Endovascular Treatment Options for Complex Abdominal Aortic Aneurysms

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ABSTRACT

Purpose: To report short-term and midterm outcomes of endovascular aneurysm repair (EVAR) of complex aneurysms requiring revascularization of visceral arteries.

Materials and Methods: Prospective data were collected from patients deemed unsuitable for conventional EVAR and conventional surgery who were treated with different endovascular approaches according to the clinical presentation of the aneurysm. Custom-made fenestrated endovascular aneurysm repair (CM f-EVAR) was used in the elective setting, homemade fenestrated endovascular aneurysm repair (HM f-EVAR) or HM f-EVAR combined with chimney endovascular aneurysm repair (ch-EVAR) was used in the emergent setting in patients with hemodynamic stability, and ch-EVAR was used in unstable cases. The study included 34 consecutive patients. Primary outcomes measured were perioperative mortality and morbidity, renal function impairment (RFI), target vessel patency, and survival at mean follow-up.

Results: In the CM f-EVAR group (7 of 34 patients; 20.6%), an intraoperative type III endoleak (1 of 7 patients; 14%) sealed spontaneously. At 8.9 months of follow-up, 1 (1 of 7 patients; 14%) death and 1 (1 of 7 patients; 14%) episode of transient RFI were documented. Visceral vessel patency rate was 95.2%. In the HM f-EVAR group (4 of 34 patients; 11.7%) and the combination of HM f-EVAR and ch-EVAR group (3 of 34 patients; 8.8%), no complications were observed at 17.3 months of follow-up. In the ch-EVAR group (20 of 34 patients; 58.8%), visceral patency was 95% at 30.9 months of follow-up. Two cases of transient RFI and 2 cases of permanent RFI were registered (2 of 20 patients; 10%). One asymptomatic renal artery branch occlusion was observed at 11 months of follow-up. No endoleaks were documented.

Conclusions: Endovascular aneurysm repair techniques including CM f-EVAR, HM f-EVAR or HM f-EVAR in combination with ch-EVAR, and ch-EVAR are valid tools to maintain blood flow in visceral arteries during treatment of complex aortic aneurysms. The proposed interventional protocol based on clinical presentation was feasible in all cases.

ABBREVIATIONS

ch-EVAR = chimney endovascular aneurysm repair, CM f-EVAR = custom-made fenestrated endovascular aneurysm repair, EVAR = endovascular aneurysm repair, HM f-EVAR = homemade fenestrated endovascular aneurysm repair, RA = renal artery, RFI = renal function impairment, SMA = superior mesenteric artery

Conventional endovascular aneurysm repair (EVAR) is not feasible in a complex aortic aneurysm with inadequate landing zone, and open surgery is still the gold standard (1,2). In patients who are not considered to be candidates for conventional surgery, different endovascular tools have been reported to exclude complex aortic aneurysms while maintaining blood flow into visceral arteries (3–6). The purpose of this study was to report our short-term and midterm results with fenestrated and chimney techniques using an interventional protocol based on clinical presentation.

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MATERIALS AND METHODS

Patients and Treatment Selection

From April 2007 to March 2013, data from patients treated with custom-made fenestrated endovascular

aneurysm repair (CM f-EVAR), homemade fenestrated endovascular aneurysm repair (HM f-EVAR), and chimney endovascular aneurysm repair (ch-EVAR) were prospectively collected into a standardized piloted form and analyzed in August 2014. All these tools were employed in patients who were not candidates for open surgery (7) presenting with complex aortic aneurysms with inadequate proximal landing zone. Complex aortic aneurysms included pararenal abdominal aortic aneurysms, suprarenal abdominal aortic aneurysms, proximal anastomotic pseudoaneurysms after abdominal aortic aneurysm open repair, and type I endoleaks after EVAR.

The endovascular approach was selected based on clinical presentation as follows: (*i*) CM f-EVAR treatment in the elective setting, (*ii*) HM f-EVAR alone or in combination with ch-EVAR in emergent settings for hemodynamically stable patients, and (*iii*) ch-EVAR in emergent settings for hemodynamically unstable patients. The institutional review board approved this retrospective study, and all patients gave written informed consent for the procedure.

The study included 34 patients, 29 (85.3%) patients were men, and mean age was 74 years (range, 58–83 y; SD, 6 y). Mean preoperative aneurysm diameter was 6.8 cm (range, 5–9 cm; SD, 2.4 cm). Baseline characteristics are summarized in **Tables 1, 2**.

Preoperative Imaging

All patients were evaluated with thoracoabdominal computed tomography (CT) angiography. OsiriX image processing software version 33.9.4 (64 bit; osirix@osirix-viewer.com) was used to assess aneurysm characteristics, including the proximal landing zone (length and diameter); thrombus or angulations, or both, of the proximal neck; iliac arteries (diameter, length, thrombus, and tortuosity); and visceral and renal arteries (**Tables 3, 4**).

Procedure

All procedures were performed under local anesthesia in the operating room using a C-arm (Euroampli Alien; Eurocolumbus SRL, Milan, Italy) by vascular surgeons trained to convert to open surgery if needed. All cases started with local anesthesia with lidocaine 1% (maximum safe dose, 4 mg/kg). In 22 of 34 (64%) cases with low tolerance to local anesthesia, intravenous conscious sedation was added 30–60 minutes after the start of the procedure. At the discretion of the anesthesiologist, propofol, midazolam, and remifentanil were used. A bolus of 5,000 units of heparin was administered intravenously after surgical access exposure.

Devices used for CM f-EVAR were Zenith (Cook, Inc, Bloomington, Indiana) and Anaconda (Vascutek/Terumo, Renfrewshire, Scotland, United Kingdom) with two to four fenestrations or one scallop configuration (**Figs 1, 2**). A bilateral femoral access was employed for introduction of the endograft main body and contralateral limb, as described by Ricotta and Oderich (8). Visceral arteries were revascularized with balloon expandable stent grafts (Advanta; Atrium Medical Corporation, Hudson, New Hampshire).

HM f-EVAR was performed with Zenith devices and balloon expandable stent grafts (Advanta). The aortic stent graft was partially deployed on the table to mark and cut the homemade fenestrations, as described by Starnes (9). These were reinforced with a double ring of gold-coated 15-mm Amplatz GooseNeck snares (ev3 Endovascular, Inc, Plymouth, Minnesota) (**Figs 3, 4**).

Zenith, Endurant (Medtronic Vascular, Inc, Santa Rosa, California), and GORE EXCLUDER (W.L. Gore & Associates, Inc, Flagstaff, Arizona) stent grafts were used for ch-EVAR with 25%–30% oversizing. Double femoral access was used for aortic stent grafts, whereas chimney endografts were introduced from above (brachial or axillary access). Chimneys were constructed with self-expandable covered stent grafts (GORE VIABAHN; W.L. Gore & Associates, Inc) eventually reinforced with bare metal stents (Protégé EverFlex; ev3 Endovascular, Inc). Aortic and chimney stent grafts were deployed simultaneously, and a kissing ballooning was performed to optimize the sealing and reduce the risk of proximal leakage around the chimney grafts (gutter channels) (**Figs 5, 6**) (10).

When HM f-EVAR and ch-EVAR techniques were combined, Advanta stent grafts were employed for fenestrations, and GORE VIABAHN or Fluency (C.R. Bard, Inc, Murray Hill, New Jersey) stent grafts were employed for chimneys. Brachial and bilateral femoral accesses were used in these patients (**Fig 7**). A completion angiogram was obtained to evaluate target vessel patency, aneurysm exclusion, and endoleak in all cases.

Outcomes

Perioperative mortality and morbidity, technical success (defined as procedure completed as intended without additional maneuvers), target vessel patency, and survival at mean follow-up for each endovascular treatment option were documented. Renal function impairment (RFI; serum creatinine increase of $\geq$ 0.5 mg/dL after the procedure) and renal function recovery (creatinine levels returned to baseline or $<$ 1.3 mg/dL) were also documented. Additional outcomes, including procedure time, contrast medium administration, fluoroscopy time, and in-hospital length of stay, were collected.

Follow-up

All patients were discharged with double oral antiplatelet therapy (aspirin 100 mg/d and clopidogrel 75 mg/d). A physical examination including duplex scan was performed before discharge; at 1, 3, 6, and 12 months; and yearly thereafter. All patients underwent CT