Brachial vein transposition arteriovenous fistulas for hemodialysis access

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Background: **An arteriovenous fistula (AVF) is the preferred vascular access for hemodialysis, offering lower morbidity, mortality, and cost compared with grafts or catheters. Patients with a difficult access extremity have often lost all superficial veins, and even basilic veins may be obliterated. We have used brachial vein transposition AVFs (BVT-AVFs) in these challenging patients and review our experience in this report.**

Methods: **The study reviewed consecutive patients in whom BVT-AVFs were created from September 2006 to March 2009. Most BVT-AVFs were created in staged procedures, with the second-stage transposition operations completed 4 to 6 weeks after the first-stage AVF operation. A single-stage BVT-AVF was created when the brachial vein diameter was ≥6 mm.**

Results: **We identified 58 BVT-AVF procedures, comprising 41 women (71.0%), 28 diabetic patients (48.3%), and 29 (50.0%) had previous access surgery. The operation was completed in two stages in 45 operations (77.6%) and was a primary transposition in 13 patients. However, five of these were secondary AVFs with previous distal AV grafts or AVFs placed elsewhere; effectively, late staged procedures. Follow-up was a mean of 11 months (range, 2.0-31.7 months). Primary patency, primary-assisted patency, and cumulative (secondary) patency were 52.0%, 84.9%, and 92.4% at 12 months and 46.2%, 75.5%, and 92.4% at 24 months, respectively. Harvesting the brachial vein was tedious and more difficult than harvesting other superficial veins. No prosthetic grafts were used.**

Conclusion: **BVT-AVFs provide a suitable option for autogenous access when the basilic vein is absent in patients with difficult access extremities. Most patients required intervention for access maturation or maintenance. Most BVT-AVFs were created with staged procedures. Cumulative (secondary) patency was 92.4% at 24 months. (J Vasc Surg 2009;50: 1121-6.)**

The National Kidney Foundation Dialysis Outcomes Quality Initiative (NKF-KDOQI) and the National Vascular Access Improvement Initiative (Fistula First) recommend arteriovenous fistulas (AVFs) as the preferred vascular access for hemodialysis.[1,2] AVFs have lower morbidity and mortality rates in addition to lower yearly Medicare cost profiles compared with grafts or catheters.[3-5] Complex medical illnesses and previous failed access operations leave some individuals with a difficult access extremity, confronting surgeons with obliterated cephalic, median antebrachial, and basilic veins.[6] Brachial vein transposition (BVT) AVFs (BVT-AVF) have been reported in these challenging patients with varying results.[7-14]

We have previously reported our experience with basilic vein transposition AVFs and our initial experience with BVT-AVFs.[11] This report focuses on our subsequent experience with BVT-AVFs and reviews other BVT-AVF publications.

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Competition of interest: none.

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METHODS

After receiving approval for this study from our Institutional Review Board, we analyzed the records of consecutive patients in our vascular access database and identified those who underwent BVT-AVFs constructions by the communicating author (W. C. J.) from September 2006 to March 2009. In addition to a physical examination, all patients underwent preoperative and postoperative ultrasound examination by the operating surgeon.[15]

Most BVT-AVFs were created using staged procedures. Minimum vein diameter for first-stage AVF creation was 2.5 mm, as measured by ultrasound examination with a tourniquet in place. The radial artery was used for inflow when feasible; otherwise, an anastomosis to the brachial artery was created.[6,11,16] Proximal radial artery end-to-side anastomoses were created through a longitudinal incision in the antecubital fossa. When the brachial artery was used for inflow, the size of the anastomosis was limited in relation to the diameter of the brachial artery, minimizing the risk of steal syndrome.[17]

The first-stage AVF was allowed to mature from 4 to 6 weeks before the second-stage transposition of the matured brachial vein was constructed. Patients were monitored in the surgical clinic, and the second-stage transposition was scheduled when the matured outflow vein diameter was measured by ultrasound to be ≥6 mm and flow was ≥300 mL/min.

A single-stage BVT-AVF was created when the brachial vein diameter was ≥6 mm throughout the arm as measured

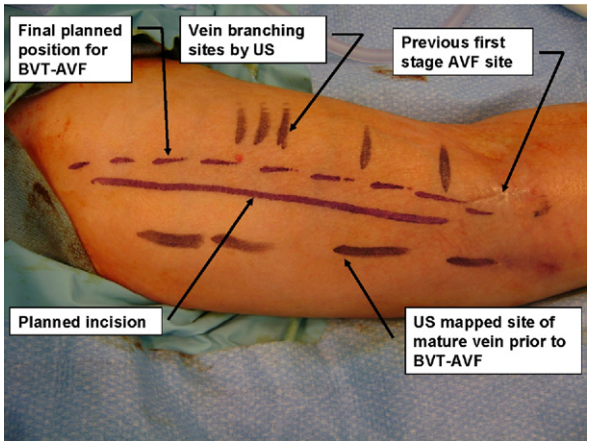

Fig 1. Brief preoperative ultrasound *(US)* mapping by the surgeon confirms the vascular anatomy, surgical plan, and incision site for the brachial vein transposition-arteriovenous fistula (*BVT-AVF*).

by ultrasound. Some of these primary procedures were actually late staged transpositions because the patients had been referred after failed forearm grafts or fistulas resulting in a larger, matured brachial vein.

Paired brachial veins often had a similar diameter at the site of the first-stage AVF creation. The choice of which vein to use was made by the surgeon using ultrasound, selecting the most direct intact channel and largest conduit throughout the upper arm to the axillary vein. This selection made later transposition of the mature vein easier and helped decrease the incidence of developing a dominant outflow channel encircling the brachial artery that would require vein division with an end-to-end reanastomosis later at the second-stage transposition.

The incision for the BVT-AVF was mapped by a brief ultrasound examination by the surgeon in the operating room just before the procedure (Fig 1). A longitudinal incision was used just anterior to the vein position, allowing a more anterior superficialization of the transposed vein for ease of cannulation. The fascia and subcutaneous tissue layers were closed with absorbable interrupted suture before final positioning of the vein. The transposed vein was then placed beneath a narrow subcutaneous flap, just anterior to the surgical incision, 3 to 4 mm deep. Interrupted sutures secured this positioning, thereby avoiding cannulation of the mature vein through the surgical scar. By mobilizing the mature brachial vein throughout the length of the upper arm into the axillary vein, adequate length could be obtained for cannulation, even in obese patients.

We generally allow access cannulation 4 to 6 weeks after transposition. Patent BVT-AVFs in this report could be used with two needles and met the hemodialysis prescription of the nephrologist at the individual dialysis unit.

Primary patency was defined as the time (months) with uninterrupted patency and without intervention. Primary-assisted patency was the time of uninterrupted patency from the original AVF construction where any interventional procedure was necessary. Cumulative (secondary) patency was the period from the original AVF construction where AVF patency was interrupted by thrombosis, with or without AVF salvage, until abandonment of the access or until completion of the study period.[18]

Operations were performed in an outpatient setting of a university-affiliated tertiary medical center. The first- and second-stage operations were both performed with local anesthetic and sedation. The transposition operations also used a regional block anesthetic administered by the surgeon through the axillary portion of the incision immediately on starting the operation with infiltration along the intercostal brachial, medial brachial cutaneous, and medial antebrachial cutaneous nerves. Our goal was to create an autogenous fistula in all patients. CV8 Gore-Tex suture (W.L. Gore and Associates, Flagstaff, Ariz) was used for each vascular anastomosis.

Statistical analysis was performed using Prism 4 software (GraphPad, San Diego, Calif).

RESULTS

We reviewed the records of 914 consecutive patients in our vascular access database. From July 2006 to March 2009, 58 BVT-AVFs were constructed by the communicating author (W. C. J.). Mean patient age was 66 years (range, 17 to 84 years), 41 (71.0%) were women, 28 (48.3%) were diabetic, and 17 (29.3%) were obese. Thirty-one individuals were African Americans, 25 were white, and two were American Indian. Twenty-nine patients (50.0%) had previous access surgery. Mean follow-up was 11 months (range, 2.0-31.7 months). Only seven patients were referred for vascular access before starting dialysis.

The BVT-AVFs were created in staged procedures in 45 individuals (77.6%) and were primary operations in 13 patients. Five of these primary transpositions were secondary AVFs with previous distal AV grafts or AVFs placed elsewhere; effectively, late-staged procedures. In the remaining eight patients, a short basilic vein segment extended the length of the transposed brachial vein conduit. The brachial vein comprised most of the transposed segment in each of these operations.

Mean time to use of staged BVT-AVFs, excluding late-staged procedures, was 3.4 months (range, 2.0-6.4 months). This included time from the first stage AVF construction, creation of the staged transposition 4 to 6 weeks later, and eventual final healing, maturation, and cannulation of the access. Mean time to use of primary BVT-AVFs was 1.8 months (range, 0.8-3.0 months).

Five patients died during the study period, 2.5 to 11 months after the BVT-AVF of causes unrelated to operative or access events. Of the patients with failed or nonfunctional BVT-AVFs, one moved and was lost to follow-up, one changed to peritoneal dialysis, and another declined further surgery and continued with catheter access. Two patients had later successful autogenous access operations in the contralateral arm: one underwent saphenous vein

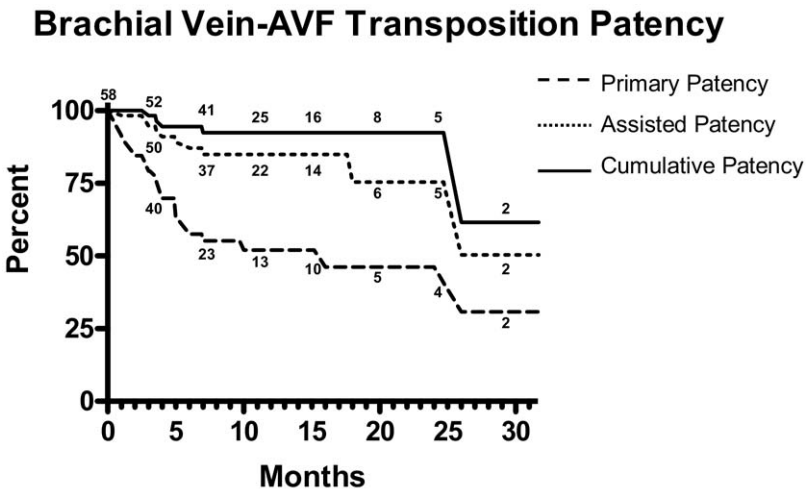

Fig 2. Kaplan-Meier analysis of primary *(dashed line)* assisted *(dotted line)*, and cumulative *(solid line)* vascular access patency shows the number at risk along curves.

translocation AVF and the other, a BVT-AVF. No patient received a kidney transplant.

Central venous stenosis caused postoperative arm swelling in two patients, and both resolved with intervention and functional fistulas were maintained. Arm swelling was not otherwise encountered and has not been a problem specific to BVT-AVFs. One patient presented with dialysis access-associated steal syndrome, which was permanently resolved and the access maintained by a flow-guided banding procedure. There were no wound infections. Two patients had small, superficial wound separations that resolved promptly. Two other individuals had postoperative hematomas that delayed access use but required no specific treatment. No patient required surgery for pseudoaneurysms during the study period.

We strive to use buttonhole access for each BVT-AVF. Our practice includes a broad range of dialysis patients, particularly those with past access failures from other areas and states, explaining the large number of patients who did not have a superficial or even a basilic vein available for construction of an autogenous access.[19]

Eight staged BVT-AVFs required vein division and end-to-end anastomosis because of a brachial vein position beneath a nerve or artery. Staged BVT-AVFs were elevated just anterior to the incision owing to the relatively short length of the brachial vein, allowing the longest cannulation segment possible. Primary transpositions generally had more vein length for a subcutaneous tunnel to be created.

AVFs were created in all patients during the study period, and no grafts were used for vascular access. Proximal radial artery inflow was used in 16 patients. Primary, primary-assisted, and cumulative (secondary) patency rates were 52.0%, 84.9%, and 92.4% at 12 months and 46.2%, 75.5%, and 92.4% at 24 months (Fig 2). Patency rates were similar for both staged and primary BVT-AVFs.

Balloon angioplasty during a diagnostic fistulogram was our preferred and most common method of intervention. Four patients required surgical revision. Access segments requiring intervention included the anastomosis, the body of the transposed vein, and at the swing site or outflow segment. We did not find a single site to dominate the areas of nonmaturation.

DISCUSSION

The use of autogenous access for hemodialysis is broadly supported in the nephrology and surgical literature.[1,2] With the national effort to decrease catheters and grafts, surgeons will increasingly be confronted with challenging chronically ill patients in whom superficial veins are not available. Peripherally inserted central catheters are common and may obliterate basilic veins. Chronic peripheral vascular disease often makes thigh access operations problematic, leaving BVT-AVFs or translocations of saphenous or femoral veins as alternative autogenous choices.

Schanzer et al[7] first reported BVT-AVFs in the English language literature in 2004, describing two patients with successful outcomes. Other reports followed and are outlined in the Table. Consensus papers and review articles have recognized BVT-AVFs as autogenous options when direct AVFs or transpositions of the basilic or cephalic veins are not feasible.[20,21]

Spergel et al[20] and other authors have commented on the quality of the brachial vein compared with the basilic vein, noting the brachial vein to be more fragile and smaller, in addition to having a shorter overall length available for superficialization vs the basilic vein. These observations led some surgeons to use staged transposition procedures rather than primary (one-stage) operations. Overall, staged procedures appear to have been more common and are generally preferred.

In our experience, the brachial vein should be used for vascular access as a staged procedure unless the diameter is ≥6 mm. A brachial vein of this size is often the result of previous access surgery with maturation due to previous AV

Table. Brachial vein transposition reports for vascular access

Communicating author	*Year*	*BVT, No.*	*Primary or staged*	*Study type*	*Outcomes/conclusions*
Schanzer[7]	2004	2	Both primary	Retrospective review; original 2 cases	Both successful at 12 mon
Angle[8]	2005	20	All staged	Retrospective review	95% primary functional patency at 14 mon
Donobantu[9]	2006	33	All staged	Retrospective review	85% overall patency at 3-26 mon (mean, 14 mon)
Elwakeel[10]	2007	21	All staged	Retrospective review	75.89% cumulative patency at 1 year and 55.34% at 24 mon
Stembengh[14]	2008	17	All primary	Retrospective review comparing basilic vs brachial VT	40% functional BVT at 12 mon; this was comparable to basilic VT patency
Angle[13]	2008	42	"Often" staged	Retrospective review comparing BVT vs prosthetic graft	BVT outperformed prosthetic grafts in early referral patients; BVT patency not reported separately.
Jemings[11]	2008	6	All staged	Retrospective review of both basilic and brachial VT	4 of 6 BVTs successful; BVT patency not reported separately
Schanzer[12]	2008	13	11 primary; 2 staged	Retrospective review comparing brachial VT vs prosthetic grafts and basilic VT	Higher complication rate and lower patency for primary BVT

BVT, Brachial vein transposition; *VT,* vein transposition.

flow through the vein offering an opportunity for a secondary AVF.[22] In a previous report, we described our decision to stage basilic vein transpositions based on vein size, reserving primary basilic vein transpositions for those veins >4 mm in diameter.[11] However, owing to a difference in brachial vein quality, length, and depth, we reserve primary brachial vein transposition for those brachial veins >6 mm in diameter.

Harvest of the brachial vein for a BVT-AVF can be challenging. The staged, mature brachial vein is, at times, densely adherent to the brachial artery and adjacent nerves. The vein itself is thinner and somewhat more fragile than a mature basilic or cephalic vein AVF. The brachial vein has more branches, both large and small, often encircling the brachial artery to communicate with the paired brachial vein. In addition, several of these branches are quite short, requiring meticulous division and closure or repair. A brief ultrasound examination by the surgeon before the operation is very useful in clarifying which outflow vein segments make up the largest and preferred conduit. Although we did not record operative times in this analysis, we estimate that BVT-AVF operations may require up to 50% more time to complete than basilic or cephalic vein transpositions.

We included patients in this analysis with a short segment of basilic vein contributing a small portion of the total transposed vein segment. Most often, we found these segmental sections of basilic vein communicated by a large branch into the brachial vein and the major portion of the basilic vein had been obliterated. These complex venous outflow situations are best identified by the operating surgeon during an ultrasound examination.

We do not view an interventional procedure as a surgical failure and immediately obtain a fistulogram if there is any question of access dysfunction. Although we do not have a formal postsurgical screening program, access problems noted in the dialysis unit, such as inadequate inflow, high venous pressures, prolonged bleeding, recirculation, difficult cannulation, and other issues, generate a surgical evaluation and ultrasound examination with a fistulogram and intervention as warranted. Interventional procedures will be necessary in a significant number of patients for maturation and maintenance of a successful fistula.

Limitations of this study include the retrospective design and that a single-surgeon experience is reported.

CONCLUSIONS

Brachial vein transposition AVFs provide a suitable option for autogenous access when the basilic vein is absent in patients with difficult access extremities. Most patients required intervention for access maturation or maintenance. Most BVT-AVFs were created with staged procedures. Cumulative (secondary) patency was 92.4% at 24 months. Harvest of the brachial vein for transposition is challenging and often more time consuming than transposition of other veins.

AUTHOR CONTRIBUTIONS

Conception and design: WJ, MS, KT, TB
Analysis and interpretation: WJ, MS, KT, TB
Data collection: WJ
Writing the article: WJ
Critical revision of the article: WJ, MS, KT, TB
Final approval of the article: WJ, MS, KT, TB
Statistical analysis: WJ
Obtained funding: WJ, MS, KT, TB
Overall responsibility: WJ

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DISCUSSION

Dr Harry Schanzer (*New York, NY*). As Dr Jennings mentioned, we described the use of the brachial vein for AV [arteriovenous] fistula 5 years ago; and 2 years ago we presented and published our experience in a series of 13 patients. We did the procedure in one stage because we had such good results with the basilic vein transposition AV fistula performed in one stage. Our results at 1 year were a primary patency rate of 24%, assisted primary patency of 45%, and a secondary patency rate of 45%. Their outcomes were significantly worse than the ones obtained with AV graft; and therefore, we concluded that this AV fistula, when done in one stage, should not replace an AV graft. Since then, there have been at least two other papers besides the series just presented by Dr Jennings that showed that the use of the brachial vein AV fistula, when performed in two stages, has significantly better results. So I think that a very important message is that if you are going to use the brachial vein as a source for AV fistula, do it in two stages.

I have two questions. You have said that when you have a vein that is larger than 6 mm, you use it in one stage. I would like to know, what is the patency rate in these one-stage procedures? And second, how do you measure the diameter? Do you measure pre-op by duplex? Do you measure it in the operating room when you expose the vein? Do you measure it when you have dilated the vein after it's already exposed?

Dr William C. Jennings. Patency for the primary operations was not significantly different from the staged operations, but the veins were larger. At least half of the few primary transpositions we did were, in effect, late staged, because they had either had a forearm graft or a fistula elsewhere when they came to us. The other primary transpositions were all short segment basilic veins entering a larger brachial vein, but still the main length of the transposed conduit was the brachial vein. We measure the diameter of the vein preoperatively with ultrasound and with a tourniquet in place, and I think that is generally the standard.

Dr Schanzer. I think that this is important. In the basilic vein that enters in the upper arm, that is really, I think, a basilic vein transposition with some proximal brachial vein. The other ones that you are mentioning had already mature brachial vein by the distal AV fistula prior. So I think that the problem with the brachial vein is that it is a different vein than the basilic vein in terms of being very thin, multiple little branches that go around the brachial vein that you have to meticulously dissect. It is very easy to torque the vein when you pass it in the tunnel, and I think that that is why the patency rate is much more inferior than in two stages.

Dr Salaheddine Tomeh (*Phoenix, Ariz*). Are you using the brachial vein for an AV fistula, as a primary choice, in the presence of superficial veins, such as a cephalic vein, or a secondary choice when superficial veins are not available?

Dr Jennings. We use the brachial vein only when all other superficial veins and the basilic veins have been exhausted.

Dr Tomeh. In that situation then, the venous outflow of the whole arm is limited. How much swelling or venous hypertension is created by using the brachial vein?

Dr Jennings. This is a frequent question, and swelling has not been a problem. If you have central venous occlusion or stenosis, as with any access, radiocephalic or anything else, you may have arm swelling. But in the absence of central venous stenosis or occlusion, we don't see significant or long-term swelling. There are the other paired brachial veins, muscular veins, and other venous channels that pick up the outflow.

Dr Joseph Schneider (*Winfield, Ill*). I'd like to just challenge you a little bit more. I have done over 500 transposed basilics in the

last 10 years and I have only had to do transposed brachial fistula three times. I am just curious about how you found so many patients that didn't have an adequate basilic vein, unless you did 5000 transposed basilics.

Dr Jennings. My practice is generally mostly vascular access and we see patients from many different areas that have already had exhausted other sites. I search for a basilic vein in these patients and that is by far my preferred choice. This is generally the final upper extremity option for autogenous access. We just see many of these patients without other vein options.

Dr William Cohen (*Los Angeles, Calif*). This pertains to a staged procedure. When you do the anastomosis, it is important to ligate all the tributaries of the brachial vein in the area. If you do not, and perform an AVG later on because of inadequate brachial vein development, these tributaries may have enlarged, and be difficult to approach because of scar tissue. A significant steal may result.

Dr Jennings. I completely agree with you but for other reasons, too. I try to stay out of the small first-stage operative field, so I ligate all side branches up to where the new incision will be for the transposition 4 to 6 weeks later. You want all the AVF outflow to go into the transposed vein.

Dr Domenico Valenti (*London, United Kingdom*). Can you tell me about the functional patency of your series?

Dr Jennings. These have been functional fistulas and used for dialysis if they are not listed as failures.

Dr Valenti. Can you tell me, what is your mean cannulation time?

Dr Jennings. I don't have that exact number. But we generally allow them to be cannulated at 4 weeks. Some end up being 2 months, but we try to use them promptly. We evaluate the fistula using ultrasound for access flow and vein diameter and mark the vein before they go back to the dialysis unit. So if we can't cannulate the fistula we'll get a fistulogram and intervention if needed.