Outcomes of Elderly Patients after Predialysis Vascular Access Creation

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ABSTRACT

Uniform vascular access guidelines for elderly patients may be inappropriate because of the competing risk of death, high rate of arteriovenous fistula (AVF) maturation failure, and poor vascular access outcomes in this population. However, the outcomes in elderly patients with advanced CKD who receive permanent vascular access before dialysis initiation are unclear. We identified a large nationally representative cohort of 3418 elderly patients (aged ≥70 years) with CKD undergoing predialysis AVF or arteriovenous graft (AVG) creation from 2004 to 2009, and assessed the frequencies of dialysis initiation, death before dialysis initiation, and dialysis-free survival for 2 years after vascular access creation. In all, 67% of patients with predialysis AVF and 71% of patients with predialysis AVG creation initiated dialysis within 2 years of access placement, but the overall risk of dialysis initiation was modified by patient age and race. Only one half of patients initiated dialysis with a functioning AVF or AVG; 46.8% of AVFs were created <90 days before dialysis initiation. Catheter dependence at dialysis initiation was more common in patients receiving predialysis AVF than in patients receiving AVG (46.0% versus 28.5%; *P*<0.001). In conclusion, most elderly patients with advanced CKD who received predialysis vascular access creation initiated dialysis within 2 years. As a consequence of late predialysis placement or maturation failure, almost one half of patients receiving AVFs initiated dialysis with a catheter. Insertion of an AVG closer to dialysis initiation may serve as a "catheter-sparing" approach and allow delay of permanent access placement in selected elderly patients with CKD.

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Approximately 80% of United States patients initiate hemodialysis with a central vein catheter (CVC), rather than a permanent vascular access, resulting in increased rates of infection, unnecessary hospitalizations, and higher mortality.[1–6] Major efforts have been undertaken by the nephrology community to increase the use of permanent vascular access, particularly arteriovenous fistulas (AVFs). One major barrier to increasing the use of AVFs at dialysis initiation has been the paucity of evidence about the optimal timing of preemptive vascular access placement.[7] If the AVF is created too late, the patient will likely start dialysis with a CVC. On the other hand, if the AVF is created too early, it may never be used because the patient dies before requiring dialysis or does not require initiation of dialysis for a prolonged period. The current guidelines from the Fistula First Breakthrough Initiative[8] and 2006 Kidney Disease Outcomes Quality Initiative (KDOQI)[9] recommend that "a fistula should be created at least 6 months or with sufficient lead time before the anticipated start of hemodialysis treatments for fistula maturation." This timing allows for vascular access evaluation and additional time for revision to ensure that a working AVF is available at initiation of dialysis therapy.

There is even greater uncertainty about the optimal predialysis vascular access strategy in elderly patients with CKD. Applying uniform vascular

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access guidelines to elderly individuals may not be appropriate because of the competing risk of death,[7,10] the high rate of AVFs that fail to mature,[11] and poor vascular access outcomes in the elderly population.[12] Thus, the objective of this study was to use a large representative United States population to identify the proportion of elderly patients with advanced CKD with predialysis AVF or arteriovenous graft (AVG) creation who survive to initiate dialysis, die before dialysis initiation, or survive dialysis free during 2 years of follow-up. In addition, we evaluated whether certain demographic and clinical factors affected the likelihood of dialysis initiation in this patient population, and we assessed the likelihood of initiating dialysis with the permanent access created before dialysis.

RESULTS

Patient Characteristics

During the 6-year period between January 1, 2004, and December 31, 2009, 3418 elderly patients (aged ≥70 years) with CKD from the 5% Medicare sample received an AVF or AVG before initiating dialysis (Figure 1). Table 1 presents the baseline patient characteristics by demographics and comorbidities, which are stratified into three groups on the basis of the patient outcomes during the 2-year period after access surgery: (*1*) patients who initiated dialysis, (*2*) patients who died without initiating dialysis, and (*3*) patients who survived without requiring dialysis therapy. After predialysis vascular access creation, the median times to dialysis initiation, patient death, and dialysis-free patient survival were 84.5 days (interquartile range, 24–233), 132 days (interquartile range, 33–343), and 730 days, respectively. The mean age of patients in this study cohort was 78.0 years. The majority of patients were men (54.0%), white (74.7%), and had AVFs inserted as the initial vascular access (80.2%). A large proportion of patients at the time of vascular access insertion had diabetes (66.2%), ischemic heart disease (64.6%), peripheral vascular disease (63.4%), and congestive heart failure (40.6%); 12.4% of patients had depression. The mean comorbidity score for all patients was 8.2.

Patient Outcomes after Predialysis Vascular Access Creation

Among the 3418 elderly patients with CKD receiving a vascular access before dialysis, 67.4% started dialysis, 15.1% died, and 17.5% survived without requiring dialysis by the end of the 2-year follow-up. Patient outcomes after vascular access creation differed significantly by age, race, comorbidities, and type of vascular access (Table 1). Patients aged between 70 and 74 years were more likely to initiate hemodialysis within 2 years of vascular access creation compared with those patients aged 75–84 years and ≥85 years (Table 1). When these age subgroups were adjusted in a proportional hazard model that treated death as a competing event, increasing age was associated with a decreased likelihood of initiating dialysis. However, only patients aged ≥85 years were less likely to start dialysis with death as a competing event compared with the reference group of patients (hazard ratio [HR], 0.83; 95% confidence interval [95% CI], 0.72 to 0.96; *P*=0.01) (Table 2).

Black patients were more likely to initiate dialysis after predialysis vascular access creation and were less likely to die before dialysis initiation compared with white patients (Table 1). When adjusted using a proportional hazards model that treated death as a competing event, black patients were more likely to start dialysis than die compared with white patients (HR, 1.14; 95% CI, 1.02 to 1.27; *P*=0.02) (Table 2).

The patients with the highest comorbidity scores (11–21) were least likely to initiate hemodialysis compared with those with lower scores (0–4 and 5–10) (Table 1). When adjusted using a proportional hazards model that treated death as a competing event, the comorbidity scores were no longer associated with likelihood of starting dialysis (Table 2).

Patients receiving an AVG were more likely to initiate dialysis after predialysis vascular access creation and were less likely to survive dialysis free compared with those receiving an AVF (Table 1). When adjusted using a proportional hazards model that treated death as a competing event, patients with predialysis AVG creation were more likely to initiate dialysis than die compared with those with predialysis AVF creation (HR, 1.30; 95% CI, 1.16 to 1.45; *P*<0.001) (Table 2).

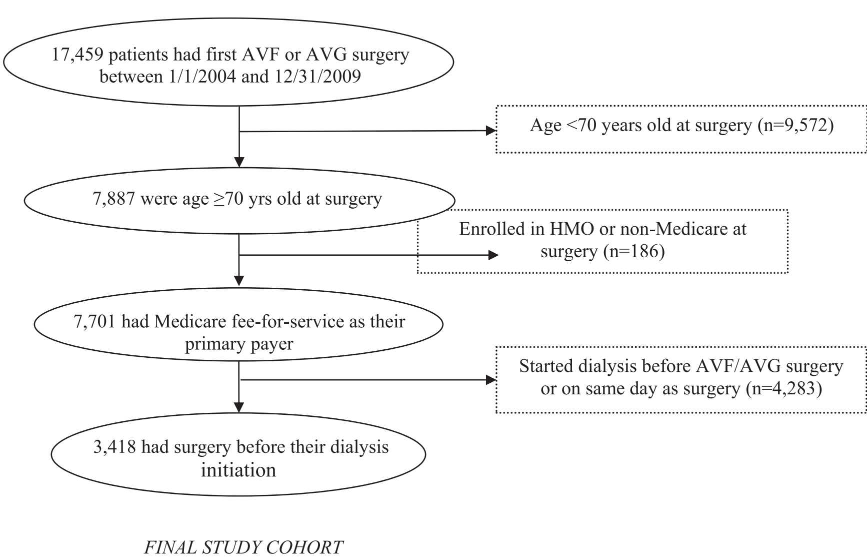

Figure 1. Patient cascade of an elderly cohort with CKD with AVF/AVG creation before initiation of dialysis using 5% Medicare sample CKD-based cohort data set. HMO, health maintenance organization.

Table 1. Outcomes of elderly patients with CKD after first vascular access insertion, according to patient demographics, vascular access type, comorbidities, and year of vascular access insertion

Covariate	Variable[a]	Initiated Dialysis[b]	Died before Dialysis[b]	Survived Dialysis Free[b]	*P* Value
Study cohort	3418 (100)	2304 (67.4)	515 (15.1)	599 (17.5)	
Age at study start (yr)					
70–<75	1047 (30.6)	724 (69.1)	127 (12.1)	196 (18.7)	<0.001
75–<85	1914 (56.0)	1306 (68.2)	288 (15.0)	320 (16.7)	
≥85	457 (13.4)	274 (60.0)	100 (21.9)	83 (18.2)	
Sex					
Men	1845 (54.0)	1255 (68.0)	290 (15.7)	300 (16.3)	0.08
Women	1573 (46.0)	1049 (66.7)	225 (14.3)	299 (19.0)	
Race					
White	2552 (74.7)	1676 (65.7)	405 (15.9)	471 (18.5)	0.003
Black	597 (17.5)	429 (71.9)	72 (12.1)	96 (16.1)	
Other/unknown	269 (7.9)	199 (74.0)	38 (14.2)	32 (11.9)	
Vascular access					
AVF	2741 (80.2)	1825 (66.6)	382 (13.9)	534 (19.5)	<0.001
AVG	677 (19.8)	479 (70.8)	133 (19.6)	65 (9.6)	
Comorbidity score					
0–4	829 (24.3)	570 (68.8)	48 (5.8)	211 (25.5)	<0.001
5–10	1474 (43.1)	1013 (68.7)	208 (14.1)	253 (17.2)	
11–21	1115 (32.6)	721 (64.7)	259 (23.2)	135 (12.2)	
Coexisting diseases					
Diabetes	2263 (66.2)	1555 (68.7)	330 (14.6)	378 (16.7)	0.07
Cancer	925 (27.1)	613 (66.3)	160 (17.3)	152 (16.4)	0.07
Ischemic heart disease	2208 (64.6)	1471 (66.6)	376 (17.0)	361 (16.4)	<0.001
Chronic obstructive pulmonary disease	1283 (37.5)	837 (65.2)	244 (19.0)	202 (15.7)	<0.001
Peripheral vascular disease	2168 (63.4)	1442 (66.5)	373 (17.2)	353 (16.3)	<0.001
Cerebrovascular disease	1368 (40.0)	919 (67.2)	240 (17.5)	209 (15.3)	0.001
Depression	423 (12.4)	254 (60.0)	99 (23.4)	70 (16.5)	<0.001
Dementia	356 (10.4)	219 (61.5)	79 (22.2)	58 (16.3)	0.001
Cardiac events					
Stroke	129 (3.8)	74 (57.4)	39 (30.2)	16 (12.4)	<0.001
Myocardial infarction	160 (4.7)	90 (56.3)	54 (33.8)	16 (10.0)	<0.001
Congestive heart failure	1388 (40.6)	915 (65.9)	294 (21.2)	179 (12.9)	<0.001
Year of vascular access insertion					
2004	569 (16.6)	391 (68.7)	105 (18.5)	73 (12.8)	0.01
2005	609 (17.8)	410 (67.3)	101 (16.6)	98 (16.1)	
2006	634 (18.5)	430 (67.8)	89 (14.0)	115 (18.1)	
2007	588 (17.2)	376 (63.9)	92 (15.6)	120 (20.4)	
2008	491 (14.4)	344 (70.1)	62 (12.6)	85 (17.3)	
2009	527 (15.4)	353 (67.0)	66 (12.5)	108 (20.5)	

The cohort was followed for 2 years after first vascular access insertion until death, initiation of dialysis, or end of follow-up. *P* values were determined by Pearson's chi-squared test. Patients' comorbidities were determined by using one inpatient and/or two outpatient claims in the 5 years preceding the study index date. Cardiac events were determined 1 year preceding the study index date using primary inpatient diagnosis only.

[a]Values are the number of patients with a given variable and the percentage of the total study cohort.

[b]Values are the number of patients and percentage of patients for that row.

Vascular Access Type and Patient Outcomes

Of the pre-ESRD accesses created, 80.2% were AVFs and 19.8% were AVGSs (Table 1). Among elderly patients with predialysis AVF creation, two thirds initiated dialysis, 13.9% died without starting dialysis, and 19.5% survived dialysis free (Table 1). Patients aged ≥85 years with predialysis AVF creation were less likely to initiate dialysis than die (HR, 0.79; 95% CI, 0.67 to 0.93; P=0.01) (Table 3). Among elderly patients with AVG creation, a slightly higher proportion, 70.8% initiated dialysis (Table 1). Among patients with AVG creation, age, sex, race, and comorbidity score did not influence the likelihood of initiating dialysis after adjusting for the competing risk of death (Table 3).

Figure 2 shows the distribution of time from vascular access creation to dialysis initiation for the 1825 patients with AVF creations and the 479 patients with AVG who began dialysis. Almost one half of AVFs (46.8%) were created <90 days before initiation of dialysis, 18.0% within 91 and 180 days, 19.7%

Table 2. Association of age, sex, race, Charlson Comorbidity Index score, and vascular access type on the likelihood of starting dialysis, using the Fine–Gray proportional model to adjust for the competing risk of deaths

Covariate	Hazard Ratios (95% CIs)	*P* Value
Age (yr)		
70–<75 (reference)		
75–<85	0.97 (0.89 to 1.07)	0.57
≥85	0.83 (0.72 to 0.96)	0.01
Sex		
Men (reference)		
Women	0.94 (0.86 to 1.02)	0.14
Race		
White (reference)		
Black	1.14 (1.02 to 1.27)	0.02
Other	1.28 (1.10 to 1.50)	0.002
Comorbidity score		
0–4 (reference)		
5–10	1.09 (0.99 to 1.20)	0.09
11–21	1.03 (0.93 to 1.15)	0.56
Vascular access type		
AVF (reference)		
AVG	1.30 (1.16 to 1.45)	<0.001

with 181 and 360 days, and the remainder (15.5%) was created a year or more before dialysis. By contrast, the majority of AVGs (63.2%) were created within 60 days of dialysis initiation, 17.6% were created within 61 and 180 days, and 19.2% were created >180 days before dialysis.

Table 4 summarizes the vascular access used at the first dialysis session between 2006 and 2011, among the study patients with a previous permanent vascular access creation. In this analysis, 1381 patients had predialysis AVFs created and 277 patients had predialysis AVGs created. Among elderly patients with a predialysis AVF who survived to initiate dialysis, 47.7% used an AVF at dialysis initiation, whereas 33.2% used a catheter with a maturing AVF. Among those patients with predialysis AVGs created who survived to initiate dialysis, 54.5% initiated dialysis with an AVG, whereas 10.1% used a catheter with a healing AVG. Overall, among elderly patients with predialysis vascular access creation, the likelihood of initiating dialysis with a catheter was greater in those receiving an AVF versus AVG (46.0% versus 28.5%; $P<0.001$). Not surprisingly, longer predialysis nephrology care was associated with lower catheter dependence at initiation of dialysis for both AVF and AVG patients (Table 4). However, the proportion of patients with catheter dependence at initiation of dialysis was higher for those with predialysis AVFs, regardless of the duration of nephrology follow-up (65.4% versus 37.5% for patients with <4 months of nephrology follow-up; 51.7% versus 30.7% for those with 4–12 months of nephrology follow-up; and 41.4% versus 25.7% for those with >12 months of nephrology follow-up; $P<0.001$ for all comparisons) (Table 4).

Table 3. The likelihood of starting dialysis by vascular access type, using the Fine–Gray proportional model to adjust for the competing risk of death

Covariate	AVF		AVG	
	HR (95% CI)	*P* Value	HR (95% CI)	*P* Value
Age (yr)				
70–<75 (reference)				
75–<85	0.98 (0.88 to 1.08)	0.65	0.96 (0.79 to 1.17)	0.71
≥85	0.79 (0.67 to 0.93)	0.01	0.97 (0.73 to 1.29)	0.83
Sex				
Men (reference)				
Women	0.93 (0.84 to 1.02)	0.12	0.97 (0.81 to 1.16)	0.73
Race				
White (reference)				
Black	1.11 (0.98 to 1.26)	0.10	1.16 (0.96 to 1.40)	0.14
Other	1.36 (1.15 to 1.60)	0.003	1.03 (0.72 to 1.48)	0.88
Comorbidity score				
0–4 (reference)				
5–10	1.09 (0.98 to 1.21)	0.12	1.08 (0.87 to 1.35)	0.47
11–21	1.12 (0.99 to 1.26)	0.08	0.83 (0.66 to 1.05)	0.13

DISCUSSION

We analyzed the clinical outcomes in a large, nationally representative Medicare population of elderly patients (aged ≥70 years) receiving predialysis vascular access creation. Our major findings were as follows: (*1*) the large majority of elderly patients with advanced CKD in the United States who have predialysis vascular access surgery survive to initiate dialysis; (*2*) the majority of elderly patients with advanced CKD have predialysis AVFs created later than recommended by national guidelines and initiate dialysis with a catheter; (*3*) the likelihood of initiating dialysis after predialysis access surgery is modified by patient age and race; and (*4*) catheter dependence at initiation of dialysis is higher in elderly patients with CKD with predialysis AVF compared with those with predialysis AVG surgery, regardless of duration of predialysis nephrology follow-up.

The optimal timing of vascular access creation in patients with advanced CKD approaching ESRD remains challenging. The Fistula First Breakthrough Initiative[8] and 2006 KDOQI[9] recommend that "a fistula should be created at least 6 months or with sufficient lead time before the anticipated start of hemodialysis treatments for fistula maturation." This allows for adequate time for an AVF to mature and necessary interventions to be performed to ensure successful AVF use at dialysis initiation. If the access is created too late, the patient is more likely to initiate dialysis with a catheter and to experience sepsis.[13] If the access is created too early, it may not be needed, either because the patient dies before needing to start dialysis or does not progress to ESRD for a prolonged

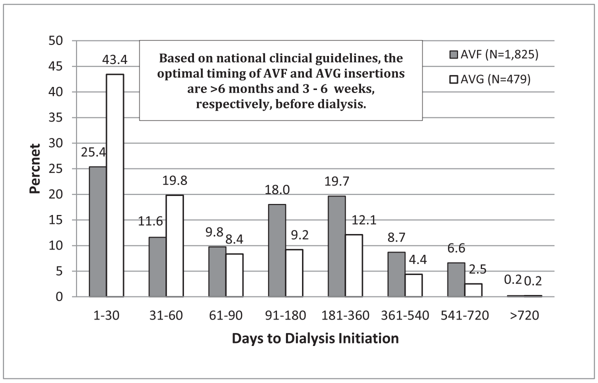

Figure 2. Time from predialysis vascular access creation to initiation of dialysis by type of vascular access.

period of time. The decision-making process is particularly challenging in elderly patients with ESRD. The older the patient, the more likely he or she is to die during the follow-up period.[7,14] Moreover, CKD progresses more slowly in older patients than younger patients.[10] As a consequence of these two factors, the likelihood of initiating dialysis after vascular access creation decreases progressively with increasing patient age. For example, Oliver *et al.* reported that the likelihood of initiating dialysis during the 2 years after access creation among a cohort of Ontario patients was 88% in adult men aged <65 years compared with 65% in men aged ≥85 years.[14] Similarly, O'Hare *et al.*[7] evaluated a US Department of Veterans Affairs (largely male) population with advanced CKD, and created a hypothetical model in which all patients with advanced CKD were assumed to receive vascular access surgery. Using this model, they calculated the proportion of patients in whom AVF creation would be necessary (patient initiated dialysis within 2 years) or unnecessary (patient died without dialysis or survived dialysis free). The ratio of unnecessary to necessary access procedures increased progressively with older patient age and with vascular access surgery occurring at a higher eGFR.[7] In contrast with this hypothetical model, the likelihood of patients with CKD actually undergoing predialysis access surgery decreased progressively with increasing patient age.[7] These observations suggest that nephrologists are appropriately incorporating patient age in determining the timing of referral for vascular access.

Our present study confirms that the majority (67%) of elderly United States patients with advanced CKD who undergo predialysis vascular access creation initiate dialysis during a 2-year follow-up. These findings are remarkably consistent with two previous Canadian studies that focused on patients of all ages with CKD. Weber *et al.* in a single-center study from Vancouver, reported that 70% of patients with who underwent AVF creation started dialysis within 2 years.[15] Likewise, Oliver *et al.*, in a regional study from Ontario, reported that 81% of all patients with CKD initiated dialysis within 2 years of AVF creation.[14] Our observation that initiation of dialysis was more likely during follow-up in patients receiving predialysis AVG versus AVF may reflect in part the practice of placing an AVG in patients with lower eGFR.

In the process of trying to balance the desire to avoid unnecessary predialysis access in elderly patients with CKD who will not require dialysis with the need to have a functioning access in those who will initiate dialysis, it is inevitable that a subset of patients will have their AVF created too late. Oliver *et al.* reported that 30% of their patients of all ages with CKD underwent AVF surgery <90 days before ESRD. In this study of elderly patients with CKD, we found that a higher proportion (47%) had their AVF created within 90 days of dialysis initiation.[16] Given the relatively long maturation time of AVF and the frequent need for interventions to promote AVF maturation,[17] a substantial proportion of patients with late AVF surgery will initiate dialysis with a catheter with its attendant complications. Notably, in our study, nearly one half of all patients with AVF creation initiated dialysis with a catheter.

One potential solution to this dilemma is to wait longer (closer to clinically requiring dialysis) before creating vascular

Table 4. Vascular access used at the first dialysis session by extent of predialysis nephrology care among patients with previous vascular access surgery by type of vascular access at initiation of dialysis

Type of Predialysis Vascular Access Creation	Predialysis Nephrology Care (*n*)	AVF	AVG	CVC				Unknown
				All	AVF-M	AVG-M	CVC Only	
AVG	277	15.9	54.5	28.5	6.1	10.1	12.3	1.1
	Nephrology evaluation							
	None or late (40)	5.0	52.5	37.5	7.5	17.5	12.5	5.0
	Intermediate (62)	21.0	48.4	30.7	9.7	4.8	16.1	0
	Early (175)	16.6	57.1	25.7	4.6	10.3	10.9	0.6
AVF	1381	47.7	3.9	46.0	33.2	1.0	11.8	2.3
	Nephrology evaluation							
	None or late (179)	30.7	1.1	65.4	47.5	1.7	16.2	2.8
	Intermediate (213)	44.6	3.3	51.7	37.6	1.4	12.7	0.5
	Early (989)	51.5	4.6	41.4	29.7	0.8	10.8	2.6

Data are given as percentages unless otherwise specified. We excluded patients who initiated dialysis in 2004 and 2005, because information on vascular access use among dialysis patients was not collected before 2005. Time between the first evaluation by a nephrologist and the start of dialysis were categorized as none or late evaluation (0–≤4 months), intermediate evaluation (4–≤12 months), and early evaluation (12–24 months). CVC, central vein catheter; AVF-M, dialysis with central vein catheter with maturing arteriovenous fistula; AVG-M, dialysis with central vein catheter with healing arteriovenous graft.

access in elderly patients with CKD, but preferentially create an AVG, rather than an AVF, in many of these patients. Given the shorter time to cannulation of AVG,[18] and the less frequent need for interventions before successful cannulation, more liberal AVG surgery in this population may be considered a catheter-sparing procedure.[19] In this study, 63% of patients receiving an AVG underwent surgery within an ideal time frame (within 60 days) to optimize initiation of dialysis without a catheter. Notably, a substantially lower proportion of patients with predialysis AVG than those with predialysis AVF used a catheter at initiation of dialysis (28.5% versus 46.0%). Two recent observations lend further support to implementing a clinical strategy of preferentially placing an AVG in older patients with advanced CKD. First, in patients with CKD who are aged ≥80 years, those with AVF creation have no significant survival benefit compared with those with predialysis AVG creation,[20] thus minimizing some of the potential benefits of AVFs in the elderly population. Second, earlier creation of AVF in elderly patients with CKD (>6–9 months) is not associated with better AVF success at dialysis initiation, but results in more predialysis interventional access procedures.[21]

We also evaluated the duration of predialysis nephrology care among patients with predialysis AVF and AVG creation. Among those with AVFs and AVGs created, 72% and 63%, respectively, had early nephrology follow-up (between 12 and 24 months before dialysis initiation). These results suggest that the large majority of elderly patients with advanced CKD have adequate predialysis nephrology follow-up. However, even among patients with predialysis AVF creation with early nephrology follow-up, 41% still initiated dialysis with a catheter.

Of interest, a subset of elderly patients undergoing predialysis vascular access creation had a different type of permanent access upon dialysis initiation. Thus, among patients who received a predialysis AVF, an AVG was in use or present as a secondary (maturing) access in 4.9% when dialysis was started. Presumably, these were patients whose AVF failed to mature, and they subsequently received a predialysis AVG. Conversely, among patients who received a predialysis AVG, an AVF was in use or present as a secondary (maturing) access in 22% when dialysis was started. One possible explanation is that the initial AVG caused dilation of the proximal veins, thereby permitting a subsequent AVF creation when the AVG failed.

The strengths of our study include the large, nationally representative sample size derived from a random 5% Medicare sample to evaluate predialysis AVF creation, which may provide broadly generalizable results. Furthermore, this data set provides a representative data sample of United States patients with advanced CKD who progress to ESRD with accurate linkage to US Renal Data System (USRDS) data to identify primary outcomes of interest. We were able to measure actual AVF use upon dialysis initiation, information not reported in previous studies such as that by Oliver *et al.*[14]

Our study also has some limitations. First, we were not able to collect information about the patients' serum creatinine, GFR, or rate of progression of CKD. However, predialysis permanent vascular accesses are usually not created until a patient reaches advanced CKD (stages 4 or 5). Second, the administrative data sets used did not include information that might affect the timing and type of predialysis vascular access, such preoperative vascular mapping, surgeon experience, or patient preferences. Third, we did not collect data on patient mortality or vascular access outcomes after dialysis initiation. However, our major goal was to study the events before dialysis initiation. Finally, there may be residual confounding because of patient characteristics that were not available in the data sets used for this study, and were therefore not incorporated into the statistical models.

In conclusion, the majority of elderly United States patients with advanced CKD receiving a predialysis permanent vascular access initiate dialysis within 2 years of access surgery. Although the large majority of patients with predialysis permanent vascular access creation have >1 year of nephrology care before initiating dialysis, a substantial proportion of those receiving an AVF undergo the surgery too late to optimize the likelihood of initiating dialysis with a mature AVF. Thus, in a subset of elderly patients with advanced CKD, the preferred strategy may be to place an AVG as a "catheter-sparing" strategy.

CONCISE METHODS

Data Sources

We utilized the 1999–2011 Medicare 5% sample CKD-based cohort data set, a nationally representative sample of Medicare patients with CKD, to conduct this study. Specifically, the CKD patient, physician/supplier, and institutional claims were used to obtain data on hospitalization, surgery, comorbidities, and outpatient encounters. Insurance status and death were determined from the CKD payer sequence and master file, respectively. The CKD master file contains two patient identification (ID) numbers. One is a unique patient ID (FIVEP_ID) used in the 5% Medicare sample population. The second number (USRDS_ID) is the unique USRDS ID that identifies patients enrolled in the ESRD program and receiving dialysis. Only patients with ESRD are assigned the second number. Patients with CKD who initiated dialysis were linked by the USRDS ID to the US Centers for Medicare and Medicaid Services (CMS) Form 2728, which is required for all newly diagnosed patients with ESRD. Starting in 2005, the CMS Form 2728, filled out upon initiation of dialysis, began collecting data regarding the initial type of vascular access used for dialysis.

Study Population

We identified 7887 Medicare patients aged ≥70 years with a predialysis vascular access surgery performed between January 1, 2004, and December 31, 2009, using Common Procedural Terminology–4 codes 36818, 36819, 36820, 36825, and 36821 for AVF and 36830 for AVG creation. These codes have been widely used in other USRDS studies on vascular access.[1,16,21–25] The date of vascular access creation was deemed the study index date. A vascular access surgery was determined to be a "first predialysis" surgery if there was no history of an earlier vascular access procedure in the 5 years before the study index date. Patients enrolled in a health maintenance organization were excluded (n=186) because we have no records of their health service utilization. We further excluded 4283 patients who started dialysis before or on the same day as the access surgery. Our final cohort includes 3418 older Medicare patients who had a predialysis vascular access created before dialysis initiation (Figure 1). A 5-year baseline before the index date (similar to one used by Oliver *et al.*[14]) was used to ensure a first predialysis vascular access surgery and to collect severity of illness and comorbidity information. A 2-year follow-up after the index date was used to examine study outcomes. Patients were followed from predialysis vascular access creation until initiation of dialysis, death, or end of 2-year follow-up.

Study Outcomes

Our primary outcome was the proportion of elderly patients with advanced CKD with AVF or AVG creation that survived to initiate dialysis, died before dialysis initiation, or survived dialysis free 2 years after vascular access creation. Our secondary analyses included the following: (*1*) the effect of demographic and clinical factors on the primary study outcomes, (*2*) the time intervals between predialysis vascular access creation and dialysis initiation, and (*3*) the type of vascular access used at the time of dialysis initiation by extent of predialysis nephrology care.

Variables of Interest

Patient demographics (age, sex, and race) were determined at the time of the index date. Comorbidities were determined by one inpatient diagnosis code (either primary or secondary) and/or two outpatient diagnosis codes in the year before the index date and included diabetes, cancer, ischemic heart disease, chronic obstructive pulmonary disease, peripheral vascular disease, cerebral vascular disease, depression, and dementia. Cardiac comorbidities (*e.g.,* stroke, myocardial infarction, and congestive heart failure) were identified based on a primary reason for hospitalization during the baseline year. Comorbidities were selected based upon published literature indicating a substantial influence on mortality among patients with late-stage CKD.[26,27] We used a comorbidity index developed and validated for dialysis patients, which outperformed the more widely used Charlson Comorbidity Index[28] in both predictive ability and inference.[29,30] At dialysis initiation, data from CMS Form 2728 on the type of vascular access used was collected, including AVF, AVG, catheter only, catheter with maturing AVF, and catheter with healing AVG. In a recent study, vascular access data as reported by CMS Form 2728 was determined to be valid and reliable for use in research studies.[31] Evaluation by a nephrologist before dialysis initiation was determined by using physician supplier claims in the 2 years preceding dialysis. Patients who initiated dialysis before 2004 and 2005 were excluded because information on vascular access was not fully collected before 2005. Time between the first evaluation by a nephrologist and the start of dialysis were categorized as none or late evaluation (0–≤4 months), intermediate evaluation (4–≤12 months), and early evaluation (12–24 months).[32]

Statistical Analyses

Patients were classified into three groups according to whether they experienced an outcome of interest (dialysis or death): (*1*) AVF/AVG created, patient survived and initiated dialysis within 2 years; (*2*) AVF/AVG created, patient died within 2 years of AVF/AVG and did not start dialysis; and (*3*) AVF/AVG created, patient survived and no dialysis initiation within 2 years of AVF/AVG creation (*e.g.,* nonprogressors). Summary statistics are presented as percentages for categorical data and means±SDs. Differences in baseline characteristics were compared using chi-squared tests. Because our cohort was exposed to mutually exclusive, competing risks of dialysis initiation and death before dialysis, the traditional Kaplan–Meier method and Cox model for survival analysis do not yield valid results.[33,34] Using a method proposed by Fine and Gray,[34] we applied a semiparametric Cox proportional hazards model that estimates the risk of starting dialysis compared with remaining in predialysis (nonprogression); in this model, death is treated as a competing event. We used SAS macro %CIF[35] to estimate cumulative probability of starting dialysis over time. Cumulative incidence functions are also compared across different age, comorbid, and vascular access groups using Gray's test.[36] To assess the effect of covariates on time to dialysis initiation, we fit a proportional subdistribution hazards model[34] by using an SAS macro[37] that is specific for survival data subject to competing risks. The model is adjusted for age, sex, race, comorbidity score, and type of vascular access insertion. All analyses assume a two-sided, type 1 error probability set at <0.05.

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DISCLOSURES

T.L. is the chairman of the Data Safety Monitoring Board for the Bioconnect OPEN study. M.A. is a consultant for CorMedix and Gore.

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