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Renal Artery Orientation Influences the Renal Outcome in Endovascular Thoraco-abdominal Aortic Aneurysm Repair☆

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WHAT THIS PAPER ADDS

Renal artery orientation significantly affects the early renal outcome of fenestrated/branched EVAR for thoraco-abdominal aneurysms. Intra-operative renal artery loss is predicted by upward renal artery orientation and branches, while early renal artery occlusion by downward + upward renal artery orientation and branches. The present data suggest that in thoraco-abdominal aneurysm, fenestrations should be the first choice for renal revascularisation in upward and downward plus upward renal artery orientation, if there are no other anatomical or clinical contraindications.

Objective: To evaluate the impact of renal artery (RA) anatomy on the renal outcome of fenestrated-branched endografts (FB-EVAR) for thoraco-abdominal aortic aneurysms (TAAA).
Methods: Between 2010 and 2016, all patients undergoing FB-EVAR for TAAA were prospectively collected. Anatomical, procedural, and post-operative data were retrospectively analysed. RA anatomy was assessed on volume rendering, multi planar and centre line reconstructions by dedicated software (3Mensio). RA diameter, length, ostial stenosis/calcification, orientation and aortic angles of the para-visceral aorta were evaluated. RA orientation was classified in four types: A (horizontal), B (upward), C (downward), D (downward + upward). RA revascularisation by fenestrations or branches was considered. Inability to cannulate and stent RA (RA loss), early RA occlusion (within three months), and composite RA events (one among RA loss, intra-operative RA lesion, RA related re-interventions, RA occlusion) were assessed.
Results: Seventy-three patients (male 77%; age 73 ± 6 years) with 39 (53%) type I, II, III and 34 (47%) type IV TAAA, underwent FB-EVAR, for a total of 128 RAs. The mean RA diameter and length were 6 ± 1 mm and 43 ± 12 mm, respectively. Type A, B, C, and D orientations were 51 (40%), 18 (14%), 48 (36%), and 11 (10%) RAs, respectively. Angulation of para-visceral aorta >45° was present in 14 cases (19%). Ostial stenosis and calcifications were detected in 20 (16%) and 16 (13%) RAs, respectively. Branches and fenestrations were used in 43 (34%) and 85 (66%) RAs, respectively. There were four (3%) intra-operative RA lesions (2 ruptures, 2 dissections). Ten (8%) RAs were lost intra-operatively because of the inability to cannulating and stenting. On univariable analysis, type B RA orientation (p = .001; OR 13.2; 95% CI 3.2—53.6), para-visceral aortic angle > 45° (p = .02; OR 4.9; 95% CI 1.3—18.5) and branches (p = .003; OR 9.0; 95% CI 1.9—46.9) were risk factors for intra-operative RA loss; type C RA orientation was a protective factor (p = .02; OR 0.1; 95% CI 0.01—0.9). On multivariable analysis, type B RA orientation (p = .03; OR 5.9; 95% CI 1.1—31.1) and branches (p = .03; OR 7.3; 95% CI 1.1—47.9) were independent risk factors for intra-operative RA loss. Fourteen patients suffered post-operative renal function worsening (> 30% of the baseline). The mean follow up was 19 ± 12 months. Four (3%) early RA occlusions occurred in three patients (2 single kidney patients required permanent haemodialysis). Type D RA orientation (p = .00; RR 17.8; 8.6—37.0) and branches (p = .004; RR 3.2; 2.4—4.1) were risk factors for early RA occlusion on univariable analysis. Five patients (7%) required early RA related re-interventions (recanalisation + relining 3; stent graft extension 1; parenchymal embolisation 1). No late RA occlusion or re-interventions were reported during follow up. Composite RA events occurred in 17 (13%) cases. Type B (p = .05; OR 3.9; 95% CI 1.1—15.7) or D (p = .006; OR 10.9; 95% CI 2.3—50.8) RA orientations and branches (p = .006; OR 5.7; 95% CI 1.6—20.3) were independent predictors of composite RA events on multivariable analysis.
Conclusion: Renal artery orientation significantly affects the early RA outcome of FB-EVAR for TAAA. Intra-operative RA loss is predicted by type B RA orientation and branches, while early RA occlusion is predicted by

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type D orientation and branches. The present data suggest that in TAAA, fenestrations should be the first choice for renal revascularisation in type B and D RA orientations.

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INTRODUCTION

Fenestrated and branched endografts (FB-EVAR) are valuable treatment options for aneurysms involving renal and splanchnic arteries.[1–4] According to recent reports, thoraco-abdominal aneurysms (TAAAs) can also be effectively treated by FB-EVAR as demonstrated by early and mid-term results.[5–8]

One of the key factors for technical and clinical success of FB-EVAR in TAAAs is target visceral vessel (TVVs) patency. TVV primary and secondary patency rates are overall satisfactory in the literature;[6,9] however, renal artery (RA) occlusion occurs more frequently than coeliac and superior mesenteric artery occlusion.[10,11]

The variability of RA anatomy could influence early and follow up renal outcomes after endovascular TAAA repair and is a critical issue during FB-EVAR planning; however, studies specifically dedicated to the evaluation of pre-operative RA anatomy on the renal outcomes of TAAA FB-EVAR are lacking.

The aim of the study was therefore to evaluate the impact of RA anatomy on the renal outcome of FB-EVAR for TAAAs.

METHODS

Selection of patients

Between January 2010 and December 2016, all patients undergoing FB-EVAR, using the Cook Zenith platform, for TAAAs were prospectively collected in a dedicated electronic database. Anatomical, procedural, and post-operative data were retrospectively analysed. Infected TAAAs or TAAAs occurring as a consequence of aortic dissection were not considered. All patients enrolled in the current study signed a dedicated informed consent. The study was approved by the local institutional review board.

Renal artery evaluation

Pre-operative thoraco-abdominal computed tomography angiography (CTA) was retrospectively reviewed. Post-processing evaluations were performed using dedicated software for advanced vessels analysis (3Mensio, Vascular Imaging, Bilthoeven, The Netherlands). RA anatomy was assessed on volume rendering, multi-planar and centre line reconstructions by vascular surgeons very experienced in FB-EVAR planning/procedure/follow up (EG, MG). They were blinded to the patient history and FB-EVAR outcomes. A semi-automated centreline of the aorta and RA was assessed by multi-planar reconstructions. Renal artery diameter, length of main trunk, ostial stenosis/calcification, orientation, and aortic angles of the para-visceral aorta were evaluated. A hypothetical line, perpendicular to the aortic centreline, was considered at the level of RA ostium. The angle between this line and the RA main trunk defined the RA orientation. The quantitative angular measurement for the angle was taken using the electronic angular caliper provided by the 3-Mensio software. According to these evaluations, RA orientation was classified in four types (Fig. 1) according to the volume rendering and coronal view: A (horizontal), B (upward), C (downward), D (downward + upward). Using the axial view, a similar assessment was performed and RA orientation was classified into three types (Fig. 2): I (lateral), II (posterior), III (anterior).

Stent graft planning and procedure

The FB-EVAR implant was planned by the same surgical team that performed the procedure and for custom made devices, planning was confirmed by the Cook Zenith Planning Centre for fenestrated and branched endograft. Renal artery revascularisation was performed by fenestration or branch design according to aortic lumen diameter at the level of renal artery origins as suggested by Greenberg et al.[12] Renal artery orientation was not considered an indication or contraindication to either fenestrated or branched graft design. Branches were used only in the caudally directed cases.

Custom made and off the shelf endografts were used according to aorto-iliac anatomical features and clinical onset (elective vs. urgent).[13] Previous publications have shown that, with respect to anatomical feasibility, there were no significant differences in terms of technical success or target visceral vessel patency between custom made and off the shelf devices for endovascular TAAA repair.[14–16] Accordingly, for the present study's outcomes custom made and off the shelf devices were not considered to be different features/variables.

Procedure, peri- and post-operative care has been accurately described in previous reports.[8,13,17,18] Concerning the type of stent graft used for target visceral vessel bridging, different approaches were used according to the design of the main endograft and the anatomy of the target vessels. For fenestrations, balloon expandable stent grafts are usually preferred in the authors' experience. However, for branches, balloon expandable stent grafts are employed only if the target vessels have straight anatomy, otherwise a combination of both balloon and self expandable stent grafts are used with the self expandable one deployed distally and the balloon expandable proximally (see supplementary figures).