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Creation of secondary AV fistulas from failed hemodialysis grafts: the role of routine vein mapping

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Abstract: Pre-existing forearm grafts lead to dilatation of upper arm veins of the ipsilateral arm that greatly facilitates the creation of secondary arteriovenous fistulas (AVF). In this retrospective review of 18 patients, the routine and periodical revision of failed grafts were discontinued. Vein mapping by physical examination or Duplex studies was performed prior to graft failure and a secondary AVF was created when the graft failed. Using this management strategy, an AVF creation success rate of 95% was achieved despite high incidence of co-morbidity factors within the patient population. This success rate demonstrates the value of vein selection by vascular mapping prior to graft failure and early vascular access planning in the successful creation of secondary AVF. (J Vasc Access 2007; 8: 91-6)

Key words: *Arteriovenous fistula, Hemodialysis vascular access, Quality improvement program of vascular access, Hemodialysis graft, Hemodialysis catheter*

INTRODUCTION

The types of permanent hemodialysis vascular access currently in use are the native arteriovenous (A-V) fistulas, the polytetrafluoroethylene (PTFE) A-V grafts and the tunneled dialysis catheters. Multiple published studies have shown that the fistulas have superior four-to-five-year patency rate and require fewer interventions compared to grafts and catheters (1, 2). During the early 1990s, the use of AVFs declined in the United States (3). Although during 1997 through 1999, there was some increase in the percent of AVF procedures (from 29% in 1997 to 36% in 1999) (4), there remains need for improvement. Data from the 2003 Annual Report of the ESRD Clinical Performance Measurements Project compiled by the Centers of Medicare and Medicaid Services showed that only 27% of incident and 33% of prevalent HD patients were receiving dialysis using an AVF at the end of 2002 (5). The National Kidney Foundation Dialysis Outcomes Quality Initiative (DOQI) Clinical Practice Guidelines workgroup recommended an AVF placement goal of 50% in all new patients, with an ultimate AVF prevalent rate of 40%. The Olympia (Washington) multidisciplinary vascular access team implemented a number of steps which resulted in the total elimination of graft use in our hemodialysis practice by the year 2000 (6). The vascular access team decided to stop routine revision of failed grafts and to facilitate secondary AVF placement when a graft failed. There was no prior literature regarding the success of grafts to AVF conversion.

METHODS

Medical records of 18 patients undergoing graft to secondary AVF creation between 1996 and 2000 were reviewed retrospectively. Data collection included patient co-morbid factors, vein mapping results, categories of AVF surgeries, success rates, and any ischemic complications. Prior to graft failure, routine monthly vein mapping by physical examination with and without a tourniquet was done in all patients with AV grafts by a single nephrologist. Out-

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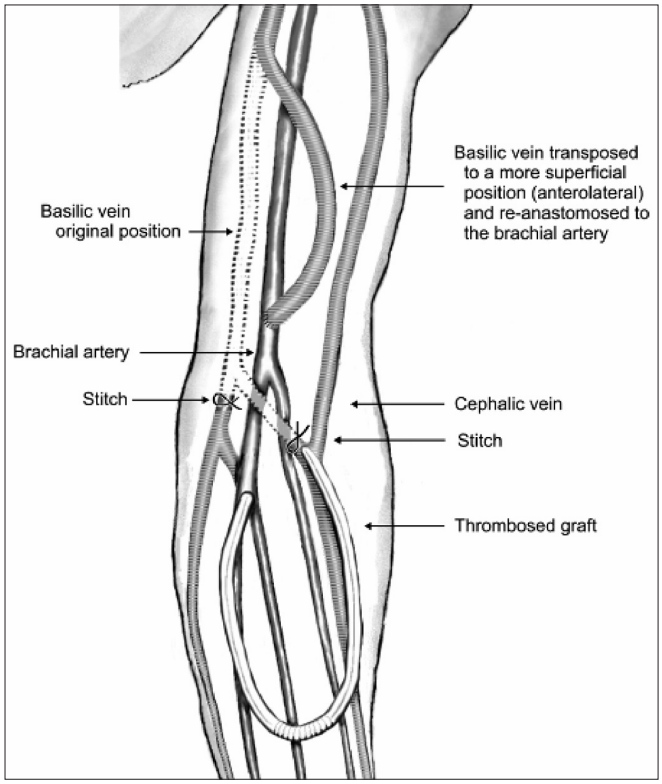

Fig. 1 - ***Secondary transposed brachio-basilic AV fistula-left arm.***

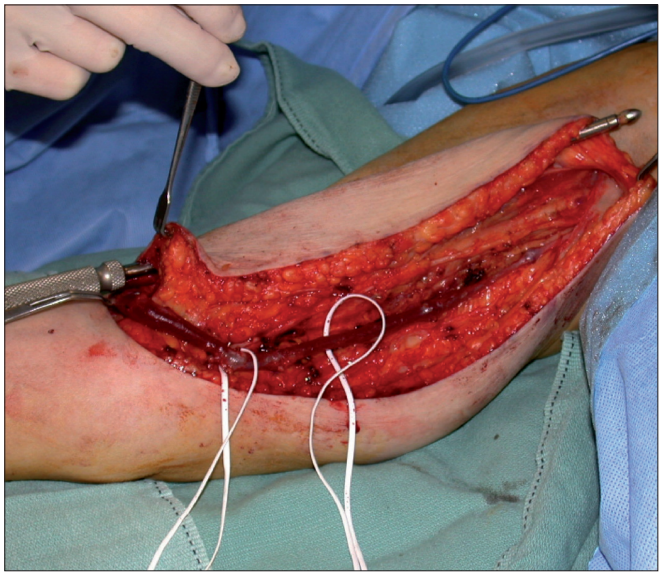

Fig. 2 - ***Detail of transposition procedure. Operating room picture of a right arm primary transposed brachio-basilic AV fistula.***

flow veins, mostly upper arm cephalic and basilic veins were identified if they were superficial enough. Ink marks were made on each side of the veins at three locations along the length of the vein. External vein diameter was measured with a ruler and average diameter was calculated. All measurements were done without using a tourniquet. Occasionally, a forearm cephalic vein was adequately dilated by the forearm grafts and could be used for AVF creation. However, many patients had no superficial veins noted during routine physical examination. In these patients, duplex mapping was conducted to measure the diameter of arm veins and their depth below the skin. Duplex mapping was done by a single vascular ultrasound technologist. Criteria for veins suitable for AVF creation included a minimum vein diameter of 2.5 mm. Vein transposition was indicated for veins located at a depth of 10 mm or more below the skin. For each patient with a graft, the nephrologists created a written long term access planning (Appendix: Dialysis Patient Vascular Access Planning). The access plan was updated monthly and was made available to all members of the vascular access team. Secondary AVF creation was done only when the AV graft failed. When grafts thrombosed, they were no longer revised. The nephrologist called the vascular surgeon for a secondary AVF placement within 72 hours with application of data from the patient's long term care plan. The same two vascular surgeons performed all the surgeries. In patients with a superficial upper arm cephalic vein which could be cannulated immediately after surgery, AVF surgery was done electively before total graft thrombosis: i.e. when the graft showed the following clinical signs of impending failure: the presence of venous pressure higher than 100 at the blood flow rate of 200 ml/min, water hammer pulse instead of access thrill on palpation, difficulty with cannulation and prolonged bleeding from access puncture sites after completion of dialysis.

The following are brief descriptions of surgical procedures for creation of secondary upper arm AVF from forearm grafts:

1. Brachio-basilic AVF with transposition (Fig. 1): an incision is made along the upper arm basilic vein. The collateral veins are ligated. A subcutaneous tunnel is created anterolaterally to the incision site with a tunneler (Fig. 2). The distal end of the vein is transected at the antecubital level if appropriate. The vein is mobilized and pulled through the tunnel with the help of the tunneler. After the anastomosis to the brachial artery, the incision is closed.

2. Brachio-cephalic AVF

a. without transposition: In case the graft is still partially patent (Fig. 3), a 2 cm segment of the venous end of the graft is resected; the new end of the graft is closed with a suture. The distal end of

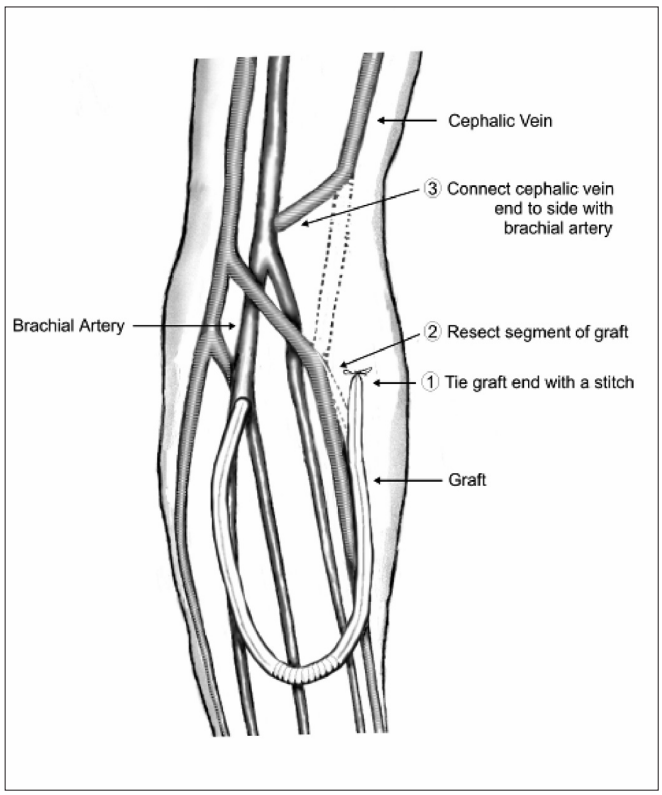

Fig. 3 - ***Secondary brachio-cephalic AV fistula-left arm, without transposition.***

TABLE I - PATIENT DEMOGRAPHICS AND CO-MORBID FACTORS

Age: 69.9 (SD 8.1)
Sex: 56% female
44% male
Co morbid factors:
Diabetes mellitus: 66.6%
Ischemic Cardio-vascular diseases: 83.3%
coronary artery disease 61%
stroke 44%
limb ischemia 50%

TABLE II - TYPES OF FISTULA CONVERTED FROM GRAFTS*

Radio-cephalic: 5.6%
Brachio-cephalic: 55.6%
Brachio-basilic: 38.8%

*Remark: 50% of all fistulas were transposed

the upper arm cephalic vein is transected, mobilized and anastomosed to the brachial artery. If the graft is completely thrombosed, the distal end of the upper arm cephalic vein is transected and mobilized and anastomosed to the brachial artery
b. with transposition: an incision is made along the deep seated cephalic vein. The vein is dissected and its collateral veins are ligated. A subcutaneous tunnel is created away from the incision with a tunneler. The distal end of upper arm cephalic vein is transected. The vein is mobilized and pulled through the tunnel with the help of the tunneler. After the anastomosis to the brachial artery, the incision is closed.
If the vein was superficial and could be cannulated within 24 hours, no hemodialysis catheter was needed. If the surgeon was not available at the time of the graft thrombosis, a temporary catheter was used till surgery. However, a tunneled catheter was placed before or at the time of surgery if transposition of the deep vein was needed. Whenever possible, catheters were placed in the internal jugular vein, contralateral to the prospective fistula placement site.

RESULTS

This group of patients had severe co-morbid factors which would tend to affect adversely the success of AVF placement (Tab. I): older age and diabetes mellitus. A majority (83.3%) had ischemic vascular diseases (coronary artery disease, stroke, or limb ischemia). Many patients had multiple ischemic vascular diseases: 11% had all three, 50% had two of the above-noted diseases.
Half of all patients in the study required Duplex mapping. The diameter of the preoperative outflow basilic and cephalic veins as measured by Duplex or physical exam was 4.8 mm (SD 1.1) prior to graft thrombosis.
A total of 18 AVF were created. Number of surgical procedures: 18. 95% of AVFs were used successfully for dialysis. One AVF (brachio-cephalic) developed early stenosis, 2 cm above the anastomosis which was diagnosed by physical examination and confirmed by a Doppler study. A surgical revision (vein bypass graft) was performed. The AVF restenosed within 4 weeks and did not mature when patient died 3 months later from an ischemic coronary event. The definition of fistula creation success is its satisfactory use over the patient lifetime or till final fistula thrombosis to provide adequate blood flow rate (usually between 300-400 ml/minutes) and adequate dialysis dose as defined by the National Kid-

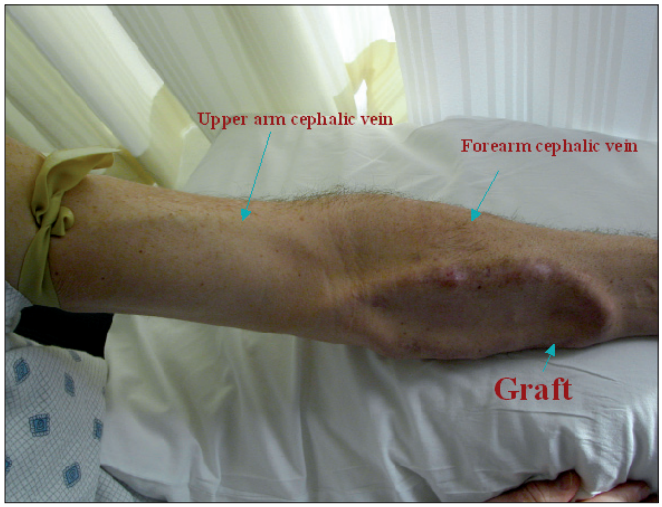

Fig. 4 - ***The presence of a forearm graft has lead to large superficial upper arm and forearm cephalic veins. After the graft fails, a secondary brachio-cephalic AVF could be placed and used immediately after surgery without the need of transitional dialysis catheter. Alternatively, a distal radio-cephalic vein could also be placed.***

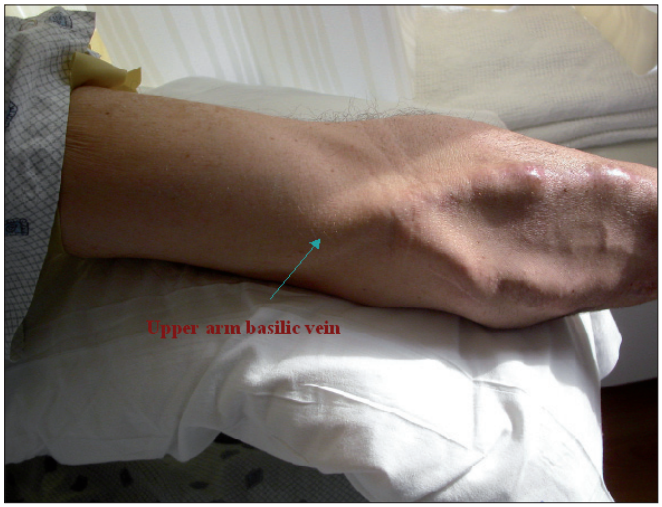

Fig. 5 - ***The presence of a forearm graft has lead to large superficial upper arm basilic vein. After the graft fails, a secondary transposed brachio-basilic AVF could be placed and used 2 months after surgery. A transitional tunneled dialysis catheter will be needed.***

ney Foundation DOQI Guidelines on Adequacy of dialysis dose. A large majority of the AVF (Tab. II) were created from forearm grafts, only 1 case from an upper arm graft. All secondary fistulas, except for one, were upper arm AVF, either brachiocephalic or brachio-basilic, reflecting the arterialization of upper arm outflow veins by forearm grafts. In fact, a review of all patients (total 49) on hemodialysis during the study period shows that both secondary and primary AVF were also predominantly upper arm AVF: 64.6% (6). In elderly, ischemic patient population like ours, distal radio-cephalic AVF is only possible in a minority of patients.

Mean time to successful cannulation was 34.1 days (SD 25, range: 1 to 56 d) after its placement. Five non-transposed brachiocephalic AVFs were successfully cannulated within 1 day of their placement. The criteria for early cannulation were subjective. Both the dialysis staff and the nephrologist performed physical examination of the veins before and after surgery and reached the early cannulation decision by consensus based on how superficial the veins were. The predictive value by physical examination by experienced staff was excellent: 5 out of 6. First time cannulation blood flow rate was limited to 200 ml/minute using 17 gauge needles. Needle size and blood flow rate were increased gradually to 15 gauge and up to 400 ml/minute.

Steal syndrome was present in 18% of all fistulas and was successfully treated with vein banding proximal to the anastomosis. None required ligation of AVF.

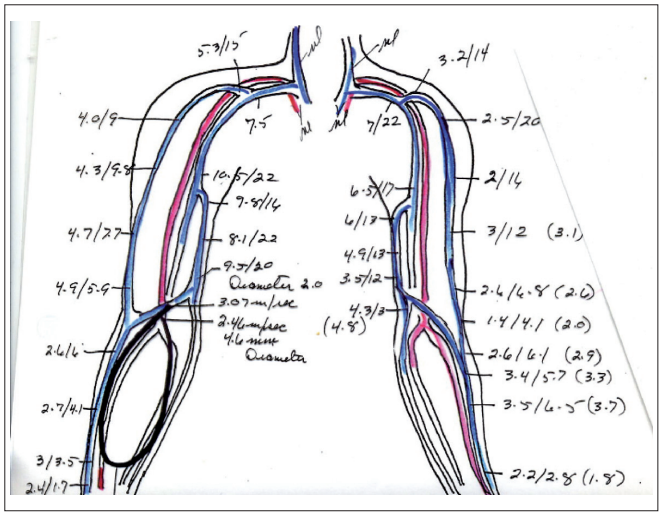

Fig. 6 - ***Doppler mapping of a 72-year-old female patient.***
The first number indicates vein diameter in mm, the second one vein depth. The number in parenthesis indicates vein diameter after compression by a tourniquet.
The presence of right forearm loop graft (drawing in black) has caused significant dilatation of the upper arm cephalic and basilic veins up to 100% as compared with the left upper arm veins.

DISCUSSION

The presence of a forearm PTFE graft may offer a great opportunity to create a secondary proximal AV fistula. The upper arm cephalic and basilic veins are often well arterialized by the presence of the AV

graft and may be dilated well enough for the successful placement of brachiocephalic (Figs. 4-6) or brachiobasilic AV fistulas. Outflow vein diameters averaged 4.8 mm. Since mature AVF is defined as having a diameter of at least 4 mm (7), these veins were already matured before AVF surgery. In fact, the success of AVF creation depends on vein size, with minimum diameter of 2.2 mm in one study (8) and the ability of the arterial and venous vessels to dilate under the influence of the increased shear rates (vessel remodeling) (8).

In addition, higher arterial blood pressure and flow rate (brachial artery) allow a more rapid maturation of antecubital AVF and higher maturation rate compared with distal radiocephalic AVF (9, 10).

Pre-Access failure Vein Mapping plays a critical role in AVF creation from failed grafts. Vein Mapping can be done by careful and periodical physical examination. However, physical exam alone was inadequate in as many as 50% of patients in our experience. These patients did not have a suitable superficial vein due to obesity or to the nature of the vein. Most upper arm basilic veins required Duplex mapping since they run a superficial course only along the lower part of the upper arm then dive deep inside to join the deep brachial vein. The measured length of the basilic vein must be adequate to allow its transposition to a more superficial position in the antero-lateral position of the upper arm. Doppler may also detect vein stenosis prior to surgery and improve surgical outcome or influence the choice of blood vessels. Doppler vein mapping is also important in other investigators' experience (11-13), especially in patients at risk of maturation failure: diabetic, elderly, peripheral vascular disease, obese etc. Pre-op physical examination alone failed to identify suitable veins for AVFs in 58 patients out of a total of 108 patients in one study (11). Indeed, pre-op Doppler assessment of vessels reduced early failure of AVFs significantly, from 36% to 8.3% (11). Duplex US is the most efficient method to assess vein diameter, depth, and integrity. In addition, more recent research suggests that artery size and function study by Doppler are equally important (8). Our team now use Duplex mapping of arm veins and arteries in all patients with high co-morbid factors, even in those with apparently adequate superficial veins.

It is important that vascular access management plan (graft to AVF creation plan) be made long before grafts show any signs of failure and be available to the whole team at all time since graft may thrombose when the primary nephrologist is not on call. After the graft thromboses, the arterialized upper arm veins may collapse due to decreased intravenous pressure and blood flow rate and may no longer be prominent even on venogram or Duplex study. Therefore, the on call team may not be able to intervene without the vascular access management plan of that particular patient.

Steal syndrome was not a major issue (18%) despite high risks of ischemia in this group of patients with multiple comorbid factors. The AVF anastomosis size was kept small (less than 4 mm) and distal arterial flow monitored with Doppler during surgery. Those patients with steal syndrome underwent successful vein banding proximal to the anastomosis and did not require ligation of the AVFs.

The very high success rate of secondary AVF creation in this study despite high patient co- morbid factors suggests that pre graft failure vein mapping either by physical exam or by Doppler may play a primary role in the successful secondary AVF creation from failed grafts. However, the present investigation is not a controlled study, and the patient population size is small, all with high co-morbid factors. The findings of this study will require confirmation by future randomized studies involving a larger patient population with a greater spread of co- morbid conditions. Of note, Fistula First Initiative has also recommended the routine creation of secondary AVF from failed grafts (www.FistulaFirst.org).

Finally, we do not recommend routine placement of grafts in order to convert them later into secondary AVF. Since we establish a collaborative multidisciplinary vascular access team in our program to promote early referral of kidney patients to nephrology service, preservation of arm veins, routine use of Duplex mapping and innovative surgical strategies, we no longer use graft in our patient population despite the high incidence of co-morbid factors (6).

CONCLUSION

Pre-existing grafts lead to arterialization and dilatation of veins in ipsilateral arm and facilitate greatly the creation of secondary AVF. The surgical success rate was 95% in our experience despite high incidence of morbidity factors among our patients. The AVF success rate was dependent upon effective vein selection for AVF creation done prior to AV graft failure and upon the development of an individualized long term vascular access plan which was available to all members of the vascular access team.

ACKNOWLEDGMENTS

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APPENDIX:

COPY OF DIALYSIS PATIENT VASCULAR ACCESS PLANNING

VASCULAR ACCESS CHECK LIST

Patient Name:

Nephrologist:

Primary Care Physician:

Previous or Current access: Date:

Vein mapping: date:
best vein: size: Depth:
2nd best vein: size: Depth:

Surgeon: Appointment date:

Surgery Plan A:

Surgery Plan B:

Tunneled catheter needed:

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