Arterial Problems Associated with Dysfunctional Hemodialysis Grafts: Evaluation of Patients at High Risk for Arterial Disease

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PURPOSE: To retrospectively review the incidence and types of arterial problems associated with dysfunctional hemodialysis grafts in patients who are at high risk for peripheral arterial disease.

MATERIALS AND METHODS: During the 1-year period from February 2001 to February 2002, 40 patients with polytetrafluoroethylene hemodialysis grafts underwent upper extremity arteriography to evaluate arterial inflow to the vascular access. The indication for arteriography was based on the presence of at least two of the following risk factors for peripheral vascular disease: diabetes mellitus, hypertension, and age greater than 65 years. Thirty-three of the 40 patients were women and the median age was 65 years. Thirty-three patients had forearm loop-configuration grafts and seven had upper-arm grafts.

RESULTS: Upper extremity arteriography revealed 13 arterial inflow lesions in 11 of the 40 patients (28%). Ten patients had stenoses at the arterial anastomosis. Two of these patients also had stenoses in the brachial artery. One patient had a single stenosis in the brachial artery. Eight of the 11 patients (73%) underwent angioplasty of seven arterial anastomotic stenoses and three brachial artery stenoses. Comparative analysis revealed that the presence of risk factors for atherosclerotic disease did not correlate with an increased incidence of arterial inflow problems. Surprisingly, patients with diabetes mellitus had a decreased likelihood ($P = .03$) of having an arterial abnormality.

CONCLUSION: Although the incidence of arterial anastomotic stenoses in our study group was higher than previously reported, patients undergoing hemodialysis who have risk factors for peripheral vascular disease do not have a high prevalence of native arterial lesions.

Index terms: Dialysis, grafts • Peripheral vascular disease

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Abbreviation: PTFE = polytetrafluoroethylene

ATHEROSCLEROTIC disease is more common in patients with end-stage renal disease than in the general population (1). Cardiovascular disease is the principal cause of morbidity and mortality in patients undergoing hemodialysis (2,3). Several studies have suggested that renal insufficiency may promote or accelerate the atherosclerotic process (4,5). In addition, several major risk factors for atherosclerotic disease, such as older age, diabetes mellitus, and hypertension, are prevalent in the population of patients in the United States undergoing hemodialysis (1,6).

We have used upper extremity arteriography increasingly to evaluate the arterial component of the vascular access circuit in patients undergoing hemodialysis. Our use of arteriography has been discriminate; only those patients with dysfunctional hemodialysis grafts who have coexisting risk factors for atherosclerotic disease undergo upper extremity arteriography. Our early anecdotal experience led us to believe that arterial inflow problems are more frequent than has been previously reported.

This retrospective investigation was undertaken to determine the incidence and type of native arterial inflow problems associated with dysfunctional hemodialysis grafts in patients with coexisting risk factors for peripheral vascular disease.

MATERIALS AND METHODS

Study Group

Our institutional review board approved this retrospective investigation. A search of our interventional radiology database revealed that, between February 2001 and February...
2002, 40 patients with polytetrafluoroethylene (PTFE) hemodialysis grafts underwent upper extremity arteriography during evaluation of their vascular access. All 40 patients were referred for fistulography because of decreased (<600 mL/min) intragraft blood flow measured during routine vascular access monitoring with use of the Transonic HD01 system (Transonic, Ithaca, NY).

This is a retrospective study. Therefore, strict indications for arteriography were not prospectively established. Our decision to perform upper extremity arteriography was informally based on the presence of coexisting medical conditions that are recognized as risk factors for peripheral vascular disease. Patients with at least two of the following risk factors underwent arteriography: diabetes mellitus, hypertension, and age greater than 65 years.

Patient demographics are provided in the Table. Thirty-three patients (83%) in the study group were women and the median age was 65 years (range, 32–89 y). Thirty-eight (95%) patients were black, 33 (83%) had hypertension, and 22 (55%) had diabetes mellitus. Nineteen patients (48%) had both hypertension and diabetes mellitus.

All patients had patent loop-configuration PTFE hemodialysis grafts. Thirty-two patients (83%) had forearm grafts and seven grafts (17%) were located in the upper arm. Before fistulography, each patient’s vascular access was examined by an interventional radiologist. None of the patients had clinical evidence of a vascular access-related infection.

The procedural films, radiology reports, and hemodialysis records for each patient were retrospectively reviewed.

### Table

<table>
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<th>Patient Demographics</th>
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<th>Arterial Abnormality Group</th>
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<td>(n = 11)</td>
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<tr>
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Note.—Values are given as percentages unless specified otherwise.

Angiography and Interventions

The apex of the graft was entered with use of an 18-gauge needle, and a 0.035-inch Bentzon guide wire (Cook, Bloomington, IN) was inserted into the arterial limb of the graft. A multipurpose angiographic catheter (Cook) was used to advance the guide wire through the arterial anastomosis. The tip of the angiographic catheter was positioned within the subclavian artery, distal to the origin of the vertebral artery. Approximately 10 mL of low-osmolarity contrast material (Optiray; Mallinckrodt Medical, St. Louis, MO) was hand-injected and digital subtraction angiography was performed. Complete imaging of the upper extremity arteries and arterial anastomosis required several separate digital subtraction angiograms. Orthogonal projections were obtained to assess the arterial anastomosis.

The tip of the angiographic catheter was then positioned within the arterial limb of the graft and a standard diagnostic fistulogram was obtained. Multiple digital subtraction images of the venous anastomosis, peripheral veins, and central veins were obtained.

The majority of patients with significant (>50%) stenoses underwent endovascular treatment. Arterial and venous interventions were performed through 7- or 8-F vascular sheaths (Mallinckrodt Medical). Heparin was not administered before the endovascular interventions. Arterial and venous angioplasty procedures were performed with use of standard techniques. Angioplasty of the arterial anastomosis and brachial artery was performed with use of 4- or 5-mm-diameter angioplasty balloons (Tru-Track, C.R. Bard, Covington, GA). Dilatation of venous stenoses was performed with use of 7- or 8-mm high-pressure angioplasty balloons (Centurion; C.R. Bard). The angioplasty balloon was inflated for at least 30 seconds for arterial and venous stenoses. A completion digital subtraction angiogram was obtained after the angioplasty procedures.

Lesion length and degree of stenosis were obtained from the procedural reports. When measured at the time of the procedure, the degrees of stenosis and lesion lengths were determined with use of the software within the digital imaging system. When this information was not provided in the procedural reports, these measurements were retrospectively obtained from the procedural films. The degrees of stenosis and lesion lengths were measured with use of a millimeter ruler. The length of stenosis was estimated with the 6-mm PTFE graft used as an internal standard. The degree of stenosis was estimated by dividing the measured diameter of the stenosis by the diameter of an adjacent segment of normal vein or artery.

Definitions

A significant stenosis was defined as greater than 50% diameter reduction compared to a normal vascular segment located adjacent to the stenosis (7). For arterial anastomotic stenoses, the reference vessel was a normal arterial segment located upstream from the anastomosis. For lesions that were of questionable significance, the degree of stenosis was measured with use of the calibrated computer software within the digital imaging system.

Anatomic success after an endovascular intervention was defined as less than 30% residual diameter stenosis (7). Clinical success was defined as the
ability to use the hemodialysis graft for at least one hemodialysis treatment after the endovascular procedure (7).

A major complication was defined as one that altered the course of the procedure or required additional treatment (8). A minor complication was defined as one that required minimal or no additional treatment (8).

Statistical Analysis

The 40 patients who underwent upper extremity arteriography were divided into two subgroups: those who had an arterial problem and those who did not (Table). The demographic parameters and coexisting medical conditions of these two subgroups were compared with use of the Student paired $t$ test and the Fisher exact test.

RESULTS

Upper extremity arteriography revealed 13 arterial inflow abnormalities in 11 (28%) of the 40 patients. Eight patients had a single stenosis at the arterial anastomosis. One patient had an atherosclerotic stenosis in the brachial artery and an arterial anastomotic stenosis. Another patient had a single focal stenosis in the brachial artery. The mean length of these 13 stenoses was 6 mm (range, 3–17 mm). The mean degree of stenosis was 78% (range, 57%–90%).

Eight patients with 10 stenoses underwent arterial angioplasty; there were seven arterial anastomotic stenoses and three brachial artery stenoses. The anatomic success rate was 75%; two of the eight patients had greater than 30% residual stenosis after angioplasty (Fig 2). However, the clinical success rate was 100%; all eight patients who underwent angioplasty were able to undergo a successful dialysis treatment after the endovascular procedure. Three patients did not undergo angioplasty of the arterial stenosis, the reasons for which were not specified in the procedural reports and remain unknown.

There was one minor complication of an arterial angioplasty procedure. In one patient, the dilation of an arterial anastomotic stenosis with use of a 5-mm-diameter balloon caused a focal rupture of the vascular wall. This injury was identified as extravasation of contrast material into the perivascular tissues during completion angiography. The bleeding was minimal and self-limited; no additional treatment was performed. A physical examination failed to demonstrate a hematoma at the site of rupture. A follow-up arteriogram obtained 18 days after the initial injury revealed favorable remodeling with minimal residual irregularity of the endovascular wall.

In addition to upper extremity arteriography, all 40 patients underwent a complete evaluation of the hemodialysis graft and native venous outflow. These diagnostic studies revealed a total of 96 additional venous and intragraft stenoses in the study group of 40 patients. The location of these lesions was as follows: venous anastomosis ($n = 38$), intragraft ($n = 30$), basilic vein ($n = 22$), cephalic vein ($n = 3$), and subclavian vein ($n = 3$). Seventy of these 96 venous and intragraft stenoses were significant and were treated with angioplasty. Seven of these patients had placement of a vascular stent after an unsuccessful angioplasty procedure. The subgroup of 11 patients who had arterial stenoses also had 19 venous stenoses. Seventeen of these venous stenoses were significant and were treated with angioplasty.

Our comparative analysis of the two subgroups (Table) revealed that coexisting risk factors for atherosclerotic disease did not correlate with an increased incidence of arterial inflow problems. Surprisingly, patients with diabetes mellitus had a decreased likelihood ($P = .03$) of having an arterial abnormality associated with their hemodialysis graft.

Figure 1. A digital subtraction arteriogram reveals fibromuscular dysplasia (arrow) in the brachial artery and a stenosis (arrowhead) at the arterial anastomosis.

Figure 2. A high-grade stenosis is visible at the arterial anastomosis.
DISCUSSION

The primary focus of hemodialysis graft intervention has been on the identification and treatment of intimal hyperplastic stenoses located at the venous anastomosis and within the native veins. Previous studies have reported that it is uncommon to find stenoses at the arterial anastomosis or in the native arteries (9,10). Kanterman and colleagues (11) reported a 4% incidence of arterial anastomotic stenosis in 90 patients with dysfunctional hemodialysis grafts. However, more recent studies have suggested that the incidence of native arterial stenoses can be substantially higher (12,13). In addition, the occurrence of atherosclerotic arterial stenoses in patients undergoing hemodialysis who are elderly, hypertensive, or diabetic is not an unexpected finding (1,2).

Eleven of the 40 patients (27.5%) in our study group had significant arterial lesions. Although these patients had risk factors for peripheral atherosclerotic disease, the majority of the stenoses were located at the arterial anastomosis and were probably not atherosclerotic in origin. These focal stenoses had the typical appearance of an anastomotic intimal hyperplastic lesion. Three stenoses were located in the brachial artery; two of these were probably atherosclerotic lesions and one was likely fibromuscular dysplasia. However, we did not obtain histologic specimens of these lesions to confirm our diagnoses.

Based on our previous anecdotal experience, this incidence of arterial problems is lower than we had expected. During a 2-year period (1998-2000), we had occasionally performed arteriography to evaluate patients whose intragraft blood flow failed to improve after an apparently successful venous angioplasty procedure. During this time, we discovered numerous arterial problems including atherosclerotic stenoses in the subclavian and brachial arteries, fibromuscular dysplasia in the brachial artery, and several occluded brachial arteries (Fig 3). In these patients, the blood flow to the hemodialysis graft was often maintained by a network of arterial collateral vessels. It was our increasing experience, not infrequent discovery of arterial stenoses, that provoked our initiation of this retrospective study. However, those patients who were found to have an arterial problem associated with their hemodialysis graft during our early experience (1998-2000) were not included in this investigation. Unfortunately, the specific indications for their diagnostic fistulogram, or for the arteriogram, were not well defined or documented during that time period.

Our study group had a high percentage of women (83%) and black patients (95%). However, a recent analysis of the demographics at our affiliated hemodialysis center revealed that 54% of the total patients were women and 91% were black. The high prevalence of black women in our study group of patients with dysfunctional hemodialysis grafts is consistent with data gathered in the United States Renal Data System Morbidity and Mortality Study (14). Gibson and colleagues (14) analyzed this data and reported that women have an 18% greater risk of primary failure of vascular access than men. Black patients had a 14% increase in the risk of primary failure compared to other racial groups (14). Therefore, considering the demographics of our hemodialysis population and the greater likelihood of vascular access failure in black women, it is not surprising that our study group of patients with dysfunctional hemodialysis grafts consisted of a high percentage of black women.

We have observed that there is often a disparity in the diameters of the native artery and the PTFE hemodialysis graft at the arterial anastomosis.
The measurement of intraaccess blood flow provides a quantitative assessment of vascular access performance and is a sensitive and specific method for the detection of access-related stenoses (16). Importantly, the measurement of intraaccess blood flow provides insight into the patency of the entire vascular access circuit, including arterial inflow, venous outflow, and the cardiac pump. Our increasing use of intragraft blood flow measurements, combined with the results of this study, has demonstrated to us that arterial stenoses are more common and more significant than generally believed.

Blood flow within a vascular access is related to the patient’s blood pressure and the total resistance of the vascular access circuit (17). Clinical studies have demonstrated that the arterial inflow resistance, not the venous outflow resistance, is the most significant component of total graft resistance (18,19). Therefore, the identification and treatment of arterial stenoses is as important, if not more so, than the treatment of venous stenoses. In addition, blood flow in the brachial artery increases 10 to 20 fold after creation of an upper extremity vascular access (20). Because of this tremendous increase in blood flow, an arterial stenosis that was previously insignificant may become flow-limiting after creation of a vascular access.

In conclusion, arterial stenoses can be a significant contributor to vascular access dysfunction and thrombosis. In this study of patients with risk factors for atherosclerotic disease, we did not find an unusually high number of native arterial lesions. However, 25% of these patients had arterial anastomotic stenoses. Arteriography should be considered during the evaluation of the dysfunctional vascular access, particularly for those patients with recurring but undiagnosed problems.

References

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