Hemodialysis Access Placement With Preoperative Noninvasive Vascular Mapping: Comparison Between Patients With and Without Diabetes

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• **We retrospectively analyzed data on preoperative vascular mapping in 195 consecutive patients to investigate the common belief that patients with diabetes are poor candidates to have an arteriovenous fistula placed as dialysis access because they lack suitable blood vessels. There was no difference in venous diameter, arterial diameter, and arterial peak systolic velocity measurements between patients with and without diabetes. Patients with diabetes had a greater prevalence of vascular calcifications and greater cuff measurements of systolic segmental arterial pressure. In 140 of 195 patients, subsequent vascular access surgery had been performed in our institution, and 127 of these patients were on hemodialysis therapy at the end of the study period. There was no difference in the prevalence of fistula placement (66% versus 60%; chi-square = 2.6; *df* = 2; *P* = 0.28, not significant [NS]) and percentage of functioning fistulae between patients with and without diabetes (67% versus 62%; chi-square = 0.27; *df* = 1; *P* = 0.61, NS). The percentage of patients dialyzed through a temporary catheter was equal in patients with and without diabetes (18%). In summary, patients with diabetes seem to be as good candidates for arteriovenous fistula placement as patients without diabetes. Additional studies are required to determine the long-term outcome of fistulae in patients with diabetes.**

INDEX WORDS: Hemodialysis (HD); vascular access; fistula; vascular mapping; duplex ultrasound; diabetes mellitus.

THE ANNUAL COST to Medicare of maintaining vascular access in the hemodialysis population has been estimated to approach $1 billion.[1] Addressing this enormous public health problem, the 1997 Dialysis Outcomes Quality Initiative recommended the use of autogenous arteriovenous fistulae as the preferential vascular access for hemodialysis because of superior long-term patency rates.[2] Diabetes mellitus has become the leading cause of end-stage renal disease in the United States.[3] There is a general belief among physicians that patients with diabetes would be poor candidates for the placement of arteriovenous fistulae because of smaller, more fragile veins and arterial disease,[1,4] but we have been unable to find data in the literature supporting this belief. Recently, Doppler pressures and duplex ultrasound examination of the upper extremities with mapping of arteries and veins have been shown to be helpful in the preoperative evaluation of patients requiring permanent dialysis access.[5] Over the past 2 years, this noninvasive procedure has been used at Mount Sinai Medical Center (New York, NY) in the setting of a multidisciplinary team effort to increase the proportion of arteriovenous fistulae among our patients. This has allowed us to accumulate data for a large number of patients.

In the present study, we performed a retrospective analysis of available data on preoperative vascular mapping and compared patients with and without diabetes. In a second phase, we surveyed these patients to determine whether dialysis had been started and which vascular access was being used.

METHODS

Starting in 1998, patients requiring permanent vascular access for chronic hemodialysis in our facility have been evaluated by duplex ultrasound of the upper extremities in the vascular laboratory. During the same period, many chronic dialysis patients with a functioning graft were also referred to the vascular laboratory for evaluation for possible fistula placement. Duplex ultrasound was performed as described previously,[5] starting at the wrist with a tourniquet placed at midforearm and dilating veins by tapping and stroking maneuvers. Veins were assessed for compressibility and diameter. Adequate veins were followed up proximally for size and continuity with the deep venous system into the

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subclavian veins. When venous anatomy was acceptable for access placement, arteries were evaluated. Peak systolic velocities, arterial diameter, and patency of the palmar arch were recorded. Ultrasound determination of systolic pressure in segmental arteries was performed using tourniquet compression of the arm. The following criteria were used for placement of an arteriovenous fistula: (1) cephalic or basilic vein greater than 2 mm in diameter, (2) patent subclavian vein on the ipsilateral side, and (3) artery measuring at least 2 mm in diameter and with a peak systolic velocity of at least 50 cm/s.

Both cephalic and basilic veins were used for surgery.[6] Fistulae were allowed a minimum of 8 to 12 weeks for maturation before cannulation. In case of early failure or poor maturation, the fistula was reevaluated and a revision or placement of a new fistula was performed if indicated. Polytetrafluoroethylene grafts were placed when a fistula could not be created. If a patient without a functional permanent vascular access required dialysis, a temporary catheter was placed.

Vascular ultrasound data from December 1998 to January 2000 were used for this retrospective analysis. Operating room records from December 1998 to May 2000 were reviewed for dialysis access procedures. All patients who underwent vascular mapping were surveyed to determine whether a dialysis access had been placed until May 2000 and if it was used for dialysis. For patients no longer receiving medical care at Mount Sinai Medical Center, their last known clinical condition was used for the survey. Patients on dialysis therapy were categorized according to the vascular access in use regardless of the presence of a second immature or nonfunctional vascular access.

Statistical analysis was performed using the Statview program (Abacus, Berkeley, CA) by means of an unpaired *t*-test to compare mean values and chi-square test for categorical variables. Statistical significance was accepted for P of 0.05 or less.

RESULTS

During the study period, venous mapping was performed on 195 consecutive patients. Eighty-two patients had diabetes and 113 patients did not. Sixty percent of patients with diabetes were women compared with 50% of patients without diabetes (chi-square = 1.7; $df = 1$; $P = 0.19$, not significant [NS]). Patients with diabetes were on average 5 years older than patients without diabetes (58 ± 2 versus 53 ± 2 years; $P = 0.04$). There was no difference in venous diameter between patients with and without diabetes (Table 1) or between different racial groups or sexes (data not shown). Arterial measurements were performed in 150 patients. Peak systolic velocity and arterial diameter were not different in patients with and without diabetes (Tables 2 and 3). Vascular calcifications were observed more frequently in patients with diabetes (64%) than patients without diabetes (35%; chi-square = 11; $df = 1$; $P = 0.001$), and systolic segmental arterial pressure measurements were greater in patients with than without diabetes (Table 4). Patients with vascular calcifications had greater arterial pressure measurements compared with patients without vascular calcifications, but there

Table 1. Comparison of Selected Venous Diameters Between Patients With and Without Diabetes

	Patients With Diabetes		Patients Without Diabetes		*P*
	No.	Diameter (cm)	No.	Diameter (cm)	(all NS)
LC, wrist	52	0.26 ± 0.18	56	0.24 ± 0.08	0.54
LC, forearm	64	0.27 ± 0.21	75	0.28 ± 0.38	0.85
L, antecubital	57	0.41 ± 0.40	66	0.39 ± 0.36	0.76
LC, upper arm	64	0.31 ± 0.18	80	0.34 ± 0.50	0.63
LC, axilla	60	0.40 ± 0.40	76	0.38 ± 0.51	0.73
LB, mid upper arm	54	0.39 ± 0.11	68	0.50 ± 0.73	0.31
LB, distal upper arm	56	0.36 ± 0.11	71	0.48 ± 0.78	0.26
LB, elbow	28	0.28 ± 0.10	40	0.40 ± 0.58	0.25
RC, wrist	53	0.24 ± 0.23	66	0.24 ± 0.10	0.95
RC, forearm	62	0.27 ± 0.33	79	0.26 ± 0.20	0.94
R, antecubital	60	0.43 ± 0.52	68	0.40 ± 0.65	0.77
RC, upper arm	63	0.34 ± 0.48	80	0.33 ± 0.42	0.28
RC, axilla	61	0.40 ± 0.57	78	0.35 ± 0.40	0.59
RB, mid upper arm	57	0.39 ± 0.11	79	0.44 ± 0.66	0.38
RB, distal upper arm	57	0.36 ± 0.13	81	0.45 ± 0.63	0.32
RB, elbow	37	0.30 ± 0.10	45	0.36 ± 0.38	0.34

NOTE. Values expressed as mean ± SD.

Abbreviations: L, left; LB, left basilic vein; LC, left cephalic vein; R, right; RB, right basilic vein; RC, right cephalic vein.

Table 2. Comparison of Arterial Peak Systolic Velocities in Patients With and Without Diabetes

	Patients With Diabetes		Patients Without Diabetes		
	No.	Peak Systolic Velocity (cm/s)	No.	Peak Systolic Velocity (cm/s)	*P* (all NS)
Distal left radial artery	35	63.4 ± 25.1	46	56.2 ± 28.2	0.24
Distal left ulnar artery	33	58.6 ± 21.3	44	53.8 ± 22.5	0.33
Distal right radial artery	37	61.5 ± 22.3	46	59.5 ± 18.0	0.66
Distal right ulnar artery	36	62.3 ± 27.6	45	57.2 ± 20.7	0.34

was no difference in peak systolic velocity (data not shown).

From December 1998 to May 2000, a total of 517 dialysis access procedures were performed in 359 patients in our institution. Of the 195 consecutive patients who underwent vascular mapping, 140 patients had a permanent vascular access placed. There was no difference in venous and arterial anatomy or prevalence of diabetes between patients who underwent subsequent vascular access surgery in our institution and those who did not (data not shown). Of 140 patients who underwent access surgery, 87 patients underwent fistula placement and 50 patients underwent graft placement, and in three instances (all in patients without diabetes), access surgery was aborted in the operating room. Forty of 61 patients with diabetes (66%) and 47 of 79 patients without diabetes (60%) received a fistula (chi-square = 2.6; $df = 2$; $P = 0.28$, NS). Thirty-five of the 40 fistulae in patients with diabetes were placed in the forearm. The number of surgical revisions required during the study period was not significantly different between patients with and without diabetes (0.4 ± 0.9 versus 0.7 ± 1.1 revisions, respectively; $P = 0.10$).

At the time of the survey, 127 of the 140 patients were on hemodialysis therapy, 5 patients had died, 2 patients changed to peritoneal dialysis, 2 patients did not start dialysis therapy, 1 patient underwent transplantation, and 3 patients were lost to follow-up. Eighty-seven percent of patients with diabetes and 93% of patients without diabetes who underwent access surgery at our institution were on hemodialysis therapy at the time of the survey (chi-square = 1.9; $df = 1$; $P = 0.17$, NS). Of the 127 patients on hemodialysis therapy, 102 patients used a permanent vascular access and 25 patients used a temporary catheter. The proportion of patients who underwent dialysis through a catheter was equal in patients with (11 of 61 patients; 18%) and without diabetes (14 of 79 patients; 18%). The percentage of fistulae placed that were successfully used was 28 of 40 fistulae (70%) in patients with diabetes and 37 of 47 fistulae (79%) in patients

Table 3. Comparison of Selected Arterial Diameters Between Patients With and Without Diabetes

	Patients With Diabetes		Patients Without Diabetes		
Artery	No.	Diameter (cm)	No.	Diameter (cm)	*P* (all NS)
Left radial proximal	22	0.29 ± 0.06	29	0.32 ± 0.09	0.24
Left radial mid	16	0.28 ± 0.05	24	0.28 ± 0.08	0.98
Left radial distal	34	0.26 ± 0.05	43	0.27 ± 0.08	0.34
Left ulnar proximal	19	0.28 ± 0.07	29	0.30 ± 0.08	0.25
Left ulnar mid	14	0.23 ± 0.05	22	0.25 ± 0.06	0.42
Left ulnar distal	30	0.23 ± 0.05	42	0.24 ± 0.06	0.73
Right radial proximal	20	0.31 ± 0.07	34	0.30 ± 0.06	0.80
Right radial mid	14	0.26 ± 0.04	24	0.27 ± 0.05	0.50
Right radial distal	45	0.24 ± 0.04	33	0.26 ± 0.05	0.09
Right ulnar proximal	19	0.28 ± 0.07	32	0.31 ± 0.08	0.31
Right ulnar mid	14	0.26 ± 0.05	22	0.25 ± 0.06	0.81
Right ulnar distal	31	0.23 ± 0.05	41	0.24 ± 0.05	0.27

NOTE. Values expressed as mean ± SD.

Table 4. Comparison of Systolic Segmental Arterial Pressures Between Patients With and Without Diabetes

	Patients With Diabetes		Patients Without Diabetes		
Artery	No.	Segmental Pressure (mm Hg)	No.	Segmental Pressure (mm Hg)	*P*
Left brachial	34	167 ± 36	47	142 ± 33	0.0019
Left radial	38	183 ± 44	47	152 ± 35	0.0004
Left ulnar	38	184 ± 44	47	150 ± 36	0.0002
Right brachial	38	170 ± 36	51	143 ± 30	0.0003
Right radial	38	185 ± 42	48	156 ± 32	0.0004
Left ulnar	38	189 ± 40	49	155 ± 35	<0.0001

NOTE. Values expressed as mean ± SD.

without diabetes (chi-square = 0.87; $df = 1$; $P = 0.35$, NS). Twenty-five fistulae were placed in patients with the ultrasound finding of vascular calcifications, and 20 of these fistulae (80%) were in use. The prevalence of fistulae among the 102 permanent vascular accesses in use was not different between patients with (28 of 42 patients; 67%) and without diabetes (37 of 60 patients; 62%; chi-square = 0.27; $df = 1$; $P = 0.61$, NS).

DISCUSSION

Analysis of our data on vascular anatomy of the upper extremities does not show a significant difference between patients with and without diabetes regarding venous and arterial diameter and peak systolic velocity. The only difference is an increased prevalence of vascular calcifications and greater arterial blood pressure measurements in patients with diabetes. An increase in peak systolic velocity could be expected with decreased arterial compliance secondary to increased age and blood pressure, but there was no significant difference in peak systolic velocity in the upper extremity between patients with and without diabetes, a finding reported previously.[7] Because arterial blood pressure measurements were obtained using a tourniquet, the higher readings could derive at least in part from artifact from calcified noncompressible blood vessels. Thus, true arterial pressure could be lower, which would explain why corresponding peak systolic velocity was not higher. In any case, the relation between peak systolic velocity and arterial pressure in the presence of diabetes mellitus is not well defined.[8]

A study of histological characteristics of veins harvested during access surgery in chronic hemodialysis patients did not detect a difference between patients with and without diabetes, which is in concordance with our ultrasound findings.[9] Vascular calcifications were described in a report of nine cases of hand gangrene in patients with diabetes on hemodialysis therapy, but were present also in dialysis patients without diabetes and not a statistically significant risk factor; leg gangrene usually preceded the development of hand gangrene.[10]

In our follow-up survey, we did not find a difference between patients with and without diabetes in terms of prevalence of fistula placement, percentage of functioning fistulae, and percentage of patients dialyzed using a catheter. It may be argued that a selection bias is present in our data because only approximately 40% of all patients who underwent dialysis access procedures during the study period underwent preoperative vascular mapping. However, we believe it is probable that more difficult cases were sent for such additional studies as vascular mapping, in which case the selection would have accentuated any differences between patients with and without diabetes.

Variable success with fistulae in patients with diabetes has been reported in the literature. Although Hakaim et al[11] obtained poor results with forearm fistulae in a group of 10 patients with diabetes, Wolowczyk et al[12] did not find a difference in forearm fistula survival between 29 patients with diabetes and 179 patients without diabetes. The worst outcome reported was a series of nine cases of hand gangrene in dialysis patients with diabetes.[10] In this report, gangrene developed in eight cases on the arm with the

vascular access and in two cases, within hours of access surgery, the nature of which, graft or fistula, was not specified. Patients in this report had severe vascular disease leading to amputation in all four extremities, and hand gangrene was always preceded by leg gangrene. We did not observe a particular problem with fistula location in the forearm in patients with diabetes.

In contrast to the previous studies, we used preoperative ultrasound testing as the most reproducible method to evaluate vascular anatomy in the upper extremity. We did not find a basis for the common belief that patients with diabetes are poor candidates to have a fistula placed as dialysis access. This finding is important because diabetes mellitus is the leading cause of end-stage renal disease and shorter patency and greater cost are associated with other types of vascular access. It was reported that prosthetic grafts fare worse in patients with diabetes compared with patients without diabetes.[13] Current differences in type of vascular access placed between patients with and without diabetes appear to be caused by physician practice patterns, and patients with diabetes may have been excluded a priori from receiving a fistula.[14]

The clinical end point for patients on our retrospective study was the type of access used for dialysis at the time of the survey. We disregarded other end points, such as maturation time, previous temporary need for a catheter, and rate of success of the first surgery performed, assuming that the benefit of having a fistula would be the most important outcome. It remains to be seen whether the long-term outcome of fistulae in patients with diabetes is as good as in patients without diabetes.

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