Therapeutics and Clinical Risk Management

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ORIGINAL RESEARCH

Predialysis hypotension is not a predictor for mortality in long-term hemodialysis patients: insight from a single-center observational study

This article was published in the following Dove Press journal:
Therapeutics and Clinical Risk Management
24 August 2016
Number of times this article has been viewed

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Introduction: Predialysis hypotension has been noted to be a predictor of mortality in hemodialysis (HD) patients. Previous studies evaluating the impact of predialysis hypotension on the mortality of HD patients did not exclude patients with diabetes mellitus (DM) or cardiovascular disease.

Methods: Eight hundred and sixty-six patients on maintenance HD were recruited. Clinical parameters were recorded and subjected to the analysis of predictors of predialysis hypotension and mortality.

Results: Multivariate logistic regression analyses indicated that DM (odds ratio [OR]: 0.439, P=0.002), hypertension history (OR: 0.634, P=0.022), Kt/V Daugirdas (OR: 2.545, P=0.001), anuria (OR: 2.313, P=0.002), serum phosphate (OR: 0.833, P=0.010), and serum triglyceride (OR: 1.002, P=0.012) were associated with predialysis hypotension. Multivariate Cox regression analysis showed that age (P<0.001), male sex (P=0.029), anuria (P=0.004), and DM (P=0.011) were associated with higher probability of 24- and 36-month mortality. Predialysis hypotension was not associated with higher probability of 12-, 24-, and 36-month mortality.

Conclusion: Predialysis hypotension is not a predictor of 12-, 24-, and 36-month survival in patients without DM and with higher dialysis adequacy.

Keywords: predialysis hypotension, hemodialysis, mortality

Introduction

Predialysis hypotension had been noted to be a predictor of mortality in hemodialysis (HD) patients.[1,2] The causes of predialysis hypotension include heart failure, coronary artery disease (CAD),[3,4] diabetes-related severe autonomic neuropathy,[5] and uremic autonomic neuropathy.[6,7] Autonomic dysfunction and myocardial fibrosis-related heart failure may cause sudden cardiac death in HD patients.[8] CAD is the most common cause of morbidity and mortality in HD patients.[9] Uremic neuropathy also contributes largely to the morbidity and mortality in patients with renal failure. Previous studies evaluating the impact of predialysis hypotension on the mortality of HD patients did not exclude patients with diabetes mellitus (DM) or cardiovascular disease (CVD). The aim of this study is to further clarify the correlation between predialysis hypotension and mortality in regular long-term HD patients.

Methods

The Institutional Review Board Committee of Chang Gung Memorial Hospital approved the study protocol. Written informed consent was obtained from all patients enrolled in this study. Senior nephrologists reviewed all medical records during the

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Dovepress
http://dx.doi.org/10.2147/TCRM.S111635

study period, including medical history, laboratory data, and inclusion and exclusion factors. In addition, all individual information was securely protected and was only available to the investigators. Finally, all primary data were collected according to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Patients

Study patients were recruited from the three hemodialysis centers of Chang Gung Memorial Hospital, Lin-Kou Medical Center, and Taipei and Taoyuan branches. Only maintenance HD (MHD) patients who were aged 18 years or older and had received HD for at least 6 months were enrolled in this study. Patients with malignancies or obvious infectious diseases, as well as those who had been hospitalized or had undergone surgery within 3 months of the investigation, were excluded. DM was defined by either a physician's diagnosis, antidiabetic drug treatment, or if two subsequent analyses demonstrated fasting blood glucose levels of >126 mg/dL. Most patients underwent 4 hours of hemodialysis three times a week. Hemodialysis was performed with single-use hollow-fiber dialyzers equipped with modified cellulose, polyamide, or polysulfone membranes. The dialysate used in all cases had a standard ionic composition with a bicarbonate-based buffer. We noted the incidence of CVDs including cerebrovascular disease, CAD, congestive heart failure, and peripheral vascular disease in these patients. Predialysis hypotension was defined as systolic blood pressure (SBP) <100 mmHg by at least two blood pressure measurements.[10] Hypertension was defined as the regular use of antihypertensive drugs to control blood pressure or at least two blood pressure measurements of >140/90 mmHg.

Laboratory parameters

All the blood samples were drawn from the arterial end of the vascular access immediately after the initial 2-day interval for HD and were then centrifuged and stored at −80°C until use.

Statistical analysis

Data were analyzed using SPSS, version 12.0 for Windows 95 (SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test was used to test if variables were normally distributed. A *P*-value of >0.05 was required to assume a normal distribution. Unless otherwise stated, continuous variables were expressed as mean ± standard deviation or median (interquartile range), and categorical variables were expressed as numbers or percentages. χ^2 or Fisher's exact tests were used to analyze the correlation between categorical variables. Comparisons between two groups were performed using the Mann–Whitney *U*-test and Student's *t*-test. Risk factors for predialysis hypotension were assessed by performing univariate logistic regression analysis, and all variables with $P<0.1$ were included in a multivariate analysis by applying a multiple logistic regression based on forward elimination of data. The data of intact parathyroid hormone, serum ferritin, and high-sensitivity C-reactive protein levels were log-transformed for regression analysis. Risk factors for mortality were assessed by performing univariate Cox regression analysis, and variables with $P<0.1$ were included in a multivariate analysis by applying a multiple Cox regression based on forward elimination of data.

Results

Subject characteristics

As shown in Table 1, 866 patients were included. The patients on HD were 56.18±13.59 years old, and 440 patients were male (50.8%). The average HD duration was 6.96±5.35 years. One hundred and fifty six patients (18%) had predialysis hypotension.

Comparison of clinical variables between patients with and without predialysis hypotension

A lower proportion of DM (12.8% vs 24.2%, $P=0.001$) and hypertension history (29.5% vs 41.3%, $P=0.007$) and higher proportion of anuria (88.5% vs 77.5%, $P=0.001$) were observed in patients with predialysis hypertension compared with predialysis nonhypotension patients. Furthermore, the predialysis hypotension patients had longer HD duration (8.20±5.88 vs 6.69±5.196 years, $P=0.001$), higher Kt/V Daugirdas (dialysis clearance of urea) (1.9013±0.35856 vs 1.7769±0.31696, $P<0.001$), and lower serum level of phosphate (4.579±1.3477 vs 4.902±1.3506, $P=0.007$) than predialysis nonhypotension patients (Table 2).

Clinical predictors of pre-dialysis hypotension

Univariate logistic regression identified several clinical variables that were significantly associated with predialysis hypotension (Table 3). Multivariate forward logistic regression analyses of all parameters indicated that DM (odds ratio [OR]: 0.476, 95% confidence interval [CI]: 0.283–0.803, $P=0.005$), hypertension history (OR: 0.596, 95% CI: 0.40–0.887, $P=0.011$), Kt/V Daugirdas (OR: 3.031, 95% CI: 1.713–5.363, $P<0.001$), anuria (OR: 2.204,

Table 1 Baseline characteristics of 866 MHD patients

Characteristics	Total (N=866) mean ± SD/median (interquartile range)
Demographics	
Age (years)	56.18±13.59
Male sex	440 (50.8%)
Body mass index (kg/m^2)	22.19±3.18
Smoking (yes)	150 (17.3%)
Comorbidity	
DM (yes)	192 (22.2%)
Hypertension history (yes)	339 (39.1%)
Previous CVD (yes)	41 (4.7%)
HBV (yes)	98 (11.3%)
HCV (yes)	168 (19.4%)
Predialysis hypotension (yes)	156 (18%)
Dialysis-related data	
Hemodialysis duration (years)	6.96±5.35
Erythropoietin (U/kg/week)	73.62±47.37
Fistula as blood access (yes)	689 (79.6%)
Hemodiafiltration (yes)	187 (21.6%)
Kt/V Daugirdas	1.79±0.32
nPCR (g/kg/day)	1.18±0.26
Residual daily urine of >100 mL (yes)	178 (20.6%)
Biochemical data	
Hemoglobin (g/dL)	10.51±1.36
Albumin (g/dL)	4.06±0.34
Creatinine (mg/dL)	10.88±2.39
Ferritin (μg/L)[a]	305.0 (129.57, 504.45)
Corrected-calcium (mg/dL)	9.94±0.93
Phosphate (mg/dL)	4.84±1.35
Intact parathyroid hormone (pg/mL)[a]	130.1 (52.52, 319.2)
hsCRP (mg/L)[a]	2.95 (1.4, 7.01)
Cardiovascular risks	
Cholesterol (mg/dL)	171.3±37.66
Triglyceride (mg/dL)	164.33±115.8
LDL (mg/dL)	94.83±30.59

Note: [a]Nonnormal distribution data are presented as median (interquartile range).
Abbreviations: MHD, maintenance hemodialysis; SD, standard deviation; DM, diabetes mellitus; CVD, cardiovascular disease; HBV, hepatitis B virus infection; HCV, hepatitis C virus infection; nPCR, normalized protein catabolic rate; hsCRP, high-sensitivity C-reactive protein; LDL, low-density lipoprotein; Kt/V urea, dialysis clearance of urea.

95% CI: 1.288–3.772, *P*=0.004), hemoglobin (OR: 1.178, 95% CI: 1.029–1.349, *P*=0.018), serum phosphate (OR: 0.826, 95% CI: 0.717–0.952, *P*=0.008), and serum triglyceride (OR: 1.002, 95% CI: 1.001–1.004, *P*=0.008) were associated with predialysis hypotension. Multivariate forward logistic regression analyses of parameters with $P<0.1$ under univariate logistic regression indicated that DM (OR: 0.439, 95% CI: 0.262–0.737, *P*=0.002), hypertension history (OR: 0.634, 95% CI: 0.430–0.936, *P*=0.022), Kt/V Daugirdas (OR: 2.545, 95% CI: 1.473–4.396, *P*=0.001), anuria (OR: 2.313, 95% CI: 1.357–3.942, *P*=0.002), serum phosphate (OR: 0.833, 95% CI: 0.725–0.957, *P*=0.010), and serum triglyceride (OR: 1.002, 95% CI: 1.001–1.003, *P*=0.012) were associated with predialysis hypotension.

Clinical predictors of 12 months mortality

Multivariate Cox regression analysis showed that age ($P<0.001$), body mass index (*P*=0.003), hepatitis B virus infection (*P*=0.026), and anuria (*P*=0.022) were associated with higher probability of 12 months mortality. Hemoglobin ($P<0.001$), serum albumin (*P*=0.039), and predialysis hypotension (*P*=0.011) were associated with lower probability of 12 months mortality (Figure 1).

Clinical predictors of 24 months mortality

Multivariate Cox regression analysis showed that age ($P<0.001$), DM ($P<0.001$), and anuria (*P*=0.031) were associated with higher probability of 24-month mortality. Serum albumin ($P<0.001$) was associated with lower probability of 24-month mortality. Predialysis hypotension was not associated with 24 months mortality (Figure 1).

Clinical predictors of 36 months mortality

Multivariate Cox regression analysis showed that age ($P<0.001$), male sex (*P*=0.029), anuria (*P*=0.004), and DM (*P*=0.011) were associated with higher probability of 36 months mortality. Use of arteriovenous fistula as vascular access (*P*=0.023), Kt/V Daugirdas (*P*=0.020), hemoglobin (*P*=0.023), serum albumin (*P*=0.002), and predialysis creatinine (*P*=0.005) were associated with lower probability of 36 months mortality. Predialysis hypotension was not associated with 36 months mortality (Figure 1).

The cumulative survival rate was different between patients with and without predialysis hypotension in 12-month observation (Figure 2A, *P*=0.045); however, the 24 (Figure 2B, *P*=0.183) and 36 (Figure 2C, *P*=0.478) months survival rates were not significantly different between patients with and without predialysis hypotension.

Discussion

Intradialytic hypotension (IDH) was usually considered as a mortality risk factor. However, observational studies had different results. Tisler et al[11] showed that neither frequent IDH nor occasional IDH was associated with mortality. Others found associations between IDH and greater all-cause mortality, a composite outcome of myocardial infarction, stroke, and cardiovascular (CV) mortality.[12,13] All patients in this study

Table 2 Comparison between with and without predialysis hypotension

Characteristics	With predialysis hypotension (N=156)	Without predialysis hypotension (N=710)	*P*-value
Age (years)	57.82±14.881	55.83±13.276	0.09
Male sex	74	366	0.37
Body mass index (kg/m^2)	22.085±2.9207	22.218±3.2428	0.61
Smoking (yes)	0.17±0.374	0.17±0.38	0.81
DM (yes)	20 (12.8%)	172 (24.2%)	0.001
Hypertension history (yes)	46 (29.5%)	293 (41.3%)	0.007
Previous CVD (yes)	7 (4.8%)	34 (4.5%)	0.87
HBV (yes)	17 (10.9%)	81 (11.4%)	0.85
HCV (yes)	37 (23.7%)	131 (18.5%)	0.14
Hemodialysis duration (years)	8.20±5.88	6.69±5.196	0.001
Erythropoietin (U/kg/week)	70.1349±47.88292	74.3889±47.25957	0.31
Fistula as blood access (yes)	0.81±0.39	0.79±0.406	0.51
Kt/V Daugirdas	1.9013±0.35856	1.7769±0.31696	<0.001
nPCR (g/kg/day)	1.1644±0.27118	1.1932±0.26639	0.22
Anuria (<100 cc/day)	138 (88.5%)	550 (77.5%)	0.001
Hemoglobin (g/dL)	10.668±1.4224	10.48±1.3547	0.13
Albumin (g/dL)	4.016±0.3321	4.074±0.3491	0.051
Creatinine (mg/dL)	10.743±2.3513	10.918±2.3995	0.40
Ferritin (μg/L)[a]	267.9 (99.2, 503.6)	313.4 (139, 505.4)	0.14
Corrected-calcium (mg/dL)	9.897±0.9518	9.892±0.9164	0.95
Phosphate (mg/dL)	4.579±1.3477	4.902±1.3506	0.007
Intact parathyroid hormone (pg/mL)[a]	144.6 (61.32, 292.15)	127.4 (50.4, 325.6)	0.5
hsCRP (mg/L)[a]	2.83 (1.54, 6.75)	2.98 (1.36, 7.12)	0.85
Cholesterol (mg/dL)	171.26±38.314	171.31±37.547	0.98
Triglyceride (mg/dL)	174.35±124.795	162.12±113.712	0.26
LDL (mg/dL)	93.46±30.576	95.13±30.617	0.54

Notes: A *P*-value of <0.05 represents significant variance between the groups. [a]Nonnormal distribution data are presented as median (interquartile range).
Abbreviations: HBV, hepatitis B virus infection; DM, diabetes mellitus; HCV, hepatitis C virus infection; nPCR, normalized protein catabolic rate; hsCRP, high-sensitivity C-reactive protein; LDL, low-density lipoprotein; Kt/V urea, dialysis clearance of urea; CVD, cardiovascular disease.

with predialysis hypotension had nadir SBP <100 mmHg, which was the definition of IDH in many studies. But the results in this study showed that predialysis hypotension was not associated with all-cause 24- and 36-month mortality. Predialysis hypotension was even associated with lower probability of 12-month mortality.

Although mostly asymptomatic or with minimal symptoms, the presence of orthostatic hypotension in the general population increases mortality and the incidence of myocardial infarction, stroke, heart failure, and atrial fibrillation independently.[14] Postprandial hypotension has also been noted to be a risk factor for CV mortality in the general population.[15] In the present study, predialysis hypotension was not a predictor of all-cause mortality. The reasons behind the opposite results of hypotension in mortality between the general population and HD patients still need further investigation.

Robinson et al[2] showed that compared with predialysis SBP of 130–159 mmHg, mortality was 13% higher in facilities that had 20% more patients with SBP of 110–129 mmHg and 16% higher in facilities that had 20% more patients with SBP of >160 mmHg. For patient-level SBP, mortality was elevated at low (<130 mmHg), not high (≥180 mmHg), SBP. The hazard ratio (HR) of SBP <110 mmHg for mortality was elevated (HR: 1.55, 95% CI: 1.39–1.71, $P<0.001$), compared with BP in the range of 130–139 mmHg. The percentages of CVD, cerebrovascular disease, congestive heart failure, lung disease, peripheral vascular disease, and cancer in patients with predialysis SBP <110 mmHg were significantly higher than the reference group, which had SBP in the range of 130–139 mmHg in the study of Robinson et al.[2] In the present study, the patients with predialysis hypotension did not have higher percentage of CVD than those without predialysis hypotension. This might be the reason that our predialysis hypotension patients did not have higher mortality rate than patients without predialysis hypotension. Inaba et al[16] also showed that in Japanese HD patients, both low and high BP were associated with all-cause mortality. Zager et al[17] demonstrated that predialysis, neither systolic nor diastolic hypertension was associated with an increase in CV mortality.

Table 3 Binary logistic regression analysis of predialysis hypotension in MHD patients

Characteristics	Univariate logistic regression	*P*-value	Forward logistic regression[a]	*P*-value	Forward logistic regression[b]	*P*-value
Variables	Odds ratio (95% confidence intervals)		Odds ratio (95% confidence intervals)		Odds ratio (95% confidence intervals)	
Age (years)	1.014 (0.997–1.032)	0.113				
Male sex	0.987 (0.561–1.737)	0.965				
Body mass index (kg/m^2)	1.059 (0.984–1.139)	0.126				
Smoking (yes)	1.003 (0.570–1.764)	0.991				
DM (yes)	0.458 (0.255–0.823)	0.009	0.476 (0.283–0.803)	0.005	0.439 (0.262–0.737)	0.002
Hypertension (yes)	0.549 (0.363–0.828)	0.004	0.596 (0.400–0.887)	0.011	0.634 (0.430–0.936)	0.022
Previous CVD (yes)	1.121 (0.434–2.895)	0.813				
HBV (yes)	0.929 (0.507–1.701)	0.811				
HCV (yes)	0.835 (0.488–1.427)	0.509				
Hemodialysis duration (years)	1.005 (0.960–1.052)	0.846				
Fistula as blood access (yes)	1.274 (0.766–2.117)	0.351				
Hemodiafiltration (yes)	1.197 (0.733–1.953)	0.472				
Kt/V Daugirdas	4.592 (1.928–10.936)	0.001	3.031 (1.713–5.363)	<0.001	2.545 (1.473–4.396)	0.001
nPCR (g/kg/day)	0.551 (0.242–1.254)	0.156				
Anuria (yes)	1.975 (1.120–3.480)	0.019	2.204 (1.288–3.772)	0.004	2.313 (1.357–3.942)	0.002
Hemoglobin (g/dL)	1.136 (0.966–1.335)	0.123	1.178 (1.029–1.349)	0.018		
Albumin (g/dL)	0.642 (0.328–1.258)	0.197				
Creatinine (mg/dL)	1.058 (0.923–1.212)	0.420				
CCa (mg/dL)	0.502 (0.224–1.123)	0.093				
Phosphate (mg/dL)	0.273 (0.056–1.326)	0.10	0.826 (0.717–0.952)	0.008	0.833 (0.725–0.957)	0.010
Log hsCRP (mg/L)	0.819 (0.548–1.223)	0.329				
Log ferritin	0.771 (0.495–1.202)	0.252				
Log iPTH	1.033 (0.719–1.484)	0.860				
Cholesterol (mg/dL)	0.998 (0.992–1.004)	0.473				
Triglyceride (mg/dL)	1.002 (1.001–1.004)	0.011	1.002 (1.001–1.004)	0.008	1.002 (1.000–1.003)	0.012

Notes: [a]All variables in univariate logistic regression were included in this model. [b]Variables with $P<0.1$ in univariate logistic regression were included in this model.
Abbreviations: MHD, maintenance hemodialysis; HBV, hepatitis B virus infection; DM, diabetes mellitus; HCV, hepatitis C virus infection; nPCR, normalized protein catabolic rate; CCa, corrected calcium levels; hsCRP, high-sensitivity C-reactive protein; LDL, low-density lipoprotein; Kt/V urea, dialysis clearance of urea; iPTH, intact parathyroid hormone; CVD, cardiovascular disease.

Postdialysis, SBP ≥180 mmHg (relative risk [RR]: 1.96, $P<0.015$) and diastolic blood pressure ≥90 mmHg (RR: 1.73, $P<0.05$) were associated with increased CV mortality. Low SBP (SBP <110 mmHg) was associated with increased CV mortality, pre- and postdialysis. The present study is the first to demonstrate that predialysis hypotension was not associated with 24- and 36-month mortality in HD patients.

Predialysis hypotension might result from heart failure,[18] diabetic autonomic neuropathy, and uremic autonomic neuropathy.[19] However, the present study showed that DM had a negative association with predialysis hypotension and that CVD was not associated with predialysis hypotension. These might be the reasons that our patients with predialysis hypotension did not have higher mortality than those without predialysis hypotension. Higher Kt/V Daugirdas was a predictor of predialysis hypotension in our study. Chan et al[20] showed that improved Kt/V Daugirdas from 1.2±0.06 to 2.04±0.08 after 2 months ($P=0.02$) using nocturnal home HD could lower 24-hour mean arterial pressure (from 102±3 to 90±2 mmHg, $P<0.01$), total peripheral resistance (from 1,967±235 to 1,499±191 dyne s cm^{-5}, $P<0.01$), and plasma norepinephrine (from 2.66±0.4 to 1.96±0.2 nmol, $P=0.04$).[20] Others also noted that improved uremia control with longer periods of intermittent dialysis (6–8 hours per session) could lower blood pressure in the absence of any change in extracellular fluid volume or dry weight.[21,22]

Patients with predialysis hypotension had lower rate of previous hypertension, and previous hypertension history was also a negative predictor of predialysis hypotension. This might also be one of the reasons that predialysis hypotension was not a predictor of mortality. Hypertension is a well-known risk factor of CVDs.[23] Hypertension is also a risk factor for heart failure, which is one reason for predialysis hypotension. Therefore, patients in this study with predialysis hypotension had fewer CVDs, and so predialysis hypotension might not be due to heart failure.

Anuria was a predictor of predialysis hypotension in this study. Anuria was also a predictor of 12-, 24-, and 36-month

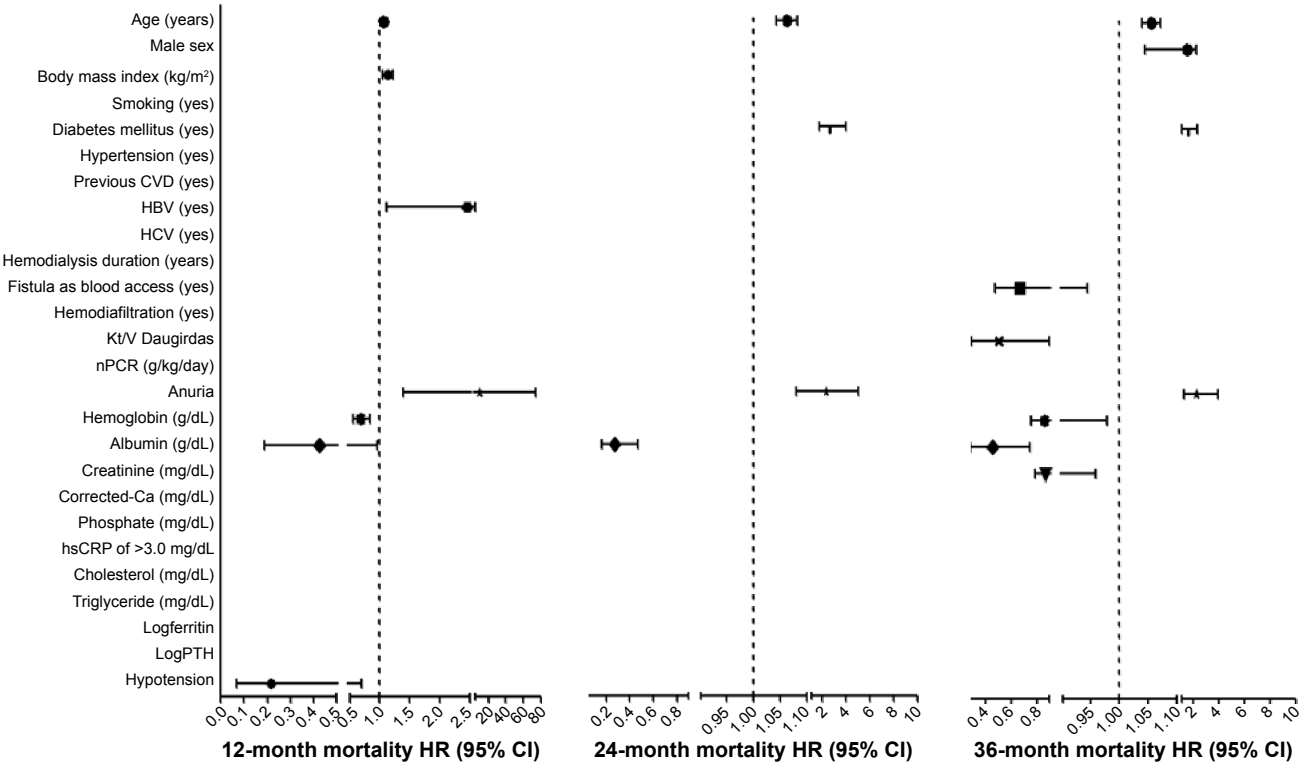

Figure 1 All-cause mortality assessed by forward stepwise Cox regression of the variables associated with 12-, 24-, and 36-month mortality risk in studied patients.

Notes: Age (OR: 1.069, 95% CI: 1.040–1.099, $P<0.001$), BMI (OR: 1.124, 95% CI: 1.039–1.215, $P=0.003$), HBV infection (OR: 2.451, 95% CI: 1.114–5.390, $P=0.026$), anuria (OR: 10.141, 95% CI: 1.393–73.803, $P=0.022$), hemoglobin levels (OR: 0.681, 95% CI: 0.552–0.841, $P<0.001$), serum albumin levels (OR: 0.425, 95% CI: 0.188–0.957, $P=0.039$), and the status of predialysis hypotension (OR: 0.216, 95% CI: 0.066–0.704, $P=0.011$) were significant risk factors for 12-month mortality. Age (OR: 1.062, 95% CI: 1.042–1.082, $P<0.001$), condition of DM (OR: 2.691, 95% CI: 1.800–4.022, $P<0.001$), anuria (OR: 2.343, 95% CI: 1.080–5.083, $P=0.031$), and serum albumin levels (OR: 0.274, 95% CI: 0.159–0.472, $P<0.001$) were significant risk factors for 24-month mortality. Age (OR: 1.055, 95% CI: 1.039–1.072, $P<0.001$), male sex (OR: 1.535, 95% CI: 1.044–2.258, $P=0.029$), condition of DM (OR: 1.605, 95% CI: 1.117–2.307, $P=0.011$), anuria (OR: 2.251, 95% CI: 1.287–3.938, $P=0.004$), use of AVF (OR: 0.663, 95% CI: 0.465–0.944, $P=0.023$), Kt/V Daugirdas (OR: 0.505, 95% CI: 0.284–0.896, $P=0.020$), hemoglobin levels (OR: 0.859, 95% CI: 0.753–0.979, $P=0.023$), serum albumin levels (OR: 0.451, 95% CI: 0.272–0.745, $P=0.002$), and predialysis creatinine (OR: 0.866, 95% CI: 0.783–0.958, $P=0.005$) were significant risk factors for 36-month mortality.

Abbreviations: AVF, arteriovenous fistula; BMI, body mass index; CI, confidence interval; CVD, cardiovascular disease; DM, diabetes mellitus; HBV, hepatitis B virus infection; HBV, hepatitis B virus; HCV, hepatitis C virus infection; hsCRP, high-sensitivity C-reactive protein; nPCR, normalized protein catabolic rate; OR, odds ratio.

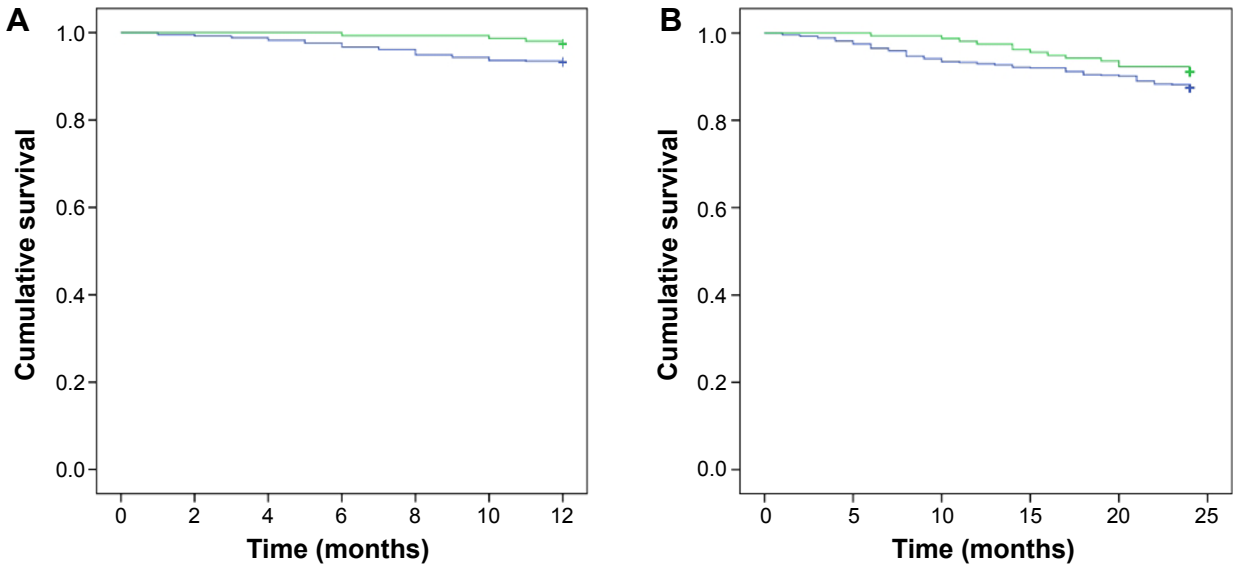

Figure 2 (*Continued*)

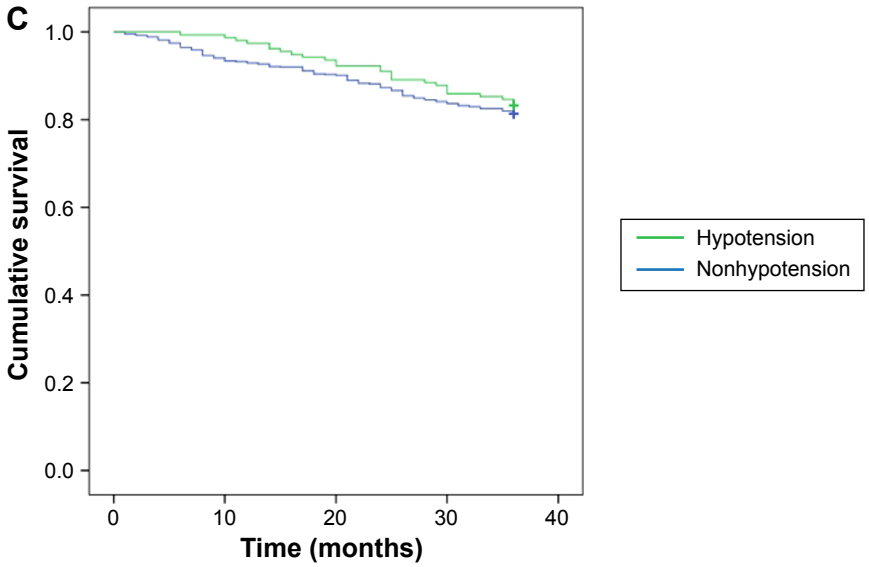

Figure 2 Kaplan–Meier survival analysis of studied patients with or without pre-dialysis hypotension.
Notes: In the 12-month observation, patients without predialysis hypotension suffered significantly higher cumulative survival than those with predialysis hypotension (**A**), log-rank test, χ^2 test =4.012, P=0.045. In 24-month (**B**), log-rank test, χ^2 test =1.77, P=0.183 and 36-month observation (**C**), log-rank test, χ^2 test =0.503, P=0.478, these two groups were not different in cumulative mortality.

mortality. Anuria impairs both the removal of fluids and the clearance of solutes, resulting in increased morbidity and mortality.[24] Residual renal function declines progressively after initiation of HD, and many patients with end-stage renal disease have no residual renal function.[25] Predialysis hypotensive patients in this study had significantly longer duration of HD, and this might be the reason that anuria was a predictor of predialysis hypotension.

Limitations

To our knowledge, there are several studies[1,2] that discuss the effect of predialysis hypotension on mortality of MHD patients. However, the results are still obscure. This study has several limitations. First, it was designed as a single-center observational study. However, due to the single-center nature of this study, the HD diet and health education are capable of being more consistently monitored. Also, all the patients were selected at random. Second, according to the focus on the association between predialysis hypotension and related variables in discussion, the data about heart function like echocardiography or autonomic dysfunction tests were not gathered. However, in our center, these aforementioned studies were not arranged for all HD patients routinely. Finally, comparing the advantages and disadvantages of predialysis hypotension with regard to mortality is difficult and complicated, particularly in such MHD patients who are at a high risk of chronic comorbidities, such as cerebrovascular disease and CVD, because many factors affect mortality. From these abovementioned points, all possible risk factors correlated with MHD mortality were considered.

Conclusion

Predialysis hypotension is not an adverse predictor for 12-, 24-, and 36-month survival in patients who do not have DM and have higher dialysis adequacy.

Acknowledgments

We thank the members of the Statistic Center in Chang Gung Memorial Hospital and Hemodialysis Center in Chang Gung Memorial Hospital for their invaluable and dedicated assistance. WHH and THY were funded by research grants from the Chang Gung Memorial Hospital, Linkou (CMRPG3D0322, G3D0012) and CHW was funded by research grants from the Chang Gung Memorial Hospital, Linkou (CMRPG5D0081).

Author contributions

All authors contributed toward data analysis, drafting and critically revising the paper and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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