Chapter 3: Vascular Access

- In 2016, 80% of patients were using a catheter at hemodialysis (HD) initiation (Figure 3.1).
- At 90 days after the initiation of HD, 69% of patients were still using catheters. (Figure 3.7.a).
- Arteriovenous (AV) fistula use at HD initiation rose from 12% to 17% over the period 2005-2016 (Figure 3.1).
- The percentage of patients using an AV fistula or with a maturing AV fistula at HD initiation increased from 28.9% to 33% over the same period (Figure 3.1).
- Seventeen percent of patients used an AV fistula exclusively at dialysis initiation. This increased to 64% by the end of one year on HD, and to 71% by the end of two years (Figure 3.7.a).
- The proportion of patients with an AV graft for vascular access was 3% at HD initiation, 15% at one year after initiation, and 17% at two years (Figure 3.7.a).
- At one year after HD initiation, 79% of patients were using either an AV fistula or AV graft without the presence of a catheter. By two years, this number rose to 88% (Figure 3.7.a).
- By May 2017, 62.8 % of prevalent dialysis patients were using an AV fistula (Figure 3.6).
- Of AV fistulas placed between June 2014 and May 2016, 39% failed to mature sufficiently for use in dialysis. Of those that did mature, the median time to first use was 108 days (Table 3.7).
- Patient demographic characteristics appear to contribute to success with AV fistula; at younger ages, the percent of AV fistulas that successfully mature is higher and the median time to first use is somewhat shorter (Table 3.7). Males had a higher AV fistula maturation rate compared to females, as well as shorter time to first use. Blacks experienced the highest AV fistula maturation failure rates, compared to other races.

Introduction

Clinical practice guidelines recommend an autogenous arteriovenous (AV) fistula as the preferred vascular access for hemodialysis (HD; National Kidney Foundation, 2006). Central venous catheters (hereafter, referred to as catheters) are associated with higher risks of death, infection, and cardiovascular events than other types of vascular access. Patients with a usable AV fistula exhibit the lowest risks for these events (Ravani et al., 2013). Interestingly, recent data suggests that patient comorbidity distribution by catheter type, rather than direct complications, may be partially responsible for this difference (Ravani et al., 2017; Brown et al., 2017).

The international Dialysis Outcomes and Practice Patterns Study (DOPPS) highlighted the fact that, with respect to vascular access, dialysis practices in the United States lagged behind other industrialized countries (Pisoni et al., 2002; Goodkin et al., 2010; Robinson et al., 2010). In large part, these international comparisons served as impetus for implementation of the Fistula First Breakthrough Initiative (FFBI) by the Centers for Medicare & Medicaid (CMS; Vassalotti et al., 2012). Over the next decade, a gradual but steady increase in AV fistula placement efforts followed in the United States, such that the proportion of prevalent HD patients using an AV fistula rose from 32% in 2003 to 63% by 2014 (USRDS, 2016).

A robust debate continues as to whether an AV fistula should remain the access of first choice for every dialysis patient, with recent attention paid to the length of time and effort AV fistula creation can consume in certain higher risk populations (Lee et al., 2015; Hall et al., 2017). An AV fistula is considered optimal because of its potential for durability, lower risk of infection, and reduced need for intervention to ensure patency. However, recent focus has shifted

somewhat toward tailoring the most appropriate access for individual patients, based upon their medical care, patient characteristics, life expectancy, preference, and other factors. Further prospective studies and clinical trials will determine whether this approach will indeed prove superior.

A landmark clinical trial, where AV fistula maturation was a secondary outcome, revealed a high failure rate of newly placed fistulas that never came into use (Dember et al., 2008). Between primary surgical failures and maturation failures, 36.2% of AV fistula placements in the United States are unsuccessful (Woodside et al., 2018). Rigorous evaluation of the many potential factors underlying this phenomenon is necessary to ensure primary surgical success and subsequent optimal maturation of the AV fistula, although dialysis vintage, age, geographic factors, and other demographic and medical comorbidities are associated with risk of maturation failure. Also, patients may benefit should surgical training programs further emphasize skill in AV fistula placement (Saran et al., 2008; Goodkin et al., 2010).

A systematic, multilevel approach is required for ensuring optimal vascular access for every HD patient (Huber, 2015), since many additional factors likely influence successful AV fistula placement. These are often beyond the capacity of individual practitioners, and include patient motivation for access placement, timeliness of referrals for nephrology and vascular access intervention, and institutional and payer support for pre-ESRD care. The role of coordination of dialysis access placement and maintenance is therefore critical.

The above considerations and other salient issues make it imperative to track carefully and comprehensively trends in vascular access placements, interventions, related practices, and outcomes. Despite the emphasis on improving AV fistula success rates, at the time of dialysis initiation, 80.3% of patients used a catheter (USRDS, 2016). Well-coordinated pre-dialysis care during the critical transition period to ESRD is likely to be the key to future improvements in this suboptimal practice pattern.

In this chapter, we describe patterns of vascular access use among incident and prevalent dialysis patients by patient characteristics and geographic region, since the mid-2000s. In addition, we explore national variation in time-to-first-use of AV fistulas after placement, as a surrogate for AV fistula maturation time.

Methods

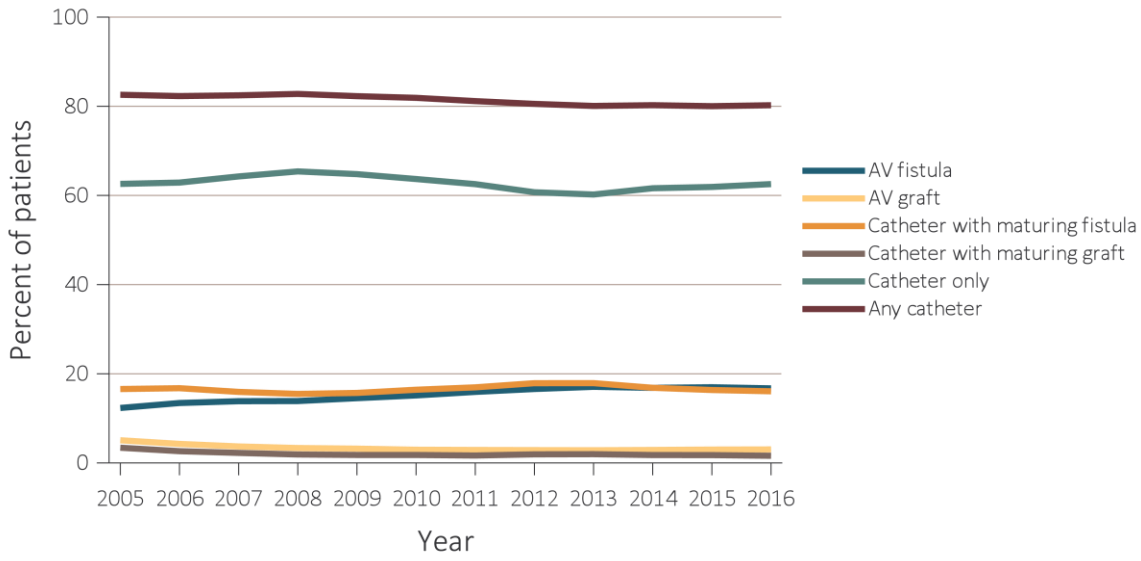
This chapter examines and reports data from the Centers for Medicare & Medicaid Services (CMS). Details of this data source are described in the *Data Sources* section of the *ESRD Analytical Methods* chapter.

For an explanation of the analytical methods used to generate the study cohorts, figures, and tables in this chapter, see the section on *Chapter 3* within the *ESRD Analytical Methods* chapter. Downloadable Microsoft Excel and PowerPoint files containing the data and graphics for these figures and tables are available on the *USRDS website.*

Vascular Access Use at Initiation of Hemodialysis

In 2016, 80.2% of patients were using a catheter at HD initiation, a rate that has changed only marginally since 2005. Figure 3.1 shows that in 2016, 62.5% of patients incident to ESRD had neither an AV fistula nor AV graft in place or maturing at their first outpatient HD session. This rate peaked at 65.4% in 2008, and has remained relatively stable since 2012, at just above 60%. Over the last several years, there has been a relatively small absolute increase in AV fistula use at HD initiation, rising from 12.3% in 2005 to 16.7% in 2016, which may be reaching a plateau. Over the same period, the percentage of patients with either an AV fistula or a maturing AV fistula increased from 28.9% to 32.8%.

vol 2 Figure 3.1 Vascular access use at hemodialysis initiation, from the ESRD Medical Evidence form (CMS 2728), 2005-2016



Data Source: Special analyses, USRDS ESRD Database. ESRD patients initiating hemodialysis in 2005-2016. Abbreviations: AV, arteriovenous; CMS, Centers for Medicare & Medicaid; ESRD, end-stage renal disease.

Table 3.1 shows dialysis access use at HD initiation, stratified by patient characteristics. The 0-21 year old age group had the highest percentage of catheter use at HD initiation (82.2%) and lowest percentage of AV fistula use (7.1%). Many of these patients were children who received a renal transplant relatively quickly, with HD serving as a bridge to transplantation, or those in the youngest age categories, who, being quite small, may have presented surgical challenges in creating an AV fistula. The 65-74 year age group had the highest percentage of patients with AV fistula use at HD initiation (18.0%), with slightly lower levels seen for individuals 75 years or older (16.6%) and those between 45-64 years (16.9%).

Patients of Hispanic ethnicity or Black/African American race displayed the lowest proportion of AV fistula use (14.7%) at HD initiation, with those of Hispanic ethnicity having the highest use of a catheter alone (66.1%). Non-Hispanic Blacks/African Americans displayed the highest proportion of AV graft use at HD initiation (4.6%), with lower AV graft use among Other races and Hispanic ethnicity combined (3.4%), while the lowest observed rate was for Hispanic ethnicity alone (1.9%).

Consistent with previous years, those with cystic kidney disease had higher rates of AV fistula use at HD initiation (38.0%), perhaps related to younger age at disease detection, slower progression of underlying CKD, earlier nephrology referral, more consistent pre-dialysis nephrology care, or relatively well preserved vasculature.

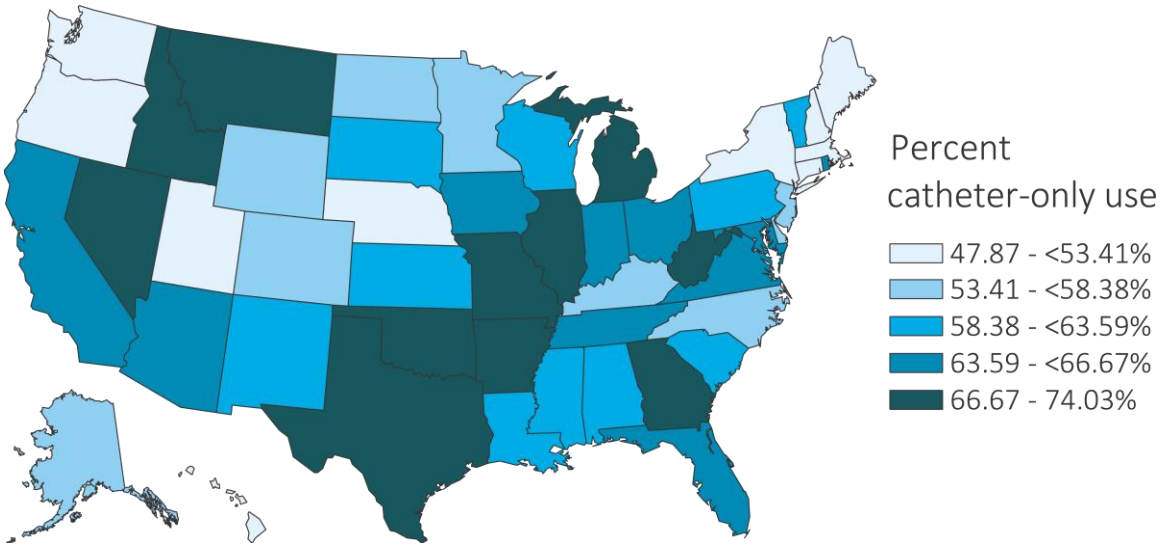
vol 2 Table 3.1 Vascular access used at hemodialysis initiation by patient characteristics from the ESRD Medical Evidence form (CMS 2728), 2016

	AV fistula	AV graft	Catheter with maturing fistula	Catheter with maturing graft	Catheter only
All	16.7	3.0	16.1	1.6	62.5
Age					
0-21	7.1	0.9	9.7	0.1	82.2
22-44	13.4	1.8	16.3	1.2	67.4
45-64	16.9	2.8	17.2	1.6	61.4
65-74	18.0	3.2	16.4	1.5	60.9
75+	16.6	3.7	14.0	1.9	63.7
Sex					
Male	18.3	2.3	16.6	1.3	61.5
Female	14.7	4.0	15.4	2.0	63.9
Race					
White	17.3	2.4	15.7	1.4	63.2
Black/African American	14.7	4.5	16.7	2.3	61.8
American Indian or Alaska Native	18.5	2.6	19.9	0.8	58.2
Asian	19.8	3.4	16.8	1.6	58.3
Other or Multiracial	18.2	3.1	16.1	1.1	61.4
Ethnicity					
Hispanic	14.7	1.9	16.2	1.2	66.1
Non-Hispanic	17.1	3.2	16.1	1.7	62
Race/Ethnicity					
Non-Hispanic White	18.0	2.6	15.6	1.4	62.4
Non-Hispanic Black/African	14.7	4.6	16.7	2.3	61.8
Primary Cause of ESRD					
Diabetes	17.4	3.2	18.3	1.7	59.4
Hypertension	17.0	3.3	15.5	1.6	62.7
Glomerulonephritis	17.5	2.4	14.1	1.7	64.3
Cystic kidney	38.0	4.6	13.2	1.1	43
Other urologic	14.4	2.0	13.5	1.3	68.9
Other cause	9.0	1.8	10.1	1.4	77.7
Unknown/Missing	9.6	2.3	8.6	0.8	78.7
Comorbidities					
Diabetes	16.5	3.1	17.4	1.7	61.3
Congestive heart failure	12.3	2.6	16.9	1.7	66.4
Atherosclerotic heart disease	16.1	3.1	17.5	1.7	61.6
Cerebrovascular disease	14.9	3.4	16.5	2.0	63.2
Peripheral vascular disease	13.9	2.8	18.1	1.8	63.4
Hypertension	17.3	3.1	16.5	1.6	61.5
Other cardiac disease	13.7	2.5	15.9	1.7	66.3

Data Source: Special analyses, USRDS ESRD Database. Abbreviations: AV, arteriovenous; CMS, Centers for Medicare & Medicaid; ESRD, end-stage renal disease.

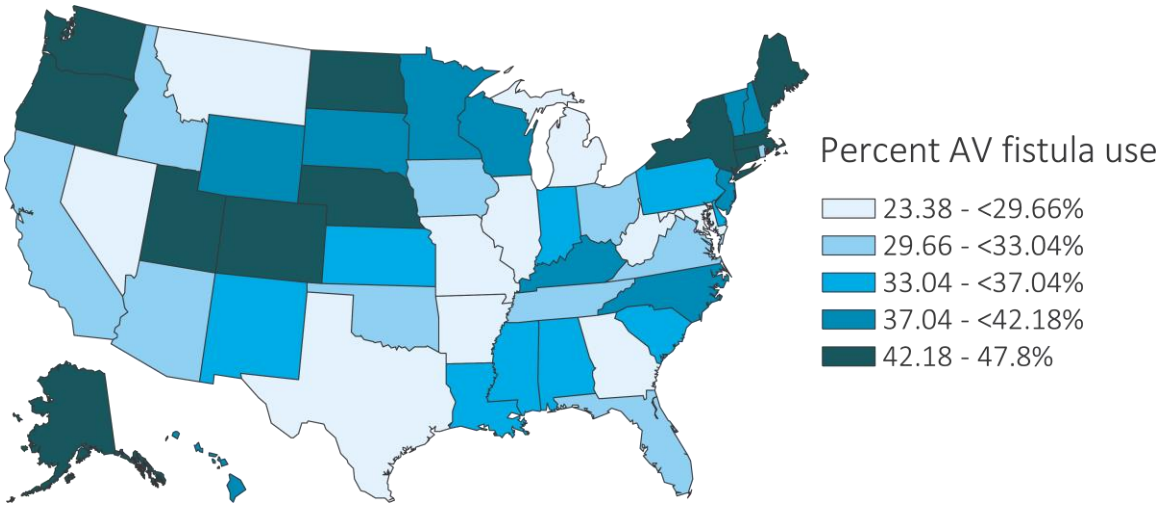
Figures 3.2 and 3.3 illustrate geographic variation by state in the use of catheters alone and AV fistulas (including catheters with a maturing AV fistula) at HD initiation. Considerable variation occurred in both of these categorizations across states. New England, the Northwest, Utah, and Nebraska tended to have a lower percentage of catheter use and a higher percentage of AV fistula use at initiation. Some Upper Midwest and Western mountain states also appeared to have a higher incidence of AV fistula use.

vol 2 Figure 3.2 Geographic variation in percentage of catheter-only use at hemodialysis initiation, from the ESRD Medical Evidence form (CMS 2728), 2016



Data Source: Special analyses, USRDS ESRD Database. Abbreviations: CMS, Centers for Medicare & Medicaid; ESRD, end-stage renal disease.

vol 2 Figure 3.3 Geographic variation in percentage of AV fistula use at hemodialysis initiation, from the ESRD Medical Evidence form (CMS 2728), 2016



Data Source: Special analyses, USRDS ESRD Database. AV fistula use includes not only AV fistulas, but also catheters with a maturing fistula. Abbreviations: AV, arteriovenous; CMS, Centers for Medicare & Medicaid; ESRD, end-stage renal disease.

Vascular Access Use among Prevalent Hemodialysis Patients

Table 3.2 shows patterns of access use among prevalent HD patients with ESRD for at least 90 days. By May 2017, 64.5% of these patients were using an AV fistula. In general, demographic variation among prevalent patients was similar to the patterns observed for incident patients. Those in the 0-21 year old age group displayed the highest catheter use, while the 45-64 year group had the lowest use. Blacks displayed the lowest AV fistula utilization, but highest AV graft use. Multiracial patients and those in the Other race category reported the highest catheter use. When examined by primary cause of ESRD, individuals with cystic kidney disease maintained the highest fistula usage. However, the differences in vascular access use among prevalent HD patients with different etiologies were smaller than those observed in incident dialysis patients. (Table 3.1).

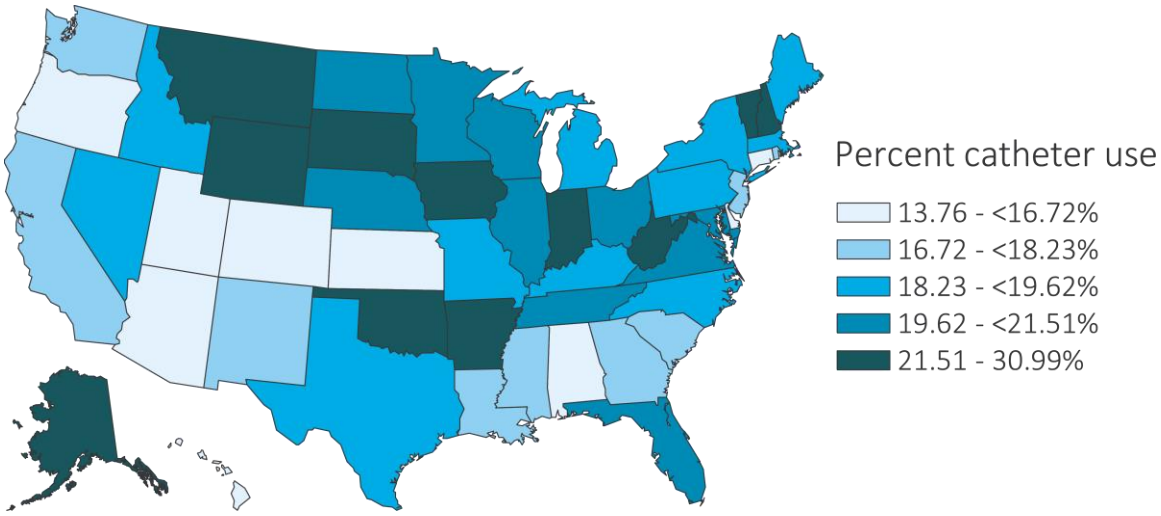
vol 2 Table 3.2 Distribution of type of vascular access in use among prevalent hemodialysis patients in 2017, from CROWNWeb data, May 2017

	AV fistula	AV graft	Catheter
All	64.5	16.6	18.9
Age			
0-21	44.0	6.8	49.3
22-44	66.2	13.6	20.2
45-64	66.6	15.5	18.0
65-74	63.9	17.4	18.7
75+	60.9	19.4	19.7
Sex			
Male	70.4	12.6	17.0
Female	56.7	21.9	21.4
Race			
White	67.3	12.8	19.9
Black/African American	59.1	23.1	17.8
American Indian or Alaska Native	75.8	10.1	14.1
Asian	68.4	15.6	16.0
Other or Multiracial	62.3	12.9	24.8
Ethnicity			
Hispanic	70.3	13.4	16.3
Non-Hispanic	63.3	17.3	19.4
Race/Ethnicity			
Non-Hispanic White	65.8	12.6	21.6
Non-Hispanic Black/African-American	59.1	23.2	17.7
Primary Cause of ESRD			
Diabetes	65.1	16.2	18.7
Hypertension	64.5	17.4	18.1
Glomerulonephritis	66.4	16.8	16.8
Cystic kidney	70.6	14.3	15.1
Other urologic	62.9	15.5	21.6
Other cause	58.5	16.2	25.3
Unknown/Missing	59.6	15.8	24.6

Data Source: Special analyses, USRDS ESRD Database. CROWNWeb data, catheter = any catheter use; fistula and graft use shown are without the use of a catheter. Abbreviations: AV, arteriovenous; CROWNWeb, Consolidated Renal Operations in a Web-enabled Network; ESRD, end-stage renal disease.

Figure 3.4 presents geographic variation of the proportion of prevalent HD patients using a catheter in 2017. Rates varied widely across the country. High catheter utilization was evident in Montana, Wyoming, South Dakota, Iowa, Indiana, West Virginia, Oklahoma, Arkansas, Vermont, New Hampshire, and Alaska. In contrast, Oregon, Utah, Arizona, Colorado, Kansas, Alabama, Hawaii, Delaware, and Connecticut exhibited lower catheter use.

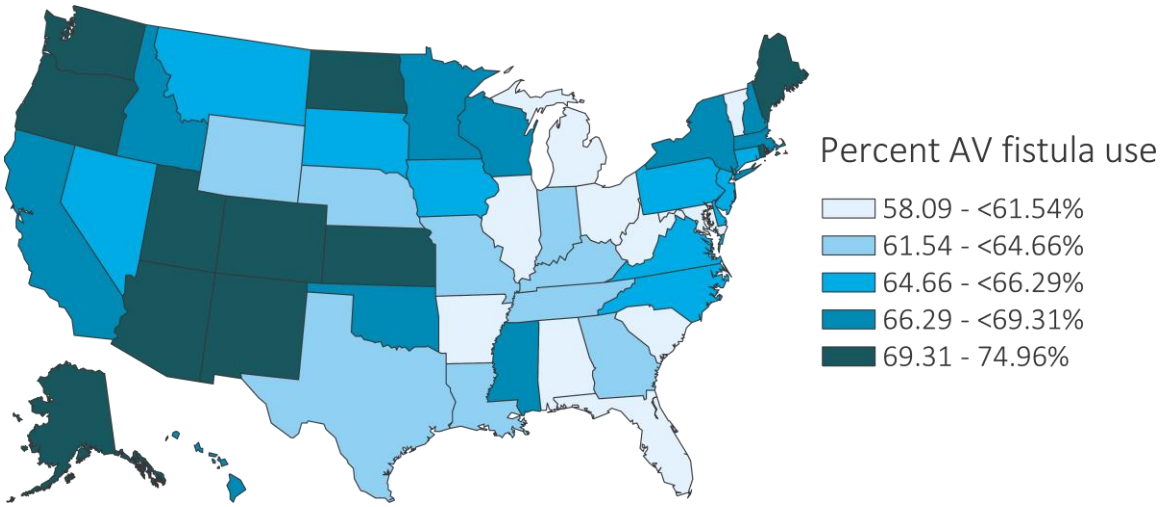
vol 2 Figure 3.4 Geographic variation in percentage catheter use among prevalent hemodialysis patients by state, from CROWNWeb data, May 2017



Data Source: Special analyses, USRDS ESRD Database. Abbreviation: CROWNWeb, Consolidated Renal Operations in a Web-enabled Network; ESRD, end-stage renal disease.

Figure 3.5 shows variation in AV fistula use among 2017 prevalent HD patients. Higher fistula use was most apparent in the Northwest, North Dakota, Maine, Rhode Island, Kansas, and the Southern Mountain States. Florida, Alabama, South Carolina, Arkansas, Michigan, Illinois, Ohio, West Virginia, Maryland, and Vermont have lower rates of fistula use.

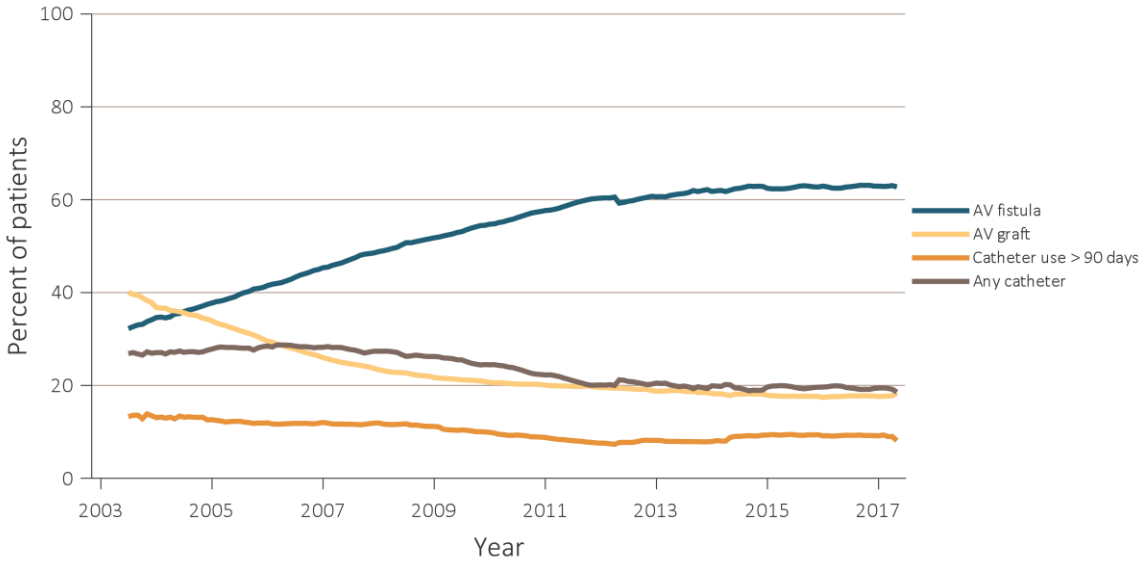
vol 2 Figure 3.5 Geographic variation in percentage AV fistula use among prevalent hemodialysis patients by state, from CROWNWeb data, May 2017



Data Source: Special analyses, USRDS ESRD Database. Abbreviations: AV, arteriovenous; CROWNWeb, Consolidated Renal Operations in a Web-enabled Network; ESRD, end-stage renal disease.

Figure 3.6 displays trends in vascular access use among prevalent HD patients from 2003 to mid-2017. Between July 2003 and April 2012, these data reflect the monthly point prevalence of vascular access at dialysis facilities from the Fistula First Breakthrough Initiative and from May 2012 through May 2017 from monthly CROWNWeb clinical data. A large increase in AV fistula use has occurred since 2003, rising from 32% to 62.8% of patients, although this change has recently plateaued. In contrast, AV graft use has decreased from 40% to 18.4% over the same period. Catheter use has had a complementary decline, decreasing from 27% to 18.6%. In May 2017, only 8.1% of prevalent HD patients had been using a catheter for greater than 90 days.

vol 2 Figure 3.6 Trends in vascular access type use among ESRD prevalent patients, 2003-2017



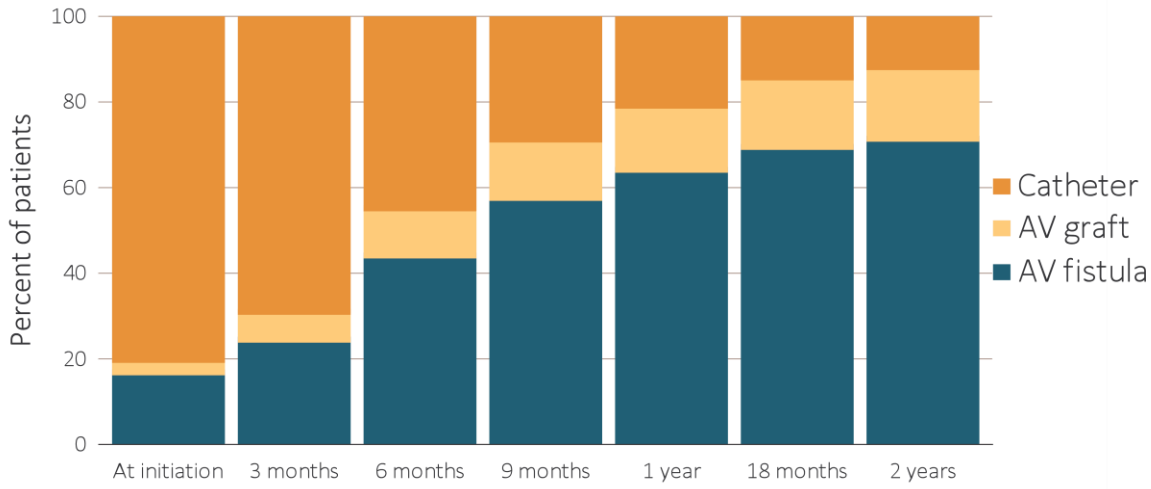
Data Source: Special analyses, USRDS ESRD Database and Fistula First data. Fistula First data reported from July 2003 through April 2012, CROWNWeb data are reported from June 2012 through May 2017. Abbreviations: AV, arteriovenous; CROWNWeb, Consolidated Renal Operations in a Web-enabled Network; ESRD, end-stage renal disease.

Change in Type of Vascular Access during the First Year of Dialysis

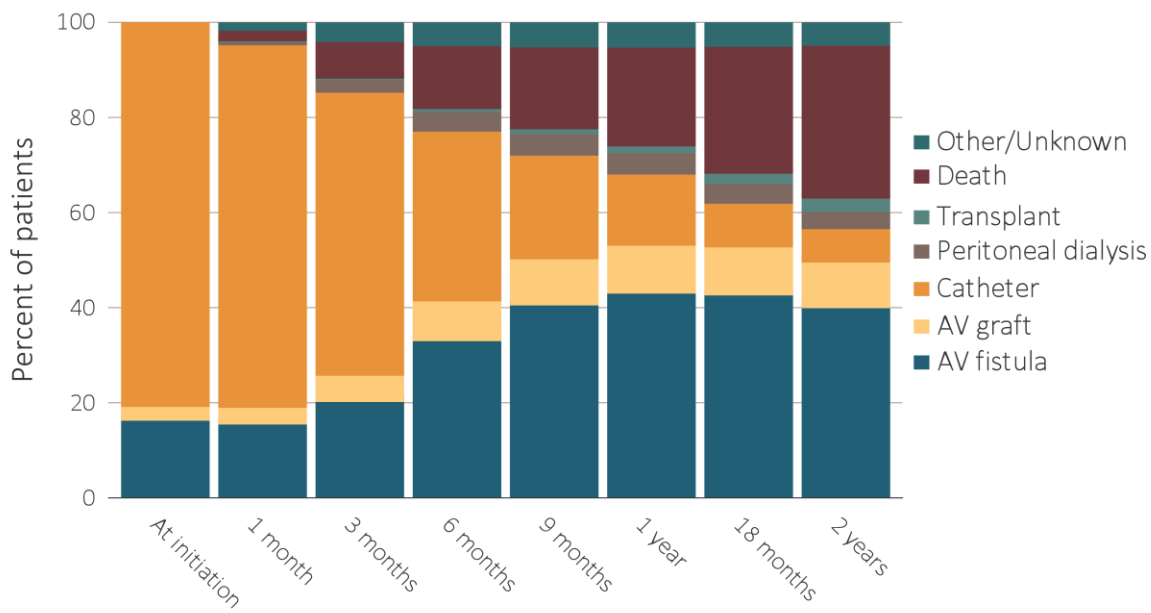
Figure 3.7.a shows cross-sectional data from both the CMS Medical Evidence form (CMS 2728) for vascular access information at initiation, and CROWNWeb for follow-up data with respect to vascular access in use at three, six, nine, and eighteen months, and one and two years. At 90 days, the majority of HD patients were still using a catheter, highlighting the importance of ongoing efforts to improve access to pre-dialysis nephrology care and surgical access planning. Compared to 17% seen at HD initiation, the percentage of patients using an AV fistula exclusively at the end of one year on dialysis increased to 64%, and to 71% by the end of two years. The proportion of patients with an AV graft for vascular access was 3% at initiation, 15% at one year, and 17% at two years. Thus, at one year, 80% of patients were using either an AV fistula or AV graft without the presence of a catheter. At two years after HD initiation, this number rose to 88%. Figure 3.7.b displays two-year longitudinal changes in vascular access use and other outcomes in the cohort of patients who initiated ESRD via HD in 2014. In the incident ESRD HD cohort, 80.3% of patients initiated HD using a central venous catheter. After 12 months, 43.6% were using an AV fistula, 10.1% were using an AV graft, and 14.9% were dialyzing with a catheter only. Of this cohort, 1.5% were living with a kidney transplant, 4.5% were receiving peritoneal dialysis, 20.8% had died, and 4.7% were classified as having an Other/Unknown outcome. After two years, 40.5% were using an AV fistula, 9.6% were using an AV graft, and 7.0% were dialyzing with a catheter only. Of this cohort, 2.8% were living with a kidney transplant, 3.6% were receiving peritoneal dialysis, 32.2% had died, and 4.3% were classified as having an Other/Unknown outcome.

vol 2 Figure 3.7 Change in type of vascular access during the first two years of dialysis among patients starting ESRD via hemodialysis in 2014: (a) type of vascular access in use (cross-sectional), and (b) longitudinal changes in vascular access use and other outcomes, ESRD Medical Evidence form (CMS 2728) and CROWNWeb, 2014-2017

(a) Type of vascular access in use (cross-sectional)



(b) Longitudinal changes in vascular access use and other outcomes



Data Source: Special analyses, USRDS ESRD Database. Data from January 1, 2014 to May 30, 2017: (a) Medical Evidence form (CMS 2728) at initiation and CROWNWeb for subsequent time periods. (b) ESRD patients initiating hemodialysis (N =104,102). Patients with a maturing AV fistula/ AV graft with a catheter in place were classified as having a catheter. Abbreviations: AV, arteriovenous; CMS, Centers for Medicare & Medicaid; CROWNWeb, Consolidated Renal Operations in a Web-enabled Network; ESRD, end-stage renal disease.

Tables 3.3 through 3.5 show cross-sectional distributions of vascular access use at several time points during the first two years of HD therapy, stratified by age, race, and sex. Catheter use was most common at initiation, at the end of one year, and at the end of two years in the 0-21 year old age group. Contributing influences discussed earlier include different pediatric nephrology practice patterns, higher transplant rates, or anatomical challenges. AV graft use was higher in the 75+ age group both at initiation and at the end of one and two years. At one year, approximately 20% of persons in all age groups, except the 0-21 year old cohort, used catheters. This number decreased to approximately 12% at two years. This indicates that barriers remain in establishing surgical access, even after one year of dialysis therapy.

Black patients had the highest proportion of AV graft use at initiation, one year, and two years. At one year, 20.2% of Black patients were using an AV graft compared to 13.1% of Asians and 12.7% of Whites. At initiation, one year, and two years, females had a higher proportion of AV graft use and males a higher proportion of AV fistula use. At one and two years, catheter use was highest among Other or Multiracial, and female patients. For most adult patients, an AV fistula prevalence greater than 60% was achieved by one year on HD. At one year, males and those of American Indian/Alaska Native race had the highest proportions of AV fistula use, while females and Blacks had the lowest AV fistula proportions.

vol 2 Table 3.3 Cross-sectional distributions of vascular access use, quarterly during the first two years of hemodialysis, among patients new to hemodialysis in 2014, by age group, from the ESRD Medical Evidence form (CMS 2728) and CROWNWeb, 2014-2017

Age	Access type	Time						
		At initiation	3 months	6 months	9 months	1 year	18 months	2 years
0-21	AV fistula	6.2	12.0	32.4	40.9	47.5	53.0	55.0
	AV graft	0.7	0.8	1.6	3.7	3.8	4.8	5.0
	Catheter	93.0	87.2	66.0	55.3	48.7	42.2	40.1
22-44	AV fistula	13.9	21.4	44.1	58.4	66.0	72.1	74.1
	AV graft	1.9	4.4	7.6	10.0	10.8	12.1	12.7
	Catheter	84.3	74.1	48.3	31.7	23.2	15.9	13.2
45-64	AV fistula	16.6	24.5	45.1	59.4	66.2	71.9	73.9
	AV graft	2.8	5.6	9.5	11.8	13.1	14.4	14.8
	Catheter	80.6	69.9	45.4	28.8	20.7	13.7	11.2
65-74	AV fistula	18.4	26.2	45.4	58.6	64.9	69.6	71.5
	AV graft	3.1	6.6	11.4	14.1	15.5	17.0	17.6
	Catheter	78.5	67.2	43.3	27.3	19.5	13.4	10.9
75+	AV fistula	17.0	24.1	41.5	53.5	59.3	64.3	66.0
	AV graft	3.4	8.9	14.9	18.0	19.7	20.7	21.0
	Catheter	79.6	66.9	43.6	28.5	21.0	15.0	13.0

Data Source: Special analyses, USRDS ESRD Database. Medical Evidence form (CMS 2728) at initiation and CROWNWeb for subsequent time periods. Abbreviations: AV, arteriovenous; CMS, Centers for Medicare & Medicaid; CROWNWeb, Consolidated Renal Operations in a Web-enabled Network; ESRD, end-stage renal disease.

vol 2 Table 3.4 Cross-sectional distributions of vascular access use, quarterly during the first two years of hemodialysis among patients new to hemodialysis in 2014, by race, from the ESRD Medical Evidence form (CMS-2728) and CROWNWeb, 2014-2017

Race/Ethnicity	Access type	Time						
		At initiation	3 months	6 months	9 months	1 year	18 months	2 years
White	AV fistula	17.4	25.6	45.9	59.7	66.4	72.0	74.0
	AV graft	2.4	5.4	9.4	11.7	12.7	13.6	14.0
	Catheter	80.3	69.0	44.8	28.6	20.9	14.4	12.0
Black/African American	AV fistula	15.3	21.4	39.3	51.9	58.2	63.2	65.1
	AV graft	4.2	9.2	15.0	18.3	20.2	22.0	22.6
	Catheter	80.5	69.4	45.8	29.7	21.6	14.9	12.3
American Indian or Alaska Native	AV fistula	16.0	25.9	53.8	67.8	75.1	79.4	79.8
	AV graft	2.0	4.0	6.8	8.3	9.4	9.9	10.6
	Catheter	81.9	70.1	39.4	23.9	15.5	10.7	9.6
Asian	AV fistula	19.5	28.2	50.2	63.2	70.4	75.7	77.1
	AV graft	3.0	7.0	10.6	12.4	13.1	14.5	15.1
	Catheter	77.5	64.8	39.2	24.4	16.5	9.8	7.8
Native Hawaiian or Pacific Islander	AV fistula	17.4	21.9	43.3	59.2	67.2	73.2	77.4
	AV graft	2.4	4.9	8.6	10.5	12.5	14.1	13.9
	Catheter	80.2	73.3	48.1	30.3	20.4	12.7	8.8
Other or Multiracial	AV fistula	14.5	20.0	40.7	60.3	65.1	71.4	71.1
	AV graft	3.9	5.6	11.3	11.4	11.8	14.3	14.2
	Catheter	81.6	74.4	48.0	28.3	23.1	14.3	14.7
Hispanic	AV fistula	14.0	22.1	43.7	59.1	66.3	72.8	75.4
	AV graft	2.1	5.0	8.9	11.3	12.6	13.7	14.3
	Catheter	84.0	72.8	47.4	29.6	21.1	13.4	10.4
Non-Hispanic	AV fistula	17.4	24.9	44.2	57.3	63.7	68.8	70.5
	AV graft	3.1	6.8	11.4	14.1	15.5	16.8	17.3
	Catheter	79.6	68.3	44.3	28.6	20.8	14.4	12.2
Non-Hispanic White	AV fistula	18.3	26.6	46.5	59.8	66.3	71.5	73.3
	AV graft	2.5	5.5	9.5	11.8	12.8	13.7	13.9
	Catheter	79.2	67.9	44.0	28.4	20.9	14.8	12.7
Non-Hispanic Black/African American	AV fistula	15.3	21.5	39.3	52.0	58.3	63.2	65.1
	AV graft	4.2	9.2	15.0	18.4	20.2	22.0	22.6
	Catheter	80.5	69.3	45.6	29.6	21.5	14.8	12.2

Data Source: Special analyses, USRDS ESRD Database. Medical Evidence form (CMS 2728) at initiation and CROWNWeb for subsequent time periods. Abbreviations: AV, arteriovenous; CMS, Centers for Medicare & Medicaid; CROWNWeb, Consolidated Renal Operations in a Web-enabled Network; ESRD, end-stage renal disease.

vol 2 Table 3.5 Cross-sectional distributions of vascular access use, quarterly during the first two years of hemodialysis among patients new to hemodialysis in 2014, by sex, from the ESRD Medical Evidence form (CMS 2728) and CROWNWeb, 2014-2017

Sex	Access type	Time						
		At initiation	3 months	6 months	9 months	1 year	18 months	2 years
Male	AV fistula	18.3	27.7	50.0	64.0	70.6	75.5	77.2
	AV graft	2.2	5.1	8.6	10.6	11.5	12.4	12.8
	Catheter	79.4	67.2	41.4	25.5	17.9	12.1	10.0
Female	AV fistula	14.8	20.0	36.2	49.0	55.5	61.3	63.4
	AV graft	3.8	8.5	14.4	17.8	19.7	21.5	22.2
	Catheter	81.4	71.5	49.5	33.2	24.8	17.2	14.4

Data Source: Special analyses, USRDS ESRD Database. Medical Evidence form (CMS 2728) at initiation and CROWNWeb for subsequent time periods. Abbreviations: AV, arteriovenous; CMS, Centers for Medicare & Medicaid; CROWNWeb, Consolidated Renal Operations in a Web-enabled Network; ESRD, end-stage renal disease.

Predictors of AV Fistula Use at Hemodialysis Initiation

The Fistula First Breakthrough Initiative, later renamed Fistula First Catheter Last, was created to inform and educate the medical community on the higher morbidity, mortality, and costs associated with catheter use, while encouraging greater AV fistula use. Although AV fistula use has increased greatly in prevalent patients, improvement in the rate of use at initiation continues to lag. There are many possible contributors to these trends, including extent of access to primary and/or nephrology care, disparities in health-care access, difficulty with AV fistula maturation in specific patient groups such as elderly diabetics or those with limited transportation or financial incentives, and the wide variation in provider expertise in creating AV fistulas. The following figures and tables examine associations between clinical and patient characteristics and successful surgical access use, for both AV fistula and AV fistula or AV graft use, at initiation of HD.

Table 3.6 examines the influence of patient characteristics and factors such as length of pre-ESRD care and specific ESRD network of residence. At HD initiation, Asians had the highest odds of AV fistula use, while Blacks had the highest odds of an AV fistula or AV graft surgical access in use. Females were less likely to be using an AV fistula or AV graft at initiation.

ESRD Network 17 (American Samoa, Guam, Mariana Islands, Hawaii, and Northern California) displayed the highest odds of patients using an AV fistula, and of AV fistula or AV graft use, at HD initiation. ESRD Networks 15 (Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming) and 16 (Alaska, Idaho, Montana, Oregon, and Washington) had outcomes approaching those of ESRD Network 17. ESRD Network 7 (Florida) had the lowest odds of patients using an AV fistula, as well as AV fistula or AV graft, at initiation.

Patients with ESRD secondary to diabetes were less likely to use an AV fistula or AV graft at HD initiation compared to patients for whom the primary cause of ESRD was not diabetes (Table 3.6). Note that this model has somewhat different findings from other published models, such as that by Zarkowsky et al. (2015), as it adjusts for different covariates.

vol 2 Table 3.6 Odds ratios and 95% confidence intervals from logistic regression models of AV fistula use at hemodialysis initiation, and AV fistula or graft use at hemodialysis initiation, from the ESRD Medical Evidence form (CMS 2728), 2016

Predictors	AV fistula use at initiation			AV fistula or graft use at initiation		
	Odds ratio	95% confidence interval		Odds ratio	95% confidence interval	
		Lower bound	Upper bound		Lower bound	Upper bound
Pre-ESRD nephrology care						
0 months	0.05	0.05	0.06	0.07	0.06	0.07
>0 - <6 months	0.27	0.26	0.29	0.29	0.27	0.30
6 - 12 months	0.61	0.59	0.64	0.63	0.60	0.65
>12 months	Ref.			Ref		
Unknown	0.21	0.20	0.22	0.21	0.20	0.23
Age 0-21	0.31	0.23	0.41	0.29	0.22	0.38
22-44	0.85	0.80	0.91	0.80	0.75	0.85
45-64	Ref.			Ref.		
65-74	0.98	0.94	1.02	1.00	0.97	1.05
75+	0.85	0.81	0.89	0.93	0.89	0.97
Sex Female	0.74	0.72	0.77	0.86	0.83	0.89
Male	Ref.			Ref.		
Race						
White	Ref.			Ref.		
Black/African American	0.94	0.91	0.99	1.14	1.09	1.18
American Indian or Alaska Native	1.01	0.86	1.20	1.04	0.88	1.22
Asian	1.07	0.98	1.16	1.08	0.99	1.17
Other or Multiracial	0.97	0.84	1.13	0.98	0.85	1.13
Ethnicity Hispanic	0.97	0.92	1.03	0.94	0.89	1.00
Non-Hispanic	Ref.			Ref		
Diabetes as cause of ESRD	0.96	0.92	0.99	0.98	0.95	1.01
Facility census < 20	Ref.			Ref.		
20-50	0.89	0.85	0.92	0.88	0.85	0.91
51-100	0.79	0.72	0.85	0.74	0.69	0.80
101-200	0.59	0.38	0.91	0.58	0.39	0.86
>200	0.43	0.25	0.74	0.36	0.22	0.60
ESRD network (vs. average network)						
1 CT, ME, MA, NH, RI, VT	1.28	1.18	1.38	1.29	1.20	1.39
2 NY	1.17	1.10	1.25	1.15	1.08	1.22
3 NJ, PR, VI	0.77	0.71	0.84	0.82	0.76	0.89
4 DE, PA	1.04	0.96	1.12	1.03	0.96	1.10
5 VA, WV, MD, DC	0.98	0.91	1.05	0.99	0.92	1.05
6 GA, NC, SC	0.89	0.84	0.94	0.86	0.82	0.91
7 FL	0.71	0.66	0.76	0.71	0.67	0.76
8 AL, MS, TN	0.96	0.89	1.03	0.97	0.91	1.04
9 IN, KY, OH	0.89	0.84	0.95	0.89	0.84	0.94
10 IL	0.91	0.83	0.99	0.94	0.87	1.02
11 MN, MI, ND, SD, WI	0.90	0.84	0.96	0.89	0.84	0.95
12 IA, KS, MO, NE	0.86	0.78	0.93	0.83	0.77	0.90
13 AR, LA, OK	1.02	0.94	1.10	0.94	0.87	1.01
14 TX	0.73	0.69	0.78	0.73	0.69	0.78
15 AZ, CO, NV, NM, UT, WY	1.32	1.22	1.41	1.26	1.17	1.34
16 AK, ID, MT, OR, WA	1.39	1.27	1.51	1.42	1.31	1.54
17 AS, GU, MP, HI, Northern CA	1.42	1.32	1.52	1.57	1.47	1.68
18 Southern CA	1.18	1.11	1.26	1.15	1.08	1.22

Data Source: Special analyses, USRDS ESRD Database. For more on ESRD networks: http://www.cms.gov/About-CMS/Agency-Information/RegionalOffices/RegionalMap.html. *Abbreviations: AV, arteriovenous; CMS, Centers for Medicare & Medicaid; ESRD, end-stage renal disease.*

Of all AV fistulas placed between June 2014 and May 2016, 38.9% failed to mature sufficiently for use in dialysis. Of those that matured and were eventually used, the median time to first use was 108 days (Table 3.7). Younger patients tended toward higher maturation rates, with patients over age 75 displaying higher failure rates than overall. Patients aged 65-74 had the longest median time to first AV fistula use (112 days), while patients aged 22-44 had the shortest (104 days). Males had a higher maturation rate compared to females, as well as shorter time to first use. AV fistula use at initiation of dialysis was lowest among Blacks compared to Whites and other races. Blacks also experienced the highest AV fistula maturation failure rates, compared to other races.

Summary and Conclusion

Timely fistula maturation continues to be an area of central interest for the dialysis community. While AV fistula utilization among prevalent HD patients has improved (Figure 3.6), the proportion of patients using a dialysis catheter at incidence of ESRD remains stubbornly high (Figure 3.1). Limiting catheter exposure time is critical, as prolonged catheter use is often associated with bacteremia, sepsis, thrombosis, and central venous stenoses (Morsy et al., 1998). Such complications limit future access patency and can result in poor long-term patient outcomes (Pisoni et al., 2009). Observational data suggest that central venous catheter use is associated with higher mortality (Powe et al., 1999). While the exact cause of this risk is difficult to discern, there is potentially greater risk for sepsis from the foreign body itself, from resulting biofilm or chronic thrombus formation, or other such mechanisms—some of which can persist after catheter removal.

While AV grafts are ready for use sooner and more reliably than fistulas, they require more procedures to assure their long-term patency. They are associated with a higher frequency of other complications that can significantly affect mortality and morbidity, including dialysis access-associated ischemia (also known as “distal hypoperfusion ischemic syndrome” or "steal syndrome") and infections (Churchill et al., 1992; Stevenson, 2002; Ravani, 2013), adding significant risk to this choice of conduit. Furthermore, the premature placement of an AV graft may limit access options in the future (NKF, 2006)—a significant concern for those with longer life expectancy.

Currently, it is unclear whether prolonged AV fistula maturation time, and the risks associated with prolonged catheter exposure, should warrant prioritizing AV graft placement in certain patient populations such as the elderly. Recent studies, however, suggest a benefit in more liberal use of AV grafts in specific populations (Lee et al., 2015; Hall et al., 2017; Woo et al., 2017). Furthermore, conversion from a catheter to a permanent vascular access of either type has a demonstrated association with better patient outcomes (Bradbury et al., 2009).

vol 2 Table 3.7 Distribution of number of days between AV fistula placement and first successful use*, overall and by patient characteristics, for new AV fistulas created in 2014-2016 (excludes patients not yet ESRD when fistula was placed), from Medicare claims and CROWNWeb, 2014-2017

	Total AV fistula placements	Percentage of failed placements	Number of days between AV fistula placement and first use			
			Average	Median	25th percentile	75th percentile
Overall	86,848	38.9	120	108	73	156
Age						
0-21	345	32.2	123	106	76	148
22-44	9,698	35.4	116	104	69	150
45-64	32,284	37.2	119	106	71	156
65-74	24,697	39.4	123	112	76	159
75+	19,824	42.7	121	109	76	156
Race						
White	54,415	37.9	121	109	75	155
Black/African American	27,154	42.0	120	108	70	160
American Indian or Alaska Native	1,109	31.6	123	113	78	153
Asian	2,980	32.8	113	104	67	146
Native Hawaiian or Pacific Islander	905	33.4	126	110	73	172
Other or Multiracial	241	38.2	114	103	44	153
Unknown	44	34.1	139	121	76	196
Ethnicity						
Hispanic	12,340	33.8	117	105	73	150
Non-Hispanic	73,952	39.7	121	109	73	157
Race/Ethnicity						
Non-Hispanic White	42,406	39.1	122	110	76	157
Non-Hispanic Black/African American	26,657	41.9	120	108	70	159
Sex						
Male	49,393	34.2	116	105	71	148
Female	37,455	45.1	128	115	76	169
Primary Cause of ESRD						
Diabetes	40,722	38.8	123	111	75	160
Hypertension	25,986	38.7	119	108	73	155
Glomerulonephritis	7,621	36.8	113	103	66	148
Cystic kidney	1,489	36.5	113	104	68	148
Other urologic	1,259	35.7	119	107	73	156
Other cause	7,554	42.5	118	107	73	153
Unknown cause	2,217	40.6	119	106	69	155

*Data Source: Special analyses, USRDS ESRD Database. *Fistulas placed between June 1, 2014 and May 31, 2016, with follow-up through May 2017; follow-up is censored at one year after fistula placement date; date of first use was the date the given access was first reported in CROWNWeb to be in used in a particular patient. Abbreviations: AV, arteriovenous; CROWNWeb, Consolidated Renal Operations in a Web-enabled Network; ESRD, end-stage renal disease.*

References

Bradbury BD, Chen F, Furniss A, Pisoni RL, Keen M, Mapes D, Krishnan M. Conversion of vascular access type among incident hemodialysis patients: description and association with mortality. *Am J Kidney Dis* 2009;53(5):804-814.

Brown RS, Patibandla BK, Goldfarb-Rumyantzev AS. The survival benefit of "fistula first, catheter last" in hemodialysis is primarily due to patient factors. *J Am Soc Nephrol* 2017;28(2): 645-652.

Centers for Medicare & Medicaid (CMS). Regional map. http://www.cms.gov/About-CMS/Agency-Information/RegionalOffices/RegionalMap.html). Accessed September 16, 2016.

Churchill DN, Taylor DW, Cook RJ, LaPlante P, Barre P, Cartier P, Fay WP, Goldstein MB, Jindal K, Mandin H, et al. Canadian Hemodialysis Morbidity Study. *Am J Kidney Dis* 1992;19(3):214-234.

Dember LM, Beck GJ, Allon M, Delmez JA, Dixon BS, Greenberg A, Himmelfarb J, Vazquez MA, Gassman JJ, Greene T, Radeva MK, Braden GL, Ikizler TA, Rocco MV, Davidson IJ, Kaufman JS, Meyers CM, Kusek JW, Feldman HI, Dialysis Access Consortium Study G. Effect of clopidogrel on early failure of arteriovenous fistulas for hemodialysis: a randomized controlled trial. *JAMA* 2008;299(18):2164-2171.

Fistula First Breakthrough Initiative (FFBI) [database online]. www.fistulafirst.org. Accessed May 12, 2015, and no longer available in the public domain. Data publicly available on the Internet Archive, Wayback Machine. https://web.archive.org/web/20120930092044/http:/www.fistulafirst.org/aboutfistulafirst/ffbidata.aspx Accessed September 29, 2015.

Goodkin DA, Pisoni RL, Locatelli F, Port FK, Saran R. Hemodialysis vascular access training and practices are key to improved access outcomes. *Am J Kidney Dis* 2010;56(6):1032-1042.

Hall RK, Myers ER, Rosas SE, O'Hare AM, Colón-Emeric CS. Choice of hemodialysis access in older adults: a cost-effectiveness analysis. *Clin J Am Soc Nephrol* 2017;12(6): 947-954.

Huber TS. A call to action for pre-end-stage renal disease care. *JAMA Surg* 2015;150(5):449.

Lee T, Thamer M, Zhang Y, Zhang Q, Allon M. Outcomes of elderly patients after predialysis vascular access creation. *J Am Soc Nephrol* 2015;25(12): 3133-3140.

Morsy AH, Kulbaski M, Chen C, Isiklar H, Lumsden AB. Incidence and characteristics of patients with hand ischemia after a hemodialysis access procedure. *J Surg Res* 1998;74(1):8-10.

National Kidney Foundation (NKF). KDOQI Clinical Practice Guidelines and Clinical Practice Recommendations, 2006 updates: hemodialysis adequacy, peritoneal dialysis adequacy and vascular access. *Am J Kidney Dis* 2006 48 (Suppl 1): S1-S322.

Pisoni RL, Arrington CJ, Albert JM, Ethier J, Kimata N, Krishnan M, Rayner HC, Saito A, Sands JJ, Saran R, Gillespie B, Wolfe RA, Port FK. Facility hemodialysis vascular access use and mortality in countries participating in DOPPS: an instrumental variable analysis. *Am J Kidney Dis* 2009;53(3):475-491.

Pisoni RL, Young EW, Dykstra DM, Greenwood RN, Hecking E, Gillespie B, Wolfe RA, Goodkin DA, Held PJ. Vascular access use in Europe and the United States: results from the DOPPS. *Kidney Int* 2002;61:305-316.

Powe NR, Jaar B, Furth SL, Hermann J, Briggs W. Septicemia in dialysis patients: Incidence, risk factors, and prognosis. *Kidney Int* 1999;55:1081–1090.

Ravani P, Palmer SC, Oliver MJ, Quinn RR, MacRae JM, Tai DJ, Pannu NI, Thomas C, Hemmelgarn BR, Craig JC, Manns B, Tonelli M, Strippoli GF, James MT. Associations between hemodialysis access type and clinical outcomes: a systematic review. *J Am Soc Nephrol* 2013 ;24(3):465-473.

Ravani P, Quinn R, Oliver M et al. Examining the association between hemodialysis access type and mortality: the role of access complications. *Clin J Am Soc Nephrol* 2017;12(6): 955-964.

Robinson BM, Port FK. Caring for dialysis patients: International insights from the Dialysis Outcomes

and Practice Patterns Study (DOPPS). Identifying best practices and outcomes in the DOPPS. *Semin Dial* 2010;23(1):4-6.

Saran R, Elder SJ, Goodkin DA, Akiba T, Ethier J, Rayner HC, Saito A, Young EW, Gillespie BW, Merion RM, Pisoni RL. Enhanced training in vascular access creation predicts arteriovenous fistula placement and patency in hemodialysis patients: results from the Dialysis Outcomes and Practice Patterns Study. *Ann Surg* 2008;247(5): 885-891.

Stevenson KB, Hannah EL, Lowder CA, Adcox MJ, Davidson RL, Mallea MC, Narasimhan N, Wagnild JP. Epidemiology of hemodialysis vascular access infections from longitudinal infection surveillance data: predicting the impact of NKF-DOQI clinical practice guidelines for vascular access. *Am J Kidney Dis* 2002;39(3):549-555.

United States Renal Data System (USRDS). 2016 USRDS annual data report: epidemiology of kidney disease in the United States. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda, MD, 201.

Vassalotti JA, Jennings WC, Beathard GA, Neumann M, Caponi S, Fox CH, Spergel LM, Fistula First Breakthrough Initiative Community Education C. Fistula First Breakthrough Initiative: targeting catheter last in fistula first. Semin Dial 2012;25(3):303-310.

Woo K, Gascue L, Goldman DP, Romley JA. Variations in outcomes of hemodialysis vascular access by race/ethnicity in the elderly. *J Vasc Surg* 2017;65(3): 783-792.e4.

Woodside KJ, Bell S, Mukhopadhyay P, et al. Arteriovenous fistula maturation in prevalent hemodialysis patients in the United States: a national study. *Am J Kidney Dis*. 2018;71(6):793-801.

Zarkowsky DS, Arhuidese IJ, Hicks CW, Canner JK, Qazi U, Obeid T, Schneider E, Abularrage CJ, Freischlag JA, Malas MB. Racial/ethnic disparities associated with initial hemodialysis access. *JAMA Surg* 2015;150(6):529-536.

Notes