CASE REPORTS

The double two-chimney technique for complete renovisceral revascularization in a suprarenal aneurysm

Jip L. Tolenaar, MD, Herman J. A. Zandvoort, MD, Constatijn E. V. B. Hazenberg, MD, Frans L. Moll, MD, PhD, and **Joost A. van Herwaarden, MD, PhD,** *Utrecht, The Netherlands*

Suprarenal pathologies can be treated with immediately available devices with the chimney technique, which offers a bail-out in patients not eligible for a branched or fenestrated stent graft. We present an adjusted chimney technique for total renal and visceral revascularization in a patient with a suprarenal aneurysm. Although short-term results look promising, longer follow-up is anticipated. (J Vasc Surg 2013;58:478-81.)

Aortic aneurysms with aortic side branch involvement require extensive open surgical repair and are associated with high morbidity and mortality rates compared with standard open surgical repair.[1,2] Branched and fenestrated stent grafts offer an attractive treatment option in high-risk patients but are not yet general applicable in the acute setting. Moreover, several patients have an unfavorable anatomy for these types of stent grafts and are considered unsuitable.[3-5] To obviate this problem, alternative interventions like the double-barrel technique, sandwich technique, and the chimney procedure have been developed. Initial results are promising, however, in absence of large series and improving techniques, it remains subject to debate.[6-8] Because of the complexity of the procedure and the potential problems, some authors state that this procedure should be limited to two branch vessels, by sacrificing the less functional or more complex renal artery if the superior mesenteric artery (SMA) needs to be preserved.[9] We used a combination of techniques in the treatment of a patient with a suprarenal aneurysm, who was considered unsuitable for a fenestrated stent graft.

CASE REPORT

A 75-year-old patient presented with a 6.3-cm saccular, suprarenal aneurysm originating proximal from the SMA and extending into the right common iliac artery (Fig 1, *A*). Medical history included 20 smoking pack years, tuberculosis, lumbar spondylodesis, and chronic obstructive pulmonary disease. Gold stage II data of last spirometry examination before surgery were as follows: forced expiratory volume in 1 second (FEV1) 1.86 L (71% of predicted FEV1) and a ratio of 55% between vital capacity and FEV1 (FEV1%VC). Concerning the compromised lung function of the patient, an endovascular treatment was chosen. However, the patient was declined for a branched or fenestrated stent graft by Cook Medical due to tortuosity and calcification of the aorta. Therefore, a chimney procedure with preservation of the celiac trunk, SMA, and both renal arteries was planned. During preoperative planning, the area of the aortic lumen that would be compromised by the grafts was calculated to ensure distal circulation. Stent grafts are routinely oversized between 20% and 30%. The patient was placed under general anesthesia, and open exposure of the femoral arteries and left brachial artery was obtained. Through the left brachial artery, a 10F sheath was advanced by, and the SMA and celiac trunk were accessed. An 8- × 50-mm self-expandable stent graft (Viabahn; W. L. Gore & Associates, Inc, Flagstaff, Ariz) was deployed in the celiac trunk and subsequently, a 9- × 50-mm Viabahn in the SMA. After both chimney grafts were deployed, they were extended proximally with balloon-expandable stents (Scuba; Medtronic Vascular, Santa Rosa, Calif), with such an overlap that the Viabahns were primarily reinforced at the level of the aortic lumen. An Endurant (Medtronic Vascular, Santa Rosa, Calif) tube graft (ENCF28-28-C45EE) was deployed with the proximal landing zone of 3.9 cm from the celiac trunk and distal landing zone 1 cm proximal to the most proximal renal artery (Fig 2, *A*), Then, the 10F sheath from the arm was repositioned and advanced in the aortic extender cuff, from which both renal arteries were catheterized. Thereafter, 7- × 50-mm Viabahn stent grafts were deployed in both renal arteries partially strengthened with balloon-expendable bare stents (Scuba; Medtronic Vascular).

A Gore excluder (31-14-13; W. L. Gore & Associates, Inc) was then deployed just below the proximal end of the chimneys

From the Department of Vascular Surgery, University Medical Center Utrecht.
Author conflict of interest: none.
Reprint requests: Joost A. van Herwaarden, MD, PhD, Department of Vascular Surgery, Room G.04.129, University Medical Center, PO Box 85500, 3508GA Utrecht, The Netherlands (e-mail: J.A.vanherwaarden@umcutrecht.nl).
The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.
0741-5214/$36.00

http://dx.doi.org/10.1016/j.jvs.2012.11.091

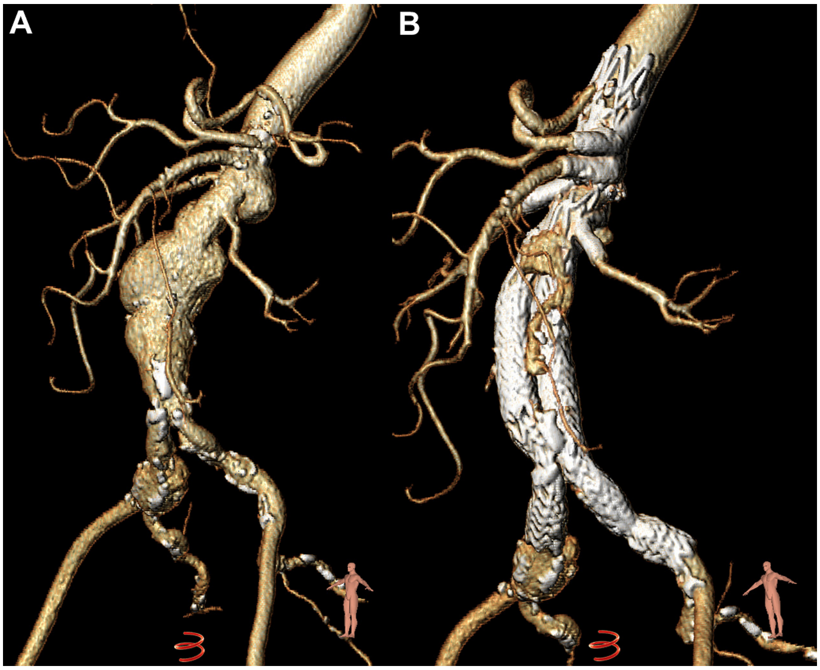

Fig 1. A, Preoperative computed tomography (CT) angiography reconstruction showing a suprarenal aneurysm, 6.3 cm in diameter. **B,** Postoperative CT angiography three-dimensional reconstruction showing total renovisceral revascularization with patent chimney grafts.

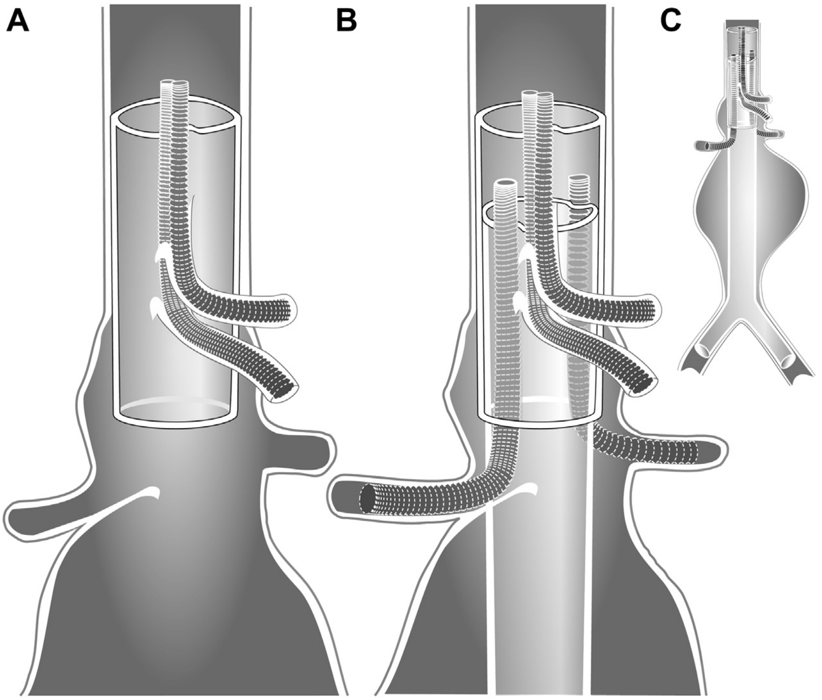

Fig 2. Schematic figure of the surgical procedure. **A,** After placement of the chimney grafts in the superior mesenteric artery (SMA) and celiac trunk, through the left brachial artery, a tube stent graft is deployed. **B,** The sheath from the left brachial artery is repositioned and chimney grafts are placed in both renal arteries; subsequently, the bifurcated stent graft is deployed. **C,** Overview of the double two-chimney technique with exclusion of a juxtarenal aneurysm.

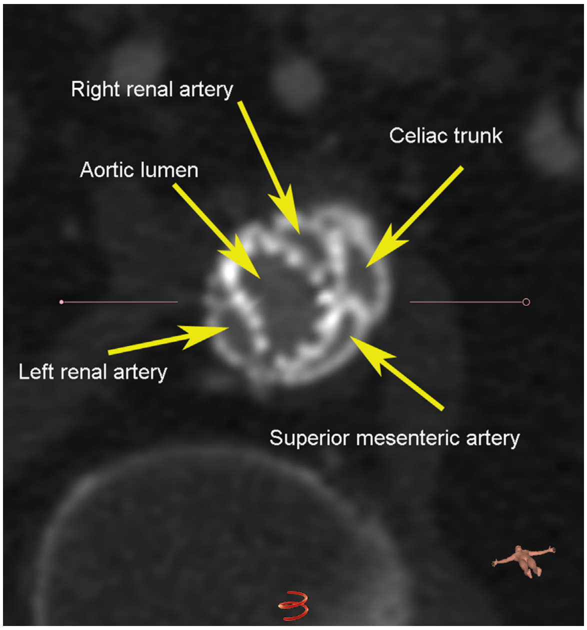

Fig 3. Computed tomography (CT) angiography transverse reconstruction after 4-month follow-up. The arrows indicate the chimney grafts in position in the superior mesenteric artery (SMA), celiac trunk, left renal artery, right renal artery, and the aortic lumen.

in the renals and with 3-cm overlap with the Endurant aortic cuff, and finally, both limbs were extended with extension grafts (Fig 2, *B* and *C*).

Completion angiography showed a small type III endoleak originating from the overlap between the bifurcated graft and the extension cuff, and an expectative policy was conducted. On the second postoperative day, a computed tomography angiography showed good patency of the chimney grafts (Fig 1, *B*) and a persistent type III endoleak. Hospitalization was uneventful, and the patient was discharged on postoperative day 4 in good health. Follow-up scan after 4 months showed adequate patency of all four chimney grafts (Fig 3) with disappearance of the type III endoleak except for a small type II endoleak. Despite the endoleak, the maximum aneurysm diameter had decreased from 66.0 to 65.1 mm and aneurysm volume from 202.1 to 161.8 mL. After 1 and 6 months, laboratory testing revealed normal creatinine levels (111 and 108 μmol/L, respectively), and the patient felt well without abdominal complaints.

DISCUSSION

Since the introduction of endovascular aortic aneurysm repair, physicians have sought to extent its applicability. Fenestrated and branched stent grafts were introduced as techniques to preserve blood flow over the aortic branches. Because of good midterm results, these techniques are currently gaining more popularity.[10-13] However, an important limitation regarding these stent grafts is that they are patient specific and have to be custom made. Moreover, 20% to 30% of patients are considered unsuitable for these stent grafts because of tortuosity, angulation, or calcifications of the aorta.[3-5] With the use of chimney grafts, an extension of the proximal landing zone can be achieved with the use of immediately available stents, avoiding open surgery.

A review of the literature concerning the use and outcome of chimney grafts, reported 93 patients with 134 treated aortic side branches.[7] In this report, technical success was 86%, and a patency rate of 97.8% was obtained. Most patients received one or two chimney grafts, whereas only three patients are reported to have complete endovascular renovisceral revascularization. Lachat et al used a Gore-TAG stent graft for a ruptured thoracoabdominal aortic aneurysm with two chimney grafts extending at the proximal landing zone and two extending to the distal landing zone.[14] Kolvebach et al used a sandwich technique in thoracoabdominal aneursysms with total renovisceral revascularization in two patients.[15] After deployment of a thoracic stent graft, chimney grafts were deployed in the visceral arteries. After placement of the bifurcated stent graft, a third bridging stent graft was placed to connect both stent grafts.

The interference of the chimney grafts on the circumferential apposition of the stent graft makes a perfect seal impossible and the presence of perigraft channels, or so-called "gutters," is therefore inevitable. These gutters predispose patients to type I endoleaks, leading to repressurization of the aneurysm and eventually rupture. Not only in theory, but an observation of a tendency of increased incidence of type I endoleak with an increasing number of chimney grafts was made by Moulakakis et al, although no significant difference was realized.[7] In both techniques, all chimney grafts are covered by one stent graft, thereby compromising the circumferential apposition to a large extent.[14,15] By placing the chimney grafts in the mesenteric arteries prior to the aortic stent graft placement, the interference of the chimney grafts on the apposition stent graft is divided by two stent grafts. Although highly speculative, by reducing the number of chimney grafts per stent graft, the incidence of proximal endoleaks may be reduced. Our choice of stent graft is based on our clinical experience with the Endurant stent graft in chimney patients. However, to avoid additional pressure by a bare stent on the chimney grafts, we opted for a C3 Excluder as bifurcated stent graft instead. Preoperative assessment for such a procedure greatly contributes to its success; multiplanar imaging and three-dimensional reconstruction can be used, not only to determine the feasibility of the procedure, but also to calculate the extent of the aortic lumen that is compromised by the grafts to ensure distal circulation.

The best result in these patients is probably obtained with the use of branched or fenestrated stent grafts, if time and the anatomy permit. The development of standardized branched stent grafts is ongoing, but these stent grafts are not yet generally available.[16,17] Until that time, the use of chimney grafts seems feasible, and with developing techniques, the results and its applicability might be improved.

CONCLUSIONS

Suprarenal pathologies can be treated with the double two-chimney technique using directly available devices, which offers a bailout in patients not eligible for a branched or fenestrated stent graft.

REFERENCES

1. Crawford ES, Crawford JL, Safi HJ, Coselli JS, Hess KR, Brooks B, et al. Thoracoabdominal aortic aneurysms: preoperative and intraoperative factors determining immediate and long-term results of operations in 605 patients. J Vasc Surg 1986;3:389-404.
2. Greenberg RK, Lu Q, Roselli EE, Svensson LG, Moon MC, Hernandez AV, et al. Contemporary analysis of descending thoracic and thoracoabdominal aneurysm repair: a comparison of endovascular and open techniques. Circulation 2008;118:808-17.
3. Abbruzzese TA, Kwolek CJ, Brewster DC, Chung TK, Kang J, Conrad MF, et al. Outcomes following endovascular abdominal aortic aneurysm repair (EVAR): an anatomic and device-specific analysis. J Vasc Surg 2008;48:19-28.
4. De Bruin JL, Baas AF, Buth J, Prinssen M, Verhoeven EL, Cuypers PW, et al. Long-term outcome of open or endovascular repair of abdominal aortic aneurysm. N Engl J Med 2010;362:1881-9.
5. Leurs LJ, Kievit J, Dagnelie PC, Nelemans PJ, Buth J. Influence of infrarenal neck length on outcome of endovascular abdominal aortic aneurysm repair. J Endovasc Ther 2006;13:640-8.
6. Hiramoto JS, Schneider DB, Reilly LM, Chuter TA. A double-barrel stent-graft for endovascular repair of the aortic arch. J Endovasc Ther 2006;13:72-6.
7. Moulakakis KG, Mylonas SN, Avgerinos E, Papapetrou A, Kakisis JD, Brountzos EN, et al. The chimney graft technique for preserving visceral vessels during endovascular treatment of aortic pathologies. J Vasc Surg 2012;55:1497-503.
8. Ohrlander T, Sonesson B, Ivancev K, Resch T, Dias N, Malina M. The chimney graft: a technique for preserving or rescuing aortic branch vessels in stent-graft sealing zones. J Endovasc Ther 2008;15:427-32.
9. Bruen KJ, Feezor RJ, Daniels MJ, Beck AW, Lee WA. Endovascular chimney technique versus open repair of juxtarenal and suprarenal aneurysms. J Vasc Surg 2011;53:895-905.
10. Chuter TA, Rapp JH, Hiramoto JS, Schneider DB, Howell B, Reilly LM. Endovascular treatment of thoracoabdominal aortic aneurysms. J Vasc Surg 2008;47:6-16.
11. Chuter TA, Hiramoto JS, Chang C, Wakil L, Schneider DB, Rapp JH, et al. Branched stent-grafts: will these become the new standard? J Vasc Interv Radiol 2008;19(6 Suppl):S57-62.
12. Greenberg RK, Clair D, Srivastava S, Bhandari G, Turc A, Hampton J, et al. Should patients with challenging anatomy be offered endovascular aneurysm repair? J Vasc Surg 2003;38:990-6.
13. Haulon S, Amiot S, Magnan PE, Becquemin JP, Lermusiaux P, Koussa M, et al. An analysis of the French multicentre experience of fenestrated aortic endografts: medium-term outcomes. Ann Surg 2010;251:357-62.
14. Lachat M, Frauenfelder T, Mayer D, Pfiffner R, Veith FJ, Rancic Z, et al. Complete endovascular renal and visceral artery revascularization and exclusion of a ruptured type IV thoracoabdominal aortic aneurysm. J Endovasc Ther 2010;17:216-20.
15. Kolvenbach RR, Yoshida R, Pinter L, Zhu Y, Lin F. Urgent endovascular treatment of thoraco-abdominal aneurysms using a sandwich technique and chimney grafts—a technical description. Eur J Vasc Endovasc Surg 2011;41:54-60.
16. Chuter T, Greenberg RK. Standardized off-the-shelf components for multibranched endovascular repair of thoracoabdominal aortic aneurysms. Perspect Vasc Surg Endovasc Ther 2011;23:195-201.
17. Sweet MP, Hiramoto JS, Park KH, Reilly LM, Chuter TA. A standardized multi-branched thoracoabdominal stent-graft for endovascular aneurysm repair. J Endovasc Ther 2009;16:359-64.

Submitted Sep 12, 2012; accepted Nov 21, 2012.