Failure of arteriovenous fistula maturation: An unintended consequence of exceeding Dialysis Outcome Quality Initiative guidelines for hemodialysis access

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Purpose: **The Dialysis Outcome Quality Initiative (DOQI) guidelines recommend that arteriovenous fistulas (AVF) be constructed in at least 50% of hemodialysis access procedures. Preoperative duplex ultrasound (US) scanning and venography may increase options for AVF with identification of veins that are not clinically evident. However, maturation of autogenous fistulas created on the basis of findings at duplex US scanning and venography has not been carefully examined.**

Methods: **From January 1999 to July 2002, 256 new hemodialysis access procedures were performed in 202 patients in an academic tertiary care center. If physical examination failed to disclose adequate vessels for hemodialysis access, patients underwent duplex US scanning mapping. Venography was performed when no usable vein or only a basilic vein was identified at duplex US scanning. Functional maturation rate and mean maturation time (time from fistula creation to initiation of hemodialysis) were determined. This experience was compared with that in a group of 128 patients in whom 148 hemodialysis access fistulas were created before we implemented liberal use of preoperative duplex US scanning and venography (January 1997–December 1998).**

Results: **From January 1999 to July 2002, preoperative duplex US scanning was performed in 68% of patients, and venography in 32% of patients. Autogenous fistula creation rate increased from 61% to 73% in all patients with hemodialysis access fistulas ($P = .15$) and from 66% to 83% in patients undergoing a first access procedure ($P < .05$). The use of basilic vein transposition also increased, from 3% in the earlier period to 13% in the later period ($P < .05$). Mean maturation time for arteriovenous fistulas was 70 days. Functional maturation rate decreased from 73% to 57% ($P < .05$) after implementation of preoperative imaging and more aggressive vein use.**

Conclusion: **Implementation of preoperative duplex US scanning and venography as a component of a more aggressive protocol to create native fistulas was pivotal in exceeding DOQI guidelines for hemodialysis access. However, this approach resulted in the unintended sequela of decreased fistula maturation rate. Our experience suggests that improved selection criteria based on findings at preoperative imaging are needed to further refine and optimize arteriovenous access surgery. (J Vasc Surg 2003;38:439-45.)**

Approximately 300,000 patients in the United States are receiving long-term hemodialysis, resulting in an annual health care expenditure in excess of two billion dollars. Approximately 30% of these costs result from efforts to maintain access site patency.[1] Clinical protocols to optimize patency and function of hemodialysis access sites could lead to substantial reduction in both patient morbidity and health care costs. It is well-established that arteriovenous fistulas (AVF) exhibit superior long-term function compared with prosthetic arteriovenous grafts.[2-7] Furthermore, AVF result in fewer infectious and ischemic complications compared with prosthetic arteriovenous grafts.[5,6]

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In 1997 (updated in 2001), The National Kidney Foundation Dialysis Outcomes Quality Initiative (DOQI) proposed guidelines that AVF be constructed in at least 50% of permanent hemodialysis access procedures, to improve quality of life and outcome in patients with end-stage renal disease. An additional DOQI goal was to achieve an AVF prevalence of 40% in all hemodialysis patients.[8,9] Data reported in The Dartmouth Atlas of Vascular Health Care[10] demonstrated that we fall far below this objective in the United States. Native AVF composed only 17% of all initial permanent hemodialysis access procedures performed in Medicare patients from 1996 to 1997.[10] In 2002, the Dialysis Outcomes and Practice Patterns Study (DOPPS), one of the largest prospective observational studies published on hemodialysis practices and outcome in 309 international dialysis facilities, reported that AVF accounted for 24% of all access procedures in the United States, compared with 80% in Europe.[7]

Since publication of DOQI guidelines, there has been a strong impetus in the vascular community to increase the AVF creation rate in vascular access practice. With the implementation of preoperative imaging protocols that include routine venous duplex US scanning in conjunction

with selective venography and arteriography, several authors have reported an increase in AVF creation rate to a level exceeding the 50% recommended rate endorsed by DOQI.[5,11-15] Such protocols potentially increase options for AVF by identifying veins that were not evident at physical examination. Silva et al[11] increased the rate of AVF creation in their practice from 14% to 63% with introduction of this preoperative imaging protocol. Ascher et al[5] observed an increase in autologous fistula creation, from 5% to 68%, in their practice. Huber et al[12] created AVF in 90% of hemodialysis access procedures on the basis of an algorithm incorporating preoperative duplex US scanning and arteriography or venography in all patients.

AVF, however, may be associated with several disadvantages. Reported AVF maturation rate varies widely, from 30% to 90%.[11-13,16] Lower maturation rate may effectively reduce the functional patency of AVF to a level approaching that of prosthetic arteriovenous grafts.[17,18] Furthermore, AVF require a longer period of maturation compared with prosthetic arteriovenous grafts. Protracted hemodialysis via percutaneous catheter may be required while awaiting fistula maturation, leading to increased risk for infection and compromised central vein patency. Overly aggressive attempts to increase AVF creation rate by means of extensive imaging methods may be detrimental to some patients. Before publication of the DOQI guidelines, our approach was to attempt native AVF whenever possible, with determination of the planned access procedure based primarily on findings at physical examination. In January 1999 we initiated a more aggressive protocol of preoperative imaging, in an attempt to maximize AVF creation rate in patients with first-time access and in patients in whom previous access sites had failed. We evaluated the success of arteriovenous access procedures performed after implementation of a preoperative imaging protocol, to determine whether overall access maturation rate was improved with such a dedicated protocol.

METHODS

A retrospective review was conducted of data for patients referred for permanent hemodialysis access to the vascular surgery practice at the University of Arizona Health Sciences Center. From January 1999 to July 2002, a prospective imaging protocol was used preoperatively to increase AVF rate (study group). This experience was compared with that in patients in whom permanent hemodialysis access was created from January 1997 to December 1998, before implementation of liberal preoperative duplex US scanning and venography (historical control group). Demographic data compiled included gender, race, age, comorbid conditions, and cause of end-stage renal disease.

Preoperative evaluation included careful assessment of the vascular anatomy. The nondominant upper extremity was preferred for creation of an access site; however, the final decision was ultimately determined according to size and quality of the vessels. Arterial examination included pulse assessment, performance of the Allen test, and bilateral upper extremity blood pressure measurement. Venous examination included inspection and palpation of the cephalic vein at the wrist and upper arm and the basilic vein at the elbow, with a tourniquet in place. If an acceptable vein was apparent at the wrist that transmitted a percussed wave a distance up the forearm, a radiocephalic fistula was planned.

If physical examination failed to disclose adequate vessels or there was uncertainty regarding the quality or continuity of the vein for arteriovenous access (ie, history of multiple venipunctures), patients underwent duplex US scanning mapping, performed by a registered vascular technologist in an accredited vascular laboratory (Intersocietal Commission for the Accreditation of Vascular Laboratories). Patients were examined while reclining, with the arm dependent. Warm ultrasound gel was applied, and veins were insonated with a 5 or 7 MHz scanning probe (HDI 2000 and UltraMark 9; Advanced Technology Laboratory, Bothell, Wash). Duplex US scanning was initiated at the wrist before and after proximal venous tourniquet occlusion at the mid-forearm. Veins were assessed for ease of compressibility, distensibility, diameter, thickness, continuity, and depth below the skin. The tourniquet was then moved to the arm, and the forearm veins were followed proximally. The acceptable threshold diameter for vein use was 2.5 mm or greater. Measurements of vein diameter were recorded from the ultrasound scans at representative sites, including wrist, distal forearm, mid-forearm, proximal forearm, antecubital fossa, distal upper arm, mid–upper arm, and proximal upper arm. Axillary and subclavian veins were assessed for patency. Brachial, radial, and ulnar arteries were evaluated for calcification. Segmental pressure and velocity waveforms were obtained. Diameter of the radial artery at the wrist and the brachial artery immediately above the antecubital fossa were also determined.

Venography was performed selectively if no suitable vein was identified at duplex US scanning. Venography also was performed if the only suitable vein identified at duplex US scanning was the upper basilic vein, to confirm that no usable forearm or upper arm cephalic vein was overlooked. Unexplained edema of the upper extremity, presence of subcutaneous collateral veins across the shoulders and chest, or extensive history of central venous cannulation also mandated venography to exclude central vein stenosis or occlusion. A superficial vein in the hand or forearm was cannulated, contrast agent was injected, and, with sequential tourniquet placement, the venous circulation from the superficial veins to the superior vena cava was imaged, to assess diameter and continuity.

The choice of access configuration was made on the basis of results of clinical examination and imaging. Local, regional, and general endotracheal anesthetic techniques were selected on the basis of the site of the planned procedure and the preferences of the anesthesiologist, surgeon, and patient. Most hemodialysis access procedures were performed on an outpatient basis. Patients were followed up in the outpatient clinic within 7 to 10 postoperative days and monthly thereafter until the fistula was sufficiently

mature for cannulation. Determination of adequate maturation for hemodialysis access was made by the vascular surgeon and nephrologist on the basis of thrill characteristics and AVF diameter. Diagnostic duplex US scanning for AVF was performed in cases of failure of adequate maturation by 4 to 6 weeks.

Information regarding cannulation dates was obtained from 10 regional dialysis centers. Each dialysis center had a database that recorded dates of dialysis sessions. Functional maturation was defined as time from the operative procedure to initiation of sustained hemodialysis (cannulated on four occasions) via the index access. Differences between the two groups were analyzed with two-tailed Student *t* test for continuous variables, and χ^2 test for categoric variables. Multivariate analysis incorporating demographic data, comorbid conditions, dialysis history, fistula configuration, use of imaging (duplex US scanning, venography), and vein diameter (2.5-3 cm, >3 cm) were performed with logistic regression to predict failed maturation. Statistical analysis was performed with SPSS software for Windows (version 11.5; SPSS Sciences, Chicago, Ill). *P* less than .05 was considered statistically significant.

RESULTS

Between January 1999 and July 2002, 256 access procedures were performed in 202 patients, who composed the study group. All procedures were performed by resident trainees under careful supervision of two experienced vascular surgeons (J.L.M., J.D.H.). The historical control group consisted of 148 access procedures performed in 128 patients between January 1997 and December 1998. Demographic data for the two groups are compared in Table I. The study group included a higher percentage of women than men (55% vs 45%), but this difference was not statistically significant. There were no significant differences in age, race distribution, and incidence of comorbid conditions between the two groups. The study group had fewer patients undergoing first-time access site creation (63% vs 78%; $P = .08$) and significantly more patients receiving hemodialysis at the time of access placement (36% vs 16%; $P < .05$). Preoperative duplex US scanning was performed in 68% of the study group versus 28% of the control group. Preoperative venography was performed in 32% of the study group compared with 13% of the control group.

Duplex US scanning enabled identification of veins suitable for AVF creation but that were not visible at clinical examination in 25% of patients. In 4% of patients, both physical examination and duplex US scanning failed to reveal a suitable vein, and thus venography was performed. The preoperatively planned access configuration correlated with the actual procedure performed in 98% of patients.

After implementation of preoperative imaging, the autogenous fistula creation rate increased from 61% to 73% ($P = .15$; Fig 1). For the subset of patients undergoing a first access procedure, the rate increased from 66% to 83% ($P < .05$). The distribution of hemodialysis access configurations in the two groups is shown in Table II. The study and control groups were comparable in distribution of radiocephalic (22% vs 21%) and brachiocephalic (35% vs 36%) AVF placed. Use of basilic vein transposition increased from 3% in the earlier period to 13% in the study group ($P < .05$). Creation of forearm AVG decreased from 30% in the control group to 11% in the study group ($P < .05$).

Mean maturation time was 70 days for AVF and 34 days for prosthetic arteriovenous grafts in the study group, compared with 82 days for AVF and 28 days for prosthetic

Table I. Comparison of demographic data and comorbid conditions

	Historical control group	*Study group*	P
No. of access procedures	148	256	
No. of patients	128	202	
Gender (M/F) (%)	45/55	55/45	
Age (y)			
Mean	60.9	58.9	
Range	18-87	9-90	
Race (%)			
White	55	55	
African American	4	7	
Hispanic	38	31	
Native American	3	7	
Comorbid conditions (%)			
Diabetes mellitus	62	64	
Hypertension	51	70	
Polycystic kidney disease	5	3	
Autoimmune disease	8	6	
First-time access (%)	78	63	.08
Active hemodialysis at access placement (%)	16	36	<.05*
Preoperative duplex ultrasound scanning (%)	28	68	<.05*
Preoperative venography (%)	13	32	<.05*

*All other *P* values not significant.

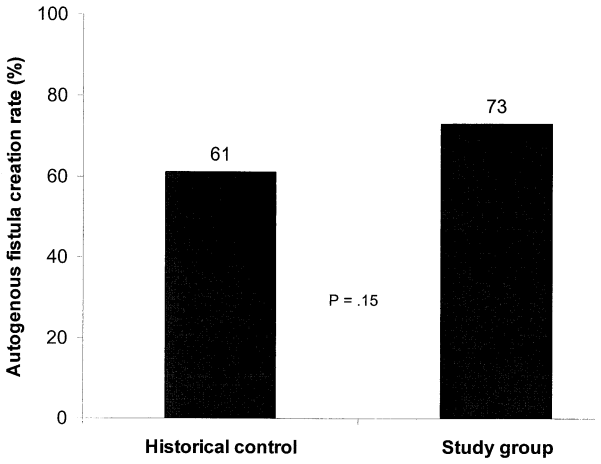

Fig 1. Comparison of autogenous fistula creation rates.

Table II. Type and distribution of vascular access procedure performed

	Historical control group		*Study group*		
Type of procedure	*n*	*%*	*n*	*%*	P
Radiocephalic	31	21	56	22	
Brachiocephalic	53	36	90	35	
Basilic transposition	5	3	33	13	<.05*
Forearm AVG	44	30	28	11	<.05*
Upper arm AVG	12	8	36	14	
Other (eg, lower extremity)	3	2	13	5	
Total	148	256			

AVG, Arteriovenous graft.
*All other *P* values not significant.

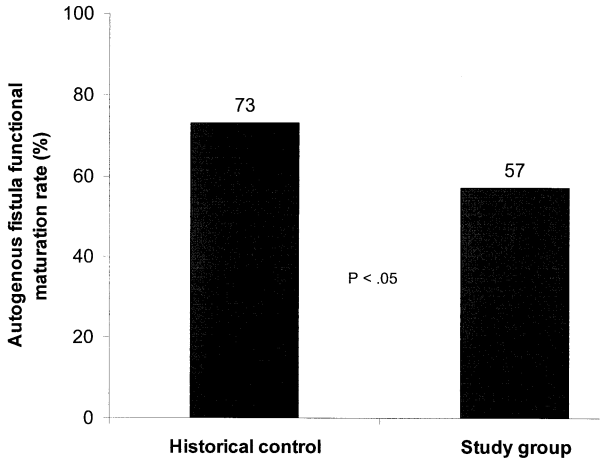

Fig 2. Comparison of autogenous functional maturation rates.

arteriovenous grafts in the study group. Additional interventions, such as operative revision, percutaneous transluminal angioplasty, and thrombectomy, were required to achieve functional maturation in 19% of AVF and 4% of prosthetic arteriovenous grafts. Functional maturation rate for AVF declined from 73% to 57% ($P < .05$) after implementation of preoperative imaging and more aggressive vein use during the study (Fig 2). There was no difference in maturation rate between the various configurations. Of 25 basilic vein transpositions performed in the contemporary period, 17 (68%) achieved functional maturation at a mean interval of 67 days, and 18% required remedial procedures. Basilic vein transposition was the initial access procedure in 29% and the secondary procedure in 71% of patients. Maturation rate for access grafts constructed exclusively on the basis of findings at physical examination was 80%. Multivariate analysis identified brachiocephalic configuration and AVF constructed on the basis of vein identified solely by preoperative venography as factors predictive of failed maturation. Gender, race, diabetes mellitus, previous failed access, and vein diameter (2.5-3 cm vs >3 cm) did not affect probability of maturation. Failed maturation was most commonly due to inadequate dilation to permit cannulation. Central vein occlusion accounted for only 3% of failed fistula maturation. There were no documented cases of failed maturation due to inadequate arterial flow or hand ischemia requiring ligation.

DISCUSSION

The ideal hemodialysis access fistula should be durable, pose minimal risk for infection, and require few interventions to maintain ongoing functional patency. It is well documented that mature AVF demonstrate superior overall patency, lower revision rate, and cost savings, compared with prosthetic arteriovenous grafts.[2-7,19] Despite almost uniform agreement on the need to increase the AVF creation rate, prevalence in the United States has increased only modestly since publication of DOQI clinical practice guidelines in 1997. Less than 30% of access sites in the United States are autogenous fistulas.[7,10] Prosthetic arteriovenous grafts may be more appealing because of ease of operative placement and cannulation, short interval required before use, anticipated limited life expectancy of some patients, and greater financial reimbursement. Some investigators have suggested that the greater early failure rate of AVF results in overall patency equivalent to that of prosthetic arteriovenous grafts.[17,18] Repeated interventions to establish access patency may exert a substantial economic and emotional toll. An effective imaging protocol should maximize the number of patients receiving functional access fistulas and minimize the number of unsuccessful attempts at fistula construction.

Preoperative assessment with duplex US scanning and venography may enable identification of veins not apparent at clinical examination and thereby lead to insertion of functional autogenous fistulas with superior longevity. Silva et al[11] increased the rate of native AVF in their practice from 14% to 63% with routine preoperative duplex US scanning. With a protocol consisting of duplex US scanning, arteriography, and venography performed preoperatively in all patients, Huber et al[12] created AVF in 90% of patients. We found that a selective protocol of duplex US scanning and venography enabled placement of autogenous access in 73% of patients. For first-time access procedures, this figure rose to 83%. However, even during the historical control period, before liberal preoperative imaging, our 61% rate of autogenous fistula creation exceeded the 50% figure recommended by DOQI. This attests to our lasting commitment in creating AVF even before more aggressive attempts to increase vein use with preoperative imaging. In our dialysis unit the prevalence of patients undergoing dialysis with an AVF during the two observational periods increased from 41% to 52%, surpassing the 40% guideline mandated by DOQI.

The 13% increase in AVF rate in our current practice compared with the historical control group can in large part be attributed to the fourfold increase in basilic vein transposition, from 3% to 13%, during the study period. This

Table III. Comparison of series using preoperative imaging before permanent access placement

	Silva et al[11]	*Ascher et al*[5]	*Robbin et al*[15]	*Fullerton et al*[20]	*Huber et al*[12]	*Konner et al*[28]	*Current study*
Year	1998	2000	2000	2002	2002	2002	2003
No. of access produced		267*		183	139	748	256
No. of patients	160	137*	52	163	131	748	202
Diabetes mellitus (%)	31†	55	44	42	49	24	64
Duplex ultrasound scanning (%)	100	Selective	100	100	100	80-90	68
Vein-size threshold (mm)	≥2.5	≥2-3	≥2.5	≥3	≥3		≥2.5
Fistula rate (%)	68‡	68*	58	23	90	100	73
Transposition rate (%)		14		6	35		13
Fistula maturation rate (%)	92‡	82		79	84		57

*Includes revisions and temporary access procedures.
†Includes patients undergoing permanent catheter placement
‡Rate determined based on total number of patients (not total number of procedures)

change reflects an increasing preference for autogenous basilic vein transposition over forearm prosthetic grafting when imaging methods reveal a viable basilic vein. DOQI guidelines recommend that when a brachiocephalic fistula fails, either a basilic vein transposition or forearm prosthetic arteriovenous graft be used. Fullerton et al[20] observed an increase in basilic vein transposition, from 0% to 26%, with adoption of an imaging protocol. Among 125 new access procedures performed with a rigorous preoperative imaging protocol, Huber et al[12] performed 49 basilic vein transpositions (39%), in preference to forearm prosthetic graft access, accounting for the leading AVF configuration in their series. Basilic vein transposition has long-term patency comparable to more traditional AVF.[21,22] Whether basilic vein transposition is superior to forearm prosthetic arteriovenous graft is debatable, and will ultimately only be determined with a prospective randomized study. Hakaim et al[16] reported a 70% nonmaturation rate for radiocephalic AVF in patients with diabetes, and recommended more liberal use of basilic vein transposition in this patient subgroup.

One of the unexpected findings in our study was that the functional maturation rate decreased, from 73% to 57%, after implementation of a preoperative imaging protocol. Although we were successful in creating more autogenous fistulas, there were correspondingly more cases of failed maturation. In contrast, Ascher et al[5] observed that the maturation rate increased, from 64% to 92%, with an imaging protocol. Mihmanli et al[23] found that preoperative duplex US scanning improved short-term AVF patency, from 75% to 94%, compared with physical examination alone. Of interest, Allon et al[24] demonstrated improved maturation rate for lower arm AVF (34% to 54%) but not upper arm AVF (59% to 56%) with implementation of an imaging protocol. We failed to demonstrate any significant differences between maturation rate of the various configurations. Perhaps, our reduction in functional maturation reflects a change in our patient population over the two periods of observation. A higher percentage of patients in the study group compared with the historical control group were already receiving dialysis at the time of index access creation (36% vs 16%; $P < .05$, and a greater percentage of patients were undergoing repeat access creation (37% vs 22%; $P = .08$). We speculate that, in addition to a shift in preference, the increase in basilic vein transposition performed in the more recent period may reflect a group of patients undergoing increasingly complex procedures, because these procedures were more often secondary procedures.

Another possibility to account for our reduction in maturation rate with implementation of an imaging protocol is a flaw in our selection criteria. Our criteria for vein selection (vein diameter >2.5 mm) based on findings at duplex US scanning and venography are similar to those reported by other authors. Mendes et al[13] found that AVF constructed with cephalic vein larger than 2 mm proceeded to functional access in 76% of patients. When cephalic vein with a minimal diameter less than 2 mm was used, a dismal maturation rate of 16% was attained. In our practice, vein smaller than 2.5 mm in diameter were almost never used. The criteria of Huber et al[8] for vein suitability included vein diameter greater than 3 mm, without evidence of stenosis. They were able to achieve a maturation rate of 84%.

Our study differs from others in that we did not routinely perform duplex US scanning in all patients (Table III). If an excellent vein was identified at physical examination, it was used for AVF creation without further imaging. The maturation rate for such AVF was 80%. It is unlikely that duplex US scanning of these veins would have improved results. Including such patients in a preoperative duplex US scanning protocol will artificially improve the estimated utility of the technique. If there was any question about vein adequacy, duplex US scanning was performed. We thus increased the frequency of preoperative duplex US scanning from 28% to 68%, and for preoperative venography from 13% to 32%. The maturation rate of duplex US scanning only–identified vein was 75%, and for venography only–identified vein was 46%. Furthermore, the proportion of patients with diabetes in our study (64%) exceeded that reported by other authors (24%-49%; Table III). Because diabetes

adversely affects AVF maturation, this may have contributed to our reduced maturation rate in comparison with other studies.[16,25,26] Vein diameter, continuity, lack of significant sclerosis, and compressibility are all established with duplex US scanning. It may be that the quality of vein visible on inspection is inherently superior to that visualized only with duplex US scanning or venography. Indeed, our data demonstrate that the maturation rate of fistulas constructed solely on the basis of imaging is inferior.

Large reported differences in type of vascular access created exist between the United States and Europe. Data from DOPPS indicate that European practices are highly successful in placing AVF. In Europe AVF account for 80% of all access sites. In contrast, data from DOPPS indicate that AVF are placed in 24% of prevalent patients and 15% of incident patients in the United States.[7,27] Konner et al,[28] in Cologne, Germany, report that between 1993 and 1998, 748 consecutive patients underwent construction of a primary AVF; in no case was it necessary to create an AVG. Duplex US scanning and venography were used selectively. Of interest, only 24% of their patients had diabetes. In DOPPS, 22% of European patients had diabetes mellitus, compared with 46% of US patients.[7] We postulate that patients in Europe compose an entirely different population group. Although European access surgeons may more aggressively attempt to place AVF compared with their American counterparts, we suspect that some of these differences in practice patterns are due to inherent differences in patient populations.

In conclusion, implementation of routine preoperative duplex US scanning likely will increase the AVF creation rate in a given vascular access practice. However, in a practice in which the philosophy of native AVF creation is ingrained, net increase in AVF creation rate is less than previously reported. In our experience, we were able to increase AVF creation in first-time patients from 66% to 83%, and in all patients from 61% to 73%, after adoption of a preoperative imaging protocol. However, as an unintended sequela, we noted an overall decrease in functional AVF maturation rate, from 73% to 57%. An acceptable AVF maturation rate will need to be defined so that we can maximize the number of patients who subsequently will have a functional access fistula without undergoing an inordinate number of unnecessary AVF procedures that are destined from the outset to fail. It may be that an AVF created on the basis of vein identification at duplex US scanning is inferior to one created on the basis of vein identification at physical examination. While our group will continue to use preoperative duplex US scanning vein mapping, we suggest that improved predictive criteria for success are required and that the proposed benefits of such a protocol may have been overstated.

REFERENCES

1. US Renal Data System 1999 annual report. Bethesda, Md: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases; 1999.
2. Gibson KD, Gillen DL, Caps MT, Kohler TR, Sherrard DJ, Stechman-Breen CO. Vascular access survival and incidence of revisions: a comparison of prosthetic grafts, simple autogenous fistulas, and venous transposition fistulas from the United States Renal Data System Dialysis Morbidity and Mortality Study. J Vasc Surg 2001;34:694-700.
3. Coburn MC, Carney WI. Comparison of basilic vein and polytetrafluoroethylene for brachial arteriovenous fistula. J Vasc Surg 1994;20:896-904.
4. Kheriakian GM, Roedersheimer LR, Arbaugh JJ, Newmark KJ, King LR. Comparison of autogenous fistula versus expanded polytetrafluoroethylene graft fistula for angioaccess in hemodialysis. Am J Surg 1986;152:238-43.
5. Ascher E, Gade P, Hingorani A, et al. Changes in the practice of angioaccess surgery: impact of dialysis outcomes and quality initiative recommendations. J Vasc Surg 2000;31:84-90.
6. Kalman PG, Pope M, Bhola C, Richardson R, Sniderman KW. A practical approach to vascular access for hemodialysis and predictors of success. J Vasc Surg 1999;30:727-33.
7. Pisoni RL, Young EW, Dykstra DM, Greenwood RN, Hecking E, Gillespie B, et al. Vascular access use in Europe and the United States: results from the DOPPS. Kidney Int 2002;61:305-16.
8. The Vascular Access Work Group. NKF-DOQI clinical practice guidelines for vascular access. National Kidney Foundation-Dialysis Outcomes Quality Initiative. Am J Kidney Dis 1997;30(suppl 3):S150-91.
9. National Kidney Foundation. K/DOQI clinical practice guidelines for vascular access, 2000. Am J Kidney Dis 2001;37(suppl 1):S137-81.
10. Use of hemodialysis access procedures. In: Cronenwett JL, Birkmeyer JD, editors. The Dartmouth atlas of vascular health care. Chicago, Ill: Health Forum; 2000. p 126.
11. Silva MB Jr, Hobson RW II, Pappas PJ, Jamil Z, Araki CT, Goldberg MC, et al. A strategy for increasing the use of autogenous hemodialysis access procedures: impact of perioperative noninvasive evaluation. J Vasc Surg 1998;27:302-7.
12. Huber TS, Ozaki K, Flynn TC, Lee WA, Berceli SA, Hirneise CM, et al. Prospective validation of an algorithm to maximize native arteriovenous fistulae for chronic hemodialysis access. J Vasc Surg 2002;36:452-9.
13. Mendes RR, Farber MA, Marston WA, Dinwiddie LC, Keagy BA, Burnham SJ, et al. Prediction of wrist arteriovenous fistula maturation with preoperative vein mapping with ultrasonography. J Vasc Surg 2002;36:460-3.
14. Parmley MC, Broughan TA, Jennings WC. Vascular ultrasonography prior to dialysis access surgery. Am J Surg 2002;184:568-72.
15. Robbin ML, Gallichio MH, Deierhoi MH, et al. US vascular mapping before hemodialysis placement. Radiology 2000;217:83-8.
16. Hakaim AG, Nalbandian M, Scott T. Superior maturation and patency of primary brachiocephalic and transposed basilic vein arteriovenous fistulae in patients with diabetes. J Vasc Surg 1998;27:154-7.
17. Brothers TE, Morgan M, Robinson JG, et al. Failure of dialysis access: revise or replace? J Surg Res 1996;60:312-6.
18. Hodges TC, Fillinger MF, Zwolak RM, Walsh DB, Bech F, Cronenwett JL, et al. Longitudinal comparison of dialysis access methods: risk factors for failure. J Vasc Surg 1997;26:1009-19.
19. Lee H, Manns B, Taub K, Ghali WA, Dean S, Johnson D, et al. Cost analysis of ongoing care of patients with end-stage renal disease: the impact of dialysis modality and dialysis access. Am J Kidney Dis 2002; 40:611-22.
20. Fullerton JK, McLafferty RB, Ramsey DE, Solis MS, Gruneiro LA, Hodgson KJ. Pitfalls in achieving the dialysis outcome quality initiative guidelines for hemodialysis access. Ann Vasc Surg 2002;16:613-23.
21. Rivers SP, Scher LA, Sheehan E, Lynn R, Veith FJ. Basilic vein transposition: an underused autologous alternative to prosthetic dialysis angioaccess. J Vasc Surg 1993;18:391-6.
22. Silva MB Jr, Hobson RW II, Pappas PJ, Haser PB, Araki CT, Goldberg MC, et al. Vein transposition in the forearm for autogenous hemodialysis access. J Vasc Surg 1997;26:981-8.
23. Mihmanli I, Besirli K, Kurugoglu S, Atakir K, Haider S, Ogut G, et al. Cephalic vein and hemodialysis fistula: surgeon's observation versus color Doppler ultrasonographic findings. J Ultrasound Med 2001;20: 217-22.

24. Allon M, Lockhart ME, Lilly RZ, Gallichio MH, Young CJ, Barker J, et al. Effect of preoperative sonographic mapping on vascular access outcomes in hemodialysis patients. Kidney Int 2001;60:2013-20.
25. Golledge J, Smith CJ, Emery J, Farrington K, Thompson HH. Outcome of primary radiocephalic fistula for hemodialysis. Br J Surg 1999;86:211-6.
26. Ravani P, Marcelli D, Malberti F. Vascular access surgery managed by renal physicians: the choice of native arteriovenous fistulas for hemodialysis. Am J Kidney Dis 2002;40:1264-76.
27. Rayner HC, Pisoni RL, Gillespie BW, Goodkin DA, Akiba T, Akizawa T, et al. Creation, cannulation, and survival of arteriovenous fistulae: data from the Dialysis Outcomes and Practice Patterns Study. Kidney Int 2003;63:323-30.
28. Konner K, Hulbert-Shearon TE, Roys EC, Port FK. Tailoring the initial vascular access for dialysis patients. Kidney Int 2002;62:329-38.

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DISCUSSION

Dr Thomas S. Huber (Gainesville, Fla). I would like to lead off the discussion, and I must confess the authors scooped me on a few of my questions.

The authors report a retrospective review of their access practice before and after the introduction of preoperative imaging protocol including duplex ultrasound and venography. They report their native fistula utilization rate increased from approximately 60% to 70% after the introduction of the protocol. However, the rate of mature fistulas suitable for dialysis access decreased from approximately 70% to 60%. Based upon these results the authors concluded that the benefits of extensive preoperative imaging as part of the evaluation for patients referred for dialysis access are overstated, although they do concede that they will continue to use these modalities in their practice.

I laud the authors' efforts to challenge several recent publications extolling the benefits of preoperative imaging prior to access surgery, and I recommend their well-written manuscript to the audience. However, I urge their results and conclusions be interpreted with some caution, and I fear that the manuscript may have the unintentional consequence of increasing the placement of prosthetic arteriovenous fistulae. My specific concerns are twofold. First, although the authors stated their purpose was to examine the success of access procedures performed after the introduction of an imaging protocol, approximately one third of the patients underwent preoperative duplex ultrasound in the historical control group and only two thirds underwent preoperative duplex imaging after initiation of the protocol. A more rigorous evaluation of the preoperative imaging would have compared physical examination alone to the various imaging modalities, and ideally would have been performed in a prospective randomized fashion.

Second, the authors' native fistula rate prior to the initiation of the study exceeded 60% and was well above the targets established by the NFK-DOQI guidelines, in stark contrast to the 17% nationwide rate reported in the Dartmouth Atlas. Additional preoperative imaging may not prove very beneficial to identify good native fistula options in this setting, because their pre-study approach was so effective. In light of these concerns, I would contend that the study is an incrimination of the authors' criteria for native fistula rather than the imaging modalities themselves.

I have three questions for the authors. First, the reported fistula maturation rates were relatively low, given the wide range reported in the literature. Have you examined or documented the various potential reasons why the fistula failed to mature? Indeed, there are multiple potential causes, including failure of the fistula to dilate, fistula stenosis, central vein occlusions, inadequate arterial inflow, and hand ischemia requiring ligation.

Second, the 2.5 mm criterion used to determine whether a vein was suitable for a native fistula seemed relatively aggressive, and may have contributed to the low fistula maturation rate. In our own practice, we have used a 3 mm cutoff, but have been anecdotally impressed that even this may be too aggressive. It has been our experience that bigger clearly is better and that veins with larger diameters translate into better success rates. Did you analyze the impact of vein diameters on the fistula success rate or incorporate this variable into your multivariate analysis?

And last, despite your results, I was impressed by the statement in your conclusions that you will continue to use preoperative duplex imaging. What are your current recommendations to less experienced access surgeons for preoperative evaluation given the NFK-DOQI targets for native fistula utilization?

Dr Sheela Thakor Patel. Thank you, Dr Huber, for your discussion.

If we had an AV fistula that was not maturing by 6 to 8 weeks, we always performed diagnostic imaging to see what the problem was. The most common reason why fistula failed was failure of the veins to dilate or thrombosis, which was most commonly due to stenosis close to the anastomosis. The most common adjunctive procedure that we performed to assist in maturation was angioplasty, which was successful in about 50% of the cases. We only had one case where the documented case of AV fistula failure was an arterial problem, an arterial stenosis.

To address your second question, we did use 2.5 mm vein criteria, based on published studies, and we did not examine the impact of vein diameter in our study. We currently recommend that patients who have visible veins on physical examination, when there is no question of continuity, then those patients do not need to be imaged. Only those patients in whom there is a question of continuity or quality or caliber of the vessels, those patients should get imaging.