Advances in complex endovascular aortic surgery
Dijkstra, Martijn Leander

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2018

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

Copyright
Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

Take-down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): http://www.rug.nl/research/portal. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Download date: 14-12-2018
Chapter 6

Initial Experience With Covered Endovascular Reconstruction of the Aortic Bifurcation in Conjunction With Chimney Grafts

M.L. DIJKSTRA,1,2 P.C. GOVERDE,3 A. HOLDEN,4 C.J. ZEEBREGTS,2 AND M.M. REIJNEN.1

1 Department of Surgery, Rijnstate Hospital, Arnhem, the Netherlands
2 Department of Surgery, Division of Vascular Surgery, University Medical Center Groningen, University of Groningen, the Netherlands
3 Department of Surgery, Vascular Clinic ZNA, Antwerp, Belgium
4 Department of Radiology, Auckland City Hospital, Auckland, New Zealand

ABSTRACT

Purpose: To show feasibility of the covered endovascular repair of the aortic bifurcation (CERAB) technique in conjunction with chimney grafts in aortic side branches for complex aortoiliac occlusive disease.

Methods: Two European centers and one facility located in New Zealand participated in a retrospective observational study that enrolled 14 consecutive patients (mean age 61.2 ± 8.9 years; 11 men) treated with CERAB in conjunction with chimney graft(s) between December 2012 and May 2015. Indications for treatment included disabling claudication in 9 and critical limb ischemia in 5. Lesions were classified as Trans Atlantic Inter-Society Consensus II B (n = 1), C (n = 1), or D (n = 12).

Results: A total of 15 chimney grafts were used to perfuse the inferior mesenteric artery (n = 8), the right renal artery (n = 4), and the left renal artery (n = 3). Technical success was achieved in all cases. Procedural complications included 5 unintended dissections and 1 vessel thrombosis, all of which were successfully treated intraoperatively. Five patients developed access-site hematoma/ecchymosis (3 at the brachial access). Mean follow-up was 12 months (range 6–24) without death or loss to follow-up. One patient suffered occlusion of a CERAB limb and an IMA chimney graft; the former was recanalized, but the IMA graft was not; there were no signs of bowel ischemia. Ankle-brachial indices significantly increased from 0.54 (range 0.47–0.60) preoperatively to 0.97 (range 0.90–1.00) in 11 patients examined at 12 months, and all patients had an improvement in the Rutherford category. All CERAB limbs, including the one recanalized, were patent at the most recent follow-up, as were 14 of 15 chimney grafts.

Conclusion: Chimney-CERAB is technically feasible and may offer an alternative to open surgery for complex aortoiliac occlusive disease. Further prospective studies are needed to confirm these findings.
INTRODUCTION

Endovascular techniques continue to evolve and are broadly applied to a variety of vascular diseases, including aortoiliac occlusive disease (AIOD). For severe AIOD, the gold standard is still open surgery, typically using an aortobifemoral bypass graft, but this procedure has considerable morbidity and mortality.\(^1\) Endovascular treatment for TransAtlantic Inter-Society Consensus (TASC) C and D lesions involving the aortic bifurcation remains a matter of debate, although the efficacy has been shown.\(^2\) The decision largely depends on patient characteristics and physician preference and experience. The covered endovascular repair of the aortic bifurcation (CERAB) technique offers an endovascular alternative for TASC C/D lesions involving the aortic bifurcation.\(^2\) This relatively new technique uses 3 balloon-expandable covered stents to create an aortic neo-bifurcation by placing one flared covered stent in the distal aorta and inserting the proximal ends of the other covered stents placed in the common iliac arteries (CIA). When indicated, the limbs can be extended using additional covered stents. Initial results have been promising, with 1-year primary and secondary patency rates of 87\% and 95\%, respectively, in a group of patients with 95\% TASC II C/D lesions.\(^3\)

The applicability of the CERAB technique may be limited by the extent or location of the occlusive lesion. One potential problem is a lesion involving a patent inferior mesenteric artery (IMA), which cannot always be sacrificed without an imminent risk of bowel ischemia, especially with a concomitant lesion in the superior mesenteric artery (SMA) and/or celiac artery (CA). Data on the consequences of covering the IMA and the risk of developing complications are lacking for endovascular treatment, but reports in open surgery suggest a decrease in the incidence of ischemic colitis when the IMA is re-implanted, especially in older patients.\(^4,5\) Also, in case of bilateral internal iliac artery (IIA) occlusion, the IMA may serve as a collateral vessel, and increased bowel ischemia and spinal cord ischemia rates have been reported in endovascular aneurysm repair in this patient subgroup.\(^6,7\) In even more extensive disease, the proximal border of the lesion can extend up to, or involve, the renal artery ostia. In these cases, coverage of a renal artery is usually not an attractive option. In addition, the placement of the proximal aortic stent in such a diseased aortic segment may cause thromboembolic events and subsequent loss of renal function.

The chimney or snorkel technique has been successfully applied to extend the proximal landing zone in the endovascular treatment of aneurysmal disease.\(^8\) This technique was adapted and implemented with the CERAB technique to allow more extensive lesions to be treated by endovascular means while keeping the target vessels patent. The aim of this study was to show the feasibility and initial results of the CERAB technique in conjunction with chimney grafts for patients with complex occlusive lesions involving the aortic bifurcation.
METHODS

Study Design and Patient Sample

Two European centers and one facility located in New Zealand participated in a retrospective observational study approved by each center’s ethics committee according to national guidelines. Fourteen consecutively treated patients (mean age 61.2 ± 8.9 years; 11 men) who underwent CERAB in conjunction with a chimney graft were treated between December 2012 and May 2015. Indication for treatment included disabling claudication (Rutherford category 3) in 9 patients and critical limb ischemia (Rutherford category 4) in 5 patients. Lesions were classified as TASC II B (n = 1), C (n = 1), or D (n = 12). The majority of patients had a distal aortic occlusion with eccentric thrombus extending up to or above one or more renovisceral vessel orifices. One patient had previous kissing stent placement in both CIAs and presented with an occlusion. Risk factors and relevant lesion characteristics are shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Patient and lesion characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk factors</td>
</tr>
<tr>
<td>Current smoking</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>Hypertension</td>
</tr>
<tr>
<td>Cardiac disease</td>
</tr>
<tr>
<td>Pulmonary disease</td>
</tr>
<tr>
<td>Renal disease*</td>
</tr>
<tr>
<td>Carotid disease</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
</tr>
<tr>
<td>Obesity</td>
</tr>
<tr>
<td>Lesion characteristics</td>
</tr>
<tr>
<td>Open runoff, right/left</td>
</tr>
<tr>
<td>External iliac artery</td>
</tr>
<tr>
<td>Internal iliac artery</td>
</tr>
<tr>
<td>Common femoral artery</td>
</tr>
<tr>
<td>Renovisceral artery patency</td>
</tr>
<tr>
<td>Renal, right/left</td>
</tr>
<tr>
<td>Celiac trunk</td>
</tr>
<tr>
<td>Inferior mesenteric artery</td>
</tr>
<tr>
<td>Superior mesenteric artery</td>
</tr>
</tbody>
</table>

*Serum creatinine > 120 mmol/L.
Patient Evaluation

All patients received secondary risk prevention according to local guidelines, and patients with disabling claudication were primarily treated with (supervised) walking exercise. After clinical evaluation, all patients underwent duplex ultrasound scanning, ankle-brachial index (ABI) measurement, and a preoperative assessment using computed tomography angiography (CTA). The CTA images and multiplanar reconstructions were evaluated on a 3D workstation for procedure planning. The decision to treat patients using the chimney-CERAB technique was made on an individual basis.

Chimney-CERAB Technique

The procedures were performed by vascular surgeons and interventional radiologists in either a hybrid suite equipped for both interventional radiology and open surgical procedures or a surgical theatre using a recent generation mobile C-arm. A detailed description of the standard CERAB technique has been previously published.1 Briefly, after antibiotic prophylaxis, both common femoral arteries were accessed either percutaneously (n = 6) or by surgical cutdown (n = 8), along with 1 brachial artery for chimney graft delivery. Heparin (5000 units) was administered after sheath insertion. The occluded segment was recanalized using regular hydrophilic wires and catheters, and the intended chimney target vessel(s) were selectively catheterized via the brachial approach, followed by insertion of a 5- to 7-mm balloon-expandable covered stent (Atrium Advanta V12; Atrium Maquet Getinge Group, Mijdrecht, the Netherlands). A 12-, 14-, or 16-mm Atrium Advanta LD-V12 (Atrium Maquet Getinge Group) was then positioned in the distal aorta and deployed. The chimney graft(s) were positioned and deployed. Subsequently, the proximal two-thirds of the aortic LD-V12 stent was flared with a 16-mm balloon to adapt to the aortic diameter while balloon(s) in the chimney graft(s) were left inflated. Two 8- or 9-mm Advanta V12 covered stents were placed in the distal third of the aortic cuff in a kissing-stent configuration within the CIAs and simultaneously inflated, simulating a new bifurcation with the hemodynamic aspects of a flow divider. If required, these 2 limbs were extended using additional covered stents.

All patients received dual antiplatelet therapy for at least 6 months postoperatively (clopidogrel and either acetylsalicylic acid or carbasalate calcium). Examples are provided of chimney-CERAB procedures in the IMA (Figure 1) and renal arteries (Figure 2). Follow-up consisted of clinic visits with monitoring of renal function and serial duplex ultrasound scanning with ABI measurement at 1, 6, and 12 months; CTA was performed if indicated by clinical suspicion or symptom recurrence.
Chapter 6

Definitions and Statistical Analysis

Technical success was defined as successful placement of both the CERAB endografts and the chimney graft(s), restoring blood flow with < 30% residual stenosis on completion angiography. Clinical improvement referred to hemodynamic improvement (ABI increase of at least 0.10) combined with symptomatic improvement (at least 1 Rutherford category).

Restenosis was defined as a lesion with a peak systolic velocity ratio > 2.5 as measured in the endograft and proximal or distal to the endograft or an angiographic diameter reduction > 50%. Previously described duplex criteria were used for the IMA.⁹

Figure 1. Chimney CERAB procedure (IMA). Peri-operative fluoroscopy and angiography images showing (A) primary angiography; the distal aorta is occluded. The IMA is patent and quite large in diameter. Patient also has a left renal artery stenosis. (B) Both external and common iliac arteries are recanalized and the IMA is selectively cannulated from the upper access site. (C) Pre-dilation of the ‘neo-bifurcation’ with the chimney covered stent in situ (not yet deployed). (D) Angiography after deployment of CERAB and IMA Chimney, all patient with contrast filling of both internal and external iliac arteries.
Continuous variables are described as mean ± standard deviation or median and interquartile range (IQR) if a Kolmogorov-Smirnov test of normality indicated nonparametric data. Differences between ABI values were tested using a paired t test. A 2-sided $p < 0.05$ was considered the threshold of significance. Data analysis was performed using SPSS statistics (version 20.0; IBM Corporation, Somers, NY, USA).

RESULTS

All lesions were recanalized, all target vessels were cannulated, and the procedures were successfully completed in all cases. A total of 15 chimney grafts were used (8 IMAs, 4 right renal arteries, 3 left renal arteries). All target chimney target vessels were patent preoperatively, but 2 IMAs had a preexisting stenosis (50%
and 70%, respectively). None of the patients who underwent IMA chimney grafting had concomitant CA or SMA stenosis or occlusion. There was, however, involvement of the IIAs in 4 patients: bilateral IIA stenosis (n = 1), 1 occluded and 1 stenosed IIA (n = 2), and bilateral occluded IIAs (n = 1). In the majority of cases (n = 10), a 12-mm Advanta LD-V12 was used as the aortic stent; in the other cases, a 14-mm (n = 3) or a 16-mm stent were used. The distal landing zone was either the CIA (9/28 on the right, 10/28 on the left) or the EIA (5/28 on the right, 4/28 on the left). In 3 iliac arteries, the covered stent was distally extended with an uncovered self-expanding stent. Access sites were typically closed using a closure device (n = 12), but compression (n = 1) and suturing (n = 1) were used in individual cases.

Median procedure time was 155 minutes (IQR 100–182) with a median contrast dose of 150 mL (IQR 140–180). Intraoperative complications included 5 unattended dissections (treated with either prolonged dilation or stent extension) and nonocclusive thrombosis of a 14-mm V12 aortic stent (treated with thrombolysis), all of which were successfully resolved during the index procedure. Five patients developed access site hematoma/ecchymosis (3 at the brachial access). There were no 30-day major adverse events or mortality.

Mean follow-up was 12 months (range 6–24), and there was no death or loss to follow-up. One serious adverse event occurred 7 months after the primary procedure. The patient suffered occlusion of a right CERAB limb and the single chimney graft (IMA). The iliac limb was successfully treated with catheter-directed thrombolysis, but no attempt was made to recanalize the side branch; there were no signs of subsequent bowel ischemia, and recovery was uneventful. There were no additional complications after 1 year. All CERAB limbs, including the one recanalized, were patent at the most recent follow-up.

ABIs significantly increased from 0.54 (range 0.47–0.60) preoperatively to 0.94 (range 0.87–1.00) at 1 month and 0.97 (range 0.90–1.00) in the 11 patients examined at 12 months. All patients showed an improvement in Rutherford category. At 12-month follow-up, 9 patients had no claudication, 1 patient had mild claudication on exertion, and 1 patient had moderate claudication with a walking distance > 200 m. Fourteen of 15 chimney grafts implanted were patent at their most recent follow-up.
DISCUSSION

This case series shows that the chimney-CERAB technique is feasible and can be performed with high technical success, acceptable morbidity, and midterm clinical improvement. Therefore, the chimney-CERAB technique may offer an attractive alternative treatment for complex AIOD that was previously not appropriate for endovascular techniques. This could be of importance especially for those patients with extensive comorbid conditions who are deemed unfit for major surgery, which in these cases would involve not only aortobifemoral bypass grafting but also visceral vessel reimplantation or bypass.

The high number of intraoperative complications should be considered in context with the disease. In AIOD, subintimal recanalization and subsequent creation of a dissection plane is observed frequently. It was decided to report the 5 dissections to give a representative view of the technical difficulty associated with this procedure. As stated, all of these were addressed intraoperatively and did not cause the patient any harm. The postoperative complications were confined to access site hematoma and ecchymosis only, the majority related to the upper access site.

Thromboembolic events are considered potentially severe complications and tend to occur in complex lesions with more extensive atherosclerotic plaques and/or thrombus. Prophylactic measures are debatable but widely used. Despite intraoperative antithrombotic therapy, one vessel in our series occluded during the procedure. In this case there was an occluded distal aorta with thrombus extending up to the renal arteries with a patent IMA. A nonocclusive thrombus in the 14-mm aortic stent was observed, possibly due to dislodgement of thrombus. Thrombolysis was initiated intraoperatively with good result. While no clinical signs of distal thromboembolic events were observed, one patient did present with an occluded CERAB limb and chimney graft 7 months postoperatively.

The current TASC guidelines recommend that endovascular treatment be reserved for less complex TASC A/B lesions. Increasing evidence indicates that the more complex TASC C/D lesions can be treated using endovascular techniques with satisfying results. The recent report of the 24-month results from the Bravissimo registry concluded that endovascular treatment may be the preferred first treatment option for all TASC classes because high levels of patency were found irrespective of the lesion classification or length (24-month patency of 91.9% for TASC C and 84.8% for TASC D). In this study, higher patency rates were achieved using covered stents compared to bare metal stents, which is in accord with the prospective randomized COBEST trial that reported superior results of covered stents in TASC C/D lesions.
Experience using the CERAB technique is still limited. Although results from a dual-center cohort study, including consecutive patients from the first-in-man trial, are encouraging, the conclusions must be interpreted with caution, and further studies are indicated. A comparison with the literature is complicated by the differences in patient and lesion characteristics and by the potential learning curve effect included in that study. When introducing a new technique, selection bias is bound to occur. In the current series, patients treated had mild comorbidities and were relatively young (mean age 61 years), both of which may positively influence outcome.

Overstenting of renovisceral arteries is generally not well tolerated, particularly the renal artery, though an ancillary renal artery may be sacrificed if there is adequate kidney function. An exception is the IMA, which is commonly covered in endovascular aneurysm treatment. In AIOD, preservation of the IMA may be of more importance since quite often one or more collateral vascular beds will be affected by significant atherosclerosis. Although not supported by scientific evidence, it seems to be wise to preserve the IMA when it has a significant diameter (≥ 5 mm) and presents in conjunction with a significant stenosis or occlusion of the SMA or CA. In case of eccentric thrombus extending to or above the renal arteries or even more proximal to the SMA or CA, it is the authors’ belief that this is always an indication for chimney grafts unless renal function is already absent. Current literature suggests a possible benefit of IMA preservation, especially in older patients with increased operative blood loss. This is based on research in IMA reimplantation during open abdominal aortic aneurysm repair.

Developments in endovascular techniques over the past 2 decades have given rise to a whole new arsenal of treatment options, all of which are far less invasive than their respective open surgical counterparts. Astute patient selection is vital, and this is particularly true for endovascular treatment. Endovascular techniques such as chimney-CERAB may be reserved for those patients unfit for surgery. However, particularly in the young patients, it might be a valid argument to preserve the surgical options and reduce the risk of potentially harmful long-term complications such as adhesions and incisional hernia. Further research is needed to identify potential risk factors and patients who will benefit most from chimney grafts during CERAB.

Patients undergoing CERAB with chimney grafts should be treated in centers where there is a broad experience with endovascular techniques in general and CERAB in particular. Preoperative planning is paramount, both to achieve optimal access as well as precise graft positioning and, ultimately, a good outcome.
A small native aorta may limit the use of chimney-CERAB; however, the native aorta is usually 20 to 25 mm, which is sufficient to host the body and chimney grafts. In the current study, this problem was not encountered, but preoperative planning should take this into consideration. Cost-effectiveness of this novel technique also warrants further attention when long-term data are available.

Limitations

All patients were selected and treated by physicians with extensive experience in endovascular techniques and CERAB; therefore, the results might not be achieved in general practice. Since this is a proof of concept study, no comparison was made between the presented treatment and gold standard open surgery. The midterm outcomes are encouraging, but the numbers are small. Longer follow-up in series with larger sample sizes is needed to strengthen these findings.

CONCLUSION

Based on the high technical success, acceptable morbidity, and midterm clinical improvement seen in this study, chimney-CERAB appears to offer a feasible alternative to open surgery for complex (TASC C/D) aortoiliac occlusive disease. Further prospective studies are needed to confirm these findings.
REFERENCES


