Frequency of critical stenosis in primary arteriovenous fistulae before hemodialysis access: Should duplex ultrasound surveillance be the standard of care?

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Objective: **Increasing use of primary arteriovenous fistulae (pAVFs) is a desired goal in hemodialysis patients (National Kidney Foundation /Dialysis Outcome Quality Initiative guidelines). However, in many instances, pAVFs fail to adequately mature due to ill-defined mechanisms. We therefore investigated pAVFs with color duplex ultrasound (CDU) surveillance 4 to 12 weeks postoperatively to identify hemodynamically significant abnormalities that may contribute to pAVF failure.**

Methods: **From March 2001 to October 2003, 54 upper extremity pAVFs were subjected to CDU assessment before access. A peak systolic velocity ratio (SVR) of ≥2:1 was used to detect ≥50% stenosis involving arterial inflow and venous outflow, whereas an SVR of ≥3:1 was used to detect ≥50% anastomotic stenosis. CDU findings were compared with preoperative vein mapping and postoperative fistulography when available.**

Results: **Of 54 pAVFs, there were 23 brachiocephalic, 14 radiocephalic, and 17 basilic vein transpositions. By CDU surveillance, 11 (20%) were occluded and 14 (26%) were negative. Twenty-nine (54%) pAVFs had 38 hemodynamically significant CDU abnormalities. These included 16 (42%) venous outflow, 13 (34%) anastomotic, and 2 (5%) inflow stenoses. In seven (18%), branch steal with reduced flow was found. In 35 of 54 (65%) pAVFs, preoperative vein mapping was available and demonstrated adequate vein size (≥3 mm) and outflow in 86% of cases. Twenty-one fistulograms (38%) were available for verifying the CDU abnormalities. In each fistulogram, the arterial inflow, anastomosis, and venous outflow were compared with the CDU findings (63 segments). The sensitivity, specificity, and accuracy of CDU in detecting pAVF stenoses ≥50% were 93%, 94%, was 97%, respectively.**

Conclusions: **Before initiation of hemodialysis, an unexpectedly high prevalence of critical stenoses was found in patent pAVFs using CDU surveillance. These de novo stenoses appear to develop rapidly after arterialization of the upper extremity superficial veins and can be reliably detected by CDU surveillance. Turbulent flow conditions in pAVFs may play a role in inducing progressive vein wall and valve leaflet intimal thickening, although stenoses may be due to venous abnormalities that predate AVF placement. Routine CDU surveillance of pAVFs should be considered to identify and correct flow-limiting stenoses that may compromise pAVF long-term patency and use. (J Vasc Surg 2005;41:1000-6.)**

More than 290,000 individuals are hemodialysis dependent in the United States, and it is estimated that this population will double by 2010.[1] Hemodialysis access failure is a major cause of morbidity and multiple hospital admissions. Furthermore, the estimated cost for vascular access morbidity exceeds 2 billion dollars annually.[1,2] Arteriovenous fistulae (pAVFs) are recognized as the gold standard of hemodialysis access because of superior long-term patency and lower infection and intervention rates when compared with prosthetic conduits.[3-5]

The Vascular Access Work Group, of the National Kidney Foundation (NKF), identified two primary goals to improve quality of life and overall outcomes for patients on hemodialysis. The first is to increase the prevalence and use of native AVFs. The second is to detect access dysfunction before occlusion. These goals are addressed in the Dialysis Outcome Quality Initiative (DOQI) guidelines.[3] The ultimate goal is that pAVFs be constructed in at least 50% of all new patients with end-stage renal disease and that 40% of patients undergo hemodialysis via a pAVF. Currently in the United States, only 31% of patients on hemodialysis dialyze through an AVF, and the incidence of AVF creation is a disappointing 28%. This failure is particularly concerning when one considers that 80% of prevalent patients on hemodialysis in Europe dialyze through pAVFs.[6] Ascher et al[4] have reported an increase in pAVF placement to at least 80% in their study cohort when DOQI guidelines are strictly followed, with a 1-year primary patency rate of 85%. The etiology of such poor pAVF prevalence rates in the United States is multifactorial and includes inadequate patient selection, surgical preference, and suboptimal technique during traumatic cannulation.

In April 2004, the need to improve AVF use was further emphasized when the Centers for Medicare and Medicaid announced a national initiative (National Vascu-

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Table I. Patient demographics

Gender	
Male (%)	39
Female (%)	61
Age (y)	55 ± 15 (24-80)
Type of fistula	
Radiocephalic	14
Brachiocephalic	23
Basilic transposition	17

lar Access Improvement Initiative [NVAII]) to foster practice patterns that would increase pAVF use in patients on Medicare. The NVAII statement recommends a multidisciplinary implementation of protocol-driven surveillance programs for early detection and treatment of failing vascular access conduits.[7] The value of a multidisciplinary approach to hemodialysis access was emphasized in a prospective study by Allon et al,[8] which demonstrated a decrease in access failure and an increase in AVF creation in new patients on dialysis from 33% to 69%.

To date, the results of color duplex ultrasound (CDU) pAVF surveillance in the first 2 to 3 months postoperatively are not known. The purpose of this retrospective study was to determine the prevalence of hemodynamically significant abnormalities in pAVFs before access cannulation using a standard protocol of CDU surveillance. We further validated the CDU surveillance results with corresponding fistulograms.

METHODS

Patient population

In this retrospective study (March 2001 to October 2003), we reviewed the CDU surveillance findings of patients referred for evaluation of upper extremity pAVFs in 54 patients within 3 months of fistula creation and before initiation of hemodialysis. During this study period, a total of 263 patients underwent AVF placement and 186 patients underwent nonautologous arteriovenous graft placement. CDU evaluation of the pAVFs was conducted to assess several aspects of fistula maturation including diameter, depth from the skin surface, side branch steal, and the presence of ≥50% stenosis in the arterial inflow, anastomosis, or venous outflow of the arterialized vein. The CDU surveillance results were compared with preoperative vein mapping and fistulography when available.

CDU evaluation

CDU examinations were performed by an experienced sonographer using an ATL HDI 5000/3000 series (Advanced Technology Laboratories, Bothell, Wash) or Acuson Sequoia 512 (Acuson Corporation, Mountain View, Calif) ultrasound machine with a 4- to 7- or a 5- to 10-MHz linear array transducer. A standard protocol for pAVF CDU evaluation was followed that included interrogation of the arterial inflow, anastomosis, and venous outflow tract. pAVF examination included Doppler spectral analysis and B-mode imaging complemented with color flow mapping.

Pulsed Doppler spectral analysis. Doppler spectral analysis was used to measure peak systolic velocity (PSV) at a 60-degree angle of insonation. An initial sweep of the arterial inflow, anastomosis, and fistula body with pulsed-wave Doppler was performed to identify areas of increased velocity. Representative measurements were taken at the arterial inflow, anastomosis, and proximal, mid, and distal venous outflow. The venous outflow was examined to the level of the axilla, including the central venous system when possible. Criteria for a hemodynamically significant stenosis (≥50%) were based on previously published reports.[9,10] Two parameters were used, the PSV and the systolic velocity ratio (SVR). The SVR was determined by calculating the ratio of the highest PSV at the suspect stenosis normalized to the prestenosis PSV. Hemodynamically significant stenosis of the arterial inflow or venous outflow was indicated when the SVR was >2. Anastomotic stenoses were determined by an SVR of 3 and a minimum PSV of 400 cm/s. Stricter criteria were used at the anastomoses because of inherently turbulent flow conditions and elevated velocities caused by the steep pressure gradient.

Side branch steal was defined as high-velocity flow through a side branch with a significant reduction in velocity through the main venous outflow. Gray scale median analysis was first used to identify the branch. PSV was then

Table II. Results of color duplex ultrasound examinations in different primary arteriovenous fistula types

	Radiocephalic (n = 14)	*Brachiocephalic (n = 23)*	*Brachiobasilic transposition (n = 17)*	*Total (n = 54)*
No abnormality	5 (36%)	8 (35%)	1 (6%)	14 (26%)
Hemodynamically significant abnormalities	6 (43%)	11 (48%)	12 (71%)	29 (54%)
Arterial inflow	0	0	2	2
Anastomosis	3	5	4	12
Venous outflow	4	6	6	16
Branch	3	3	1	7
				37
Occlusion	3 (21%)	4 (17%)	4 (23%)	11 (20%)

Chi-square analysis showed no statistical difference between groups, $P = .249$. Types of abnormalities that were found are listed for each group. A total of 37 abnormalities were found in 29 abnormal examinations.