Clinical Studies

Use of Stent Grafts to Repair Hemodialysis Graft–related Pseudoaneurysms

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PURPOSE: To review the author’s early experience with stent grafts to repair hemodialysis graft–related pseudoaneurysms.

MATERIALS AND METHODS: Eleven patients had undergone insertion of a stent graft to repair a pseudoaneurysm arising from a PTFE hemodialysis graft. The study group consists of seven women and four men with a mean age of 50.7 years. The primary indications for stent graft placement were: rapid enlargement of a pseudoaneurysm in four patients, difficulty with cannulating the graft in two patients, high risk of acute rupture in three patients, persistent bleeding from the pseudoaneurysm in one patient, and one was incidentally discovered during diagnostic fistulography. In 10 of the 11 patients, the pseudoaneurysm arose from the arterial limb of a loop-configuration graft. A stent graft was successfully deployed in all patients. The radiological and surgical records were reviewed.

RESULTS: The Viabahn endoprosthesis was successfully inserted and deployed in all 11 patients. Six patients underwent subsequent interventions, which ended primary patency at 39 days, 40 days, 63 days, 104 days, 120 days, and 327 days after insertion of the stent graft. However, no additional interventions have been performed in five patients and primary patency continues. In these five patients the interval of continuing primary patency is 55 days, 92 days, 103 days, 139 days, and 196 days. In this small group of patients the primary patency rate is 71% at 3 months and 20% at 6 months.

DISCUSSION: Early experience has demonstrated that a stent graft can successfully exclude a pseudoaneurysm from a hemodialysis graft and may prevent further enlargement and decrease the likelihood of rupture. However, in two of these 11 patients, the large pseudoaneurysm remained problematic and required subsequent surgical repair.


THE development of a hemodialysis graft–related pseudoaneurysm is a multifactorial pathological process. The two factors which are primarily responsible are the presence of a venous outflow stenosis and fragmentation of the polytetrafluoroethylene (PTFE) graft material (1,2).

Repeated needle cannulation may cause disruption and fragmentation of the PTFE graft material (3,4). This is particularly true if the sites of cannulation are not uniformly distributed along the entire length of the hemodialysis graft. However, even with good cannulation techniques, an older graft will develop well-worn areas which have little remaining PTFE material. A hemodynamically significant stenosis at the venous anastomosis or in the adjacent outflow vein will cause increased intragraft pressure. If the integrity of the graft material is compromised the increased intragraft pressure can force blood through the damaged graft wall into the perigraft tissue thereby creating a pseudoaneurysm. As the severity of the stenosis increases, the rising intragraft pressure may accelerate this process and cause continued expansion of the pseudoaneurysm (2).

One approach to halt the growth of a graft-related pseudoaneurysm is to angioplasty all hemodynamically significant stenoses in the venous outflow tract. This reduces intragraft pressure and decreases blood flow into the pseudoaneurysm. The authors’ observations suggest that the size of a pseudoaneurysm will often stabilize until the redevelopment of another venous outflow stenosis.

However, in some instances, more aggressive management of a pseudoaneurysm may be appropriate. Progressive enlargement of a pseudoaneurysm can interfere with needle cannulation or lead to secondary complications including breakdown of the overlying skin, spontaneous bleed-
ing, and rupture. The 2000 K/DOQI Guidelines recommend surgical repair if the size of the pseudoaneurysm limits the available cannulation sites or if the integrity of the overlying skin is compromised (5).

Previous investigators have reported successful treatment of graft-related pseudoaneurysms with stent grafts deployed through a percutaneous approach (6–10).

However, the majority of these studies used the Wallgraft (Boston Scientific, Natick, MA) to repair clinically significant pseudoaneurysms arising from PTFE hemodialysis grafts.

**MATERIALS AND METHODS**

This retrospective review was approved by the Human Studies Committee at the authors’ institution.

Between December 2003 and February 2005, eleven patients underwent percutaneous insertion of a Viabahn stent graft to repair a pseudoaneurysm arising from a PTFE hemodialysis graft. The study group consists of seven women and four men with a mean age of 50 years (range, 23–70 years).

Nine of the 11 patients were referred to interventional radiology specifically for treatment of pseudoaneurysms. The primary indications for stent graft placement were rapid enlargement of a pseudoaneurysm in four patients, difficulty with cannulating the graft in two patients, high risk for acute rupture in three patients, persistent bleeding from the pseudoaneurysm in one patient, and one was incidentally discovered during diagnostic fistulography. This pseudoaneurysm arose from a “blown-out” venous anastomosis and was thought to be compromising the blood flow from the vascular access.

All 11 patients had loop-configuration PTFE hemodialysis grafts, eight were located in the left forearm, one in the left upper arm, one in the left thigh, and one in the right thigh. In ten patients the pseudoaneurysm arose from the arterial limb of the loop-configuration graft. In one patient the pseudoaneurysm arose from a “blown-out” venous anastomosis. The mean age of the hemodialysis graft at the time of stent placement was 4.4 years (range, 1.2–6.4 years).

Demographic and vascular access patency information was obtained from the medical records at each patient’s hemodialysis treatment center. The radiological images and reports were reviewed to obtain procedural information. The surgical records were reviewed to verify accuracy of the vascular access patency data.

**Viabahn Stent Graft**

The Viabahn endoprosthesis is constructed of tubular PTFE graft material which is externally supported by a self-expanding nitinol stent. The endoprosthesis is compressed and attached to a dual lumen polyethylene delivery catheter. The endoprosthesis is released from the delivery catheter by pulling the deployment knob away from the hub adapter.

In the author’s community, the majority of hemodialysis grafts are constructed with 6-mm-diameter PTFE conduit. According to the manufacturer, the 7-mm-diameter Viabahn endoprosthesis is appropriate for use with endoluminal diameters between 5.6 and 6.5 mm. The 7-mm-diameter endoprosthesis is attached to a 75-cm-long delivery catheter which requires a 9-F introducer sheath. The 7-mm-diameter Viabahn is available in four lengths; 25 mm, 50 mm, 100 mm, and 150 mm.

The Viabahn endoprosthesis has been approved by the United States Food and Drug Administration for treatment of tracheobronchial strictures. The use of this device for treatment of hemodialysis graft–related pseudoaneurysms represents an off-label application.

**Procedure**

An 18-gauge needle was used to enter the apex of the loop-configuration PTFE graft in all patients. A 5-F angiographic catheter was advanced into the arterial limb of the graft and positioned with the distal tip in the native artery adjacent to the arterial anastomosis. A thorough diagnostic fistulogram was obtained to evaluate the hemodialysis graft and native outflow veins.

Eight patients underwent venous angioplasty procedures prior to repair of the pseudoaneurysm. Six patients had angioplasty of the venous anastomosis, one patient had angioplasty of a stenosis in the basilic vein, and one patient required angioplasty of multiple stenoses in the cephalic vein. One patient presented emergently with an acute pseudoaneurysm caused by a traumatic needle cannulation. The fistulogram did not reveal any venous stenoses associated with this patient’s hemodialysis graft. Of note, the remaining two patients who did not have angioplasty at the time of the pseudoaneurysm repair had undergone previous venous angioplasty procedures 51 days and 64 days prior to the date of stent graft insertion.

Following the diagnostic fistulogram and venous angioplasty procedures a 9-F sheath was inserted into the apex of the graft and directed toward the pseudoaneurysm. A 0.035-inch Bentson guide wire (Cook, Bloomington, IN) was advanced through the graft and used for the stent graft insertion procedure. As previously described, the majority of the hemodialysis grafts in our community are constructed with 6-mm-diameter PTFE conduit. Therefore, 7-mm-diameter Viabahn stent grafts were used in all 11 patients.

The length of the pseudoaneurysm segment was measured with the calibrated software within the digital imaging system. The specific length of stent graft was chosen so that it extended at least 10 mm beyond each side of the pseudoaneurysm segment. Only one stent graft was used in each patient; a 50-mm-long Viabahn was used in eight patients and three patients received a 100-mm-long endoprosthesis.

With fluoroscopic observation, the Viabahn delivery catheter was advanced into the graft and the endoprosthesis was appropriately positioned across the pseudoaneurysm segment (**Fig. 1**). The endoprosthesis was released and the delivery catheter was removed. After deployment, a 7-mm-diameter angioplasty balloon was used to fully expand the endoprosthesis and to ensure complete apposition between the stent graft and the hemodialysis graft. A final fistulogram was obtained to evaluate stent
graft position and to assess for leakage of blood into the pseudoaneurysm.

At the completion of the procedure, the sheath was removed and a purse-string suture was used to close the access site at the graft apex. Anticoagulation or antibiotics were not administered during, or after, any of these stent graft insertion procedures.

Early in the authors’ experience an attempt was made to decompress the pseudoaneurysm sac to provide a more cosmetically pleasing result. In three patients an 18-gauge needle was inserted into the pseudoaneurysm and used to aspirate residual blood. Mild manual compression was applied to the pseudoaneurysm to facilitate evacuation. In two patients this maneuver provided a moderate reduction in the size of the pseudoaneurysm (Fig 2). The third pseudoaneurysm contained chronic thrombus and only a small amount of blood could be aspirated. In this patient there was no improvement in the appearance of the pseudoaneurysm.

Initially, no specific instructions were given to avoid needle cannulation sites, the authors now recommend that the stent graft segment should not be used for needle cannulation for 30 days.

**Statistical Analysis**

Primary patency is defined as the time interval between insertion of the Viabahn stent graft and the next graft-related event. A Kaplan-Meier survival analysis was performed to determine the primary patency rate at 3 months and 6 months.
RESULTS

The Viabahn endoprosthesis was successfully inserted and deployed in all 11 patients. No complications occurred during the stent graft insertion procedure.

Six patients have undergone subsequent interventions which ended primary patency at 39 days, 40 days, 63 days, 104 days, 120 days, and 327 days after insertion of the stent graft. However, no additional interventions have been performed in five patients and primary patency continues. In these five patients the interval of continuing primary patency is 55 days, 92 days, 103 days, 139 days, and 196 days.

With Kaplan-Meier analysis the primary patency rate is 71% at 3 months and 20% at 6 months (Fig 3).

Two patients underwent surgical revision at 39 days and 63 days to decrease the size of the pseudoaneurysm. In both patients the large pseudoaneurysm continued to interfere with needle cannulation of the hemodialysis graft. Although these surgical procedures ended primary patency, the Viabahn stent graft was well-functioning at the time of the surgical repair in both patients.

Two patients had partial recurrence of their pseudoaneurysm. Diagnostic fistulography performed 59 days and 373 days after stent graft insertion revealed small leaks through the stent graft likely caused from repeated needle cannulation. In the first patient a second Viabahn stent graft was inserted. In the second patient the recurrent pseudoaneurysm was injected with thrombin with ultrasound (US) guidance. This caused near complete thrombosis of the pseudoaneurysm.

In three patients the authors attempted to aspirate blood from the pseudoaneurysm immediately after insertion of the Viabahn stent graft. This maneuver was initially successful in two patients. However, in one patient the pseudoaneurysm refilled with fluid approximately 8–12 hours after stent graft insertion. A diagnostic fistulogram obtained 24 hours after stent graft insertion failed to reveal any evidence of leak into the pseudoaneurysm. At that time an 18-gauge needle was reinserted into the pseudoaneurysm sac and approximately 10 mm of serosanguinous fluid was aspirated. This patient underwent surgical revision of the pseudoaneurysm 39 days after stent graft insertion. Aspiration of blood from the pseudoaneurysm was unsuccessful in the third patient because of the presence of chronic, hardened thrombus within pseudoaneurysm.

Figure 2. (a) Photograph of a pseudoaneurysm arising from the arterial limb of a PTFE hemodialysis graft. (b) Another photograph obtained immediately after insertion of a stent graft and aspiration shows diminution in the size of the pseudoaneurysm.

Figure 3. Primary patency of the vascular access circuit after stent graft repair of the pseudoaneurysm. The 95% confidence limits are denoted by the shaded lines.
Figure 4. Digital radiographic image reveals damage to a Viabahn endoprosthesis from repeated needle cannulation.

DISCUSSION

The traditional treatment of a clinically significant pseudoaneurysm is surgical ligation or resection of the hemodialysis graft followed by insertion of a new interposition graft segment (11). The use of a stent graft provides an alternative, less invasive method to repair a pseudoaneurysm while maintaining patency of the vascular access. The authors’ early experience has demonstrated that insertion of a stent graft can effectively exclude a pseudoaneurysm and thereby prevent further enlargement and decrease the likelihood of rupture.

An interesting observation is that in the authors’ study group of 11 patients, nearly all of the pseudoaneurysms were located in the arterial limb of their hemodialysis graft. Although several patients also had pseudoaneurysms arising from the venous limb, the largest pseudoaneurysms arose from the arterial limb. In their insightful series of investigations Sullivan and Besarab have demonstrated that there is a substantial pressure gradient along the length of a hemodialysis graft (12,13). The intragraft pressure decreases 50%–60% between the arterial anastomosis and venous anastomosis because of energy lost through the synthetic conduit. In the absence of a native arterial problem, the intravascular pressure at the arterial anastomosis should match the patient’s systemic blood pressure. As described by Sullivan (12), the pressure within the arterial limb is 20%–40% higher than the pressure in the venous limb. This difference in intragraft pressures is often maintained in the presence of a venous anastomotic stenosis, and may be responsible for the preponderance of pseudoaneurysms arising from the arterial limb.

The authors findings in this small group of patients support the belief that venous stenoses are a primary causative factor for the development of a pseudoaneurysm. At the time of pseudoaneurysm repair, eight of these 11 patients had hemodynamically significant venous stenoses requiring angioplasty. Two additional patients had undergone angioplasty of significant venous stenosis within 2 months prior to the stent graft procedure. The final patient had a pseudoaneurysm arising from a “blown out” venous anastomosis, likely the result of a previous angioplasty procedure. Furthermore, these patients had older, well-worn hemodialysis grafts. The mean age of these 11 grafts was 4.4 years and the oldest graft was 6.4 years old. Over years of use, repeated needle cannulation had resulted in fragmentation of the original PTFE graft material, a milieu favorable for the development of a pseudoaneurysm.

The use of stent grafts for the treatment of hemodialysis graft-related pseudoaneurysms has been previously reported (6–9). The majority of the patients described in these case reports were treated with the Wallgraft endoprosthesis. However, the Wallgraft endoprosthesis is constructed of polyethylene terephthalate material which has been reported to incite a perigraft inflammatory response and intimal hyperplasia (10). The authors preferred to use the Viabahn endoprosthesis because it is constructed of expanded PTFE (ePTFE), the same synthetic material that is used for the original vascular access. The Viabahn and Wallgraft endoprostheses are both self-expanding stent grafts, a potentially advantageous characteristic when these devices are placed in a subcutaneous hemodialysis graft which may be subjected to extrinsic compression. The Viabahn endoprosthesis is constructed with internal PTFE material supported by an external metal stent, whereas the Wallgraft is constructed with external woven polyester material supported by an internal metal stent. It has been suggested that this external layering of graft material may provide a more effective closure after removal of the hemodialysis needles (6).

Several investigators have recommended that the stent graft should not be cannulated for 2 to 4 weeks, or not at all (7,9,10). The insertion of a large diameter (15-gauge) hemodialysis cannula may cause damage to the graft material or metal struts (Fig 4). As is customary with surgically implanted PTFE hemodialysis grafts, a 1 month delay before use allows incorporation of the graft material into the surrounding subcutaneous tissue. The development of a dense fibrous tissue layer around the graft inhibits perigraft bleeding after removal of the hemodialysis cannulae. Although speculative, a similar process may occur after percutaneous insertion of a stent graft to treat a pseudoaneurysm. If the stent graft is tightly sealed, thereby stopping blood flow into the pseudoaneurysm, the blood contained within the pseudoaneurysm should thrombose. Although the time course remains unknown, this thrombus may undergo retraction and fibrosis with the potential for developing a protective, fibrotic layer at the interface between the thrombus and stent graft.

Hausegger and colleagues described two patients who developed new pseudoaneurysms at sites of repeated needle puncture within the stent grafted segment (10). In the present study, two patients had partial recurrence of the pseudoaneurysm at 59 days and 373 days. In both patients the recurrent pseudoaneurysm appeared to originate from a needle puncture in the stent graft (Fig 5).

The experience of other investigators has demonstrated that the stent graft can be used for needle cannulation within several days after placement (6,11). Lin et al (11) created an experimental model in dogs to assess the durability of the Wallgraft endo-
prosthesis for the repair of pseudoaneurysms. The Wallgraft was first cannulated 1 week after implantation and subsequently used for 10 hemodialysis sessions. With color-flow Doppler US these investigators demonstrated transient perigraft leaks after removal of the needles. However, these leaks were no longer detectable 24 hours after each hemodialysis session. These investigators also evaluated explanted Wallgraft endoprostheses and reported that when the intragraft pressure exceeded 120 mmHg there was leakage through the needle holes in the graft material (11).

Previous studies have reported that pseudoaneurysms may decrease in size after successful exclusion with a stent graft (6,8). Unfortunately, because of the retrospective nature of this investigation, the evolution of the treated pseudoaneurysms in the 11 study patients was not systematically followed. However, two study patients required surgical repair at 39 days and 73 days because the large pseudoaneurysm continued to interfere with needle cannulation of the hemodialysis graft. In these two patients there was no reduction in the size of the pseudoaneurysm after insertion of the stent graft.

This study had several limitations, most notably the small size of the study group. It would have been advantageous to perform this study as a prospective investigation. The natural history of these pseudoaneurysms could have been more carefully and systematically assessed after insertion of the stent graft. In addition, in a prospective study the stent graft could have been periodically evaluated to determine the degree of damage from repeated needle cannulation. All of this information would have contributed to a better understanding of this new percutaneous technique.

In summary, insertion of a stent graft may be an effective treatment for repair of a clinically significant hemodialysis graft-related pseudoaneurysm. The safety of use of the stent graft for needle cannulation soon after insertion remains an unanswered question. If possible, the conservative approach would be to wait 30 days after insertion before cannulating the stent graft. Future improvements in stent graft materials and design may provide us with a more durable endoprosthesis for this application.

References


