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Effect of preoperative sonographic mapping on vascular access outcomes in hemodialysis patients

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Background. Current DOQI guidelines encourage placing arteriovenous (AV) fistulas in more hemodialysis patients. However, many new fistulas fail to mature sufficiently to be useable for hemodialysis. Preoperative vascular mapping to identify suitable vessels may improve vascular access outcomes. The present study prospectively evaluated the effect of routine preoperative vascular mapping on the type of vascular accesses placed and their outcomes.

Methods. During a 17-month period, preoperative sonographic evaluation of the upper extremity arteries and veins was obtained routinely. The surgeons used the information obtained to plan the vascular access procedure. The types of access placed, their initial adequacy for dialysis, and their long-term outcomes were compared to institutional historical controls placed on the basis of physical examination alone.

Results. The proportion of fistulas placed increased from 34% during the historical control period to 64% with preoperative vascular mapping ($P < 0.001$). When all fistulas were assessed, the initial adequacy rate for dialysis increased mildly from 46 to 54% ($P = 0.34$). For the subset of forearm fistulas, the initial adequacy increased substantially from 34 to 54% ($P = 0.06$); the greatest improvement occurred among women (from 7 to 36%, $P = 0.06$) and diabetic patients (from 21 to 50%, $P = 0.055$). In contrast, the initial adequacy rate of upper arm fistulas was not improved by preoperative vascular mapping (59 vs. 56%, $P = 0.75$). Primary access failure was higher for fistulas than grafts (46.4 vs. 20.6%, $P = 0.001$), but the subsequent long-term failure rate was higher for grafts than fistulas ($P < 0.05$). Moreover, grafts required a threefold higher intervention rate (1.67 vs. 0.57 per year, $P < 0.001$) to maintain their patency. The overall effect of this strategy was to double the proportion of patients dialyzing with a fistula in our population from 16 to 34% ($P < 0.001$).

Conclusions. Routine preoperative vascular mapping results in a marked increase in placement of AV fistulas, as well as an improvement in the adequacy of forearm fistulas for dialysis. This approach resulted in a substantial increase in the proportion of patients dialyzing with a fistula in our patient population. Fistulas have a higher primary failure rate than grafts, but have a lower subsequent failure rate and require fewer procedures to maintain their long-term patency.

Key words: fistula, vascular access, gender, race, grafts, dialysis access, arteriovenous fistula, patency.

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Vascular access procedures and their subsequent complications represent a major cause of morbidity, hospitalization and cost for chronic hemodialysis patients [1–4]. Recognizing the superiority of fistulas over grafts, the National Kidney Foundation Dialysis Outcomes Quality Initiative (DOQI) guidelines on vascular access recommend attempting a fistula placement in at least 50% of patients, with arteriovenous (AV) grafts being reserved for patients whose vascular anatomy does not permit construction of a native AV fistula [5]. Notwithstanding these national recommendations, only about 20% of hemodialysis patients in the United States have an AV fistula as their vascular access [6]. In fact, the rate of fistula placement in new hemodialysis patients actually declined between 1986 and 1990 [7].

In an attempt to maximize the proportion of patients who dialyze with fistulas, two competing observations need to be balanced. Once fistulas achieve adequacy for dialysis, they have increased longevity as compared with grafts [8–11] and are less prone to recurrent stenosis, thrombosis, and infection [12]. However, fistulas have a high rate of primary failure (early thrombosis or inadequate maturation) that preclude their successful use for dialysis [11, 13, 14]. An aggressive approach to fistula placement further increases the likelihood of primary fistula failure among patients with marginal vasculature [14]. Moreover, the relatively long time required for fistulas to achieve adequacy (~3 months vs. 2 to 3 weeks for grafts) translates into a larger population requiring temporary catheters for dialysis access, with the atten-

dant risks of catheter thrombosis, infection, and inadequate dialysis caused by suboptimal blood flows.

In order to increase the proportion of patients dialyzing with fistulas the following two concurrent measures are required: (*1*) a concerted effort to increase the number of fistula placements and (*2*) methods to increase the proportion of fistulas that achieve adequacy for dialysis. At the University of Alabama at Birmingham (UAB) we have undertaken an aggressive approach to attempt fistula placement in as many hemodialysis patients as possible. Analysis of our initial two-year experience (April 1, 1996 to March 31, 1998) was disappointing [14]. During this period, 33% of the vascular accesses placed were fistulas, and only 47% of all fistulas placed matured adequately to be useable for dialysis. Moreover, a mere 34% of forearm fistulas were useable for dialysis, as compared with 59% of upper arm fistulas. The adequacy rate of forearm fistulas was particularly poor in women (7%) and diabetic patients (21%) [14]. In an attempt to increase the proportion of patients dialyzing with fistulas, we introduced a multidisciplinary approach involving routine preoperative sonographic vascular mapping to assist the surgeons in planning the optimal vascular access. A pilot study in 52 consecutive patients revealed that the anatomic information obtained during vascular mapping prompted the surgeons to change their planned surgical procedure in 31% of the cases [15]. The goal of the present study was to evaluate the effect of routine preoperative sonographic vascular mapping on the types of vascular access placed and their clinical outcomes.

METHODS

Patient population

The University of Alabama at Birmingham (UAB) provides chronic dialysis to approximately 500 patients, of whom 85% receive in-center hemodialysis at one of seven outpatient dialysis units. The demographics of our patient population are as follows: 28% of the patients are age 65 or older; 46% of the patients are female; 76% of the patients are black and 24% are white; and 44% of the patients have diabetes. The medical care of these patients is provided by eight clinical nephrologists, all of whom are full-time University faculty in the Division of Nephrology. All patient hospitalizations, surgical procedures, and radiologic procedures are done at UAB Hospital. All vascular access procedures are performed by one of three experienced renal transplant surgeons. The Division of Interventional Radiology performs radiologic diagnostic tests and interventions for dialysis vascular access. The Division of Ultrasound performs all preoperative vascular mapping procedures.

Preoperative vascular mapping

Strict criteria for sonographic vascular mapping and subsequent access recommendations were developed jointly by the nephrologists, radiologists, and surgeons providing the medical care to the dialysis patients [15]. These criteria defined the minimal requirements for construction of a fistula or a graft. The minimum arterial diameter had to be $\geq$2 mm for all fistulas and grafts. The vein diameter had to be $\geq$2.5 mm for construction of a fistula, and $\geq$4.0 mm for graft placement [16]. In addition, sonographic vascular evaluation was used to exclude stenosis or thrombosis in the planned draining vein up to the medial subclavian vein, as well as to assess the brachiocephalic vein and superior vena cava indirectly for significant stenosis or occlusion [15]. The surgeons reviewed the results of the vascular mapping prior to planning the surgical procedure. Construction of a radiocephalic fistula was the first choice, followed by a brachiocephalic fistula. If neither was possible based on the vein diameters, an upper arm basilic vein transposition fistula was considered. An arteriovenous (AV) graft was placed if none of these fistulas was feasible.

Clinical management of vascular access

Fistulas were typically allowed to mature for six to eight weeks prior to their first cannulation for dialysis. If they failed to mature adequately, were difficult to cannulate, or resulted in infiltration, the patient was referred to Radiology at the discretion of the nephrologist for further evaluation by an ultrasound or fistulogram. This evaluation occasionally resulted in an angioplasty of a stenotic draining vein, ligation of large tributary veins, or superficialization of a deep draining vein. If a fistula clotted, thrombectomy was not attempted, as we have had very poor success with this intervention at our institution. AV grafts were typically cannulated two to three weeks after their construction. They were monitored for clinical evidence of stenosis and referred for a fistulogram with possible angioplasty as indicated. Thrombosed grafts were referred for mechanical thrombolysis and angioplasty by radiology. If the radiologic procedure was unsuccessful, they were referred for surgical thrombectomy and revision. If the graft could still not be salvaged, the patient underwent placement of a new vascular access.

Data analysis

A full-time dialysis access coordinator scheduled all of the vascular access procedures and maintained a prospective, computerized record of all procedures performed [17]. Consent for review of the patients' medical records for research purposes was obtained from the UAB Institutional Review Board. During the 17-month period from November 1998 to March 2000 a total of 255 vascular accesses were placed at UAB following preoperative vascular mapping. The following clinical and demographic information was collected: patient age, gender, race, diabetic status, body mass index, and surgeon.