◆ CASE REPORT ◆

Treatment of Juxtarenal Aortic Aneurysm With the Multilayer Stent

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Purpose: To report the use of a new type of uncovered stent to treat aortic aneurysms.

Case Report: Under compassionate use, an 81-year-old man with multiple comorbidities and an expanding 63-mm juxtarenal abdominal aortic aneurysm was treated with a 28×100-mm Multilayer flow-modulating stent. Immediately, the blood flow velocity inside the aneurysm sac appeared reduced on fluoroscopy. All aortic branches covered by the stent (celiac trunk, superior mesenteric artery, and renal arteries) remained patent. Serial computed tomography at up to 12 months has shown excellent stent and visceral artery patency and progressive reduction in the sac diameter (58 mm) and volume (84.9 cm^3 to 82.8 cm^3).

Conclusion: This case shows that the use of an uncovered multilayer stent reduces the flow in the aneurysm but preserves perfusion of the branch arteries, which is impossible with covered stents.

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Key words: abdominal aortic aneurysm, juxtarenal aneurysm, stent, flow-modulating stent, sac diameter reduction, visceral artery perfusion

Endovascular aneurysm repair (EVAR) has played an increasingly important role in the management of abdominal aortic aneurysm (AAA) since the first procedures more than two decades ago. While endovascular stent-grafts and delivery systems have evolved considerably in that time, further refinements are needed to broaden the applicability of the procedure to more complex lesions, such as juxtarenal aortic aneurysms. Although the introduction of fenestrated stent-grafts has made it possible to offer an endovascular option to patients with an aneurysm that does not have an adequate proximal or distal sealing zone,[1–3] fenestrated stent-grafts are costly and time-consuming to manufacture, which limits their applicability, especially in an emergency procedure.[3] For such scenarios, the chimney technique may be a valid alternative to a fenestrated stent-graft,[4,5] and hybrid approaches can be successfully utilized in these cases.[6] A new type of uncovered stent with flow-modulating properties has been developed and tested in vitro and in vivo.[7–9] The initial clinical applications of this stent in the treatment of renal[10] and visceral[11] aneurysms and thoracoabdominal dissection[12] have produced encouraging results, and we now report the use of this stent in the treatment of a juxtarenal aortic aneurysm.

The authors have no commercial, proprietary, or financial interest in any products or companies described in this article.

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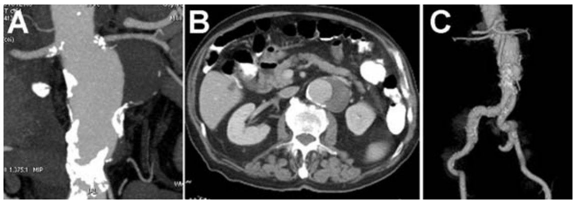

Figure 1 ◆ Preoperative CT scans in the (**A–C**) of the 62-mm juxtarenal aortic aneurysm.

CASE REPORT

An 81-year-old man with a history of smoking, hypertension, severe coronary artery disease, myocardial infarction, heart failure, and AAA was admitted to the hospital for evaluation of a positive fecal occult blood test. During computed tomography (CT) that identified a large tumor in the cecum, the juxtarenal aortic aneurysm measured 63 mm in diameter (Fig. 1), compared to 48 mm a year earlier. No infection or inflammatory parameters were highlighted. A right hemicolectomy was performed, and 3 options were proposed to treat the AAA: open surgery, a fenestrated stent-graft, or compassionate use of a new Multilayer stent (Cardiatis SA, Isnes, Belgium). Open and hybrid procedures were abandoned owing to the patient's high surgical risk (ASA 4). A fenestrated stent-graft was too expensive and difficult to perform due to the small diameters of 2 of the 3 renal arteries (4 and 3.5 mm, respectively, on the left and 7 mm on the right). The concept and risks of the new stent were explained to the patient, who provided written informed consent. The procedure was approved by the ethical committee of our hospital. The patient was on aspirin (100 mg/d), and treatment with clopidogrel (75 mg/d) was begun 3 days before the planned procedure.

The intervention was performed under locoregional anesthesia. After surgical exposure and arteriotomy of the right common femoral artery, a 0.035-inch guidewire was inserted, and 5000 units of heparin were given intra-arterially. A percutaneous access to the left common femoral artery was obtained, and a 5-F graduated pigtail catheter was inserted for aortography. The diameter of the proximal landing zone (above the celiac trunk) measured 23 mm and the distal landing zone (below the inferior mesenteric artery) was 21 mm. Allowing oversizing of 20% (the device behaves like a self-expanding stent and not an endograft), a 28×100-mm Multilayer stent was selected and deployed through an 18-F delivery system, covering the celiac trunk, the aneurysm, and the splanchnic and renal arteries (Fig. 2). Unfortunately, the stent length was reduced during deployment, so the distal landing zone was upstream from the inferior mesenteric artery. Immediately, the blood flow velocity inside the aneurysm sac appeared slower on fluoroscopy, so a decision was made not to implant a second stent. All the branches remained patent. No perioperative complications occurred. The patient was discharged on the third postoperative day with instructions to continue the clopidogrel for 1 month and aspirin indefinitely. Upon discharge, renal function (serum creatinine 1.1 mg/dL) was normal and blood pressure (145/85 mmHg)

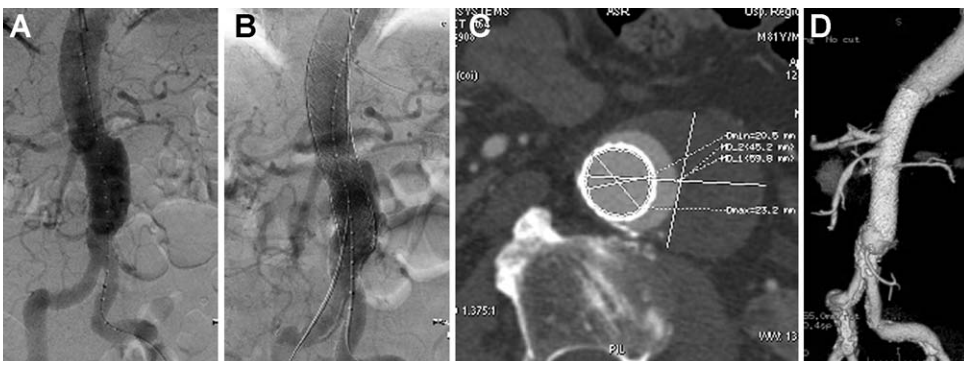

Figure 2 ◆ (**A**) Intraoperative and (**B**) postoperative aortography and CT scans at discharge, showing minimal sac perfusion (**C**) and patency of the stent and visceral artery branches (**D**).

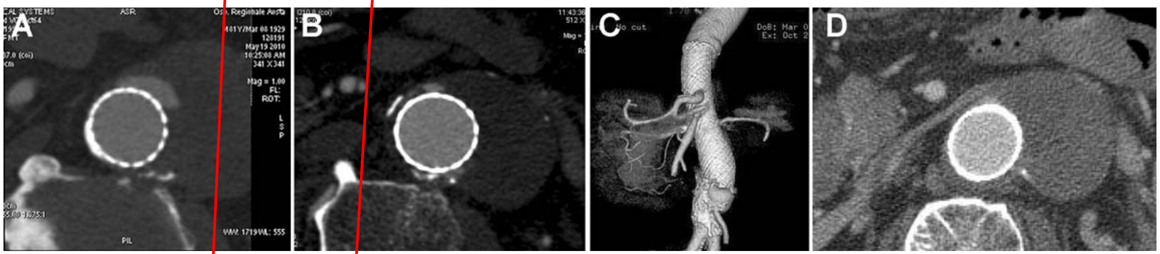

Figure 3 ◆ The CT scans at (**A**) 1 and (**B**) 6 months show progressively reduced sac perfusion and (**C**) patency of the visceral branches. At 12 months (**D**), the AAA diameter is reduced to 58 mm.

was controlled; the CT (Fig. 3) showed graft and visceral artery patency and minimal perfusion of the aneurysm sac owing to reduced shear stress produced by the geometry of the multilayer stent. Serial CT scans up to 12 months (Fig. 5) have shown excellent stent and visceral artery patency and progressive reduction in the sac diameter (58 mm) and volume (84.9 cm^3 to 82.8 cm^3) at 1 year; no intrasac pressure measurement was performed. The patient remains stable, with controlled blood pressure (140/80 mmHg) and renal function (serum creatinine 1.0 mg/dL).

DISCUSSION

Successful endovascular aneurysm sac exclusion depends upon stable attachment and hemostatic seal between the nonaneurysmal aorta and the stent-graft. Obtaining a stable seal becomes more difficult as neck length shortens and the aneurysm approaches the visceral and renal arteries. Thus patients with juxtarenal AAA who are not eligible for standard EVAR often require complex surgical open repair, which is associated with increased mortality and morbidity from cardiopulmonary and renal complications.[1] A hybrid approach, combining stent-grafting with open surgical visceral artery debranching, had enabled treatment of these complex aneurysms,[6] but it does not entirely eliminate the morbidity associated with major open vascular procedures.

Fenestrated stent-grafts, on the other hand, have been under development for some time as a means of repairing complex aneurysms using minimally invasive techniques exclusively.[1,2] Branched aortic stent-grafts were developed to obtain a more secure seal than is possible with fenestrated stent-grafts, but there are limitations to the use of any multibranched stent-graft. These devices are relative large and require the use of up to 24-F sheaths. Access can also be limited by tortuosity and circumferential calcification. Orienting the stent-graft branches in the axial plane is very difficult even for interventionists with highly developed catheter skills. Moreover, the technique cannot be used if arteries are too small to accommodate a covered stent (typically $<$4 mm in diameter). Importantly, most fenestrated and multibranched stent-grafts need to be custom made for each patient, so the costs are high and the waiting period for manufacture is long.

A valid alternative to a fenestrated stent-graft may be the chimney graft technique.[4,5] Chimney grafts are delivered to the visceral branches to make it possible to use standard off-the-shelf stent-grafts to treat lesions with inadequate fixation zones. Chimney grafts may also be utilized in selected planned cases that are unsuitable for a fenestrated or branched stent-graft due to vessel tortuosity.[13]

In any configuration, stent-grafts can cause problems (component disconnection, endoleaks), and they do not allow flow to collateral branches in their path. The fluid-modulating braided Multilayer stent, on the other hand, allows treatment of the aneurysm while preserving branch artery patency. In their study of multilayer stent, Wailliez and Coussement[7] demonstrated the influence of stents on flow in different aneurysms. Typically, the flow in an aneurysm is very chaotic, with zones of recirculation; in the presence of a multilayer stent, however, the flow becomes more laminar in the main part of the sac, which decreases shear stress on the wall. The hemodynamic changes induced by placement of a multilayer stent can have a favorable influence on aneurysm evolution: velocity in the sac decreases an average of 88%, organized thrombus forms, and the risk of rupture is strongly reduced. In aneurysms with branches, the multilayer stent encourages laminar flow along the vessel wall and into the collateral, preserving branch patency.[9] In a porcine aneurysm model, Bonneau and Kang[8] demonstrated good permeability of collateral arteries covered by the stents, excellent stent endothelialization, and total absence of intimal hyperplasia.

In our initial experience, the inaccurate delivery system (no repositioning option), the low flexibility of the device, and the need for large-caliber sheaths were the main limitations associated with the use of this stent. Moreover, during deployment, the stent can jump forward or shorten.

Conclusion

In this compassionate use case, the Multilayer stent appeared to be a viable treatment option for juxtarenal AAA. The technique is simple to perform and preserved patency of the visceral branches in this patient at 1-year follow-up, but larger experiences and longer follow-up are necessary to evaluate the effectiveness and durability of this technique.

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