Endovascular Repair of Hemodialysis Graft-Related Pseudoaneurysm: An Alternative Treatment Strategy in Salvaging Failing Dialysis Access

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Introduction Hemodialysis access–related pseudoaneurysm is a known complication in patients requiring hemodialysis via prosthetic arteriovenous grafts (AVGs). The traditional treatment strategy of AVG-related pseudoaneurysms is either AVG ligation or interposition replacement with another prosthetic graft segment or autogenous veins.

Patients and methods From June 2002 to August 2007, 32 self-expanding stent grafts were implanted in 26 patients with AVG pseudoaneurysms. Indications for treatment consisted of large AVG pseudoaneurysm size, localized pain at pseudoaneurysm site, enlarging pseudoaneurysm, and skin site breakdown. AVG pseudoaneurysm exclusion was accomplished with Wallgrafts, Viabahn endoprosthesis, and Fluency endograft. Technical success was achieved in all patients. Nineteen patients experienced a marked decrease in the size of their pseudoaneurysm following endograft exclusion. Successful hemodialysis was resumed through endograft-excluded AVG in all patients within 48 hours.

Conclusions Endoluminal exclusion of AVG pseudoaneurysms using endografts is a safe and effective treatment strategy in patients with hemodialysis-related pseudoaneurysm.

Keywords: arteriovenous grafts; endograft exclusion; endovascular repair; hemodialysis; hemodialysis complication pseudoaneurysm; stent graft repair

Introduction

With the escalating prevalence of diabetes and hypertension, end-stage renal disease (ESRD) in combination with hemodialysis has become a significant source of morbidity and mortality. The number of renal patients undergoing maintenance hemodialysis has steadily risen to greater than 330,000 according to United States Renal Data System and may surpass 500,000 in the next 5 years.¹,² As a result, the most common vascular operations in the United States today have become surgical procedures for hemodialysis access. Although arteriovenous fistula is the more preferred method of long-term dialysis access, nearly 60% of dialysis patients eventually require arteriovenous graft (AVG) because of failure and limited access sites.³ The resultant complications with both vascular access and AVG placement continue to present a leading source of morbidity in ESRD patients.⁴

Graft infection, thrombosis, and pseudoaneurysm formation comprise the primary complications associated with AVG placement.⁵ Recurrent needle puncturing at the graft site during hemodialysis results...
in prosthetic graft thinning and weakening and ultimately contributes to pseudoaneurysm formation (Figure 1). Furthermore, poor puncture technique involving the use of AVGs prior to full maturation can also result in a pseudoaneurysm. Traditionally, AVG pseudoaneurysms have been repaired by surgical resection or ligation of the abnormal segment followed by replacement with an interposition graft. Despite fair results, however, revision procedures require another 3 to 4 weeks of maturation, place the patient through further invasive surgery, and limit the availability of extremity access sites in the future. Consequently, alternative methods to open AVG pseudoaneurysm repair are needed in treating renal patients and maintaining the patency of dialysis access. Endoluminal stent grafts within the aneurysmal segment provide a less invasive, more successful approach. This report describes our clinical experience with endoluminal stent-graft exclusion of AVG pseudoaneurysms.

Methods

Patient Cohort

From June 2002 to August 2007, clinical records of all patients who underwent endovascular exclusion of AVG pseudoaneurysm using commercially available stent grafts were reviewed. All procedures were performed in the operating room by vascular surgeons using either mobile fluoroscopic equipment (OEC9800, General Electric, New York, NY) or fixed imaging unit (Axiom, Siemens, New York, NY). In addition to demographic information, data were obtained regarding the indication of AVG repair, clinical presentation, pertinent operative variables, and clinical outcome. Follow-up consisted of a clinic appointment, physical examination, and duplex ultrasound at 1, 3, and 6 months and then annually or sooner.

Stent-Graft Devices

Three separate devices, approved for assorted peripheral vascular and tracheobronchial applications, were used for AVG pseudoaneurysm exclusion: the Wallgraft endoprosthesis (Boston Scientific Corporation, Natick, MA) in 18 patients (69%), the Viabahn endoprosthesis (Gore & Associates, Flagstaff, AZ) in 6 patients (23%), and the Fluency (Bard, Tempe, AZ) in 2 patients (8%). The Wallgraft device was developed with an outer layer composed of textured polyethylene terephthalate yarn in a braided, multifilament form. The inner layer, manufactured separately, consisted of a braided, flexible Elgiloy stent with platinum tracer wires, coated with Corethane adhesive (Boston Scientific Corporation) to bond the entire device. The Viabahn graft was composed of an expanded polytetrafluoroethylene (ePTFE) inner structure with a nitinol self-expanding exoskeleton. The Fluency stent graft is composed of a self-expanding Nitinol stent skeleton encapsulated with ePTFE graft material. To enhance its fluoroscopic visibility, 4 radiopaque tantalum markers are attached at the either end of the Fluency device. It is noteworthy that the Viabahn stent graft has been approved by the Food and Drug Administration (FDA) for symptomatic superficial femoral artery lesions, whereas the Wallgraft and Fluency are approved for tracheobronchial application. The use of these endoprostheses in the treatment of AVG pseudoaneurysm and their exposure to puncture for hemodialysis represents an off-label use.

Procedure Technique

Routine venography was performed in all patients prior to undergoing endovascular exclusion repair. Through a Seldinger needle inserted into the AVG, a 0.035-in. Bentzon wire (Boston Scientific) was introduced. Under direct fluoroscopy, a 10-Fr Pinnacle sheath (Boston Scientific) was placed over the wire and the patient was given 3000 units of intravenous heparin. A calibrated guidewire was
used to measure the diameter of the proximal and distal AVG segments. As per manufacturer recommendations, the endograft devices selected for insertion were 15% to 20% larger than the normal caliber graft diameter adjacent to the pseudoaneurysm. Positioning and deployment of the endoprosthesis were carried out in a consistent, careful manner. A completion angiogram was taken after removal of the delivery device to ensure that no endoleak or filling of the pseudoaneurysm sac was apparent (Figures 2 and 3). The insertion venipuncture site was then closed with a purse-string suture.

Treatment Indications

In this multicenter study, endoluminal stent-graft exclusion was used for treatment of AVG pseudoaneurysm in a total of 26 patients (24 men, overall mean age 52 ± 8.5 years). Indications for treatment consisted of: (a) large AVG pseudoaneurysm size (n = 13, mean luminal diameter 4.8 cm, range 3.7 to 6.3 cm); (b) localized pain at pseudoaneurysm site (n = 4); (c) enlarging pseudoaneurysm (n = 3, mean luminal diameter 4.3 cm, range 3.8 to 5.7 cm); and (d) skin site breakdown (n = 6). Anesthetic modalities used during endovascular repair included local anesthesia (n = 16), general anesthesia (n = 4), or conscious sedation/regional block (n = 6).

Statistical Analysis

Primary outcomes included patency rate, which is analyzed using Kaplan–Meier life table method and procedure-related complications. Secondary outcomes included freedom from secondary reintervention and late complications.

Results

Patient Demographic Information

Technical success was achieved in all 26 patients (100%). A total of 21 patients (81%) required only 1 endograft component to fully exclude the AVG pseudoaneurysm, whereas 4 patients (15%) required 2 endograft devices for complete AVG pseudoaneurysm exclusion. One patient required 3 endograft components to exclude the endograft due, in part, to the lack of suitable endograft length at the time of the procedure. All patients underwent hemodialysis with needle venipuncture through the endograft-excluded AVG pseudoaneurysm within the following 2 postoperative days. Four patients (15%) underwent surgical revision at 21, 25, 45, and 49 days due to either return of AVG pseudoaneurysm pulsatility (n = 2) or persistently large AVG pseudoaneurysm size (n = 2). The mean diameter of AVG pseudoaneurysm in these 3 patients was 4.3 ± 1.5 cm. The relatively large size of these AVG pseudoaneurysms precludes safe needle venipuncture during hemodialysis, even though 2 of these patients had complete AVG pseudoaneurysm exclusion by the Wallgraft endoprosthesis. Four patients developed early thrombosis of the endograft-excluded AVG pseudoaneurysm at 17, 29, 41, and 63 days. Among them, 2 patients received the Wallgraft device, whereas 1 patient received the Viabahn endograft. One procedure-related complication occurred in a patient who received 2 Wallgraft endoprostheses to exclude his AVG pseudoaneurysm, which related to stent-graft separation following initial successful pseudoaneurysm exclusion. This event occurred 6 weeks after endograft implantation. This patient underwent AVG pseudoaneurysm excision and bypass graft interposition using a prosthetic graft. A total of 19 patients (73%) developed complete resolution or marked decrease in the size of their pseudoaneurysms after endograft exclusion. Two of these patients died from heart failure and pneumonia at 5 and 6 months, respectively. Six patients underwent subsequent interventions after endograft insertion; their AVG primary patency ended at 55, 68, 72, 79, 95, and 168 days. These 6 patients were able to receive hemodialysis 3 times per week with

Figure 2. (A) Venogram demonstrating an arteriovenous graft (AVG) pseudoaneurysm. (B) Completion venogram shows a fully excluded AVG pseudoaneurysm by the Wallgraft (arrow).
routine needle venipuncture through the endograft-excluded AVG. The mean follow-up period in our patients was 9 months (range 1 to 15 months). Serial ultrasound surveillance at 1, 3, and 6 months showed no endoleak outside the excluded endografts. In all cases, pulsatility could be detected within the AVG pseudoaneurysms for at least 24 hours after endograft exclusion, despite the absence of endoleak on completion venography. Kaplan–Meier analysis revealed a primary patency rate of 82% at 30 days and 28% at 6 months in AVG pseudoaneurysm following successful endograft exclusion (Figure 4).

Discussion

Pseudoaneurysm formation is a well-known complication after AVG or fistula creation, and the incidence
rates range between 2% and 10%. The traditional treatment approach is surgical excision or ligation of the pseudoaneurysm followed by interposition grafting with a prosthetic conduit. The possibility of treating an AVG pseudoaneurysm with a stent-graft device for pseudoaneurysm exclusion provides a less invasive treatment alternative along with several advantages. First, it permits continuous hemodialysis access of the AVG without the need of temporary dialysis catheter placement. Second, no surgical incision is necessary for stent-graft placement, which may be associated with decreased blood loss. Lastly, it preserves the patency of the same AVG for continuous hemodialysis without the need for searching for potential sites for a new AVG placement.

The application of stent-graft devices in the management of AVG-related complications is not a novel concept. However, its application has been largely limited to the management of venous anastomotic stenosis or occlusion. Other studies have shown that stent-graft device is beneficial in the treatment of venous outflow stenosis by providing a scaffold to maintain the outflow patency. Researchers also postulated that the stent graft may provide a theoretic advantage of reducing restenosis by excluding the anastomotic stenosis from direct contact with the procoagulant elements in the circulation. Several studies have similarly reported various endovascular strategies for AVG pseudoaneurysms. Selby et al described percutaneous placement of a detachable balloon to induce pseudoaneurysm thrombosis but with varying degrees of success. Others have created a homemade stent-graft device with the Palmaz stent (Cordis Endovascular, a Johnson & Johnson company, Miami, FL) and PTFE graft to exclude AVG pseudoaneurysm. Such a treatment strategy has not been widely embraced because of the risk of crushing the balloon-expandable stent from external arm compression. Hausegger et al reported their experience with Cragg Endo-Pro stent grafts (Boston Scientific) to exclude AVG pseudoaneurysms and noted that the repeat puncture of the stent graft may lead to delayed pseudoaneurysm recurrence from degenerative breakdown of the graft materials.

The approval of Wallgraft for clinical application by the FDA in 2001 created new treatment strategies in endoluminal exclusion of peripheral arterial aneurysms, including AVG-related pseudoaneurysm. The first reported application of Wallgraft to exclude AVG pseudoaneurysm involved the use of this device in ten patients who were able to receive continual hemodialysis following Wallgraft exclusion of AVG pseudoaneurysm. In that study, all patients were able to resume hemodialysis in the Wallgraft-treated AVG site within 48 hours, and postoperative duplex scan showed successful exclusion in AVG pseudoaneurysms without endoleak. Similar reports of technical feasibility of stent-graft exclusion of AVG pseudoaneurysm with subsequent successful hemodialysis were reported by many researchers. Vesely used the Viabahn stent graft to successfully exclude AVG pseudoaneurysm in 11 patients. Among them, 6 patients (55%) underwent reintervention following stent-graft exclusion with primary patency of 39, 40, 63, 104, 120, and 327 days. Two patients were deemed to have treatment failure with AVG pseudoaneurysm exclusion and had to undergo surgical repair. In contrast to Vesely, who used the Viabahn device in his series, we used the Wallgraft endograft in 88% of our patients. The primary patency rate in our series was 25% at 6 months, which was similar to his findings.

Although our experience in endovascular AVG pseudoaneurysm exclusion was largely based on the Wallgraft and Viabahn endoprostheses, it is noteworthy that the Fluency Plus stent graft (Bard) can be used in a similar off-label fashion for AVG pseudoaneurysm exclusion. Moszkowicz and associates reported on 28 stent-graft placements in 16 patients with hemodialysis access pseudoaneurysms or areas of graft degeneration using the Fluency Plus, with follow-up performed at an average of 3 months after stent placement. Four patients exhibited complications after stent deployment; 3 of these 4 experienced endoleak, and 1 had a stent migration. The
investigators found that true pseudoaneurysms responded more favorably than did areas of degradation, with the former requiring placement of a single stent and the latter requiring two or more. They concluded that the use of stent grafts in treating clinically significant pseudoaneurysms appears to be a viable option for patients who might not be capable of undergoing further surgery to create a new fistula or who are unable to undergo further surgical revision of their grafts.19

Since the publication of studies reporting the technical feasibility of using stent grafts to exclude AVG pseudoaneurysm,9,16-18 debates have arisen with regard to the safety of needle puncturing across the stent graft for hemodialysis. In a study by Ryan and associates, who used Wallgrafts for AVG pseudoaneurysm exclusion, it is noteworthy that these researchers demonstrated that these posttreatment AVG pseudoaneurysms can tolerate immediate needle puncture for immediate hemodialysis on the following day after the Wallgraft placement.17 Additionally, they reported no recurrence of the pseudoaneurysms or distortion of the covered stent and the grafts remained patent during the follow-up period. The follow-up period in this study, however, was short (3 to 11 months) and the study was limited to 4 patients. In a similar report by Rhodes et al,20 who assessed routine venipuncture of Wallgraft-excluded arteriovenous fistula pseudoaneurysm, the authors noted Wallgraft can withstand routine venipuncture for hemodialysis without flow-limiting distortion.

To further investigate the device durability of Wallgraft following venipuncture for hemodialysis, we performed an in vitro study that examined the structural integrity of Wallgraft after hemodialysis in an AVG pseudoaneurysm model with duplex scanning to assess peri-Wallgraft endoleak.21 Using a porcine femoral AVG model, which was excluded with the Wallgraft endoprosthesis, we showed a transient peri-Wallgraft endoleak within 6 hours following conventional hemodialysis. This transient endoleak was due to the needle track placed across the Wallgraft. When placing an explanted Wallgraft in a flow circuitry analysis, we showed that the Wallgraft endoprosthesis was durable to withstand the hemodialysis at a flow rate of 600 mL/min. This finding underscored the durability of the endograft device to withstand the physical fatigue endured from routine hemodialysis-associated venipuncture.

In conclusion, pseudoaneurysm formation is a known complication following AVG creation. While surgical revision remains the mainstay treatment strategy, endovascular repair with stent-graft exclusion represents a minimally invasive treatment alternative. Numerous clinical reports have demonstrated short-term clinical efficacy for maintaining continual hemodialysis and prolonging the AVG life expectancy. Our in vitro analysis demonstrated that this treatment modality permitted repeated needle puncture for continuous hemodialysis. Our study supports further clinical evaluations for this device in the treatment of pseudoaneurysm exclusion.

References


