Hemodialysis Vascular Access Survival: Upper-Arm Native Arteriovenous Fistula

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• Achieving Dialysis Outcomes Quality Initiative guidelines for native arteriovenous fistulae using the radiocephalic forearm fistula (lower-arm fistula [LAF]) is difficult. This study reports results using the upper-arm native arteriovenous fistula (UAF). From a prospective access database (1992 to 1998), this study was based on 204 patients (322 accesses). Average patient age was 56 ± 1 years, 63% were men, and 47% had diabetes. A native fistula was the first access in 73% of patients (36%, LAFs; 37%, UAFs) and accounted for 48% of subsequent accesses (13%, LAFs; 35%, UAFs). Younger men were more likely to receive an LAF, but there was no demographic difference between patients receiving a UAF or arteriovenous graft (AVG). Both primary unassisted and cumulative access patencies were significantly better for UAFs than either LAFs or AVGs. For first accesses, cumulative access patency rates at 1, 3, and 5 years were 71%, 57%, and 57% for UAFs; 54%, 46%, and 36% for LAFs; and 54%, 28%, and 0% for AVGs ($P < 0.01$). Despite shorter access survival, AVGs required more total access procedures than either UAFs or LAFs (procedures per access: 2.5, 1.0, and 0.6 for AVGs, UAFs, and LAFs, respectively). When used, catheters were required for dialysis for a longer time for UAFs (median catheter days, 36, 53, and 56 for AVGs, LAFs, and UAFs, respectively; $P < 0.05$). Access flow rates were greater in UAFs (1,247 mL/min; n = 48; $P < 0.01$) than AVGs (851 mL/min; n = 30) or LAFs (938 mL/min; n = 31). There was no evidence that UAFs were banded or ligated for steal syndromes or heart failure more often than AVGs or LAFs. These results show that the UAF is a good alternative to an AVG for achieving Dialysis Outcomes Quality Initiative guidelines.

INDEX WORDS: Surgical arteriovenous shunt; hemodialysis (HD); brachiocephalic fistula; access potency; access complications.

VASCULAR ACCESS failure is a major problem in providing care to patients on hemodialysis therapy.[1] A recent report analyzing US Renal Data System (USRDS) data found an overall primary unassisted access patency rate of only 53% at 1 year.[1] For prosthetic arteriovenous grafts (AVGs), the 1-year primary unassisted patency rate was only 49% compared with 62% for native arteriovenous fistulae.[1] Many recent studies have confirmed the improved patency rate for native arteriovenous fistulae compared with prosthetic grafts.[1-6] Despite this improved outcome for native arteriovenous fistulae, the trend in the United States has been to place more prosthetic AVGs.[7,8] By the most recent estimates, prosthetic grafts account for 65% of accesses used in the United States.[8,9] By comparison, prosthetic grafts are created in less than 35% of hemodialysis patients in Canada and only 10% of patients in Europe.[6,8,9]

Clinical practice guidelines for vascular accesses were recently established by the National Kidney Foundation-Dialysis Outcomes Quality Initiative.[10] These guidelines encouraged the placement of at least 50% native arteriovenous fistulae. The forearm radiocephalic fistula is considered the optimal first choice for a native fistula.[10] Once established, it has the advantage of good long-term survival, a low complication rate, and preservation of more proximal sites in the arm for future accesses.[10] However, the radiocephalic fistula has the disadvantage that it is more difficult to create and often fails to mature in older patients, women, and those with significant underlying vascular disease, particularly diabetics.[11-15] The upper-arm native arteriovenous fistula (UAF) offers an alternative surgical option for creating a native arteriovenous access in these difficult patients.[2,15-20] However, less information is available on the long-term survival of

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this type of access, and there is concern regarding the potential for high-output failure and distal steal syndromes, making it is unclear how this access should fit into clinical practice guidelines.[10,11,15,16,18,21]

Since 1991, our dialysis program has kept a prospective database of all access-related procedures performed at our institution. Our program has a surgical emphasis on placing native fistulae and particularly has emphasized the use of the UAF for the last 5 years. The purpose of this study is to analyze our database and compare long-term survival, complications, and safety of the UAF compared with forearm fistulae and prosthetic grafts.

METHODS

Study Setting

The setting is a single-center university-based teaching hospital. Six staff surgeons accounted for 80% of all vascular access placements. Twenty-three accesses (7%) were placed outside the university setting before transferring care to our hemodialysis unit. The study population included all patients seen at the university hospital who required access placement for hemodialysis.

Vascular Access Database

Starting in 1991, a prospective database of all vascular access–related procedures performed at the university hospital was established and maintained by dialysis unit staff. Database entries were made for every new vascular access placement, including catheters. Every subsequent revision or procedure performed also was recorded. When an access could no longer be used for dialysis, the date, as well as the reason for discontinuation, was recorded. Patient status and dates of important events also were recorded in the database, including whether the patient received a transplant, was transferred to another unit, died, or withdrew from dialysis for another reason.

Decisions on Vascular Access Management

Selection of the location and type of access to be constructed was at the discretion of the attending surgeon. Preoperative Doppler mapping was routinely performed to assess venous anatomy before access creation. The preferred forearm native fistula (LAF) was the radiocephalic fistula. Surgical preference for the UAF was the end-to-side brachiocephalic fistula (93% of UAF). The most common configuration for a prosthetic graft (AVG) was the polytetrafluoroethylene forearm loop. Starting in January 1999, detection of access dysfunction was based on direct measurement of access flow rates (Transonic Hemodialysis Monitor; Transonic Systems Inc, Ithaca, NY). Because this might influence the primary outcome variable, access patency, the present analysis was limited to the period before January 1, 1999.

Data Coding and Outcome Measures

All vascular accesses created in the upper extremity and followed up at our dialysis unit between January 1, 1992, and January 1, 1999, were used for the present analysis. Hospital billing records were used to cross-check the vascular access database for accuracy and completeness. Ten patients in the database had their first access placed before January 1, 1992, and were excluded. This left 204 patients who received 322 accesses (64% native fistulae) and were followed up at our center. Hospital charts of all 204 patients were reviewed to confirm the accuracy, uniformity, and completeness of the database for these subjects.

Any access attempt was recorded as a procedure. Primary unassisted patency was defined as the time from access creation to the first access failure, manifested by access thrombosis or the need for an access-related procedure (surgical revision, angioplasty, or thrombolysis). Cumulative (assisted) patency was defined as the total time from access creation to the time that the access could not be used for dialysis, regardless of the number of procedures required to maintain access patency. Primary access failure (failure to mature) was defined as an access that failed before starting dialysis therapy, or if the patient started on dialysis therapy, had a catheter in place for dialysis for all but 7 days of the cumulative life of the access. For accesses that failed to mature before being used for dialysis, access failure was defined by the earliest occurrence of either loss of a palpable thrill on follow-up examinations or need to place a different access for dialysis. All catheter placements and catheter survival days were recorded. Catheter days were attributed to an access only for the time that they both overlapped. To determine comorbid conditions that might be associated with access survival, we used hospital computer records based on *International Classification of Diseases, Ninth Revision* codes for patient diagnoses, including diabetes, hypertension, peripheral vascular and carotid disease combined, coronary disease, hyperlipidemia, and tobacco use.

Access Flow Measurements

Flow measurements were performed monthly by a saline-infusion ultrasound dilution technique using the Transonic Hemodialysis Monitor (HD01; Transonic Systems Inc) and dual flow/dilution sensors. At least two measurements at each visit were performed on all patients. If measurements varied by more than 10%, a third measurement was performed, and results were averaged to provide the monthly flow for each patient. To determine whether access flow rate influenced adequacy of dialysis, we recorded the machine blood flow rate at the time of the access measurement and calculated the single-pool Kt/V (spKt/V) for urea performed the same month as the access flow measurement. spKt/V was calculated using a standard formula from the plasma urea nitrogen level obtained predialysis and at 5 minutes postdialysis with the machine in bypass.[22]

Statistical Analysis

Data were analyzed using StatView statistical software (version 5.0; Abacus Concepts Inc, Berkeley, CA). Differences between the frequency of nominal variables were compared using the chi-square statistic. Continuous variables were compared by analysis of variance (ANOVA). Logistic regression analysis was used to determine whether patient demographic and comorbidity factors varied as a function of access number. Access patency and patient survival data were analyzed using the Kaplan-Meier method, with differences compared by the log-rank statistic. Patient survival data were calculated from the date of starting dialysis therapy and censored if a patient transferred to another unit or initiated another form of renal replacement therapy. Access patency was calculated from the date of each access placement and censored if the patient had a functional access at the time of transfer to another unit, transfer to an alternate form of renal replacement therapy, or death. Covariates for both patient and access survival were analyzed using a Cox proportional hazards model. In this model, all nominal patient demographic and comorbidity data were coded as either present or absent. The continuous variable age was analyzed per unit decade of life. Body mass index was analyzed in several ways, but did not significantly affect patient or access survival for any of these analyses. Results for body mass index as a linear variable are reported. Data for the number of access procedures per year were highly skewed. We used Poisson regression analysis (performed using S-Plus-2000; MathSoft, Seattle, WA) to compare the number of access procedures per year for different access types, recognizing that this may somewhat overstate the observed level of significance for the statistic because the number of access procedures in a given patient may be correlated. To analyze access flow rates, we averaged monthly flow rates for each patient, and this value was used in subsequent analyses. The distribution of flow rates was skewed, particularly for native fistulae. Log transformation was used to help normalize flow rate data. ANOVA was used to compare log-transformed access flow data between access type. Data for continuous variables is reported as mean ± SEM. $P < 0.05$ is considered statistically significant.

RESULTS

Patient Characteristics

Patient characteristics at the time of first access placement (204 patients) and for all access placements combined (322 accesses) are listed in Table 1. In comparison to incident patients reported to the USRDS in 1995, our incident patients overall were younger (56 versus 60 years), more frequently men (63% versus 53%), mostly white (93% versus 62%), and had a greater incidence of diabetes (47% versus 40%).[23] When patients were further stratified by the type of access they received, it was noted that patients who received an LAF were more likely to be younger and men than patients who received either a UAF or AVG. Conversely, there was no difference in demographic or comorbid characteristics of patients who received either an AVG or UAF.

Demographic and comorbid factors at the time of all access placements combined are listed in Table 2 and were generally similar to those for first access placements. However, a diagnosis of hyperlipidemia was significantly more common in patients who received a native fistula (either UAF or LAF) than patients who received an AVG.

Table 1. Patient Characteristics Stratified by Access Type at Time of the First Access Placement

	AVG (56 patients)	UAF (75 patients)	LAF (73 patients)	Total (204 patients)
Age (y)	58.1 ± 2.3	59.1 ± 1.9	51.6 ± 2.3*	56.2 ± 1.2
Men (%)	48	55	82†	63
Race W/B/O (%)	91/7/2	95/1/4	92/4/4	93/4/3
Diabetes (%)	43	52	45	47
Hypertension (%)	77	87	92	86
Peripheral vascular disease (%)	21	28	15	22
Coronary disease (%)	38	51	37	42
Tobacco (%)	20	15	21	18
Hyperlipidemia (%)	21	29	37	30
Body mass index (kg/m^2)	27.3 ± 0.9	25.4 ± 0.7	26.3 ± 0.6	26.2 ± 0.4

NOTE. N = 204 patients.
Abbreviations: W, white; B, black; O, other.
*$P < 0.001$ for LAFs compared with UAFs or AVGs.
†$P < 0.01$ for LAFs compared with UAFs or AVGs.

Table 2. Patient Characteristics Stratified by Access Type at Time of Each Access for All Access Placements Combined

	AVG (117 accesses)	UAF (117 accesses)	LAF (88 accesses)	Total (322 accesses)
Age (y)	59.3 ± 1.6	57.8 ± 1.6	50.9 ± 1.9*	56.4 ± 1.0
Men (%)	53	56	81†	61
Race W/B/O (%)	88/5/7	92/4/4	89/6/5	90/5/5
Diabetes (%)	47	56	47	50
Hypertension (%)	81	89	90	86
Peripheral vascular disease (%)	26	28	16	24
Coronary disease (%)	43	49	39	44
Tobacco (%)	15	13	18	15
Hyperlipidemia (%)	17‡	26	36‡	26
Body mass index (kg/m^2)	26.9 ± 0.6	25.5 ± 0.6	26.8 ± 0.6	26.3 ± 0.3

NOTE. N = 322 accesses.
Abbreviations: W, white; B, black; O, other.
*$P < 0.001$ for LAFs compared with UAFs or AVGs.
†$P < 0.01$ for LAFs compared with UAFs or AVGs.
‡$P < 0.01$ for LAFs or AVGs compared with UAFs.

Access Selection

For first accesses, 36% were LAFs, 37% were UAFs, and 27% were AVGs. For all subsequent accesses, 52% were AVGs, 35% were UAFs, and 13% were LAFs. When first access placement was analyzed by study year, it was apparent that a significant shift in type of access placed occurred between 1994 and 1995. Over the duration of the study, the number of grafts placed remained relatively stable from year to year at approximately 26% of the total. Conversely, between 1994 and 1995, there was a reversal in the type of native AVF placed, away from LAFs to more UAFs (Fig 1). There was no major change in university surgical staff performing access surgeries between 1994 and 1995; rather, the shift from LAFs to UAFs between 1994 and 1995 represented a shift in the choice of first access placement by staff surgeons.

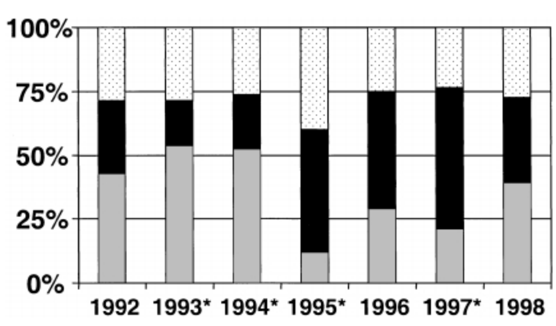

Fig 1. Variation in distribution of first access placed by year of study. Data expressed as percentage of the total number of first accesses placed each year. There were significant differences in the distribution of fistulae between LAFs and UAFs in 1993, 1994, 1995, and 1997 (*P* < 0.05). (□) AVG; (■) UAF; (■) LAF.

Access Survival

For the first access, median primary unassisted patency was 11.5 months, and median cumulative patency was 27.1 months. When patency of the first access was stratified by access type, it was found that both the primary unassisted and cumulative patencies for UAFs were significantly longer than for AVGs or LAFs (Fig 2). Cumulative patency rates for UAFs were 71% at 1 year and 57% at 5 years compared with 54% and 0% for AVGs, respectively (Fig 2B). The survival curve for LAFs was intermediate between those for UAFs and grafts. Access patency data for all 322 access placements combined showed similar results as for first accesses (Table 3).

Primary access failure (failure to mature), defined in the Methods, occurred in 31.5% of LAFs (n = 23), 22.6% of AVGs (n = 13), and 28% of UAFs (n = 21; P = not significant [NS] for comparison between access types). By logistic regression analysis, none of the measured covariates was found to be a significant predictor of primary failure. However, for first accesses, we found a trend for age (relative risk [RR], 1.202 per decade; confidence interval [CI], 0.966 to 1.496; $P = 0.099$), female sex (RR, 1.938; CI,

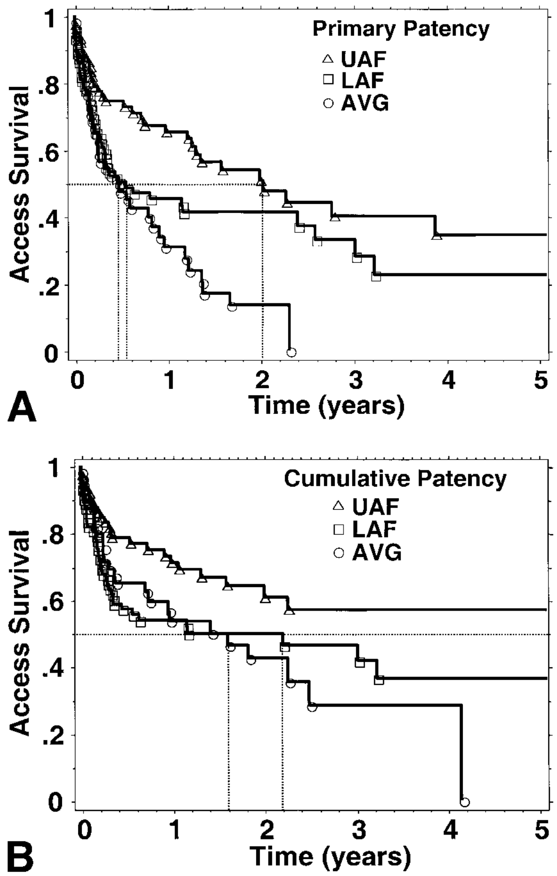

Fig 2. Kaplan-Meier analysis of access patency for first vascular accesses stratified by access type. (A) Primary unassisted access patency and (B) cumulative (assisted) access patency. Dotted lines highlight the median access patency for each of the three access types. By log-rank test, primary unassisted patency was significantly better for UAFs compared with either LAFs ($P < 0.01$) or AVGs ($P < 0.001$). Cumulative patency for UAFs was significantly better than for either LAFs or AVGs ($P < 0.05$).

0.915 to 4.115; $P = 0.084$), and hypertension (RR, 2.881; CI, 0.858 to 9.670; $P = 0.087$) to predict primary failure. Diabetes and access type were not found to be significant. Because accesses that fail to mature by definition have no useful life, we reanalyzed survival data after setting access survival for accesses that failed to mature to zero. For first accesses, the cumulative survival of UAFs was still better than either AVGs or LAFs (1-, 3-, and 5-year survival rates for UAFs, 69.7%, 59.5%, and 59.5%; for LAFs, 54.8%, 47%, and 37%; and for AVGs, 53.3%, 28.2%, and 0%, respectively; $P = 0.05$ by log-rank test).

Although we did not identify differences in demographic or comorbid factors between patients receiving a UAF compared with an AVG as the first access, it is possible that differences in access patency were caused by other unmeasured factors. To further assess this possibility, we examined the database and found that 11 patients had received a UAF after having had an AVG as either the first or second access that had failed. We examined the cumulative patency of UAFs (second or third access) placed after an AVG (first or second access) and compared this with the cumulative patency of all first or second UAFs and found no difference in the patency of UAFs placed after a previous AVG (access patency at 5 years, 70% for UAFs after AVGs versus 59% for first and second UAFs; P = NS). This further suggests that underlying patient comorbid or demographic factors do not account for the difference in patency between UAFs and AVGs.

To determine whether the effect of access type on access patency was independent of other measured covariates, we analyzed the data using a Cox proportional hazards model. As listed in Table 4, the only factors that significantly influenced primary unassisted patency of the first access were type of vascular access and surgeon, particularly those with fewer than 12 access procedures. The strong effect of access type and surgeon was observed for both primary and cumulative access patency for both first accesses and all accesses combined (Table 5). When all accesses were combined, a history of hyperlipidemia also was found to significantly affect cumu-

Table 3. Primary Unassisted and Cumulative Access Patency Rates at 1, 2, 3, and 5 Years After Creation for All Accesses Combined

	Year 1 (%)	Year 2 (%)	Year 3 (%)	Year 5 (%)
Primary patency				
AVG (117)	27	13	7	0
UAF (117)	62	48	37	32
LAF (88)	44	40	31	22
Overall (322)	44	33	24	19
Cumulative patency				
AVG (117)	54	42	31	19
UAF (117)	69	59	53	53
LAF (88)	52	48	43	34
Overall (322)	59	50	42	35

Table 4. Analysis of Covariates for Primary Access Patency by Cox Proportional Hazards Model

Covariate (all tested)	RR (95% CI)	*P*
Access type (reference = UAF)		
AVG	2.61 (1.54-4.42)	0.0004
LAF	1.82 (1.10-3.02)	0.02
Surgeon (reference = surgeon A)		
Surgeons ≤ 12 procedures	3.00 (1.62-5.56)	0.0005
Surgeon B	1.37 (0.61-3.04)	NS
Surgeon C	1.23 (0.58-2.59)	NS
Surgeon D	1.24 (0.60-2.57)	NS
Surgeon E	1.61 (0.90-2.88)	NS
Age (each 10 y)	1.10 (0.97-1.25)	NS
Sex (women)	1.08 (0.69-1.69)	NS
Race		
Other	1.82 (0.63-5.29)	NS
Black	0.83 (0.29-2.46)	NS
Diabetes (present)	1.21 (0.81-1.83)	NS
Hypertension (present)	1.49 (0.81-2.73)	NS
PVD/carotid disease (present)	0.85 (0.51-1.40)	NS
Coronary disease (present)	1.10 (0.70-1.72)	NS
Tobacco (present)	0.82 (0.47-1.43)	NS
Hyperlipidemia (present)	0.88 (0.56-1.38)	NS
BMI	0.99 (0.96-1.02)	NS

NOTE. Data show RR with 95% CIs and *P* for the contribution of various covariates to primary unassisted patency of the first accesses.

Abbreviations: PVD, peripheral vascular disease; BMI, body mass index.

lative access patency (Table 5). Diabetes had an adverse effect on cumulative access patency that did not reach criteria for statistical significance.

Patient Survival

We analyzed overall patient survival to determine whether patient survival was different when stratified by access type. Overall cumulative patient survival from initiation of dialysis therapy decreased nearly linearly, with a median survival of 3.14 ± 0.15 years (unadjusted death rate, 16.7 deaths/100 patient-years). Median survival for patients who received an AVG as the first access (2.59 ± 0.52 years) was shorter than for those who received a UAF (3.08 ± 0.28 years) or LAF (3.46 ± 0.04 years). However, using a proportional hazards model to correct for covariates, patient survival was not significantly different for any type of access. The only factors listed in Table 1 that significantly influenced overall patient survival were older age (RR, 1.274 per decade; CI, 1.079 to 1.503; $P < 0.004$) and the presence of diabetes (RR, 1.785; CI, 1.073 to 2.950; $P < 0.023$). The presence of coronary disease had an effect on survival that was of borderline significance (RR, 1.52; CI, 0.933 to 2.488; $P = 0.093$).

Access Procedures

Despite shorter access survival, AVGs required more total access procedures than either UAFs or LAFs (total procedures, including diagnostic fistulograms: 289 for 117 AVGs compared with 116 for 117 UAFs and 53 for 88 LAFs). Excluding diagnostic fistulograms, numbers of procedures were 228, 76, and 26 for AVGs, UAFs, and LAFs, respectively. When the total number of procedures attributed to each access per year is calculated, results are strikingly skewed, with many accesses requiring no procedures, whereas a few accesses require several procedures over a very short life span. The median number of access procedures per year of cumulative patency for an AVG was 2 compared with 0 for both a UAF and LAF. The third quartile was 6.19 procedures per year for an AVG compared with 1.71 for a UAF and 0.95 for an LAF. By Poisson regression analysis, the number of access procedures for an AVG per year was 3.84 (CI, 3.71 to 3.97) compared with 2.71 (CI, 2.65 to 2.78) for a UAF and 1.44 (CI, 1.39 to 1.50) for an LAF.

Table 5. Analysis of Covariates for Cumulative Patency of All Accesses by Cox Proportional Hazards Model

Covariate (significant only)	RR (95% CI)	*P*
Access type (reference = UAF)		
AVG	1.84 (1.21-2.81)	0.005
LAF	2.20 (1.39-3.49)	0.0008
Surgeon (reference = surgeon A)		
Surgeons ≤ 15 procedures	1.76 (1.00-3.08)	0.05
Surgeon F	3.43 (1.59-7.39)	0.002
Hyperlipidemia (present)	0.60 (0.39-0.94)	0.025
Diabetes (present)	1.42 (0.98-2.05)	0.064

NOTE. Data show RR with 95% CIs and *P* for only the statistically significant covariates.

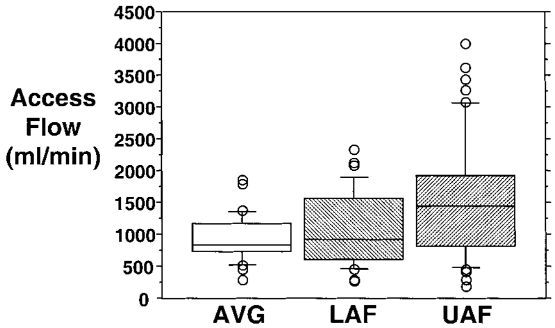

Fig 3. Comparison of access flow rates for each access type. Each point represents the average monthly flow rate for a patient with the specified access type. The horizontal line represents the median, upper and lower limits of the box include the first and third quartiles, and bars enclose 90% of data. Fifteen percent of UAFs had access flow rates greater than 2,500 mL/min. Analysis of log-transformed data by ANOVA showed that access flow rates for UAFs were significantly greater than for either AVGs or LAFs (*P* < 0.001).

Catheter Requirements

Twenty-eight accesses failed before starting dialysis therapy (14 LAFs, 7 UAFs, and 7 AVGs) and did not require a catheter. In accesses that were patent at the time of starting dialysis therapy, a catheter was required most frequently for AVGs (74%), followed by UAFs (64%) and LAFs (50%; $P < 0.05$ for AVGs compared with UAFs or LAFs and for UAFs compared with LAFs). For accesses that required a catheter, the catheter remained in for a longer time in UAFs compared with AVGs (median number of catheter days, 36, 53, and 56 days for AVGs, LAFs, and UAFs, respectively; $P < 0.05$ by Kuskal-Wallis test). There was no significant difference in total catheter days between LAFs and UAFs.

Access Flow Rate

One concern regarding UAFs is the presence of greater flow rates, leading to possible increased problems with high-output cardiac failure or vascular steal syndromes.[18,21,24,25] We measured access flow rates in our patients on a monthly basis. Log transformation of the mean monthly flow rate for each patient was used for statistical analysis. As shown in Fig 3, flow rates for UAFs were significantly greater than those for LAFs or AVGs (log average flow rate: UAF, 3.096 ± 0.43 [SEM]; 48 patients; LAF, 2.972 ± 0.046; 31 patients; AVG, 2.930 ± 0.032; 30 patients; $P < 0.01$ for UAFs compared with LAFs or AVGs). These log-transformed values correspond to mean flow rates of 1,247, 938, and 851 mL/min for UAFs, LAFs, and AVGs, respectively. Several patients with UAFs had measured flow rates up to 4 L/min, and 15% of all UAFs had access flow rates greater than 2,500 mL/min compared with none of the patients with an AVG or LAF ($P < 0.01$; Fig 3). However, when we analyzed our data looking for the number of accesses that were either banded or ligated for steal or high-output syndromes, we found that only 3 of 117 UAFs (2.6%) compared with 4 of 117 AVGs (3.4%) and 2 of 88 LAFs (2.3%) had undergone this procedure (P = NS).[3]

Access flow rates less than 400 mL/min were found in 7.2% of all access measurements (11%, 4.4%, and 8.7% for AVGs, UAFs, and LAFs, respectively). To determine whether there was an effect of flow rate on adequacy of dialysis, we analyzed spKt/V and machine blood flow rate. spKt/V was measured the same month as the access flow measurement, and the machine blood flow rate was measured at the same time as the access flow measurement. Comparing accesses with flow rates greater than 400 mL/min (1,281 ± 25 mL/min) versus those with flow rates of 400 mL/min or less (mean flow, 276 ± 12 mL/min) showed that both machine blood flow and spKt/V were slightly but significantly lower in patients with lower access flow rates (machine blood flow, 407.4 ± 1.2 mL/min; n = 756 compared with 395.2 ± 6.3 mL/min; n = 65; spKt/V, 1.51 ± 0.007; n = 880 versus 1.45 ± 0.034; n = 63; $P < 0.05$).

For grafts, the ability to maintain a good machine flow rate and Kt/V even at a low access flow rate was documented to be secondary to midgraft stenoses. The midgraft stenosis is bypassed by the arterial and venous needles during dialysis, but is detected when the needles are reversed to measure access flow rate. Similarly, low flow rates in native fistulae may be caused by collateral vessels that steal blood from the vein when configured for access flow measurement, but permit adequate delivery of blood flow during dialysis. Overall, most patients with a low access flow rate were receiving adequate dialysis. This confirms that access blood flow is a much more sensitive index of access dysfunction than either machine blood flow or Kt/V.

DISCUSSION

A recent review of hemodialysis vascular access management recommended the UAF as an alternative to a graft for a second vascular access procedure.[11] However, concern also was expressed over the lack of knowledge on long-term survival and possible complications related to high access flow rates.[11] Subsequent studies have shown that UAFs can be used effectively to increase the prevalence of native fistulae and improve short-term outcome, even in women, older patients, and those with diabetes, for whom an LAF is difficult to establish.[15,26] The present prospective observational study further confirms these recent findings and provides additional information on long-term access survival and complications of using a UAF, specifically the end-to-side brachiocephalic fistula.

Survival rates for native fistulae in the present study are similar to those reported in the recent literature. Patency rates for UAFs have been reported in several studies.[16-18,20,27,28] For native brachiocephalic UAFs, cumulative 1- and 3-year patency rates have been reported to be between 67% to 84% and 50% to 78%, respectively.[16-18,27] Similar patencies have been reported with the transposed brachiobasilic fistula.[17,20,28] These observations are similar to those reported for UAFs in the present study (71% and 57% for 1 and 3 years, respectively; Table 3) and suggest that the observed patency for UAFs may be broadly attainable. Patency of LAFs depends on patient selection. However, several recent studies report 1- and 3-year patency rates (primary unassisted and cumulative) of 48% to 69% and 36% to 48% for LAFs, respectively.[5,12,14,29] These are similar to results found in the present study for LAFs (Table 3). By comparison, 1-year cumulative patency rates for prosthetic grafts have been reported to be 40% to 71% in recent studies.[3,5,26,30,31]

There are no randomized trials comparing the patency of native fistulae to grafts. However, numerous (but not all) observational studies have reported improved patency for native fistulae compared with grafts.[1-4,6,19,21,26,32-34] The most commonly used native fistula in these studies has been the LAF. Once established, the long-term complication-free patency of an LAF is much better than grafts.[1,3,4,19,21,32,35] However, early failure rates for LAFs can be substantial, particularly in women, older patients, and those with diabetes.[1,12-15] Given the trend for increasing age and prevalence of diabetes in incipient hemodialysis patients, this has raised questions about whether LAFs should be the first choice of vascular access, particularly in these higher risk patients.[12] A recent study by Miller et al[15] reported adequacy rates for forearm fistulae of only 7% for women, 12% in patients 65 years or older, and 21% for patients with diabetes. Conversely, they reported adequacy rates for UAFs of 56% in women, 54% in older patients, and 48% in patients with diabetes.[15] Our results are generally consistent with these observations and suggest that in selected patients, a UAF may be the most appropriate choice for a first access and is a better alternative than a graft for a second access attempt.

Because none of the available studies are randomized, concerns may be raised about the potential for selection bias to influence the comparison of patency data. In the present study, bias was clearly present in the selection of patients (younger men) for an LAF. However, there was no evidence for any difference in demographic characteristics between patients receiving a UAF or AVG. It is possible that vessel anatomy or other patient characteristics that were not recorded nevertheless influenced access selection and might have affected access survival. However, the patency of a UAF placed after a failed AVG was the same as a UAF placed without a previous AVG. These observations suggest that selection bias was not the major reason for the better access patency of UAFs compared with AVGs.

Using a Cox proportional hazards model to correct for possible differences in measured covariates, the only factors that significantly influenced access patency in the present study were type of access selected and surgeon. The influence of the operating surgeon was previously reported by Prischl et al[14] to be the major factor in determining both short-term and long-term patency of radiocephalic LAFs. The effect of the surgeon on access patency has not been analyzed in most recent series; however, it likely contributes in part to the variation in access patency reported in the literature. Other factors that may influence access patency include patient age, diabetes, and sex; however, the effect of these factors has not been consistent.[1,5,6,14,19,29,30,33] In the present study, none of these factors was found to affect primary unassisted patency (Table 4). However, the presence of diabetes was found to have a borderline effect to adversely affect cumulative patency, particularly in subsequent access attempts, many of which were grafts (Table 5).

Currently, prosthetic AVGs account for 65% of accesses used in the United States.[8,9] If this trend was reversed and the majority of accesses placed were native fistulae, what survival benefit would result? Woods et al[1] recently analyzed 784 randomly selected incident hemodialysis patients in the USRDS database (69% AVGs and 31% native fistulae, primarily LAFs) and found an overall 1-year primary unassisted patency rate of 53%. Their study understates the overall magnitude of the access problem because only patients with a functional access within 30 to 120 days after starting dialysis therapy were included on the study.[1] We reanalyzed our data to exclude patients who did not have a functional access at 30, 60, or 120 days after starting dialysis therapy, and the revised average 1-year primary unassisted patency rates were 68.9%, 71.6%, and 75.7%, respectively. This suggests that an increase in the percentage of first accesses that are native fistulae from the current level of 31% reported by Woods et al[1] to 72.5% in the present study would result in an overall increase in the 1-year primary unassisted access patency rate of 16% to 23%. Moreover, given that survival curves for native fistulae continued to diverge beyond 1 year (Fig 2), overall long-term access patency would be even better. Finally, the significantly fewer number of procedures required to maintain a native fistula compared with an AVG would further reduce overall access-related costs.

Several concerns have been raised regarding the use of UAFs, including loss of more distal access sites, difficulty cannulating the access, and the potential for greater access flow rates, leading to high-output failure or problems with ischemia in the distal extremity.[10,18,21,24,25] In general, the most distal sites should be used for placement of the native access, but an LAF is not possible in many current patients. In these patients, use of a UAF would be preferred over an AVG. Cannulation of a UAF can be more difficult than an AVG, particularly in patients who are obese. However, given the large difference in patency and complications for the two types of accesses, we do not believe that this is a good argument against using a UAF. Regarding the problem of high-output failure and distal ischemia, Zibari et al[21] reported that 8% of brachiocephalic UAFs required ligation for steal compared with only 1.7% for LAFs and 1.8% for AVGs. A more recent report found that 4% of native fistulae (53% UAFs and 47% LAFs combined) were ligated for steal syndrome compared with 0.8% for grafts.[26] However, several other studies found no increased risk for high-output failure or steal syndromes with UAFs.[16,27] Although our prospective flow monitoring over the last 2 years identified a subgroup of patients with very high fistula flow rates, there was no increase in the percentage of UAF accesses ligated for steal syndromes in the preceding 7 years of this study. Moreover, after correcting for covariates, the survival rate for patients with a UAF was no worse than those for patients with an AVG or LAF. Further prospective investigation is needed into the long-term outcome of patients with these high access flow rates. However, in our experience, access-related ischemia is not sufficiently common to proscribe routine placement of UAFs.

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