Tortuosity is the Significant Predictive Factor for Renal Branch Occlusion after Branched Endovascular Aortic Aneurysm Repair

M. Sugimoto *, G. Panuccio, T. Bisdas, B. Berekoven, G. Torsello, M. Austermann
Department of Vascular and Endovascular Surgery, St. Franziskus Hospital, Muenster, Germany

WHAT THIS PAPER ADDS
After multi-branched endovascular aneurysm repair, renal branch occlusion is the most frequent form of branch failure; however, the optimal shape of renal branches is unknown. The morphology of renal branch paths has been quantified by post-operative CT angiography and impacts on analyzed patency. In the results, high tortuosity was a significant risk factor for the occlusion of renal branches, but the bridging stent length and the extent of renal coverage were not. This study advocates that the highly tortuous renal branch should be avoided, even though it takes a longer path.

Objective: After multi-branched endovascular aneurysm repair (mbEVAR), renal branch occlusion is the most frequent form of branch failure. Pre-operative renal angulation and post-operative morphology of the renal branch were quantified and their impact on occlusion was analyzed.

Methods: Patients who underwent mbEVAR between January 2010 and December 2013 were reviewed retrospectively. Only renal branches constructed with caudally directed cuffs were included. Patients without post-operative computed (CT) angiography were excluded. The main outcome was the primary patency of the renal branches. The renal angulation and the morphology of renal branch (bridging length, renal coverage length, tortuosity index, and angulation of distal renal artery) were quantified using CT. The impacts of morphology, implanted stents, and patient characteristics were investigated by time to event analyses.

Results: Ninety renal arteries in 49 patients were enrolled. Median follow up was 12 months (IQR 6–20 months). Balloon expandable stent grafts were used in 93% (84/90) of renal branches. Self expandable stent grafts were used in 12. Ninety-one percent (82/90) were lined with self expandable bare stents. Ten branches occluded after 8 months (median; IQR 1–14 months). Four of them underwent re-interventions, achieving secondary patency. The median renal angulation was −10° (IQR −40 to 0). The median bridging length was 42 mm (IQR 39–46 mm) and renal coverage 17 mm (IQR 12–22 mm). Median tortuosity index was 1.11 (IQR 1.04–1.19). The angulation of the distal renal artery was 140.7 ± 20.5°. In multivariate analysis, a tortuosity index > 1.11 was identified as the only significant predictor for occlusion (hazard ratio: 4.94; 95% CI: 1.01–24.30, p = .04).

Conclusions: High tortuosity was a significant predictor for the occlusion of renal branches, but renal angulation, bridging length, and the extent of renal coverage were not. By avoiding highly tortuous renal branch paths, good outcomes are expected even in upwardly directed renal arteries. Longer paths are acceptable.

© 2015 European Society for Vascular Surgery. Published by Elsevier Ltd. All rights reserved.
Article history: Received 14 May 2015, Accepted 12 September 2015, Available online 26 October 2015

Keywords: Thoraco-abdominal aortic aneurysm, Multi-branched endovascular aneurysm repair, Renal branch occlusion

INTRODUCTION
Thoraco-abdominal aortic aneurysm (TAAA) has been a formidable pathology due to the high mortality and morbidity following open surgical repair.1–4 The emergence of the endovascular aneurysm repair has altered the treatment of TAAAs. In particular, multi-branched endovascular aneurysm repair (mbEVAR) is a promising solution with its characteristic minimal invasiveness.3,5,6

The obligatory covered stents, which construct bridges between the cuffs of endografts and target vessels, is one of the features in mbEVAR. This is an essential, but sometimes challenging part of the procedure.

Theoretically, some branch positions may lead to a morphologically strained bridging path with higher...
tortuosity and/or greater distance to the target vessel. Longer bridgings with higher tortuosity increase the resistance to blood flow, lumen shear stress, and wall tension, and can even result in occlusion because of the risk of kinking and the turbulence.\textsuperscript{7,8} In the long-term the turbulence caused by a strained path enhances intimal hyperplasia, which can also cause the failure of bridging stents.\textsuperscript{7,9,10}

To avoid these potential risks, morphologically optimal bridging paths must be obtained. Some authors proposed that bridging paths should be as short as possible to lessen tortuosity and to reduce the risk of morphological changes.\textsuperscript{6,11} Intuitively this concept is acceptable, however there is little evidence to clarify what the definitive morphological factor for bridging graft patency is. Whether the long and straight path is worse than the short, but curved, one is questioned.

Another uncertain point of discussion is regarding the anatomy of target vessels, such as the take off angulation from the aorta and the shape of the distal part of the target vessel. Among those target vessels, renal arteries are the core of present concerns, because renal branch occlusion is the most frequent form of branch failure after mbEVAR.\textsuperscript{11–14}

In this study the pre-operative angulation of the renal artery from the aorta and the morphology of renal branch paths were quantified to evaluate whether they have a significant impact on the fate of renal branches.

**PATIENTS AND METHODS**

**Study population**

Data of patients with TAAAs who had undergone mbEVAR between January 2010 and December 2013 at St. Franziskus Hospital were reviewed retrospectively.

**Implantation procedures**

Details of the selection criteria, devices used, and methods of implantation have been described previously.\textsuperscript{5,15,16}

Custom made Zenith branched devices (Cook Medical Inc., Bloomington, IN, USA) were used for early cases. In the present study, the performance of caudally directed cuffs were studied, and helical shaped or cranially heading renal cuffs in custom made devices were excluded from analysis. After its introduction in 2012, the Zenith t-branch (Cook Medical) was also available for anatomically suitable cases.

Covered stent grafts were used as bridging endografts for the renal arteries. In the study population, the V12 iCast/Advanta (Atrium Medical Corp, Hudson, NH, USA) or VIABahn (W.L. Gore & Associates, Flagstaff, AZ, USA) were selected. In most cases, they were lined with self expandable bare stents. The indication and selection of bridging endografts were dependent on the surgeon’s preference and intra-operative decision.

**Surveillance protocol**

The protocol for follow up surveillance has been described in detail.\textsuperscript{15} Before discharge and if the glomerular filtration rate (GFR) was greater than 60 mL/min/1.73 m\textsuperscript{2}, computed tomography angiography (CTA) was routinely performed. Periodic follow up studies containing CTAs and X-ray were performed at 6 and 12 months and annually thereafter. In cases of renal impairment, a plain CT scan and duplex ultrasound imaging were performed to assess aneurysm progression and the patency of the branches, respectively. The following renal artery findings were indications for re-intervention: asymptomatic > 50% stenosis, symptomatic (flank pain, glomerular filtration rate decrease > 15% from baseline) occlusion, and stent fracture or deformation leading to branch associated endoleak (distal type 1 or type 3). In duplex ultrasound imaging, elevated peak systolic velocity ≥ 2.5 m/second in the distal renal artery was also considered a significant stenosis.

**Data collection**

All morphological quantifications were performed using a three dimensional workstation, AquariusNET software (TeraRecon Inc., Foster City, CA, USA). To measure pre-operative renal artery angulation, a semi-automatic centerline of flow was generated in the aorta on the workstation. Renal artery angulation was defined as the two dimensional angulation formed by the tangent of the aortic centerline and the target renal artery. This angle was measured in the curved multiplanar reconstruction (MPR). The angle above the orthogonal plane perpendicular to the aortic centerline was defined as positive angulation and the angle below was defined as negative angulation\textsuperscript{11} (Fig. 1).

In the pre-discharge CT scan, a centerline of flow was generated along the path consisting of the branch cuff, bridging devices, and distal renal artery. With stretched MPR views perpendicular to the centerline, the lengths between anatomical landmarks were measured (Fig. 2). The bridging length (BL [mm]) was defined as the length over the centerline between the end of cuff (P1) and the end of bridging covered stent (P3). The renal coverage length (RCL [mm]) was defined as the length between the renal ostium (P2) and the end of bridging covered stent (P3). The presence of lining stents, which were recorded in the operation reports, were confirmed by checking their distal ends (P4). Tortuosities of renal bridging stents were quantified with the tortuosity index (TI), which was defined as the ratio of the path length of the bridge (BL) over the linear distance between the end of branch cuff and the distal end of covered renal stent. The angulation of distal renal artery (Angle) was defined as the three dimensional angle formed by two vectors from the end of the covered bridging stent to 2 cm distal (DistRA) and proximal (ProxRA) points along the centerline. If the renal bifurcation was within 2 cm of the end of the bridging covered stent, the bifurcated point was used as DistRA. All measurements in this study were performed by one author (M.S.), so inter-observer variability was not a consideration. The information about the types of branched endografts (t-branch or the custom made), bridging covered stents, and relining stents were collected from the medical records and included in the database.
Data concerning patients’ clinical backgrounds and follow-up outcomes were also prospectively added to the database. GFR was estimated at pre- and post-operative time points. Following the RIFLE criteria, a decrease in GFR of more than 25% was defined as post-operative acute renal failure (ARF).\(^{17}\)

**Study design**

The main outcome measure was the primary patency of the renal branches constructed with standard caudally directed cuffs. Loss of primary patency was defined as any occlusion or re-intervention. Other stent related re-

---

**Figure 1.** Illustrations of renal angulation measurement. (A) Curved multiplanar reconstruction view. The dotted line indicates a semi-automatic centerline of flow. (B) Renal artery angulation (RAng) was defined as the two dimensional angulation formed by the tangent between the aortic centerline and the target renal artery. The angle above the orthogonal plane perpendicular to the aortic centerline was defined as positive angulation and the angle below was defined as negative angulation.

**Figure 2.** Illustrations of measurement protocol. (A) Multiplanar reconstruction view. (B) Three dimensional view. The tortuosity index is defined as the bridging over the linear distance between P1 and P3. ProxRA and DistRA are 2 cm proximal and distal points on the centerline from P3. When the renal bifurcation is within 2 cm of P3, the bifurcation point was used as DistRA. Angle is the three dimensional angle formed by two vectors heading to ProxRA and DistRA from P3. P1 = the end of endograft cuff; P2 = the renal ostium; P3, the end of bridging covered stent; P4, the end of lining bare stent; BL = bridging length; RCL = renal covered length; TI = tortuosity index.
interventions, mortality, and morbidity were also recorded. The impacts of morphological factors, types of bridging stents, relining stents, and patient characteristics on the main outcome were statistically investigated by a time to event analysis.

**Statistical analysis**

Continuous variables with normal distributions were expressed as the mean ± standard deviation (SD). Medians and interquartile ranges (IQRs) were used for other continuous variables. Categorical data were presented as percentages.

Kaplan–Meier methods for univariate compare were performed to select candidates for the multivariate Cox proportional hazards model, in which risk factors for the main outcome were determined. Correlations between variables were evaluated with Pearson’s correlation coefficients. The significance of difference was estimated by log-rank tests. A p value < .05 was considered significant for all analyses. Statistical analyses were performed using IBM Statistics Statistical Package for Social Science (SPSS) version 21 (IBM Corporation, Armonk, NY, USA).

The study is in accordance with the principles in the declaration of Helsinki and was approved by the institutional review board. All patients gave their written informed consent.

**RESULTS**

From January 2010 to December 2013, 56 patients underwent mbEVAR with t-branch (N = 20) or with custom made devices (N = 36), and 101 renal arteries were reconstructed. Among them, two renal arteries in one patient, were treated with helical shaped designed cuffs and one renal artery in another case was reconstructed with a cranially headed with helical shaped designed cuffs and one renal artery in one patient, were treated with helical shaped designed cuffs and one renal artery in another case was reconstructed with a cranially headed designed cuff. They were excluded from the study.

In five cases with eight renal arteries, post-operative CTA was not performed. Among them, unstable hemodynamics followed by death prevented post-operative CTA in one patient. Another four patients had post-operative ARF. However, three of them recovered their renal function after discharge. There were no patients with renal failure and branch occlusion. Because morphological measurements were impossible, they were also excluded.

Finally, the residual 90 renal arteries in 49 cases were enrolled.

Patient demographics and operative details are summarized in Table 1. The median pre-operative renal angulation was $-10^\circ$. In hospital mortality included four patients who died within 1 month of pulmonary embolism, intracranial hemorrhage, heart failure, and complications of coronary bypass surgery. Another two patients died at 2 months from multiple organ failure and respiratory failure. Five patients (10.2%) died during follow up; at 3 months of multiple organ failure in another institution, at 10 months of intracranial hemorrhage, at 20 months of pulmonary embolism, and at 25 months of heart failure. There were no aneurysm ruptures.

Four patients suffered from post-operative ARF. Two of them died from multiple organ failure. However, another two patients recovered and required no renal replacement therapy during the follow up period.

**Characteristics of renal branches**

The profiles of implanted stents are shown in Table 2. The Advanta covered stent was primarily used in 93% (84/90) of renal branches during the study period. Viabahn was applied in 12 renal branches, among which it was used alone in five branches and in combination with Advanta in seven. In 91% (82/90) of renal branches, self expandable bare stents were also implanted for the purpose of lining the covered stents.

The results of morphological measurements of renal branches (the median length of bridge, that of covered

---

**Table 1. Patient demographics.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>49 cases</th>
<th>90 RAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>70.5 ± 7.2</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Follow up (months)</td>
<td>12 (6–20)</td>
<td></td>
</tr>
<tr>
<td>Crawford classification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>19 (38.8)</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>26 (53.1)</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>4 (8.1)</td>
<td></td>
</tr>
<tr>
<td>RA angulation (degree)</td>
<td>−10 (−40 to 0)</td>
<td></td>
</tr>
<tr>
<td>Procedure time (min)</td>
<td>272 (244–302)</td>
<td></td>
</tr>
<tr>
<td>Aortic diameter at RA</td>
<td>39 (32–53)</td>
<td></td>
</tr>
<tr>
<td>Dose of contrast agent (mL)</td>
<td>203 (175–240)</td>
<td></td>
</tr>
<tr>
<td>Type of graft</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Custom made device</td>
<td>32 (65.3)</td>
<td>57 (63.3)</td>
</tr>
<tr>
<td>t-Branch</td>
<td>17 (34.7)</td>
<td>33 (36.7)</td>
</tr>
<tr>
<td>Symptomatic</td>
<td>8 (16.3)</td>
<td></td>
</tr>
<tr>
<td>Comorbidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASA classification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>11 (22.4)</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>38 (77.6)</td>
<td></td>
</tr>
<tr>
<td>History of smoking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>20 (40.8)</td>
<td></td>
</tr>
<tr>
<td>Ex- or current smoker</td>
<td>29 (59.2)</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>44 (89.8)</td>
<td></td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>27 (55.1)</td>
<td></td>
</tr>
<tr>
<td>CAD</td>
<td>20 (40.8)</td>
<td></td>
</tr>
<tr>
<td>COPD</td>
<td>11 (22.4)</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>3 (6.1)</td>
<td></td>
</tr>
<tr>
<td>PAD</td>
<td>16 (32.7)</td>
<td>3 (6.1)</td>
</tr>
<tr>
<td>ESRD on HD</td>
<td>3 (6.1)</td>
<td></td>
</tr>
<tr>
<td>In hospital mortality</td>
<td>6 (12.2)</td>
<td></td>
</tr>
<tr>
<td>Death during the follow up</td>
<td>5 (10.2)</td>
<td></td>
</tr>
<tr>
<td>Re-interventions</td>
<td>6 (6.7)</td>
<td></td>
</tr>
</tbody>
</table>

**Note.** Categorical data are expressed as numbers (%). Continuous data are expressed as the means ± SD or median (IQR). RA = renal artery; ASA = American society of anesthesiologists; CAD = coronary arterial disease; COPD = chronic obstructive pulmonary disease; PAD = peripheral arterial disease; ESRD = end stage renal disease; HD = hemodialysis.
renal artery, median tortuosity index, and the angulation of distal renal artery) are also shown in Table 2.

### Fate of renal branches

During follow up, re-interventions for six renal arteries were performed. One renal artery required balloon angioplasty to treat a distal endoleak of a renal bridging stent. Another was embolized percutaneously to cope with serious renal bleeding, which occurred on the 19th post-operative day. Ten (11.1%) renal arteries were found to be occluded during follow up. Among them, four renal arteries in three patients underwent percutaneous thrombectomy combined with additional stenting, resulting in the successful secondary patency.15,18 The primary patency rate was 88% and 84% at 1 and 2 years respectively and the secondary patency rate was 94% at 1 and 2 years.

### Risk factor analysis for primary patency

Table 3 shows the results of univariate analysis of patient characteristics, morphological factors of renal branches, and used stents associated with the risk of occlusion. Renal artery angulation more than −10°, which dichotomized at the median, was not a significant predictor for branch occlusion in univariate analysis (p = .84). Correlation analysis showed weak correlation between renal angulation and tortuosity index (r = .31) (Fig. 3).

Variables with p < .25 in the univariate analysis were subjected to multivariate Cox proportional hazards model analysis. Morphological factors of renal branches were also forcibly subjected to multivariate analysis. As a result, a tortuosity index > 1.11, which was dichotomized at the median, was identified as the only significant risk factor for occlusion (HR: 4.94; 95% CI: 1.01—24.30, p = .04). The lengths of bridging covered stents, angulations of distal renal artery, and patient characteristics were not identified as significant risk factors for the occlusion.

### DISCUSSION

mbEVAR requires reconstruction of several branches including the celiac trunk, superior mesenteric artery (SMA), and renal arteries. Among them, renal arteries are known to be significantly susceptible to loss of patency. Because mbEVAR is an emerging technique, there are only a few reports of series about this method. Chuter’s group has followed 148 renal branches constructed with caudally directed cuffs for a mean follow up of 21.2 months and reported that the rate of renal branch occlusion was 6.1%, which was remarkably high in contrast to 2.6% in the celiac
trunk and 0% in the SMA. Mastracci et al. reported a 2.2% (24/1111) occlusion rate of renal branches in their 650 patients who were treated with fenestrated endografts for renal branches for a mean follow up of 3 years.

Fenestrated endograft is another endovascular option for TAAA repair. Mastracci et al. are skeptical about the application of caudally directed branches for renal artery reconstruction, and insist on the advantages of fenestrations, especially for cranially oriented renal arteries. However, fenestrations have some limitations. Anatomical indications are restricted compared with mbEVAR. The aortic angulation at the level of the renovascular segment must be less than 45°. Fenestrations have little safety margin for anatomical planning, so there are no off the shelf fenestrated devices as yet, and such a concept seems not to be practical. The indications for both devices are still subject to controversy, but for the present branches are preferred to fenestrations, even in cases with cranially oriented renal arteries. In the results, pre-operative upward renal angulation correlated with greater tortuosity of the completed renal bridging, as expected. However, the correlation was weak and the upward renal angulation was not a significant predictive factor for branch occlusion in time to event analysis. Because there were many other factors including extent of aneurysm, device designs, implanted positions, and location of the renal orifice relative to other visceral arteries, renal angulation might have a relatively lower impact on the tortuosity and the fate of branches.

At present, a custom made device and a t-branch device are available in Europe. The key characteristic of the t-branch is the standardized position of the caudally directed cuffs. The suitability of the t-branch compared with custom made devices has been reported, but a trend towards more renal branch occlusions after t-branch implantation has been observed. Although the t-branch can fit a large proportion of patients pret-a-porter, its cuffs might not remain in the optimal position compared with a custom made device. Conceptually, in the deployment of the t-branch, the position of the endograft was determined using the SMA orifice as the primary reference point with the positions of renal cuffs secondary. As a consequence the relationship between the cuffs and renal ostia might not always be optimal. In the present study, however, there was no significant difference in renal branch patency between the custom made device and the t-branch.

As mentioned previously the renal branch is potentially the most fraught with trouble among the branch arteries in mbEVAR. This fragility probably derives from the significant mobility of the kidney, as a consequence of diaphragmatic movement during respiration. Renal arteries become relatively straight during inspiration, but become more curved during expiration. This cyclic bending exposes the bridging covered stents to mechanical stress.

In theory, the risk of stent failure can be minimized by avoiding long stents extending to the distal part of renal artery, where the arterial bending is greater than proximally. However, the length of the covered stent in the renal artery was not a significant risk factor for occlusion. Chuter’s group also reported recently that their morphological analysis had found no significant difference of the stent graft length in renal artery between the occluded and the patent renal branches.

In the present situation where the dedicated endograft for bridging is absent, the selection of devices is another point of discussion.

In Chuter’s series, renal branches were constructed with self expanding stents. In contrast, 93% of renal branches were constructed with balloon expandable covered stents in the present series. The advantage of balloon expandable stents is more precise positioning during deployment. But, there is a potential disadvantage. Once balloon expandable stents are deformed by mechanical stress, they never get back to the initial configuration spontaneously. This could lead to loss of patency, collapse, and dislocation. To deal with this problem in this series, 90% of renal branches were lined with self expanding bare stents. Moreover, the lining stents extended beyond the end of covered stents and were also expected to prevent kinking of the distal renal artery and to improve the fate of branches. Nevertheless, the outcome has failed to show the advantage of lining stents for the prevention of occlusion. On the other hand, no disadvantages of the lining stents which elongate the stented length, have been observed. In this context, the recent study, which included the celiac artery and SMA in addition to renal artery branches, also failed to confirm the efficacy of the relining stents and the impact of multiple bridging stents. Additionally, angulation of the distal renal artery, adopted as an indicator for distal kinking, was not a significant risk factor in the results. In the present study, the number of branches without lining stents might have been too small to detect the clinical effects in this limited follow up period. Another possibility is that the data might have been biased because the indication for lining was operator dependent and the most angulated vessels would have been lined. These problems still remain to be elucidated in the future. At the same time, dedicated devices optimally designed for the purpose of bridging are awaited.
The results indicated that the longer renal branch does not always result in higher complication rates as long as its tortuosity is not severe. In other words, the results advocate that the highly tortuous renal branch should be avoided, even though it takes a longer path. For example, when the target renal artery has upward angulation from the aorta, the cuff should be intentionally located at a proper distance from the ostium. In this situation, the immediate close cuff force the bridging stents to bend acutely in order to conform to the renal artery, and occasionally results in a highly tortuous path. In contrast, the moderate distance offers an extra margin for a more “smooth” curvature. In the results, the correlation between the renal angulation and the tortuosity of the branch was weak. However, this finding suggests that there is room for ingenuity to avoid tortuous paths even in upward target renal arteries.

The present study had some other limitations. The study design was retrospective, and the follow up period was short. Heterogeneous bare stents were used for lining. The influence of arterial remodeling, changes in aneurysm dimensions, and endurance of the implanted devices were not considered.

This study has advocated that bridging with smoother curvature is preferable even though it is longer. However, the anatomical changes over a longer period could possibly have an impact on this result. For example, longer bridging stents in a large aneurysm, which shrinks significantly after the repair, would be related to late occlusion because the space between the cuff and the renal artery would become shorter and cause kinking.

In this study, the tortuosity index was dichotomized at its median value and > 1.11 was defined as “highly” tortuous. However, an index of 1.12 does not always appear to be tortuous to candid observers. If a larger cohort had been available, the tortuosity index could have been divided into more categories, such as “low, moderate, and high” tortuosity.

The angulation of the distal renal artery was not a significant factor in the results. However, static images from single CTA might not be suitable for the evaluation of the dynamic effects of renal artery movements and the advantages of lining stents. Any other protocols, such as comparison of inspiration and expiration, should be considered for study focusing on this point.

CONCLUSIONS

Pre-operative renal angulation and the morphology of renal branch paths in mBEVAR were quantified and impacts on the fate of renal branches were analyzed.

The results failed to show a significant impact of pre-operative renal angulation on loss of primary patency in renal branches. A tortuosity index > 1.11 was an independent risk factor. On the other hand, the length of bridging and that of the covered renal artery were not significant factors. This study advocates that good outcomes can be expected even in upward target renal arteries by avoiding highly tortuous renal branches. Longer paths are acceptable. Further studies are necessary to elucidate the effects of remodeling and long-term results.

CONFLICT OF INTEREST

T.B. reports a lecturer’s fee from COOK Medical, Inc. The company had no role in the study design.

FUNDING

None.

REFERENCES

16 Bisdas T, Panuccio G, Sugimoto M, Torsello G, Austermann M. Risk factors for spinal cord ischemia after endovascular repair

Eur J Vasc Endovasc Surg (2016) 51, 357

COUP D’OEIL

Primary Aortocaval Fistula and Juxtarenal Aortic Aneurysm

Z. Szeberin *, C. Csobay-Novák
Department of Vascular Surgery, Cardiovascular Centre, Semmelweis University, Budapest, Hungary

A 71-year-old man with hypertension presented with abdominal pain and dyspnoea; he had an 8-cm juxtarenal abdominal aortic aneurysm (unsuitable for standard endovascular aneurysm repair, owing to saccular outpouching of the immediate infrarenal area; arrow in [A]). Physical examination revealed signs of right heart failure: bilateral ankle oedema, hepatomegaly and right pleural effusion. An aortocaval fistula was noticed on computed tomographic angiography. Following suprarenal aortic clamping and distal inferior vena cava balloon control, an aorto-bi-iliac Dacron graft was implanted with primary closure of the fistula (B) from the aortic side. The patient’s postoperative course was uneventful and he was discharged home on the sixth postoperative day.

* Corresponding author.
E-mail address: szeberin.zoltan@kardio.sote.hu (Z. Szeberin).
1078-5884/© 2015 European Society for Vascular Surgery. Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ejvs.2015.12.003