

Association of blood pressure with mortality in hemodialysis patients with a tunneled cuffed catheter

A single-center observational study

Yoshinosuke Shimamura, MD, MPH^{*} , Takuto Maeda, MD, PhD, Koki Abe, MD, PhD, Hideki Takizawa, MD, PhD

Abstract

The use of tunneled cuffed catheters (TCCs) for permanent blood access is increasing as the hemodialysis population ages. However, the higher mortality and complication rates associated with their use have been significant concerns. This single-center observational cohort study aimed to investigate clinical factors affecting mortality and complications in Japanese hemodialysis patients with a TCC.

We enrolled 64 consecutive patients receiving hemodialysis through a TCC between 2012 and 2019. The primary outcome was all-cause mortality and the secondary outcome was the incidence of catheter-related complications at 2 years. Cox proportional hazards models were used to examine variables associated with these outcomes.

At 2 years, death from any cause and catheter-related complications occurred in 27/64 (42%) and 23/64 (36%) patients, respectively. There were 14 bacteremia events, 7 catheter obstructions, and 8 instances of restricted blood flow. Multivariate analysis showed that systolic blood pressure (SBP) < 100 mm Hg at the time of catheter insertion was associated with higher all-cause mortality (hazard ratio, 2.59; 95% confidence interval, 1.05–6.41) and catheter-related complications (hazard ratio, 2.57; 95% confidence interval, 1.52–22.2). The Kaplan–Meier analyses also showed that patients with SBP < 100 mm Hg had higher mortality ($P = .001$) and a higher incidence of catheter-related complications ($P = .0068$).

SBP < 100 mm Hg at the time of catheter insertion is associated with mortality and catheter-related complications in hemodialysis patients using a TCC. Further multi-center studies are required to validate our results.

Abbreviations: ADL = activities of daily living, AVF = arteriovenous fistula, AVG = arteriovenous graft, BMI = body mass index, CI = confidence interval, CVC = central venous catheter, eGFR = estimated glomerular filtration rate, GNRI = geriatric nutritional risk index, HR = hazard ratio, nPCR = normalized protein catabolic rate, SBP = systolic blood pressure, TCC = tunneled cuffed catheter.

Keywords: blood pressure, hemodialysis, mortality, tunneled cuffed catheter, tunneled cuffed catheter-related complications

1. Introduction

The number of incident hemodialysis patients has been increasing worldwide, mainly due to population aging and the rising

prevalence of diabetes mellitus and hypertension.^[1–3] The Japanese Society for Dialysis Therapy guideline and the Kidney Disease Outcomes Quality Initiative clinical practice guideline strongly recommend the creation of arteriovenous fistulas (AVFs) and advise against central venous catheter (CVC) use,^[4,5] including tunneled cuffed catheters (TCCs), for long-term vascular access. However, as the age of incident hemodialysis patients continues to rise, the total number initiating hemodialysis with a CVC also increases.^[4,6] Patients above 75 years of age may be considered ineligible for AVF or arteriovenous graft (AVG) creation because of a higher surgical risk, a limited life expectancy, and/or higher probability of primary failure.^[7] However, CVC use is also believed to be associated with higher probabilities of access-related complications and death, compared to AVFs or AVGs.^[8–10] For instance, an observational study of the United States Medicare dialysis population reported that patients with CVCs had higher likelihood of death than those with AVFs or AVGs.^[8] Another study, which used propensity score-matching to minimize selection bias, also demonstrated similar results.^[9] Additionally, other previous studies have reported that a history of bacteremia, anemia, and diabetes were risk factors for infectious complications in hemodialysis patients with a CVC.^[10–12] However, other unidentified factors that may influence the occurrence of access-related complications and mortality may also exist. This prospective observational

Editor: Dominik Steubl.

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

Department of Nephrology, Teine Keijinkai Medical Center, Sapporo, Hokkaido, Japan.

* Correspondence: Yoshinosuke Shimamura, Department of Nephrology, Teine Keijinkai Medical Center, Sapporo, Hokkaido, 0068555 Japan (e-mail: yshimamura.tkh@gmail.com).

Copyright © 2020 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial License 4.0 (CCBY-NC), where it is permissible to download, share, remix, transform, and buildup the work provided it is properly cited. The work cannot be used commercially without permission from the journal.

How to cite this article: Shimamura Y, Maeda T, Abe K, Takizawa H. Association of blood pressure with mortality in hemodialysis patients with a tunneled cuffed catheter: a single-center observational study. *Medicine* 2020;99:37(e22002).

Received: 17 January 2020 / Received in final form: 26 May 2020 / Accepted: 31 July 2020

<http://dx.doi.org/10.1097/MD.00000000000022002>

study aimed to explore clinical factors affecting mortality and access-related complications in hemodialysis patients on dialysis with a TCC.

2. Methods

2.1. Study design and participants

This was a prospective observational study conducted at Teine Keijinkai Medical Center, a 650-bed tertiary referral institute in Sapporo, Japan. Inclusion criteria were age ≥ 18 years; use of a TCC between January 1, 2012, and March 31, 2019; initial use of a non-tunneled CVC, or AVF or AVG followed by switching to a TCC within 120 days; follow-up of at least 1 month; and consent to enroll in the study. Exclusion criteria were dialysis via an AVF or AVG, or peritoneal dialysis; switching to peritoneal dialysis within 6 months after TCC insertion; unavailability of baseline data; and refusal to participate in the study. This study was conducted according to the principles of the Declaration of Helsinki and was approved by the institutional review board of Teine Keijinkai Medical Center (approval number 2019–12). All study participants provided written informed consent.

2.2. Outcomes

The primary outcome of interest was all-cause mortality. In this study, we measured the time to death from the date of hemodialysis initiation to preclude lead time bias. The secondary outcome was TCC-related complications, including TCC obstruction, restricted blood flow, TCC-related bloodstream infection, and other infections. TCC obstruction was defined as the quantity of blood flow of 0 mL/min due to any catheter-related event. Restricted blood flow was defined as blood flow < 100 mL/min due to any catheter-related event. TCC-related bloodstream infection was diagnosed when the patient had a positive blood culture obtained from a TCC, at least 1 positive blood culture obtained from a peripheral vein, and the same organism was isolated from the catheter segment and peripheral blood.^[13] Other infections included exit-site infections, tunnel infections, or clinical sepsis without bacteremia.^[4] Our facility removed and exchanged TCCs for all patients with catheter-related bacteremia and did not use antibiotic locks to salvage TCCs. Patients were followed up until the study end date (October 31, 2019), or until they switched to peritoneal dialysis, were lost to follow-up, had their care withdrawn, or died. Patients who were lost to follow-up before death were not considered for further analysis. The maximum follow-up time was 2 years.

2.3. Exposures

The exposures of interest were baseline patient characteristics, including age, sex, presence of diabetes mellitus, and hypertension, Barthel index,^[14] Charlson comorbidity index,^[15] systolic blood pressure (SBP), prescribed medications (renin angiotensin system inhibitors and beta blockers), dialysis vintage, and primary kidney disease (diabetic nephropathy, glomerulonephritis, hypertensive glomerulosclerosis, and unknown causes); nutrition-related parameters, including body mass index [BMI; body weight (kg)/height² (m²)], serum albumin levels, and Geriatric Nutritional Risk Index (GNRI)^[16]; dialysis-related parameters, including weekly dialysis time, normalized protein catabolic rate (nPCR),^[17] single-pool Kt/V, and quantity of blood

flow; catheter-related parameters, including catheter length, and site of catheter insertion (right or left jugular vein); and laboratory parameters, including blood urea nitrogen, serum creatinine levels, estimated glomerular filtration rate (eGFR),^[18] hemoglobin, albumin-corrected serum calcium levels [calculated as serum calcium (mg/dL) + (4-albumin (g/dL))], phosphate levels, C-reactive protein, and ejection fraction. Laboratory parameters and SBP were collected at the first dialysis session after TCC insertion, and dialysis prescription-related parameters were collected at the session 1 month after insertion. The patients were divided into 2 groups based on SBP, patients with SBP ≥ 100 or < 100 mm Hg, collected at the first dialysis session after TCC insertion. The Bio-Flex Tesio catheter (Medical Components, Inc., Harleysville, PA), a TCC used only for hemodialysis, was used in all patients. Catheter insertion was performed under fluoroscopy and ultrasound guidance, and catheter care was strictly followed according to the Centers for Disease Control and Prevention guidelines.^[13]

2.4. Statistical analyses

Continuous variables are presented as means with standard deviations or medians with associated interquartile ranges and were compared using Student *t* test or the Wilcoxon rank-sum test according to distribution. Categorical variables are presented as numbers and percentages and were compared using the Chi-squared test. The Shapiro–Wilk *W* test was used to analyze the normality of the variance for continuous variables. Cox proportional hazards models were used to investigate factors associated with mortality and TCC-related complications, and the hazard ratio (HR) and corresponding 95% confidence intervals (CIs) were also calculated. For mortality, the independent variables included in the Cox proportional hazards model were age, Barthel index, GNRI, ejection fraction, diabetes mellitus, SBP, and eGFR. For TCC-related complications, the independent variables included in the Cox proportional hazards models were age, Barthel index, GNRI, diabetes mellitus, insertion site of the TCCs, catheter length, BMI, and SBP. We selected these variables based on previous studies and our clinical experience.^[8–12] Variables associated with mortality and TCC-related complications at *P*-values $< .1$ in the univariate analysis were selected as independent variables in the multivariable analysis. To assess whether an association between the Barthel index and the primary outcome was different in patients with SBP ≥ 100 or < 100 mm Hg, the effect modification between the Barthel index and the SBP categories was assessed by the inclusion of interaction terms in the multivariate analyses. We confirmed the proportional hazards assumption with a log-log plot of survival. The Kaplan–Meier method was used to estimate the incidence of death and TCC-related complications in patients with SBP ≥ 100 mm Hg and those with SBP < 100 mm Hg and the results were compared by the log-rank test. For statistical analyses, we used STATA version 15.1 (Stata Corp LLC, College Station, TX). All the reported *P*-values are 2-sided. Significance level (α) was set at 0.05.

3. Results

3.1. Study population

A total of 762 consecutive patients were potentially eligible for the study and 64 were included in our analyses after

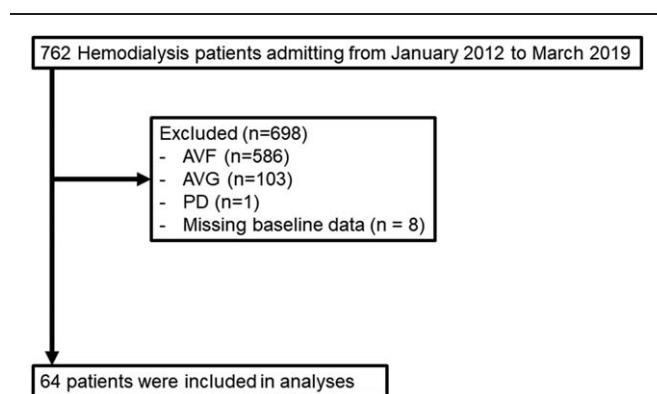


Figure 1. Flow chart showing the selection process of the study population. AVF = arteriovenous fistula, AVG = arteriovenous graft, PD = peritoneal dialysis.

application of the exclusion criteria (Fig. 1). The median age was 75 years. Among the included patients, 23% were women, 32% had diabetes mellitus, and 28% had hypertension. Compared to patients with SBP >100 mm Hg, those with SBP ≤100 mm Hg exhibited significantly lower rates of diabetes mellitus and a lower quantity of blood. The eGFR, Barthel index, GNRI, BMI, catheter lengths, nPCR, and sp Kt/V were comparable in both groups (Table 1).

3.2. Predictors of death

At 2 years, 42% of patients had died (incidence rate of 1.03 events/ 1000 catheter-days) (Table 2). We evaluated possible predictors of death, including age, Barthel index, GNRI, diabetes mellitus, ejection fraction, eGFR, and SBP ≥ 100 or < 100 mm Hg using Cox proportional hazards models (Table 3). In the univariate analyses, Barthel index (HR, 0.97; 95% CI, 0.95–0.98), GNRI (HR, 0.93; 95% CI, 0.87–0.96), and SBP < 100 mm Hg (with SBP ≥100 mm Hg as a reference; HR, 3.23; 95% CI, 1.96–5.17), were associated with higher mortality. In the multivariate analyses, SBP <100 mm Hg (compared to SBP ≥100 mm Hg; HR, 2.59; 95% CI, 1.05–6.41), and Barthel index (HR, 0.97; 95% CI, 0.96–0.99) remained as independent factors associated with all-cause mortality. However, an effect modification of the Barthel index on SBP was not observed ($P = .593$). Kaplan–Meier survival analysis showed that patients with SBP < 100 mm Hg had a significantly higher incidence of death compared those in the SBP ≥100 mm Hg group ($P = .001$) (Fig. 2).

3.3. Causes and risk factors for TCC-related complications

The cumulative incidence of TCC-related complications at 2 years was 36% (n=23), with an incidence rate of 6.26 events/1000 catheter-days. These included TCC-related bacteremia, 14/23 (22%), 0.40 events/1000 catheter-days; TCC obstruction, 7/

Table 1

Baseline characteristics of the study participants according to systolic blood pressure.

	All (n=64)	SBP < 100 (n=17)	SBP ≥100 (n=47)	P value
Age (yr; median [25%, 75%])	75 [65, 81]	74 [63, 79]	75 [65, 81]	.6156
Female, no. (%)	23 (37)	5 (29)	18 (38)	.513
BUN (mg/dL; median [25%, 75%])	73 [51, 101]	79.7 [64.6, 98.3]	72.1 [47.4, 100.9]	.5686
sCr (mg/dL; median [25%, 75%])	6.2 [5.2, 7.4]	6.6 [5.3, 7.2]	6.2 [5.2, 7.5]	.8612
eGFR (mL/min/1.73m ² ; median [25%, 75%])	7 [5, 8]	7 [6, 9]	7 [5, 8]	.3185
Hypertension, no. (%)	32 (50)	3 (18)	29 (62)	.002
Diabetes mellitus, no. (%)	28 (44)	1 (6)	27 (57)	<.001
Primary kidney disease diabetic nephropathy, no. (%)	20 (31) 2 (3) 15 (23) 27 (42)	0 (0) 1 (6) 6 (35) 10 (59)	20 (43) 1 (2) 9 (19) 17 (36)	.873
Glomerulonephritis, no. (%) Hypertensive glomerulosclerosis, no. (%) unknown, no. (%)				
Barthel index (points; median [25%, 75%])	45 [10,80]	15 [5, 70]	50 [15, 85]	.1277
Charlson comorbidity index (points; median [25%, 75%])	2 [2, 4]	3 [3, 4]	3 [2, 4]	.4215
GNRI (points; median [25%, 75%])	44 [39, 50]	44 [40, 50]	44 [39, 50]	.7209
Hemoglobin (g/dL; median [25%, 75%])	9.0 [7.7, 10.5]	9.2 [8.5, 10.4]	8.7 [7.5, 10.5]	.1961
Corrected calcium (mg/dL; median [25%, 75%])	9.3 [8.9, 9.7]	9.4 [9.2, 9.8]	9.2 [8.8, 9.7]	.1592
Phosphate (mg/dL; median [25%, 75%])	4.5 [3.8, 5.7]	4.2 [3.4, 5.3]	4.6 [4.1, 5.9]	.138
Weekly dialysis time (h; median [25%, 75%])	9 [9, 12]	9 [9, 9]	9 [9, 12]	.1233
RASI, no. (%)	10 (16)	2 (12)	8 (17)	.609
Beta-blocker, no. (%)	26 (41)	8 (47)	18 (38)	.529
Ejection fraction (%; median [25%, 75%])	60 [36, 66]	54 [19, 63]	60 [43, 65]	.4476
Exit site (right intrajugular vein), no. (%)	34 (53)	10 (59)	24 (51)	.583
Body mass index (kg/m ² ; median [25%, 75%])	21 [18, 24]	21 [18, 24]	21 [19, 24]	.8972
Dialysis vintage (d, median [25%, 75%])	281 [93, 894]	185 [85, 284]	378 [100, 902]	.092
QB (mL/min; median [25%, 75%])	200 [190, 200]	200 [150, 200]	200 [200, 200]	.0394
Catheter length (cm; median [25%, 75%])	23 [21, 25]	21 [18, 25]	23 [21, 25]	.3181
C-reactive protein (mg/dL; median [25%, 75%])	2.1 [0.5, 7.0]	2.2 [0.5, 9.0]	2.1 [0.5, 6.8]	.6593
Total cholesterol (mg/dL; median [25%, 75%])	132 [102, 161]	116 [85, 144]	132 [103, 161]	.323
Albumin (g/dL; median [25%, 75%])	2.8 [2.4, 3.2]	2.7 [2.6, 3.1]	2.8 [2.4, 3.2]	.6151
nPCR (g/kg/d; median [25%, 75%])	1.13 [0.80, 1.65]	1.19 [0.83, 1.76]	1.09 [0.80, 1.58]	.4337
sp Kt/V (median [25%, 75%])	1.40 [1.1, 1.89]	1.44 [1.11, 1.90]	1.39 [1.10, 1.88]	.8137

BUN = blood urea nitrogen, eGFR = estimated glomerular filtration rate, GNRI = geriatric nutritional risk index, nPCR = normalized protein catabolic rate, QB = quantity of blood, RASI = renin-angiotensin system inhibitor, SBP = systolic blood pressure, sCr = serum creatinine, sp Kt/V = single-pool Kt/V.

Table 2**Primary and secondary outcomes according to systolic blood pressure.**

	All (n = 64)	Incidence rate (/1,000 catheter-days)	SBP < 100 (n = 17)	SBP ≥ 100 (n = 47)
Death, n (%)	27 (42)	1.03	10 (59)	17 (36)
All complications, n (%)	23 (36)	6.26	8 (47)	15 (32)
Bacteremia, n (%)	14 (22)	0.40	5 (29)	9 (19)
Obstruction, n (%)	7 (11)	0.18	6 (35)	1 (2)
QB ≤ 100 mL/min, n (%)	8 (13)	0.22	7 (41)	1 (2)
Other infections, n (%)	14 (22)	0.27	8 (47)	6 (13)

QB=quantity of blood, SBP=systolic blood pressure.

Table 3**Univariate and multivariate analyses of factors affecting mortality (n=64).**

	Univariate			Multivariate		
	Hazard ratio	95% CI	P value	Hazard ratio	95% CI	P value
Age	1.01	0.97–1.04	.734			
Barthel index	0.97	0.95–0.98	<.001	0.97	0.96–0.99	.001
GNRI	0.93	0.87–0.96	.015	0.94	0.88–1.00	.057
Diabetes mellitus	0.66	0.29–1.46	.304			
Ejection fraction	0.99	0.97–1.01	.306			
eGFR	1.04	0.89–1.21	.581			
Systolic blood pressure ≥ 100	Reference			Reference		
SBP < 100	3.23	1.96–5.17	<.001	2.59	1.05–6.41	.04
SBP < 100*Barthel index				1.41	0.40–5.05	.593

CI=confidence interval, eGFR=estimated glomerular filtration rate, GNRI=geriatric nutritional risk index, SBP=systolic blood pressure.

23 (11%), 0.18 events/1000 catheter-days; restricted blood flow, 8/23 (13%), 0.22 events/1000 catheter-days; and other infections, 14/23 (22%), 0.27 events/1000 catheter-days (Table 2). Among patients who experienced TCC-related complications, 22% had 2 complications and 9% had at least 3. As per the univariate analyses (Table 4), patients with SBP < 100 mm Hg (HR, 5.00; 95% CI, 1.40–17.8) had a significantly increased risk of TCC-related complications than those with SBP ≥ 100 mm Hg. Patients with a lower GNRI (HR, 1.06; 95% CI, 0.99–1.11) and higher BMI (HR, 1.10; 95% CI, 0.99–1.21) were more likely to experience TCC-related complications, but the difference did not

reach statistical significance ($P = .054$ and $P = .050$, respectively). In contrast, the catheter insertion site was not associated with the incidence of TCC-related complications (HR, 0.84; 95% CI, 0.24–2.92). In a multivariate analysis adjusted for SBP, GNRI, and BMI, SBP < 100 mm Hg was consistently associated with higher risk of TCC-related complications (HR, 2.57; 95% CI, 1.57–22.2) (Table 4). The Kaplan–Meier survival analysis also (Fig. 3) showed that patients with SBP < 100 mm Hg had a significantly higher incidence of TCC-related complications ($P = .0068$).

4. Discussion

This single-center observational cohort study of Japanese hemodialysis patients using TCCs for vascular access investigated the factors associated with mortality and TCC-related complications. The results showed that at 2 years, 42% of patients had died (1.03 events/1000 catheter-days) and 36% had experienced a TCC-related complication (6.26 events/1000 catheter-days). Bacteremia was the most common complication at 0.40 events/1000 catheter-days. We also found that patients with SBP < 100 mm Hg at the time of TCC insertion had higher risk of all-cause mortality and TCC-related complications than those with SBP ≥ 100 mm Hg, even after adjustment for covariates. Additionally, we found that the Barthel index was associated with all-cause mortality.

The mortality rate of the patients using TCCs for hemodialysis in our study was comparable to that in previous studies.^[8–12] Xue et al reported a 1-year crude death rate for patients with hemodialysis catheters of 41.5%,^[8] which was significantly higher than that for patients with AVFs. Polkinghorne et al performed a propensity score analysis to investigate the effect of

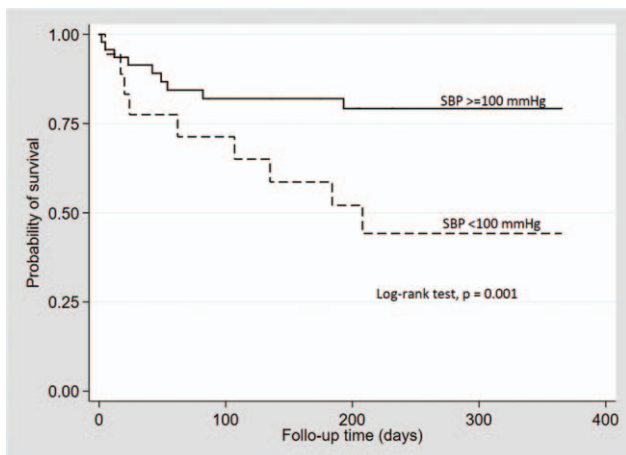


Figure 2. Kaplan–Meier curves showing mortality in the systolic blood pressure ≥ 100 mm Hg and < 100 mm Hg groups. SBP=systolic blood pressure.

Table 4
Univariate and Multivariate analyses of factors affecting tunneled cuffed catheter related complications (n=64).

	Univariate			Multivariate		
	Hazard ratio	95% CI	P value	Hazard ratio	95% CI	P value
Age	0.98	0.94–1.03	.500			
Barthel index	1.00	0.98–1.02	.834			
GNRI	1.06	0.99–1.11	.054	1.01	0.43–2.37	.979
Diabetes mellitus	0.76	0.24–2.43	.645			
Right intrajugular vein	Reference					
Left interjugular vein	0.84	0.24–2.92	.782			
Catheter length	0.99	0.81–1.23	.960			
BMI	1.10	0.99–1.21	.050	1.10	0.23–5.31	.905
SBP ≥100	Reference			Reference		
SBP <100	5.00	1.40–17.8	.013	2.57	1.52–22.2	.010

BMI=body mass index, CI=confidence interval, GNRI=geriatric nutritional risk index, SBP=systolic blood pressure.

access type on total mortality,^[9] demonstrating that the incidence of death in patients with catheters was 261/1000 person-years. By contrast, the incidence of catheter-related bacteremia in our study (0.40 events/1,000 catheter-days) was relatively lower than what has been reported in the literature (0.5–5.5 events/1000 catheter-days).^[12] However, these results cannot be directly compared because of differences in the study period and the sample size; the observational study by Xue et al analyzed the 1-year mortality rate after dialysis initiation in 66,595 United States incident Medicare patients with end-stage kidney disease,^[8] whereas Polkinghorne et al investigated the association between access type and 6-month mortality risk in 3752 incident hemodialysis patients in Australia and New Zealand.^[9] Adherence to the Centers for Disease Control and Prevention guidelines by all healthcare personnel at our facility and periodic patient education on daily skin cleansing may have contributed to this favorable result.^[13]

Our finding that patients with SBP < 100 mm Hg at the time of TCC insertion had a higher mortality is not unexpected because a previous study reported similar results. They observed a statistically significant association between low pre-dialysis SBP and higher risk of all-cause mortality.^[19] The reasons are

unclear, but 1 possible explanation is that low SBP may be act as a potent marker of other comorbid conditions, such as bacteremia and systolic dysfunction.^[20] Patients with SBP < 100 mm Hg in our cohort tended to have a higher incidence of bacteremia (29% vs 19%, *P* = .380) and lower ejection fraction [54 (19, 67) % vs 60 (43, 65) %, median (interquartile ranges) ; *P* = .448) than those with SBP > 100 mm Hg; however, the difference was not statistically significant.

In addition, we also found that patients with low SBP had an increased risk of TCC-related complications. This may be biologically plausible because low SBP may lead to a higher probability of reduced blood flow to the catheter lumen and subsequent reduction of the quantity of blood or obstruction of the TCC. As expected, patients in the SBP < 100 mm Hg group had higher rates of TCC obstruction (35% vs 2%; *P* < .001) and restriction of blood flow (41% vs 2%; *P* < .001). Moreover, our results showed that patients with a TCC placed into the left internal jugular vein did not have an increased risk of TCC-related complications than those with a TCC in their right internal jugular vein. This contradicts a previous study that reported a significantly shorter patency of catheters inserted into the left internal jugular vein.^[21] This discrepancy may have been caused by the small sample size of our study (type II error).

Our finding that a lower Barthel index is associated with all-cause mortality is important to consider with respect to previous studies demonstrated that activities of daily living (ADL) affect mortality in hemodialysis patients.^[22,23] Although a prospective study reported that ADL is influenced by age,^[22] the Barthel index was not correlated with age in our cohort (Spearman’s rho=0.574). This may indicate that improvement of ADL through rehabilitation may decrease mortality in this population as ADL,^[23] unlike age, is a modifiable factor.

Finally, our finding of an association between hypotension and mortality in patients using a TCC may add to prior studies that showed that TCCs can be used for permanent vascular access when other forms of access are not available.^[24–27] Numerous studies have reported that patients undergoing dialysis with a CVC had a higher probability of access-related complications and death^[8–12]; however, recent evidence suggested that they were likely confounded by selection bias.^[24–27] For instance, Brown et al have reported that patient survival is comparable between patients starting hemodialysis using a CVC after an unsuccessful attempt at AVF creation and those who started dialysis with an AVF.^[27]

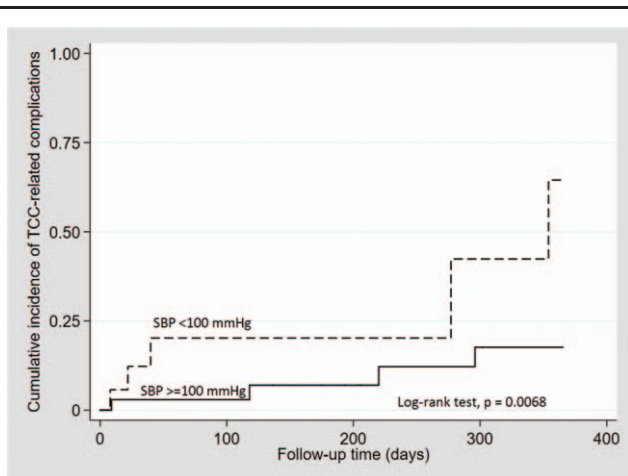


Figure 3. Kaplan–Meier curves of the incidence of catheter-related complications in the systolic blood pressure ≥100 mm Hg and < 100 mm Hg groups. SBP=systolic blood pressure.

This study has 2 main strengths: the long observation period, and the detailed assessment of potential confounding factors, including comorbid conditions; prescribed medications; laboratory parameters; and nutritional-related, dialysis prescription-related, and catheter-related parameters.

However, this study also has several limitations. First, this study had a small sample size and wide CIs, meaning that interpretation of the results must be limited to this context. However, to our knowledge, the association between low SBP and mortality and TCC-related complications has not been described before. Second, residual confounding factors may still have existed despite adjustment for several demographic, clinical, and catheter-related variables. Third, we did not collect information on methicillin-resistant *Staphylococcus aureus* carriage and the history of prior catheter infection.^[11] Fourth, our results may not be generalizable to other countries due to the variation in hemodialysis practice patterns.^[1–5] Fifth, we did not directly compare patients with a TCC with those with other forms of vascular access. However, most of our results agree with those of previous studies,^[8,9] suggesting that we investigated a rather representative study population. Obviously, further studies comparing mortality between patients with AVF/AVF and those with TCC are needed. Sixth, relatively long follow-up time in our cohort might impact on the outcomes because clinical guidelines and standard of care may have changed during that period. Due to the aforementioned reasons, we advise caution when interpreting our results. We suggest that future prospective studies investigate whether interventions for blood pressure control can contribute to improved outcomes in this particular population.

In conclusion, this study showed that SBP < 100 mm Hg was associated with all-cause mortality and the incidence of TCC-related complications. Despite its small sample size, our study suggests that the assessment of SBP is critical to identify and intervene in patients who are at a higher risk of death.

Acknowledgments

We would like to thank Editage (www.editage.jp) for English language editing.

Author contributions

Conceptualization: Yoshinosuke Shimamura, Hideki Takizawa.

Data curation: Yoshinosuke Shimamura, Takuto Maeda, Koki Abe.

Formal analysis: Yoshinosuke Shimamura.

Investigation: Yoshinosuke Shimamura, Takuto Maeda.

Methodology: Yoshinosuke Shimamura, Koki Abe.

Project administration: Hideki Takizawa.

Resources: Yoshinosuke Shimamura, Takuto Maeda, Koki Abe.

Software: Yoshinosuke Shimamura.

Supervision: Hideki Takizawa.

Validation: Yoshinosuke Shimamura, Koki Abe.

Visualization: Yoshinosuke Shimamura, Takuto Maeda.

Writing – original draft: Yoshinosuke Shimamura.

Writing – review & editing: Hideki Takizawa.

References

- [1] Liyanage T, Ninomiya T, Jha V, et al. Worldwide access to treatment for end-stage kidney disease: a systemic review. *Lancet* 2015;385:1975–82.
- [2] Chapter 1: Incidence, Prevalence, Patient Characteristics, and Treatment Modalities. Available online: https://www.usrds.org/2017/view/v2_01.aspx (accessed on December 27, 2019).
- [3] Masakane I, Taniguchi M, Nakai S, et al. Annual dialysis data report 2016, JSDT renal data registry. *Ren Replace Ther* 2018;4:45.
- [4] Kukita K, Ohira S, Amano I, et al. 2011 update Japanese society for dialysis therapy guidelines of vascular access construction and repair for chronic hemodialysis. *Ther Apher Dial* 2015;19:1–39.
- [5] National Kidney FoundationKDOQI clinical practice guidelines and clinical practice recommendations for 2006 updates: hemodialysis adequacy, peritoneal dialysis adequacy and vascular access. *Am J Kidney Dis* 2006;48:1–322.
- [6] Pisoni RL, Zepel L, Port FK, et al. Trends in US vascular access use, patient preferences, and related practices: an update from the US DOPPS practice monitor with international comparisons. *Am J Kidney Dis* 2015;65:905–15.
- [7] Canaud B, Tong L, Tentori F, et al. Clinical practices and outcomes in elderly hemodialysis patients: results from the dialysis outcomes and practice patterns study (DOPPS). *Clin J Am Soc Nephrol* 2011;6:1651–62.
- [8] Xue JL, Dahl D, Ebben JP, et al. The association of initial hemodialysis access type with mortality outcomes in elderly Medicare ESRD patients. *Am J Kidney Dis* 2003;42:1013–9.
- [9] Polkinghorne KR, McDonald SP, Atkins RC, et al. Vascular access and all-cause mortality: a propensity score analysis. *J Am Soc Nephrol* 2004;15:477–86.
- [10] Taylor G, Gravel D, Johnston L, et al. Prospective surveillance for primary bloodstream infections occurring in Canadian hemodialysis units. *Infect Control Hosp Epidemiol* 2002;23:716–20.
- [11] Poinen K, Quinn RR, Clarke A, et al. Complications from tunneled hemodialysis catheters: a Canadian observational cohort study. *Am J Kidney Dis* 2019;73:467–75.
- [12] Delistefani F, Wallbach M, Müller GA, et al. Risk factors for catheter-related infections in patients receiving permanent dialysis catheter. *BMC Nephrol* 2019;20:199.
- [13] O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of intravascular catheter-related infections. *Clin Infect Dis* 2011;52:e162–93.
- [14] Mahoney FI, Barthel DW. Functional evaluation: the Barthel Index. *Md State Med J* 1965;14:61–5.
- [15] Sundararajan V, Henderson T, Perry C, et al. New ICD-10 version of the Charlson comorbidity index predicted in-hospital mortality. *J Clin Epidemiol* 2004;57:1288–94.
- [16] Bouillanne O, Morineau G, Dupont C, et al. Geriatric nutritional risk index: a new index for evaluating at-risk elderly medical patients. *Am J Clin Nutr* 2005;82:777–83.
- [17] Panzetta G, Tessitore N, Faccini G, et al. The protein catabolic rate as a measure of protein intake in dialysis patients: usefulness and limits. *Nephrol Dial Transplant* 1990;5:125–7.
- [18] Matsuo S, Imai E, Horio M, et al. Revised equations for estimated GFR from serum creatinine in Japan. *Am J Kidney Dis* 2009;53:982–92.
- [19] Chang TI, Friedman GD, Cheung AK, et al. Systolic blood pressure and mortality in prevalent haemodialysis patients in the HEMO study. *J Hum Hypertens* 2010;25:98–105.
- [20] Coeckelenbergh S, Van Nuffelen M, Mélot C. Sepsis is frequent in initially non-critical hypotensive emergency department patients and is associated with increased mortality. *Am J Emerg Med* 2019;37:2242–5.
- [21] Shingarev R, Barker-Finkel J, Allon M. Natural history of tunneled dialysis catheters placed for hemodialysis initiation. *J Vasc Interv Radiol* 2013;24:1289–94.
- [22] Oller GA, Riberiro Rde C, Travagim DS, et al. Functional independence in patients with chronic kidney disease being treated with hemodialysis. *Rev Lat Am Enfermagem* 2012;20:1033–40.
- [23] Endo M, Nakamura Y, Murakami T, et al. Rehabilitation improves prognosis and activities of daily living in hemodialysis patients with low activities of daily living. *Phys Ther Res* 2017;20:9–15.
- [24] Allon M. Vascular access for hemodialysis patients: new data should guide decision making. *Clin J Am Soc Nephrol* 2019;14:954–61.
- [25] Dumaine C, Kiaii M, Miller L, et al. Vascular access practice patterns in Canada: a national survey. *Can J Kidney Health Dis* 2018;5:2054358118759675.
- [26] Quinn RR, Ravani P. Fistula-first and catheter-last: fading certainties and growing doubts. *Nephrol Dial Transplant* 2014;29:727–30.
- [27] Brown RS, Patibandla BK, Goldfarb-Rumyantsev AS. The survival benefit of “fistula first, catheter last” in hemodialysis is primarily due to patient factors. *J Am Soc Nephrol* 2017;28:645–52.