Evaluation of the efficacy of the transposed upper arm arteriovenous fistula: A single institutional review of 190 basilic and cephalic vein transposition procedures

Karen Woo, MD,[a] Alik Farber, MD,[b] Gheorghe Doros, PhD,[c] Kelly Killeen, MD,[a] and **Som Kohanzadeh, MD,[a]** *Los Angeles, Calif; and Boston, Mass*

Introduction: **Although autogenous brachial-basilic upper arm transpositions (BVT) have been extensively utilized, there has been significant disparity in published patency rates. Very little is known about the efficacy of autogenous brachial-cephalic upper arm transpositions (CVT). We evaluated our experience with transposed upper arm arteriovenous fistulas (tAVF) in order to assess patency and identify factors that affect efficacy. We then compared our tAVF patients with a cohort of upper arm arteriovenous grafts (AVG).**

Methods: **A retrospective review was conducted of tAVF performed at our institution from 1998 to 2004. The tAVF group consisted of 119 BVT and 71 CVT procedures. We compared these with 164 AVG. tAVF were placed only for veins ≥2.5 mm in diameter by duplex ultrasonography.**

Results: **Mean follow-up was 28 months. With the exception of mean vein diameter, the patients in the BVT and CVT groups had similar demographic parameters and complication rates. Primary and secondary patency rates were 52% and 62% at 5 years for BVT and 40% and 46% at 5 years for CVT, respectively (P = NS). Multivariate analysis revealed that hemodialysis dependence at the time of fistula placement and history of previous upper arm access independently affected primary patency. History of upper torso dialysis catheters independently affected secondary patency. Comparison of the tAVF and AVG groups revealed that tAVF patients were significantly younger, more likely to be male, less likely to be African American (AA) and less likely to have a history of previous AV access. The primary patency rate for tAVF was significantly higher than for AVG: 48% vs 14% at 5 years (P < .001). The secondary patency rate for tAVF was also significantly higher than for AVG: 57% vs 17% at 5 years (P < .001). Among the tAVF procedures, 9% required one or more revisions to maintain secondary patency, compared to 51% with the AVG group (P < .001). Multivariate analysis revealed that presence of AVG and a history of previous upper arm access negatively affected primary and secondary patency.**

Conclusions: **Autogenous BVT and CVT have similar, high patency rates. Transposed upper arm arteriovenous fistulas have higher patency rates than upper arm AVG and require significantly fewer revisions. Our data strongly support the contention that as long as the patient is a candidate for an upper arm tAVF, based on anatomical criteria, a tAVF should always be considered before an AVG. (J Vasc Surg 2007;46:94-101.)**

End-stage renal disease (ESRD) is a significant public health problem in the United States.[1] During the past decade, increasing prevalence of patients requiring hemodialysis [2] has resulted in dialysis access procedures becoming some of the most common operations performed by vascular surgeons. Long-term hemodialysis access includes native arteriovenous fistulas (AVF) and prosthetic arteriovenous grafts (AVG). In the mid 1990s, only 20% of patients in the United States were dialyzing with native AVF.[3] Because of data illustrating superior patency of native AVF, the National Kidney Foundation Dialysis Outcome and Quality Initiative (DOQI) recommended, that native AVF should be constructed in at least 50% of permanent hemodialysis access procedures.[4-6] The recently created Fistula First Initiative further encourages use of native AVF by providing physicians with an algorithm designed to optimize care of patients with ESRD.[7] Despite these recommendations, native AVF use was only 36% in 2004.[7]

Increasing age and complexity of patients with ESRD has commonly been associated with clinical scenarios where wrist or simple antecubital AVF construction is not possible. Upper arm transposed AVF (tAVF) such as autogenous brachial-basilic upper arm transposition (BVT) have been described in patients who are not candidates for forearm native AVF.[8] There are a number of reports describing excellent patency of BVT.[9-13] However, some studies report equivocal results.[14,15] Autogenous brachial-cephalic upper arm transposition (CVT) AVF has been described but their utility and efficacy have not been well defined

From the Department of Surgery,[a] Cedars Sinai Medical Center, Los Angeles, the Section of Vascular Surgery,[b] Boston University Medical Center, Boston, and the Department of Biostatistics,[c] Boston University School of Public Health, Boston.

Additional material for this article may be found online at www.jvascsurg.org

Competition of interest: none.

Presented at the 2005 Annual Meeting of the Western Vascular Society, Park City, Utah, Sept 24-27, 2005.

Reprint requests: Alik Farber, MD, Section of Vascular Surgery, Boston University Medical Center, C-500, 88 E. Newton St, Boston, MA 02118 (e-mail: alik.farber@bmc.org).

CME article

0741-5214/$32.00

doi:10.1016/j.jvs.2007.02.057

because the cephalic vein is often superficial and transposition is not necessary.[16] Also, simple brachiocephalic fistulas are often performed without concern for vein depth since some surgeons rely on secondary fistula elevation procedures.[13,17] In order to avoid difficulties with fistula access and secondary fistula elevation procedures, we were liberal to transpose the cephalic vein when it was not superficial.

We evaluated our extensive experience with upper arm BVT and CVT procedures in order to assess and compare patency rates, as well as to determine factors that affect efficacy. We then combined our BVT and CVT patients into a tAVF group and compared it with a cohort of upper arm AVG.

METHODS

We retrospectively evaluated upper arm tAVF performed at Cedars-Sinai Medical Center in Los Angeles, California between January 1998 and September 2004. The fistula group consisted of consecutive upper arm BVT and CVT procedures. This tAVF group included patients who had previous access construction in the ipsilateral as well as the contralateral upper extremity.

A comparison AVG cohort was selected from a group of procedures chosen from the middle of our study period. Only primary upper arm AVG were included for evaluation; there were no previous access procedures performed in the ipsilateral upper extremity of the AVG patients. Some AVG patients did have previous access procedures performed in the contralateral upper extremity.

Office, hospital, and electronic charts were reviewed after Institutional Review Board exemption status was granted. Comorbid conditions were noted and graded according to the recommended reporting standards.[18] Dialysis dependence at the time of AVF placement and history of upper torso (subclavian or jugular) dialysis catheters were recorded.

All patients underwent preoperative noninvasive vascular evaluation that included brachial pressures and waveforms, Allen's test, and brachial/radial artery diameter measurements. Vein mapping was routinely performed to outline and define the size and quality of basilic and cephalic veins. Vein diameter was recorded and the mean vein diameter was calculated for tAVF patients.

In our practice, we attempted to first place a wrist radiocephalic fistula if anatomically favorable. From there, we moved to a simple brachiocephalic fistula at the antecubital fossa. If this was not feasible, we placed either an upper arm AVG or an upper arm tAVF. The forearm transposed fistula or loop graft was rarely used.

The decision to construct an upper arm tAVF was based, in general, on the presence of adequate arterial inflow into the arm, upper arm vein diameter $\geq$2.5 mm and absence of suitable forearm site for an autogenous fistula. If upper arm cephalic vein was judged adequate on duplex evaluation and superficial on tourniquet-aided examination by the surgeon, an antecubital nontransposed brachiocephalic fistula was constructed. Otherwise, either an upper arm BVT or CVT was placed. The larger of the two upper arm veins, as measured by duplex, was used preferentially. We were liberal to transpose the cephalic vein if it was not easily palpable on tourniquet-assisted physical examination. Patients who were not judged to be candidates for a native AV fistula were treated with upper arm, straight configuration, 6 mm polytetrafluoroethylene (PTFE) AV grafts (WL Gore and Associates Inc, Phoenix, Ariz, and Bard Inc, Tempe, Ariz). No looped arm, forearm, or tapered AVG were utilized. Ultimately, the decision of type of access was determined by surgeon preference.

Operative details are described in Appendix I (online only).

Perioperative and postoperative complications were followed by the operative surgeon. Complications were graded according to the recommended standards for reports dealing with arteriovenous hemodialysis access procedures. The complications that followed were grade 2 wound infection (requiring operative exploration or removal of access), grade 3 (severe) steal (requiring mandatory intervention), grade 3 postoperative hemorrhage (necessitating return to the operating room), and fistula thrombosis within 24 hours.[18] Grade 3 steal was treated either with fistula banding or the distal revascularization interval ligation procedure. Thirty-day mortality rate was calculated.

A follow-up visit with the vascular surgeon was scheduled during the first month after discharge for suture removal and at that time fistula patency was assessed by physical examination. Transposed AVF were allowed to mature for a minimum of 8 weeks, and the decision when to use the access for the first time was made either by the attending surgeon or nephrologist. Grafts were typically accessed for dialysis 10 to 14 days after implantation.

No routine surveillance was performed. Noninvasive imaging was used in the initial evaluation of a malfunctioning access. A fistulagram was performed only when symptomatic fistula or graft stenosis were suspected. This was done when intra-access flow was less than 600 mL/min and static or dynamic venous pressures were high. In addition, elevated access recirculation also prompted referral for fistulagraphy. Invasive imaging was not routinely performed for asymptomatic stenosis.

When a prosthetic access occluded, it was reopened using either mechanical or surgical thrombectomy. If mechanical thrombectomy was used, balloon angioplasty of the culprit stenosis was attempted. If surgical thrombectomy was used, surgical repair of the underlying lesion was attempted. Occluded tAVF were either abandoned or reopened using mechanical thrombectomy. In the latter case, percutaneous angioplasty or surgical revision was attempted.

Statistical analysis was performed using the statistical analysis system (SAS). Summary results for were presented as mean $\pm$ standard deviation continuous variables and as frequency (percent) for categorical variables. Two-group comparisons were assessed by the independent samples t test or the Wilcoxon rank sum test, as appropriate of continuous variables and by χ^2 test or Fisher exact test for

categorical variables. Fistula and graft patency and limb abandonment rates at each time point were calculated by the life table method as outlined by the Society of Vascular Surgery Ad Hoc Committee on Reporting Standards[39] (Appendix IV to XI, online only). Survival differences were tested with the log rank test.

Primary patency was defined as time of access placement until first thrombosis or any intervention designed to maintain patency.[18] Follow-up for primary patency rate calculations ended when the graft was confirmed to require intervention, thrombosed, or last known to be patent (whichever was shorter). Placement of a dialysis catheter in a patient with a presumably functioning graft, death, or kidney transplantation were additional endpoints for termination of patency. Secondary patency was defined as the interval from the time of access placement until access abandonment.[18] Secondary patency rate calculations ended when the patient had a new surgical dialysis access placed. Multivariate Cox proportional hazard models were evaluated to assess association of type of vein (BVT vs CVT) and type of surgery (AVG vs tAVF) on the hazard of primary or secondary access failure while controlling for other independent predictor variables. To search for a final model, we used the stepwise selection.

RESULTS

During the 6.5-year study period, 190 upper arm tAVF were constructed in 190 limbs of 190 patients. There were 119 BVT and 71 CVT procedures. During that time period, 828 upper arm AVG and 81 antecubital nontransposed brachiocephalic AVF were placed. One hundred and sixty-four primary upper arm AVG performed during the period of 1999 to 2001 in 164 limbs in 139 patients were chosen for our comparative analysis.

The etiology of ESRD in our tAVF patient cohort was hypertensive nephropathy in 25.8%, diabetic nephropathy in 39.5%, and autoimmune disease in 9.5% of the patients. In 17.4%, other causes such as polycystic kidney disease and contrast nephropathy were culprit, and in 7.8%, the etiology of renal failure was unknown.

There was no significant difference in the mean age, gender, race, history of previous access, and diabetes between the BVT and CVT cohorts. On average, basilic veins used for BVT were larger than cephalic veins used for CVT (4.4 mm vs 3.8 mm, respectively, $P < .001$). A similar proportion of BVT and CVT patients were undergoing hemodialysis at the time of access construction (59% BVT, 65% CVT, P = NS). Finally, 50% of BVT and 55% of CVT patients had a history of previous upper torso dialysis catheters (P = NS) (Table I A).

The mean age of the tAVF group was significantly lower than the mean age of the AVG group: 63 vs 67 years ($P = .019$). There were a significantly higher percent of men in the tAVF group compared with the AVG group: 63% vs 48% ($P = .004$). The percent of African Americans (AA) in the tAVF group was significantly lower than in the AVG group: 25% vs 38% ($P = .006$). Finally, fewer patients in the tAVF group had a history of previous access procedures: 19% vs 32% ($P = .007$). There was no significant group difference in the percent of patients with diabetes (Table I B).

Table I A. Patient characteristics according to tAVF type

	BVT (%)	*CVT (%)*	*P-value*
Mean age ± SD	64 ± 19	60 ± 16	.161
Male gender	79 (66)	41 (58)	.277
AA race	30 (25)	17 (24)	.999
Diabetes (grade 1-3)	54 (48)	40 (56)	.295
Previous UE access	21 (18)	16 (23)	.451
Mean vein diameter (mm)	4.4 ± 0.99	3.8 ± 0.83	<.001
On dialysis	70 (59)	46 (65)	.445
Previous catheter	60 (50)	39 (55)	.553

SD, Standard deviation; *AA*, African-American; *UE*, upper extremity.

Table I B. Patient characteristics according to access type

	tAVF (%)	*AVG (%)*	*P-value*
Mean age ± SD	63 ± 18	67 ± 16	.019
Male gender	120 (63)	78 (48)	.004
AA race	47 (25)	63 (38)	.006
Diabetes (grade 1-3)	97 (51)	74 (45)	.287
Previous UE access	37 (19)	53 (32)	.007

SD, Standard deviation; *AA*, African-American; *UE*, upper extremity.

Table II A. Mortality and complications according to tAVF type

	BVT (%)	*CVT (%)*	*P-value*
30 day mortality	5 (4.2)	0 (0.0)	.159
Infection (grade 2)	3 (2.5)	0 (0.0)	.294
24 hour thrombosis	0 (0.0)	1 (1.4)	.374
Bleeding (grade 3)	6 (5.0)	1 (1.4)	.260
Steal (grade 3)	3 (2.5)	3 (4.2)	.673

There was no significant difference in the thirty day mortality, grade 2 wound infection, 24 hour thrombosis, grade 3 postoperative hemorrhage, or grade 3 steal between the BVT and CVT groups (Table II A). Mean follow-up was 28 months. The primary patency of BVT was 71% and 52% at 1 year and 5 years, respectively. The primary patency of CVT was 56% and 40% at 1 year and 5 years, respectively (P = NS) (Fig 1, *A*). The secondary patency of BVT was 76% and 62% at 1 year and 5 years, respectively. The secondary patency of CVT was 66% and 46 % at 1 year and 5 years, respectively (P = NS) (Fig 1, *B*).

Four surgical and 22 endovascular revision procedures were performed in the BVT and CVT groups to maintain secondary patency; 92% of BVT and 91% of CVT required no revisions (P = NS). Bivariate analysis revealed that vein type was not associated with any difference in primary and secondary patency across subgroups defined by age, gender, race, and diabetic status (Appendix II and III, online only). Multivariate analysis revealed that being dialysis de-

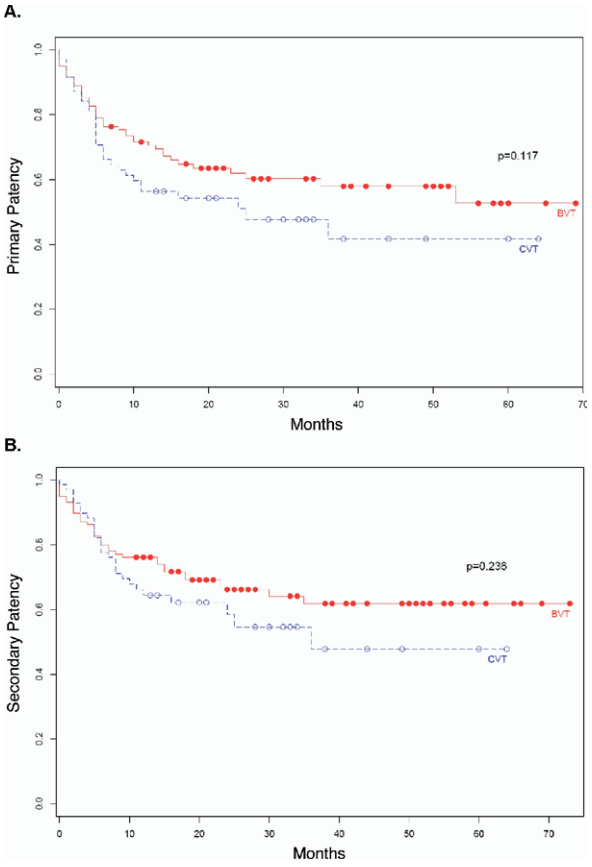


Fig 1. A, Kaplan-Meier curves of primary patency for BVT and CVT. **B**, Kaplan-Meier curves of secondary patency for BVT and CVT.

pendent at the time of fistula placement (HR 1.98, 95% confidence interval [CI] 1.13 to 3.47, P =.017) and a history of previous upper arm access (HR 1.85, 95% CI 1.10 to 3.14, P = .021) increased the risk of primary failure. History of previous upper torso catheter increased the risk of secondary failure (HR 2.17, 95% CI 1.29 to 3.65, P = .003). Vein type was not a significant predictor of access patency.

Autogenous BVT and CVT were combined into one tAVF group and compared with the AVG cohort. The thirty-day mortality rate was 2.6% in patients with tAVF and 5.5% in those with AVG (P = .151). There was a significantly lower risk of grade 2 wound infection in the tAVF group compared with AVG group: 1.6% vs 10.4% (P < .001). There was no significant difference in 24-hour thrombosis rates between the groups. There was a higher, albeit not statistically significant, incidence in postoperative bleeding requiring re-operation in the tAVF group: 3.7% vs 0.6% (P = .07). Finally, there was a significantly decreased incidence of grade 3 steal in the tAVF group: 3.2% vs 8.5%, (P = .037) (Table II B).

The primary patency rate for the tAVF cohort was 65% and 48% at 1 year and 5 years, respectively. The primary

Table II B. Mortality and complications according to access type

	tAVF (%)	*AVG (%)*	*P-value*
30 day mortality	5 (2.6)	9 (5.5)	.151
Infection (grade 2)	3 (1.6)	17 (10.4)	<.001
24 hour thrombosis	1 (0.5)	2 (1.2)	.598
Bleeding (grade 3)	7 (3.7)	1 (0.6)	.070
Steal (grade 3)	6 (3.2)	14 (8.5)	.037

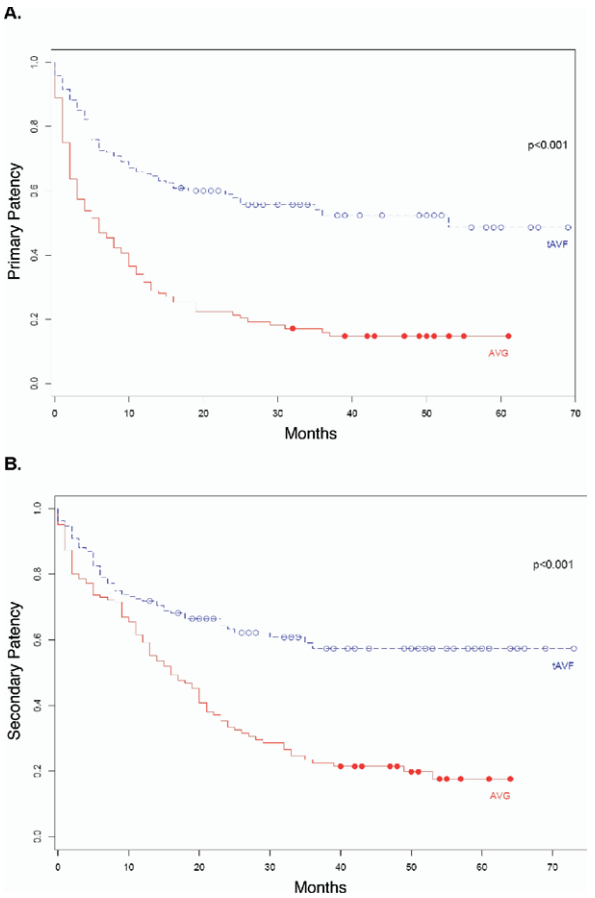


Fig 2. A, Kaplan-Meier curves of primary patency for tAVF and AVG. **B**, Kaplan-Meier curves of secondary patency for tAVF and AVG.

patency rate for the AVG cohort was 34% and 14% at 1 year and 5 years, respectively. Primary patency in the tAVF group was significantly higher than for the AVG group (P < .001) (Fig 2, *A*).

The secondary patency rate for the tAVF cohort was 72% and 57% at 1 year and 5 years, respectively. The secondary patency for the AVG group was 63% and 17% at 1 year and 5 years, respectively. Secondary patency in the tAVF group was significantly higher than in the AVG group (P < .001) (Fig 2, *B*).

In the tAVF cohort, there were four surgical and 22 endovascular revision procedures performed during the

follow-up period. In the AVG group, 106 surgical and 134 endovascular revision procedures were performed. Among the tAVF procedures, 9% required one or more revisions to maintain secondary patency, compared with 51% in the AVG group ($P < .001$). When a revision was necessary, a mean and median of 1.5 and 1 revision in the tAVF group vs 2.8 and 3 in the AVG group were performed, respectively.

Sub-group analysis of AA patients, patients greater than 80 years old and those with diabetes revealed that tAVF had significantly higher primary patency rates compared with AVG ($P = .004$, $P = .020$, and $P < .001$, respectively). Multivariate analysis revealed that presence of tAVF decreased the risk for primary (HR 0.40, 95% CI 0.30 to 0.54, $P < .001$) and secondary failure (HR 0.49, 95% CI 0.36 to 0.67, $P < .001$). History of previous access increased the risk of primary (HR 1.76, 95% CI 1.30 to 2.39, $P < .001$) and secondary failure (HR 1.75, 95% CI 1.27 to 2.42, $P = .001$). Age, gender, diabetes, and race did not significantly influence primary or secondary failure.

DISCUSSION

In 1976, Dagher was the first to describe the use of the elevated brachial-basilic upper arm AV fistula,[7] also termed basilic vein transposition (BVT). Although BVT has been described to have excellent patency rates[10-13,19-21] some authors report less spectacular results.[14,15] We evaluated our experience with BVT and CVT procedures to compare our patency rates with those published in the literature and determine whether using one type of vein is superior.

Our BVT primary and secondary patency rates compare favorably with published patency rates.[10,12,14,19-23] The BVT and CVT groups were well matched with respect to demographics with the exception of the fact that basilic veins were on the average somewhat larger. Analysis revealed that there was no significant difference between these procedures in terms of complication rates, patency, or the number and type of revisions performed. Bivariate and multivariate analysis confirmed that vein type did not affect patency rates. These findings are not surprising since both BVT and CVT are based on deeper veins less likely to have been violated by venipuncture and both procedures are of similar operative complexity.

We found that dialysis dependence at the time of fistula placement negatively affects primary patency rates of the BVT and CVT procedures. This finding likely reflects the fact that prolonged dialysis leads to eventual obliteration of central venous outflow and consequent fistula failure. Our finding that previous upper torso catheters negatively affect secondary patency has been demonstrated by others and is, likewise, related to catheter induced central venous outflow obliteration.[24]

Comparison studies of BVT and AVG reveal results that range from demonstration of superior patency of BVT over AVG[12,21] to reports of similar patency rates[22,25] between the two types of access procedures. To address this controversy, we elected to compare our tAVF cohort with a sample of upper arm AVG. Our AVG cohort represented a typical group of AVG patients but was not case matched with the tAVF cohort. The patients in the tAVF group were significantly younger, a higher proportion was male, fewer were African American, and fewer patients had a history of previous access operations compared with the patients in the AVG group (Table I B). These differences parallel findings from multiple other studies.[3,25-29]

In our series, tAVF had a lower rate of grade 2 infections, more grade 3 postoperative bleeding, and less grade 3 steal than the AVG cohort. This has been noted by others.[9,12,14,20,25,30-33] Our tAVF patency rates are much higher than those of AVG (Fig 2). Comparison of tAVF and AVG in the literature reveals that in many[12,21] but not all[22,25] series, tAVF had improved primary and secondary patency compared with the AVG cohorts. Notwithstanding lower access patency rates, patients who received AVG in our study required significantly more interventions to maintain secondary patency compared with those in the tAVF group. This has been described by others.[3,25,34] In fact, one author described up to 91% higher incidence of revisions for AVG compared with native AVF[22].

Multivariate analysis of our data revealed that history of previous access operations increased the risk for primary and secondary failure. History of previous access surgery may be linked to worse outcomes [20,22] because of its effect on arterial and venous anatomy and possibly due to other poorly defined patient factors such as predisposition to an aggressive neointimal hyperplastic response.

In our series, gender, history of diabetes, and patient age did not exert an effect on access patency. Some authors have noted that female gender correlates with decreased fistula maturation and patency rate.[3,35,36] Although there is evidence that diabetes decreases patency of radiocephalic AVF, it does not correlate with increased risk for failure of transposed upper arm AVF.[3,11] Older age has been associated with decreased AVF patency[37,38] and age greater than 60 years has been noted to correlate with diminished BVT maturation in one series.[14] However, in another large series, age did not affect BVT patency.[22]

The main limitation of this study is that it is a retrospective review. Certainly this allows for introduction of bias and confounding variables that may affect our conclusions. Another limitation of the study is that the exact reason behind the choice to perform a given operation was not known and, therefore, surgeon bias could not be well controlled. Finally, the AVG group was not matched with the tAVF group and there were significant differences between these patients. Therefore, patency and subgroup comparison of these groups is subject to bias.

Although the most recent DOQI Guidelines edition recommends utilization of BVT, there are conflicting reports regarding its performance. Our series of 119 BVT procedures suggests that this arteriovenous fistula has excellent patency rates. Autogenous BVT perform similarly to CVT and both outperform AVG. These data support the conclusion that patients who are not candidates for simple radiocephalic or brachiocephalic AVF but who are candi-

dates for upper arm tAVF, based on anatomical criteria, should always be offered the latter procedure. Upper arm AVG should be utilized only in those patients in whom tAVF construction is not possible.

AUTHOR CONTRIBUTIONS

Conception and design: AF, KW, SK
Analysis and interpretation: AF, KW, SK, GD
Data collection: KW, SK, KK
Writing the article: AF, KW, SK, GD
Critical revision of the article: AF, KW, KK, GD
Final approval of the article: AF, KW, SK, KK, GD
Statistical analysis: GD
Obtained funding: Not applicable
Overall responsibility: AF
KW and AF contributed equally to this work.

REFERENCES

1. Owen WF. Patterns of care for patients with chronic kidney disease in the United States: dying for improvement. J Am Soc Nephrol 2003;14: S76-80.
2. Xue JL, Ma JZ, Louis TA, Collins AJ. Forecast of the number of patients with end-stage renal disease in the United States to the year 2010. J Am Soc Nephrol 2001;12:2753-8.
3. Allon M, Robbin ML. Increasing arteriovenous fistulas in hemodialysis patients: problems and solutions. Kidney Int 2002;62:1109-24.
4. NKF-DOQI Clinical practice guidelines for vascular access. Am J Kidney Dis 1997;30S3:S150-89.
5. NKF-K/DOQI Clinical practice guidelines for vascular access: update 2000. Am J Kidney Dis 2001;37S1:S137-79.
6. NKF-K/DOQI Clinical practice guidelines for vascular access: update 2006. Am J Kidney Dis 2006:48S1:S176-273.
7. Beasley C, Rowland J, Spergel L. Fistula first, an update for renal providers. Nephrology News Iss 2004;18:88-90.
8. Dagher FJ, Gelber R, Ramos E, Sadler J. The use of basilic vein and brachial artery as an AV fistula for long-term hemodialysis. J Surg Res 1976;20:373-6.
9. Dagher FJ. Upper arm arteriovenous fistula for chronic hemodialysis: 20 years later. Transpl Proc 1996;28:2325-7.
10. Humphries AL, Colborn GL, Wynn JJ. Elevated basilic vein arteriovenous fistula. Am J Surg 1999;177:489-91.
11. Hakaim AG, Nalbandian M, Schott T. Superior maturation and patency of primary brachiocephalic and transposed basilic vein arteriovenous fistulae in patients with diabetes. J Vasc Surg 1998;27:154-7.
12. Coburn MC, Carney WI. Comparison of basilic vein and polytetrafluoroethylene for brachial arteriovenous fistula. J Vasc Surg 1994;20:896-902.
13. Hossny A. Brachiobasilic arteriovenous fistula: different surgical techniques and their effects on fistula patency and dialysis-related complications. J Vasc Surg 2003;27:821-6.
14. Rao RK, Azin GD, Hood DB, Rowe VL, Kohl RD, Katz SG, et al. Basilic vein transposition fistula: a good option for maintaining hemodialysis access site options? J Vasc Surg 2004;39:1043-6.
15. Murphy GJ, White SA, Knight AJ, Doughman T, Nicholson ML. Long-term results of arteriovenous fistulas using transposed autologous basilic vein. Brit J Surg 2000;87:819-23.
16. Hill SL, Seeger JM. The arm as an alternative site for vascular access for dialysis in patients with recurrent access failure. South Med J 1985;78: 37-40.
17. Cull DL, Taylor SM, Carsten CG, Youkey JR, Snyder BA, Sullivan TM, et al. The fistula elevation procedure: a valuable technique for maximizing arteriovenous fistula utilization. Ann Vasc Surg 2002;16:84-8.
18. Sidawy AN, Gray R, Besarab A, Henry M, Ascher E, Silva M, et al. Recommended standards for reports dealing with arteriovenous hemodialysis access. J Vasc Surg 2002;35:603-10.
19. Dagher FJ. The upper arm AV hemoaccess: long-term follow-up. J Cardiovasc Surg 1986:27:447-9.
20. Ascher E, Hingorami A, Gunduz Y, Yorkovich Y, Ward M, Miranda J, et al. The value and limitations of the cephalic and basilic vein for arteriovenous access. Ann Vasc Surg 2001;15:89-97.
21. Matsuura JH, Rosenthal D, Clark M, Shuler FW, Kirby L, Shotwell M, et al. Transposed basilic vein versus PTFE for brachial-axillary arteriovenous fistulas. Am J Surg 1998;176:219-21.
22. Gibson KD, Gillen DL, Caps MT, Kohler TR, Sherrard DJ Stehman-Breen CO. 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. J Vasc Surg 2001;34:694-700.
23. Davis JB, Howell CG, Humphries AL. Hemodialysis access: elevated basilic vein arteriovenous fistula. J Ped Surg 1986;21:1182-3.
24. Erkut B, Unlu Y, Ceviz M, Becit N, Ate A, Colak A, et al. Primary arteriovenous fistulas in the forearm for hemodialysis: effect of miscellaneous factors in fistula patency. Ren Fail 2006;28:275-81.
25. Oliver MJ, Mccann RL, Indridason OS, Butterly DW, Schwab SJ. Comparison of transposed brachiobasilic fistulas to upper arm grafts and brachiocephalic fistulas. Kidney Int 2001;60:1532-9.
26. Hirth RA, Turenne MN, Woods JD, Young EW, Port FK, Pauly MV, et al. Predictors of type of vascular access in hemodialysis patients. JAMA 1996;276:1303-8.
27. O'Hare AM, Dudley A, Hynes DM, McCulloch CE, Navarro D, Colin P, et al. Impact of surgeon and surgical center characteristics on choice of permanent vascular access. Kidney Int 2003;64:681-9.
28. Frankenfield DL, Ramirez SPB, McClellan WM, Frederick PR, Rocco MV. Differences in intermediate outcomes for Asian and non-Asian adult hemodialysis patients in the United States. Kidney Int 2003;64: 623-31.
29. Reddan D, Klassen P, Frankenfield DL, Szczech L, Schwab S, Coladonato J, et al. National profile of practice patterns for hemodialysis vascular access in the United States. J Am Soc Nephrol 2002;13:2117-24.
30. Fitzgerald JT, Schanzer A, Chin AI, McVicar JP, Perez RV, Troppmann C. Outcomes of upper arm arteriovenous fistulas for maintenance hemodialysis access. Arch Surg 2004;138:201-8.
31. Windus DW. The effect of comorbid conditions on hemodialysis access patency. Adv Renal Repl Ther 1994;1:148-54.
32. Gormus N, Ozergin U, Durgut K, Yuksek T, Solak H. Comparison of autologous basilic vein transpositions between forearm and upper arm regions. Ann Vasc Surg 2003;17:522-5.
33. Haimov M, Schanzer H, Skladani M. Pathogenesis and management of upper extremity ischemia following angioaccess surgery. Blood Purif 1996;14:350-4.
34. Dixon BS, Novak L, Fangman J. Hemodialysis vascular access survival: upper-arm native arteriovenous fistula. Am J Kidney Dis 2002;39:92-101.
35. Huber TS, Ozaki K, Flynn TC, Lee WA, Berceli SA, Hirneise CM, et al. Prospective validation of an algorithm to maximize native arteriovenous fistulae for chronic hemodialysis access. J Vasc Surg 2002;36:452-9.
36. Golledge J, Smith CJ, Emery J. Outcome of primary radiocephalic fistula for hemodialysis. Brit J Surg 1999;6211-6.
37. Feldman HI, Joffe M, Rosas SE, Burns E, Knauss J, Brayman K. Predictors of successful arteriovenous fistula maturation. Am J Kidney Dis 2003;42:1000-12.
38. Woods JD, Turenne MC, Strawderman RL, Young EW, Hirth RA, Port FK. Vascular access survival among incident hemodialysis patients in the United States. Am J Kidney Dis 1997;30:50-7.
39. Rutherford RB, Baker JD, Ernst C, Johnston KW, Prter JM, Ahn S, et al. Recommended standards for reports dealing with arteriovenous hemodialysis access. J Vasc Surg 2002;35:603-10.

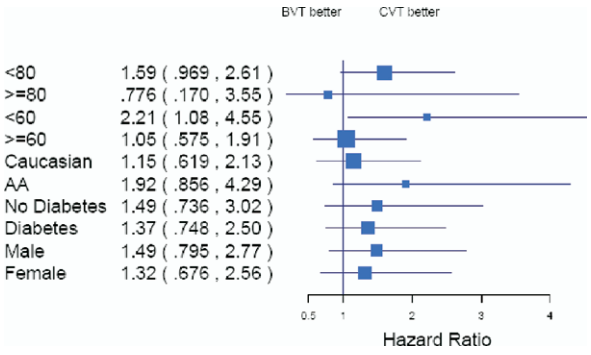
Submitted Jul 10, 2006; accepted Feb 21, 2007.

Additional material for this article may be found online at www.jvascsurg.org.

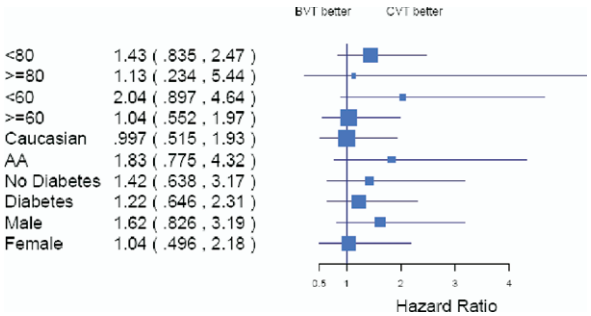
Appendix I. (online only)

Operative technique In the operating room, the majority of procedures were performed under local anesthesia with sedation. For patients who did not tolerate local anesthesia, general anesthesia was required. The basilic or cephalic vein was exposed and dissected from 1 to 2 cm distal to the antecubital fossa to the proximal axilla or shoulder, respectively. All branches were controlled with silk suture and the vein was divided distally. The brachial artery was then exposed immediately proximal to the antecubital fossa and the vein was tunneled superficially to lie next to the brachial artery. In most CVT procedures, the brachial artery was exposed through a separate, medial antecubital incision. After administration of systemic or local heparin, an end to side anastomosis was constructed between the transposed vein and brachial artery. The use of systemic heparin was based on surgeon preference. When systemic heparin was given, it was always reversed with protamine. For upper arm AVG procedures, the brachial artery and axillary vein were exposed through distal and proximal medial upper arm incisions, respectively. Venous and arterial anastomoses were constructed in an end to side fashion. The majority of patients were discharged the same day. Patients who were felt to require observation due to comorbidities or other extenuating circumstances were admitted to the hospital and were discharged on the first postoperative day.

Appendix II. (online only) Forest plot for primary patency of BVT and CVT



Appendix III. (online only) Forest plot of secondary patency of BVT and CVT



Appendix IV. (online only) Life table for primary patency for BVT

Patency time	*Effective sample size*	*Failed*	*Censored*	*Primary patency*	*Standard error*
0	115.5	13	7	100.00%	0
3	98	11	2	88.74%	0.029
6	85	4	2	78.78%	0.038
9	76	4	8	75.08%	0.041
12	65	4	6	71.12%	0.043
15	54	2	8	66.75%	0.046
18	46	1	4	64.28%	0.047
21	40.5	1	5	62.88%	0.048
24	34.5	1	5	61.33%	0.050
27	30	0	2	59.55%	0.051
30	29	0	0	59.55%	0.051
33	27	1	4	59.55%	0.051
36	22.5	0	3	57.34%	0.053
39	19.5	0	3	57.34%	0.053
42	17.5	0	1	57.34%	0.053
45	17	0	0	57.34%	0.053
48	15.5	0	3	57.34%	0.053
51	11	1	6	57.34%	0.053
54	6.5	0	1	52.13%	0.069
57	5	0	2	52.13%	0.069
60	2	0	4	52.13%	0.069

Appendix V. (online only) Life table for secondary patency for BVT

Patency time	*Failed*	*Censored*	*Effective sample size*	*Secondary patency*	*Standard error*
0	12	6	116	100.00%	0
3	8	3	99.5	89.66%	0.028
6	6	1	89.5	82.45%	0.035
9	1	8	79	76.92%	0.039
12	2	7	70.5	75.95%	0.040
15	2	7	61.5	73.79%	0.042
18	2	4	54	71.39%	0.044
21	2	6	47	68.75%	0.046
24	0	8	38	65.82%	0.048
27	0	2	33	65.82%	0.048
30	1	0	32	65.82%	0.048
33	1	4	29	63.77%	0.051
36	0	3	24.5	61.57%	0.054
39	0	3	21.5	61.57%	0.054
42	0	2	19	61.57%	0.054
45	0	0	18	61.57%	0.054
48	0	3	16.5	61.57%	0.054
51	0	6	12	61.57%	0.054
54	0	2	8	61.57%	0.054
57	0	2	6	61.57%	0.054
60	0	5	2.5	61.57%	0.054

Appendix VI. (online only) Life table for primary patency for CVT

Patency time	*Effective sample size*	*Failed*	*Censored*	*Secondary patency*	*Standard error*
0	69.5	9	3	100.00%	0
3	58.5	11	1	87.05%	0.040

Appendix VI. (online only) Life table for primary patency for CVT Continued.

Patency time	*Effective sample size*	*Failed*	*Censored*	*Secondary patency*	*Standard error*
6	45	5	4	70.68%	0.055
9	36.5	4	3	62.83%	0.059
12	29	0	4	55.94%	0.061
15	25	1	4	55.94%	0.061
18	21.5	0	1	53.71%	0.063
21	19	0	4	53.71%	0.063
24	16.5	2	1	53.71%	0.063
27	13.5	0	1	47.20%	0.070
30	11.5	0	3	47.20%	0.070
33	9	0	2	47.20%	0.070
36	7	1	2	47.20%	0.070
39	5	0	0	40.45%	0.086
42	4.5	0	1	40.45%	0.086
45	4	0	0	40.45%	0.086
48	3.5	0	1	40.45%	0.086
51	3	0	0	40.45%	0.086
54	3	0	0	40.45%	0.086
57	3	0	0	40.45%	0.086
60	1.5	0	3	40.45%	0.086

Appendix VII. (online only) Life table for secondary patency for CVT

Patency time	*Effective sample size*	*Failed*	*Censored*	*Secondary patency*	*Standard error*
0	69	5	4	100.00%	0
3	61.5	7	1	92.75%	0.031
6	52	7	4	82.20%	0.046
9	41	3	4	71.13%	0.056
12	33	1	6	65.93%	0.059
15	26	1	6	63.93%	0.060
18	21.5	0	1	61.47%	0.063
21	19	0	4	61.47%	0.063
24	16.5	2	1	61.47%	0.063
27	13.5	0	1	54.02%	0.074
30	11.5	0	3	54.02%	0.074
33	9	0	2	54.02%	0.074
36	7	1	2	54.02%	0.074
39	5	0	0	46.30%	0.095
42	4.5	0	1	46.30%	0.095
45	4	0	0	46.30%	0.095
48	3.5	0	1	46.30%	0.095
51	3	0	0	46.30%	0.095
54	3	0	0	46.30%	0.095
57	3	0	0	46.30%	0.095
60	1.5	0	3	46.30%	0.095

Appendix VIII. (online only) Life table for primary patency for AVG

Patency time	*Effective sample size*	*Failed*	*Censored*	*Primary patency*	*Standard error*
0	155.5	57	17	100.00%	0
3	88	17	4	63.34%	0.038
6	67	12	4	51.11%	0.041
9	51.5	10	3	41.95%	0.041
12	38.5	7	3	33.81%	0.040

Appendix VIII. (online only) Life table for primary patency for AVG

Patency time	*Effective sample size*	*Failed*	*Censored*	*Primary patency*	*Standard error*
15	29.5	3	1	27.66%	0.039
18	25.5	3	1	24.85%	0.038
21	22	0	0	21.92%	0.037
24	21.5	3	1	21.92%	0.037
27	18	1	0	18.87%	0.036
30	16.5	1	1	17.82%	0.035
33	15	0	0	16.74%	0.035
36	14.5	2	1	16.74%	0.035
39	11.5	0	1	14.43%	0.033
42	9	0	4	14.43%	0.033
45	6.5	0	1	14.43%	0.033
48	5	0	2	14.43%	0.033
51	3	0	2	14.43%	0.033
54	1.5	0	1	14.43%	0.033
57	1	0	0	14.43%	0.033
60	0.5	0	1	14.43%	0.033

Appendix IX. (online only) Life table for secondary patency for AVG

Patency time	*Failed*	*Censored*	*Effective sample size*	*Secondary patency*	*Standard error*
0	31	17	155.5	100.00%	0
3	9	5	113.5	80.06%	0.032
6	3	4	100	73.72%	0.035
9	13	4	93	71.50%	0.036
12	10	4	76	61.51%	0.040
15	7	1	63.5	53.42%	0.042
18	8	3	54.5	47.53%	0.043
21	6	1	44.5	40.55%	0.043
24	4	2	37	35.08%	0.042
27	3	0	32	31.29%	0.042
30	2	1	28.5	28.36%	0.041
33	3	0	26	26.37%	0.040
36	1	1	22.5	23.32%	0.039
39	1	1	20.5	22.29%	0.039
42	0	4	17	21.20%	0.038
45	0	1	14.5	21.20%	0.038
48	1	3	12.5	21.20%	0.038
51	1	3	8.5	19.50%	0.039
54	0	3	4.5	17.21%	0.040
57	0	1	2.5	17.21%	0.040
60	0	2	1	17.21%	0.040

Appendix X. (online only) Life table for primary patency for tAVF

Patency time	*Failed*	*Censored*	*Effective sample size*	*Secondary patency*	*Standard error*
0	22	10	185	100.00%	0
3	22	3	156.5	88.11%	0.023
6	9	6	130	75.72%	0.031
9	8	11	112.5	70.48%	0.034
12	4	10	94	65.47%	0.036
15	3	12	79	62.68%	0.037
18	1	5	67.5	60.30%	0.038

Appendix X. (online only) Life table for primary patency for tAVF Continued.

Patency time	*Failed*	*Censored*	*Effective sample size*	*Secondary patency*	*Standard error*
21	1	9	59.5	59.41%	0.038
24	3	6	51	58.41%	0.039
27	0	3	43.5	54.97%	0.041
30	0	3	40.5	54.97%	0.041
33	1	6	36	54.97%	0.041
36	1	5	29.5	53.45%	0.043
39	0	3	24.5	51.64%	0.045
42	0	2	22	51.64%	0.045
45	0	0	21	51.64%	0.045
48	0	4	19	51.64%	0.045
51	1	6	14	51.64%	0.045
54	0	1	9.5	47.95%	0.055
57	0	2	8	47.95%	0.055
60	0	7	3.5	47.95%	0.055

Appendix XI. (online only) Life table for secondary patency for tAVF

Patency Time	*Failed*	*Censored*	*Effective sample size*	*Secondary patency*	*Standard error*
0	17	10	185	100.00%	0

Appendix XI. (online only) Life table for secondary patency for tAVF Continued.

Patency Time	*Failed*	*Censored*	*Effective sample size*	*Secondary patency*	*Standard error*
3	15	4	161	90.81%	0.021
6	13	5	141.5	82.35%	0.028
9	4	12	120	74.78%	0.032
12	3	13	103.5	72.29%	0.033
15	3	13	87.5	70.20%	0.034
18	2	5	75.5	67.79%	0.036
21	2	10	66	65.99%	0.037
24	2	9	54.5	63.99%	0.039
27	0	3	46.5	61.65%	0.040
30	1	3	43.5	61.65%	0.040
33	1	6	38	60.23%	0.042
36	1	5	31.5	58.64%	0.044
39	0	3	26.5	56.78%	0.046
42	0	3	23.5	56.78%	0.046
45	0	0	22	56.78%	0.046
48	0	4	20	56.78%	0.046
51	0	6	15	56.78%	0.046
54	0	2	11	56.78%	0.046
57	0	2	9	56.78%	0.046
60	0	8	4	56.78%	0.046