Vascular Access and Risk of Bloodstream Infection Among Older Incident Hemodialysis Patients

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Rationale & Objective: Most new patients with end-stage renal disease (ESRD) initiate hemodialysis (HD) with a central venous catheter (CVC) and later transition to a permanent vascular access with lower infection risk. The benefit of early fistula use in preventing severe infections is incompletely understood. We examined patients' first access and subsequent transitions between accesses during the first year of HD to estimate the risk for bloodstream infection (BSI) associated with incident and time-dependent use of HD access.

Study Design: A retrospective cohort study using enhanced 5% Medicare claims data.

Setting & Participants: New patients with ESRD initiating HD between January 1, 2011, and December 31, 2012, and having complete pre-ESRD Medicare fee-for-service coverage for 2 years.

Exposure: The incident and prevalent use of CVC, graft, or fistula as determined from monthly reports to the Centers for Medicare & Medicaid Services by HD providers.

Outcome: Incident hospitalization with a primary/secondary diagnosis of BSI (International Classification of Diseases, Ninth Revision, Clinical Modification code 038.xx or 790.7).

Analytical Approach: Extended survival analysis accounting for patient confounders.

Results: Of 2,352 study participants, 1,870 (79.5%), 77 (3.3%), and 405 (17.2%) initiated HD with a CVC, graft, and fistula, respectively. During the first year, the incident BSI hospitalization rates per 1,000 person-days were 1.3, 0.8, and 0.3 (P<0.001) in patients initiating with a CVC, graft, and fistula, respectively. After adjusting for confounders, incident fistula use was associated with 61% lower risk for BSI (HR, 0.39; 95% CI, 0.28-0.54; P<0.001) compared with incident CVC or graft use. The prevalent fistula or graft use was associated with lower risk for BSI compared with prevalent CVC use (HRs of 0.30 [95% CI, 0.22-0.42] and 0.47 [95% CI, 0.31-0.73], respectively).

Limitations: Restricted to an elderly population; potential residual confounding.

Conclusions: Incident fistula use was associated with lowest rates of BSI, but the majority of beneficiaries with pre-ESRD insurance initiated HD with a CVC. Strategies are needed to improve pre-ESRD fistula placement.

Improving care and outcomes for individuals with chronic kidney disease (CKD) has been the focus of recent national attention and a priority of the current administration.[1] End-stage renal disease (ESRD) is the most severe stage of CKD that requires kidney replacement

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therapy, such as dialysis or kidney transplantation, for patient survival. At present, about 458,000 patients with ESRD in the United States are treated with hemodialysis (HD).[2] Although life-sustaining, HD is associated with high morbidity and mortality, especially in the first year of dialysis, and requires establishing reliable vascular access to the bloodstream.[3] One of the frequently used types of HD vascular access in the United States, particularly at HD initiation, is a central venous catheter (CVC). Although CVCs can be placed in a timely fashion without surgical intervention, CVCs have been linked with frequent severe infectious complications, such as septicemia,[4] and high mortality.[5-9] As a result, guidelines from the Centers for Disease Control and Prevention (CDC) and the clinical practice guidelines for vascular access of the National

Kidney Foundation's Dialysis Outcomes Quality Initiative recommend the use of arteriovenous accesses designed for long-term use, such as fistulas and grafts.[10,11]

Among the 2 types of permanent vascular accesses, a native fistula is considered the gold standard due to advantages over grafts, including better primary patency[12] and lower rates of infectious complication.[4,13] It is also more cost-effective than a graft access.[14] In recognition of the advantages of fistula use, in 2003 the Centers for Medicare & Medicaid Services (CMS) launched the Fistula First Breakthrough Initiative, which contributed to an increase in prevalent fistula use from 32.2% in 2003 to 62.8% in 2017.[15] This success corresponded with a relatively minor decrease in prevalent CVC use: from 27% to 20% in the same period. Because about one-third of all patients with ESRD receiving HD are new patients,[2] the primary contributor to the suboptimal progress in decreasing prevalent CVC use is the high incident CVC use, which for the last 2 decades has been at 80%. Although multiple causes might contribute to the high rates of incident CVC use, one consistent factor reported by studies is lack of access to pre-ESRD nephrology care and vascular access planning.[16,17] For the majority of patients with

CKD, having comprehensive health insurance coverage is particularly important and is believed to facilitate early referral to nephrology care and the opportunity for timely placement of a fistula.[18]

Considering the current evidence and its limitations, this study evaluated the role of early use of fistulas in preventing severe bloodstream infections (BSIs) among older HD patients. Further, by examining changes in vascular accesses during the first year of HD, we estimated the risk for BSI associated with continued or time-dependent use of each vascular access type.

METHODS

Study Objective and Design

Using a retrospective cohort study design, we examined the risk for hospitalization with BSI among new patients with ESRD receiving HD by incident and time-dependent (prevalent) vascular access during the first year of HD. The CDC Human Research Protection Office determined that this work was exempt from the regulations governing the protection of human subjects in research under 45 CFR 46.101(b)(5). The use of informed consent was also waived because the study used deidentified data.

Our study population included ESRD Medicare beneficiaries who initiated maintenance HD between January 1, 2011, and December 31, 2012, and continued using HD throughout follow-up. The study period included a 1-year baseline period and up to a 1-year follow-up period after initiation of HD. The follow-up period for each beneficiary started at the first HD session and ended at the first occurrence of a BSI event, death, switch to peritoneal dialysis, acquisition of a kidney transplant, or end of the first year of HD. To ensure new ESRD status, patients' claims from the 2 years before initiation of HD were interrogated for evidence of prior HD, peritoneal dialysis, and preemptive kidney transplantation. The sample was restricted to those with continuous full fee-for-service Medicare insurance for the 2 years preceding initiation of HD through the end of the follow-up period.

Selection of the study cohort used institutional and noninstitutional claims and the Medicare beneficiary annual summary files (MBSFs) from the 2009 to 2013 Enhanced Medicare 5% random samples as shown in Figure 1. First, we identified beneficiaries who were 67 years or older in the 2011 to 2012 MBSF. To confirm that the population was limited to new patients with ESRD, we searched for any dialysis-related claims during the baseline period of each beneficiary in inpatient, outpatient, skilled nursing facility, and home health agency claims and selected beneficiaries without preemptive kidney transplantation and whose first dialysis claim was for HD in 2011 to 2012. Last, we selected those for whom HD access type was reported within 60 days of the HD initiation based on outpatient HD claims.

Exposures and Outcome

Vascular access used at the last HD session of the month is required for CMS reporting as of July 2010[19] and has an excellent level of agreement (94%) with those reported in the Medical Evidence Form (CMS-2728).[20] Using the modifier codes in the first outpatient HD claim (V5, V6, and V7 for CVC, graft, and fistula, respectively), we characterized our study population by incident vascular access. Then we obtained vascular access modifier codes from all subsequent monthly HD claims submitted during follow-up and divided the follow-up period into respective monthly intervals. Each interval was defined by a start date (date of a previous claim) and end date (date of a current claim) (Fig 2). The vascular access reported on a previous claim was assigned to be the prevalent access of the current interval.

The primary outcome of the study was an incident hospitalization with BSI during the observation period and was identified through 2011 to 2013 inpatient claims with a primary/secondary diagnosis of BSI (*International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM] code 038.xx or 790.7).

Potential Confounders

Potential confounders to the relationship between vascular access and risk for BSI were considered. Comorbid conditions at baseline were determined for each patient using the chronic condition flag provided in the MBSFs.[21] The Gagne comorbidity score, a validated predictor of mortality, was calculated using inpatient claims for the baseline year.[22] The location of first HD session, inpatient or outpatient, was based on the originating claim, including inpatient, outpatient, home health, and skilled nursing facility, and was used as a marker of patient health status at HD initiation. Prior health care use, an indirect indicator of health status, was measured by total Medicare reimbursement during the baseline year. Demographics were obtained from the MBSF.

Analysis

We used Mantel-Haenszel χ^2 test to assess group differences in values of categorical variables and *t* test for continuous variables. To study the impact of incident access on risk for BSI hospitalization, we used the Kaplan-Meier method and multivariable Cox regression adjusting for baseline confounders. Observations were censored at death or change in dialysis mode from HD to peritoneal dialysis or kidney transplantation. Kaplan-Meier curves for incident vascular access groups were compared using log-rank test. The impact of prevalent access on risk for BSI was examined using an extended Cox proportional method that allows for the investigation of time-varying exposure.[23] A time-lag effect was applied to estimate the probability of survival without BSI during an interval depending on the observed value of HD access reported at the end of the previous interval.
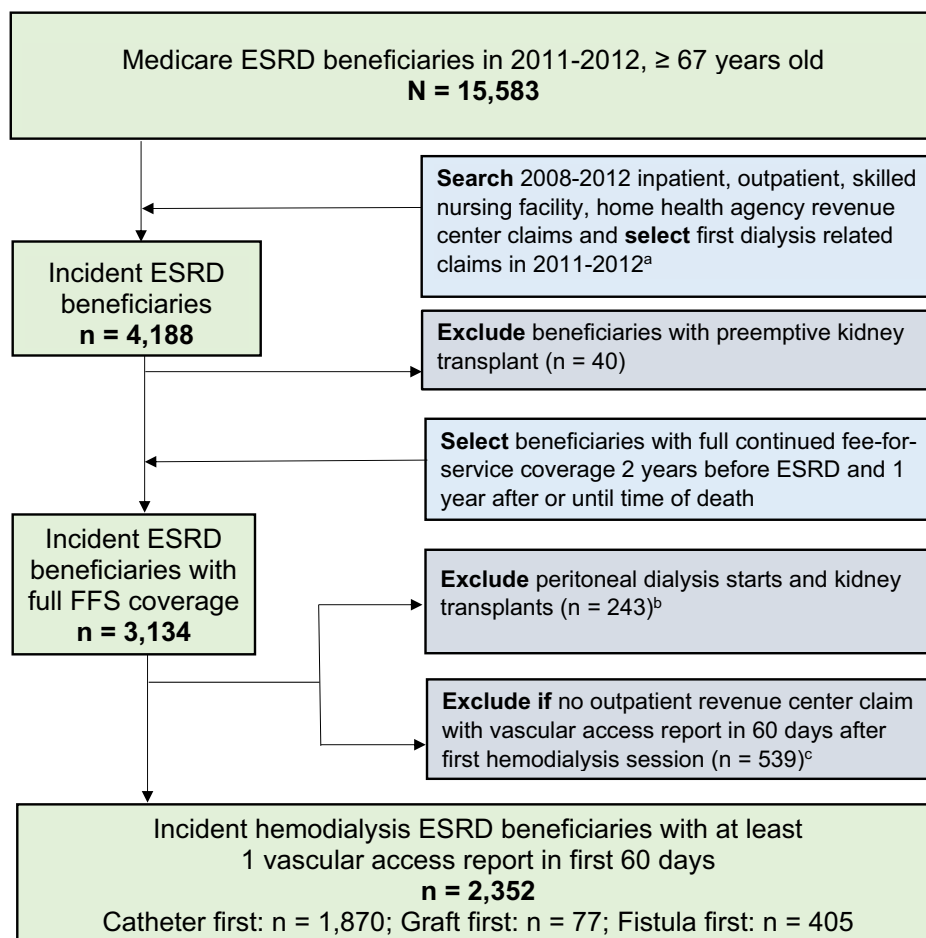
Figure 1. Flow chart presents steps in selecting the study cohort of new maintenance hemodialysis (HD) patients using Medicare insurance claims that satisfied the following criteria: new patients with end-stage renal disease (ESRD) who initiated HD in 2011 to 2012, continually used HD as the only mode of kidney replacement therapy during follow-up, were 67 years or older, had full continued fee-for-service (FFS) Medicare coverage 2 years before and 1 year after initiation of HD (or until death), and had vascular access type reported to the Centers for Medicare & Medicaid Services within 60 days after initiation of HD. Data Source: Medicare Beneficiary Summary File. ªDialysis related claims were identified through revenue center codes: 0800-0804, 0809-0814, 0819-0825, 0829-0835, 0839-0845, 0849-0855, 0859, 0880-0882, and 0889. ᵇThis was achieved by including only HD claims using revenue center codes for HD: 0800-0801, 0820-0825, and 0829. Kidney transplantations were identified using *International Classification of Diseases, Ninth Revision, Clinical Modification* code V420 and procedure code 5569 in base inpatient and outpatient claims. ᶜVascular access type was determined by searching Healthcare Common Procedure Coding System (HCPCS) modifier codes in outpatient revenue center claims in which codes V5, V6, and V7 represented central venous catheter, arteriovenous graft, and arteriovenous fistula, respectively. Abbreviation: ESRD, end-stage renal disease.

Although fistula remains a gold standard for HD access, several reports indicated a potentially high fistula maturation failure rate, which could contribute to the high incident CVC use.[24] To examine whether fistula maturation failure had an impact on high incident CVC use in our study cohort, we reviewed fistula placement procedures in the 12 months before HD initiation for those initiating with a CVC. Fistula maturation failure was defined as incident CVC use in patients with fistula placement procedure in more than 90 days before the start of HD. Fistula placements were identified by *Current Procedural Terminology, 4th Edition* (36818, 36819, 36820, 36821, and 36832) and ICD-9-CM (39.27) codes[25] in inpatient/outpatient revenue center and inpatient base claims, respectively.

Analyses were conducted using SAS, version 9.4, statistical software (SAS Institute). Alpha was set to 0.05 for all statistical analyses.

RESULTS

As detailed in Figure 1, of 15,583 ESRD beneficiaries who were 67 years or older in the 5% Medicare enrollment database in 2011 to 2012, a total of 2,352 (15.1%) met our study selection criteria. Of those, 1,870 (79.5%), 77 (3.3%), and 405 (17.2%) started HD with a CVC, graft, and fistula, respectively. Mean age was 78 years. Patients initiating with a fistula were more likely to be men and white, as compared with patients starting with a CVC or
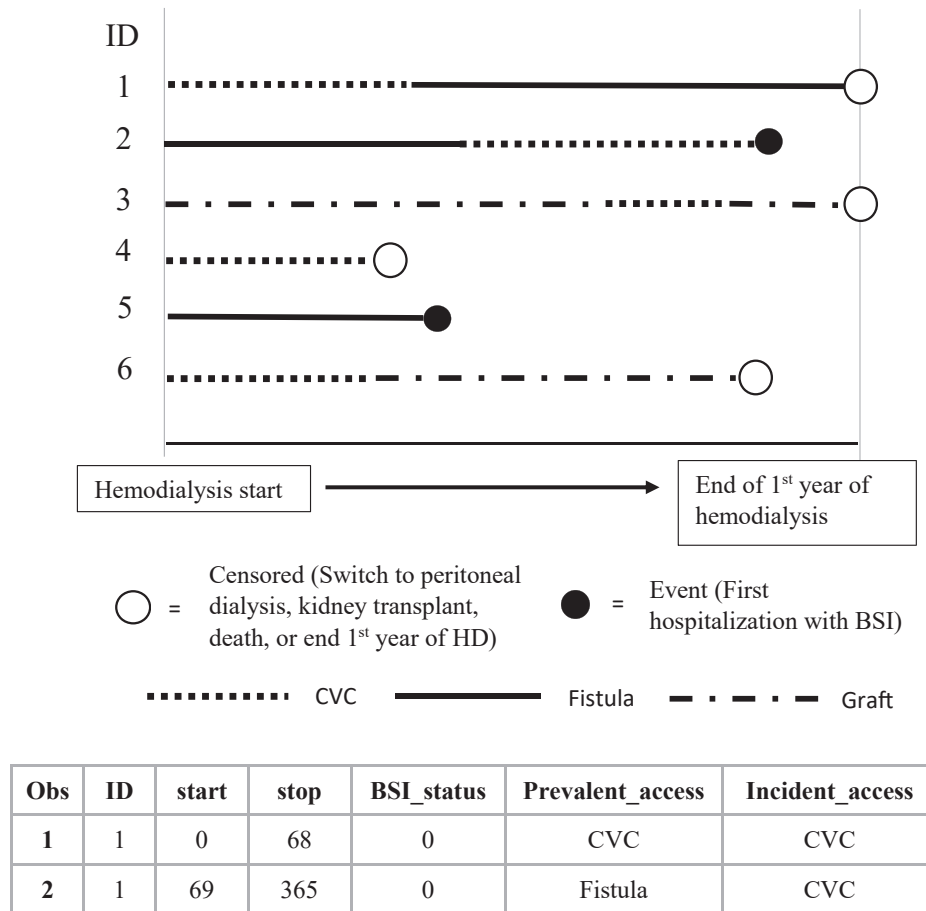
Figure 2. Schematic depiction of survival data for 6 hypothetical patients with a time-dependent (prevalent) vascular access exposure. Abbreviations: BSI, bloodstream infection; CVC, central venous catheter; HD, hemodialysis.

graft (Table 1). The proportion of patients who died during the first year of HD was significantly higher among those initiating with CVCs (37.5%) than among those starting with grafts (16.9%) or fistulas (12.8%) (Table 2). Similarly, significantly more patients with incident CVC use had a Gagne comorbidity score of 1 or greater, suggesting lower likelihood of survival than those initiating with a graft or fistula. Chronic conditions were more prevalent among CVC starters as compared with those initiating with either a graft or fistula (Table 1). The unadjusted mean total Medicare reimbursement for health care delivered during the pre-ESRD year was significantly higher for CVC starters as compared with graft or fistula starters. Patients initiating HD with a CVC were almost twice as likely to have their first HD session in a hospital (83.6%) as compared with those initiating with a graft (50.6%) or fistula (44.2%).

The initial access did not change throughout follow-up for the majority of our study population. Specifically, 81.2%, 70.1%, and 50.2% of beneficiaries initiating with a fistula, graft, and CVC, respectively, continued using their initial vascular access throughout follow-up. However,

18.8% and 29.9% of those initiating with a fistula or graft also used a CVC at least once during their follow-up and 49.8% transitioned from a CVC to a fistula or graft (Table 2). Of 1,870 patients starting with a CVC, fistula placement procedure codes were found in 379 (20%) patients in the baseline year. Of those, 78 (4%) had a fistula placement procedure performed more than 90 days before HD initiation and likely represent fistula maturation failures.

Hospitalization With BSI

Of 2,352 patients, 607 (25.8%) were admitted to a hospital with a diagnosis of BSI at least once during the first year of HD (29.3% of CVC starters, 23.4% of graft starters, and 10.1% of fistula starters). Unadjusted rates of incident BSI hospitalization per 1,000 patient-days were 1.28, 0.81, and 0.33 among beneficiaries initiating with a CVC, graft, and fistula, respectively (Table 2). The likelihood of avoiding hospitalization with BSI was significantly higher (log-rank test P<0.001) among beneficiaries initiating with a fistula and graft than those initiating with a CVC (Fig 3).

Table 1. Baseline Characteristics of 2,352 New ESRD Medicare Beneficiaries on Maintenance Hemodialysis in 2011-2012 by Vascular Access Type at Hemodialysis Initiation

	Central Venous Catheter First	Arteriovenous Graft First	Arteriovenous Fistula First	P[a]
N	1,870 (79.5%)	77 (3.3%)	405 (17.2%)	
Age, y	78.8 (6.6)	78.6 (5.9)	77.9 (6.5)	<0.001
Black race	384 (20.5%)	24 (31.2%)	76 (18.3%)	0.11
Male sex	937 (50.1%)	32 (41.6%)	250 (61.7%)	<0.001
Chronic conditions				
Alzheimer disease	82 (4.4%)	—[b]	11 (2.7%)	0.22
Alzheimer disease and related disorders	296 (15.8%)	13 (16.9%)	36 (8.9%)	<0.001
Cataracts	261 (13.9%)	10 (12.9%)	74 (18.3%)	0.03
Chronic obstructive pulmonary disease	636 (34%)	21 (27.3%)	94 (23.2%)	<0.001
Chronic heart failure	1,452 (77.6%)	49 (63.6%)	242 (59.7%)	<0.001
Diabetes	1,288 (68.9%)	49 (63.6%)	253 (62.5%)	0.009
Glaucoma	152 (8.1%)	—	50 (12.4%)	0.009
Ischemic heart disease	1393 (74.5%)	52 (67.5%)	277 (68.4%)	0.008
Depression	382 (20.4%)	14 (18.2%)	65 (16.1%)	0.04
Osteoporosis	124 (6.6%)	—	15 (3.7%)	0.02
Rheumatoid arthritis or osteoarthritis	775 (41.4%)	24 (31.2%)	119 (29.4%)	<0.001
Stroke or transient ischemic attack	171 (9.1%)	—	21 (5.2%)	0.008
Breast cancer	75 (4.0%)	—	11 (2.7%)	0.19
Colorectal cancer	62 (3.3%)	—	—	0.24
Prostate cancer	113 (6.04%)	—	22 (5.4%)	0.51
Lung cancer	28 (1.5%)	—	—	0.68
Endometrial cancer	10 (0.5%)	—	—	0.74
Anemia	1795 (95.9%)	74 (96.1%)	392 (96.8%)	0.46
Asthma	144 (7.7%)	—	20 (4.9%)	0.04
Hyperlipidemia	1391 (74.4%)	56 (72.7%)	297 (73.3%)	0.63
Benign prostatic hyperplasia	262 (14.0%)	—	58 (14.3%)	0.98
Hypertension	1,793 (95.9%)	73 (94.8%)	379 (93.6%)	0.04
Hypothyroidism	431 (23.1%)	16 (20.8%)	71 (17.5%)	0.02
Gagne score				
0	1,273 (68.1%)	57 (74.0%)	321 (79.3%)	<0.001
≥1	597 (31.9%)	20 (25.9%)	84 (20.7%)	
Health care use				
Total pre-ESRD reimbursement by Medicare	$54,518 ($47,305)	$40,805 ($34,566)	$29,871 ($31,593)	<0.001
Inpatient location of 1st HD	1,563 (83.6%)	39 (50.6%)	179 (44.2%)	<0.001

Note: Values are given as number (percent) or mean (standard deviation).
Abbreviations: ESRD, end-stage renal disease; HD, hemodialysis.
[a]Calculated using unadjusted Mantel-Haenszel χ^2 test for categorical variables and *t* test for continuous variables.
[b]Small cell count of 10 or fewer is not reported.

Multivariable Analysis

For incident access, the risk for BSI hospitalization was 61% lower among patients initiating HD with a fistula (hazard ratio [HR], 0.39; 95% confidence interval [CI], 0.28-0.54) as compared with those initiating with a CVC, after adjustment for potential confounders in the Cox proportional hazards regression model (Table 3). For incident use of grafts, the risk for BSI hospitalization was also lower; however, it was not significantly different from incident CVC use (HR, 0.82; 95% CI, 0.51-1.31). Prevalent use of either a graft (HR, 0.47; 95% CI, 0.31-0.73) or fistula (HR, 0.30; 95% CI, 0.22-0.42) was associated with significantly lower risk for BSI when compared with prevalent CVC use.

DISCUSSION

This study used a nationally representative cohort of new patients with ESRD receiving HD with established and complete Medicare coverage for 2 years before initiation of maintenance HD and demonstrated that patients initiating HD with an arteriovenous fistula had substantially lower risk for acquiring BSI in the first year of HD compared with those initiating with a CVC. This has not previously been demonstrated in a contemporary cohort restricted to patients with pre-ESRD Medicare coverage and adjusting for various potential confounders. Furthermore, we found that prevalent or continued use of a fistula or graft was associated with lower risk for BSI than prevalent use of a CVC. Last, this study indicates the incomplete role of

Table 2. Incident Hospitalization With Bloodstream Infection, Deaths, and Follow up Among New HD Patients

	Central Venous Catheter First	Arteriovenous Graft First	Arteriovenous Fistula First	P^a
N	1,870 (79.5%)	77 (3.3%)	405 (17.2%)	
Died during follow up	702 (37.5%)	13 (16.9%)	52 (12.8%)	<0.001
Incident hospitalization with bloodstream infection	548 (29.3%)	18 (23.4%)	41 (10.1%)	<0.001
Days between first HD and hospitalization with bloodstream infection, median (p25th, p75th percentiles)	88 (30, 180)	84 (40, 238)	139 (44, 233)	<0.001
Total follow-up by incident access, d	429,333	22,157	125,864	<0.001
Median patient follow-up, d				
Prevalent CVC access	127	91	59	<0.001
Prevalent graft	176	320	145	
Prevalent fistula	149	6	336	
Incident hospitalization rate per 1,000 person-d (95% CI)	1.28 (1.17-1.39)	0.81 (0.51-1.29)	0.33 (0.24-0.44)	
No. of times vascular access type changed during follow-up				
No change	939 (50.2%)	54 (70.1%)	329 (81.2%)	<0.001
1	754 (40.3%)	12 (15.6%)	25 (6.2%)	
2	82 (4.4%)	—	37 (9.1%)	
>2	95 (5.1%)	—	14 (3.5%)	

Note: Values are given as number (percent), unless otherwise noted.
N = 2,352
Abbreviations: CI, confidence interval; CVC, central venous catheter; HD, hemodialysis; p25, 25th percentile.
^aCalculated using unadjusted Mantel-Haenszel χ^2 test for categorical variables and *t* test for continuous variables.

fee-for-service Medicare insurance in achieving high incident fistula use because only 17% of the study population initiated HD with a fistula.

Our findings of the beneficial role of early fistula use in preventing serious infectious complications strengthens relevant observations from similar studies. Powe et al[6] analyzed risk factors for septicemia among a cohort of HD patients that initiated dialysis in 1986 to 1987 and found that incident use of a temporary CVC (within the first 6 weeks of HD start) was associated with 48% higher
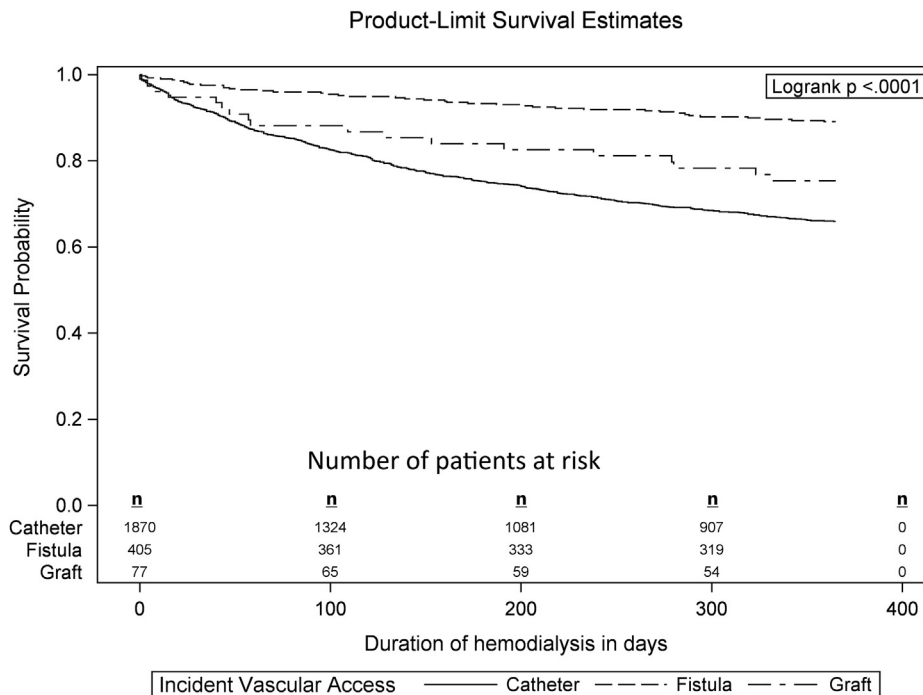

Product-Limit Survival Estimates

Logrank p <.0001

Figure 3. Kaplan-Meier survival without event (incident hospitalization with bloodstream infection) by incident vascular access type: fistula, graft, and central venous catheter. Survival is censored at time of death, transition to peritoneal dialysis, acquisition of kidney transplant, or end of first year of hemodialysis.

Table 3. Cox Proportional Hazards Regression for Relative Hazard of Incident BSI Hospitalization by Incident and Prevalent Vascular Access Types

	Model 1		Model 2[a]	
	HR (95% CI)	P	HR (95% CI)	P
Incident Vascular Access				
Central venous catheter first	Referent			
Arteriovenous graft first	0.82 (0.51-1.31)	0.40		
Arteriovenous fistula first	0.39 (0.28-0.54)	<0.001		
Prevalent Vascular Access				
Central venous catheter			Referent	
Arteriovenous graft			0.47 (0.31-0.73)	0.001
Arteriovenous fistula			0.30 (0.22-0.42)	<0.001

Note: N = 2,352. This table shows the adjusted relative hazards of incident hospitalization with BSI during follow-up, associated with incident (model 1) and prevalent vascular access (model 2). All models include the following adjustors: Gagne score, age, race, sex, total Medicare reimbursement in the pre-ESRD year, location of first hemodialysis, and chronic conditions significant in the bivariate analysis presented in Table 1.
Abbreviations: BSI, bloodstream infection; CI, confidence interval; ESRD, end-stage renal disease; HR, hazard ratio.
[a]Model 2 applied extended Cox proportional hazards regression with time-varying exposure to study relative hazard of incident BSI hospitalization by prevalent access.

risk for septicemia, and incident use of a graft was associated with 34% higher risk for septicemia when compared with incident use of a fistula. However, in that study, incident use of a permanent CVC was not statistically significantly associated with higher risk for septicemia than incident use of a fistula. Because the study substantially preceded the Fistula First Initiative and the distribution of initial vascular access types was markedly different in that historical cohort, the findings might not be applicable to the current HD population and context of care delivery.

The lower risk for BSI among patients with ESRD initiating HD with a fistula than among those initiating with a graft may reflect the month-to-month changes in vascular access type. In our cohort, we found a significantly higher rate of changes in access type among graft starters than among fistula starters. The higher prevalent CVC use among graft starters is likely to translate into an added risk for infectious complications. However, when longevity of a vascular access is preserved, the risk for serious infectious complications may decrease.[26] Further, we determined that primary fistula failure occurred among ~4% of patients initiating with a CVC and therefore was an insignificant contributor to the high use of CVCs at HD initiation. Although experts have debated the benefits of fistulas versus grafts when access failure rates are considered,[27,28] in this study, fistulas were superior to grafts, likely in part because of their successful patency and longevity. Further, 50% of patients who initiated HD with a CVC transitioned to a fistula or graft; that suggests that those patients were not poor surgical candidates and could benefit from fistula or graft placement before HD initiation.

The low fistula use in our study population indicates that barriers to predialysis care exist for patients on fee-for-service Medicare coverage. Previous studies linked incident CVC use with late nephrologist referral and lack of pre-ESRD nephrology care.[16,29] Gillespie et al[17] found that 33% of new patients with ESRD, the majority of whom were Medicare beneficiaries, received no prior nephrology care.

There are other potential barriers as well, such as patient denial of the severity of CKD; poor patient education on vascular access; lack of staff to guide patients through the vascular access process; lack of coordinated multidisciplinary approaches with surgeons, radiologists, and nephrologists working together as a team; and poor patient follow-up.[30-32] In the elderly population we studied, the low incident fistula use might reflect individualized goals for care that are not simply to extend life. Many patients might not have been good candidates for fistula placement or may have had other complex medical conditions that limited their life expectancy. Of note, Swaminathan et al[33] found that insurance coverage in the form of Medicaid expansion led to reductions in mortality and increases in incident fistula or graft use among new patients with ESRD. The survival benefit was most pronounced in patients aged 19 to 44 years, suggesting that insurance coverage may play a greater role in younger persons with CKD.

Apart from health insurance, several reports indicate that a successful reversal in current practice patterns is possible.[32] For example, implementation of a multidisciplinary program to prioritize fistula creation in a New Jersey Medical Center resulted in an increase in incident fistula use from 20% to 60%.[34] In health care systems with a more defined patient population, such as the Department of Veterans Affairs, the Department of Defense, and Kaiser Permanente, close to 60% of incident fistula use was achieved by determining the CKD stage of all of their patients with CKD, providing vascular access education, having a CKD/ESRD coordinator, and tracking optimal dialysis starts.[35]

Reducing long-term CVC use is an important actionable target for improving outcomes for HD patients. In our study, 32% used a CVC from the start and never transitioned to a permanent access. Issues such as unsuitable veins may have made some of these patients poor candidates for a fistula or graft. Presently, many patients initiate HD abruptly and have no choice but to use a CVC for

access. However, the likelihood of successful fistula placement declines with extended CVC use[36] due to vein damage,[37,38] and more established patient preferences for a CVC over time might also present a challenge.[37] In future studies of vascular access, it will be important to investigate both patient- and system-level factors that could contribute to sustained CVC use in this population.

Another important finding is the high proportion of patients initiating HD in an inpatient setting. In our study population, a substantial number of patients with established permanent vascular access, specifically 50% of patients initiating HD with a graft and 44% initiating with a fistula, received their first HD in a hospital. This is consistent with the results of another study by Ishani et al,[39] which found that among patients initiating HD with an optimal vascular access, despite substantial predialysis care and presence of a functioning fistula, 40.8% initiated HD in a hospital, resulting in higher resource use and cost to CMS. The reasons for this practice and how HD initiation in the hospital can be reduced requires further study.

Our study had several strengths. First, we used a national contemporary cohort of new HD patients with ESRD. Second, using preexisting chronic condition data from Chronic Conditions Data Warehouse and Medicare claims data from across the continuum of health care settings enabled censoring at critical events (eg, changes in dialysis mode, vascular access type, or attainment of a transplant) and adjusting for important confounders. Last, the study applied rigorous methods of cohort selection and extended survival analysis, accounting for time-varying vascular access exposures. To our knowledge, this is the first study that applied this methodology to investigate vascular access, which is an important advancement in addressing the potential bias frequently present in observational studies.

As a retrospective cohort study using administrative data, there is potential for misclassification bias in our exposure. Because dialysis providers are required by CMS to report vascular access used for the last HD session of the reimbursement month, it is possible that the actual first access was different from the one reported in the initial claim and as a result was misclassified. Similarly, the prevalent access assignment might be affected by inaccurate reporting. However, the misclassification is likely to occur at random and affect all access categories equality, influencing the estimated effects toward the null. Likewise, our analysis of fistula placements in the pre-ESRD period relied on identification of procedure codes in claims, and it is possible that fistula placements could have been missed, resulting in misclassification. In addition, use of a 90-day minimum time to fistula maturation instead of a longer time may have resulted in an overestimate of failure rate, given a median of 111 days to first reported fistula use following placement.[40]

Further, because patients initiating HD with a CVC were more likely to die, this censoring event represented a competing risk, likely biasing risk estimates toward the null. In addition, due to the small number of patients initiating

HD through graft access in our sample, our power to estimate the relationship between this access type and risk for subsequent BSI may have been limited. Notably, CIs for the incident and prevalent graft exposures in models 1 and 2, respectively, were more than twice as wide as the intervals for the corresponding fistula exposures. However, despite the reduced precision, the prevalent graft access still showed a protective effect compared with CVC access. Last, because we limited our study cohort to patients 67 years or older, our study population was older than the general population of new patients with ESRD, limiting its generalizability However,. it is notable that we identified a substantial benefit to early arteriovenous fistula use even in this cohort of patients with ESRD with advanced age.

This national study demonstrated that initiating HD with a fistula as opposed to a CVC or graft was associated with the lowest rates of BSI in the first year of HD. In this elderly population with pre-ESRD Medicare coverage, only 17% of patients initiated HD with a fistula, 4% of patients who initiated HD with a CVC had a failed fistula, and a substantial proportion of all patients initiated HD in the hospital. The challenge of achieving early fistula use and reducing CVC prevalence likely requires a combination of strategies, beyond pre-ESRD insurance, to successfully reach and prepare patients for dialysis and coordinate CKD care with future dialysis needs.

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