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Outcome of visceral chimney grafts after urgent endovascular repair of complex aortic lesions

Adel Bin Jabr, MD, PhD, Bengt Lindblad, MD, PhD, Thorarinn Kristmundsson, MD, PhD, Nuno Dias, MD, PhD, Timothy Resch, MD, PhD, and **Martin Malina, MD, PhD,** *Malmö, Sweden*

Objective: **Endovascular abdominal aortic repair requires an adequate sealing zone. The chimney graft (CG) technique may be the only option for urgent high-risk patients who are unfit for open repair and have no adequate sealing zone. This single-center experience provides long-term results of CGs with endovascular repair for urgent and complex aortic lesions.**

Methods: **Between July 2006 and October 2012, 51 patients (16 women) with a median age of 77 years (interquartile range, 72-81 years), were treated urgently (within 24 hours [61%]) or semiurgently (within 3 days [39%]) with endovascular aortic repair and visceral CGs (n = 73). Median follow-up was 2.3 years (interquartile range, 0.8-5.0 years) for the whole cohort, 3 years for 30-day survivors, and 4.8 years for patients who are still alive.**

Results: **Five patients (10%) died within 30 days. All of them had a sacrificed kidney. All-cause mortality was 57% (n = 29), but the chimney- and procedure-related mortality was 6% (n = 3) and 16% (n = 8), respectively. Chimney-related death was due to bleeding, infection, renal failure, and multiple organ failure. There were two postoperative ruptures; both were fatal although not related to the treated disease. The primary and secondary long-term CG patencies were 89% (65 of 73) and 93% (68 of 73), respectively. Primary type I endoleak (EL-I) occurred in 10% (5 of 51) of the patients, and only one patient had recurrent EL-I (2%; 1 of 51). No secondary endoleak was observed. Chimney-related reintervention was required in 16% (8 of 51) of the patients because of EL-I (n = 3), visceral ischemia (n = 4), and bleeding (n = 2). The reinterventions included stenting (n = 5), embolization (n = 3), and laparotomy (n = 2). Thirty-one visceral branches were sacrificed (9 celiac trunks, 9 right, and 13 left renal arteries). Among the 30-day survivors, 8 of 17 patients (47%) with a sacrificed kidney required permanent dialysis; of these, seven underwent an urgent index operation. The aneurysm sac shrank in 63% (29 of 46) of cases.**

Conclusions: **The 6% chimney-related mortality and 93% long-term patency seem promising in urgent, complex aortic lesions of a high-risk population and may justify a continued yet restrictive applicability of this technique. Most endoleaks could be sealed endovascularly. However, sacrifice of a kidney in this elderly cohort was associated with permanent dialysis in 47% of patients. (J Vasc Surg 2016;63:625-33.)**

Endovascular aneurysm repair (EVAR) is safe, durable, and efficient when there are adequate proximal and distal sealing and fixation zones.[1,2] Fenestrated and branched stent grafts (SGs) have made EVAR possible for elective cases that do not have an adequate proximal or distal sealing zone.[3,4] Fenestrated and branched SGs are not routinely available for urgent interventions because they are custom-made, which is time-consuming and costly. Open repair has been the procedure of choice for such urgent cases, although many of the patients are unfit. Therefore, the chimney graft (CG) technique is a tempting alternative for this group of patients.[3,5] Using standard off-the-shelf SGs, the CG technique preserves blood flow to vital side branches while extending the sealing zones of the aortic SG.[3,5] Lately, the CG technique has also been used for semiurgent as well as for elective cases.[3,5-7]

The main drawback of the CG technique is the potential risk for a proximal type I endoleak (EL-I). Most reports indicate a higher incidence of EL-I (10%-26%)[3,5-9] compared with fenestrated EVAR. The gutters alongside the chimney walls have been claimed as a potential source for endoleak and transmission of pressure into the aneurysmal sac with sustained risk of bleeding or rupture. The use of several chimneys may increase the risk for endoleakage and necessitates multiple brachial access sites, which is why CGs have been combined with sacrifice of a renal artery in a significant proportion of cases. Other reasons for sacrificing a visceral artery could be a narrow aortic lumen that cannot accommodate multiple CGs, obvious risk of EL-I that necessitates an extension of the sealing zone, urgency and instability of the patient that do not allow enough time for additional CGs, accidental overstenting of an aortic side branch in the presence of technical difficulty, and failed attempt to stent a targeted vessel. Data concerning the safety and efficacy of this technique are still limited. The aim of this study was to report our long-term experience of visceral CGs in high-risk (unfit for open repair) patients with mainly urgent, complex abdominal aortic lesions.

From the Vascular Center, Skåne University Hospital/Malmö, Medical Faculty, Lund University.

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Correspondence: Adel Bin Jabr, MD, PhD, Vascular Center, Skåne University Hospital, Lund University, Ruth Lundskogsgata 10 plan 1, 20502 Malmö, Sweden (e-mail: adel.bengabr@med.lu.se; adelgabr1@gmail.com).

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METHODS

Among 785 EVARs (including 160 fenestrated EVARs and 227 thoracic EVARs) performed at our tertiary referral center between June 2006 and October 2012, 51 patients with a median age of 77 (72-81) years (69% male; n = 35) received one or several visceral CGs (43 with EVAR and eight with thoracic EVAR) and were selected for this study. The patients' data were collected prospectively and analyzed retrospectively. No patient was lost to follow-up.

The majority of patients (61%; n = 31) were deemed urgent and reconstructed within 24 hours; most of them required emergent treatment (within 4 hours). The others were treated semiurgently within 3 days (39%; n = 20). All patients were considered too urgent to await a customized SG. Visceral CGs for aortic occlusive disease were excluded and have been reported elsewhere.[10] CGs for lesions of the thoracic aorta including the arch have also been excluded and reported elsewhere,[11] except for seven thoracoabdominal cases with visceral CGs. These seven cases are shared between the thoracic and visceral groups of patients because of common characteristics and were part of the recent publication in the *Journal of Vascular Surgery*.[11] Elective cases in which open repair or fenestrated or branched SGs could be used were not considered for the CG technique.

The surveillance scheme varied over time. Postoperative computed tomography angiography (CTA) was performed at least at 1 month and yearly. Delayed scans were included. Most patients also had plain radiography in two projections. Additional examinations were offered liberally. Creatinine concentration was followed, particularly in connection with the contrast-enhanced computed tomography scans. The films were scrutinized particularly for vessel patency, endoleaks, and distortion of the stents. The Swedish national registry allows us to confirm survival of all patients.

Renal length was assessed sporadically when there was doubt about adequate perfusion on CTA or when renal function did not allow the use of a contrast agent. On such occasions, duplex scanning was added to confirm renal perfusion.

Data and patient characteristics. Data were assembled according to the guidelines for reporting standards in EVAR.[12] Data distribution is presented as median and interquartile range (IQR) unless otherwise indicated. Procedure-related mortality and all-cause mortality are given at 30 days and at follow-up. By formal definition, all 30-day deaths are procedure related. However, none of the 30-day deaths was caused by any complication of the CGs, such as EL-I, visceral ischemia or infarction, or guidewire perforation. Such specific causes of death were defined as chimney related and are listed separately. Hence, chimney-related mortality is defined as any mortality that was directly related to a complication of the CG itself. Primary EL-I refers to endoleaks that were diagnosed within the first 30 postoperative days, and secondary endoleaks are those that were diagnosed thereafter. Persistent renal impairment was defined as increase in creatinine concentration of >20% from baseline (preprocedural value) or >200 μmol/L. In this context, the term *chimney graft* includes both chimney stent and chimney SG.

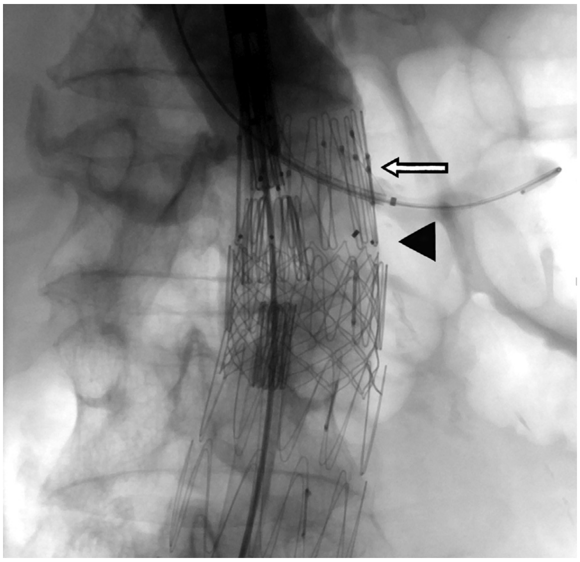

Fig 1. A chimney graft (CG) was implanted for extension of a previously failed endovascular aneurysm repair (EVAR) because of type I endoleak (EL-I). The *arrowhead* shows the proximal end of the failed graft's fabric; the *arrow* shows where the second stent graft (SG) is being deployed. A left renal CG is inserted and ready to be deployed.

The indications for using a CG were symptomatic (n = 19) or ruptured (n = 18) aortic aneurysm, pseudoaneurysm (n = 4), aortic dissection (n = 1), accidental overstenting of visceral arteries (n = 5), EL-I after previous aortic repair (n = 3; Fig 1), and fracture of previous visceral stent (n = 1); 13 patients (25%) had previous aortic repair (5 open and 8 endovascular). The majority of aortic aneurysms were abdominal aortic aneurysms (AAAs) (n = 32), and five were thoracoabdominal aortic aneurysms. The median aneurysm diameter was 75 mm (63-90 mm).

We refrained from reporting the diameter of the aneurysm neck because CGs were used in such complex settings that meaningful and reproducible measurements could not be obtained.

Statistics. Data are presented in numbers, rates, medians, and IQR unless otherwise indicated. The Kaplan-Meier outcome curves demonstrate the estimate of freedom from CG-related death, EL-I, aorta-related death, and all-cause death (Fig 2) and primary, assisted primary, and secondary CG patency (Fig 3). IBM SPSS program version 20 (IBM Corp, Armonk, NY) was used for these analyses.

Ethical approval. The Ethical Advisory Board approved the study, and informed consent was obtained from all patients. No human identity or privacy is involved.