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Conversion of tunneled hemodialysis catheter–consigned patients to arteriovenous fistula

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Objective. Despite their high incidence of complications, costs, morbidity, and mortality, nearly 27% of the chronic hemodialysis (HD) patients are receiving treatment via a tunneled hemodialysis catheter (TDC).

Methods. In this prospective analysis, an interventional nephrology team employed an organized program consisting of vascular access (VA) education and vascular mapping (VM) to TDC-consigned patients. A full range of surgical approaches for arteriovenous fistula (AVF) creation, including vein transpositions, was exercised. Physical examination was performed every 1 to 2 weeks after surgery to assess the development of the AVF. Fistulas that failed to develop adequately to support HD (early failure) underwent salvage [percutaneous transluminal angioplasty (PTA), accessory vein obliteration (AVL)] procedures.

Results. One hundred twenty-one TDC-consigned patients received VA education. Eighty-six (71%) agreed to undergo VM. Two groups were identified. Group I ($N = 66$; using TDC for 7.2 ± 1.8 SD months) had never had an arteriovenous access; group II ($N = 20$; using TDC for 12.3 ± 4.0 months) had a history of one or more previously failed arteriovenous accesses. Upon VM, 64/66 (97%) in group I and 18/20 (90%) in group II were found to have adequate veins for AVF creation. Seven patients (11%) in group I and 3 (17%) in group II refused surgery. In group I, 57 (89%) received an arteriovenous access (radiocephalic AVF = 15, brachiocephalic AVF = 35, transposed brachiobasilic AVF = 3, brachiobasilic AVG = 4). In group II, 15 (83%) received a transposed AVF (radiobasilic = 2, brachiobasilic = 13). Sixteen fistulas (30%) in group I and 8 (53%) in group II had early failure. All except for one fistula in each group were salvaged using PTA and/or AVL. All 70 accesses (AVF = 66, AVG = 4) remain functional, with a mean follow-up of 8.5 ± 3.6 months.

Conclusion. These results demonstrate that an organized approach based upon a comprehensive program utilizing VA counseling, VM, application of full range of surgical techniques, and salvage procedures can be very successful in providing optimum vascular access to the catheter-dependent patient.

Key words: tunneled dialysis catheter, arteriovenous fistula, immature fistula, fistula salvage, interventional nephrology.

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The National Kidney Foundation-Dialysis Outcomes Quality Initiative (NKF-DOQI) guidelines for vascular access discourage the use of tunneled dialysis catheters (TDCs) as long-term access for hemodialysis [1]. Although these guidelines state that less than 10% of the chronic dialysis patients should be maintained on tunneled dialysis catheters [2], recent data have emphasized that up to 27% of the end-stage renal disease patients in the United States are using TDC as their permanent access [3, 4]. Of particular concern is the fact that the use of TDCs as permanent dialysis access is steadily on the rise, with placement rates having doubled since 1996 [3]. A variety of factors are responsible: the lack of vascular access counseling, delays in referral of patients with advanced chronic kidney disease to nephrologists, lack of timely surgical placement of an arteriovenous access (fistula/graft), the logistic ease of inserting a vascular catheter that is immediately available for use as compared to the difficulties and delays associated with the successful creation of an arteriovenous access, as well as patient choice of a TDC owing to fear of pain associated with needle insertion into arteriovenous accesses and cosmetic concerns [1, 3, 4]. Another critical factor contributing to the increasing use of TDCs is the eventual exhaustion of the traditional vascular sites for creation of arteriovenous fistula in long-term hemodialysis patients who have suffered multiple failed arteriovenous accesses.

Compared to arteriovenous accesses, TDCs are associated with lower blood flows, increased incidence of local and systemic infection, development of central venous stenosis and thrombosis, and increased morbidity and mortality [1, 6, 7]. It is for these reasons that NKF-DOQI vascular access guidelines have recommended that all end-stage renal disease (ESRD) patients initiating hemodialysis should be aggressively educated about the risks and benefits associated with catheters, and strongly encouraged to allow the creation of an arteriovenous fistula (AVF) where appropriate [8]. In keeping with this focus, the National Vascular Access Improvement Initiative ("Fistula First") also mandates that whenever possible, an AVF should be placed in patients using tunneled hemodialysis catheters [9].

The purpose of this study was to determine the impact of aggressive vascular access education, vascular mapping, and endovascular interventions offered by interventional nephrologists, as well as the application of full range of appropriate surgical techniques on the creation of AVFs in patients consigned to TDCs.

METHODS

Out of a total of 355 ESRD patients from the three University of Miami chronic hemodialysis centers, 121 were identified that had used a TDC for more than 3 months without a future plan for surgical creation of an arteriovenous access, and were enrolled in this prospective analysis. Eighteen patients had been receiving dialysis using a TDC for less than three months and failed to meet the inclusion criteria.

A team approach composed of the primary nephrologist, vascular access nephrology nurses, nurse practitioner, interventional nephrologist, and renal fellows on the interventional service was employed. A slight change in the traditional surgical venue was made. A surgeon was selected who was committed to the principals of the "Fistula First" project [9], was familiar with the impact of the basic principles of vascular access on dialysis outcomes, offered the full range of appropriate surgical approaches for AVF placement, including vein transpositions, and was willing to work with the nephrology team to provide optimal vascular access care. Regular communication was established between the surgeon and the nephrology team by telephone meetings.

Vascular access education

Based on NKF-DOQI guidelines [1], patients were educated regarding vascular access types and their associated complications, including the risk of morbidity and mortality. Specifically highlighted for TDCs were local and systemic infectious complications, catheter-related central vein stenoses and thromboses with consequent preclusion of future arteriovenous access creation in the upper extremities, the impact of low catheter flows on dialysis adequacy, and the increased overall morbidity and mortality. The AVF was highlighted as the best available access with the lowest incidence of complications. Better access and patient survival for an AVF was emphasized. Patients were encouraged to request the creation of an AVF at their appointment with the surgeon.

Vascular mapping

To investigate the possibility of creation of an arteriovenous access, both venous and arterial evaluation was undertaken by means of vascular mapping (VM).

Vein mapping using venography was offered and performed by the interventional nephrologist. Briefly, after obtaining informed consent, a peripheral vein on the dorsum of the hand was cannulated. Low osmolarity contrast medium (Isovue 370; Bracco, Minneapolis, MN, USA) (10–20 mL) diluted with 10 to 20 mL of normal saline was injected through the cannula. Fluoroscopy was performed using the pulse (15 frames per second) and road map feature (15 frames per second). A tourniquet was not applied to distend and enhance the size of the veins. All angiograms utilized in this study were obtained using a fluoroscopy machine (GE 9800, GE Medical Systems, Milwaukee, WI, USA) calibrated for measurements using a radiopaque ruler. Images were obtained from the wrist veins to the right atrium. The criteria used to determine suitability of veins was based on a prior benchmark study [10], and included vein size of at least 2.5 mm, absence of stenosis within the vein, and continuity with downstream patent veins. Vein mapping was performed on both upper extremities. Peripheral as well as central veins were evaluated for all patients. A stenosis equal to or exceeding 50% compared to normal adjacent vessel was considered as significant stenosis based on K-DOQI guidelines [1].

The arterial system was evaluated using the recommendations delineated by the NKF-DOQI vascular access guidelines [1]. A detailed physical examination of the arterial system, including blood pressure, arterial pulses, capillary refill, and the Allen test in both extremities was performed as described previously by Beathard [11]. Specifically required were a blood pressure differential of $\leq$20 mm Hg and a negative Allen test (patent palmar arch). Neither arteriography nor Doppler ultrasound determination were performed.

Upon conclusion of the venous imaging, the fluoroscopy monitor was placed in front of the patient for viewing of the venography images. Using lay terminology, the venography findings were described to the patients as they were educated about possible site(s) for fistula creation. Patients found to have patent veins suitable for an arteriovenous access were referred to the vascular surgeon. A detailed report was sent to the vascular surgeon that included venogram images, as well as recommendations for possible site(s) of access creation. During phone communications with the surgeon, the venogram images were discussed, the need for arteriovenous access creation was emphasized, and the creation of an AVF was requested in every case.

Postsurgical follow-up

After surgical creation of the arteriovenous access, patients were followed carefully by the interventional nephrology team. At one- to two-week intervals, physical examination of the newly created access was performed on each patient to assess the developmental progress

Table 1. Demographics of the tunneled hemodialysis catheter–consigned patients

Number of patients	121
Age *years*	47.9 ± 10.9
Gender	
Women%	44%
Race/ethnicity	
Hispanic	48 (40%)
African American	44 (36%)
Caucasian	18 (15%)
Haitian	11 (9%)
Cause of ESRD	
Diabetic nephropathy	51 (42%)
Hypertension	46 (38%)
Glomerulonephritis	11 (9%)
HIV-associated nephropathy	7 (6%)
Lupus nephritis	4 (3%)
Polycystic kidney disease	2 (2%)

Data are mean ± SD.

of the arteriovenous access. Based on the physical examination performed by interventional nephrologists, if the fistula developed adequately and attained a diameter of ≥0.4 cm, cannulation for dialysis was recommended. The cannulation was discussed with the hemodialysis nurse taking care of the patient either by telephone call or by examination of the patient with the nurse. A simple question was asked of the nurse: "Can this fistula be cannulated?" Once the arteriovenous access was used successfully for three consecutive dialysis sessions, the TDC was removed by interventional nephrology.

Postsurgical interventions (percutaneous salvage procedures)

Early failure was defined as a fistula that failed to develop adequately to support dialysis after construction, or failed within three months of its initial use. This was assessed by physical examination. The application of physical examination to evaluate fistula failure was based on a recent benchmark study [12]. Patients with early failure were referred to the interventional team for a salvage procedure. Salvage procedures included percutaneous balloon angioplasty, accessory vein ligation, and sequential dilatation of stenotic lesions. The techniques for these were used based on the previous descriptions by Beathard et al [12]. All procedures were performed on an outpatient basis and under local anesthesia and conscious sedation.

RESULTS

Demographic characteristics of the patients are shown in Table 1.

Out of the 121 TDC-consigned [8.3 ± 3.2 months (SD)] patients, 86 (71%) agreed to proceed with vascular mapping and possible creation of arteriovenous access after aggressive education regarding the types of vascular accesses and their associated complications and morbidity and mortality. Of the 86 patients who agreed to have vascular mapping, two subsets of patients were identified (Fig. 1). Group I, those who had never had an arteriovenous access ($N = 66$; using TDC for 7.2 ± 1.8 months), and group II, those who had had one or more previously failed arteriovenous accesses and were now catheter dependent ($N = 20$; using TDC for 12.3 ± 4.0 months).

In all 86 patients, the Allen test was negative, indicating patent radial and ulnar arteries supplying the palmar arch and the bilateral upper extremity blood pressure differential did not exceed ≥20 mm Hg. Capillary refill ranged from 2 to 3 seconds, and brachial, ulnar, and radial pulses were 2+ to 3+.

In group I ($N = 66$), 64 (97%) patients were found to have adequate veins for arteriovenous fistula creation on venography (cephalic vein in the forearm and/or arm and basilic vein) (Fig. 1). Out of the 64 patients, 7 (11%) refused surgery, and 57 (89%) were referred for AVF creation. Of the 57 patients who proceeded with surgery, 15 demonstrated adequate cephalic veins in the forearm and received a radiocephalic fistula. Thirty-five patients demonstrated an adequate cephalic vein in the upper arm. All of these received a brachiocephalic fistula. The remaining seven patients demonstrated only an adequate basilic vein for AVF creation. Of these, three received a transposed brachiobasilic fistula, and four had a brachiobasilic graft inserted. Unilateral central venous stenosis was seen in 9/66 (14%) patients. However, this did not preclude the creation of an arteriovenous access on the opposite side.

In group II ($N = 20$), 18 (90%) patients were found to have veins available for fistula creation (forearm and arm basilic veins = 2, arm basilic veins = 16), while two patients (10%) did not have veins suitable for AVF creation and remained with catheters (Fig. 1). Three (17%) deferred surgery. The remaining 15 (83%) received a transposed basilic fistula (transposed radiobasilic = 2, transposed brachiobasilic = 13). Three (17%) patients in group II demonstrated central venous blockage; one belonged to the group that refused surgery. In the other two, central venous blockage did not preclude surgery on the opposite side.

Overall in group I, out of the 64 patients who were found to have adequate veins for fistula creation, 53 (83%) received an AVF, four (6%) had an AVG, and seven (11%) refused to undergo surgery (Fig. 1). In this group, 41 (72%) patients (AVF = 38, AVG = 3) had the arteriovenous access created contralateral to the TDC, while 16 (28%) (AVF = 15, AVG = 1) had the access constructed ipsilateral to the catheter. In group II, 15/20 (75%) received a transposed basilic fistula (Fig. 1). In this group, nine (60%) patients had the arteriovenous the fistula created contralateral to the TDC, while six (40%) had an AVF constructed ipsilateral to the catheter.

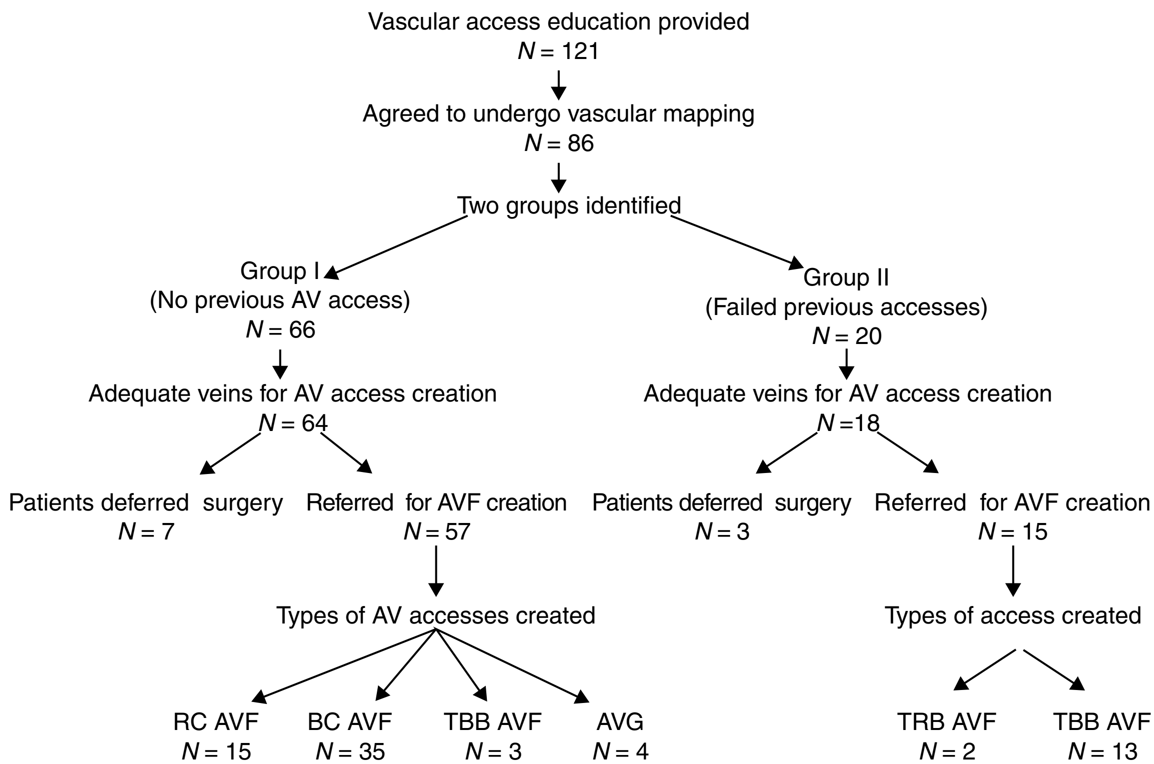

Fig. 1. Fate of 121 catheter-consigned patients who underwent vascular access education. Arteriovenous access (AV), arteriovenous fistula (AVF), radiocephalic (RC), brachiocephalic (BC), transposed brachiobasilic (TBB), transposed radiobasilic (TRB), arteriovenous graft (AVG).

When asked, all the patients in this study denied having been educated regarding vascular access types, their associated complications and morbidity and mortality, or having been given the option of vascular mapping prior to interaction with the interventional nephrology team.

In group I, 16/53 (30%) fistulas had early failure, (5/15 radiocephalic, 10/35 brachiocephalic, and 1 brachial-basilic fistula) (Fig. 2). All except for one radiocephalic fistula were successfully salvaged through interventional treatment. The salvage procedures included percutaneous balloon angioplasty ($N = 14$) and PTA plus accessory vein obliteration procedure ($N = 2$) (Fig. 2). One brachiocephalic fistula underwent a repeat PTA procedure (sequential dilatation) to salvage the access (Fig. 2). In group II, 8/15 (53%) transposed brachiobasilic fistulas had early failure. All were successfully salvaged by the interventional nephrologist except for one (Fig. 2). The salvage procedure included percutaneous balloon angioplasty ($N = 7$) and accessory vein obliteration procedure ($N = 1$). One brachiobasilic fistula (Fig. 2) needed a repeat angioplasty procedure (sequential dilatation).

Overall, 66/86 (77%) of the TDC-consigned patients who underwent vein mapping achieved a functioning arteriovenous fistula, while only 4/86 (5%) of the patients received an AVG. In all of these cases (66 fistulas and 4 grafts), TDCs were removed by interventional nephrology under local anesthesia after three consecutive successful hemodialysis sessions though the arteriovenous access. All 70 arteriovenous accesses are functional, with a mean follow-up of 8.5 ± 3.6 SD months.

Cumulative procedure-related complications included grade I hematoma ($N = 2$) during angioplasty that sealed automatically, and did not require any specific intervention other than manual pressure. One patient experienced transient paresthesia in the cubital fossa after vein ligation using the cut down technique that resolved after six months. None of the patients suffered any complications during vein mapping or TDC removal procedures.

DISCUSSION

The vascular access options available to nephrologists caring for hemodialysis patients typically have been limited by the availability of diagnostic and percutaneous technologies and the repertoire of their surgical colleagues. The advent of interventional nephrology has widened the horizons of both diagnostic and procedural options available for nephrologists to offer their hemodialysis patients, particularly those who had been consigned to tunneled catheters for receiving dialysis therapy. This study demonstrates that patients consigned to hemodialysis by means of percutaneous vascular catheters may be excellent candidates for successful placement of autologous arteriovenous native fistulas,

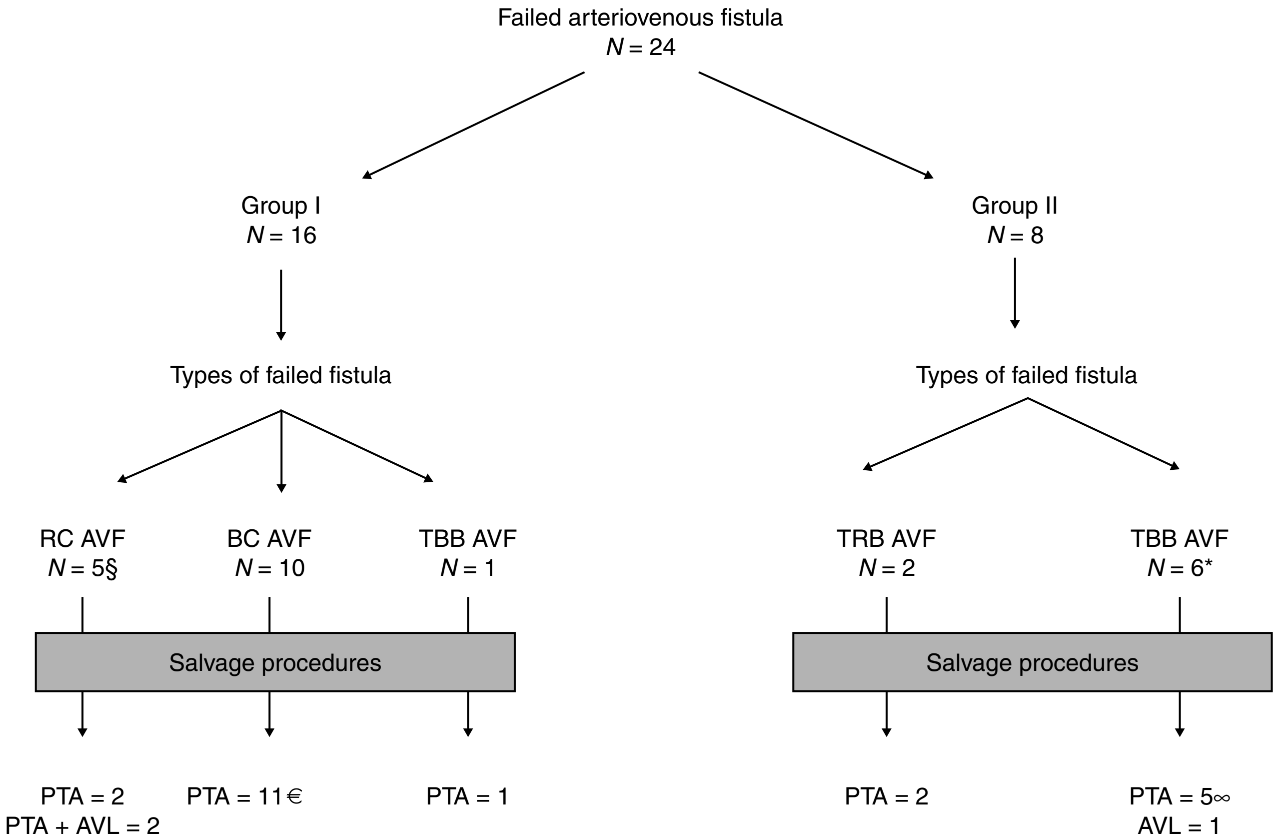

Fig. 2. Fate of failed arteriovenous fistulas. Arteriovenous fistula (AVF), radiocephalic (RC), brachiocephalic (BC), transposed brachiobasilic (TBB), transposed radiobasilic (TRB), percutaneous transluminal balloon angioplasty (PTA), accessory vein ligation (AVL). §, One radiocephalic fistula could not be salvaged.€, Repeat angioplasty (sequential dilatation) was needed in one brachiocephalic fistula. *, One transposed brachiobasilic fistula could not be salvaged. ∞, One transposed brachiobasilic fistula needed repeat PTA (sequential dilatation).

provided that both vascular access education highlighting the impact on dialysis access type on morbidity and mortality and a thorough preoperative vascular assessment are performed. A no less important finding is that the arteriovenous accesses placed in these clinical situations often may require postoperative interventional salvage procedures to achieve a functioning arteriovenous access.

Recent data have demonstrated that preoperative vascular assessment utilizing ultrasonography or venography is far superior to physical examination (inspection of veins by naked eye using the tourniquet placed on the upper arm) in evaluating vessels suitable for arteriovenous fistula creation [13–17]. Relying on the physical examination to assess the vascular system may result in exclusion of patients in whom venography actually will demonstrate adequate veins for AVF creation. Allon et al [13] documented a dramatic increase in arteriovenous fistula creation when preoperative vascular mapping using sonography was employed compared to the traditional physical examination approach (preoperative physical examination = 34%, preoperative sonographic vascular mapping = 64%; $P < 0.001$). Indeed, using preoperative mapping approach, these investigators demonstrated a doubling of the patients dialyzing successfully with a fistula (preoperative physical examination = 16%, preoperative sonographic vascular mapping = 34%; $P < 0.001$) [13]. Another study documented a significant improvement in arteriovenous fistula creation (from 14% to 63%), reduction in AVG placement (from 62% to 30%), and reduction in tunneled hemodialysis catheters insertion (from 24% to 7%) when preoperative mapping of the arteries and veins was performed using Doppler duplex ultrasonography [8]. These studies applied preoperative vascular assessment by ultrasonography to the patients initiating chronic hemodialysis [8, 13].

In contrast to the above-cited studies, we prospectively identified hemodialysis patients who were consigned to permanent long-term treatment by means of tunneled catheters and provided vascular access counseling. Upon our asking, all the patients in this study denied having been educated regarding vascular access types, their associated complications and morbidity and mortality, or having been given the option of vascular mapping prior to interaction with interventional nephrology team. However, it is conceivable that some of these patients may have been asked for access placement in passing. Vascular mapping was then performed by interventional nephrology for the purpose of identifying vessels that might be available for creation of arteriovenous accesses. Of 86 patients agreeing to vascular mapping, 80 patients (95%) were found to have patent veins suitable for arteriovenous access placement. Only four patients (5%) were found not to have suitable veins for placement of an arteriovenous access and, therefore, were truly dependent on tunneled catheters for hemodialysis therapy. It is noteworthy that 94% of patients with no prior arteriovenous accesses (64 of 66) had suitable veins, and that 90% of patients with previously failed arteriovenous accesses (18 of 20) had suitable veins, all basilic veins in the latter cases (forearm + arm = 2, arm = 16). These findings clearly demonstrate the value of vascular mapping in detecting vessels suitable for arteriovenous access placement, even in patients previously consigned to percutaneous catheters because of prior vascular access failures. Indeed, these results virtually mandate the search for patent veins suitable for arteriovenous access placement in every patient dialyzing with a percutaneous catheter.

In this study, bilateral upper extremity venography (including the side of the catheter) was performed in all patients. This was done to map all of the possible sites for access creation. This also provided information that could be used for future placement of a fistula. In contrast to Silva et al [8], in the current study, outflow occlusion during venography was not performed. Occluding the venous outflow distends the veins and introduces the possibility of overestimating the actual size of the vein. At the time of fistula creation during surgery, outflow occlusion to distend the veins is not performed. In this context, it is conceivable that a vein that appeared 2.5 mm on ultrasound evaluation might actually be less than the sonographically determined size, creating a dilemma at the time of surgery. To help avoid the possibility of this scenario, we did not perform outflow occlusion. Of interest, we did not find evidence for arterial insufficiency to preclude AVF creation in any of our cohort. Although Doppler ultrasound has been highlighted to offer the advantage of arterial evaluation, we find that physical examination provides ample information for arteriovenous fistula creation. Indeed, for arterial evaluation, NKF-DOQI guideline 2 recommends that Doppler examination or arteriography should only be performed in the presence of markedly diminished arterial pulses on physical examination [9]. Further, the Work Group concluded that arteriography is only rarely required. Our approach was based on this recommendation. However, it is worth noting that this recommendation is opinion based.

Having discovered patent veins, the surgical challenge is to successfully create a functioning arteriovenous access suitable for hemodialysis therapy. A surgeon must be willing to utilize a full range of appropriate surgical approaches, including vein transpositions, to successfully create an AVF, have a basic knowledge of the complications associated with dialysis access types, and be willing to work as a team member with nephrologists. Using this approach at our center, 68 of the 86 patients (79%) who underwent vascular mapping received an arteriovenous fistula. Of note, 18/68 (26%) required a vein transposition (radiobasilic = 2, brachiobasilic = 16) to create an arteriovenous fistula. Fifteen of the transposed fistulas were in patients with prior failed vascular accesses. In this study, only four patients received a brachiobasilic graft. All four had a basilic vein; however, the decision to place a graft was based on findings at the time of surgery.

Recently, the superiority of transposed fistulas has been documented over arteriovenous grafts [18–25]. Although transposition of the basilic vein to create an AVF is a surgical procedure noted in the dialysis literature for over 30 years [26], this has been a vastly underutilized technique until very recently. The current study clearly demonstrates that the basilic vein of the upper arm commonly is patent, even in the hemodialysis patient who has had multiple failed vascular accesses. This finding is consistent with the previous documentation that this vein is present in over 95% of these patients [20, 25]. In communities where the surgical repertoire does not include the creation of autologous fistulas by means of basilic vein transpositions, it is probable that a significant percentage of hemodialysis patients will have become permanently dependent on TDCs needlessly. Therefore, it seems prudent to always undertake a search for patency of the basilic vein before consigning a patient to permanent dependence on a percutaneous vascular catheter.

The current report found a higher percentage of fistula placement (79%) compared to 64% and 63% that was reported by Allon [13] and Silva [8], respectively. The organized team approach, a change to a surgeon who utilized a full range of surgical techniques including vein transpositions, referral for fistula only, aggressive input and follow-up by the nephrology team, and the availability of venographic images demonstrating the actual size instead of distended veins might have been the reasons for this difference. Is venography superior to sonographic evaluation? To the best of our knowledge, there have not been any randomized studies comparing venography and vascular ultrasound mapping to establish the superiority of one preoperative imaging technique over the other. In the absence of such studies, it is difficult to report which mapping technique is superior. Indeed, using a combination of preoperative noninvasive (Doppler ultrasound) and invasive (venography and arteriography) techniques, Huber et al [14] did demonstrate a higher percentage of fistula creation (90%) than our study. One clear advantage of venography is direct imaging of the central veins instead of indirect assessment provided by Doppler evaluation. Alternatively, ultrasound offers the advantage of noninvasive arterial evaluation. Regardless, both techniques offer a clear advantage over inspection of veins by the naked eye using a tourniquet [8, 13].

This study demonstrates the error of the commonly held perception that there is nothing to be done to save the autologous arteriovenous fistula that fails to mature sufficiently to provide dialysis. Using percutaneous balloon angioplasty and/or accessory vein obliteration procedures, Beathard et al [12] provided evidence for successful salvage of fistulas that had failed to mature sufficiently to be able to sustain adequate hemodialysis. In their study, out of the 100 patients with failed fistulas, 92% were able to initiate dialysis using the fistula after percutaneous interventions by interventional nephrologists. Using this approach we were able to salvage a great majority of failed fistulas. We elected to wait for four weeks before fistula cannulation, even if the desired 0.4 cm size was achieved. This was done to allow for complete resolution of postoperative edema and wound healing by primary and secondary intentions, which generally takes about four weeks to complete. We also took into consideration the report by Rayner et al [27], which demonstrated that cannulation of a fistula within two weeks of its construction led to a higher failure rate.

Previous investigators have demonstrated a decline in primary failure rate when preoperative vascular assessment was undertaken [8]. We did not find a lower incidence of early fistula failure in our analysis. The overall early failure rate for fistulas in the current report was 35% (24 of 68 AVFs). Fifteen of the 50 (30%) nontransposed (radiocephalic = 5 and brachiocephalic = 10) and nine of the 18 transposed fistulas (50%) had early failure [19, 23, 24]. Indeed, in their study, even with the application of preoperative vascular mapping, Allon et al [13] also failed to find an improvement in early fistula failure. In our study, the cohort with transposed fistulas, in fact, had a higher early failure rate. The cause for this higher failure rate in the transposed fistulas is unclear. We speculate that the presence of multiple swing points and utilization of the single stage transposition procedure may have been responsible. However, to the best of our knowledge, there have been no randomized studies comparing the failure rate between single-stage and two-stage transposition of basilic vein for AVF creation. Of interest, this report found the early failure rate to be higher in women [58% (14/24)] than in men. This observation is consistent with the findings of Miller [28], as well as Gibson et al [29], who also reported a higher incidence of early fistula failure in women.

Thirty-four percent of our 355 prevalent hemodialysis patients had been receiving hemodialysis by means of percutaneous vascular catheters. With the interventional nephrology team approach, the catheter-consigned population was reduced to 14%. The demographic characteristics of the study patients did not reveal an overabundance of groups that traditionally have been labeled as having inadequate veins for AVF creation, specifically women, the elderly, or patients with diabetes or diseases treated long-term with steroids, such as lupus (Table 1). There were no significant differences between the demographic characteristics of patients who refused vascular mapping/surgery and those who received vascular mapping and surgery. The age of the patients in our study is significantly younger than the United States ESRD population. This may be due to the fact that our center represents an immigrant (Hispanic and Haitian) and inner city African American population, which is not reflective of the larger Medicare United States ESRD population. Prior to the advent of our interventional nephrology program, most of the patients dialyzing with vascular catheters would not have been considered as candidates for an arteriovenous vascular access. Indeed, none of these patients reported having been approached with the possibility. This is not an indictment of their nephrologist's prior commitment to optimizing their vascular health care, but rather a statement regarding options that became available and accessible with the advent of vascular access management by nephrologists. Of note, 37% (45/121) of the patients refused either vascular mapping ($N = 35$) or access surgery ($N = 10$), even after full explanation of the complications, morbidity, and mortality associated with catheters. We do not have an exact explanation of this refusal; however, painless dialysis with catheters and fear of surgery may have been the culprits. Indeed, from the patient's perspective, pain has been the most common problem during cannulation of an arteriovenous access [30].

CONCLUSION

While there has been much speculation regarding the multiple reasons for the dependence on TDC and AVF underutilization, the results of this study demonstrate that an organized approach based upon a program utilizing VA counseling, VM, application of a full range of surgical techniques, and salvage procedures can be very successful in providing optimum vascular access to the catheter-dependent patient.

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