Keyhole technique for autologous brachiobasilic transposition arteriovenous fistula

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Background: Autologous brachiobasilic transposition arteriovenous fistulas (AVFs) are desirable but require long incisions and extensive surgical dissection. To minimize the extent of surgery, we developed a catheter-based technique that requires only keyhole incisions and local anesthesia.

Methods: The technique involves exposure and division of the basilic vein at the elbow. A guidewire is introduced into the vein, and a 6F “push catheter” is advanced over the guidewire and attached to the vein with sutures. Gently pushing the catheter proximally inverts, or intussuscepts, the vein. Side branches that are felt as resistances when pushing the catheter forward are localized, clipped, and divided under direct vision. Throughout the procedure, the endothelium always remains intraluminal. The basilic vein is externalized at the axilla without dividing it proximally and is tunneled subcutaneously, where it is anastomosed to the brachial artery.

Results: Thirty-two patients underwent the procedure—31 as outpatients. The mean duration of operation was less than 90 minutes. All patients tolerated the procedure well, and 31 required only intravenous sedation and local anesthesia. At a mean follow-up of 8 months, the primary patency rate of AVFs in patients with basilic vein diameters of 4 mm or more on preoperative duplex ultrasonography was 80%, vs 50% for those with vein diameters less than 4 mm. Overall, 78% of patent AVFs were being successfully accessed and 22% were still maturing at last follow-up.

Conclusions: Autologous brachiobasilic transposition AVFs can be created by using catheter-mediated techniques that facilitate the mobilization and tunneling of the basilic vein through small incisions. Medium-term data suggest that the inversion method results in acceptable maturation and functionality of AVFs created with this technique. (J Vasc Surg 2005;42:945-50.)

Hemodialysis access is an important component of peripheral vascular surgical practice. Long-term patency rates for prosthetic dialysis access grafts remain poor. This has provided an impetus for more autologous arteriovenous fistula (AVF) procedures in patients requiring hemodialysis. The National Kidney Foundation Dialysis Outcomes Quality Initiative (NKF-DOQI) guidelines were created in 1997 and updated in 2000 to help physicians best manage their renal-failure patients. These guidelines advise that autologous AVF procedures be performed in the upper arm if forearm veins are unavailable or inadequate. Most surgeons consider the brachiobasilic transposition AVF procedure a major operation that often requires general anesthesia and overnight hospitalization.

We compared techniques for minimally invasive vein harvesting and gained experience with an over-the-wire inversion method for saphenectomy. Histologic comparison of veins harvested by inversion and standard techniques showed similar minimal disruption. The inversion method was adapted to brachiobasilic transposition AVF procedures. The procedure can be performed through small incisions under local anesthesia, and patients can be discharged home on the day of operation.

METHODS

The technique involves exposure and division of the basilic vein at the elbow. A straight, stiff, 0.035-inch, 180-cm-long Glidewire (Terumo Medical Corporation, Somerset, NJ) is introduced into the vein and advanced until the tip is approximately at the superior vena cava/right atrial junction as determined by the length of the guidewire introduced. The guidewire position is secured to the scrub technologist’s Mayo stand by using a nonpenetrating clamp. While the guidewire position is held steady, a 6F “push catheter” (Vein Extraction Catheter; Grove Medical, Portola Valley, Calif) is advanced over the guidewire and attached to the vein with sutures (Fig 1). Gently pushing the catheter proximally over the wire inverts, or intussuscepts, the vein (Fig 2). The endothelium always remains intraluminal throughout the procedure. Side branches that are felt as resistances when pushing the catheter forward are localized, clipped, and divided under direct vision through a single counterincision that is typically made in the upper arm midway between the distal and proximal incisions. Care must be taken to avoid injury to the ulnar nerve in the proximal upper arm where it lies in close proximity to the basilic vein. The basilic vein is exten-
nalized through a short axillary incision without dividing it proximally (Fig 3). Once fully mobilized, the basilic vein is checked for leaks, prepared in the usual fashion, and tunneled subcutaneously, where it is anastomosed to the brachial artery in the distal upper arm (Figs 4 and 5).

A retrospective review was conducted to identify all patients who had basilic vein inversion for AVF creation during the study period. Data collected included patient demographics, operation time, AVF patency and functionality at last follow-up, and complications, including wound problems, arterial steal through the AVF, nerve injury, and arm edema. In the patients who had their basilic veins studied before surgery by duplex ultrasonography, AVF patency rates were compared on the basis of basilic vein diameter. Statistical analysis of patency outcomes was performed by using life-table analysis and comparison of two survival distributions. Statistical significance was defined as a confidence interval greater than 95% ($P < .05$).
RESULTS

Thirty-two patients (17 men and 15 women) underwent the procedure from June 2001 through December 2003. Twenty-three of the 32 patients had preoperative vein mapping by duplex ultrasonography, and only patients who were not candidates for radial-cephalic or brachiocephalic AVFs were treated with the brachiofascial transposition procedure. The patients who did not have preoperative vein mapping had previous arteriovenous (AV) access procedures and were not candidates for a forearm AVF. These patients had either venography as a preoperative study or a fistulogram for maintenance of a previously placed access and were deemed not to be candidates for brachiocephalic AVFs. All patients who underwent the basilic transposition procedure were included so that the learning curve was represented in the study.

All operations were performed with sedation and local anesthesia. All patients tolerated the procedure well, and less than 25 mL of lidocaine 1% was required for anesthesia. The mean operative time was 82 ± 12 minutes.

Thirty-one patients were treated as outpatients, and one was treated as an inpatient as a result of her tenuous anticoagulation status and chronic pain syndrome. This patient was receiving chronic warfarin therapy for thromboembolic complications related to systemic lupus erythematosus. She developed a hematoma that required evacuation on postoperative day 2 as an inpatient, but her fistula remained patent and functioned until she died 9 months later secondary to lupus-related complications. One patient had arm edema that resolved after 2 weeks. Another patient developed a hematoma around the graft while being anticoagulated during dialysis days after the operation, and the graft failed (presumably from compression) and was not salvaged. No patient developed significant arterial steal.

The mean duration of follow-up was 9.1 ± 8.7 months (range, 2-27 months). Nine AVFs failed to mature or occluded and were not salvaged. All failures occurred within 5 months of operation except for one that occurred at 13 months. The mean failure interval from the time of operation was 4.1 ± 3.8 months. Overall, primary patency was 66% (19/32), primary-assisted patency was 69% (20/32), and secondary patency was 72% (23/32). At last follow-up, 20 of 23 patent fistulas were being accessed successfully, and 3 were still maturing. Life-table analysis showed similar primary patency at the fourth postoperative month but showed a trend for the AVFs created with basilic veins 4 mm or more in diameter to have a higher primary patency at 8 months than AVFs created with veins that were less than 4 mm in diameter (80% vs 50%). This difference, however, did not reach statistical significance (P = .74; Fig 6).

DISCUSSION

The keyhole technique for creation of transposition brachiofascial AVFs is feasible and has advantages over the open surgical technique. The minimally invasive nature of this procedure changes it from a major operation that requires general anesthesia to a minor outpatient procedure that can be performed with local anesthesia. Incisions are smaller and less painful. The technique is fairly easy to learn, and a senior general surgery resident with average skills can safely perform the procedure with less difficulty than a standard open transposition procedure. Patent ipsilateral central veins and superior vena cava are obviously necessary for success, and the inversion technique should not be attempted in patients with a history of ipsilateral venous stenting.

We did not quantitate the number of veins divided as part of the retrospective study, but a single short incision midway between the elbow and axilla is adequate for exposing and dividing the venous branches. In the antecubital fossa, the distal incision provides access to the branches superficial to the fascia. The location of a vein branch is noted when resistance is felt as the inversion catheter is pushed forward over the guidewire. Markings on the catheter indicate where the inverted edge of the vein is relative to the point where the basilic vein was initially divided. The catheter tip travels twice the distance of the infolding edge of the vein. This rule helps in determining where to make the midarm incision. Standard retractors such as an Army-Navy or Senn retractor are helpful for exposure purposes. One can clip the side of the vein branch that will remain in the tissue bed and ligate the side that will be inverted inside the basilic vein as the inversion process continues, or if exposure is difficult, it is...
sometimes best to simply clip the side of the vein that will remain and not ligate the side that will invert, with the plan to oversew it once the vein is fully externalized through the axillary incision and pulled back to its original length. The largest branches are the bridging veins that connect the basilic and brachial veins along the subfascial segment of the basilic vein in the upper arm. The total number of tributaries and bridging veins that require exposure and division is typically between 4 and 8. Also of note is a large bridging vein typically present in the axilla that can be divided or left intact, depending on the length of the basilic vein and the course of the superficial tunnel. In our experience, no vein injuries have occurred that have precluded completion of the procedure. Avulsions of small vein tributaries near thin valve sites have required suturing with 7-0 Prolene (Ethicon, Inc, Somerville, NJ); however, with veins 4 mm in diameter or larger, this has been infrequent. The length of basilic vein mobilized is typically between 17 and 23 cm.

The NKF-DOQI guidelines encourage the use of native AVFs over prosthetic AV grafts because of better patency rates with AVFs and the need for fewer interventions to maintain their patency compared with grafts. Native fistulas are also less likely to have infection-related complications. Our experience with the inversion technique is consistent with this, but, as our data suggest, veins with diameters of 4 mm or larger may have a higher maturation rate than previously reported in the literature. At the time of our data analysis, maturing AVFs were an average of 2.4 months from the time of operation. Preoperative duplex scanning is critical for proper patient selection. Because of the better maturation and functionality of the larger-diameter veins, we no longer perform the inversion procedure in cases for which the vein diameter is less than 4 mm. Veins less than 3 mm in diameter are not used. If the basilic vein is between 3 and 4 mm on the preoperative duplex study, a two-stage procedure is planned: the first stage is creation of an AVF between the basilic vein and brachial artery without transposition of the vein to a more superficial plane. The newly created fistula is allowed to mature for 1 to 2 months, after which the diameter is checked again by duplex scanning. If it is 4 mm or more, a second-stage procedure is performed with the inversion technique and transposition. Our experience has shown that maturing AVFs can be divided and inverted just as easily as in the case of the one-stage procedure. We have performed more than 10 two-stage procedures in basilic veins that originally measured between 3 and 4 mm in diameter. In all cases, the vein had enlarged to 4 mm or more throughout its length by the sixth postoperative week. Most patients are able to start dialysis after the AVF is allowed to mature for only 2 months after a one-stage procedure and for one additional month after a second-stage procedure.

Vein mapping to identify tributaries and bridging veins is an interesting concept; however, we have not done this routinely, even though we always require duplex scanning to identify candidates for the inversion procedure. The added information would not likely change how we perform the procedure, because we would still make a mid- to upper-arm incision to divide the tributaries, and the appropriate location of the incision is determined easily by noting the catheter markings at the level where the vein was originally divided.

In recent years, widespread recognition of the NKF-DOQI guidelines has generated a trend toward more native AVFs and fewer prosthetic AV grafts. Most hemodialysis patients have basilic veins large enough for the transposition AVF procedure. It is the authors’ opinion that a brachiobasilic transposition AVF should be created for hemodialysis access instead of placing a prosthetic AV graft if the basilic vein is of good quality and 4 mm or more in diameter.

REFERENCES


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DISCUSSION

Dr Willis Wagner (Los Angeles, Calif). Dr Hill and colleagues from Stanford have presented their experience with a novel technique for basilic vein transposition. Using minimally invasive technology, they have converted a moderately large operation, which is typically performed under general anesthesia, into an outpatient procedure under a local anesthetic. Standard open transposition is associated with a significant incidence of wound complications. The Stanford approach has obvious appeal, particularly since basilic transposition has consistently been the most common autogenous fistula created in our practice over the last 5 years. Their mean operative time of 82 minutes compares favorably to open operations, which vary between 1 and 2 hours depending on the size of the upper arm. My first question is, does the size of the arm influence the time or difficulty of your procedure?

Minimally invasive saphenous vein harvest has been performed for more than 10 years. However, vascular surgeons have not universally adopted this technology. This is probably due to a combination of the time involved and concerns about injuring the conduit. You have demonstrated that your elegant technique does not prolong the procedure. However, have you encountered any vein injuries that you feel may have contributed to graft failure?

At the confluence of the basilic and brachial veins, the distal brachial vein and several large penetrating collateral veins must be divided. Because there is considerable variability in the upper arm anatomy, do you use ultrasound to assist you in placement of the counterincision in the mid arm?

In your manuscript, you appropriately emphasize the importance of vein diameter for the long-term success of the procedure. However, the method of statistical comparison is inappropriate. The patients with vein diameters greater than or equal to 4 mm had a primary patency rate of 81% at a mean follow-up of 8.2 months. This was compared with a patency rate of 28% with smaller veins at a mean follow-up of 16.4 months—twice the follow-up of the comparison group. Although the conclusion is likely correct, the comparison of patency rates should be made between groups with a similar duration of follow-up, preferably by life-table analysis.

Because of your poor results with veins less than 4 mm in diameter, you advise a two-stage procedure with smaller veins. Recognizing that the basilic vein is frequently not uniform in caliber and that it may be relatively small for a short distance at the antecubital fossa, how do you determine whether to transpose in one or two stages? Do you rely solely on vein mapping or on intraoperative exploration of the vein?

It is difficult to find something I didn’t like about this technique. There are apparent benefits in terms of cost, discomfort, and operative risks. I want to thank the Stanford group for sharing their experience with a technique I hope to offer my patients soon.

Dr Hill. The size of the arm does influence the difficulty of the procedure, because in the obese arm, a longer vein is required for tunneling purposes and to give the dialysis technicians enough length of fistula to cannulate. I believe that the obese patients probably do benefit more from the inversion procedure than thinner patients because they are more at risk for wound complications when a long incision is made.

Your second question was about vein injuries and have they contributed to graft failure. Early on we did see problems, which was the reason we decided not to use the inversion technique in patients who have basilic veins less than 4 mm in diameter on the preoperative duplex. We obtain preoperative vein mapping on all patients, and if the basilic vein is less than 3 mm, we do not use it at all. If the vein diameter is between 3 and 4 mm, we perform a two-stage procedure that involves creating the brachio-basilic fistula just distal to the elbow and allowing it to mature for 4 to 6 weeks. We then obtain another duplex study, and if the vein diameter has increased to 4 mm or larger, we then proceed with the second stage, which involves dividing the vein, inverting it for mobilization, tunnelling the vein in a more superficial plane, and, finally, reanastomosis. Thus far, we have found the two-stage procedure to be a good alternative in patients who have basilic vein diameters between 3 and 4 mm.

You asked if we use ultrasonography for deciding where to make incisions intraoperatively. I prefer to use a pencil Doppler for mapping out the location of the basilic and antecubital veins for incision purposes. I give the forearm a squeeze and note where the veins are by listening to the Doppler signals. Another useful way to locate vein tributaries and collaterals involves the catheter markings. The catheter has marks that indicate how far the tip of the catheter is from the starting point. It is important to remember that the in-folding edge of the vein will always be one half the distance from the starting point to the catheter tip. With that information, you know precisely where to make the counterincision. A midarm counterincision is usually all that is required to gain access to all the tributaries and collaterals.

With regard to the statistical analysis, I agree that a life-table comparison could be done; however, the numbers in this retrospective study are small and probably inadequate for making definitive conclusions. We definitely see a trend in our data, which makes logical sense, with the larger veins having a higher patency rate over time than the smaller veins.

Dr Moneta. Brad, I have one comment and then a question. My late partner used to say that with a little effort there is almost nothing in vascular surgery that can’t be made more efficient than it has to be. It seems like the main reason for suggesting this is getting these patients to have an outpatient procedure under local anesthetic, but I am a little concerned that the picture that you showed prominently several times may underestimate the amount of incision that you are actually saving. I mean, how often do you have to make more than one counterincision to find the veins? What would keep you from just doing a regular technique under local if you just wanted to give a little bit more lidocaine?

Dr Hill. Typically this procedure requires one distal incision through which the basilic vein and brachial artery are mobilized, a single counterincision between the elbow and the axilla that typically is about 1.5 cm or 2 cm in length, and one short axillary incision. The main advantage of the small incisions is that not very much lidocaine is required, usually less than 25 mL of lidocaine 1%.

Another important aspect worth mentioning is the ease with which the basilic vein tributaries and collaterals can be located because the guidewire is passing through the center of the vein. Using a finger to blindly feel the guide wire will lead directly to the tributary or collateral that needs dividing. This makes hunting for the vein relatively easy through the small incisions.

Dr James Watson (Seattle, Wash). One of the tenets of hemodialysis access surgery is not to use up venous capital. Our principle is before we will go to an upper arm basilic vein transposition, we will do a synthetic loop in the forearm rather than perform an AV fistula at the elbow. Argue why you would not perform a synthetic loop in the forearm in order to mature the vein in the upper arm, as well as providing usual access until that access then occludes. Our principle is that once that graft occludes, if the upper vein has matured we just go right then to basilic vein transposition in the upper arm. My question is, rather than performing an AV fistula at the elbow, why not just use a synthetic graft in the forearm?

Dr Hill. The DOQI guidelines address that question. According to DOQI, the third choice for preference of access placement is either a loop AV graft in the forearm or a basilic vein transposition AV fistula. My feeling is that the reason there are two options is because the basilic vein transposition historically has
been an operation of much larger magnitude than the other AV fistula procedures. If the procedure is less invasive, then it becomes more attractive and preferable, in my opinion, to putting a graft in the forearm because of the lower patency rate and risk of infection with prosthetic grafts.

Dr Jerry Chen (Vancouver, BC, Canada). I enjoyed your paper very much. I was wondering if you have had any experience using a vein-harvesting scope to try to minimize the number of incisions with your technique.

Dr Hill. I have not tried using an endoscope to minimize the number of incisions. I think it is not an unreasonable idea; however, the more complex the procedure, the more cumbersome and difficult it becomes. So it may be worth looking into, but the procedure must be kept relatively simple.