Repair of juxtarenal para-anastomotic aortic aneurysms after previous open repair with fenestrated and branched endovascular stent grafts

Donald J. Adam, MD, FRCSEd,[a] Michael Berce, FRACS,[b,c] David E. Hartley, FIR, FRANZCR (Hon),[d] and **John L. Anderson, FACS, FRACS,[c]** *Birmingham, United Kingdom; Adelaide and Ashford, South Australia; and Perth, Western Australia*

Three patients with juxtarenal para-anastomotic aortic aneurysms after previous open abdominal aortic aneurysm repair were treated with custom-designed fenestrated and branched Zenith endovascular stent grafts. Six renal arteries and two superior mesenteric arteries were targeted for incorporation by graft fenestrations and branches. The fenestration/renal ostium interface was secured with balloon-expandable Genesis stents (n = 5) or Jostent stent grafts (n = 1). Completion angiography demonstrated no endoleaks and antegrade perfusion in all target vessels. During follow-up, one patient developed asymptomatic renal artery occlusion and underwent further endovascular intervention for type I distal endoleak. Computed tomography at 12 months demonstrated complete aneurysm exclusion in all patients with antegrade perfusion in the remaining target vessels. Fenestrated and branched endovascular stent grafts may be an acceptable alternative to conventional open repair in this group of patients. (J Vasc Surg 2005;42:997-1001.)

Para-anastomotic aneurysm (PAA) formation is a relatively uncommon complication of open surgical repair of infrarenal abdominal aortic aneurysms (AAAs).[1] Conventional surgical repair of these lesions, particularly those involving the proximal abdominal aorta, may be technically demanding and is associated with considerable morbidity and mortality.[2,3] By contrast, endovascular repair of aortic PAA is associated with minimal morbidity and mortality and excellent medium-term results in selected patients.[4] However, some patients with proximal aortic PAA and short, wide, or poor-quality proximal aortic necks may not be candidates for endovascular repair with noncustomized commercially available devices. Graft fenestration techniques have been used successfully in the endovascular management of patients with juxtarenal AAA.[5-8] We report three patients with juxtarenal PAA who were treated successfully with custom-designed fenestrated and branched endovascular stent grafts (EVSGs) incorporating the superior mesenteric (SMA) and renal arteries.

CASE REPORT

Patients. Between September 2002 and March 2003, three patients underwent endovascular repair of juxtarenal PAA under the care of J.L.A. No patient had any evidence of sepsis or graft infection. Informed consent was obtained from all patients.

Aneurysm assessment, graft design, and implantation technique. Aneurysm morphology was assessed by spiral computed tomographic angiography (CTA) from the mid thoracic aorta to the common femoral arteries (CFAs). Axial images were reconstructed at 1-mm intervals throughout the visceral segment of the abdominal aorta. Transfemoral digital subtraction angiography (DSA) with a calibrated catheter was also performed.

All procedures were performed with patients under general anesthesia in a dedicated angiography suite by using high-resolution imaging (Advantx; GE Medical Systems, Milwaukee, Wis). *N*-Acetyl cysteine and a perioperative aminophylline infusion were used for renal protection. Custom-designed Zenith endoluminal prostheses were used in all patients (William A. Cook Australia Pty Ltd, Brisbane, Australia). Details of graft design and the implantation technique have been described previously.[5]

Some minor refinements in graft design and endovascular technique have occurred since the original article. A tubular component with graft fenestrations or branches for the target vessels was designed for deployment within the visceral segment of the aorta. A bifurcated system similar to the commercially available Zenith EVSG, but without the bare metal stents for suprarenal fixation, was then deployed within the fenestrated EVSG to complete the repair. The fenestration/renal ostium interface was secured with (1) a balloon-expandable Genesis stent (Cordis Corporation, Miami Lakes, Florida, USA) or a Palmaz stent if there was good contact between the vessel wall and the fenestration or with (2) a Jostent stent graft (Abbott Laboratories, Abbott Park, Illinois, USA) if there was no contact or if laminated intraluminal thrombus was present. These stents were deployed and flared as previously described.[5]

Case 1. A 73-year-old man presented with back pain 12 months after open repair of a ruptured infrarenal AAA with an aortobi-iliac graft. The patient was hemodynamically stable and had no clinical or hematologic evidence of graft infection. Comor-

From Birmingham Heartlands Hospital,[a] Royal Adelaide Hospital,[b] Ashford Community Hospital,[c] and Medical Research Foundation, Royal Perth Hospital.[d]

Competition of interest: Dr Anderson has received financial assistance from Cook Inc for travel and accommodation to attend meetings. Dr Hartley has registered patents assigned to Cook Inc and is a paid consultant to Cook Inc.

Reprint requests: Donald J. Adam, MD, FRCSEd, University Department of Vascular Surgery, Birmingham Heartlands Hospital, Research Institute, Lincoln House, Bordesley Green East, Birmingham B9 5SS, UK (e-mail: donald.adam@heartofengland.nhs.uk).

0741-5214/$30.00

doi:10.1016/j.jvs.2005.05.062

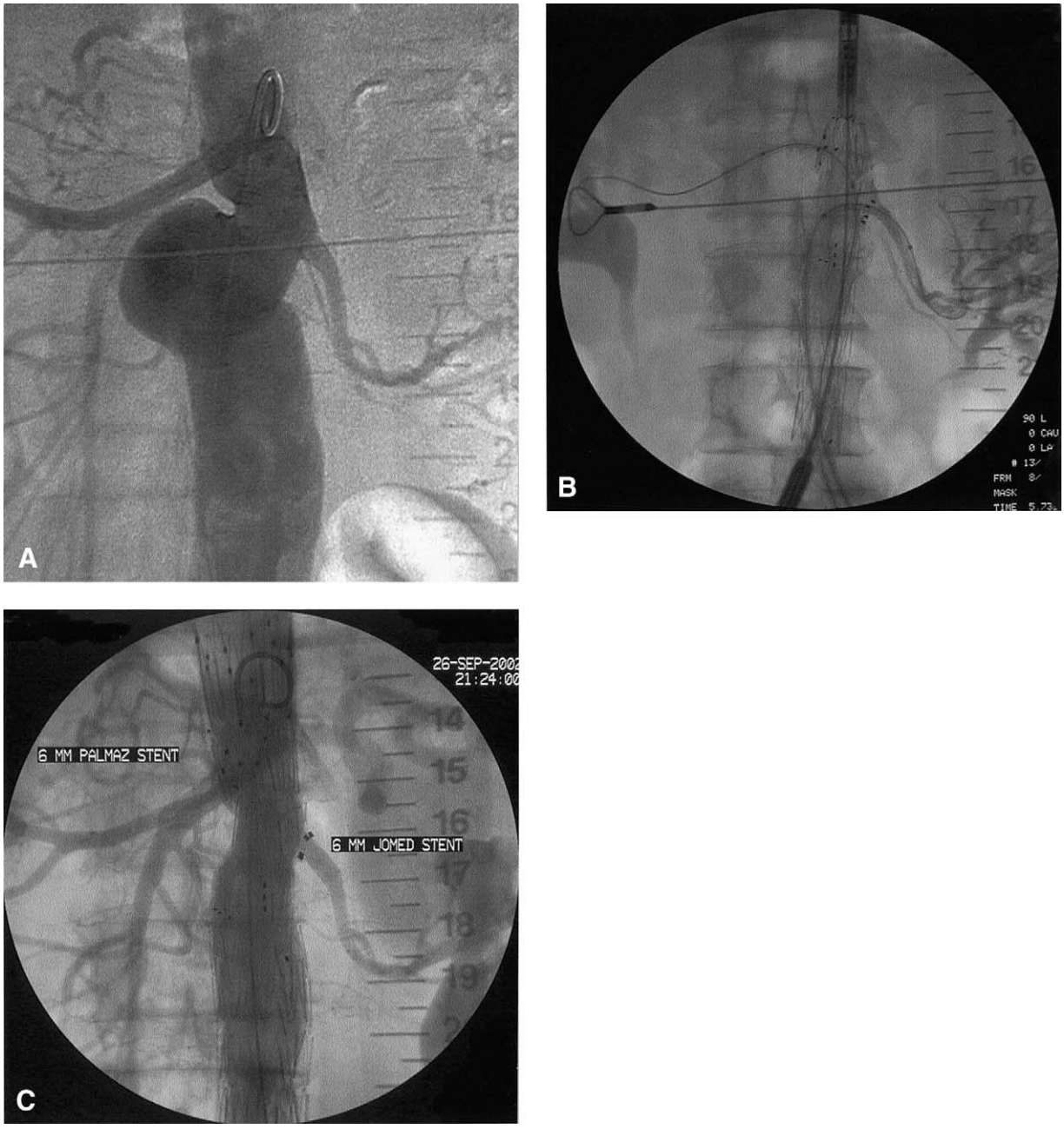

Fig 1. Intraoperative imaging in patient 1.

bidity consisted of controlled hypertension (HT), and the patient was assessed as American Society of Anesthesiologists (ASA) grade II. CTA demonstrated an intact 50-mm-diameter pseudoaneurysm of the juxtarenal aorta with no infrarenal aortic neck (Fig 1A).

Both CFAs were exposed surgically. A tubular EVSG module with two fenestrations to accommodate the SMA and right renal artery and a short branch for the left renal artery (Fig 2) was delivered through the right CFA. The graft was deployed in a satisfactory position (Fig 1B and C), and the interface between the graft fenestration and the right renal artery orifice was secured with a 6-mm-diameter Genesis stent. The interface between the branch and the left renal artery orifice was secured with a 6-mm-diameter Jostent stent graft. The procedure was completed by deployment of the bifurcated components from within the fenestrated component to the common iliac arteries bilaterally. Completion angiography demonstrated no endoleak and antegrade perfusion of the SMA and both renal arteries (Fig 1C). The patient had an uncomplicated recovery and was discharged home on the second postoperative day. CTA at 24 months demonstrated complete aneurysm exclusion with three patent target vessels (Fig 3).

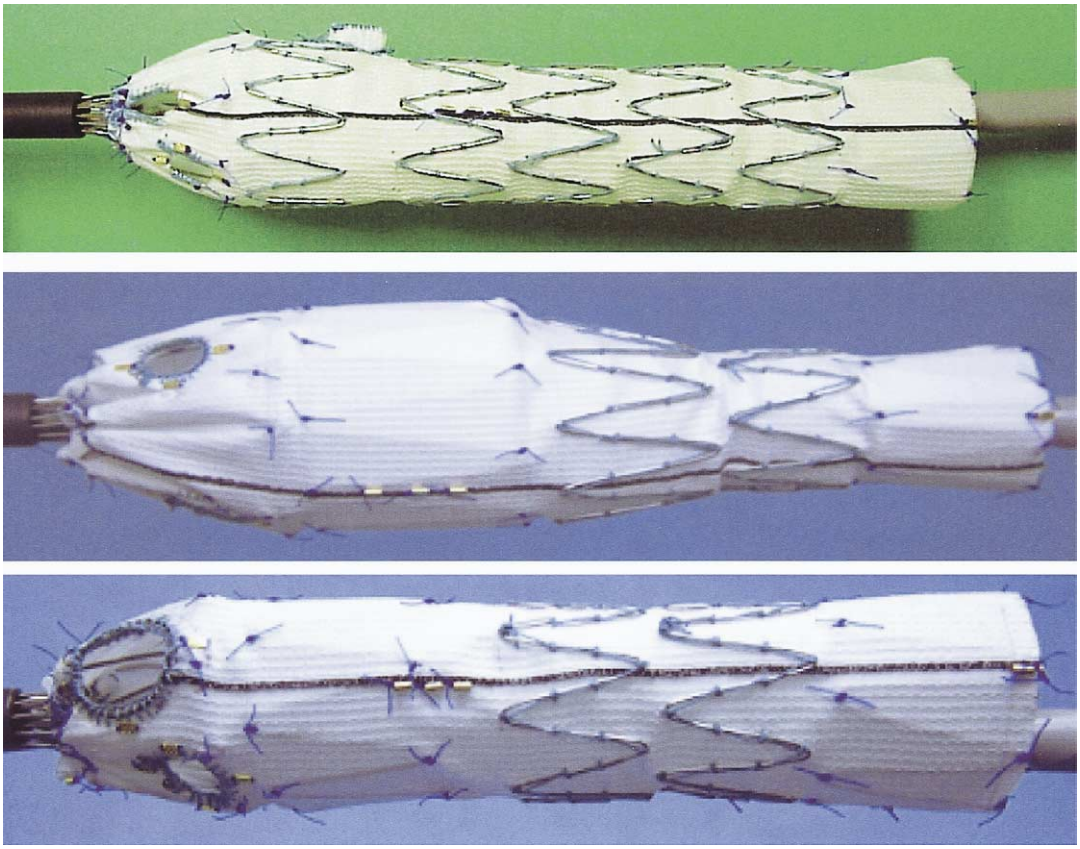

Fig 2. Custom-designed Zenith fenestrated and branched stent grafts deployed in patients 1 to 3.

Case 2. A 74-year-old man presented with an asymptomatic 53-mm-diameter juxtarenal PAA 10 years after open repair of ruptured infrarenal AAA with an aortoaortic graft. Comorbidity consisted of controlled HT, ischemic heart disease, chronic obstructive pulmonary disease, and previous coronary artery bypass grafting. The patient was assessed as ASA grade III. CTA and DSA demonstrated a conical-shaped infrarenal aortic neck increasing from 20 mm immediately below the lowest renal artery to 25 mm over 10 mm.

The right CFA was exposed surgically, and a percutaneous approach was used to the left CFA. A tubular EVSG module with three fenestrations to accommodate the SMA and both renal arteries was delivered through the right CFA (Fig 2). The graft was deployed in a satisfactory position, and the interface between the graft fenestrations and the renal artery orifices was secured with 6-mm-diameter Genesis stents. The fenestrated module did not seal within the previous surgical graft. Although preoperative planning had intended for a bifurcated module to be implanted to complete the procedure, it was decided to deploy a 22-mm-diameter straight stent graft to bridge the gap between the fenestrated component and the original aortoaortic graft. Completion angiography demonstrated no endoleak and antegrade perfusion of the SMA and both renal arteries. The patient had an uncomplicated recovery and was discharged home on the second postoperative day.

CTA at 1 month demonstrated complete aneurysm exclusion with three patent target vessels. At a routine 6-month postoperative review, the patient was asymptomatic, but serum creatinine had increased from 100 to 170 μmol/L. CTA demonstrated occlusion of the left renal artery. At 8 months after the operation, the patient was admitted to hospital with abdominal pain, and CTA demonstrated a type I distal endoleak and re-expansion of the PAA. The endoleak was sealed by implanting a bifurcated Zenith system within the fenestrated component. Kinking of the right graft limb was corrected with a 12-mm Genesis stent. The contralateral short limb failed to open and could not be catheterized. The left common iliac artery was occluded by coil embolization, and a right-to-left femorofemoral crossover graft was inserted. The patient had an uncomplicated recovery and was discharged on the fifth postoperative day. CTA at 12 months after graft revision demonstrated complete aneurysm exclusion with antegrade perfusion in the SMA and right renal artery. The patient has remained asymptomatic with stable serum creatinine during follow-up.

Case 3. A 68-year-old man presented with an asymptomatic 42-mm-diameter juxtarenal PAA 10 years after open AAA repair with an aortoaortic graft. Comorbidity consisted of controlled HT, previous myocardial infarction, and previous coronary artery bypass grafting. The patient was assessed as ASA grade III. CTA and DSA demonstrated a saccular 42-mm PAA with an aortic diameter of 35 mm immediately below the level of the lowest renal artery.

The right CFA was exposed surgically, and a percutaneous approach was used to the left CFA. A tubular EVSG module with two fenestrations to accommodate both renal arteries was deliv-

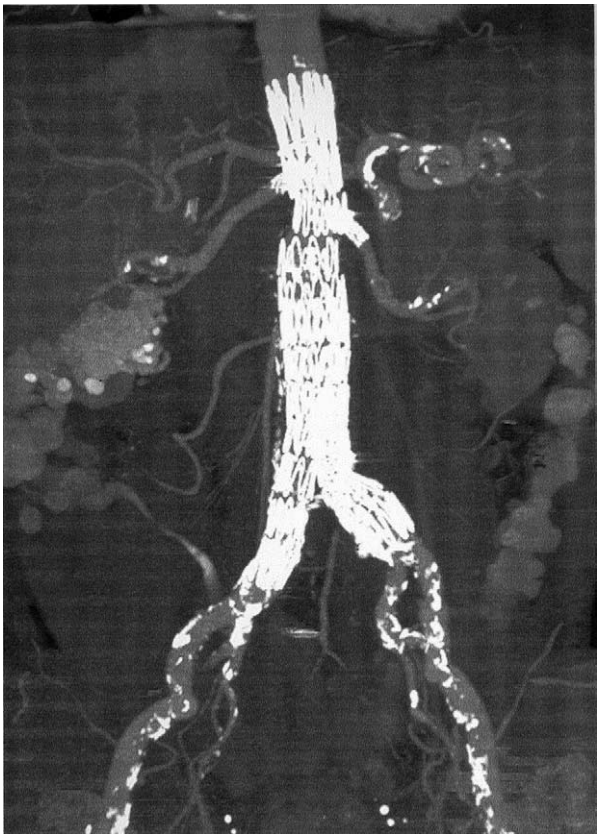

Fig 3. Follow-up computed tomographic angiography in patient 1.

ered through the right CFA (Fig 2). The graft was deployed in a satisfactory position, and the interface between the graft fenestrations and the renal artery orifices was secured with 6-mm-diameter Genesis stents. The procedure was completed by deployment of the bifurcated components from within the fenestrated component to the common iliac arteries bilaterally. Kinking of the right graft limb was corrected with a 12-mm Genesis stent. Completion angiography demonstrated no endoleak and antegrade perfusion of the SMA and both renal arteries. The patient had an uncomplicated recovery and was discharged home on the second postoperative day. CTA at 12 months demonstrated complete aneurysm exclusion with three patent target vessels.

DISCUSSION

Surgical repair of juxtarenal PAA is a technically demanding procedure, and the physiological insult to the patient is considerable. The increased blood loss and transfusion requirement associated with surgical dissection in a previously operated field and the increased ischemic insult associated with suprarenal or supraceliac aortic clamping result in increased morbidity and mortality compared with elective infrarenal or juxtarenal AAA repair.[2,3,9] Endovascular repair seems to be an attractive alternative to surgical repair in this difficult clinical situation. Careful review of the literature, however, reveals many individual case reports but few series of patients undergoing endovascular repair of the proximal abdominal aortic PAA.[4,10,11] Morrisey et al[4] and Van Herwaarden et al[10] successfully treated seven and four patients, respectively, with no perioperative mortality, whereas Liewald et al[11] treated four patients with a perioperative mortality rate of 50%. In these studies, PAA with short proximal neck lengths were treated with commercially available stent grafts with transrenal fixation, but such an approach is limited by the need for sufficient length and quality of infrarenal aortic neck to provide a secure proximal seal. If there is little or no infrarenal aortic neck, then fenestrated endovascular repair is the only alternative to conservative management or open surgical repair. We and others[5-8] have previously demonstrated that endovascular repair with custom-designed fenestrated EVSGs is an acceptable alternative to surgical repair in selected patients with juxtarenal AAA. Relative anatomic limitations to this technique include severe proximal neck angulation, large-diameter suprarenal aorta, and small-diameter, calcified, and excessively tortuous iliac arteries. Specific complications include target vessel occlusion and type III endoleak at the modular joint. Although the implantation technique required to repair juxtarenal PAA is identical to that for primary juxtarenal AAA,[5-8] graft maneuverability within an aortic prosthesis is inferior, and this has the potential to cause difficulties with graft alignment and deployment. Factors that contribute to this inferior maneuverability include the relatively small luminal diameter of the surgical graft, oversizing of the EVSG to seal within the suprarenal aorta, and frictional forces between the outer surface of the EVSG and the inner surface of the surgical graft. Although there were no design modifications to the grafts implanted in this study, the recent introduction of fenestrated EVSGs with double diameter-reducing restraining ties may improve maneuverability in these difficult cases.

The second patient presented at 6 months with an asymptomatic renal artery occlusion and subsequently developed a type I distal endoleak. There are several possible explanations for the loss of renal arteries after fenestrated stent grafting, including longitudinal graft migration and torque, hypotension, and neointimal hyperplasia.[12] There was no evidence of technical error at graft implantation, CTA at 1 month was satisfactory, and CTA at 6 months and subsequent intraprocedural imaging during revisional surgery for endoleak did not demonstrate stent deformity. It is possible, therefore, that the renal artery occlusion in patient 2 occurred secondary to neointimal hyperplasia. The distal type I endoleak in this patient was not a consequence of a planning error or a graft design fault. The graft had been planned as a fenestrated module and a bifurcated module, but a decision was made to complete the procedure with a distal aortic extension cuff. Although a recent report demonstrated insecure distal fixation that resulted in type 1 endoleak between the EVSG and the previous aortic graft in two patients with proximal PAA treated with a tube graft,[10] the senior author has successfully implanted longer fenestrated modules within previous surgical grafts as part of more complex endovascular reconstructions, without complications. It is possible, however, that the graft

configuration of a short fenestrated module with a distal extension cuff may be susceptible to type I distal endoleak. To date, there have been no complications during early follow-up in the two patients who underwent repair with a bifurcated stent graft.

In conclusion, this article describes the use of fenestrated and branched EVSGs as a salvage procedure in patients with juxtarenal PAAs after previous open AAA repair. The procedure can be performed with no perioperative mortality and minimal morbidity and requires only a short hospital stay. This technology has the potential to replace surgical repair in this difficult clinical situation.

REFERENCES

1. Hallett JW Jr, Marshall DM, Patterson TM, Gray DT, Bower TC, Cherry KJ, et al. Graft-related complications after abdominal aortic aneurysm repair: reassurance from a 36-year population-based experience. J Vasc Surg 1997;25:277-86.
2. Allen RC, Schneider J, Longnecker L, Smith RB, Lumsden AB. Para-anastomotic aneurysms of the abdominal aorta. J Vasc Surg 1993;18: 424-32.
3. Curl GR, Faggioli GL, Stella A, D'Addato M, Ricotta JJ. Aneurysmal change at or above the proximal anastomosis after infrarenal aortic grafting. J Vasc Surg 1992;16:855-60.
4. Morrisey NJ, Yano OJ, Soundararajan K, Eisen L, McArthur C, Teodorescu V, et al. Endovascular repair of para-anastomotic aneurysms of the aorta and iliac arteries: preferred treatment for a complex problem. J Vasc Surg 2001;33:503-12.
5. Anderson JL, Berce M, Hartley DE. Endoluminal aortic grafting with renal and superior mesenteric artery incorporation by graft fenestration. J Endovasc Ther 2001;8:3-15.
6. Greenberg RK, Haulon S, Lyden SP, Srivastava SD, Turc A, Eagleton MJ, et al. Endovascular management of juxtarenal aneurysms with fenestrated endovascular grafting. J Vasc Surg 2004;39:279-87.
7. Greenberg RK, Haulon S, O'Neill S, Lyden S, Ouriel K. Primary endovascular repair of juxtarenal aneurysms with fenestrated endovascular grafting. Eur J Vasc Endovasc Surg 2004;27:484-91.
8. Verhoeven ELG, Prins TR, Tielliu IFJ, van den Dungen JJAM, Zeebregts CJAM, Hulsebos RG, et al. Treatment of short-necked infrarenal aortic aneurysms with fenestrated stent-grafts: short-term results. Eur J Vasc Endovasc Surg 2004;27:477-83.
9. Sarac TP, Clair DG, Hertzer NR, Greenberg RK, Krajewski LP, O'Hara PJ, et al. Contemporary results of juxtarenal aneurysm repair. J Vasc Surg 2002;36:1104-11.
10. Van Herwaarden JA, Waasdorp EJ, Bendermacher BLW, van den Berg JC, Teijink JAW, Moll FL. Endovascular repair of paraanastomotic aneurysms after previous open aortic prosthetic reconstruction. Ann Vasc Surg 2004;18:280-6.
11. Liewald F, Kapfer X, Gorich J, Halter G, Tomczak R, Scharrer-Pamler R. Endograft treatment of anastomotic aneurysms following conventional open surgery for infrarenal aortic aneurysms. Eur J Vasc Endovasc Surg 2001;21:46-50.
12. Haddad F, Greenberg RK, Walker E, Nally J, O'Neill S, Kolin G, et al. Fenestrated endovascular grafting: the renal side of the story. J Vasc Surg 2005;41:181-90.

Submitted Feb 18, 2005; accepted May 31, 2005.