Racial Disparities in the Arteriovenous Fistula Care Continuum in Hemodialysis Patients

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Abstract

Background and objectives Arteriovenous fistulas are the optimal vascular access type for patients on hemodialysis. However, arteriovenous fistulas are used less frequently in Black than in White individuals. The arteriovenous fistula care continuum comprises a series of sequential steps. A better understanding is needed of where disparities exist along the continuum in order to mitigate racial differences in arteriovenous fistula use.

Design, setting, participants, & measurements Using Medicare claims data from the United States Renal Data System, longitudinal analyses of patients ≥67 years initiating hemodialysis with a central venous catheter between July 1, 2010 and June 30, 2012 were performed. Three patient cohorts were identified: patients initiating hemodialysis with a catheter (n=41,814), patients with arteriovenous fistula placement within 6 months of dialysis initiation (n=14,077), and patients whose arteriovenous fistulas were successfully used within 6 months of placement (n=7068). Three arteriovenous fistula processes of care outcomes were compared between Blacks and Whites: (1) arteriovenous fistula creation, (2) successful arteriovenous fistula use, and (3) primary arteriovenous fistula patency after successful use.

Results An arteriovenous fistula was placed within 6 months of dialysis initiation in 37% of patients initiating dialysis with a catheter. Among the patients with arteriovenous fistula placement, the arteriovenous fistula was successfully used for dialysis within 6 months in 48% of patients. Among patients with successful arteriovenous fistula use, 21% maintained primary arteriovenous fistula patency at 3 years. After adjusting for competing risks, Black patients on hemodialysis were 10% less likely to undergo arteriovenous fistula placement (adjusted subdistribution hazard ratio, 0.90; 95% confidence interval, 0.87 to 0.94); 12% less likely to have successful arteriovenous fistula use after placement (adjusted subdistribution hazard ratio, 0.88; 95% confidence interval, 0.83 to 0.93); and 22% less likely to maintain primary arteriovenous fistula patency after successful use (subdistribution hazard ratio, 0.78; 95% confidence interval, 0.74 to 0.84).

Conclusions Lower arteriovenous fistula use among Blacks older than 67 years of age treated with hemodialysis was attributable to each step along the continuum of arteriovenous fistula processes of care.

Introduction

Over 450,000 individuals undergo hemodialysis for treatment of kidney failure in the United States (1). Delivering hemodialysis thrice weekly requires a reliable conduit to the vasculature (“vascular access”) that can provide a high blood flow to the dialysis circuit. In this regard, the vascular access may be the single most important component of hemodialysis, as it is critical to its success. Arteriovenous fistulas (AVFs) are the preferred vascular access type, compared with arteriovenous grafts (AVGs), because AVFs are associated with arteriovenous grafts (AVGs), because AVFs are associated with greater patency, fewer interventions to maintain long-term patency, fewer infections, and improved patient survival (2,3).

Several national initiatives, such as the Kidney Disease Outcomes Quality Initiative (2), the Fistula First Initiative (4), and Healthy People 2020 (1), have urged providers to increase AVF use in patients on hemodialysis. Despite a remarkable increase in overall AVF use, from 24% to 63%, in the United States between 1998 and 2016 (4), AVF use remains lower in Black patients on hemodialysis (5), who comprise 36% of patients with kidney failure (1). Three major sequential processes of care are essential to achieving successful AVF use in patients on hemodialysis who initiate dialysis with a catheter: (1) AVF placement by a surgeon, (2) AVF maturation leading to its successful use for dialysis, and (3) maintenance of primary AVF patency after its successful use (6). All three processes of care constitute a continuum of care that must be optimized to maximize AVF use. The racial disparities in AVF use among patients on hemodialysis suggest that one or more of these AVF processes of care differ between Blacks and Whites.

Using the United States Renal Data System (USRDS), a national registry of patients receiving KRT, and Medicare claims data, we determined whether racial differences in the AVF care continuum...
may explain the racial discrepancy in AVF use among individuals treated with hemodialysis, thereby identifying optimal areas for future intervention efforts.

Materials and Methods

Data Sources and Study Population

Our primary data source was derived from the 2010 to 2016 USRDS standard analytic files. We first identified patients on incident hemodialysis aged 67 years and older to ensure the availability of 2 years of Medicare information prior to reaching kidney failure. From this population, we used the Medical Evidence Form to identify a cohort that initiated hemodialysis through a central vein catheter (CVC) between July 1, 2010 and June 30, 2012. Patients who underwent AVF or AVG surgery in the 2-year prekidney failure period were excluded using Current Procedural Terminology-4 (CPT-4) codes of 36818, 36819, 36820, 36821, and 36825 for AVF and 36800, 36810, and 36830 for AVG (7,8). This cohort was further restricted to those who were White or Black race. The final study population included three nesting patient cohorts. Cohort 1 comprised 41,814 patients who initiated hemodialysis with a CVC. From Cohort 1, we then identified two subcohorts: Cohort 2 had an AVF placed within 6 months after dialysis initiation with a CVC and comprised 14,077 patients, and Cohort 3 had an AVF that matured within 6 months of its placement and comprised 7058 patients. Details of the cohort formation are shown in Figure 1. Institutional review board approval was exempt because all data were encrypted and deidentified.

Study Outcomes and Follow-Up

The study outcomes were AVF placement within 1 year of dialysis initiation with a CVC, successful AVF use (AVF maturation) within 6 months of AVF placement, and primary AVF patency after successful use within 3 years of AVF maturation for Cohorts 1, 2, and 3, respectively. We identified AVF placement by using CPT-4 codes as listed above for AVF placement. Successful AVF use was ascertained by using the first vascular access modifier code “V7” reported from the institutional details claims file or the first AVF used with two needles reported from the CrownWeb clinical file as previously published (9,10). The V codes are reported monthly by every dialysis facility and reflect the vascular access type on the last hemodialysis session of each month. These reports are completed by nurses at each dialysis unit. If a patient has both a CVC and AVF, the patient is reported as using a CVC. We defined primary AVF patency loss as the first revision procedure after maturation. We defined secondary AVF patency loss (abandonment) as 3 consecutive months of CVC use or a new vascular access placement. The date of AVF abandonment was attributed to the first month after AVF maturation during which CVC use was reported. We defined primary AVF patency as continual use for dialysis after successful use without undergoing a subsequent surgical or percutaneous AVF intervention. Follow-up time was 1 year from dialysis initiation with a CVC, 6 months from AVF placement, and 3 years from AVF maturation for Cohorts 1, 2, and 3, respectively. The latest end date of follow-up was June 30, 2016. Patients who died, switched to peritoneal dialysis, or received a kidney transplant during the follow-up period were censored; these events were identified by using the USRDS death file, the transplant file, and the dialysis institutional claims file.

Variables of Interest

The main study exposure was patient race, categorized as White or Black, as collected using the Centers for Medicare and Medicaid Services Form 2728 (1,11). We also captured
data on patient age, sex, and proxies for health status, such as the underlying cause of kidney failure (diabetes, GN, hypertension, cystic kidney, or other); functional status (amputation, inability to ambulate or transfer, needs assistance with daily activities, and being institutionalized); baseline laboratory values at dialysis initiation (hemoglobin, serum albumin, and eGFR); body mass index; and duration of prekidney failure nephrology care from the 2728 form. Hemodialysis facility type and profit status were ascertained from the USRDS facility file. Comorbidity data in the 2 years prior to initiation of dialysis were extracted from prekidney failure Medicare data, as previously published (12,13). The major comorbid conditions extracted were diabetes, hypertension, coronary artery disease, congestive heart failure, peripheral vascular disease, cerebrovascular disease, stroke, chronic obstructive pulmonary disease, cancer, depression, and dementia. A specialized kidney comorbidity index (14) was calculated to measure the severity of patient comorbid conditions on the basis of the presence or absence of nonkidney disease and validated in patients on dialysis.

Statistical Analyses
We present summary statistics for the entire cohort and aggregated by race as frequency and percentages for categorical data and means ± SDs for continuous variables. We treated death, kidney transplant, or switch to peritoneal dialysis prior to each AVF outcome of interest as a competing risk and classified patients into three mutually exclusive groups according to whether they experienced the cohort-specific AVF outcome. We adjusted for competing events for each individual group. Kidney transplant and switching to peritoneal dialysis were negligible for each cohort (Supplemental Table 1). The three mutually exclusive groups were (1) patients who experienced the outcome of interest, (2) patients who had a competing event before experiencing the outcome of interest, and (3) patients who did not experience the outcome of interest or a competing event. The three cohort-specific outcomes were placement of AVF (Cohort 1), successful use of AVF (Cohort 2), and primary AVF patency (Cohort 3). We calculated crude and adjusted subdistribution hazard ratios (sSHRs) and their associated 95% confidence intervals (95% CIs) for AVF outcomes by race for each cohort. Kaplan–Meier plots displayed the survivor functions by race for each outcome of interest. All statistical tests were two sided, and a P value <0.05 was considered statistically significant. We used the STROBE guidelines to improve the reporting of our observational research study.

Results
Study Population and Patient Characteristics
Figure 1 depicts the patient cascade for each study cohort. Of the 41,814 patients who initiated hemodialysis with a dialysis catheter (cohort 1), 21% were Black. At baseline, Cohort 1 Blacks were younger, were more frequently women, and had a lower frequency of prekidney failure nephrology care and worse functional status. Whites had more comorbidities, including higher Liu comorbidity score, coronary artery disease, congestive heart failure, peripheral vascular disease, chronic obstructive pulmonary disease, cancer, and depression (Table 1).

Racial Differences in Arteriovenous Fistula Processes of Care
Among the 41,814 patients who initiated hemodialysis with a catheter (Cohort 1), 37% had an AVF placed within 1 year. Among the 14,077 patients who underwent AVF placement (Cohort 2), 48% had successful AVF use for dialysis within 6 months. Among the 7068 patients who achieved successful AVF use (Cohort 3), only 21% maintained AVF use at 3 years without a subsequent intervention (Figure 1). Median duration of follow-up was 128 (interquartile range [IQR], 57–365) days for Cohort 1, 5 (IQR, 4–6) months for Cohort 2, and 3 (IQR, 1–9) months for Cohort 3.

Among patients initiating dialysis with a catheter, AVF placement within 1 year was lower in Blacks (36% versus 38%). Similarly, among patients with AVF placement, successful AVF use within 6 months was also lower in Blacks (39% versus 45%). Finally, among patients whose AVF was successfully used for dialysis, Blacks had a lower rate of primary AVF patency over the ensuing 3 years (9% versus 20%) (Figure 2). These comparisons were all statistically significant. The survival differences in AVF processes of care between Black and White patients on dialysis are presented graphically by Kaplan–Meier survival curves in Figure 3. These curves demonstrate that AVF placement, successful AVF use on dialysis, and primary AVF patency after successful use are all lower in Black compared with White patients on hemodialysis.

Competing Risk Analyses of Individual Processes of Care Steps
After adjustment for competing risks, Blacks had lower AVF placement (adjusted sHR, 0.90; 95% CI, 0.87 to 0.94), lower successful AVF use after placement (adjusted sHR, 0.88; 95% CI, 0.83 to 0.93), and lower primary AVF patency after successful use (adjusted sHR, 0.78; 95% CI, 0.74 to 0.84) (Figure 2). The racial differences in these sequential AVF processes of care are displayed graphically in Figure 4. The relative difficulty in achieving each AVF process of care is indicated by the height of the hurdle, with successful AVF use (i.e., AVF maturation) being the most difficult (highest) hurdle. The difference between Black and White patients in achieving each AVF hurdle is denoted in the red print. Loss of secondary AVF patency was not significantly different between Blacks compared with Whites (adjusted odds ratio, 1.04; 95% CI, 0.91 to 1.19). Overall, Blacks had a 10% lower likelihood of AVF placement, a 12% lower likelihood of successful AVF use after placement, and a 22% lower likelihood of primary AVF patency following successful AVF use.

Sensitivity Analyses
We performed two sensitivity analyses to assess whether center characteristics or socioeconomic status explained racial differences in the individual AVF processes of care. We repeated the primary analysis after including only those patients who lived and received care in zip codes with >5% or >10% Black patients with kidney failure. By linking our study data with zip code–level data published
in the Dialysis Facility Report, we were able to adjust for this factor in our regression models. The results of this sensitivity analysis were similar to those obtained using the entire study cohort (Supplemental Table 2). In a second sensitivity analysis, we used Medicaid insurance status (reported in the Medical Evidence Form) as a surrogate marker for low socioeconomic status. Adjustment for this factor did not alter observed racial differences in the individual steps in the AVF processes of care (Supplemental Table 3).
Discussion

In a large national cohort of older adults who initiated hemodialysis with a catheter, we examined three sequential processes of care critical in determining overall AVF use and compared them in Blacks versus Whites. We present several novel findings: (1) Blacks were less likely to have an AVF placed; (2) among patients undergoing AVF creation, Blacks were less likely to have successful AVF use; and (3) among patients with successful AVF use, Blacks were less likely to maintain primary AVF patency. Thus, our results highlight sequential racial disparities in the AVF care continuum that may explain the lower frequency of AVF use in Black patients on hemodialysis.

There are numerous disparities between Black and White patients with kidney disease (15,16). In particular, multiple aspects of kidney failure care are inferior in Blacks. Blacks, who represent 13% of the US population, make up 36% of all patients on dialysis (17). Compared with White patients, Black patients have a higher risk of progression to kidney failure and delayed referral to a nephrologist, a lower rate of peritoneal dialysis use, a higher frequency of peritonitis, and a lower likelihood of kidney transplantation (15). Blacks are also less likely to dialyze with an AVF (10), the focus of this study. However, there have been no systematic efforts to examine differences in vascular access surgical processes of care or patient factors leading to the racial disparities in AVF use.

In our study, we found that Blacks had a 10% lower likelihood of AVF placement, a 12% lower likelihood of successful AVF use after placement, and a 22% lower likelihood of primary AVF patency following successful AVF use. Potential explanations for the lower likelihood
of AVF placement in Blacks include late referral to nephrology, patient preferences for other vascular access types, patient apprehension about undergoing surgery due to prior negative experiences with the health care system, and possible surgeon bias in patient selection for AVF placement (18). This racial disparity may also be related in part to Blacks having smaller vein diameters on preoperative mapping (19). The lower rate of successful AVF use after its placement in Blacks is in agreement with a previous multicenter study (20), and it is consistent with the lower rates of postoperative AVF diameter ≥4 mm, a surrogate marker of clinical AVF maturation (21). Another potential explanation for the racial differences in successful AVF use for dialysis is that the procedures necessary to promote successful AVF use are offered less frequently to Blacks. The shorter primary AVF patency after its successful use may reflect disparities in the overall quality of care received among Black patients on dialysis related to patient, clinician, and health system barriers (22).

Interestingly, secondary AVF patency did not differ by race. This observation suggests that, after successful AVF maturation has been achieved, long-term AVF patency can be maintained equally well by timely interventions in Blacks and Whites.

Our study has several strengths. First, we used a large national dialysis database representative of vascular access practices across the United States. Second, the use of V codes to ascertain the vascular access type in use each month enabled us to accurately determine when an AVF was successfully used. Third, our analyses adjusted for the competing risk of death to account for the high mortality rate in older adults with kidney failure. Finally, previous publications on racial disparities in AVF use have simply identified nonmodifiable factors associated with a lower likelihood of AVF use among Blacks. In contrast, this study provides rich granular data on racial differences in the individual AVF processes of care, leading to potentially actionable interventions to improve AVF outcomes in Black patients on dialysis.

Our study also has several limitations. First, because we used administrative data from the USRDS and Medicare claims, we focused on older adults (≥67 years). Our results may not generalize to younger patients on hemodialysis, but given that 52% of incident patients and 47% of prevalent patients on hemodialysis in the United States are older than 65 years, our findings are relevant to about half of the hemodialysis population (1). Second, because our study used a national administrative database and was observational, the rationale and preference for placement of an AVF in individual patients could not be determined. We did not have information in this administrative database about whether preoperative ultrasound vascular measurements, a tool used to guide AVF placement, differed between Blacks and Whites, thereby potentially affecting the likelihood of AVF placement and successful AVF use. We also did not have information about AVF location, which may affect successful AVF use and subsequent AVF patency. Third, there may have been misclassification of race, as this was captured administratively and not necessarily self-reported by each patient. However, prior studies have validated the reliability of race designations within the USRDS database (11). Finally, there was likely residual confounding, as it was not possible to adequately adjust for all patient- or systems-level factors that may affect our measured clinical AVF outcomes.

How can our results be translated to improve clinical AVF outcomes in elderly patients with kidney failure? First, we need a better understanding of why Blacks are less likely to have an AVF placed. Prospective studies are required to assess views on AVFs by patients, providers, and health care systems. Second, our study also highlights the need to better understand why AVFs in Blacks are less likely to be successfully used for dialysis and, when used, have shorter primary AVF patency. Future work should investigate mechanisms underlying race differences in the AVF maturation process, including those at the patient, clinician, and health system levels. Progressing along the AVF care continuum may be influenced by factors beyond the individual level, such as dialysis facility–level characteristics.
Each step along the continuum represents a potential point of intervention to improve AVF care and outcomes for patients on dialysis (23). For example, AVF placement requires the patient to complete the preoperative ultrasound, the preoperative surgical visit, the preoperative anesthesia visit, and the actual AVF surgery. Many patients may face barriers to completing these steps, and missing any of them will result in a delay in AVF placement. One potential solution would be to assign patient navigators, an approach that has been used successfully to expedite the numerous sequential steps required to be listed for a kidney transplant (24).

Our findings provide a foundation for future research informing the design of interventional and implementation approaches to increase AVF success. This information is timely, as the newly published 2019 Kidney Disease Outcomes Quality Initiative Vascular Access Guideline Update emphasizes a patient-centered approach to vascular access, which includes the development of an “ESKD Life-Plan” (25). The “ESKD Life-Plan” will address key issues, such as kidney replacement modality options and vascular access utilization across a patient’s anticipated life span, paying special attention to overall medical condition, current and future life goals, patient preferences, social support, functional status, and logistics related to KRT (25).

Black patients older than 67 years are less likely to undergo AVF placement, less likely to have successful AVF use after placement, and less likely to maintain primary AVF patency after successful use. These discrepancies along the AVF processes of care continuum may explain why overall AVF use is lower in Blacks. Factors underlying these disparities in processes of care require further investigation to maximize AVF use in Black patients on hemodialysis.

Disclosures
M. Allon reports receiving personal fees as a consultant for CorMedix, outside the submitted work. T. Lee reports serving as a consultant for Boston Scientific, Merck, and Proteon Therapeutics, Inc., outside the submitted work. M. Thamer is a consultant for Proteon Therapeutics, Inc. and reports receiving a grant funded by Proteon Therapeutics, Inc., which was developing an investigational therapy for hemodialysis vascular access, outside the submitted work. All remaining authors have nothing to disclose.

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Supplemental Material
This article contains the following supplemental material online at http://cjASN.asnjournals.org/lookup/suppl/doi:10.2215/CJN.03600320/-/DCSupplemental.

Supplemental Table 1. Competing events for the individual patient cohorts.
Supplemental Table 2. Sensitivity analysis restricting to patients in HD units with >5% or >10% Blacks.
Supplemental Table 3. Sensitivity analysis after adjustment for Medicaid insurance coverage.

References

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