Arteriovenous Fistula Maturation in Prevalent Hemodialysis Patients in the United States: A National Study

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Background: Arteriovenous fistulas (AVFs) are the preferred form of hemodialysis vascular access, but maturation failures occur frequently, often resulting in prolonged catheter use. We sought to characterize AVF maturation in a national sample of prevalent hemodialysis patients in the United States.

Study Design: Nonconcurrent observational cohort study.

Setting & Participants: Prevalent hemodialysis patients having had at least 1 new AVF placed during 2013, as identified using Medicare claims data in the US Renal Data System.

Predictors: Demographics, geographic location, dialysis vintage, comorbid conditions.

Outcomes: Successful maturation following placement defined by subsequent use identified using monthly CROWNWeb data.

Measurements: AVF maturation rates were compared across strata of predictors. Patients were followed up until the earliest evidence of death, AVF maturation, or the end of 2014.

Results: In the study period, 45,087 new AVFs were placed in 39,820 prevalent hemodialysis patients. No evidence of use was identified for 36.2% of AVFs. Only 54.7% of AVFs were used within 4 months of placement, with maturation rates varying considerably across end-stage renal disease (ESRD) networks. Older age was associated with lower AVF maturation rates. Female sex, black race, some comorbid conditions (cardiovascular disease, peripheral artery disease, diabetes, needing assistance, or institutionalized status), dialysis vintage longer than 1 year, and catheter or arteriovenous graft use at ESRD incidence were also associated with lower rates of successful AVF maturation. In contrast, hypertension and prior AVF placement at ESRD incidence were associated with higher rates of successful AVF maturation.

Limitations: This study relies on administrative data, with monthly recording of access use.

Conclusions: We identified numerous associations between AVF maturation and patient-level factors in a recent national sample of US hemodialysis patients. After accounting for these patient factors, we observed substantial differences in AVF maturation across some ESRD networks, indicating a need for additional study of the provider, practice, and regional factors that explain AVF maturation.

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Compared with other forms of vascular access, arteriovenous fistulas (AVFs) are viewed as the best vascular access for most long-term hemodialysis (HD) patients, displaying better long-term outcomes and lower rates of thrombosis, infection, hospitalization, and mortality.[1-5] Despite many potential advantages of the AVF, the United States has historically relied heavily on arteriovenous grafts (AVGs) and central venous catheters. More recently, US clinical guidelines, such as the National Kidney Foundation–Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) and the Fistula First Breakthrough Initiative, have prioritized AVFs over AVGs, attempting to minimize central venous catheters.[6,7] In the United States, AVF use among prevalent long-term dialysis patients increased from 32% in 2003 to 65% in 2014.[8] Despite these efforts, 80% of incident dialysis patients initiate with a catheter, with only a quarter of those patients having a maturing AVF or AVG in place.

Successful establishment of an optimally functioning AVF is a highly desirable outcome that can directly improve patient outcomes and lower the cost of care. However, despite gradual improvement in historically low rates of AVF placement in the United States, suboptimal AVF maturation rates are increasingly problematic.[8,9] Prior work has credited the improvement to the key roles of preoperative planning and surgical techniques,[10-12] as well as the dedication and training of those responsible for both vascular access monitoring[13] and placement.[14]

Motivated by this topic's critical importance and paucity of relevant national data, we sought to characterize time to first use of an AVF after surgical placement as a surrogate of successful maturation. In particular, we explored factors associated with time to first successful AVF use by using newer data from CROWNWeb available from the US Renal Data System (USRDS). CROWNWeb is a web-based data collection system that was implemented across all Medicare-certified dialysis facilities throughout the United States in June 2012 and has replaced the Standard Information Management System. CROWNWeb incorporates a number of clinical data elements, including monthly

information for dialysis vascular access use. We previously brought attention to the much longer times to first cannulation of AVFs in the United States compared with other countries.[15] Now, we hypothesize that in addition to patient-level factors, regional differences may exist with respect to time to AVF maturation, and rates of successful AVF maturation might be reflective of national practice variations.

Methods

Study Population and Data Sources

The study population included 39,820 HD patients with AVF placement in 2013, as identified in Medicare claims. The Centers for Medicare & Medicaid Services (CMS) Medical Evidence Form 2728 was used to ascertain dialysis therapy initiation date and comorbid conditions at dialysis incidence. All Medicare claims among prevalent HD patients in 2013 were explored to identify procedure codes for AVF placements. Monthly CROWNWeb data for the study period of January 1, 2013, to December 31, 2014, were analyzed to determine vascular access "in use." To be included in the analyses, patients were required to have vascular access use data in CROWNWeb following the fistula placement procedure. Patients were excluded if such vascular access use follow-up data were not available at any point during the study period. We did not formally censor the patients at modality switch. However, because the patient is not in CROWNWeb after a modality switch, they would be treated as "lost to follow-up" and so should not overly influence the outcome. In the merged CROWNWeb-Medicare data set, 1.12% of records were missing data for access type. Analyses were limited to vascular accesses placed among prevalent HD patients because non–dialysis-dependent patients would not need to have their AVFs cannulated and likely would not have the same clinical urgency for timely AVF use. Medicare claims and CROWNWeb data were linked using a patient identifier, allowing us to determine the first month in which the AVF was being used for HD (defined as successful 2-needle cannulation) subsequent to the AVF placement date, which reflects clinical AVF maturation.

Statistical Analysis

AVF placement was identified through inpatient, outpatient, and physician and supplier Medicare claims using the following *International Classification of Diseases, Ninth Revision* procedure codes: 36818, 36819, 36820, 36821, and 36825. Subsequent first use of the placed fistula, defined in CROWNWeb as successful access use with both input and output needles, was obtained from CROWNWeb through the end of 2014. Because data for direct clinical assessment are not available in the databases, whether and when maturation occurred was determined by using the date of AVF placement in Medicare claims and date of first use of the AVF in CROWNWeb. If CROWNWeb data indicated the AVF was used following the placement, without evidence of intervening new AVF or AVG placements, the fistula was considered to have successfully matured for use.

A patient could contribute more than 1 record to the analysis if he or she had more than 1 AVF placed. For each patient AVF record, follow-up started at placement and finished at the earliest of maturation, death, subsequent AVF placement, or end of the study period (December 31, 2014). The set-up is consistent with the classic competing-risks structure[16]; in our case, competing risks are maturation, death, or subsequent AVF or AVG placements. We analyzed the cause-specific hazard of maturation,[16,17] which amounts to the AVF maturation rate among patients who are alive and have not had a subsequent AVF or AVG placement. Naturally, for a given patient–AVF-placement combination (ie, for a given record used in our analysis), successful AVF maturation (per our described definition) can only occur before death and before subsequent AVF or AVG placement. From this perspective, the cause-specific hazard of maturation, which we refer to as the "maturation rate," estimates the rate of AVF maturation counting only the follow-up time when maturation could occur.

The maturation rate (cause-specific hazard of maturation) was modeled using cause-specific hazards models. The model included the following covariates: age, race, sex, comorbid conditions at incidence (Table S1), dialysis vintage (time since declaration of end-stage renal disease [ESRD] or time on dialysis therapy) at AVF creation, vascular access type in use at incidence, and ESRD network region. We used a robust (sandwich) estimator for the variance, in order to address the correlation across records within patient. The relationship of each covariate on the outcome was estimated by its cause-specific hazard ratio (HR). For example, the HR for females would represent the maturation rate for females, divided by the maturation rate for males, with the comparison being between a hypothetical female and male, with all other covariates being equal. An HR > 1 reflects faster maturation, whereas

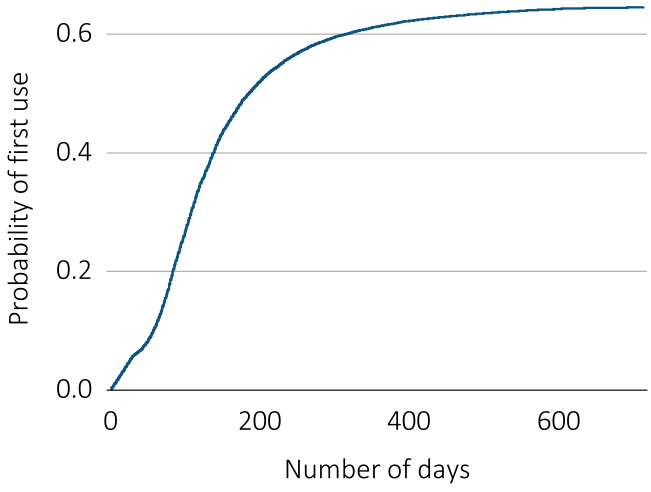

Figure 1. Cumulative probability of first use of arteriovenous fistulas placed in prevalent hemodialysis patients in the United States in 2013.