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Mortality benefits of different hemodialysis access types are age dependent

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Objective: Risk of death in dialysis patients is lowest with arteriovenous fistulas (AVFs), followed by arteriovenous grafts (AVGs) and then intravenous hemodialysis catheters (HCs). Our aim was to analyze the effects of age at hemodialysis initiation on mortality across different access types.

Methods: All patients ≥18 years in the United States Renal Data System between the years 2006 and 2010 were analyzed. Spline modeling and risk-adjusted Cox proportional hazard models were used to analyze the effect of age on mortality for first dialysis access with AVF vs AVG vs HC.

Results: The study analyzed 507,791 patients (63.4 ± 0.02 years; 56.5% male; 40.9% mortality; follow-up, 1.57 ± 1.36 years). Increasing age was a significant predictor of overall mortality (adjusted hazard ratio [aHR], 1.03; $P < .001$). Compared with patients with HCs (n = 418,932), overall risk-adjusted mortality was lowest in patients with AVFs (n = 71,316; aHR, 0.63; $P < .001$) followed by AVGs (n = 17,543; aHR, 0.83; $P < .001$). AVF was superior to both HC and AVG for all age groups ($P < .001$). However, there was a significant change in the relative efficacy of AVG at ages 48 years and 89 years based on spline modeling; there were no significant differences comparing adjusted mortality with AVG vs HC for patients aged 18 to 48 years or for patients >89 years, but AVG was superior to HC for patients 49 to 89 years of age (aHR, 0.811; $P < .001$). The mortality benefit of AVF was consistently superior to that of AVG and HC for patients of all ages (all, $P < .001$).

Conclusions: AVF is superior to AVG and HC regardless of the patient's age, including in octogenarians. In contrast, the mortality benefit of AVG over HC may not apply to younger (18-48 years) or older (>89 years) age groups. All patients 18 to 48 years should receive AVF for dialysis access whenever possible. (J Vasc Surg 2015;61:449-56.)

A number of prior studies have evaluated the benefits of initiating dialysis with an arteriovenous fistula (AVF) vs arteriovenous graft (AVG) or intravenous hemodialysis catheter (HC), demonstrating overwhelming favor of AVF.[1-8] As a result, the National Vascular Access Improvement Initiative, later renamed the Fistula First Breakthrough Initiative, was started in 2003 in an attempt to increase AVF use and to reduce HC use for dialysis access.[9] Consistent with this initiative, the National Kidney Foundation Kidney Disease Outcomes Quality Initiative published guidelines in 2006 endorsing the creation of an AVF as the initial form of dialysis access.[10] When patients are deemed unsuitable for AVF placement, AVG placement is recommended.[11] Despite these initiatives, incident AVF prevalence in the United States remains less than 20%[12] and has shown minimal improvement in recent years (Malas et al, in press).

One potential reason that may be contributing to the low incident AVF rates is the perception that permanent dialysis access is not necessary within certain patient populations. For example, the Kidney Disease Outcomes Quality Initiative calls for permanent dialysis only among pediatric patients who are expected to require dialysis for longer than 1 year, with the thought that many young patients are listed for prompt renal transplantation and therefore can be bridged appropriately with an HC.[13] Similarly, AVFs are often avoided in older populations, with the thought that elderly patients have a higher risk of death before starting dialysis and on dialysis initiation, making the benefits of AVF over AVG or HC less clear.[14,15]

Although a handful of studies have investigated the mortality rates with different forms of dialysis access within specific young[16-20] and elderly populations,[4,21-24] there are minimal data evaluating variations in mortality across a wide range of ages. Our aim was to analyze the effects of age and initial dialysis access type on mortality.

METHODS

This study was a retrospective review of data from the prospectively maintained United States Renal Data System

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(USRDS) database. The USRDS maintains a prospective database, tracking each end-stage renal disease (ESRD) patient receiving renal replacement therapy within the United States. Annual reports published since 1988 appear at usrds.org and provide information on epidemiology, hospitalization, mortality, and cost, among other parameters.[25] The USRDS maintains a robust database on every ESRD patient by integrating patient-specific data from the Centers for Medicare and Medicaid Services (CMS), Centers for Disease Control and Prevention, United Network for Organ Sharing, and ESRD networks. The Johns Hopkins Hospital Institutional Review Board and the USRDS approved this study before its initiation. Data from the USRDS are in the public domain, and thus informed consent was not required for this study.

All patients in the USRDS database aged ≥18 years who initiated dialysis between 2006 and 2010 were included. Patients missing data pertaining to age or initial dialysis access type, as well as those who stated dialysis before 2006 or received a kidney transplant during the course of the study period (as determined by records from the United Network for Organ Sharing), were excluded. In addition, we excluded all patients who died within 90 days of initiating dialysis because it takes up to 90 days for patients to obtain complete Medicare coverage, resulting in a high likelihood that dialysis access type and mortality were skewed in this population. Data on patient characteristics, including baseline demographics, comorbidities, etiology of ESRD, access to nephrologist care, and initial dialysis access type, were collected from CMS Form 2728, End Stage Renal Disease Medical Evidence Report. Data on patient mortality were collected from CMS Form 2746, ESRD Death Notification Form.

Statistical methods. The aim of this study was to compare the association between age and initial dialysis access type with all-cause mortality. As such, all patients were classified into one of three study groups for analysis: AVF, AVG, and intravenous HC. Patients with HC and a maturing AVF or AVG at the time of dialysis initiation remained classified as HC on the basis of our prior work that demonstrated a significant mortality benefit with initial AVF or AVG over HC with maturing AVF or AVG (Malas et al, in press) and in accordance with prior work investigating mortality outcomes based on initial dialysis access used.[21] All patients were classified by an intention-to-treat approach, meaning that they were classified as AVF vs AVG vs HC by the type of dialysis access with which they initiated dialysis; changes in access type during the course of the study period were not accounted for.

Descriptive (mean ± standard error of the mean or count with percentage) and univariable (analysis of variance and Pearson χ^2 tests) statistics were used to evaluate baseline characteristics and to compare overall mortality between study groups. The overall effect of age on mortality was assessed by univariable and multivariable Cox proportional hazard models. The covariates included in the adjusted models were predictive of mortality in the USRDS population on the basis of univariable analyses and likelihood ratio tests and included dialysis access type, gender, body mass index (BMI), insurance status before ESRD coverage, comorbidities (congestive heart failure, atherosclerotic heart disease, cerebrovascular disease, peripheral vascular disease, hypertension, diabetes mellitus, chronic obstructive pulmonary disease, cancer), smoking history, alcohol and drug dependence, ability to ambulate, etiology of ESRD, and access to nephrologist care.

Table I. Distribution of dialysis access method by age category

	AVF (*n* = *71,316*), *No.* (*%*)	*AVG* (*n* = *17,543*), *No.* (*%*)	*HC* (*n* = *418,932*), *No.* (*%*)
Age category			
18-34 years	2070 (2.90)	446 (2.54)	20,723 (4.95)
35-44 years	4577 (6.42)	929 (5.30)	31,262 (7.46)
45-54 years	10,567 (14.8)	2259 (12.9)	62,789 (15.0)
55-64 years	17,175 (24.1)	4073 (23.2)	94,705 (22.6)
65-74 years	18,528 (26.0)	4668 (26.6)	97,559 (23.3)
75-84 years	14,962 (21.0)	4137 (23.6)	85,784 (20.5)
>84 years	3437 (4.82)	1031 (5.88)	26,110 (6.23)

AVF, Arteriovenous fistula; *AVG,* arteriovenous graft; *HC,* hemodialysis catheter.

To more fully explore the effects of age and dialysis access type on mortality, we used risk-adjusted Cox proportional hazard models to test the risk of mortality for AVF and AVG vs HC for incrementally increasing age groups as categorized by 10- and then 5-year increments. On the basis of an apparent interaction between age and mortality among younger and older patients, we then performed spline modeling to estimate the age at which the relative mortality benefits of different forms of dialysis access changed. The spline technique applies a piece-wise approach to the evaluation of points (knots) at which significant changes occur in the trend of the age-mortality function.[26] Differences in mortality at certain age cutoffs as identified by the spline model were explored with multivariable analyses of the slopes of the spline graph for each treatment before and after each designated age cutoff. Multivariable Cox proportional hazard models using moving averages ±2 years were then employed to estimate the precise age at which there was an inflection point in the mortality benefit of a specific treatment and to describe the adjusted hazard ratios (aHRs) for mortality for AVF and AVG vs HC over each age range. For all analyses, HC served as the reference group.

All data analyses were performed with Stata 12.1 statistical software (StataCorp, College Station, Tex), with a level of $P < .05$ denoting statistical significance.

RESULTS

Patient characteristics. During the 5-year study period, 553,064 patients initiated dialysis in the USRDS database. Of these, 45,273 (8.19%; AVF, 2262; AVG, 874; HC, 41,773) died within 90 days and were excluded, leaving a total of 507,791 patients for analysis (mean age,

Table II. Patient characteristics by dialysis access method

	AVF (n = 71,316), No. (%)	*AVG (n = 17,543), No. (%)*	*HC (n = 418,932), No. (%)*
Age, years, mean ± SEM	64.1 ± 0.05	65.5 ± 0.10	63.2 ± 0.02
BMI, kg/m^2, mean ± SEM	29.3 ± 0.03	29.4 ± 0.06	28.9 ± 0.01
Gender			
Male	64.2	44.1	55.7
Female	36.8	55.9	44.4
Race			
White	56.3	43.2	51.5
Black	26.1	41.4	29.2
Hispanic	11.5	10.1	14.1
Other	6.11	5.28	5.16
Insurance status			
None	4.02	4.32	8.49
Medicaid	9.35	11.5	12.1
Private	61.8	66.1	58.0
Medicare, Veterans Affairs	24.8	18.2	21.4
ESRD etiology			
Diabetes	48.3	51.2	45.1
Hypertension	29.4	30.0	28.7
Glomerulonephritis	7.86	5.33	5.65
Polycystic kidney disease	4.43	2.47	1.23
Other urologic	1.18	1.27	1.43
Other	6.25	7.09	13.8
Unknown	2.58	2.66	4.09
Comorbidities			
CHF	26.6	31.7	35.1
ASHD	22.3	22.4	21.8
CVD	8.99	12.0	9.79
PVD	13.4	15.8	14.5
Hypertension	89.1	87.6	84.2
Diabetes			
No	46.5	42.6	46.2
Diet controlled	5.26	5.64	4.93
Oral medication	13.3	13.3	11.9
Insulin dependent	34.9	38.5	37.0
COPD	7.47	8.22	9.94
Current smoker	5.95	5.88	6.43
Cancer	6.87	7.03	7.83
Alcohol dependence	0.89	0.99	1.91
Drug dependence	0.85	1.29	1.57
Inability to ambulate	3.02	6.44	8.27
Nephrologist care	95	85.2	55.9

ASHD, Atherosclerotic heart disease; *AVF,* arteriovenous fistula; *AVG,* arteriovenous graft; *BMI,* body mass index; *CHF,* congestive heart failure; *COPD,* chronic obstructive pulmonary disease; *CVD,* cerebrovascular disease; *ESRD,* end-stage renal disease; *HC,* hemodialysis catheter; *PVD,* peripheral vascular disease; *SEM,* standard error of the mean.

63.4 ± 0.02 years; 56.5% male; follow-up, 1.57 ± 1.36 years). Of these, hemodialysis was initiated with AVF in 14.0% (n = 71,316), AVG in 3.45% (n = 17,543), and HC in 82.5% (n = 418,932) (Table I). Overall mortality was 40.9% (n = 207,896). A complete summary of patient characteristics stratified by incident dialysis access type is provided in Table II.

Association between dialysis access method and mortality. As we previously demonstrated in this patient population (Malas et al, in press), initial dialysis access type was a significant predictor of mortality. On univariable analysis, mortality was significantly lower with AVF (HR, 0.63; 95% confidence interval [CI], 0.62-0.64) and AVG (HR, 0.83; 95% CI, 0.81-0.85) compared with HC ($P <$ .001). Multivariable analysis adjusting for age, gender, BMI, insurance status, comorbidities, etiology of ESRD, and nephrologist access similarly showed a significantly lower mortality risk with AVF (aHR, 0.65; 95% CI, 0.64-0.66) and AVG (aHR, 0.82; 95% CI, 0.80-0.84) compared with HC ($P <$ .001).

Association between age and mortality. Mean age at the time of dialysis initiation was lowest for patients with HC (63.2 ± 0.02 years), followed by AVF (64.1 ± 0.05 years) and AVG (65.5 ± 1.04 years) ($P <$ .001). Increasing age was a significant predictor of mortality on both univariable (HR, 1.04; 95% CI, 1.04-1.04) and multivariable (aHR, 1.03; 95% CI, 1.03-1.03) analysis adjusting for dialysis access type, gender, BMI, insurance status, comorbidities, etiology of ESRD, and nephrologist access (both, $P <$ .001).

Based on 10-year age categories, the mortality benefit with AVF was superior to that with both HC and AVG for all age groups ($P <$ .001; Fig 1), including among the elderly (≥75 years of age; aHR, 0.66; 95% CI,

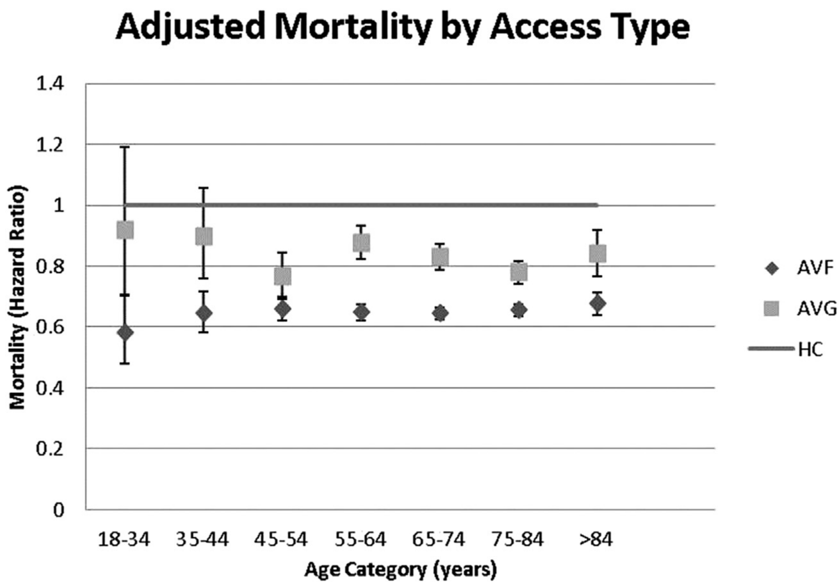

Fig 1. Risk-adjusted mortality based on age and first dialysis access type. Based on 10-year age categories, arteriovenous fistula (*AVF*) was superior to both hemodialysis catheter (*HC*) and arteriovenous graft (*AVG*) for all age groups, including among the elderly (all, $P < .001$). There was no significant mortality benefit with AVG vs HC for patients aged 18 to 44 years ($P > .18$). However, AVG was superior to HC for all age groups ≥45 years.

Table III. Risk-adjusted mortality hazard ratios (*HRs*) for arteriovenous fistula (*AVF*) and arteriovenous graft (*AVG*) vs hemodialysis catheter (*HC*) by 5-year age category

	Percentage mortality, No. (%)			*Adjusted mortality, HR (95% CI)*			
Age category	*AVF (32.4%) (n = 23,086)*	*AVG (43.1%) (n = 7558)*	*HC (48.1%) (n = 201,572)*	*AVF vs HC*	*P value*	*AVG vs HC*	*P value*
18-24 years	26 (6.8)	9 (11.5)	652 (11.6)	0.874 (0.560-1.36)	.552	0.852 (0.399-1.82)	.678
25-29 years	49 (8.1)	26 (21.0)	1053 (16.2)	0.504 (0.346-0.733)	<.001	0.962 (0.605-1.529)	.869
30-34 years	96 (8.9)	46 (18.9)	1712 (19.2)	0.534 (0.414-0.690)	<.001	0.881 (0.621-1.250)	.477
35-39 years	220 (12.3)	84 (22.1)	2731 (21.3)	0.747 (0.630-0.887)	<.001	0.874 (0.668-1.144)	.328
40-44 years	390 (14.0)	125 (22.8)	4628 (25.1)	0.596 (0.521-0.682)	<.001	0.906 (0.735-1.118)	.359
45-49 years	697 (15.9)	252 (27.2)	7810 (29.5)	0.615 (0.557-0.678)	<.001	0.875 (0.750-1.020)	.09
50-54 years	1215 (19.7)	356 (26.7)	12,302 (33.9)	0.687 (0.639-0.739)	<.001	0.693 (0.607-0.791)	<.001
55-59 years	1816 (22.9)	612 (32.6)	17,424 (38.5)	0.609 (0.572-0.647)	<.001	0.857 (0.778-0.994)	.002
60-64 years	2500 (27.1)	823 (37.5)	21,419 (43.3)	0.674 (0.640-0.710)	<.001	0.887 (0.815-0.965)	.005
65-69 years	3059 (32.6)	986 (42.0)	24,916 (50.6)	0.652 (0.622-0.683)	<.001	0.842 (0.780-0.908)	<.001
70-74 years	3525 (38.5)	1149 (50.0)	28,040 (58.0)	0.635 (0.607-0.663)	<.001	0.815 (0.759-0.875)	<.001
75-79 years	3938 (46.1)	1257 (54.4)	30,753 (65.5)	0.661 (0.635-0.689)	<.001	0.782 (0.731-0.836)	<.001
80-84 years	3431 (53.4)	1129 (61.9)	27,825 (71.7)	0.654 (0.625-0.684)	<.001	0.774 (0.719-0.832)	<.001
85-89 years	1778 (60.8)	560 (66.3)	15,905 (76.8)	0.681 (0.640-0.725)	<.001	0.811 (0.733-0.897)	<.001
>89 years	346 (67.6)	144 (77.4)	4437 (82.3)	0.684 (0.595-0.787)	<.001	1.045 (0.850-1.284)	.677

CI, Confidence interval.

0.65-0.68; $P < .001$). There was no significant mortality benefit with AVG vs HC for patients aged 18 to 34 years (aHR, 0.92; 95% CI, 0.71-1.19; $P = .52$) or 35 to 44 years (aHR, 0.90; 95% CI, 0.76-1.06; $P = .19$). However, AVG was superior to HC for all age groups ≥45 years ($P < .001$; Fig 1).

When age category was broken down further into 5-year groups, adjusted mortality was similar for patients 18 to 25 years regardless of initial dialysis access type (all, $P > .55$; Table III). There were also no significant differences comparing adjusted mortality with AVG vs HC for patients aged 25 to 44 years (aHR, 0.90; 95% CI, 0.78-1.04; $P = .14$) or for patients ≥89 years (aHR, 1.05; 95% CI, 0.85-1.28; $P = .67$). For patients aged 45 to 49 years, there was a trend toward benefit with AVG vs HC, but this was not statistically significantly (aHR, 0.88; 95% CI, 0.75-1.02; $P = .09$). AVF was superior to AVG and HC for all patients ≥25 years (aHR, 0.65; 95% CI, 0.64-0.66; $P < .001$).

Results of spline modeling. Based on the multivariable regression results, we performed spline modeling to estimate the age at which the relative mortality benefits of AVF and AVG changed compared with HC. Visual representation of the adjusted spline model suggested a change in benefit with different forms of dialysis access at ages 25, 48, and 89 years (Fig 2).

For HC, the slope of the spline graph for mortality was significantly higher for patients aged 18 to 25 years compared with older age groups (slope, 1.10; 95% CI, 1.07-1.14; $P < .001$). The slope of the line was relatively stable for patients aged >25 to 48 years (slope, 1.02; 95% CI, 1.02-1.02) and 49 to 89 years (slope, 1.03; 95% CI, 1.03-1.03), with a slight increase in patients >89 years (slope, 1.06; 95% CI, 1.04-1.07). These data suggest that mortality with HC was increasing most rapidly as a function of age among patients 18 to 25 years, followed by patients >89 years and then patients 49 to 89 years and patients 26 to 48 years.

For AVF, the slope of the spline graph was slightly less steep for patients aged 18 to 25 years compared with older ages (slope, 0.90; 95% CI, 0.80-1.01; $P = .07$), although this was not statistically significant. Regardless, the mortality benefit of AVF was consistently superior to that of AVG and HC for patients aged 18 to 48 years (overall aHR, 0.62; 95% CI, 0.58-0.67; $P < .001$) and >48 years (overall aHR, 0.65; 95% CI, 0.64-0.67; $P < .001$), including among patients >89 years (aHR, 0.69; 95% CI, 0.60-0.79; $P < .001$; Fig 3, *A*). These data suggest that the mortality benefit of AVF was consistently superior to that of AVG and HC for patients of all ages.

For AVG, the slope of the spline graph line demonstrated a significant decrease relative to HC at age >48 years compared with younger ages (slope, 0.98; 95% CI, 0.97-0.99; $P = .02$) and a significant increase relative to HC at age >89 years (slope, 1.07; 95% CI, 1.01-1.15; $P = .04$). Consistent with this pattern, there was a significant change in the relative mortality benefit of AVG vs HC at ages >48 years and >89 years (both, $P < .001$; Fig 3, *B*). There were no significant differences in comparing adjusted mortality with AVG vs HC for patients aged 18 to 25 years (aHR, 0.90; 95% CI, 0.81-1.01; $P = .07$) or 26 to 48 years (aHR, 0.90; 95% CI, 0.78-1.04; $P = .14$), but AVG was superior to HC for patients 49 to 89 years (aHR, 0.81; 95% CI, 0.79-0.84; $P < .001$). For patients >89 years of age, adjusted mortality was similar between AVG and HC (aHR, 1.05; 95% CI, 0.85-1.28; $P = .67$). These data suggest that the mortality benefits of AVG are restricted to patients aged 49 to 89 years.

DISCUSSION

Despite the overwhelming data and subsequent call for action to preferentially use AVF over AVG, with HC as a last resort,[1-8] the nuances of different forms of dialysis access within particular patient populations are not well described. Few prior studies have looked at the benefits of AVF vs AVG vs HC over a continuous range of patient ages. In general, most reports focus on the outcomes benefits of AVF and AVG within the adult population as a whole, adjusting for age as a potential confounding variable but never explicitly addressing the significance of how age affects mortality.[2-4,6,8,27] Other studies have attempted to address age-based differences in dialysis access mortality by evaluating patients in a binary division of "elderly" vs "younger," the former of which has varied anywhere from ≥67 years[4,21,22] to ≥70 years[21] to ≥80 years ("octogenarian")[23,24] to ≥90 years ("nonagenarian").[21,22]

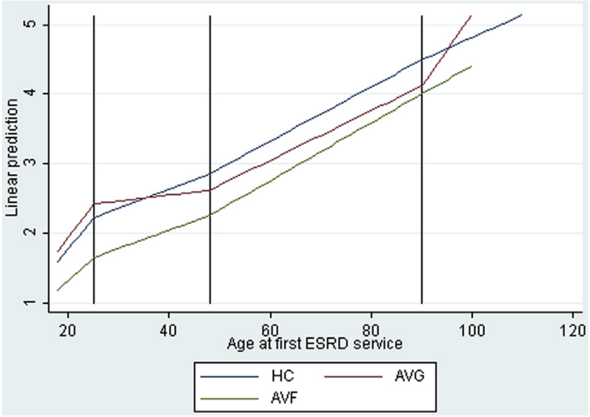

Fig 2. Adjusted spline model to determine age cutoffs where the relative benefits of arteriovenous fistula (*AVF*) vs arteriovenous graft (*AVG*) vs hemodialysis catheter (*HC*) changed. Visual representation of the adjusted spline model suggested a potential change in benefit with different forms of dialysis access at ages 25, 48, and 89 years. For HC, mortality was highest among patients 18 to 25 years. For AVG, there was a significant change in the relative mortality benefit vs HC at ages >48 years and >89 years (both, $P < .001$); there were no significant differences comparing adjusted mortality with AVG vs HC for patients aged 18 to 48 years or for patients >89 years ($P \geq .069$), but AVG was superior to HC for patients 49 to 89 years of age ($P < .001$). The mortality benefit of AVF was consistently superior to that of AVG and HC for patients of all ages (all, $P < .001$). *ESRD,* End-stage renal disease.

In the current study, we aimed to analyze the effects of age and initial dialysis access type on all-cause mortality over a broader age spectrum. We demonstrate that the previously reported mortality outcomes with permanent access compared with HC are age dependent. Specifically, among patients initiating dialysis access with AVG, there was a significant change in the relative mortality benefit vs HC at ages >48 years and >89 years. We observed no significant differences in comparing adjusted mortality with AVG vs HC for patients aged 18 to 48 years or for patients >89 years, but AVG was superior to HC for patients >48 to 89 years of age. Overall, these data suggest that the mortality benefits of AVG over HC are restricted to patients aged >48 to 89 years. This is the first study that we know of to demonstrate a changing benefit with AVG depending on the patient's age. In contrast, the mortality benefit of AVF was consistently superior to that of AVG and HC for patients of all ages. Use of HC in patients 18 to 25 years resulted in a higher rate of mortality compared with other age groups.

Our finding that the slope of the mortality hazard ratio line was highest in patients aged 18 to 25 years is in line with observations reporting that a consistent benefit with

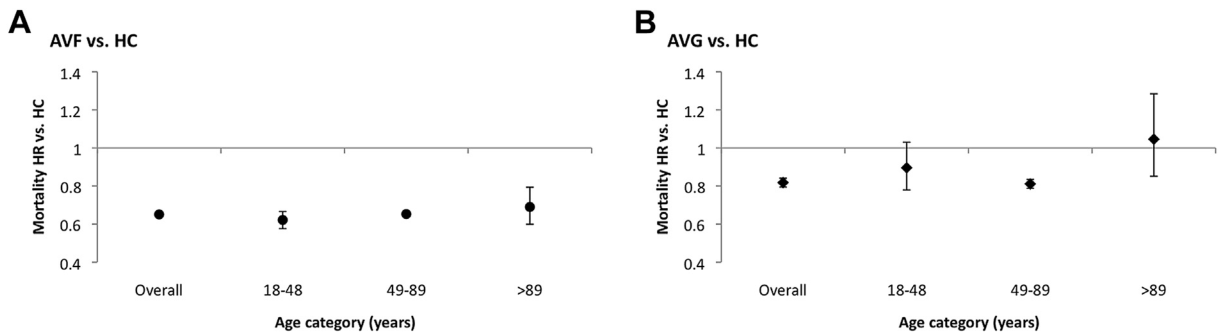

Fig 3. Mortality benefits of arteriovenous fistula (*AVF*) and arteriovenous graft (*AVG*) vs hemodialysis catheter (*HC*) for different age categories. **A,** The mortality benefit of AVF was consistently superior to that of HC for patients of all ages (all, $P < .001$). **B,** There were no significant differences comparing adjusted mortality with AVG vs HC for patients aged 18 to 48 years ($P \geq .07$) or for patients aged >89 years ($P = .67$), but mortality with AVG was superior to that with HC for patients aged 49 to 89 years ($P < .001$). *HR,* Hazard ratio.

AVF over HC for hemodialysis is even recognized in young populations.[16,28-30] Similar to findings in adults, AVFs have been shown to have significantly higher access survival rates and lower infection and access malfunction hospitalization rates than HC among patients <21 years of age.[29,31] There is some evidence in the pediatric population to suggest that both 1- and 5-year survival is similar with AVF (74% and 59%, respectively) and AVG (96% and 40%, respectively)[16] and significantly better than survival with HC (27%-62%).[17-20] These findings were consistent regardless of the patient's weight or age.[16]

In our study, we do not address the association between access type and mortality in patients younger than 18 years, but we do see a consistent benefit with AVF over both AVG and HC in all age groups based on spline modeling, including those at the younger (18-25 years) and older (>89 years) extremes of age. Contrary to the results reported in children, we did not observe a benefit of AVG over HC within the groups aged 18 to 25 years or 26 to 48 years. The relative number of patients in the younger age group was relatively small compared with the rest of the cohort. However, our study was much larger than previously published studies reporting outcomes in young adult or pediatric populations.[16,29,31] In addition, we are evaluating the association between initial dialysis access catheter type and mortality rather than longitudinal trends over time. Changes in vascular access type are common in the first 6 months after starting of dialysis,[8] probably because of the 4- to 6-week period—or up to 6-month period in younger and smaller patients—that is often required for AVF maturation as well as unrealized needs for prolonged dialysis access in patients listed for kidney transplantation.[28] It is also possible that the stenosis, infection, and thrombosis rates with AVGs are different in young adults compared with pediatric patients, making patients in the 18- to 48-year age group more susceptible to graft failure and thus a reduced benefit with AVG over HC. Additional analyses assessing the mortality benefit of AVF vs AVG vs HC that allow the incorporation of data describing access changes over time as well as analyses pertaining to cause of death (eg, renal-related, infection-related) would likely be beneficial in this population. Regardless, the apparent lack of benefit with AVG over HC in the younger population suggests that patients aged 18 to 25 years who are not candidates for AVF placement may be more appropriately served by receiving an expedited transplant rather than permanent dialysis access with a graft conduit. The potential policy implications of this approach as well as its appropriateness within the pediatric population (<18 years of age) remain to be determined.

Within the older population, the association between dialysis access type and all-cause mortality is less clear.[14] In 2013, DeSilva et al evaluated mortality based on initial dialysis access type placement in 115,425 patients ≥67 years and showed a significant detriment with HC (mortality HR, 1.77) but no differences in survival comparing AVG vs AVF (mortality HR, 1.05).[22] When the authors stratified the study cohort into smaller age groups, they demonstrated a significant benefit with AVF over both AVG and HC among patients aged 67 to 69 years, but outcomes with AVF and AVG were similar among patients 79 to 89 years and ≥90 years. Initial dialysis access with HC was associated with worse outcomes across all age groups. However, other studies have reported improved survival outcomes with AVF over AVG and HC in a range of elderly populations.[4,21,23,24,32] Xue et al reported mortality benefits of initiating dialysis with AVF over AVG and HC of 16% and 70%, respectively.[4] Similarly, in 2012, DeSilva et al reported mortality rates of 15.4%, 22.6%, and 36.8% among 82,202 patients initiating dialysis with AVF, AVG, and HC, respectively.[21] When stratified into age categories of 70 to 80 years, 81 to 90 years, and >90 years, AVF was consistently superior to HC for all groups, but the benefit of AVG over HC was lost among patients aged >90 years. This was in contrast to the above-mentioned 2013 DeSilva study showing no differences with AVG vs AVF in a patient cohort ≥67 years of age[22] but in direct support of the findings that we report in which the mortality benefits of AVG are restricted to patients 49 to 89 years of age. The variability of mortality with AVF vs AVG or HC reported in the elderly population may be indicative of the wide range of conditions that are likely to exist in an older cohort of patients and highlights the importance of individualized patient care, particularly in this age group.[14]

The limitations of the current study include its retrospective design and our use of an "incident dialysis access" analysis approach that does not account for changes in access methods over time. By excluding patients with mortality within 90 days of the start of dialysis, we aimed to minimize biases introduced by missing data or early death that is likely more attributable to the patient's condition than to access type. Vascular access types have been noted to change over time, especially within 6 months of initiation of dialysis,[8] but we chose to follow an intention-to-treat approach to address the effects of age on mortality outcomes based on initial dialysis access used. The reason for doing this was mainly to address previous assertions within the elderly population that older patients may appropriately receive HC for dialysis initiation, with the thought that they can transition to permanent access if they survive to that point rather than receive an unnecessary AVF that will never be used.[15] However, we note a significant benefit with AVF over both AVG and HC even among the octogenarian and nonagenarian age groups, and because we analyzed all patients with HC and maturing AVF or AVG as being in the HC group, we actually probably underestimated the relative mortality benefits with these approaches. In our previous work, we demonstrated a consistent mortality benefit with AVF and AVG even over that of patients with HC and maturing AVF (HR, 0.77; $P < .001$) and AVG (HR, 0.90; $P < .001$) (Malas et al, in press). Therefore, if we had stratified patients within the current HC group into HC only vs HC with maturing AVF vs HC with maturing AVG, the mortality benefits of AVF and AVG that we report would likely have been even higher. Finally, we evaluated all-cause mortality to remain consistent with prior age-related studies on dialysis access types.[4,21,23,24,32] Additional studies investigating renal-specific mortality and mortality during a longer time (ie, 5-year mortality) would be useful in delineating whether the age-related changes we observe are due to dialysis-specific differences or otherwise.[33]

CONCLUSIONS

In the current study, we demonstrate that age has a significant effect on all-cause mortality with different types of dialysis access. AVF was superior to AVG and HC for all age groups, including among the elderly. In contrast, the mortality benefits of AVG over HC appear to be restricted to patients aged 49 to 89 years. This is the first study that we know of to report a changing benefit with AVG vs HC depending on the patient's age. On the basis of these findings, we recommend an emphasis on the need for a consistent Fistula First approach in all patients, including those at the younger and older extremes of age. If autogenous access is not possible in younger (18-48 years) and older (>89 years) patients, AVG should not be considered superior to HC. Younger patients lacking an autogenous access should be considered for expedition on the transplant list. Although patient-level factors will ultimately determine the most appropriate form of dialysis access for each individual, quality improvement strategies including early nephrologist and surgery referral and use of preoperative duplex ultrasonography may help improve maturation rates that allow dialysis initiation with AVF and ultimately improve dialysis survival outcomes.

AUTHOR CONTRIBUTIONS

Conception and design: CH, JC, TR, JB, MM
Analysis and interpretation: CH, JC, IA, DZ, TR, JB, MM
Data collection: IC, IA, UQ
Writing the article: CH, JC, MM
Critical revision of the article: CH, JC, IA, DZ, UQ, TR, JB, MM
Final approval of the article: CH, JC, IA, DZ, UQ, TR, JB, MM
Statistical analysis: CH, JC, IA
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DISCUSSION

Dr Ronald L. Dalman (*Stanford, Calif*). How was it that you excluded the transition from catheter to fistula or graft? You said these were patients on chronic dialysis. Did you say it was more than 6 months, or how was it that you defined the fact that they weren't just starting dialysis and they were going to move on?

Dr Mahmoud B. Malas. Information on patient characteristics was obtained from the Centers for Medicare and Medicaid Services Form 2728. This form, completed by physicians and dialysis unit nurses, specifically excludes patients with acute renal failure. We excluded all patients who died within 3 months from dialysis initiation and all patients with prior access.

Dr Dalman. There is, however, some possibility that some of these patients are transitioning to another form of dialysis?

Dr Malas. Absolutely. However, we performed subgroup analysis for patients initiating dialysis with catheter while having maturing fistula or graft. Not surprisingly, they did better than patients who had a catheter only and worse than patients who already had a mature fistula or graft. This is likely a reflection of transitioning to permanent access at some point during the study period. The limitation of our study is the inability to determine when this transition occurred. Our intention-to-treat analysis likely underestimated the mortality associated with catheter since many of these patients eventually transitioned to permanent access.

Dr Ahmed Abou-Zamzam (*Loma Linda, Calif*). Is this really just a marker for better health care prior to dialysis? The people who have the fistulas have anticipatory health care that is identifying them early as potentially progressing to end-stage renal disease, so you're selecting out a well-cared-for population vs a population that didn't get prior health care.

Dr Malas. Health care, nephrology care, and insurance coverage were all independent predictors of establishing permanent access.

However, the surprising finding in this study was that many of the patients dialyzed through catheter did have proper insurance coverage and access to health care prior to dialysis. The survival benefit of autogenous access persisted after adjusting for age, gender, race, comorbidities, and insurance status. With the four different matching techniques we used in our analysis, we confirmed that over 90% of patients initiating hemodialysis with catheter match patients initiating hemodialysis with fistula or graft based on age, gender, race, comorbidities, and insurance coverage.

Dr Matthew Langenberg (*Willoughby, Ohio*). Do you, or the committee, have any thoughts or suggestions on ways we can engage our nephrology colleagues in hopes of more timely referrals?

Dr Malas. Propensity score analyses showed that nephrology care increases the patient's chance of getting a fistula by 11-fold. I believe there are several interventions we can do to achieve the Fistula First Breakthrough Initiative recommendations. First, we need to establish better communication with our colleagues in nephrology. Second, we need to better educate our patients and involve them in the decision making. The third component is our responsibility as surgeons to perform timely proper access type customized for each one of our patients.

Dr Ravi Veeraswamy (*Atlanta, Ga*). Just a quick question about the data. Is this placement of access or successful access? In other words, if they get a fistula and it doesn't mature and then they get a catheter and that's what they use for their first dialysis, how is that catheter.

Dr Malas. For this analysis, we excluded all patients with any prior access types including the nonsuccessful ones. Every patient included in this study is having initial dialysis for chronic renal failure through his or her first catheter, graft, or fistula.