Superior maturation and patency of primary brachiocephalic and transposed basilic vein arteriovenous fistulae in patients with diabetes

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Purpose: **Primary radiocephalic arteriovenous fistulas (RCAVFs) have classically been used for the initiation of dialysis. If a suitable forearm cephalic vein can be demonstrated, it is used to construct such a fistula. However, we have noted a tendency for RCAVF in patients with a history of diabetes mellitus (type I and type II) to remain patent but not mature to the point of cannulation. Therefore, the present study was undertaken.**
Methods: **Fifty-eight consecutive patients with diabetes who required initial access for hemodialysis at an urban medical center and tertiary Veterans Medical Center underwent creation of an RCAVF (n = 10), brachiocephalic arteriovenous fistula (BCAVF; n = 22), or transposed basilic vein arteriovenous fistula (TBAVF; n = 26). The vein used was determined by physical examination with tourniquet compression. If neither forearm or upper-arm cephalic veins were 2 mm in diameter, a TBAVF was created after venography. Patency was determined by Kaplan-Meier estimate; differences between groups were assessed by Fisher's exact test.**
Results: **The 70% rate of nonmaturation of RCAVFs was significantly greater than the 27% rate for BCAVFs and 0% for TBAVFs ($p < 0.05$). The 33% cumulative primary patency rate at 18 months for RCAVFs was significantly less than 78% for BCAVFs and 79% for TBAVFs ($p < 0.001$). Within and between groups, there were no significant differences in age, gender, aspirin use, history of congestive heart failure, erythropoietin use, hematocrit level, history of peripheral vascular disease, or mortality rate.**
Conclusions: **In patients with renal failure and a history of diabetes, both primary BCAVFs and TBAVFs demonstrate significantly greater maturation and increased primary cumulative patency rates compared with RCAVFs; therefore, these autogenous conduits are considered to be optimal in this group of patients. Whether the discrepancy in lower-arm vein maturation is a result of a lack of compensatory increase in radial arterial flow or an intrinsic defect in the lower-arm cephalic vein is currently under investigation. (J Vasc Surg 1998;27:154-7.)**

Vascular access for chronic hemodialysis has classically been initiated by the creation of a primary radial artery–to–cephalic vein arteriovenous fistula (RCAVF). Since its first description by Brescia et al.[1] in 13 patients with end-stage renal failure caused by chronic glomerulonephritis and polycystic kidney disease, there is no question that for the majority of patients who start hemodialysis RCAVF remains the procedure of choice. Between 1977 and 1989, published reports of 823 RCAVFs have detailed a 2-year primary patency rate of 67%, with a combined early thrombosis or nonmaturation rate between 11% and 27%.[2-5] Interestingly, only 6% to 13% of patients had a history of diabetes mellitus. In these patients, our clinical impression had been that when RCAVFs are created the majority do not mature to the point of cannulation.

Upper-arm brachiocephalic arteriovenous fistulas (BCAVFs) have recently been reported in three large series as secondary procedures after failure of distal

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sites.[6-8] Collectively, 306 BCAVFs had a 1-year primary patency rate between 54% and 90%. Unfortunately, a history of diabetes was not reported in two series and was present in only 16% of patients in the most recent series.[6] Interestingly, BCAVF was first reported as a primary access procedure in nine patients with occluded radial arteries; however, a history of diabetes was not documented.[9]

Transposed basilic vein arteriovenous fistulas (TBAVF) have also been considered secondary procedures after exhaustion of distal sites. Collectively, 130 TBAVFs have been created in children and adults who required chronic hemodialysis.[10-13] The earliest series included 23 TBAVFs as the initial procedure in 21 patients, none of whom had diabetes. In the subsequent series, creation of TBAVFs followed failure of more distal access procedures in the majority of patients. Unfortunately, a history of diabetes was not reported in these series.

The present study was undertaken to compare the degree of maturation and primary patency rate of primary RCAVFs, BCAVFs, and TBAVFs in patients with a history of diabetes mellitus.

MATERIALS AND METHODS

Patient information. From August 1992 through December 1996, a total of 58 autogenous arteriovenous fistulas were created in 18 women and 40 men with a mean age of 61 years (range, 35 to 85 years). All patients had a history of either type I or type II diabetes mellitus.

Seven patients had undergone initial creation of an RCAVF that failed to mature and underwent creation of a BCAVF (n = 3) or TBAVF (n = 4). The remaining 44 patients had not undergone a previous access procedure.

Technique of RCAVF creation. RCAVF were created after documentation of a negative Allen test result and demonstration of a cephalic vein of at least 2 mm diameter with tourniquet compression at the antecubital fossa. With the patient under local anesthesia, a longitudinal incision was made midway between the cephalic vein and radial artery. Anastomosis was performed in an end-to-side fashion using 6-0 polypropylene suture in a continuous fashion. After arterialization, cephalic vein branches were ligated with 3-0 silk suture via separate incisions. Fistulas were allowed to mature for a minimum of 4 weeks and a maximum of 16 weeks before cannulation.

Technique of BCAVF creation. BCAVFs were created after documentation of a negative Allen test result and demonstration of a cephalic vein of at least 2 mm diameter with tourniquet compression at the axillary fold. Surgical exposure and cephalic vein mobilization with the patient under local anesthesia have been previously described.[9] However, we have limited the length of the arteriotomy to 4 mm to prevent subsequent steal phenomenon.[2] Once again, fistulas were allowed to mature for a minimum of 4 weeks and a maximum of 16 weeks before cannulation.

Technique of TBAVF creation. Patients who did not have an adequate upper-arm cephalic vein underwent either preoperative or intraoperative venography to demonstrate patent basilic and brachial veins, because after TBAVF creation the latter would serve as the primary venous drainage of the forearm.

The surgical technique used represents a modification of previous techniques.[11-13] All TBAVFs were created with the patient under general anesthesia, with a medial longitudinal incision placed directly anterior to the basilic vein, as demonstrated on venography.

After mobilization of the basilic vein to the level of the antecubital veins, the brachial artery was dissected from within the longitudinal incision, avoiding a second incision as has been previously described. A commercially available tunneling device with interchangeable heads (Impra, Inc., Tempe, Ariz.) was used to create an 8 mm subdermal tunnel. With the tunneling device in place, the distal antecubital vein in continuity with the basilic vein was transected. The basilic vein was irrigated gently with normal saline solution containing heparin (5000 U/L) and occluded with a plastic bulldog clamp. The basilic vein was then retracted from beneath the lateral cutaneous nerve. The 8 mm tunneling head was replaced with the 2 mm head, and the vein was secured with a 2-0 silk suture. The tunneling device was then removed from the distal incision. In this fashion, the basilic vein was transposed with gentle distension, avoiding axial rotation.

The brachial arteriotomy was limited to 4 mm, and anastomosis was created using a single 6-0 polypropylene suture in continuous fashion. TBAVFs were allowed a minimum of 3 weeks and a maximum of 6 weeks to mature before cannulation.

Statistical analysis. Survival and cumulative primary patency estimates were determined by the Kaplan-Meier technique (Lifetest, SAS, licensed to Boston University). Comparison of estimates was performed with the log-rank test. The Cox proportional hazards model was used to construct univariate analysis, and χ^2 and Fisher's exact tests were used to compare categorical variables.

RESULTS

For the entire series, there were no operative deaths or fistula thrombosis. The follow-up interval extended to 50 months (mean, 25 months; median, 19 months). A wound infection occurred in one patient with a TBAVF, for an overall incidence of 1.7%. This infection was treated conservatively with culture-specific oral antibiotics and daily wound care and resulted in salvage of the fistula. The 70% rate of nonmaturation for RCAVFs occurred despite observation up to 16 weeks. This rate was significantly greater than that for BCAVFs and TBAVFs (Table I). The seven patients with nonmaturing RCAVFs subsequently underwent creation of a BCAVF (n = 3) or TBAVF (n = 4), whereas the six patients with nonmaturing BCAVFs underwent revision to a polytetrafluoroethylene (PTFE) brachial artery–to–axillary vein arteriovenous fistula.

Primary patency estimates indicated a significant advantage for BCAVFs and TBAVFs at 18 months when compared with RCAVFs ($p < 0.01$). There was no significant difference between patency estimates for BCAVFs and TBAVFs.

Table I. Characteristics of 58 autogenous arteriovenous fistulas created for chronic hemodialysis in 51 patients with diabetes

		Upper arm	
	Forearm (RCAVF; n = 10)	*BCAVF (n = 22)*	*TBAVF (n = 26)*
Mean age (yr)	64	62	59
Female:male	3:7	5:18	10:16
Nonmaturation rate (%)	70	27*	0
Mortality rate (%)	11	22	20
Cumulative patency rate (18-month; %)	33	78†	79†
Prior distal RCAVF (%)	—	13	15
Aspirin (%)	33	10	25
Congestive heart failure (%)	67	44	50
Erythropoietin (%)	67	78	80
History of PVD (%)	22	56	52
Hematocrit level (%)	28 ± 3	28 ± 2	29 ± 3

*$p < 0.05$.
†$p < 0.01$.
PVD, Peripheral vascular disease.

DISCUSSION

Traditionally, the initial approach to vascular access for dialysis has been the creation of an RCAVF, followed by use of more proximal sites. This strategy maximizes the longevity of available fistulas for long-term hemodialysis. In the present study, 10 patients with a history of diabetes underwent creation of an RCAVF, with nonmaturation of the fistula in more than two thirds and an 18-month cumulative primary patency rate of 30%. Although this number of patients is small, a larger series of primary radiocephalic fistulas in patients with diabetes has not been reported. Given these results, it is difficult to justify subjecting additional patients to RCAVF creation when options for durable alternative autogenous fistulas exist.

All patients had a history of diabetes and required exogenous insulin therapy before the development of end-stage renal failure. Although diabetes mellitus is a very well-described cause of glomerulosclerosis, a cause-effect relationship in patients who have end-stage renal failure is problematic. In the majority of cases, a biopsy of the atrophic kidney is of little value in differentiating the cause of renal failure. Recently, the ability to differentiate type I, or insulin-dependent, and type II diabetes using monoclonal antibody determination of antiislet autoantibodies has been demonstrated.[14,15] Such determinations may allow for more precise classification of patients with diabetes who require hemodialysis for end-stage renal failure.

The reasons for nonmaturation of RCAVFs in patients with diabetes remain to be defined. The diameter of the vein at the site of anastomosis, in the present series and in patients without diabetes, was at least 2 mm in all cases of forearm and upper-arm primary arteriovenous fistulas and TBAVFs. Therefore, a smaller-diameter vein could not be implicated in nonmaturing RCAVFs.

It is generally accepted that in patients with a history of diabetes medial calcification develops in distal upper and lower extremity arteries. Although such calcification can be demonstrated with duplex scanning using a 7.5 MHz probe, demonstration of circumferential calcification, which may be hemodynamically significant, remains problematic. In addition, the proximal radial and distal brachial arteries are difficult to image because of their anatomic course. Lastly, intraoperative assessment of the degree of calcification was limited to the 3 to 4 cm segment of artery that was mobilized to create the end-to-side anastomosis. In no case was a calcified vessel encountered that precluded creation of the anastomosis.

It is well established that hemodynamic changes must occur to sustain, and increase flow through, an arteriovenous fistula. Both antegrade and retrograde flow increase toward the low-resistance arteriovenous fistula, resulting in arterial dilatation. Because

patients who have a history of diabetes commonly display medial calcification, this may prevent such dilatation and increased fistula blood flow.

One explanation may be a structural defect in the forearm cephalic vein—although one would expect the same venous architecture in the upper-arm vein—which matures in the majority of BCAVFs. This may also explain the reported decreased primary patency rate of forearm radial artery–to–antecubital vein straight and loop PTFE dialysis grafts (46% at 18 months), resulting in frequent thrombectomy.[16,17]

On the basis of these reports, we have little enthusiasm to create forearm PTFE AVFs in patients with diabetes and prefer construction of a more durable upper-arm autogenous arteriovenous fistula. The technical modifications for creation of TBAVFs described herein include the use of a standardized tunneling device to limit axial rotation, venography, and surgical exposure through a single incision rather than a separate incision for brachial artery exposure, as has been previously described.[11-13] These modifications have resulted in a 1.7% wound infection rate, a mean operating time of 90 minutes (range, 62 to 150 minutes), and minimal forearm venous congestion.

In our experience, RCAVFs in patients without diabetes displayed a 20% nonmaturation rate and an 80% 18-month primary patency rate, which are significantly different than those in patients with diabetes ($p < 0.05$). Of the seven RCAVF failures that were converted to BCAVFs (n = 3) and TBAVFs (n = 4), nonmaturation and 18-month primary patency rates were not significantly different than those for BCAVFs (n = 19) and TBAVFs (n = 22). In addition, our 18-month primary patency estimates of 78% for BCAVFs and 79% for TBAVFs compare favorably with those reported for patients without diabetes (75% at 1 year; 85% at 19 months).[8,12]

Lastly, creation of an autogenous upper-arm hemodialysis fistula as the initial access procedure does not preclude subsequent placement of a PTFE dialysis graft. In the present study, six patients who had nonmaturing BCAVFs underwent creation of an ipsilateral brachial artery–to–axillary vein PTFE AVF. This approach has also been used after failed TBAVFs.[13]

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