Vascular access survival and incidence of revisions: A comparison of prosthetic grafts, simple autogenous fistulas, and venous transposition fistulas from the United States Renal Data System Dialysis Morbidity and Mortality Study

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Objective: **The study's aim was to evaluate access patency and incidence of revisions in patients initiating hemodialysis and to determine differences in access performance by type of access among patient subgroups.**
Methods: **The study used data from the United States Renal Data System Dialysis Morbidity and Mortality Study Wave 2, which contained a random sample of dialysis patients initiating dialysis in 1996 and early 1997. Failures and revisions were evaluated among 2247 newly placed hemodialysis accesses by using Cox proportional hazards regression model and Poisson regression. Primary and secondary patency rates were estimated using the Kaplan-Meier method.**
Results: **Fifteen hundred seventy-four prosthetic grafts, 492 simple autogenous fistulas, and 181 venous transposition fistulas were available for evaluation. Prosthetic grafts had a 41% greater risk of primary failure compared with simple fistulas (relative risk, 1.41; 95% CI, 1.22-1.64; $P < .001$) and a 91% higher incidence of revision (relative risk, 1.91; 95% CI, 1.60-2.28; $P < .001$). At 2 years, autogenous fistulas demonstrated superior primary patency (39.8% versus 24.6%, $P < .001$) and equivalent secondary patency (64.3% versus 59.5%, $P = .24$) compared with prosthetic grafts. When compared with simple fistulas, vein transpositions demonstrated equivalent secondary patency at 2 years (61.5% versus 64.3%, $P = .43$) but inferior primary patency (27.7% versus 39.8%, $P = .008$) and had a 32% increased incidence of revision ($P = .04$). Autogenous fistulas had superior primary patency compared with prosthetic grafts in all patient subgroups except for patients with previously failed access. Vein transpositions showed the greatest benefit in terms of patency and incidence of revision in women and in patients with previously failed access.**
Conclusions: **The preferential placement of autogenous fistulas may increase primary patency and decrease the incidence of revisions. Vein transpositions had similar secondary patency compared with simple fistulas, but required more revisions. The greatest benefit of a vein transposition fistula was seen in women and in patients with a history of access failure. (J Vasc Surg 2001;34:694-700.)**

The number of patients dependent on hemodialysis has steadily increased, with an estimated 250,000 persons in the United States currently requiring chronic hemodialysis.[1] Care of patients with end-stage renal disease has considerable economic impact, with the estimated total cost in the United States exceeding 1 billion dollars. Up to 17% of total spending for hemodialysis per patient per year is associated with hemodialysis access–related morbidity.[1,2] Repeated interventions to maintain access patency exact an economic toll, and the physical and emotional tolls are equally burdensome.

There is agreement that the ideal hemodialysis access should be durable, have minimal risk of infection, and require few interventions to maintain patency, but there is significant controversy regarding which type of access should ultimately be placed. Studies comparing long-term and short-term performance of the two most common types of hemodialysis access, autogenous arteriovenous fistulas (AVFs) and prosthetic bridge grafts, have conflicting results. A substantial number of studies have shown that AVFs demonstrate superior overall patency and revision rates compared with prosthetic access.[2-5] Some investigators, however, have found that the early failure of autogenous AVFs results in overall patency equivalent to prosthetic grafts. The superior performance of autologous access is not seen in all subgroups, particularly in elderly

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and diabetic patients.[6-8] Vein transpositions represent an alternative method of autogenous access creation.[9] Several investigators have shown that vein transpositions are a reliable access alternative for hemodialysis, with patency rates comparable with those of historical simple AVFs.[10,11] However, there are few data regarding which patients are most likely to benefit from creation of a venous transposition fistula.

Less than 30% of the accesses placed in the United States are autogenous fistulas. Evidence supporting the use of autogenous rather than prosthetic conduit has lead many researchers to advocate strategies to reverse the trend toward increased use of synthetic hemodialysis access.[2,12,13] Recommendations published by the National Kidney Foundation Dialysis Outcome and Quality Initiative (DOQI) in 1997 included goals that a minimum of 50% of new accesses placed be autogenous fistulas and that patients with failed access be reevaluated for construction of an autogenous access.[14] However, it is not clear whether simple fistulas, vein transposition fistulas, and prosthetic hemodialysis accesses perform similarly among all subgroups of patients. We used data from the United States Renal Data System to identify factors that influence access patency and incidence of access revision and to determine if there are identifiable groups of patients in whom the placement of autogenous conduits is particularly advantageous.

METHODS

Patient population and data collection. The study used the database from the United States Renal Data System Dialysis Morbidity and Mortality Study Wave 2,[15] a true prospective study that contains a random sample of 4065 incident-hemodialysis and peritoneal-dialysis patients initiating dialysis in 1996 or early 1997 at 799 dialysis facilities. For the purposes of this study, peritoneal-dialysis patients (n = 2168) and patients in whom follow-up data were not available (n = 314) were excluded, leaving 1583 hemodialysis patients and 2247 hemodialysis accesses available for analysis. Follow-up time ranged from 1 day to 3 years, with a mean follow-up time of 340 days.

Variables we abstracted included patient sex, age, race (African American, white, other), smoking history (never, previous, current), history of diabetes, access type (prosthetic graft, simple AVF, or venous transposition AVF), and history of previous access. Longitudinal follow-up on access failure or revision was determined via the Wave 2 database until completion of the study (9-12 months). Access survival after the completion of Wave 2 was determined by identifying procedural codes for vascular access failure and revision in the Medicare Part B claims records that are part of the US Renal Data System database. Procedures of interest were identified using current procedural terminology codes and were deemed reliable only if the Medicare Part B claims records listed a monetary reimbursement for the filing physician. Until January 2000, no specific current procedural terminology codes for autogenous vein transposition existed. The code used for abstracting vein transpositions in this database was for "creation of arteriovenous fistula by other than direct arteriovenous anastomosis, autogenous graft".

Table I. Patient characteristics

Characteristic	*n*
Demographics	
Mean age (y) (± SD)	66.0 (± 15)
Male	1182 (52.6%)
African American	762 (33.9%)
Comorbidities	
Presence of diabetes	1211 (53.9%)
Smoking history	
Nonsmoker	1258 (56.0%)
Former smoker	683 (30.4%)
Current smoker	306 (13.6%)
Operative details	
First access	1566 (69.7%)
Type of access	
Prosthetic graft	1574 (70.0%)
Simple autogenous fistula	492 (21.9%)
Venous transposition fistula	181 (8.1%)

Analysis. Time to primary access patency was defined as the length of time between access placement and either permanent failure or first revision requiring a procedure to restore or maintain patency. An access revision was considered to have occurred when the access failed or when a code identifying thrombectomy, thrombolysis, angioplasty, or major revision was found. Time to secondary access patency was defined as the length of time between access placement and permanent failure of the access. Access failure was considered to have occurred when a new vascular access was created or when a venous hemodialysis catheter was inserted. Accesses were censored if the patient died or had a transplant with a patent access, reached the end of the study with a patent access (December 31, 1997), stopped dialysis, or was lost to follow-up.

Primary and secondary graft patency rates were analyzed by using the Kaplan-Meier method with log-rank testing to compare patency between groups. Univariate and multivariate analyses of factors associated with primary and secondary access failure were performed by using Cox proportional hazards models. Poisson regression was used to analyze the total number of revisions per access. Adjustment variables were included in the multivariate models if it was a priori believed that they might confound the relationship between access type and outcome or if they were found to be associated with outcome alone via exploratory data analyses. Because of the clustered nature of the data (multiple accesses per person), robust standard errors were used when forming confidence intervals and obtaining *P* values.

To ascertain whether access types performed similarly in different subgroups of patients, an analysis was performed comparing patency and incidence rate of revision between prosthetic grafts and simple AVFs, venous transpositions and simple AVFs, and venous transpositions and

Table II. Multivariate analysis of factors associated with risk of primary access failure and incidence rate of access revision*

	Primary patency		*Access revision*	
Covariate	*aRR (95% CI)*	P *value*	*aIRR (95% CI)*	P *value*
Age (10 y)	1.01 (0.97-1.05)	.616	1.01 (0.96-1.06)	.671
Sex (female vs male)	1.18 (1.05-1.32)	.004	1.02 (0.89-1.16)	.827
Race (African American vs non–African American)	1.14 (1.01-1.28)	.032	1.14 (1.00-1.31)	.057
Previous accesses placed (yes vs no)	1.81 (1.60-2.05)	<.001	1.83 (1.60-2.10)	<.001
Diabetes (yes vs no)	1.10 (0.98-1.23)	.112	1.10 (0.96-1.25)	.167
Access type		<.001		<.001
Simple autogenous fistula	1.0		1.0	
Venous transposition fistula	1.13 (0.89-1.44)	.326	1.32 (1.01-1.72)	.041
Graft	1.41 (1.22-1.64)	<.001	1.91 (1.60-2.28)	<.001

*Adjusted for age, sex, race, previous access placement, diabetes, and access type.
aRR, Adjusted relative risk; *aIRR*, adjusted incident rate ratio.

prosthetic grafts among distinct patient subgroups. These subgroups included age (>66 years old versus <66 years old, the median population age), sex, race (African American versus non–African American), history of diabetes, and history of access failure. Statistical analysis was performed using SPSS (SPSS Inc, Chicago, Ill), STATA (StataCorp, College Station, Tex), and S Plus (MathSoft, Seattle, Wash).

RESULTS

Population characteristics. Table I displays characteristics of the study population. During the study period, 2247 hemodialysis accesses were placed. These accesses consisted of 1574 prosthetic grafts (70%), 492 simple AVFs (21.9%), and 181 venous transpositions (8.1%).

Primary patency. At 1 and 2 years, primary patency rates for simple AVFs were 56.1% and 39.8%, compared with 38.2% and 24.6% for synthetic grafts ($P < .001$). When compared with simple fistulas, venous transpositions demonstrated inferior primary patency with rates of 43.5% at 1 year and 27.7% at 2 years ($P = .008$).

Factors that were associated with primary access failure are shown in Table II. After adjustment for age, race, history of previous access placement, diabetes, and access type, it was estimated that the risk of primary access failure was 18% greater in women than in men (relative risk [RR], 1.18; 95% CI, 1.05-1.32; $P = .004$). African Americans had an estimated 14% increase in the risk of primary access failure when compared with non–African Americans (RR, 1.14; 95% CI, 1.01-1.28; $P = .032$). A history of access failure was associated with an 81% increase in risk of primary access failure (RR, 1.81; CI, 1.60-2.05; $P < .001$). The relationship between diabetes and risk of primary access failure was marginally significant ($P = .11$). Diabetic patients were estimated to have a 10% increase in risk of primary access failure (RR, 1.10; 95% CI, 0.98-1.23). Age was not found to be significantly associated with primary access failure. The risk of primary access failure associated with venous transposition fistulas was not found to be significantly different from that of simple AVFs (RR, 1.13; 95% CI, 0.89-1.44; $P = .33$); however, prosthetic grafts were associated with a 41% increase in risk of primary failure compared with simple AVFs (RR, 1.41; 95% CI, 1.22-1.64; $P < .001$).

Secondary patency. At 1 and 2 years, secondary patency rates for simple AVFs were 73.2% and 64.2%, compared with 71.8% and 59.5% for synthetic grafts, showing no statistical difference ($P = .24$). Likewise, venous transpositions demonstrated similar secondary patency compared with simple AVFs, with secondary patency rates of 67.9% at 1 year and 59.5% at 2 years ($P = .43$).

Table III displays the RR of secondary access failure associated with sex, race, previous access placement, diabetes, and access type. After adjustment for these covariates, the association between race and access failure was marginally significant ($P = .084$). African American patients were 14% more likely to have permanent access failure than non–African American patients (RR, 1.14; 95% CI, 0.98-1.31). Patients with a history of failed access had 2.56 times the risk of failure compared with patients with a first access (RR, 2.56; 95% CI, 2.15-3.04; $P < .001$). Sex and diabetes were not associated with an increased risk of secondary access failure. The relationship between access type and the risk of access failure was not constant across age ($P < .001$ for the age-access type interaction). The risk of secondary access failure comparing venous transposition fistulas with simple AVFs decreased with increasing age. In patients younger than 60 years, the risk of secondary access failure was estimated to be greater with venous transposition fistulas than with simple AVFs. In contrast, simple AVFs were associated with an increased risk of access failure when compared with venous transposition fistulas in patients older than 60 years. Similarly, a comparison of prosthetic grafts with simple AVFs revealed that as patient age increased, the RR of secondary prosthetic access failure decreased.

Revisions. A total of 2582 access revisions occurred in the study period. There were no differences in incidence of revision between sexes, history of diabetes, or by age (Table II). African American patients had a greater incidence of revision of 14% compared with non–African American patients (incidence rate ratio [IRR], 1.14; 95%

Table III. Multivariate analysis of factors associated with risk of secondary access failure

Covariate	*aRR (95% CI)**	P *value*
Sex (female vs male)	1.08 (0.94-1.24)	.298
Race (African American vs non–African American)	1.14 (0.98-1.31)	.084
Previous accesses placed (yes vs no)	2.56 (2.15-3.04)	<.001
Diabetes (yes vs no)	1.11 (0.97-1.28)	.134
Access type†		
Patient age, 30 y		
Simple autogenous fistula	1.0	
Venous transposition fistula	2.68 (1.41-5.12)	.003
Graft	1.32 (0.85-2.03)	.216
Patient age, 40 y		
Simple autogenous fistula	1.0	
Venous transposition fistula	1.90 (1.16-3.11)	.011
Graft	1.18 (0.85-1.64)	.318
Patient age, 50 y		
Simple autogenous fistula	1.0	
Venous transposition fistula	1.34 (0.92-1.95)	.123
Graft	1.06 (0.84-1.35)	.621
Patient age, 60 y		
Simple autogenous fistula	1.0	
Venous transposition fistula	0.95 (0.69-1.31)	.746
Graft	0.95 (0.79-1.16)	.633
Patient age, 70 y		
Simple autogenous fistula	1.0	
Venous transposition fistula	0.67 (0.46-0.97)	.035
Graft	0.86 (0.69-1.07)	.165

*Referent group is simple AVF. RRs are adjusted for age, sex, race, previous access placement, diabetes, and access type.
†Interaction between age and access type significant at $P < .001$.
aRR, Adjusted relative risk.

CI, 1.00-1.31; $P = .057$) The rate of revision in patients with previous access failure was estimated to be 83% higher than in patients with a first access (IRR, 1.83; 95% CI, 1.60-2.10; $P < .001$). Compared with simple AVFs, vein transposition fistulas had a 32% higher incidence of revisions (IRR, 1.32; 95% CI, 1.01-1.72; $P = .04$), whereas prosthetic grafts had a 91% higher incidence of revision (IRR, 1.91; 95% CI, 1.60-2.28; $P < .001$).

Subgroup analysis. The results of a subgroup analysis are presented in Figs 1, 2, and 3.

Fig 1, *A* graphically depicts the performance of prosthetic grafts compared with simple AVFs with respect to primary patency across subgroups defined by age, sex, race, previous access placement, and diabetes. Simple AVFs outperformed grafts in every subgroup. In patients without diabetes, the risk of primary failure was 68% higher in prosthetic grafts compared with simple AVFs (RR, 1.68; 95% CI, 1.40-2.10), whereas in patients with diabetes, this increase in risk of failure was only 19% (RR, 1.19; 95% CI, 1.00-1.40). The RR associated with primary access failure was similar when comparing all other patient subgroups.

Fig 1, *B* displays a comparison of grafts with simple fistulas with respect to access revision. Simple AVFs outperformed prosthetic grafts in every subgroup. In men, grafts were associated with a 2.24-fold increase in the rate of access revision (IRR, 2.24; 95% CI, 1.8-2.8), whereas in women this increase in risk was estimated to be 1.45-fold (IRR, 1.45; 95% CI, 1.1-1.9). The rate of revision associated with prosthetic grafts in nondiabetic patients was estimated to be 2.55-fold greater than the rate of revision associated with simple AVFs (IRR, 2.55; 95% CI, 1.9-3.3). In diabetic patients, the rate of revision associated with prosthetic grafts was 49% higher than the rate associated with the simple AVFs (IRR, 1.49; 95% CI, 1.2-1.9).

Subgroup analysis results comparing venous transposition fistulas with simple AVFs with respect to the risk of primary access failure and the rate of access revision are displayed in Figures 2, *A* and 2, *B*, respectively. In patients with a first access, the risk of primary failure was estimated to be 1.55 when comparing venous transposition fistulas with simple AVFs (RR, 1.55; 95% CI, 1.2-2.1), whereas in patients with a past access failure, venous transpositions outperformed simple fistulas (RR, 0.71; 95% CI, 0.5-1.1). There were no other significant differences when comparing the performance of venous transpositions with that of simple AVFs with respect to primary access failure among subgroups. The largest differences in the impact of access type on the rate of access revision were seen between sexes and in patients with and without history of access. The rate of revision associated with venous transpositions in male patients was estimated to be 72% greater than the rate of revision associated with simple AVFs (IRR, 1.72; 95% CI, 1.2-2.5). In women, the rate of revision associated with grafts was estimated to be 15% lower than the rate associated with simple AVFs (IRR, 0.85; 95% CI, 0.6-

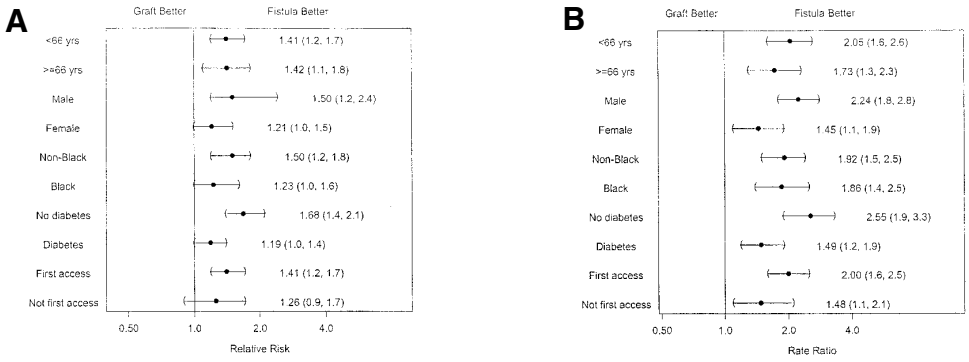

Fig 1. Subgroup estimates comparing prosthetic grafts with simple fistulas regarding **(A)** the risk of primary access failure and **(B)** the rate of access revision.

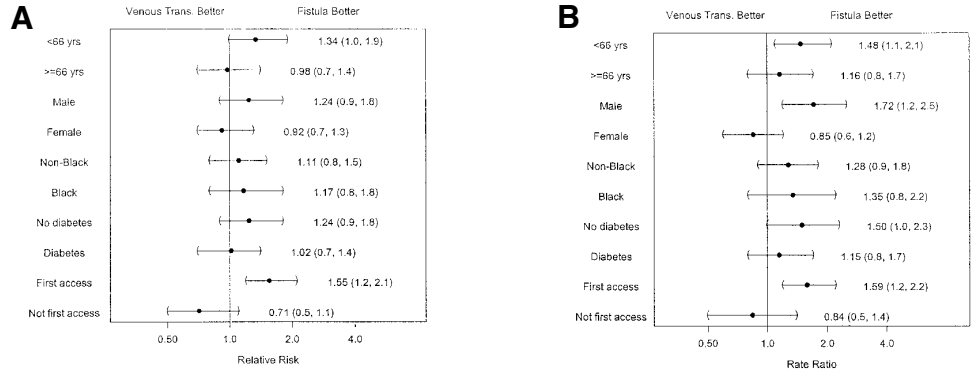

Fig 2. Subgroup estimates comparing venous transposition fistulas with simple fistulas regarding **(A)** the risk of primary access failure and **(B)** the rate of access revision.

1.2). In patients without previous access placement, the rate of revision associated with venous transposition fistulas was 59% greater than the rate of revision of simple AVFs (IRR, 1.59; 95% CI, 1.2-2.2). Conversely, in patients with a history of access placement, venous transposition fistulas decreased the rate of access revision by 16% when compared with simple AVFs (IRR, 0.84; 95% CI, 0.5-1.4).

DISCUSSION

Our data demonstrate that in the study population overall, the performance of simple AVFs was superior to those of prosthetic grafts and vein transpositions. Primary patency was superior in simple AVFs at 1 and 2 years, and the RR of failure was lowest with simple AVFs in multivariate regression analysis. We saw no difference in secondary patency between simple AVFs, prosthetic grafts, and vein transpositions in our Kaplan-Meier survival analysis. Multivariate regression adjusting for sex, age, race, diabetes status, and access history demonstrates that the risk of permanent access failure of each type of access varies with the patient's age. Younger patients showed the greatest benefit of simple AVFs, whereas in patients older than 70 years, venous transpositions actually had the best secondary patency. An additional benefit of simple AVFs was a decreased incidence rate of revision to maintain access patency compared with simple fistulas to prosthetic grafts and vein transpositions. The percentage of autogenous access placed (30%) was significantly lower than recommended by DOQI guidelines; however, we found that autogenous access was beneficial only in certain patient subgroups. The differential performance of autogenous access in patients with different risk factors for failure may make achievement of DOQI goals difficult in some patient populations.

Our data demonstrate that vein transpositions only show superior performance in select populations. The performance of vein transpositions in this population was poorer than that reported in other series.[6,11,12,16] There are several possible reasons for our differing results. The previous studies were smaller, conducted on select populations, and did not compare prosthetic grafts, vein transpositions, and simple AVFs in a single study population, resulting in difficulties generalizing previous results to the general population of dialysis patients. It is also possible that some vein transposition fistulas may have been mis-

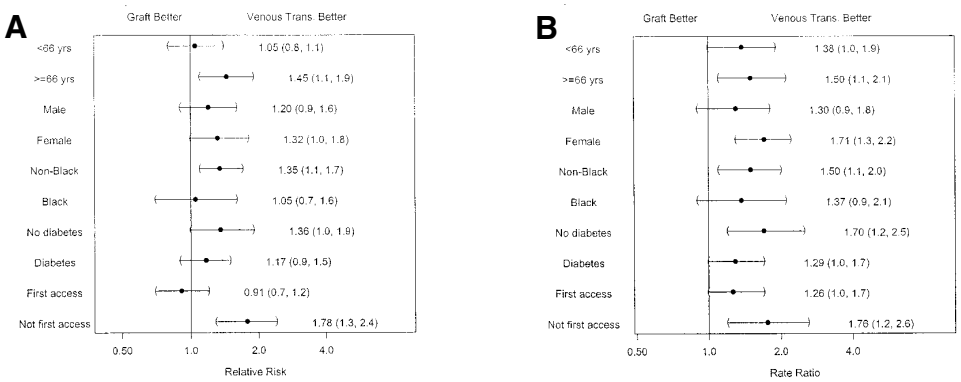

Fig 3. Subgroup estimates comparing prosthetic grafts with venous transposition fistulas regarding **(A)** the risk of primary access failure and **(B)** the rate of access revision.

coded in the USRDS database. Finally, vein transposition fistulas were more likely to be placed in patients with a history of access (10.1% versus 7.2%; $P = .02$), suggesting that transposition fistulas are placed in patients already at higher risk of access dysfunction.

Although in 1997 51% of the incident chronic hemodialysis population were older than 65 years, placement of autogenous fistulas in older patients is controversial. Most investigators have found that autogenous fistulas have poorer patency rates in older patients.[6] Our data demonstrate that patient age had no effect on primary patency or incidence of access revision. In our subanalysis, both simple AVFs and vein transpositions had superior primary patency and decreased incidence of revisions than did prosthetic grafts in patients older than 66 years. Vein transpositions and simple AVFs had equivalent primary patency and incidence of revisions in this group. Because most vein transpositions are constructed in the upper arm, these data agree with a recent paper by Berardinelli and Vegeto,[16] who suggest that upper-arm fistulas may be the access of choice in older patients. In contrast, patients in our younger age group had superior primary patency with simple AVFs and a decreased incidence of access revision with simple AVFs and vein transpositions compared with prosthetic grafts. Clearly, autogenous access should be used preferentially in younger patients with end-stage renal disease.

Little is known about the ideal access type in women. Investigators have found that patency of autogenous access in women is inferior to that in men[18] and that female sex is an independent risk factor for access-related hospitalization.[19] In our population, women were significantly less likely to have an autogenous access than were men. Overall, the women in our population had inferior primary access patency but equivalent secondary patency and incidence of revision when compared with men. In both sexes, simple AVFs had superior primary patency and decreased incidence of revision compared with vein transpositions and prosthetic grafts. However, in women, vein transpositions were clearly superior to prosthetic grafts and equivalent to simple AVFs in terms of primary patency and incidence of revisions.

Non–African Americans had significantly better primary patency and fewer revisions than did African American patients across all access types, consistent with data from other authors showing that African American patients have a higher rate of hospitalization for access-related morbidity.[19] African Americans in our study were significantly less likely to have an autogenous access compared with non–African Americans. The reason for the poor outcome of hemodialysis access in the African American population is not readily apparent, but could possibly be related to an increased percentage of prosthetic access, differences in access to health care, or differences in vascular biology such as the development of intimal hyperplasia.

Fully 30% of the patients required a second access to be placed during the relatively short study period. Previous access failure imparted a 1.8-fold increase in risk of primary access failure, a 2.6-fold risk of secondary access failure, and a 1.8-fold increase in incidence of access revision. Interestingly, patients with a history of access failure demonstrated no difference in primary patency when comparing simple AVFs and prosthetic grafts, but vein transpositions had clearly superior primary patency and decreased incidence of access revision compared with prosthetic grafts and simple AVFs. The reason for the advantage of vein transposition fistulas in this population is not inherently obvious, but patients with previously failed access may have already used their forearm veins or had poor forearm veins to begin with and, as such, be poor candidates for a second access using forearm veins or the upper arm cephalic vein. The basilic vein, often used in venous transpositions, is deep and less often used for intravenous access or for hemodialysis access. The basilic vein is of adequate quality and caliber for access creation in 95% of patients.[5] It may, therefore, represent the ideal access conduit in patients in whom simple AVFs or prosthetic grafts have failed.

This study had several limitations. The retrospective nature may limit the applicability of some of our conclu-

sions; however, our data are in agreement with those of numerous other studies in finding that autogenous fistulas demonstrate superior patency as compared with prosthetic grafts. Another limitation of this study is the short follow-up time. This diminishes the validity of our findings for secondary access patency. Although there are several limitations, this is the first large population-based study to identify factors associated with patency and revisions among hemodialysis access types—prosthetic grafts, simple autogenous fistulas, and venous transpositions. In addition, as a population-based study, the results are generalizable to the dialysis population as a whole and are not a reflection of unit-specific or surgeon-specific practices.

CONCLUSIONS

Although our data would suggest that simple autogenous fistulas are the access of choice when evaluating our population as a whole, these results are not generalizable to all patient groups. Sex, race, access history, and age may all have an impact on access survival and may also influence the availability of usable veins for the creation of autogenous access. Men, non–African Americans, and patients with a first access appreciated the greatest benefit from simple autogenous fistulas. Vein transposition fistulas had the greatest advantage in elderly patients, in women, and particularly in patients with a history of failed access. The ideal access for a patient must be individualized according to which access type would be most durable and require the least number of revisions.

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