

# Characterization of long-term survival in Medicare patients undergoing arteriovenous hemodialysis access

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## ABSTRACT

**Background:** Patients undergoing arteriovenous (AV) access creation for hemodialysis often have significant comorbidities. Our goal was to quantify the long-term survival and associated risks factors for long-term mortality in these patients to aid in optimization of goals and expectations.

**Methods:** The Vascular Implant Surveillance and Interventional Outcomes Network Vascular Quality Initiative Medicare linked data was used to assess long-term survival in the HD registry. Demographics, comorbidities, and interventions were recorded. Because the majority of hemodialysis patients are provided Medicare, Medicare linkage was used to obtain survival data. Multivariable analysis was used to identify independent associations with mortality.

**Results:** There were 13,945 AV access patients analyzed including 10,872 (78%) AV fistulas and 3073 (22%) AV grafts. The median age was 67 years and 56% of patients were male. Approximately one-third had a prior AV access and 44.7% had prior tunneled dialysis catheters. Patients receiving an AV fistula, compared with AV grafts, were more often younger, male, White, obese, independently ambulatory, preoperatively living at home, and less often have a prior AV access and tunneled dialysis catheters ( $P < .05$  for all). The 5-year mortality overall was 62.9% with 61.2% for AV fistulas and 68.8% for AV grafts ( $P < .001$ ). On multivariable analysis for 5 year mortality, nonambulatory status (hazard ratio [HR], 1.67; 95% confidence interval [CI], 1.53-1.83;  $P < .001$ ), lower extremity access (HR, 1.67; 95% CI, 1.35-2.05;  $P < .001$ ), human immunodeficiency virus or acquired immunodeficiency syndrome (HR, 1.44; 95% CI, 1.13-1.82;  $P < .001$ ), White race (HR, 1.43; 95% CI, 1.35-1.51;  $P < .001$ ), congestive heart failure (HR, 1.33; 95% CI, 1.26-1.41;  $P < .001$ ), chronic obstructive pulmonary disease (HR, 1.23; 95% CI, 1.15-1.31;  $P < .001$ ), and AV graft placement (HR, 1.12; 95% CI, 1.02-1.23,  $P = .016$ ) were most associated with poor survival. Factors associated with improved survival were never smoking (HR, .73; 95% CI, 0.67-0.79;  $P < .001$ ), prior/quit smoking (HR, .78; 95% CI, 0.72-0.84;  $P < .001$ ), preoperative home living (HR, .75; 95% CI, 0.68-0.83;  $P < .001$ ), and hypertension (HR, .89; 95% CI, 0.8-0.99;  $P = .03$ ).

**Conclusions:** Long-term survival in Medicare patients undergoing AV access creation is poor with nearly two-thirds of patients having died at 5 years. There are many modifiable risk factors that may improve survival in these patients and give an opportunity for transplantation. (J Vasc Surg 2024;79:925-30.)

**Keywords:** Dialysis; Access; Survival

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Arteriovenous (AV) access creation, either with an autogenous fistula or with an AV graft, is the most common method for establishing long-term hemodialysis access. Although AV access is meant to be a temporary bridge to kidney transplantation, it is often a destination treatment for patients with end-stage renal disease (ESRD).<sup>1</sup> The Fistula First initiative resulted in more autogenous AV access creations, however many patients still initiate dialysis with a tunneled dialysis catheter (TDC) or need a prosthetic graft for access owing to the lack of or exhaustion of autogenous options.<sup>1-6</sup> Unfortunately, long-term hemodialysis is necessary in many patients because kidney transplantation opportunities are limited owing to not having a donor, ineligibility, or not surviving long enough to be offered a deceased donor kidney.

Overall, patients with ESRD have decreased long-term survival compared with the general population.<sup>7,8</sup> These patients often have many comorbidities that contribute

to their decreased survival in addition to the ESRD itself. Long-term survival rates have varied over time. According to the US Renal Data System (USRDS), the adjusted mortality rate decreased from 186.4 to 162.7 per thousand person-years between 2010 and 2019 and has risen in 2020. There is also considerable variation by state and region in the United States. This variability by time and geography demonstrates that many risk factors can be adjusted and significant opportunities are present for improvement.

Our goal was to assess the long-term survival of patients with ESRD and associated risk factors after undergoing AV access creation. Establishing baseline survival in this population and identifying risk factors can allow for risk factors modification and improved patient-centered decision making. We utilized the Vascular Implant Surveillance and Interventional Outcomes Network (VISION) and Vascular Quality Initiative (VQI) database, which links Medicare beneficiaries in the VQI with Medicare claims to permit for evaluation of long-term postoperative survival.

## METHODS

The VISION VQI Medicare-linked data (2011-2018) were used to assess long-term survival for  $\leq 5$  years among patients undergoing AV access creation in the VQI registries.<sup>9</sup> The VQI registries is composed of data from >1000 medical centers in North America. VISION is a collaboration of the VQI, the US Food and Drug Administration, and the medical device industry. The goal of VISION is to evaluate the quality of vascular devices by using longitudinal data. Medicare linkage provides accurate long-term survival data for Medicare beneficiaries undergoing interventions within the VQI. The Boston University Institutional Review Board approved this as nonhuman subjects research and the VQI National Research Advisory Committee approved this proposal.

Unique patients undergoing AV access creation from January 2011 to December 2018 were included. Patients with venous anastomosis at the central catheter were excluded. Demographics including age, sex, ethnicity, race, and preadmission living were recorded. Comorbidities included obesity (body mass index  $\geq 30$  kg/m<sup>2</sup>), hypertension, diabetes, coronary artery disease, congestive heart failure (CHF), chronic obstructive pulmonary disease, peripheral artery disease, anemia (hemoglobin <10 g/dL), prior intravenous drug use, human immunodeficiency virus or acquired immunodeficiency syndrome, prior coronary artery bypass graft, or percutaneous coronary intervention, previous AV access procedures or TDC use, and medications. Procedural details included were outpatient setting, general anesthesia use, and any concomitant procedures (eg, arterial or venous angioplasty/stent, or arterial endarterectomy). The primary outcome was 5-year mortality. Event of death was assessed with Medicare Master Beneficiary Summary File. If patients did not die after AV

## ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective analysis of large multi-institutional data
- **Key Findings:** The 5-year mortality overall was 62.9% with 61.2% for arteriovenous (AV) fistulas and 68.8% for AV grafts ( $P < .001$ ). On multivariable analysis of 5-year mortality, nonambulatory status, lower extremity access, human immunodeficiency virus or acquired immunodeficiency syndrome, White race, congestive heart failure, chronic obstructive pulmonary disease, and AV graft placement were most associated with poor survival. Factors associated with improved survival were never smoking, preoperative home living, and hypertension.
- **Take Home Message:** Long-term survival in Medicare patients undergoing AV access creation is poor with nearly two-thirds of patients having died at 5 years. There are many modifiable risk factors that may improve survival in these patients and provide an opportunity for transplantation.

access creation, they were censored at the time of dropping out Medicare fee-for-service entitlement or on December 31, 2018, whichever was earlier.

**Statistical analysis.** Patient demographics and procedural characteristics were reported as categorical variables (number [%]), or continuous variables, median with interquartile range, as appropriate. Patient and procedure details were analyzed using the Wilcoxon rank-sum test for continuous measures and the  $\chi^2$  test for categorical measures. Kaplan-Meier analysis and log-rank tests were used to compare long-term mortality between autogenous fistula and AV graft cohorts. Multivariable Cox proportional hazards models including all patient and procedural factors were performed to determine factors significantly associated with long-term mortality. The relationships between those baseline variables and long-term survival were expressed as hazard ratios (HRs) with corresponding 95% confidence intervals (CIs). A  $P$  value of  $< .05$  was set as statistically significant. All analyses were performed using SAS v9.4 (SAS Institute Cary, NC).

## RESULTS

There were 13,945 AV access patients analyzed, which included 10,872 (78%) AV fistulas and 3,073 (22%) AV grafts. The median age was 67 years and 56% of patients were male (Table 1). Approximately one-third had a prior AV access and 44.7% had prior TDCs. Patients receiving an AV fistula, compared with AV graft, were more often younger, male, of White race, obese, independently ambulatory, preoperatively living at home, and less often have a prior AV access and TDCs ( $P < .05$  for all) (Table 1). The majority were created in the outpatient setting

**Table I.** Demographics and comorbidities

Covariate	Overall (n = 13,945)	Autogenous (n = 10,872)	Craft (n = 3073)	P value
Age, years	67 (56-75)	67 (56-74)	67 (56-76)	<.01
Male sex	7807 (56)	6397 (58.8)	1410 (45.9)	<.001
White race	8172 (58.7)	6581 (60.6)	1591 (51.9)	<.001
Hispanic ethnicity	719 (5.2)	554 (5.1)	165 (5.4)	.51
Obesity	5764 (41.6)	4648 (43)	1116 (36.5)	<.001
Ambulatory - independent	10,247 (74.4)	8229 (76.6)	2018 (66.6)	<.001
Ambulatory - with assistance	2380 (17.3)	1736 (16.2)	644 (21.3)	
Nonambulatory	1142 (8.3)	775 (7.2)	367 (12.1)	
Preoperative living status home	13,072 (94)	10,287 (94.9)	2785 (90.8)	<.001
Smoking - current	2031 (14.6)	1617 (14.9)	414 (13.5)	.13
Smoking - prior	5399 (38.8)	4209 (38.8)	1190 (38.9)	
Smoking - never	6478 (46.6)	5019 (46.3)	1459 (47.6)	
Hypertension	13,014 (93.6)	10,198 (94.1)	2816 (92.1)	<.001
Diabetes	8302 (59.7)	6576 (60.6)	1726 (56.3)	<.001
Coronary artery disease	3252 (23.4)	2576 (23.7)	676 (22)	.05
CHF	4289 (30.8)	3305 (30.4)	984 (32.1)	.09
COPD	2751 (19.8)	2165 (19.9)	586 (19.1)	.29
Peripheral artery disease	13,868 (99.8)	10,818 (99.8)	3050 (99.8)	.62
Anemia	4438 (31.8)	3489 (32.1)	949 (30.9)	<.001
Prior IV drug use	178 (1.3)	124 (1.1)	54 (1.8)	.007
HIV/AIDS	177 (1.3)	131 (1.2)	46 (1.5)	.44
Prior CABG/PCI	3118 (22.4)	2499 (23)	619 (20.1)	<.001
Prior AV access	4526 (32.5)	2902 (26.7)	1624 (52.8)	<.001
Prior TDC	6239 (44.7)	4659 (42.9)	1580 (51.4)	<.001

AIDS, Acquired immunodeficiency syndrome; AV, arteriovenous; CABG, Coronary artery bypass graft; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; HIV, human immunodeficiency virus; IV, intravenous; PCI, percutaneous coronary intervention; TDC, tunneled dialysis catheter.  
Values are median (interquartile range) or number (%).

(85.8%) and 38.3% used general anesthesia (Table II). Overall, the three most common AV access configurations were brachiocephalic (31.7%), brachio basilic (22.4%), and radiocephalic (21%).

The 5-year mortality overall was 62.9% with 61.2% for AV fistulas and 68.8% for AV grafts ( $P < .001$ ) (Table III, Figure). This trend continued out to seven years with almost 75% of patients not surviving 7 years after AV access creation (Table III, Figure). On multivariable analysis for 5-year mortality, nonambulatory status (HR, 1.67; 95% CI, 1.53-1.83;  $P < .001$ ), lower extremity access (HR, 1.67; 95% CI, 1.35-2.05;  $P < .001$ ), human immunodeficiency virus or acquired immunodeficiency syndrome (HR, 1.44; 95% CI, 1.13-1.82;  $P < .001$ ), White race (HR, 1.43; 95% CI, 1.35-1.51;  $P < .001$ ), CHF (HR, 1.33; 95% CI, 1.26-1.41;  $P < .001$ ), chronic obstructive pulmonary disease (HR, 1.23; 95% CI, 1.15-1.31;  $P < .001$ ), and AV graft placement (HR, 1.12; 95% CI, 1.02-1.23;  $P = .016$ ) were most associated with poor survival. Factors associated with improved survival were never smoking (HR, .73; 95% CI, 0.67-0.79;  $P < .001$ ), prior/quit smoking (HR, .78; 95% CI, 0.72-0.84;  $P < .001$ ), preoperative home living (HR, 0.75; 95% CI,

0.68-0.83;  $P < .001$ ), and hypertension (HR, 0.89; 95% CI, 0.80-0.99;  $P = .03$ ) (Table IV).

## DISCUSSION

Patients undergoing AV access creation had poor long-term survival with almost two-thirds dying within 5 years. Patients with potentially modifiable comorbidities, such as ambulatory status, cardiac and pulmonary conditions, and smoking were identified as highest risk for death. Prosthetic graft placement was independently associated with decreased survival, which reinforces the efforts to establish autogenous upper extremity access when possible. Markers of a more complicated access history, including lower extremity access, previous access creation, and previous TDC were also at higher risk for death. These data can help with shared decision-making, patient education, and targeting risk factors for improvement.

The mortality rate in our analysis was high at 62.9% at 5 years, with the greatest increase being the first year after access creation, with almost one-quarter of patients receiving an AV graft not surviving 1 year. This high

**Table II.** Procedural details

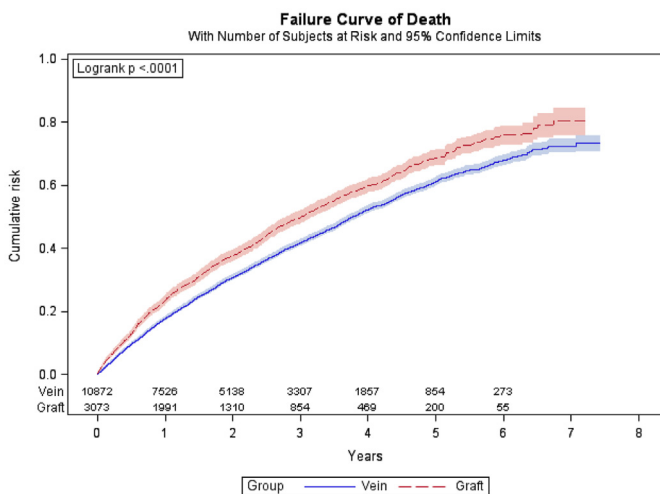
Covariate	Overall (n = 13,945)	Vein (n = 10,872)	Graft (n = 3073)	P value
Outpatient setting	11,892 (85.8)	9451 (87.4)	2441 (80)	<.001
General anesthesia use	5325 (38.3)	3586 (33)	1739 (56.8)	<.001
Concomitant procedure	164 (1.2)	79 (.7)	85 (2.8)	<.001
Discharge medication				
Aspirin	6735 (48.4)	5307 (48.9)	1428 (46.7)	.03
P2Y12 inhibitor	1875 (13.5)	1478 (13.6)	397 (13)	.36
Anticoagulation	1959 (14.1)	1484 (13.7)	475 (15.5)	.009

Values are number (%).

**Table III.** Yearly mortality by access type

Years	Overall	Vein	Graft	P value
1	18.9% (18.2%-19.6%)	17.6% (16.9%-18.4%)	23.3% (21.8%-24.9%)	<.001
2	32.2% (31.4%-33.1%)	30.7% (29.8%-31.7%)	37.6% (35.7%-39.5%)	<.001
3	43.5% (42.5%-44.5%)	41.7% (40.7%-42.8%)	49.7% (47.6%-51.8%)	<.001
4	54% (53%-55.1%)	52.4% (51.2%-53.6%)	59.8% (57.6%-62%)	<.001
5	62.9% (61.7%-64.1%)	61.2% (59.8%-62.6%)	68.8% (66.3%-71.2%)	<.001
6	69.8% (68.3%-71.3%)	68% (66.3%-69.7%)	75.9% (72.9%-78.9%)	<.001
7	74.2% (72.2%-76.2%)	72.5% (70.3%-74.7%)	80.3% (75.8%-84.5%)	<.001

Values are number (95% confidence interval).



**Figure.** Long-term mortality comparing autogenous access with arteriovenous (AV) grafts.

mortality rate necessitates a need to improve these patients' care. According to the USRDS, there is significant state and regional variability in all-cause mortality in patient with ESRD. The adjusted mortality was highest in the upper and central Midwest, the Ohio River Valley, and Southern Texas with improved survival rates in the Southwestern and along the East Coast of the United States. Survival rates have also adjusted over time as median survival was approximately 42 months for patients

initiating dialysis in 2006 and improved to 47 months for those initiating dialysis in 2016. Adjusted all-cause mortality decreased from 2010 and 2019 before increasing in 2020. This result is likely due to a combination of COVID-19 infection, as well as decreased access to care and dialysis further showing modifiable conditions.<sup>10,11</sup> These variations in geography and time show that improvement is possible in this vulnerable population. There have not been many reports of 5-year survival rates for patients with ESRD. A registry from Taiwan reported a 55.3% survival rate at 5 years for all patients on dialysis and a single-center review from Brazil showed a 49% survival rate.<sup>12,13</sup> However, an analysis from the 1980s showed that the United States had a 5-year survival of only 40%. When these patients were compared with Japan and Europe, the US patients had higher rates of diabetics and older patients, both of which were associated with worse outcomes in our analysis.<sup>14</sup> This finding reinforces that there is still much room for improvement, as rates have remained similar across decades. When examining patients with a wide range cardiovascular comorbidities, the 2022 USRD reports that survival rates are <50% at 2 years, emphasizing the role of comorbidities. Prior AV access, TDC use, and leg grafts were associated with lower long-term survival in this study. These are likely markers of not only complicated access patients, but long-term access patients that have exhausted other options.<sup>5,6,15</sup> AV graft creation was also independently associated with poor survival. This finding is likely

**Table IV.** Multivariable analysis of factors associated with long-term survival after arteriovenous (AV) access creation

Covariate	HR	95% CI	P value
Nonambulatory	1.67	1.53-1.83	<.0001
Lower extremity access	1.67	1.35-2.05	<.0001
HIV/AIDS	1.44	1.13-1.82	.0028
White race	1.43	1.35-1.51	<.0001
CHF	1.33	1.26-1.41	<.0001
Ambulatory with assistance	1.29	1.2-1.37	<.0001
COPD	1.23	1.15-1.31	<.0001
Anticoagulation	1.21	1.13-1.3	<.0001
Diabetes	1.2	1.13-1.27	<.0001
Anemia	1.19	1.12-1.26	<.0001
Prior CABG/PCI	1.18	1.1-1.27	<.0001
Coronary artery disease	1.18	1.1-1.27	<.0001
Prior TDC	1.13	1.07-1.19	<.0001
AV graft	1.12	1.02-1.23	.016
Prior AV access	1.11	1.04-1.17	.0007
Age	1.027	1.024-1.029	<.0001
Hypertension	0.89	0.8-0.99	.03
Obesity	0.84	0.79-0.89	<.0001
Preoperative living status home	0.75	0.68-0.83	<.0001
Smoking - prior	0.78	0.72-0.84	<.0001
Smoking - never	0.73	0.67-0.79	<.0001

*AIDS*, Acquired immunodeficiency syndrome; *CABG*, coronary artery bypass graft; *CHF*, congestive heart failure; *COPD*, chronic obstructive pulmonary disease; *HIV*, human immunodeficiency virus; *HR*, hazard ratio; *PCI*, percutaneous coronary intervention; *TDC*, tunneled dialysis catheter.

multifactorial, owing to increased access occlusion, infectious complications, and associated hospitalizations and procedures. Impaired ambulatory status was the risk factor most associated with mortality. This result is likely due to lower physiological reserve, difficulty attending clinic appointments including dialysis sessions, seeking health care for comorbidities, and fall-related injuries.<sup>16,17</sup> According to the USRDS, more than one-half of deaths are thought to be due to cardiovascular disease. This finding is consistent with our data showing cardiovascular risk factors associated with poor survival including coronary artery disease, CHF, and diabetes as potentially modifiable comorbidities. Smoking also affected long-term survival with active smokers at greater risk, which represents a clear area for patient education and intervention, as well as referral to assist with smoking cessation and improve survival.<sup>18,19</sup> Ultimately, the most modifiable risk factors is the presence of ESRD. Kidney transplantation affords the greatest chance to improve survival in these patients and further work is needed to improve both allograft availability. However, additional improvements are needed to optimize these patients to allow them to be eligible for a kidney transplant and improve survival for them to undergo kidney transplantation while being placed on a waiting list.

This study has multiple limitations. Selection bias is present for those undergoing AV fistula or AV graft creation. The sample only includes patients undergoing AV access creations and is not reflective of peritoneal dialysis and patients with destination TDC. The cause for death could not be determined. Changes in the patient's dialysis access and for those that may have had a kidney transplant were not available.

## CONCLUSIONS

Long-term survival in Medicare patients undergoing AV access creation is poor with nearly two-thirds of patients having died at 5 years. There are many modifiable risk factors that may improve survival in these patients and give an opportunity for transplantation.

Data for this project were generated by the Vascular Implant Surveillance and Interventional Outcomes Network (VISION) (<http://mdepinet.org/vision-crnl/>), a partnership between the Vascular Quality Initiative and the Medical Device Epidemiology Network (MDEpiNet), a Food and Drug Administration supported initiative aimed at developing distributed research networks. VISION links VQI data to Medicare claims to enhance long-term follow-up data in the VQI. Use of the VQI-Medicare linked data is governed by CMS Data Use



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## AUTHOR CONTRIBUTIONS

Conception and design: MS, JS

Analysis and interpretation: MS, TC, EK, MW, AF, VC, JS

Data collection: Not applicable

Writing the article: MS, TC, JS

Critical revision of the article: EK, MW, AF, VC

Final approval of the article: MS, TC, EK, MW, AF, VC, JS

Statistical analysis: JS

Obtained funding: Not applicable

Overall responsibility: JS

## DISCLOSURES

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