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Original Investigation

Vascular Access Type and Patient and Technique Survival in Home Hemodialysis Patients: The Canadian Organ Replacement Register

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Background: While central venous catheter (CVC) use has expanded home hemodialysis (HHD) eligibility to many patients who may be unable to self-cannulate an arteriovenous (AV) access, the association between CVC use and mortality has not been directly examined among HHD patients.

Study Design: Registry-based retrospective observational cohort study.

Setting & Participants: Incident HHD patients in The Canadian Organ Replacement Register who had information for vascular access type (CVC vs AV access) within the first year of HHD therapy initiation.

Predictor: Use of a CVC versus an AV access (AV fistula or graft) within the first year of HHD therapy initiation.

Outcome: The composite of all-cause mortality and technique failure (long-term transfer to an alternate dialysis modality). A Cox proportional hazards model was used to evaluate the adjusted composite outcome and each outcome separately.

Results: 1,869 patients initiated HHD therapy in Canada in 1996 to 2012, of whom 1,217 had an access type recorded within the first year of HHD therapy initiation. Compared to CVC use (n = 523) and during a median follow-up of 513 and 427 days for AV access and CVC patients, respectively, AV access use (n = 694) was associated with lower risk for the composite event of death and technique failure (490 events; adjusted HR, 0.78; 95% CI, 0.64-0.94) and lower adjusted all-cause mortality (129 deaths; adjusted HR, 0.63; 95% CI, 0.43-0.91); the risk for technique failure was nominally lower, but this result was not statistically significant (361 events; adjusted HR, 0.84; 95% CI, 0.67-1.05). Results were robust to sensitivity analyses and after missing data imputation.

Limitations: Missing information for vascular access type (n = 659 [35% of patients]) and lack of information for longitudinal changes in vascular access type.

Conclusions: Compared to CVC use, AV access use was associated with superior survival. Minimizing CVC use and maximizing AV access use while addressing barriers to their placement and self-cannulation may improve HHD outcomes.

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INDEX WORDS: Arteriovenous fistula (AVF); arteriovenous graft (AVG); Canadian Organ Replacement Register (CORR); central venous catheter (CVC); hemodialysis vascular access; home hemodialysis (HHD); self-cannulation; technique survival; survival; renal replacement therapy (RRT).

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Dr Uldall is credited for developing both the first nocturnal home hemodialysis (HHD) program in Toronto, Canada,[1] and one of the first permanent indwelling internal jugular central venous catheters (CVCs) to be used as hemodialysis (HD) vascular access (Uldall–Cook catheter; Cook Critical Care).[2] Initially, CVCs were seen as the ideal option for patients choosing HHD for whom self-cannulation of an arteriovenous (AV) access would be associated with physical and psychological challenges and potential accidental access dislodgement. Therefore, in the initial Toronto HHD experience, CVCs were the exclusive HHD access type.[1]

Since that time, among conventional facility-based maintenance HD patients, several observational studies have highlighted the significant mortality, infection-related morbidity, and hospitalization risk associated

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with CVC use relative to an AV access.[3-12] This risk may be mediated by higher rates of CVC-attributable complications compared to an AV access. These complications include higher access-related infectious events, greater susceptibility to thrombosis, inadequate blood flow, and higher risk for central venous stenosis that may preclude future surgical vascular access creation.[13-15]

For these reasons, national and international guidelines promote the placement of AV access as the preferred HD vascular access.[16-18] However, to date, the observational data used to support these guidelines were largely derived from cohorts of conventional HD patients while excluding HHD patients.[16-18] Therefore, better understanding of the risks of CVC use among HHD patients is needed. Given that self-cannulation of an AV access remains a major barrier to HHD adaptation,[19] many patients are maintained on HHD therapy using a CVC by choice despite being potentially eligible for an AV access. Moreover, compared with conventional facility-based HD patients, HHD patients are traditionally a self-selected "healthier" maintenance HD cohort who are younger, with fewer comorbid conditions, and less disability.[20-23] The risks associated with CVC use may be different for this population relative to their conventional HD counterparts. Moreover, AV access complications and the need for AV access interventions have been demonstrated to be higher with both frequent and home HD, so HHD may mitigate the risks associated with CVC use.[24] In the present study, our primary objective was to assess the impact of CVC use compared to AV access use on the risks for death and technique failure in a pan-Canadian HHD cohort. Our secondary objective was to describe the distribution and trends of vascular access type among HHD patients in Canada.

METHODS

Data Source, Definitions, and Collection

This registry-based observational cohort study included all adult patients (aged ≥18 years at initiation of dialysis therapy) who initiated HHD in Canada January 1, 1996, to December 31, 2012, with documentation of type of vascular access use within one year of HHD therapy initiation. All subtypes of HHD (short daily HHD, conventional HHD, and nocturnal HHD) were included. We analyzed data from the Canadian Organ Replacement Register (CORR), a national registry that captures the incidence, prevalence, and outcomes of >99% of long-term dialysis patients and solid-organ transplant recipients in Canada[25] and that has recently been validated.[26,27] Data from the Province of Quebec were not included because of the need for additional ethics and data permissions. The research study protocol was approved by CORR.

Our primary exposure compared all incident HHD patients with a documented AV access versus a CVC within 90 days prior to HHD therapy initiation or within one year after HHD therapy initiation. Data for AV fistulas (AVFs) and AV grafts (AVGs) were aggregated because of the small number of AVGs (n = 46) among HHD patients. In CORR, ascertainment of vascular access subtype (AVF, AVG, or CVC) occurs at the first initial outpatient dialysis treatment and using a follow-up form annually as of October 31. In Canada, most HHD patients initiate dialysis therapy with a non-HHD modality and subsequently convert to HHD. For those who had HHD as their initial modality, vascular access type was ascertained at the time of HHD therapy initiation. Among the remainder of patients who transferred to HHD therapy from either a failed kidney transplant or another dialysis modality, vascular access type was documented at annual follow-up after the initiation of HHD therapy, which may have been up to one year after HHD therapy initiation (depending on the HHD initiation date relative to annual vascular access ascertainment). In addition, the distribution of vascular access type at HHD therapy initiation was also compared relative to those receiving conventional HD within the same period.

Comorbid conditions were documented by the individual facilities at the time of first dialysis treatment or kidney transplantation using the initial CORR registration forms as previously described.[28] In addition, distance to the dialysis center was calculated as the direct linear distance (in kilometers) from the patient's primary residence (by postal code) at the time of dialysis therapy initiation to the nearest dialysis provider using the Vincenty formula. The HHD center size was calculated as facility tertiles (small [1-4 patients], medium [5-9 patients], and large [10-43 patients]) based on mean HHD patient volume per year across all study years. Income quintiles were calculated using median neighborhood income (classified by quintile) as a measure of socioeconomic status. These income data were compiled by linking 2006 Statistics Canada census data with postal codes for patients' residences.

Outcome

The primary outcome was a composite of time to death and/or HHD technique failure. This was chosen because of the concern that there may be fewer deaths in an HHD cohort compared to a conventional HD cohort, and that technique failure in Canada is most commonly related to a premorbid event leading to cognitive or physical incapacity to perform HHD.[22] Secondary outcomes included all-cause mortality and all-cause technique failure, considered separately. The definition of HHD technique failure was transfer to either facility-based HD or peritoneal dialysis therapy for 90 days or longer. All events, including death, technique failure, kidney transplantation, and loss to follow-up, were captured within CORR.

Statistical Analysis

Baseline differences among categorical variables were compared using χ^2 test. The nonparametric Wilcoxon 2-sample test was used to analyze differences among continuous variables. We used Cox proportional hazards regression to compare the primary outcome of case-mix–adjusted mortality and technique failure, as well as mortality and TF each separately, between CVC and AV access HHD patients. In addition, we compared adjusted rates of censoring due to kidney transplantation to explore whether this potentially informative censoring event was different between CVC and AV access patients. All models were adjusted for age, sex, race, cause of end-stage kidney disease, a validated end-stage kidney disease comorbidity index,[29] body mass index, facility size, income quintile, HHD subtype, distance from the dialysis center, era of dialysis therapy initiation, prior end-stage renal disease (ESRD) vintage, and region. Among all Cox models, no violations of the proportionality assumption occurred, which was tested by incorporating a time-dependent explanatory variable. Follow-up time started at the time of vascular access ascertainment. Censoring events included kidney transplantation, loss to follow-up, or being alive at the end of the observation period (December 31, 2013). Direct adjusted survival curves were created based on a Cox model and estimators were constructed by taking the average of the individual predicted survival curves.[30] All analyses were performed using SAS, version 9.2 (SAS Institute Inc).