From the Society for Clinical Vascular Surgery

Results of repeated percutaneous interventions on failing arteriovenous fistulas and grafts and factors affecting outcomes

Kimberly T. Malka, MD, PhD, Julie Flahive, MS, Alex Csizinscky, MD, Francesco Aiello, MD, Jessica P. Simons, MD, Andres Schanzer, MD, Louis M. Messina, MD, and **William P. Robinson, MD,** *Worcester, Mass*

Objective: **Repeated percutaneous interventions on failing arteriovenous fistulas (AVFs) and arteriovenous grafts (AVGs) for hemodialysis are common, but the outcomes are largely unknown. We sought to determine the results of the second percutaneous intervention on failing AVGs and AVFs and to identify factors associated with loss of patency.**

Methods: **For the purpose of this study, the second percutaneous intervention was identified as the index procedure. We reviewed the second percutaneous interventions on failing AVFs and AVGs at a single institution between 2007 and 2013. Patient comorbidities, graft or fistula configuration, lesion characteristics, and procedural characteristics of the intervention performed were analyzed with respect to technical success, primary patency, primary assisted patency, and secondary patency. Patency was defined per Society for Vascular Surgery recommended reporting standards and was determined from the time of the index procedure. Cox proportional hazards multivariable modeling was performed to identify independent determinants of loss of patency.**

Results: **Among 91 patients, 96 second-time percutaneous interventions were performed on 52 AVFs and 44 AVGs. Patients included 56% men and 44% women with a mean age of 64 ± 17 years. The lesions intervened on were primarily located along the accessed portion of the outflow in AVFs and within the length of the graft and at the venous anastomosis in AVGs. Transluminal angioplasty alone was performed in 82 procedures (85%), and uncovered or covered stents were placed in 15 procedures (16%). Pharmacomechanical thrombectomy was performed in 32 patients (34%) and was more commonly performed in AVGs compared with AVFs (53% vs 17%; $P = .0002$). Technical success was achieved in 90 procedures (97%; n = 92). One-year primary patency, assisted primary patency, and secondary patency rates were 35%, 86%, and 86%, respectively. One-year primary patency did not differ between AVFs and AVGs, but secondary patency was lower for AVG in comparison to AVF ($P = .04$). On multivariable analysis, only the need for pharmacomechanical thrombectomy significantly predicted failure of primary patency (hazard ratio, 2.6; 95% confidence interval, 1.6-4.3). The presence of an AVG rather than an AVF independently predicted failure of secondary patency (hazard ratio, 2.9; 95% confidence interval, 1.0-8.2).**

Conclusions: **The second percutaneous interventions on AVFs and AVGs are associated with excellent technical success but poor primary patency. The need for pharmacomechanical thrombectomy predicts the need for additional percutaneous intervention to maintain patency. With additional interventions, acceptable secondary patency out to 5 years can be achieved, although AVGs have inferior secondary patency to AVFs. To develop optimal practice management algorithms, the effectiveness of repeated percutaneous interventions for failing AVGs and AVFs vs creation of a new access should be further investigated. (J Vasc Surg 2016;63:772-7.)**

As of 2009, there were approximately 370,000 patients on hemodialysis in the United States. Access durability is a vexing problem as primary patency remains suboptimal. Primary patency rates for arteriovenous fistulas (AVFs) and arteriovenous grafts (AVGs) are reported to be 72% and 58% at 6 months and only 51% and 33% at 18 months, respectively.[1] Accordingly, most surgeons advocate a policy of aggressive reintervention on failing arteriovenous access to maintain patency. Huber et al[1] reported that performing endovascular and open interventions for stenotic or thrombosed access can improve patency rates for AVFs and AVGs to 86% and 76% at 6 months and 77% and 55% at 18 months, respectively. However, patency rates of AVFs and AVGs after multiple percutaneous interventions are unknown.

The current Society for Vascular Surgery guidelines recommend using both endovascular and open surgery to maintain and to restore the patency of AVFs and AVGs; however, because of the limited data available, this recommendation is based on only grade 2 evidence.[2] Bountouris et al[3] showed that 50% of AVFs and AVGs undergoing

From the Division of Vascular and Endovascular Surgery, University of Massachusetts Medical School.

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Correspondence: William P. Robinson, MD, Department of Vascular Surgery, University of Massachusetts Medical School, 55 Lake Ave North, Worcester, MA 01604 (e-mail: william.robinson@umassmemorial.org).

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percutaneous transluminal angioplasty (PTA) will ultimately require reintervention, indicating that multiple percutaneous interventions are often performed in an attempt to prolong or to restore functional patency of arteriovenous access. Although it is common, the results of a strategy of repeated percutaneous intervention on failing arteriovenous access have not been well described. The objective of this study was to determine the patency of the second percutaneous intervention on failing arteriovenous access and to identify predictors of loss of patency after the second percutaneous intervention.

METHODS

Patients and procedures. All patients undergoing percutaneous interventions on AVFs or AVGs at the University of Massachusetts Medical Center between 2007 and 2013 were entered into our database. This study was reviewed by the University of Massachusetts Medical School Institutional Review Board, and the need for informed consent was waived. The database was searched to identify patients who had multiple percutaneous interventions. If patients had multiple percutaneous interventions on separate access sites, each access site could be counted in this study. For the purpose of this study, the second percutaneous intervention was identified as the index procedure. A detailed chart review was performed to identify the type of dialysis access, procedural characteristics, anatomic characteristics of lesions, number and timing of additional interventions, and patient comorbidities. These comorbidities were determined as they were documented as chronic medical conditions in the patients' medical records.

Indications for interventions. Indications for the index procedure were clinical dysfunction of the AVF or AVG when it was used for hemodialysis or abnormalities on physical examination of the AVF or AVG in conjunction with a hemodynamically significant stenosis (>60% diameter reducing) demonstrated in the access by fistulography. In the majority of patients, fistulography was performed for difficulty in accessing the fistula or graft, low flow rates, impaired clearance or recirculation, high venous pressure, prolonged bleeding after decannulation, or extremity swelling. In some cases, changes in the access on physical examination, including diminished thrill, increased pulsatility of the AVF or AVG, and focal aneurysmal dilation, prompted fistulography. Although duplex ultrasound examination of AVFs and AVGs was used in some patients before fistulography and intervention, we do not use a routine duplex ultrasound surveillance protocol, and therefore interventions were not resultant from asymptomatic abnormalities detected on surveillance. Our group maintains a hemodialysis access program that works with local nephrology practices and local dialysis centers in maintaining hemodialysis access for patients in our region, which is predicated on prompt and aggressive evaluation of failing hemodialysis access by a vascular surgeon's evaluation and percutaneous fistulography and intervention when indicated. The indications for the initial percutaneous intervention as well as percutaneous interventions subsequent to the index procedure were the same as those for the index intervention. Open surgical revisions are used by our group for side branch ligation and superficialization and are preferred in the treatment of ulceration and aneurysmal dilation. All reinterventions on AVFs and AVGs begin with fistulography and are carried out percutaneously if possible. Open interventions for stenotic lesions are pursued only if percutaneous interventions fail. Patients with a history of open revision of the AVF or AVG were excluded from the study. To put the use of second percutaneous interventions into the context of our hemodialysis access program, our group performed the following procedures between 2007 and 2013: 1131 permanent access creations (830 AVFs and 301 AVGs), 1613 diagnostic fistulography examinations or percutaneous interventions on stenotic AVFs, 310 percutaneous pharmacomechanical thrombectomy procedures on occluded AVFs and AVGs, and 273 open surgical revisions.

Conduct of procedure. In the majority of cases, ultrasound guidance was used to establish access with a micropuncture sheath in the efferent limb of the AVF or AVG just distal to the arterial anastomosis. Complete angiography was performed through the sheath, including visualization of the proximal portion of the access and the arterial anastomosis, the entire length of the fistula, and the outflow veins and central veins. The micropuncture catheter was exchanged for an interventional sheath (generally 6F or 7F), through which wire traversal of the lesion and subsequent intervention were performed. In most cases, systemic heparin was administered. The choice of PTA alone or stent use was made by the vascular surgeon performing the procedure. Balloon angioplasty, most often performed with high-pressure noncompliant balloons, was performed for approximately 2 minutes. Stents were generally used to treat lesions refractory to PTA. For those patients who presented with occluded AVFs or AVGs, pharmacomechanical thrombectomy with tissue plasminogen activator infusion and the AngioJet device (Boston Scientific, Natick, Mass) was performed to open the fistula or graft and to allow fistulography for identification and treatment of the underlying stenotic lesion. Tissue plasminogen activator was either infused directly into the occluded AVF or AVG through a 6F sheath placed in the proximal efferent limb and allowed to dwell for 10 minutes before percutaneous thrombectomy or laced into the thrombosed access using the "pulse spray" mode of the AngioJet device. Percutaneous thrombectomy of the efferent limb using the AngioJet was then performed. In many instances, a second access in the distal portion of the efferent limb directed toward the arterial anastomosis allowed over-the-wire thrombectomy of the thrombus plug at the anastomosis and proximal efferent limb. After clearance of thrombus and establishment of flow, fistulography and intervention on any hemodynamically significant lesions were performed.

Outcomes. Technical success was defined as restoration of flow through the occluded AVF or AVG and