2. Tibbles PM, Edelsberg JS: Hyperbaric-oxygen therapy. N Engl J Med 1996; 334:1642–8

3. Aguiluz L, Vrevich N, Hill RK Jr: Ambulatory patient-controlled analgesia devices in the hyperbaric environment. J Hyperb Med 1990; 5:247–57

4. Manubens E, Estañol N, Robert M: La medicina hiperbárica y la anestesiología. Rev Esp Anestesiol Reanim 1996; 43:321–6

5. Radcliffe JJ, Spencer I: Performance of the Baxter disposable patient-controlled analgesia infusor under hyperbaric conditions. Anaesthesia 1994; 49:796–7

6. Akman MN, Loubser PG, Fife CE, Donovan WH: Hyperbaric oxygen therapy: Implications for spinal cord injury patients with intrathecal baclofen infusion pumps. Case report. Paraplegia 1994; 32: 281–4

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Endovascular Aortic Aneurysm Repair in a Patient with Prohibitive Cardiopulmonary Risk

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ENDOVASCULAR abdominal aortic aneurysm (AAA) repair is a minimally invasive approach that does not require laparotomy. Multiple surgical trials have investigated a variety of aortic stent graft designs.[1–7] The AneuRx stent graft (Medtronic, Inc., Minneapolis, MN) is a new modular, self-expanding endoluminal graft. The device is currently in the final stages of evaluation by the Food and Drug Administration. This article describes the perioperative management of a high-risk patient who was treated with the AneuRx endoluminal stent graft system.

Case Report

A 77-yr-old man presented with an enlarging 7.5-cm infrarenal AAA. Two months before surgery, the patient underwent cardiac arrest during a coronary angiogram that revealed a high-grade stenosis of the left anterior descending coronary artery that was not amenable to angioplasty. After resuscitation, a myocardial infarction was confirmed by creatine phosphokinase isoenzyme elevation. He was deemed to be too high risk for coronary bypass. He also suffered from severe chronic obstructive pulmonary disease and required nightly oxygen at 2 l/min by nasal cannula. The forced expiratory volume in 1 s was 0.55 l, and forced vital capacity was 1.66 l. Blood gas analysis while breathing room air showed a *p*H of 7.37, carbon dioxide partial pressure of 58 mmHg, and oxygen partial pressure of 59 mmHg. The patient was taking aspirin 325 mg/day, and the bleeding time was 9.5 min. Echocardiogram showed left ventricular hypertrophy, and ejection fraction was within normal limits. Spiral computed tomography scan of the abdomen and pelvis showed an infrarenal AAA with a 20-mm diameter, 2-cm-long proximal neck, and normal common iliac arteries (fig. 1).

Written informed consent from the patient and institutional review board approval were obtained. The procedure was performed in an operating room. On the day of surgery, radial artery catheterization was performed; general anesthesia was induced with 70 mg propofol, 50 μg fentanyl, and 10 mg vecuronium; and the trachea was intubated. A pulmonary artery catheter was placed. Anesthesia was maintained with 0.5% isoflurane, 50 $\mu g \cdot kg^{-1} \cdot min^{-1}$ propofol, oxygen, air, and a total of 150 μg fentanyl.

The surgical procedure was as follows. Both common femoral arteries were exposed through 3-cm oblique groin incisions. Introducer sheaths were inserted into both common femoral arteries over guidewires, and 100 U/kg heparin was administered intravenously. For selecting the appropriate size of device, intravascular ultrasound (Sonicath Ultra 6, 20-MHz imaging catheter; Medi-tech, Boston Scientific Corp., Watertown, MA) was used to measure the diameter of the infrarenal aorta just distal to the renal arteries (22 mm) and the diameters of the common iliac arteries (12 mm bilaterally). Length measurements from the renal arteries to the aortic bifurcation and from the renal arteries to the origins of the internal iliac arteries were also made (11 cm and 15 cm, respectively). A 13.5-cm-long, modular, bifurcated AneuRx endoluminal graft with a 24-mm diameter proximal aortic end and a 14-mm diameter distal iliac end was selected (fig. 2). The graft size selected was approximately 15% greater in diameter than the measured proximal aorta and distal iliac sizes. Each component consisted of a thin-walled, noncrimped, woven polyester graft with a self-expanding nickel-titanium (nitinol) exoskeleton.[8] Proximal and distal extender cuffs were available in different lengths and diameters if needed to obtain a "best fit." Femoral sheaths were exchanged for larger

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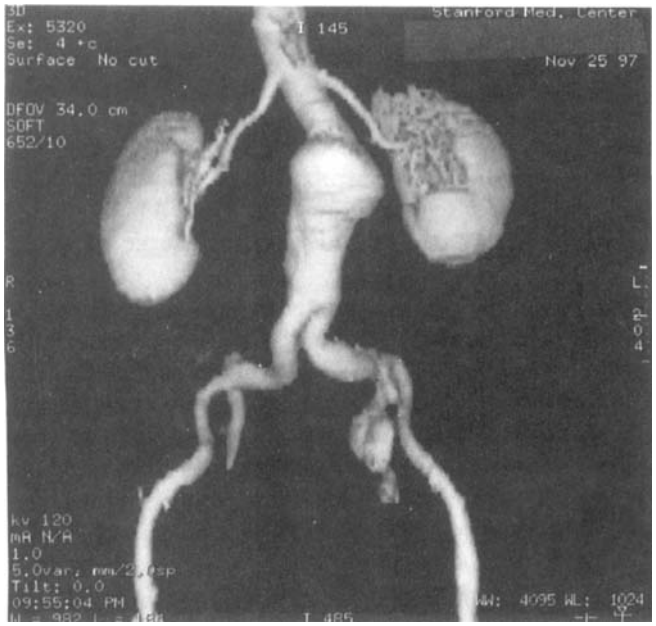

Fig. 1. Three-dimensional reconstruction of the blood flow lumen from a spiral computed tomography angiogram depicts an infrarenal abdominal aortic aneurysm.

device delivery sheaths (16 and 22 French). The primary stent graft module was introduced through the 22-French right femoral artery sheath and advanced into the abdominal aorta using fluoroscopic guidance. The device was deployed so that its proximal end sealed within the aorta just distal to the renal arteries and the distal end sealed within the ipsilateral common iliac artery. The nitinol exoskelton expanded at body temperature to form a tight seal at the proximal and distal ends of the graft. The contralateral iliac limb measured 14 mm in diameter and 8.5 cm in length. It was introduced through the left 16-French femoral sheath and deployed so that its proximal end sealed within a "gate" in the primary module and its distal end sealed within the left common iliac artery, thereby completing the bifurcated endoluminal graft deployment. The femoral introducers were removed, and the femoral arteriotomies were repaired. Bupivicaine was injected locally into the femoral incisions before closure.

The surgery time was 2.6 h, and estimated blood loss was 400 ml. Intravenous crystalloid (1 l) was administered, and no blood products were transfused. The cell saver is routinely used for these cases; however, the patient was stable, and the amount of blood loss did not justify processing. The patient was transferred to the intensive care unit and received a propofol infusion at 50 $\mu g \cdot kg^{-1} \cdot min^{-1}$. Bladder temperature was 36.7°C on admission to the intensive care unit. Four hours later, bladder temperature was 37.0°C, and the propofol infusion was discontinued. The trachea was extubated 2 h later. There were no postoperative complications. On the second postoperative day, a spiral computed tomography scan showed exclusion of the aneurysm and no evidence of endoleak (fig. 3). The patient was discharged from the hospital on postoperative day 3.

Discussion

This case report demonstrates endovascular aortic aneurysm repair in a high-risk surgical patient. The indication for AAA repair in this patient is aneurysm size alone. If untreated, the typical expansion rate for this patient's 7.5-cm AAA would be 0.5–1 cm/yr, and the rate of rupture within 5 yr would be 25–43%.[9] The patient's medical comorbidities place him at high risk for elective aneurysm repair, with a predicted operative mortality rate of 8–30%.[10] Elective repair is crucial because even in low-risk patients, operative mortality for attempted repair of a ruptured AAA is 25–70%.[9] Endovascular AAA repair is an attractive alternative to open aneurysm repair in this case because it does not require laparotomy or retroperitoneal dissection.

Food and Drug Administration–approved clinical trials are underway to evaluate the safety and efficacy of several different aortic stent graft systems. A multicenter phase I and II clinical trial compared 190 patients who underwent AAA repair using the AneuRx endoluminal graft with 60 patients who underwent open repair. The

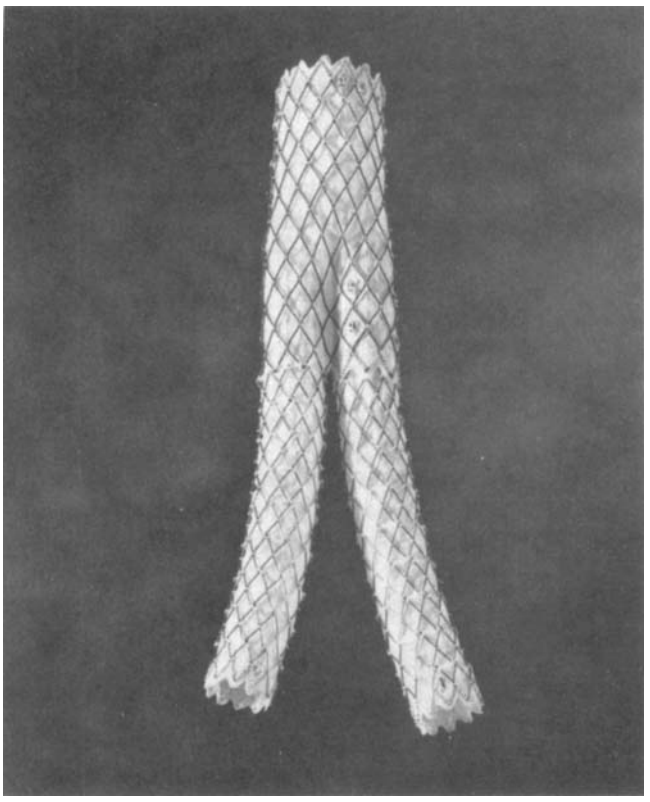

Fig. 2. The AneuRx modular aortic stent graft consists of a primary aorto-iliac component and a contralateral limb that fuse together to form a bifurcated endoluminal graft as shown Each component consists of a thin-walled, noncrimped, woven polyester graft with a self-expanding nickel-titanium (nitinol) exoskeleton. Primary modules, iliac limbs, and proximal and distal extender cuffs are available in different lengths and diameters to obtain a "best fit."

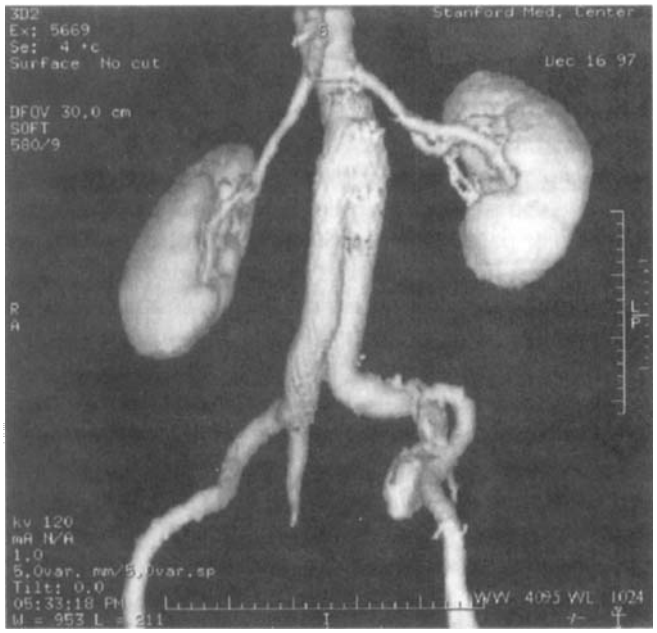

Fig. 3. Three-dimensional reconstruction of the postoperative spiral computed tomography angiogram shows exclusion of the aortic aneurysm by the endoluminal graft.

patient in the present case report was a participant in this clinical trial. Patients who had endoluminal repair had reduced morbidity and time to extubation, less operative blood loss, and decreased length of stay in the intensive care unit and hospital.[11] Major morbidity occurred in 23% of patients who had open repair compared with 12% who had endovascular repair ($P < 0.05$). There were no aneurysm ruptures and no conversions to open repair in the AneuRx-treated group.

Brewster *et al.*[12] compared 30 endovascular AAA repairs to a matched concurrent cohort of open repairs. Endovascular procedures were associated with significantly less operative blood loss, decreased lengths of stay in the intensive care unit and hospital, and quicker patient recovery.

Not all reports of endovascular AAA repair describe such favorable results. Mialhe *et al.*[6] reported a series of endovascular AAA repair with an in-hospital mortality of 25% in patients with American Society of Anesthesiologists physical status 3 and 4. Baker *et al.*[13] analyzed anesthetic care in a series of 100 patients who had endoluminal graft placement (97 AAA and 3 thoracic aortic aneurysms) using a Dacron-covered stent with hooks at either end. The deployment procedure required balloon dilation for 30–60 s, which temporarily occluded aortic blood flow. In this series, 14% of patients required conversion to open repair, 36% required postoperative ventilation in the intensive care unit, and 18% had a hemoglobin level < 8 g/100 ml intraoperatively or postoperatively. Postoperative in-house complications included respiratory dysfunction (16%), congestive heart failure (11%), acute renal failure requiring dialysis (9%), and cerebral vascular accident (2%). Median length of stay in hospital was 10 days. Complications associated with endovascular AAA repair may be closely related to device limitations and surgeon experience.

Similarly, a review of 669 attempted AAA repairs using the EVT endoluminal aortic graft (Endovascular Technologies, Menlo Park, CA) showed a mortality rate of 1.5% for all patients who underwent endoluminal aortic graft placement. Mortality rates were higher for patients who required conversion to open repair at the time of initial operation (11%) and for patients who required conversion at a later time (7%). The investigators concluded that device improvement and operator experience are critical for minimizing morbidity and mortality associated with immediate and late device explantation.[14]

Significant blood loss can occur during endovascular AAA repair. Zarins *et al.*[11] compared endovascular repair to open AAA repair and found less estimated blood loss associated with endovascular repair (641 ml *vs.* 1,596 ml; $P < 0.001$). During endovascular repair, blood is lost through 16–22-French or larger femoral artery sheaths as guidewires, catheters, and devices are inserted and removed through leaky valves. Vigilance regarding hypovolemia is required. The procedure is performed using fluoroscopic guidance in a darkened room. The image intensifier tube is positioned over the abdomen, blocking the anesthesiologist's view of the femoral area, which makes estimation of ongoing blood loss difficult. Quantification of blood loss requires that the surgeon collect all arterial blood spillage into an underlying basin, which can then be suctioned into a cell saver or suction bottle. Walker *et al.*[15] compared blood product requirements in a series of 132 patients who had endovascular AAA repair with a historic cohort of patients who had open AAA repair. Approximately the same percentage of patients required blood transfusion in both groups: 62% (82 of 132) for endovascular repair *versus* 77% (27 of 35) for open repair ($P = 0.4$).

Endovascular AAA repair is likely to become more widespread, and anesthesiologists need to be informed of the procedure and how it differs from open AAA repair. Endovascular treatment of AAA in patients with prohibitive risks for open repair is possible with low morbidity.

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References

1. Parodi JC, Palmaz JC, Barone HD: Transfemoral intraluminal graft implantation for abdominal aortic aneurysms. Ann Vasc Surg 1991; 5:491-9

2. Parodi JC: Endovascular repair of abdominal aortic aneurysms and other arterial lesions. J Vasc Surg 1995; 2:549-57

3. Chuter TAM, Wendt G, Hopkinson BR, Scott RAP, Risberg B, Walker PJ, White G: Transfemoral insertion of a bifurcated endovascular graft for aortic aneurysm repair: The first 22 patients. J Cardiovasc Surg 1995; 3:121-8

4. Chuter TAM, Risberg B, Hopkinson BR, Wendt G, Scott RAP, Walker PJ, Viscomi S, White G: Clinical experience with a bifurcated endovascular graft for abdominal aortic aneurysm repair. J Vasc Surg 1996; 24:655-66

5. Moore WS, Rutherford RB for the EVT Investigators: Transfemoral endovascular repair of abdominal aortic aneurysm: Results of the North American EVT phase 1 trial. J Vasc Surg 1996; 23:543-53

6. Mialhe C, Amicabile C, Becquemin JP for the Stentor Retrospective Study Group: Endovascular treatment of infrarenal abdominal aneurysms by the Stentor system: Preliminary results of 79 cases. J Vasc Surg 1997; 26:199-209

7. Blum U, Voshage G, Lammer J, Beyersdorf F, Tollner D, Kretschmer G, Spillner G, Polterauer P, Nagel G, Holzenbein T, Thurmher S, Langer M: Endoluminal stent-grafts for infrarenal abdominal aortic aneurysms. N Engl J Med 1997; 336:13-20

8. Allen RC, Zarins CK, Fogarty TJ: The Medtronic-AneuRx modular bifurcated graft, Techniques in Vascular and Endovascular Surgery. Edited by Yao JST, Pearce WH. Stamford, CT, Appleton and Lange, 1998, pp 401-9

9. Zarins CK, Harris EJ Jr: Operative repair for aortic aneursyms: The gold standard. J Endovasc Surg 1997; 4:232-41

10. Hollier LH, Taylor LM, Ochsner J: Recommended indicators for operative treatment of abdominal aortic aneuryms. J Vasc Surg 1992; 15:1046-56

11. Zarins CK, White RA, Schwarten D, Kinney E, Diethrich EB, Hodgson KJ, Fogarty TJ: AneuRx stent graft vs. open surgical repair of abdominal aortic aneurysms: Multicenter prospective clinical trial. J Vasc Surg 1999; 29:292-308

12. Brewster DC, Geller SC, Kaufman JA, Cambria RP, Gertler JP, LaMuraglia GM, Atamian S, Abbott WM: Initial experience with endovascular aneurysm repair: Comparison of early results with outcome of conventional open repair. J Vasc Surg 1998; 27:992-1005

13. Baker AB, Lloyd G, Fraser TA, Bookallil MJ, Yezerski SD: Retrospective review of 100 cases of endoluminal aortic stent-graft surgery from an anaesthetic perspective. Anaesth Intensive Care 1997; 25:378-84

14. Jacobowitz GR, Lee AM, Riles TS: Immediate and late explantation of endovascular aortic grafts: The endovascular technologies experience. J Vasc Surg 1999; 29:309-16

15. Walker SR, Stone R, Yusuf SW, Braithwaite B, Wenham PW, Hopkinson BR: Blood product requirments in patients undergoing elective endovascular abdominal aortic aneurysm repair. Eur J Vasc Endovasc Surg 1998; 16:390-4

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Intraoperative Anaphylactic Shock from Bacitracin Nasal Packing after Septorhinoplasty

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ANAPHYLAXIS is a life-threatening immunologically mediated reaction related to the administration of a substance that causes mast cell degranulation. We report a case of life-threatening anaphylaxis after topical application of bacitracin to the nasal mucosa at the conclusion of an anesthetic.

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Case Report

A 48-yr-old man with a history of traumatic nasal deformity and nasal obstruction was scheduled to undergo septorhinoplasty as a same-day admission. He had a history of hypertension but had not taken his prescribed dose of hydrochlorthiazide the morning of surgery. He was otherwise healthy, reported no allergies, and weighed 98 kg.

In the operating room, electrocardiogram, pulse oximetry, and noninvasive blood pressure monitoring were established. Midazolam 2 mg was administered intravenously, and induction proceeded with propofol 200 mg, sufentanil 25 μg, rocuronium 4 mg, and succinylcholine 130 mg. Anesthesia was maintained with isoflurane and nitrous oxide