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Lachat, Mario ; Bisdas, Theodosios ; Rancic, Zoran ; Torsello, Giovanni ; Mayer, Dieter ; Gil-Sales, Josep ; Pecoraro, Felice ; Donas, Konstantinos P

Abstract: **PURPOSE:** To present a technique for transfemoral implantation of parallel grafts into the renal arteries in patients with anatomy or morphology that blocks standard antegrade chimney graft delivery. **TECHNIQUE:** In a totally percutaneous approach, a 5-F pigtail angiographic catheter is passed into the aorta above the renal arteries via a 0.035-inch hydrophilic guidewire, followed by an 8-F sheath. The target vessel is cannulated with the hydrophilic wire followed by a 5-F reverse curve catheter; the wire is changed for a Rosen wire. The main stent-graft body is delivered and parked at the level of the aortic bifurcation. The Viabahn chimney endograft is advanced 1 to 2 cm into the target renal artery and deployed such that its proximal end faces downward; its distal end is fixed in place with an inflated angioplasty balloon. A stiff guidewire is inserted coaxially through the 8-F sheath, the Rosen guidewire is removed, and the 8-F sheath is carefully pushed over the stiff guidewire, lifting the sheath and chimney endograft upward. With the chimney reoriented cranially, the aortic stent-graft is deployed immediately. The abdominal stent-graft and the chimney graft(s) are molded synchronously using kissing balloons. **CONCLUSION:** Transfemoral placement of chimney covered stents by the lift technique in cases of unsuccessful or hazardous catheterization of the target vessels via the upper extremity is safe and feasible in centers experienced with the standard chimney technique.

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◆ TECHNICAL NOTE ◆

Chimney Endografting for Pararenal Aortic Pathologies Using Transfemoral Access and the Lift Technique

Mario Lachat, MD^{1*}; Theodosios Bisdas, MD^{2*}; Zoran Rancic, MD, PhD¹;
Giovanni Torsello, MD, PhD²; Dieter Mayer, MD¹; Josep Gil-Sales, MD³; Felice Pecoraro, MD^{1,4};
and Konstantinos P. Donas, MD, PhD²

¹Clinic for Cardiovascular Surgery, Zurich University Hospital, Zurich, Switzerland ²Department of Vascular Surgery, St. Franziskus Hospital and Münster University Hospital, Münster, Germany.

³Servicio de Cirugía Vascular, Complejo Hospitalario de Toledo, Hospital Virgen de la Salud, Toledo, Spain. ⁴Vascular Surgery Unit, University Hospital P. Giaccone, Palermo, Italy.

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Purpose: To present a technique for transfemoral implantation of parallel grafts into the renal arteries in patients with anatomy or morphology that blocks standard antegrade chimney graft delivery.

Technique: In a totally percutaneous approach, a 5-F pigtail angiographic catheter is passed into the aorta above the renal arteries via a 0.035-inch hydrophilic guidewire, followed by an 8-F sheath. The target vessel is cannulated with the hydrophilic wire followed by a 5-F reverse curve catheter; the wire is changed for a Rosen wire. The main stent-graft body is delivered and parked at the level of the aortic bifurcation. The Viabahn chimney endograft is advanced ~1 to 2 cm into the target renal artery and deployed such that its proximal end faces downward; its distal end is fixed in place with an inflated angioplasty balloon. A stiff guidewire is inserted coaxially through the 8-F sheath, the Rosen guidewire is removed, and the 8-F sheath is carefully pushed over the stiff guidewire, lifting the sheath and chimney endograft upward. With the chimney reoriented cranially, the aortic stent-graft is deployed immediately. The abdominal stent-graft and the chimney graft(s) are molded synchronously using kissing balloons.

Conclusion: Transfemoral placement of chimney covered stents by the lift technique in cases of unsuccessful or hazardous catheterization of the target vessels via the upper extremity is safe and feasible in centers experienced with the standard chimney technique.

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Key words: endovascular repair, abdominal aorta, pararenal aorta, aneurysm, endovascular aneurysm repair, stent-graft, chimney graft, chimney technique, deployment technique, self-expanding stent-graft

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Totally endovascular repair with off-the-shelf devices using the chimney technique is gaining ever greater acceptance as an effective alternative for the repair of pararenal aortic pathologies in selected patients.¹⁻³

However, this method requires selective catheterization of the target vessels through the subclavian or axillary artery, which may be hazardous or challenging in several situations.^{3,4} Thus, an alternative approach would

*Mario Lachat and Theodosios Bisdas contributed equally to this work and have shared first authorship.

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Corresponding author: Theodosios Bisdas, MD, Department of Vascular Surgery, St. Franziskus Hospital and Münster University Hospital, Albert-Schweitzer-Campus 1, D-48149 Münster, Germany. E-mail: theodosios.bisdas@ukmuenster.de; th.bisdas@gmail.com

be mandatory in patients with anatomy or morphology that blocks standard antegrade chimney graft delivery, such as small axillary arteries (<5 mm), highly calcified aortic arches, calcified/occluded arch branches, or upward (cephalad) oriented renal arteries. Patients who had myocardial revascularization involving the left internal mammary artery (which would be occluded by the sheath) or unstable patients with transbrachial balloon occlusion for a ruptured abdominal aortic aneurysm would also need another solution. To overcome these challenging conditions, we developed the lift technique to transfemorally insert chimney covered stents and deploy them into the target vessels in the intended standard cranial orientation.

TECHNIQUE

A totally percutaneous approach using a 10-F Prostar XL or 9-F Proglide vascular closure device (Abbott Vascular, Redwood City, CA, USA) is preferred. The first step consists of advancing a 5-F pigtail angiographic catheter (Cordis Endovascular, Miami Lakes, FL, USA) into the aorta above the level of the renal arteries via a 0.035-inch hydrophilic guidewire (Radiofocus; Terumo Medical, Tokyo, Japan). Additionally, an 8-F shuttle sheath (Cook Medical, Bloomington, IN, USA) or an 8-F Arrow superflex sheath (Arrow International, Reading, PA, USA) is advanced transfemorally up to the renal arteries. After catheterization of the renal artery with the hydrophilic wire and delivery of a 5-F MPA or Chuang visceral reverse curve catheter (Cook Medical), the wire is changed for a Rosen wire (Infiniti Medical, Malibu, CA, USA) as described elsewhere.²

The self-expanding chimney endograft (Viabahn; W.L. Gore & Associates, Flagstaff, AZ, USA) is advanced inside the renal artery until its distal end is ~1 to 2 cm into the vessel. After endograft deployment, its proximal end is oriented downward toward the aortic bifurcation (Fig. 1). A 5 to 8-mm×20-mm angioplasty balloon is then introduced into the distal end of the chimney endograft and inflated, affixing the stent-graft safely in the renal segment. A stiff Lunderquist (Cook Medical) or Amplatz (Boston Scientific, Natick,

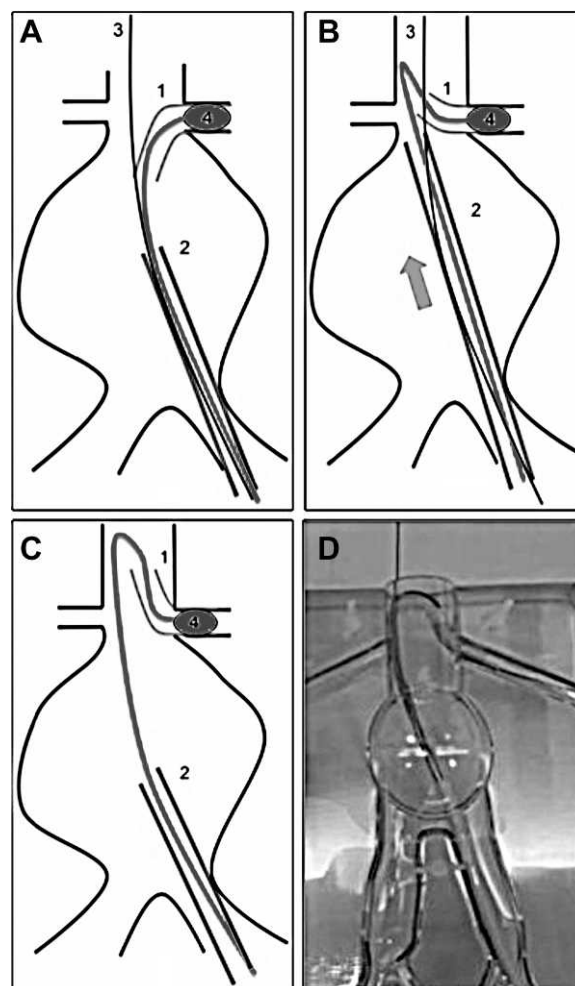


Figure 1 ♦ (A–C) Schematic presentation and (D) a glass model of the “lift” technique to facilitate transfemoral implantation of chimney endografts. The chimney endograft (1) is advanced through an 8-F sheath (2) inside the renal artery. After deployment, the proximal end of the endograft is looking downward to the aortic bifurcation. A stiff guidewire (3) followed by an angioplasty balloon are introduced in the aorta and the chimney stent-graft; the balloon (4) is inflated at the distal end of the chimney endograft, fixing it safely into the renal segment. The 8-F sheath (B) is pushed (arrow) over the stiff guidewire, and the chimney endograft follows the upward movement of the sheath. At the end, the proximal part of the chimney endograft takes the intended cranial position (C,D).

MA, USA) guidewire is inserted coaxially through the 7- or 8-F sheath, with its floppy tip above the celiac trunk at the thoracoabdominal junction. The main stent-graft body is

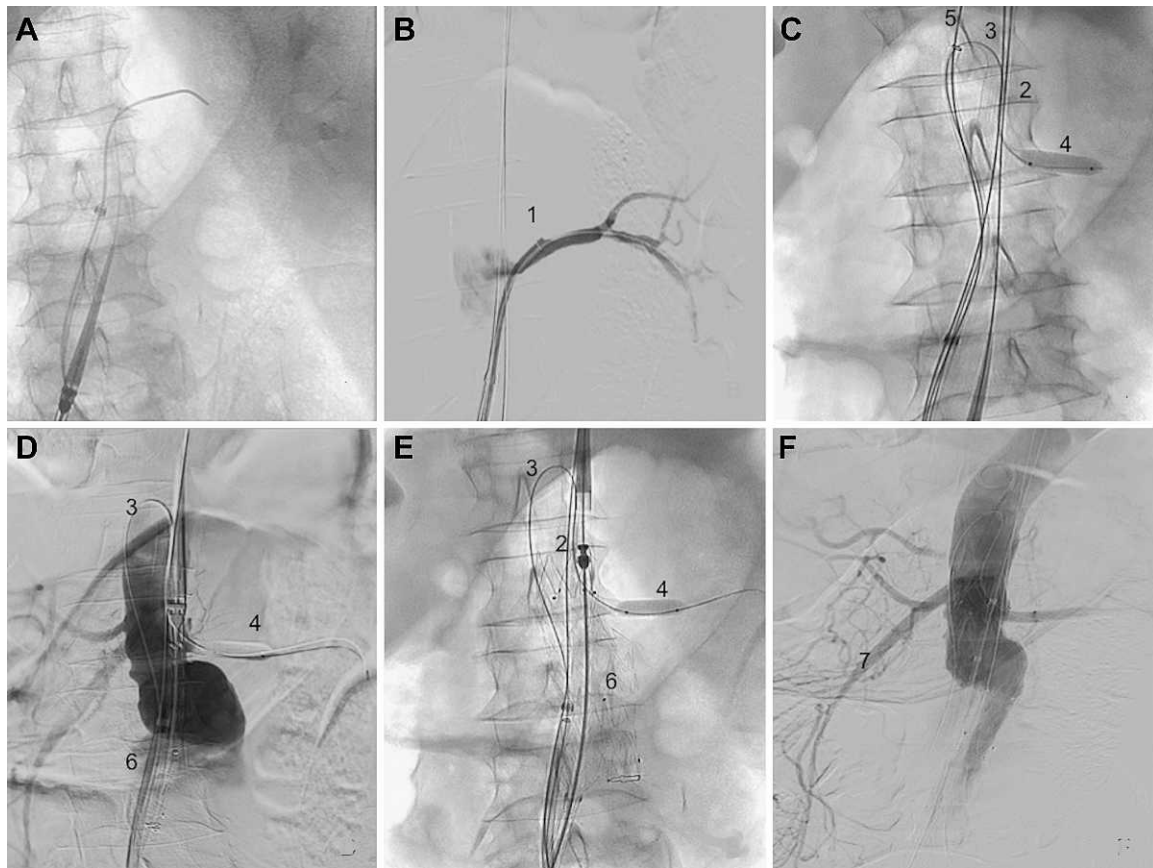


Figure 2 ♦ Intraoperative angiography demonstrating the steps in the “lift” technique during chimney endografting. (A) Advancement of an MPA catheter into the renal artery in order to safely introduce the Rosen wire into the distal branches. (B) Advancement of a 5-F Chuang visceral reverse curve catheter (1) up to the orifice of the renal artery and angiographic control. (C) After previous transfemoral introduction and deployment of the Viabahn stent-graft (2) over the Rosen wire, introduction of the PTA catheter (3), removal of the Rosen wire, inflation of the balloon (4), and upward movement of the PTA catheter supported by the Chuang reverse curve catheter over the Lunderquist wire (5). (D) The proximal part of the chimney endograft assumes the intended cephalad orientation, and the angiogram assesses the position of the contralateral renal artery for the final positioning and deployment of the main abdominal endograft (6). (E) Deployment of the main abdominal endograft parallel to the chimney endograft. (F) Angiographic control showing absence of type I endoleak and perfusion of both renal arteries, as well as of the superior mesenteric artery (7).

then delivered and parked at the level of the aortic bifurcation. The Rosen guidewire must now be removed in order to take advantage of the flexibility of the angioplasty catheter as it moves the endograft cranially. To execute the “lift,” the 8-F sheath is carefully pushed over the stiff guidewire; the chimney endograft follows the upward movement of the sheath. At the finish, the proximal part of the chimney endograft assumes the intended cranial position (Fig. 1). For bilateral chimney endografts, the same procedure is followed for the second renal artery. To restore renal perfusion as

soon as possible, the Rosen guidewire can be reintroduced inside the renal arteries through the balloon catheter before deflating the balloon. The aortic stent-graft that was parked at the aortic bifurcation is deployed immediately after lifting the chimney graft(s) to the correct position. The last step is synchronously molding the main abdominal stent-graft and the chimney graft(s) using kissing balloons (Fig. 2).

From January 2008 to February 2013, the lift technique has been applied in 12 patients treated at 2 centers, representing ~7% of the

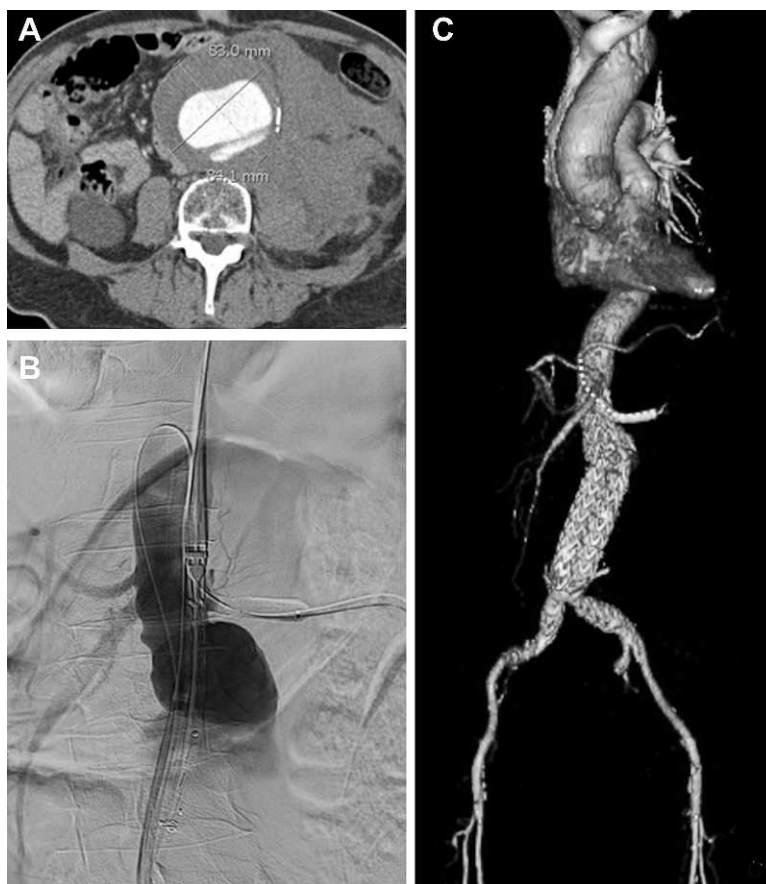


Figure 3 ♦ (A) A ruptured abdominal aorta that underwent (B) chimney endografting of the left renal artery using the transfemoral approach and the lift technique. (C) Postoperative CTA.

extensive experience with chimney grafting at these institutions (85 and 79 patients, respectively). Two patients were treated for a contained ruptured aneurysm (Fig. 3). Most of the renal chimney grafts were between 5 and 15 cm and unilateral (n=10). Technical success was 93%; one 15-cm long chimney graft intended to revascularize a polar renal artery could not be introduced into the vessel, but as the aortic arch was extensively atherosclerotic, it was decided to sacrifice this polar artery. Postoperative imaging disclosed no renal events or types I/III endoleaks. Patency of the remaining 13 lifted chimney grafts was 100% at a median 7-month follow-up (range 1–18).

DISCUSSION

The chimney technique is becoming a valid therapeutic modality for patients with pararenal

aortic pathologies who are unfit for open repair or unsuitable for a fenestrated endograft.^{3,5} In this context, even particularly challenging anatomies such as tortuous and highly calcified iliac vessels and severely angulated aneurysm necks can be effectively repaired.^{6–8} Two-year imaging follow-up of chimney endografting has demonstrated a statistically significant shrinkage of the aneurysm sac as well as excellent patency of the chimney stent-grafts.⁵ The recently published pooled data analysis of the literature comparing fenestrated and chimney endografts for the treatment of pararenal aortic pathologies found no statistically significant differences between the methods as regards 30-day mortality, renal impairment, or type I endoleaks.³

Although the chimney technique is feasible in the majority of pararenal aneurysms with a

reported technical success >97%,^{2,3,5} there are still some anatomical situations that may challenge the implantation of chimney endografts through the traditional subclavian or axillary access. The diameter of the axillary artery may be problematic for the insertion of two 7- or 8-F sheaths for bilateral renal chimneys and may cause arterial injury, necessitating time-consuming repair. Besides, any open exposure of the left or right axilla is associated with a relative risk of brachial plexus injury. In cases requiring additional catheterization of the superior mesenteric artery, a third sheath would be advanced through the right axillary artery.⁷ In such cases, manipulation at the level of the aortic arch may lead to neurological events. In this context, calcifications of the aortic arch or compromised supra-aortic vessels (e.g., occlusion of the subclavian artery) may complicate catheterization of the target vessel. Additionally, we consider any previous aorto-coronary bypass grafting involving the left internal mammary artery as a relative contraindication for axillary or subclavian access due to the risk of temporary occlusion caused by the sheath. Finally, the cephalic orientation of the renal arteries with or without stenosis may complicate chimney endografting through the axillary artery. Thus, insertion of the chimney stent-graft through the femoral artery may solve the problem.

Ricci et al.⁹ published the transfemoral approach for double renal chimney grafting in 2011. We used the same concept in our first case some years earlier, implanting the chimney endograft through an 8-F sheath without the support of the stiff guidewire. However, this was unsuccessful for both renal arteries because the pushability of the 8-F sheath was lost at the pelvic level due to the severe tortuosity of the iliac vessels. We solved this problem by introducing a stiff guidewire coaxially through the 8-F sheath, which allowed safe and easy upward scrolling of the sheath and coverage of the Viabahn stent-graft.

The main weak point of the technique is the potential loss of access to the renal artery after kissing balloon molding of all components at the level of the renal segment due to chimney compression/collapse. In these cas-

es, transaxillary access might be required. This would not be a problem in normal aortic arches, but in the case of a hostile aortic arch, introduction of the Rosen wire and balloon catheter is probably less dangerous than advancement of a long 8-F sheath necessary for the chimney. One could keep the angioplasty balloon inflated in the distal part of the chimney graft until the main graft is deployed; however, this would prolong the ischemia time of the kidney. To solve this problem, we advanced the modular aortic stent-graft in the intended position prior to the "lift" maneuver in all cases but one. When the chimney endograft reached the desired position, the main graft was rapidly positioned and deployed. We observed no complications or dislocation of the chimney grafts with this technique, even when a compressed chimney graft had to be re-accessed to perform additional dilation.

Further bailout strategies are available should challenges arise. For example, if the chimney graft is dislodged from the renal artery during the "lift," additional placement of a self-expanding bare metal stent may be useful if the deployed chimney is still in the artery; if not, another covered stent may be positioned. If it proves impossible to lift the deployed chimney, use a snare from the upper extremity to lift it. If the chimney is compressed and needs additional stenting, use a 0.014-inch non-hydrophilic guidewire with superb steerability and a soft shapeable tip, like Abbott's Spartacore, to advance a low-profile balloon to dilate the crushed chimney and reinforce it with a bare metal stent.

Furthermore, we recommend precise measurement and positioning of the chimney endografts prior to the rotation and deployment of the main abdominal graft because cranial extension of the chimney graft is extremely demanding, if not impossible, from the transfemoral approach once the aortic stent-graft is deployed. Thus, cautious analysis of the 3-dimensional imaging reconstructions is essential to prevent such complications. However, if a proximal extension remains mandatory, pulling the main graft downward to the aortic bifurcation and shifting the chimney graft back to the caudal position will allow fitting of a proximal extension to the

Viabahn stent-graft. Thereafter, the same maneuver to establish the cranial position can be repeated with the “extended” chimney endograft.

Conclusion

The transfemoral “lift” technique appears to be feasible and safe in centers with experience in the standard chimney technique. It allows positioning of the chimney endograft in the desired cephalad orientation when renal endografts are deployed transfemorally as periscope grafts.¹⁰ The Viabahn stent-graft is the bridging endograft of choice. This approach might be used in challenging cases where the transaxillary approach is hazardous or as a bailout method when catheterization of the target vessels through the axillary artery is expected to be unsuccessful (e.g., cephalic orientation of the renal arteries); it could even completely replace the traditional transbrachial approach.

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