nutritional management should be considered to reduce the high mortality and morbidity rates in HD-dependent patients.

For perioperative management to improve outcomes of valvular surgery in HD-dependent patients, adequate patient selection based on nutritional evaluation, aggressive perioperative nutritional management, and control of chronic microinflammation associated with malnutrition should be considered. The current study indicated that serum albumin <3.0 mg/dl and emergent/urgent operation affect short- and long-term survival. These results may be relevant to patient selection. Intravenous hyperalimentation and serum albumin supply should be considered for aggressive preoperative nutrition control, in addition to the conventional nutritional interventions such as dietary care and nutritional supplements. Nutritional intervention to increase serum albumin was reported to improve outcomes in CKD patients [20]. From the perspective of chronic microinflammation associated with HD, perioperative proinflammatory cytokine control may be effective. Aggressive cytokine removal by online hemodiafiltration, continuous hemodiafiltration, or the use of polymethylmethacrylate hemofilter has potential benefits to control chronic microinflammation.

Malnutrition, which was demonstrated as a strong predictor of hospital mortality, may be closely related to infection-related complications such as mediastinitis and sepsis. Although infection-related deaths were only 2 (18 %) in this study, 10 infection-related complications (34 %) occurred. This high incidence of infection-related postoperative complications may be related to malnutrition, while we introduced prophylactic negative pressure wound therapy for high-risk patients such as HD-dependent patients to prevent postoperative surgical site infection. This effort may partially contribute low infection-related mortality rate.

There are several limitations to our study. First, it was a non-randomized and retrospective study. Second, the small sample size and relatively short-term follow-up are clear limitations. Third, this study encompasses data over a timeline of 15 years. Variability, such as surgical technique and perioperative management including HD management, can influence outcomes. Fourth, valve selection was biased, with most patients in this study receiving mechanical prostheses. Although valve selection has been reported not to influence short- and long-term survival, this issue remains controversial.

In conclusion, surgical outcomes of valvular surgeries for HD-dependent patients were poor. Our results indicated that hypoalbuminemia and emergent/urgent operation are strong predictors of in-hospital and remote death in HD-dependent patients undergoing valve surgery. Appropriate surgical strategies based on nutritional assessment and aggressive perioperative nutritional management might contribute to improvements in clinical outcomes after valvular surgery in HD-dependent patients.

Compliance with ethical standards

Conflict of interest None declared.

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