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IN SITU FENESTRATION FOR BRANCH VESSEL PRESERVATION DURING EVAR

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Introduction

Unfavorable proximal aortic neck anatomy poses a formidable challenge to the successful repair of endovascular aortic aneurysms.[1, 2] Currently, there are no commercially available devices in the United States for the endovascular management of pararenal or juxtarenal aneurysms, or even aneurysms with short (i.e., <10 mm) infrarenal necks. We report a successful and totally percutaneous endovascular aneurysm repair of a juxtarenal abdominal aortic aneurysm with preservation of renal artery perfusion using in-situ fenestration of a repositionable commercially available device. The procedure was uncomplicated, and the patient returned to normal activities. At 1-month follow-up there was no evidence of endoleak, no migration or stent occlusion, and patent bilateral renal arteries. This innovative technique is attractive for patients with suitable anatomy and offers another approach to the ever-growing alternatives for dealing with a hostile proximal aortic neck during EVAR.

Introduction

Unfavorable proximal aortic neck anatomy remains a formidable challenge to successful endovascular aortic aneurysm repair (EVAR).[1, 2] Despite the increasing numbers of experienced operators and significant advancements in stent-graft technology, no current commercially available device exists in the United States for the endovascular management of pararenal or juxtarenal aneurysms, or even aneurysms with short (i.e., <10 mm) infrarenal necks. The following report describes a successful percutaneous endovascular repair of a juxtarenal abdominal aortic aneurysm (AAA) with preservation of renal artery perfusion using in-situ fenestration of a repositionable commercially available device.

Case

The patient is a 70-year-old man with a past medical history of diabetes who was found to have a 7 cm infrarenal AAA during work-up for renal stones. The aneurysm was complicated by an inadequate proximal landing zone, as the main left renal artery had a take-off only 1 mm proximal to the aneurysm. The right renal artery and an accessory left renal artery were a sufficient distance from the aneurysm to allow for an adequate landing zone. The main left renal artery supplied approximately 70–80% of the blood flow to the left kidney. We informed the patient that open repair was likely the best option to preserve the left kidney, but he wished to pursue endovascular options. Therefore, after obtaining informed consent, exclusion of the aneurysm was planned using a recapturable Gore® C3 Excluder (W.L. Gore & Associates, Flagstaff, AZ) device and in-situ fenestration and stent-graft placement into the left renal artery. Extensive preoperative planning was undertaken using M2S software and angiographic films (Figure 1). The procedure had also undergone both animal and bench-top testing in our laboratory, providing evidence that the procedure was not only feasible but also safe.

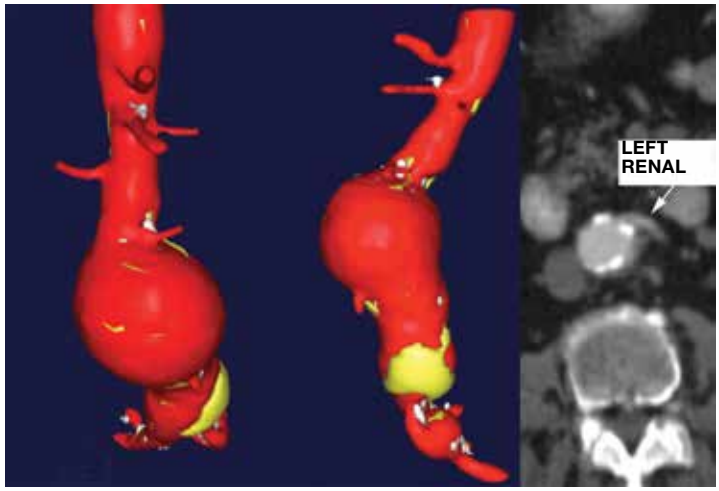

Figure 1. M2S reconstruction of initial computed tomographic angiogram demonstrating left renal artery at proximal extend to aneurysm with no proximal end of aneurysm.

Technique

The left brachial artery and bilateral femoral arteries were accessed under ultrasound guidance. A 4-French (Fr) sheath was advanced into the brachial artery using a Glidewire® (Boston Scientific, Natick, MA) and Glide catheter (Boston Scientific, Natick, MA) to advance into the abdominal aorta. A pigtail catheter was advanced through the femoral access, allowing for angiogram and pertinent measurements to be obtained. After securing 10-Fr Prostar XL devices (Abbott Vascular, Santa Clara, CA) in the common femoral arteries bilaterally, 18-Fr and 12-Fr sheathes were placed into the left and right common femoral arteries, respectively. The main body C3 Excluder device (28 x 14 x 12 cm) was advanced through the left femoral access and partially deployed 5 cm distal to the right renal artery. The contralateral gate was then cannulated using a Bern catheter (Boston Scientific,

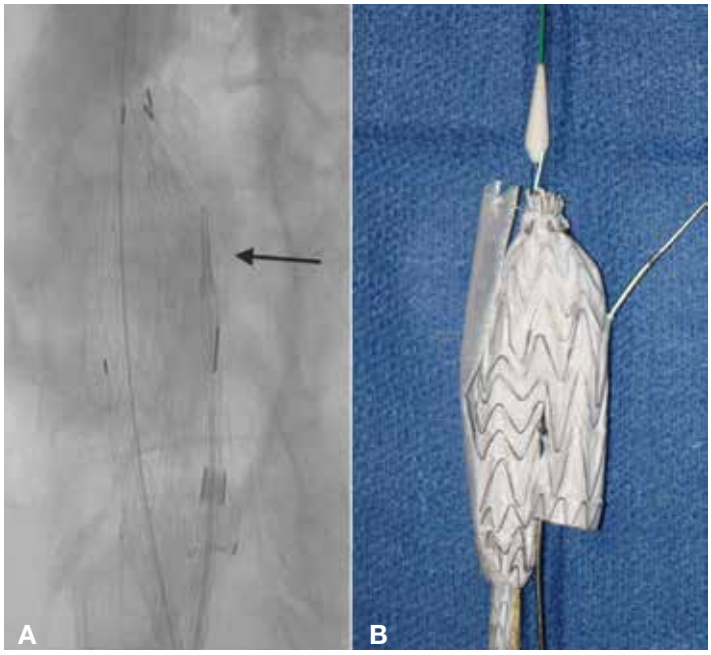

Figure 2. (A) Fluoroscopic image of BRK transseptal needle puncturing side wall of constrained Gore C3 stent graft. (B) Bench-top model of transseptal needle puncturing through stent-graft.

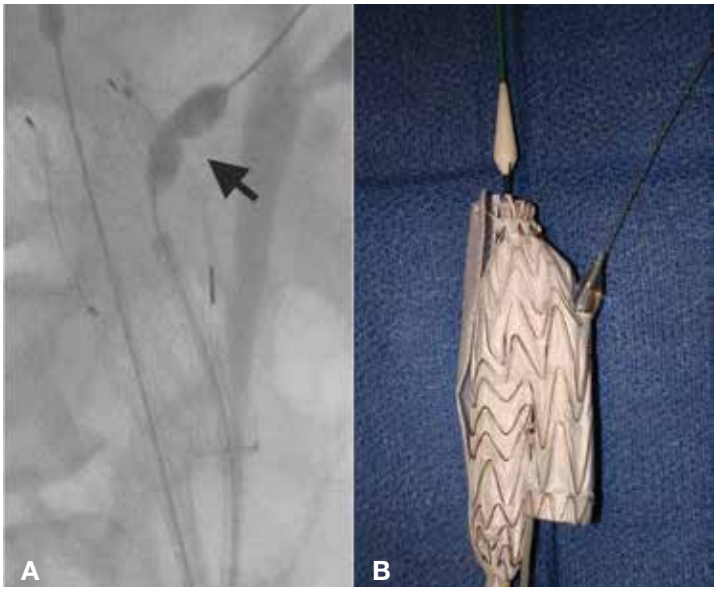

Figure 3. (A) Fluoroscopic image of cutting balloon enlarging fenestration in stent graft. (B) Bench-top model of cutting balloon expanded through fenestration.

Natick, MA), Glidewire, and ultimately an 8-Fr sheath, with angiographic confirmation. Using a transseptal BRK™ needle (St. Jude Medical, Inc., St. Paul, Minnesota), in situ fenestration was performed 2 cm below the top of the graft while it was positioned well within the aneurysm sac to ensure that no aortic injury occurred (Figure 2). A .014" wire was then advanced across the aneurysm sac into the left renal artery, followed by a Quick-Cross® catheter (Spectranetics, Colorado Springs, CO). The .014" wire was exchanged for a .018", and a total of four angioplasties were performed using cutting balloons to dilate the fenestration

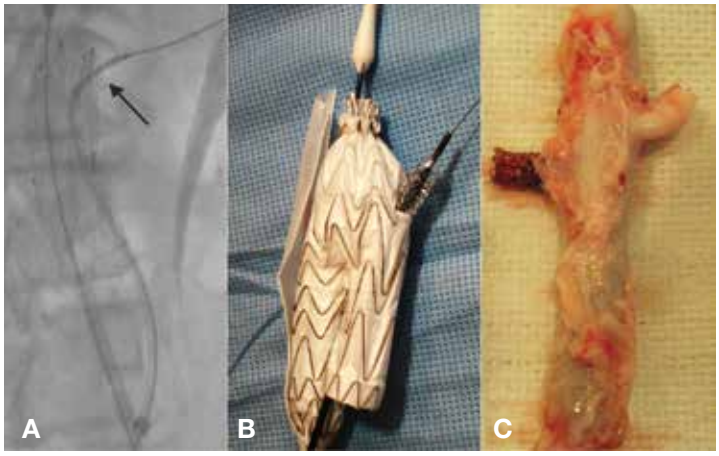

Figure 4. (A) Fluoroscopic image of iCast stent positioned in left renal artery. (B) Bench-top model of iCast stent deployed through fenestration. (C) Porcine aorta with bare-metal stent deployed into renal artery.

(Figure 3). We then exchanged the .018" for a Rosen wire (Cook Medical, Bloomington, IN) and brought up a 6 mm iCast™ stent (Atrium Medical Corporation, Hudson, NH) while simultaneously moving the main body of the device proximally into position in the infrarenal aorta. After fully deploying the main body, the renal stent was deployed (Figure 4), followed by ipsilateral limb deployment and extension into the common iliac with a 14 mm x 12 cm extension. The contralateral limb was then deployed using a 20 mm x 10 cm extension into the iliac artery.

Upon completion aortogram, a type I endoleak was noted. Repeat ballooning in the main device with Coda® balloon (Cook Medical, Bloomington, IN) as well as ballooning of the left renal stent did not resolve the endoleak (Figure 5). Therefore, the device was extended proximally with an aortic cuff, and a 6 mm Viabahn® stent (W.L. Gore & Associates, Inc., Flagstaff, AZ) was advanced into the iCast in the left renal artery (Figure 4). At this point, angiography revealed brisk flow through the entire aortoiliac segment as well as all visceral branches. A small type 2 endoleak persisted from the inferior mesenteric artery but was felt to be insignificant. At that time, sheaths were removed, hemostasis achieved, and groin incisions were closed. Doppler signals were present in the posterior tibial arteries bilaterally at the termination of the case. At 1 month follow-up, the patient remained without complication. Creatinine remained at his baseline of 0.9 with a glomerular filtration rate of 83 ml/min. There is no evidence of endoleak, no migration or stent occlusion, and bilateral renal arteries remain patent (Figure 6).

Discussion

Over the past 2 decades, endovascular repair of AAA has become a widely accepted technique that reduces the risk of significant systemic complications associated with conventional open aortic repair. Anatomic considerations account for patient exclusion from endovascular repair in 24–40% of cases.[1–3] A recent review of more than 3,000 patients with AAA found that of those considered ineligible for endovascular repair secondary to anatomic constraints, 77% were rejected based on inadequate aneurysm neck length.[3] As a result, endovascular alternatives have been developed that allow for perivisceral graft deployment without compromising perfusion.

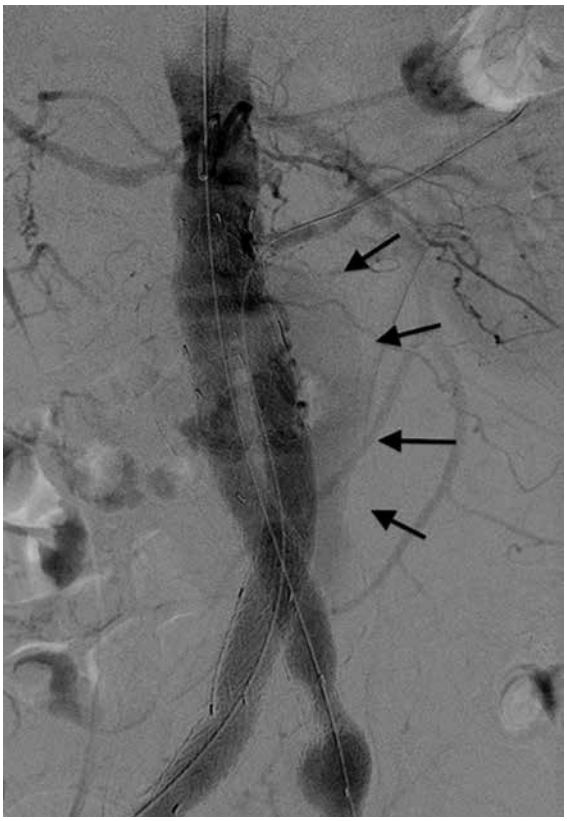

Figure 5. Aortogram with Type 1 endoleak (arrows).

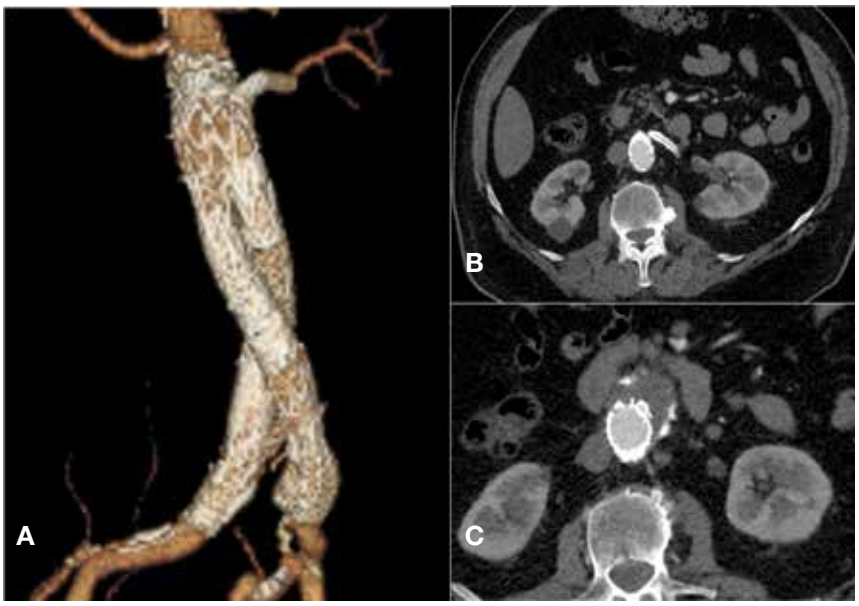

Figure 6. (A) CT reconstruction at 1 month demonstrating graft patency. (B) Axial slice from follow-up CT showing patent left renal artery. (C) Axial slice from CT showing patency of stent graft and no evidence of endoleak.
CT: computed tomography.

One such approach has been to create fenestrated stent grafts, which are intended for repairing aneurysms that do not involve the visceral vessels but that have inadequate landing zone for achieving an adequate seal. These stent grafts typically have prefabricated holes (or fenestrations) in the graft fabric for both renal arteries and either a scallop or a fenestration for the superior mesenteric artery. Prefabricated fenestrations are reinforced with nitinol to improve durability, a result of early work in which unsupported fenestrations were a source of weakness in the graft. However, it is our experience that the polytetrafluoroethylene used in the Gore device is quite different from the Endologix devices, and in our bench-top and animal testing, reinforcement in the stent grafts proved unnecessary. Since it was first described in the mid-1990s, several groups in Europe and more recently the United States have reported both technical success and acceptable midterm results for fenestrated stent grafts.[4, 5] A series of 119 patients out of the Cleveland Clinic demonstrated a 0.8% 30-day survival and 12-, 24-, and 36-month mortalities of 92%, 83%, and 79%, respectively, with a single patient with a type 1 endoleak, and 92% branch vessel patency.[6] However, manufacture of these devices for patient-specific anatomy can take up to 8 weeks, requires excellent preoperative imaging and planning, and is prohibitively costly. In Europe, however, off-the-shelf options are available that fit relatively standard anatomy, although they are not suitable in every case.

In-situ fenestration presents an alternative option for total endovascular repair. This approach was first explored in patients with aortic arch pathology, as it is often difficult to obtain a good hemostatic seal in the arch without coverage of the left subclavian artery (LSA). In 2004, McWilliams reported the first successful case of in-situ fenestration of the LSA in a patient with a thoracic aortic aneurysm.[7] Since then, a limited number of case reports for treating aortic arch pathology in this manner have been published with good short-term results.[8, 9] However, there are no large series, and mid-term and long-term outcomes data have not yet been published. Tessarek has described a series of 13 patients in which retrograde in-situ fenestrations of the superior mesenteric artery through an open abdominal incision were performed in the setting of both ruptured/symptomatic (9) and elective (4) repairs.[10] In their series, no operation had to be converted to an open aortic repair, and bowel ischemia time was reduced to 3–5 minutes. Two intraoperative deaths occurred secondary to shock and heart failure, and two patients developed ischemic pancreatitis leading to one death and one prolonged ICU stay. All of the perioperative mortality and episodes of major morbidity occurred in the patient group with ruptured repairs. Importantly, this work demonstrated that in situ fenestration of the visceral vessels was feasible both in the emergent and elective setting. However, unlike the case reported here, the procedures were not totally percutaneous.

Conclusion

This case describes a novel approach for managing a juxtarenal aortic aneurysm in the setting of atypical anatomy with in-situ fenestration and stenting of the left renal artery. There were no intraoperative complications and good 30-day outcomes. Currently, several novel approaches to endovascular management of aortic aneurysms are being explored, and several groups have described back-table fenestration, an approach that relies heavily on precise preoperative imaging, exact measurements, and device deployment. Larger series with long-term follow-up will be necessary to enhance our understanding of appropriate patient selection for this technique.

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References

1. Carpenter JP, Baum RA, Barker CF, Golden MA, Mitchell ME, Velazquez OC, et al. Impact of exclusion criteria on patient selection for endovascular abdominal aortic aneurysm repair. J Vasc Surg. 2001 Dec;34(6):1050-4.
2. Moise MA, Woo EY, Velazquez OC, Fairman RM, Golden MA, Mitchell ME, et al. Barriers to endovascular aortic aneurysm repair: past experience and implications for future device development. Vasc Endovascular Surg. 2006 May-Jun;40(3):197-203.
3. Keefer A, Hislop S, Singh MJ, Gillespie D, Illig KA. The influence of aneurysm size on anatomic suitability for endovascular repair. J Vasc Surg. 2010 Oct;52(4):873-7.
4. Park JH, Chung JW, Choo IW, Kim SJ, Lee JY, Han MC. Fenestrated stent-grafts for preserving visceral arterial branches in the treatment of abdominal aortic aneurysms: preliminary experience. J Vasc Interv Radiol. 1996 Nov-Dec;7(6):819-23.
5. Wilderman M, Sanchez LA. Fenestrated grafts or debranching procedures for complex abdominal aortic aneurysms. Perspect Vasc Surg Endovasc Ther. 2009 Mar;21(1):13-8.
6. O'Neill S, Greenberg RK, Haddad F, Resch T, Sereika J, Ketz E. A prospective analysis of fenestrated endovascular grafting: intermediate-term outcomes. Eur J Vasc Endovasc Surg. 2006 Aug;32(2):115-23.
7. McWilliams RG, Murphy M, Hartley D, Lawrence-Brown MM, Harris PL. In situ stent-graft fenestration to preserve the left subclavian artery. J Endovasc Ther. 2004 Apr;11(2):170-4.
8. Manning BJ, Ivancev K, Harris PL. In situ fenestration in the aortic arch. J Vasc Surg. 2010 Aug;52(2):491-4.
9. Hongo N, Miyamoto S, Shuto R, Wada T, Matsumoto S, Kiyosue H. Endovascular aortic arch reconstruction using in situ stent-graft fenestration in the brachiocephalic artery. J Vasc Interv Radiol. 2011 Aug;22(8):1144-8.
10. Tessarek J. Retrograde in situ fenestration in abdominal debranching procedures. Endovasc Today (Suppl) [Internet]. 2009 Mar [cited 2012 Nov 8];(Suppl):3-5. Available from: http://microsystems.stanford.edu/microwiki_upload/a/a6/TaylorEVTodaySupp09.pdf.