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Association of Vascular Access Type with Mortality, Hospitalization, and Transfer to In-Center Hemodialysis in Patients Undergoing Home Hemodialysis

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Abstract

Background and objectives In individuals undergoing in-center hemodialysis (HD), use of central venous catheters (CVCs) is associated with worse clinical outcomes compared with use of arteriovenous access. However, it is unclear whether a similar difference in risk by vascular access type is present in patients undergoing home HD.

Design, setting, participants, & measurements Our study examined the associations of vascular access type with all-cause mortality, hospitalization, and transfer to in-center HD in patients who initiated home HD from 2007 to 2011 in 464 facilities in 43 states in the United States. Patients were followed through December 31, 2011. Data were analyzed using competing risks hazards regression, with vascular access type at the start of home HD as the primary exposure in a propensity score–matched cohort (1052 patients; 526 with CVC and 526 with arteriovenous access).

Results Over a median follow-up of 312 days, 110 patients died, 604 had at least one hospitalization, and 202 transferred to in-center hemodialysis. Compared with arteriovenous access use, CVC use was associated with higher risk for mortality (hazard ratio, 1.73; 95% confidence interval, 1.18 to 2.54) and hospitalization (hazard ratio, 1.19; 95% confidence interval, 1.02 to 1.39). CVC use was not associated with increased risk for transfer to in-center HD. The results of analyses in the entire unmatched cohort (2481 patients), with vascular access type modeled as a baseline exposure at start of home HD or a time-varying exposure, were similar. Analyses among a propensity score–matched cohort of patients undergoing in-center HD also showed similar risks for death and hospitalization with use of CVCs.

Conclusions In a large cohort of patients on home HD, CVC use was associated with higher risk for mortality and hospitalization. Additional studies are needed to identify interventions which may reduce risk associated with use of CVCs among patients undergoing home HD.

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Introduction

In the United States, >110,000 individuals with ESRD initiate maintenance dialysis each year (1). Although the vast majority of these patients are treated with in-center hemodialysis (HD), there has been a recent resurgence in use of home HD (2,3). Growth in use of home HD has been facilitated by data suggesting clinical benefit with more frequent HD treatments as well as the introduction of simple to operate systems for home HD (4,5).

One of the persistent barriers to greater adoption of home HD is the need for patients or caregivers to perform frequent cannulation of arteriovenous (AV) access (fistula or graft) (6–8). Data from the Frequent Hemodialysis Network Trial have also shown a higher incidence of interventions on AV access with higher frequency of use as occurs with home HD (9). An alternative to cannulation of AV access is the use of tunneled central venous catheters (CVCs) as long–term vascular access for patients treated with home HD. In patients undergoing in-center HD, use of CVCs is associated with greater risk of adverse clinical outcomes, including higher rates of mortality and hospitalization, at least in part because of greater incidence of infection-related complications (10–14). In contrast, there are only limited data examining the association of vascular access type with clinical outcomes for patients undergoing home HD, individuals in whom incidence of nosocomial infection may be lower (15).

Using nationally representative data from a large dialysis provider in the United States, we undertook this study to examine the null hypothesis that, in patients undergoing home HD, use of a CVC compared with

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use of an AV access is not associated with higher risk of mortality, time to first hospitalization, or transfer to in-center HD. In addition, we sought to juxtapose our findings for patients undergoing home HD with those for patients undergoing conventional three times per week HD.

Materials and Methods

Data Source

The study population comprised patients ≥18 years of age who started maintenance dialysis from 2007 to 2011 and received care at one of the facilities operated by DaVita, Inc. for at least 60 days (16). Patients who underwent treatment with home HD for ≥45 days were included in the primary analysis (Supplemental Figure 1). Patients who were only treated with conventional three times per week in–center HD were analyzed as part of a secondary analysis (Supplemental Figure 2). For each patient, the follow-up period was divided into 91-day periods from the date of first dialysis. Because of the small number of patients treated with an AV graft (n=323) in the primary cohort, the data from patients with an AV graft or fistula were pooled into a single group for the primary analysis. Characteristics of patients included in the cohorts compared with those excluded because of missing vascular access type are reported in Supplemental Tables 1 and 2.

Data from dialysis facility electronic medical records were used to determine demographics and comorbidities. Dialysis facility experience with home HD was defined as the number of 91-day patient periods in which patients on home HD were treated at that facility. Similarly, facility home HD CVC experience was defined as the number of 91-day periods in which patients on home HD were treated with a CVC at that facility. Laboratory measurements were averaged for each patient for each 91-day period. All laboratory values were measured in the central DaVita, Inc. laboratory (Deland, FL). The Institutional Review Boards at the Los Angeles Biomedical Research Institute and the University of Washington approved the study as exempt from informed consent.

Statistical Analyses

Data were complete for age, sex, diabetes, cause of ESRD, primary health insurance, and cardiovascular comorbidities. Data for race; dialysis facility region; serum calcium, potassium, and bicarbonate; and erythropoietin dose were missing for <1% of the cohort. Data for serum albumin, parathyroid hormone, phosphorus, alkaline phosphatase and creatinine, blood hemoglobin, total iron–binding capacity, ferritin, and white blood cell count were missing for 1%–7% of the cohort. Missing covariate data were imputed using multiple imputation with five repetitions (17). Vascular access type was complete for 95% of patients. Missing data for vascular access type were not imputed.

For the primary analysis, a propensity score–matched cohort was constructed to minimize the influence of bias caused by confounding by indication. A logistic regression model was built with CVC as initial access type as the outcome and the following variables as predictors: age, sex, race, diabetes status, primary health insurance, cause of ESRD, cardiovascular comorbidity, year of start of maintenance dialysis, time from start of dialysis to start of home HD, facility geographic region, body mass index, serum albumin, calcium, potassium, creatinine, bicarbonate, alkaline phosphatase, parathyroid hormone, blood hemoglobin, ferritin, transferrin saturation, white blood cell count, percentage of lymphocytes, cumulative iron dose, and weekly dose of erythropoietin. This model was used to calculate the probability of each patient being treated with a CVC at the time of start of home HD (propensity scores). Propensity scores were used to identify one patient initiating home HD with an AV access for each patient with a CVC using a greedy matching algorithm with a caliper width of 0.1 SDs (18). Standardized differences between the CVC and AV access groups in the matched cohort were calculated for each variable and qualitatively compared with the standardized differences between the groups in the unmatched cohort to confirm the success of the matching (Supplemental Table 3).

Unadjusted time to event competing risks survival analyses (19) were performed within the propensity score–matched cohort to determine the associations of CVC use at the start of home HD with all-cause mortality, first hospitalization, and transfer to in-center HD. For each analysis, the referent group comprised patients treated with an AV access. Censoring reasons included transplant, discharge to a facility operated by another dialysis provider, discontinuation of dialysis or recovery of renal function, and end of follow-up (Supplemental Table 4). For each outcome, the presence of effect modification by facility experience with incident home HD overall and use of CVC for home HD was tested through assessment of the significance of the first–order interaction term.

To further examine the robustness of our findings and incorporate information on changes in vascular access and time-varying confounders during follow-up, we performed competing risk regression analyses within the entire unmatched cohort (n=2481), modeling vascular access as a time-varying exposure that was updated at the start of each 91-day period of follow-up. Three nested hierarchical models were examined: (*1*) unadjusted; (*2*) adjusted for age, sex, race/ethnicity, and diabetes status; and (*3*) additionally adjusted for duration of dialysis treatment before start of home HD, dialysis facility home HD experience, body mass index, time–varying serum albumin and creatinine, and time–varying blood hemoglobin.

Two sets of sensitivity analyses were performed. In the first set of analyses, vascular access type at the start of home HD was modeled as a static baseline exposure in the survival analyses. In the second set, AV fistula and AV graft were assessed as distinct exposures rather than pooled together into a single AV access group. As an exploratory analysis, we performed competing risk regression to examine the association of vascular access type with first bacteremia, defined as first incidence of a positive outpatient blood culture. Additionally, we assessed for evidence of effect modification by duration of CVC use during home HD on the association between initial vascular access type and outcomes through assessment of significance of the first–order interaction term.

Finally, for comparison and to enhance the external validity of our findings, we performed a propensity score–matched analysis of patients only treated with conventional

Table 1. Characteristics of unmatched (*n*=2481) and propensity score–matched (*n*=1052) study cohorts stratified by initial vascular access type at the time of initiation of home hemodialysis

Characteristics	Unmatched Cohort			Propensity Score–Matched Cohort	
	CVC (*n*=579)	AV Access (*n*=1794)	Missing (*n*=108)	CVC (*n*=526)	AV Access (*n*=526)
Age, yr	54±15	52±14	52±14	53±15	52±14
Sex, % men	61	67	67	62	66
Diabetes mellitus, %	61	60	57	61	60
Body mass index, kg/m^2	29±8	30±7	31±10	29±8	29±7
Time from start of dialysis to HHD, d	157 [45, 369]	308 [124, 583]	252 [95, 606]	166 [52, 382]	197 [71, 407]
Race/ethnicity, %					
White	75	67	73	74	73
Black	17	22	20	17	19
Hispanic	6	6	2	6	5
Asian	1	3	3	1	1
Other	1	2	2	2	2
Cause of ESRD, %					
Diabetes	38	34	32	38	38
Hypertension	17	24	23	18	17
GN	19	18	18	19	20
Other	26	24	27	5	5
Comorbid conditions, %					
Atherosclerotic heart disease	28	27	19	27	26
Congestive heart failure	53	49	34	52	52
Other cardiovascular diseases	26	22	14	24	24
Primary insurance					
Medicare	39	39	46	39	37
Medicaid	3	3	4	3	5
Other	58	57	50	58	58
Dialysis facility region					
Northeast	15	17	17	15	15
West	18	21	20	19	16
Midwest	34	24	19	32	36
South	34	39	45	35	33
Laboratory data					
Serum albumin, g/dl	3.8±0.5	4.0±0.4	3.9±0.5	3.8±0.5	3.9±0.5
Serum calcium, mg/dl	8.9±0.6	8.9±0.6	9.0±0.7	8.9±0.6	8.9±0.6
Serum parathyroid hormone, pg/ml	320 [179, 527]	343 [223, 534]	342 [209, 573]	327 [181, 549]	333 [204, 530]
Serum phosphorus, mg/dl	5.1±1.2	5.1±1.2	5.3±1.4	5.1±1.2	5.1±1.2
Blood hemoglobin, g/dl	11.1±1.4	11.2±1.3	11.4±1.5	11.1±1.3	11.1±1.3
Serum ferritin, ng/ml	328 [185, 597]	380 [205, 621]	417 [197, 725]	323 [184, 558]	387 [200, 598]
Serum total iron binding capacity, mg/dl	241±55	252±46	244±52	245±5	243±46
Median erythropoietin dose, units/wk	5842 [2199, 13,656]	4878 [1599, 11,488]	4400 [1468, 12,570]	5819 [2097, 13,548]	5500 [1894, 13,006]
Iron dose, mg/mo	0 [0, 300]	0 [0, 300]	0 [0, 0]	0 [0, 300]	12.5 [0, 300]
White blood cell count, $\times 10^3/\mu$l	7.5±2.6	7.0±2.3	7.4±2.8	7.4±2.5	7.3±2.9

Table 1. (Continued)

Characteristics	Unmatched Cohort			Propensity Score–Matched Cohort	
	CVC (*n*=579)	AV Access (*n*=1794)	Missing (*n*=108)	CVC (*n*=526)	AV Access (*n*=526)
Lymphocyte, %	22±8	24±8	22±9	22±8	23±9
Potassium, mEq/L	4.3±0.6	4.4±0.6	4.4±0.6	4.4±0.6	4.4±0.5
Bicarbonate, mEq/L	24±2	24±3	23±3	24±2	24±3
Alkaline phosphatase, U/L	83 [65, 116]	78 [61, 102]	76 [63, 116]	82 [65, 114]	82 [65, 112]
Creatinine, mg/dl	6.8±3.0	7.9±3.2	7.5±3.0	7.0±2.9	7.2±3.0

Data are presented as means±SDs, median [interquartile range], or percentage. CVC, central venous catheter; AV, arteriovenous; HHD, home hemodialysis.

three times per week in–center HD (22,431 pairs of patients). Time to event competing risk survival analyses were performed to determine the associations of CVC use at the start of in-center HD with all-cause mortality and first hospitalization.

Statistical analyses were performed using SAS, version 9.3 (SAS Institute Inc., Cary, NC).

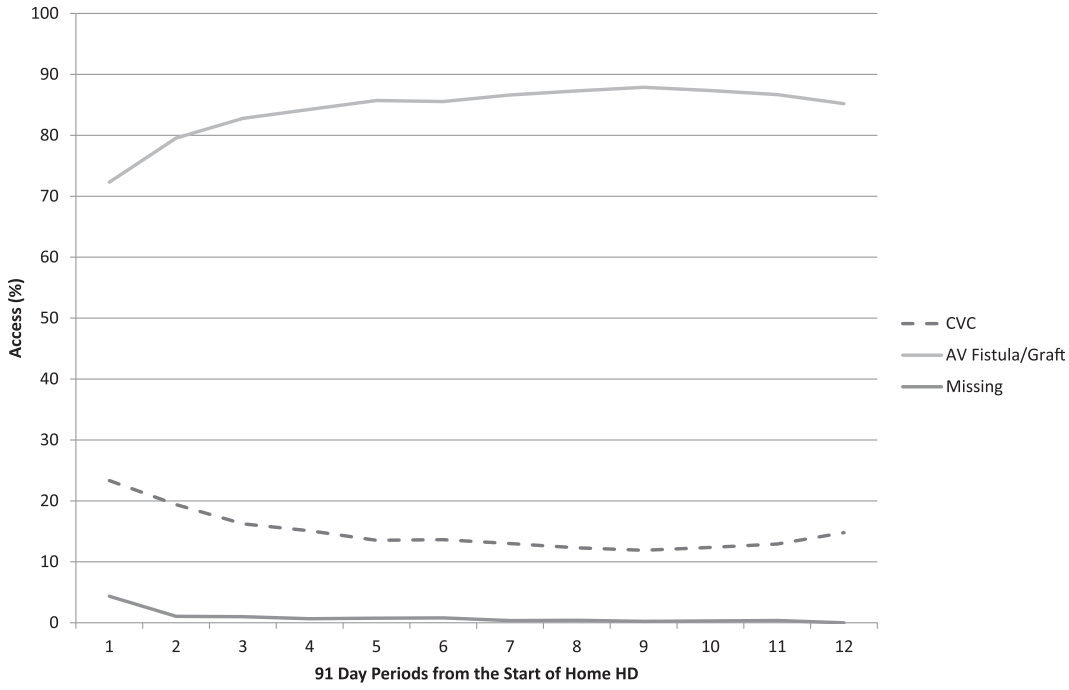
Results

Home HD Study Population

Between January 1, 2007 and December 31, 2011, 2543 patients started home HD in 464 facilities in 43 states. Of these, 2481 patients had at least one 91-day period in which there was available information on vascular access type. For the unmatched cohort (2481 patients), compared with patients initiating home HD with an AV access, patients with a CVC were older, had a shorter interval from date of first-ever dialysis to home HD, were more likely to be black, were more likely have diabetes or cardiovascular comorbidity, and had lower baseline serum albumin and creatinine (Table 1). The propensity score–matched cohort comprised 526 pairs of individuals with CVC or AV access at time of start of home HD. In contrast to the unmatched cohort, there were no meaningful differences between the groups with CVC or AV access in any of the measured baseline demographic characteristics or laboratory variables.

The median duration of maintenance dialysis treatment before start of home HD was 157 days (interquartile range [IQR] =45–369) for patients with a CVC and 308 days (IQR=124–583) for patients with AV access (Table 1). Median treatment time per session and mean number of treatments per week were 168 (IQR=150–191) minutes and 4.1±1.4 treatments for patients with a CVC and 161 (IQR=146–180) minutes and 4.2±1.3 treatments for patients with AV access, respectively. Among all study patients, 72% started home HD with an AV access; the prevalence of AV access increased to 86% by end of year 1 and remained constant over the remainder of the follow-up period (Figure 1); <10% of patients who initiated home HD with an AV access switched to use of a CVC (Figure 2). In contrast, for patients initiating home HD with CVC, >50% after 1 year had switched to use of an AV access (Figure 2).

Overall, 174 patients with known initial vascular access type died, 1199 were hospitalized at least one time, and 386 patients transferred to in-center HD over 2549 person-years of follow-up. Within the propensity score–matched cohort, the crude mortality rate for patients with CVC was 12.1 (95% confidence interval [95% CI], 9.5 to 62.9) per 100 person-years compared with 6.9 (95% CI, 5.1 to 9.2) per 100 person-years for patients with AV access (Table 2). The hospitalization and transfer to in–center HD rates were 56.3 (95% CI, 50.4 to 62.9) and 18.1 (95% CI, 14.9 to 22.0) per 100 person-years for patients using a CVC compared with 46.8 (95% CI, 41.7 to 52.6) and 16.3 (95% CI, 13.2 to 19.9) for patients using AV access. The proportions of patients who underwent kidney transplantation, regained kidney function, or transferred to a nonaffiliated dialysis facility were similar, irrespective of initial vascular access type (Supplemental Table 4).



Number at risk

CVC	579	422	278	207	127	85	73	61	51	43	34	29
AV Fistula/Graft	1794	1731	1418	1155	804	533	486	433	377	304	228	167
Missing	108	23	17	9	7	5	2	2	1	1	1	0
Censored	0	305	768	1110	1543	1858	1920	1985	2052	2133	2218	2285

Figure 1. | **Vascular access over study follow-up among patients undergoing home hemodialysis (HD; *n*=2481).** AV, arteriovenous; CVC, central venous catheter.

Association of Vascular Access Type with All-Cause Mortality in Home HD

Within the propensity score–matched cohort, patients undergoing home HD with CVCs had greater risk for all-cause mortality compared with patients using an AV access (hazard ratio [HR], 1.73; 95% CI, 1.18 to 2.54) (Figure 3). There was no effect modification by dialysis facility home HD experience (*P* value for interaction =0.81) or facility home HD CVC experience (*P* value for interaction =0.28).

The results of secondary analyses within the entire unmatched cohort were similar to analyses within the propensity score–matched cohort (Figure 3). Using an unadjusted model, time–varying CVC use was associated with higher risk for all-cause mortality (HR, 2.36; 95% CI, 1.73 to 3.22). After adjustment for potential confounders, the association with all-cause mortality was substantially attenuated (HR, 1.39; 95% CI, 0.99 to 1.95) (Figure 3).

Association of Vascular Access Type with Hospitalization in Home HD

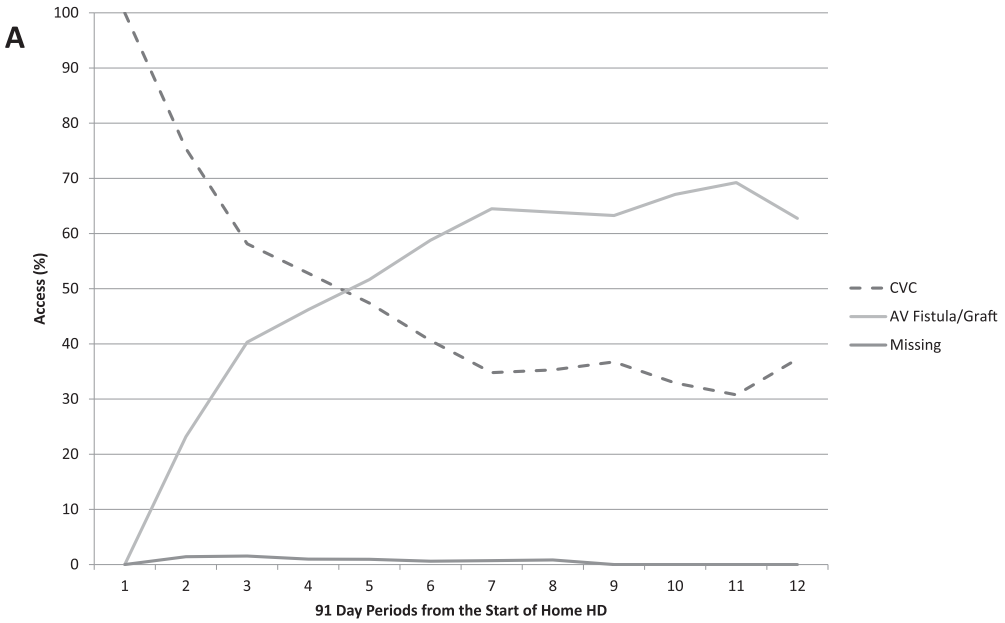
Compared with patients undergoing home HD with an AV access, patients using a CVC had a higher risk for hospitalization (HR, 1.19; 95% CI, 1.02 to 1.39). Analyses in the unmatched cohort were similar to those in the propensity score–matched cohort, regardless of level of adjustment. As for mortality, there was no evidence for effect modification by either dialysis facility home HD experience (*P* value for interaction =0.61) or facility home HD CVC experience (*P* value for interaction =0.10).

Association of Vascular Access Type with Transfer to In-Center HD in Home HD

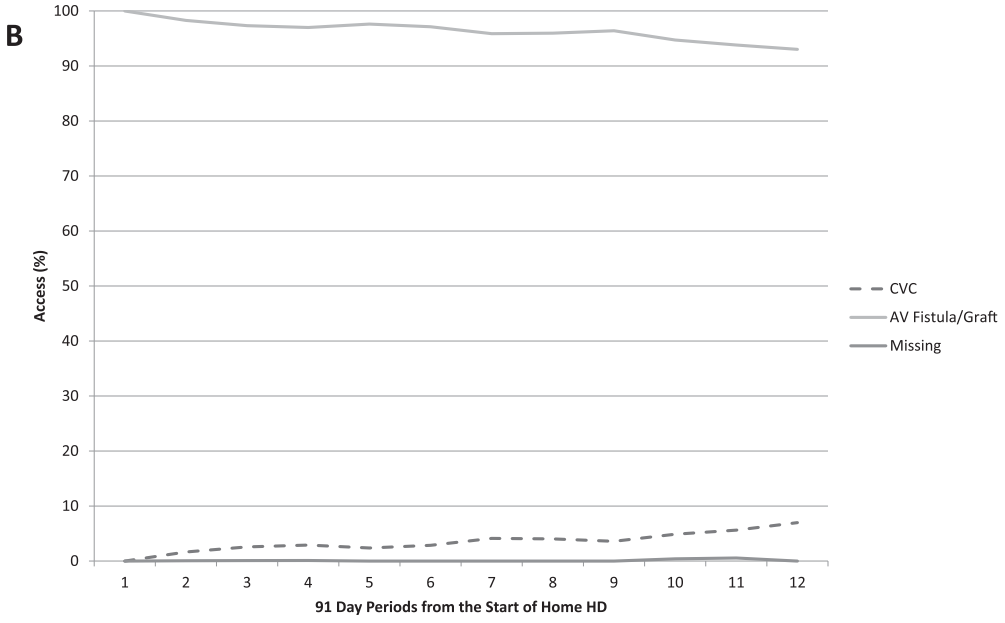
There was no statistically significant association between vascular access type and risk for transfer to in-center HD in the propensity score–matched cohort or the unmatched cohort after full adjustment for potential confounders (Figure 3). However, the relationship between CVC use and risk for transfer to in-center HD was significantly modified by the cumulative dialysis facility CVC experience (*P* value for interaction <0.01), with a trend toward stronger risk for patients undergoing dialysis in facilities with lower home HD CVC experience (Supplemental Figure 3, Supplemental Table 5). There was no evidence of effect modification by facility home HD experience (*P* value for interaction =0.28).

Association of Vascular Access Type with All-Cause Mortality and Hospitalization in Conventional In–Center HD

The propensity score–matched cohort of patients undergoing in-center HD comprised 22,431 pairs of individuals with CVC or AV access at time of start of dialysis. There were no meaningful differences between the groups with CVC or AV access in any of the measured



Number at risk	1	2	3	4	5	6	7	8	9	10	11	12
CVC	579	371	225	160	100	67	48	42	36	26	20	19
AV Fistula/Graft	0	114	156	140	109	97	89	76	62	53	45	32
Missing	0	7	6	3	2	1	1	1	0	0	0	0
Censored	0	87	192	276	368	414	441	460	481	500	514	528



Number at risk	1	2	3	4	5	6	7	8	9	10	11	12
CVC	0	26	32	29	16	12	16	14	11	12	10	9
AV Fistula/Graft	1794	1549	1205	966	657	408	372	333	295	233	167	120
Missing	0	1	1	1	0	0	0	0	0	1	1	0
Censored	0	218	556	798	1121	1374	1406	1447	1488	1548	1616	1665

Figure 2. | Vascular access over study follow-up among patients undergoing home hemodialysis (HD) stratified by initial vascular access type. (A) Patients with initial vascular access as central venous catheter (CVC; *n*=579). (B) Patients with initial vascular access as arteriovenous (AV) access (*n*=1794).

baseline demographic characteristics or laboratory variables (Supplemental Tables 6 and 7). Individuals with a CVC had a significantly higher risk for death (HR, 1.30; 95% CI, 1.25 to 1.35) and hospitalization (HR, 1.37; 95% CI, 1.34 to 1.40) compared with individuals with an AV access (Figure 4).

Table 2. Follow-up, number of events, and event rate by initial vascular access type in propensity score–matched (n=1052) and unmatched (n=2481) cohorts

Access	Patient-Yr of Follow-Up	Mortality		Hospitalization		Transfer to In-Center Hemodialysis	
		Events	Crude Rate (95% CI)[a]	Events	Crude Rate (95% CI)[a]	Events	Crude Rate (95% CI)[a]
Propensity score–matched cohort							
Central venous catheter	563	68	12.1 (9.5 to 15.3)	317	56.3 (50.4 to 62.9)	102	18.1 (14.9 to 22.0)
Arteriovenous access	613	42	6.9 (5.1 to 9.3)	287	46.8 (41.7 to 52.6)	100	16.3 (13.2 to 19.9)
Unmatched cohort							
Central venous catheter	629	78	12.4 (9.9 to 15.5)	361	57.4 (51.8 to 63.6)	111	17.7 (14.7 to 21.3)
Arteriovenous access	1920	96	5.0 (4.1 to 6.1)	838	43.6 (40.8 to 46.7)	275	14.3 (12.7 to 16.1)

95% CI, 95% confidence interval.
[a]Rate per 100 person-years.

Sensitivity and Exploratory Analyses

In sensitivity analyses modeling vascular access type at the start of home HD as the primary exposure within the entire unmatched cohort, results were similar to those from the primary analyses (Supplemental Table 8). In a second set of sensitivity analyses assessing AV fistula or AV graft as distinct exposures, patients dialyzing with a graft did not have a higher risk for all-cause mortality, hospitalization, or transfer to in-center HD compared with those using a fistula, regardless of the level of covariate adjustment. Results of an exploratory analysis examining the association of initial vascular access type with first bacteremia events showed higher risk for bacteremia with use of CVC within the propensity score–matched cohort (HR, 2.59; 95% CI, 1.60 to 4.20) as well as within the unmatched cohort, irrespective of the level of statistical adjustment (HR, 3.22; 95% CI, 2.21 to 4.68 for the fully adjusted model). Finally, there was no evidence of effect modification by duration of CVC use on the association of initial vascular access type with outcomes.

Discussion

In this large study of patients on incident home HD, we found that treatment with a CVC was associated with a higher risk for death and hospitalization but not transfer to in-center HD compared with treatment with an AV access. These findings were observed in an analysis of a propensity score–matched cohort as well as after adjustment for potential confounders in a larger unmatched cohort using baseline or time–varying vascular access. Additionally, the magnitude of higher risk for death and hospitalization observed with use of a CVC in home HD was similar to that observed in a parallel analysis of patients undergoing conventional in–center HD.

Numerous studies over the past two decades have shown associations between CVC use and higher risk for adverse clinical outcomes in patients undergoing in-center HD (10–14,20–22). However, there are important ways in which home HD differs from in-center HD that may substantially alter the risks associated with CVC use. Patients undergoing in-center HD have three times per week exposure to dialysis facilities, in which they come into contact with other chronically ill patients as well as facility staff members, presenting opportunities for exposure to exogenous organisms, including multidrug-resistant organisms (23–25). Although rates of colonization with multidrug-resistant organisms are unknown in patients undergoing home HD, it is plausible that less frequent contact with health care facilities would result in less frequent colonization and infection. Beyond potential differences in risk for nosocomial infection, HD in the home setting may lead to higher risk for rare but potentially catastrophic AV access–related adverse events (26,27).

Although these differences provide a rationale for why CVC risk may be different for in-center HD and home HD, the results of our study show that higher risks for mortality and hospitalization associated with CVC use also exist for patients undergoing home HD and are similar in magnitude (22). These results support the findings of previous observational studies that have shown similar rates of complications, including infection, thrombolytic

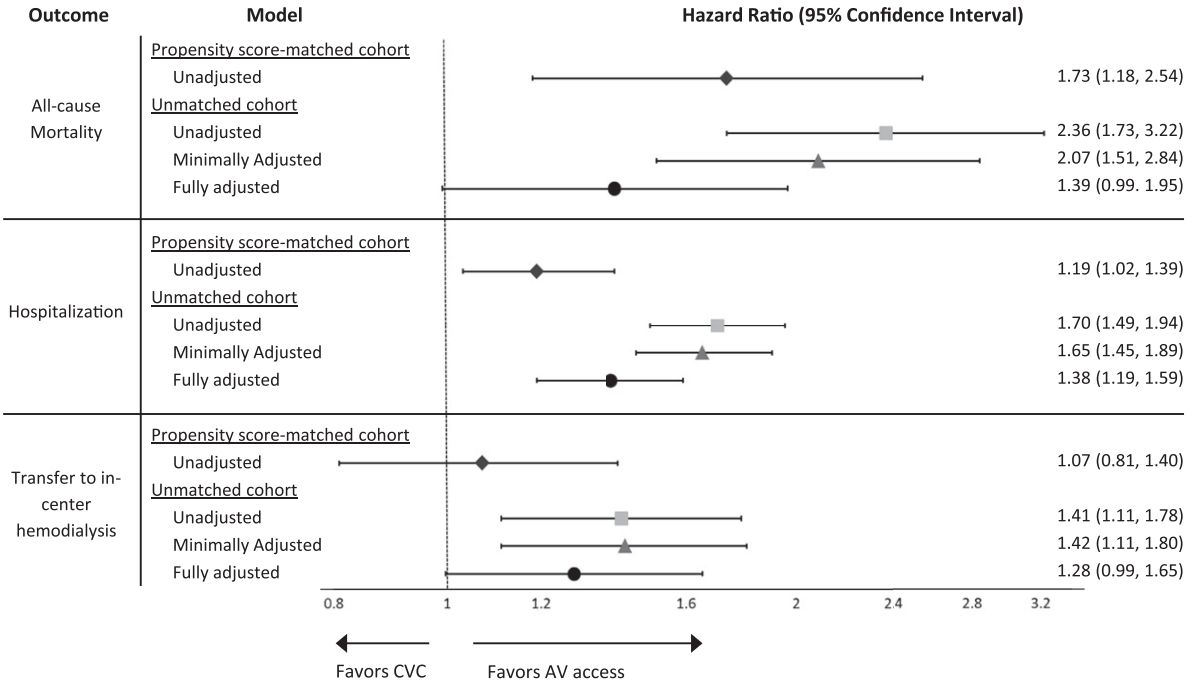


Figure 3. | Association of central venous catheter (CVC) use with risk for all-cause mortality, hospitalization, and transfer to in-center hemodialysis in patients undergoing home hemodialysis. The reference group was arteriovenous (AV) access. The propensity score–matched cohort included 1052 patients (CVC, *n*=526; AV access, *n*=526); the unmatched cohort included 2481 patients. Hazard ratios are subdistribution hazard ratios from competing risks regression. The minimally adjusted model was adjusted for age, sex, diabetes, and race and/or ethnicity. The fully adjusted model was further adjusted for duration of dialysis treatment before the start of home hemodialysis, dialysis facility home hemodialysis experience, body mass index, serum albumin, serum creatinine, and blood hemoglobin.

administration, or access-related hospitalization, associated with CVCs among patients undergoing daily or nocturnal HD compared with those undergoing in-center HD (28,29). There are multiple potential mechanisms by which CVCs may lead to adverse clinical outcomes, regardless of whether used for in-center or home HD. A CVC represents a foreign body in the vascular space, presenting a risk for colonization and subsequent catheter–related bacteremia. CVCs may also predispose to chronic systemic inflammation, which in turn, has been shown to predict cardiovascular events in patients undergoing maintenance dialysis (13,30). Finally, although rare, malpositioned catheter tips are associated with cardiac arrhythmias as well as such catastrophic complications as cardiac perforation and tamponade (31).

The results of our study support current guidelines that encourage patients and their providers to work diligently to establish and maintain AV access, including when dialyzing at home. We found that that over one half of patients who remained on home HD for at least 1 year and initially started home HD with a CVC switch to use of AV access. This finding emphasizes the importance of continued engagement with patients regarding optimal vascular access, even after the initial transition to maintenance dialysis.

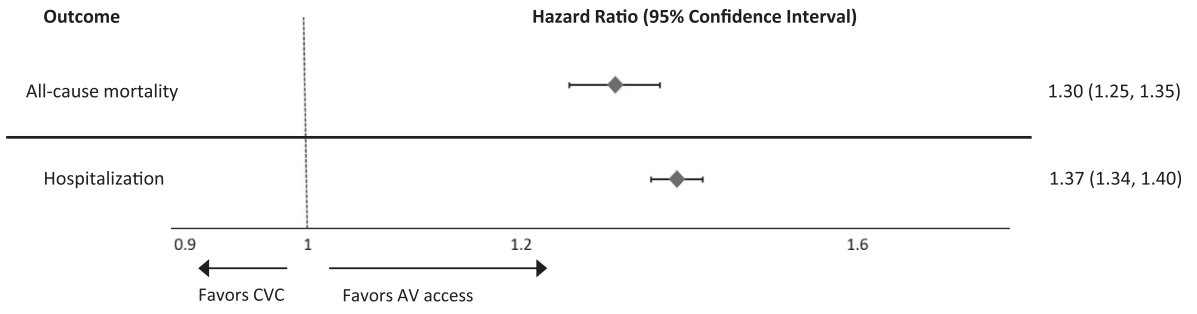


Figure 4. | Association of central venous catheter (CVC) use with risk for all-cause mortality and hospitalization among a propensity score–matched cohort of patients undergoing conventional three times per week in–center hemodialysis. The reference group was arteriovenous (AV) access. Results are presented for the propensity score–matched cohort of 44,862 patients (CVC, *n*=22,431; AV access, *n*=22,431). Hazard ratios are subdistribution hazard ratios from competing risks regression.

Our study has multiple strengths. First, we used data from patients in >400 facilities across >40 states. This approach enhances external validity of our findings and also, provides substantial power to detect differences in outcomes among patients with differing vascular access. Second, we performed the primary analysis in a propensity score–matched cohort, a statistical technique shown to reduce bias from nonrandom exposure assignment (32–34). Third, our study accounts for important inter–related competing risks among the primary outcomes through application of competing risk regression (35). Fourth, we observed similar results when we modeled vascular access type as a time-varying exposure or a baseline exposure at the time of start of home HD, an important consideration to ensure accuracy in attribution of risk to vascular access type.

Despite its strengths, our study has several limitations. Although we identified a number of important associations, given the observational nature of our study, there remains the possibility of residual confounding. Additionally, data were not available on cause-specific mortality or hospitalizations, limiting our ability to determine associations between vascular access type and outcomes, such as access-related hospitalizations. We were also not able to account for whether patients used high–frequency, low–dialysate volume equipment or conventional HD machines or whether treatments were administered during the day or at night. Furthermore, the overall number of events limited power to examine whether the associations that we observed vary in patient subgroups.

In conclusion, in a large, nationally representative cohort of patients on incident home HD, use of a CVC compared with an AV access was associated with higher risk for death and hospitalization. Future studies should investigate whether interventions exist that may reduce the risk associated with use of CVCs among patients undergoing home HD or whether there are key subgroups among whom this higher risk does not exist.

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Disclosures

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