Impact of Polar Renal Artery Coverage after Fenestrated Endovascular Aortic Repair for Juxtarenal and Type IV Thoracoabdominal Aortic Aneurysms

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**Impact of polar renal artery coverage following fenestrated endovascular aortic repair
(FEVAR) for juxta-renal and type IV thoraco-abdominal aortic aneurysms**

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aneurysm, thoraco-abdominal aneurysm

Abstract

Introduction: Fenestrated endovascular aortic repair (FEVAR) of complex aneurysm can require the coverage of polar renal artery. The aim of this study was to investigate the impact of the procedure on post-operative outcomes in patients with juxta-renal or thoraco-abdominal aortic aneurysms.

Material and methods: Patients who had FEVAR for juxta-renal or type IV thoraco-abdominal aortic aneurysm were retrospectively included between January 2010 and October 2017. The estimated glomerular filtration rate (eGFR) was recorded before and at 1, 7-day post-surgery and at the last follow-up. The occurrence of renal infarct was analyzed on the injected CT-scan images.

Results: Forty-three patients deemed at high-risk for open repair underwent FEVAR; 10 patients (23.3%) had polar renal artery coverage and were compared to patients without polar renal artery. The eGFR did not differ between the groups at 1 and 7 days following FEVAR (respectively 69 vs 61.6 mL/mn/1.73m², p=0.8708 and 68.4 mL/mn/1.73m² vs 68, p=0.9440). For a median follow-up of 233 days, the eGFR at the latest follow-up was 38 mL/mn/1.73m² (21.8 – 56.3) in patients who had polar renal artery covered and 57 mL/mn/1.73m² (46.5 – 76) in patients without polar renal artery (P=0.0748). Patients who had polar renal artery had a higher rate of post-operative kidney renal infarct (60% vs 21.2%, p=0.0441). The proportion of vascular complications did not differ (30% vs 30.3%, p=0.9999). No endoleak related to polar renal artery coverage was observed. The 30-day post-operative mortality was 4.7%.

Conclusion: Polar renal artery coverage during FEVAR is not associated with critical renal and vascular short-term outcomes but could impact long-term renal function.

53

54 **Introduction**

55 Since its development, endovascular aneurysm repair (EVAR) has rapidly evolved and has
56 become an alternative therapeutic option to open surgery in patients with aortic aneurysm (1)
57 (2). The development of new devices has allowed to propose EVAR in patients with
58 challenging anatomy including hostile neck, difficult vascular access or inclusion of visceral
59 arteries (3-6). When the aneurysm is located above the renal arteries, the endovascular
60 treatment requires to incorporate the visceral vessels to avoid ischemia and this can be
61 achieved using fenestrated endografts (3). However, even if fenestrated endografts spare the
62 main visceral vessels such as the mesenteric, renal and celiac arteries, their placement leads to
63 the coverage of other collateral arteries. The vascular anatomy of the kidney region can differ
64 among individuals (7) and the presence of a polar renal artery represents a frequent anatomic
65 variation which can be observed between 12 and 25% of the population (7-9). When the
66 aneurysm is juxta-renal or thoraco-abdominal, the presence of a polar renal artery may require
67 its coverage by the fenestrated endograft. The impact of polar renal artery coverage during
68 fenestrated endovascular aneurysm repair (FEVAR) has been so far poorly investigated. In
69 this context, the aim of this study was to investigate the impact of polar renal artery coverage
70 during FEVAR on early post-operative outcome.

71

72

73 **Material and methods**

74

75 *Population*

76 A retrospective study was performed in the Department of Vascular Surgery at the University
77 Hospital of Nice. The study was registered with the authorization number
78 E.H.V./C.G/2018/095 287 – 288. Consecutive patients deemed at high risk for open repair

and who had a fenestrated endovascular aortic repair (FEVAR) for juxta-renal or type IV thoraco-abdominal aortic aneurysms were included from January 2010 to October 2017. Type IV thoraco-abdominal aortic aneurysms were defined according to Crawford classification (10). The indication of FEVAR was evaluated by a pluridisciplinary team composed of vascular surgeon and anesthetist based on clinical and anatomical characteristics of patients, according to current guidelines (11, 12). The surgical risk was evaluated by a multidisciplinary team including vascular surgeons and anesthetists. Zenith fenestrated aortic endografts (Cook Medical®, Bloomington, Ind) were used for all patients. The surgical procedure was performed by the same team composed of two trained operators in a non-hybrid operating room. The sizing of the stent grafts was performed by an experienced vascular surgeon with subsequent agreement with the manufacturer who reviewed the graft plan in every case. Clinical pre-operative characteristics were collected and included age, body mass index, the presence of cardiovascular risk factors, cardiac, pulmonary and renal comorbidities as well as the American Society of Anesthesiologists (ASA) score. Pre-operative treatment was collected and change of medical treatment after the intervention was defined as the adjunction or the withdrawal at the time of discharge of at least one drug including angiotensin II converting enzyme inhibitor, beta-blocker, angiotensin II receptor blocker, calcium channel blockers, diuretics, antiplatelet therapy, oral anti-diabetic, anticoagulant or statin. Aneurysm characteristics and the anatomy of polar renal arteries were characterized on the pre-operative CT-scan by two independent operators. The technical success of the intervention was defined according to the Society for Vascular Surgery guidelines and corresponded to the successful introduction and deployment of the device, in the absence of surgical conversion to open repair, death at 24 h, type I or III endoleak, or graft obstruction (13).

Renal and vascular outcomes

Renal function was evaluated based on the serum creatinine concentrations and the estimated glomerular filtration rate (eGFR) was calculated according to the Chronic Kidney Disease EPIdemiology collaboration (CKD-EPI) equation (14). Chronic renal failure was defined as eGFR inferior to 60 mL/mn/1.73m² according to the chronic kidney disease staging system developed by the National Kidney Foundation and was graded as followed: grade 3A for an eGFR between 45 and 59 mL/mn/1.73m²; grade 3B for an eGFR between 30 and 44 mL/mn/1.73m²; grade 4 for an eGFR between 15 and 29 mL/mn/1.73m² and grade 5 for an eGFR inferior to 15 mL/mn/1.73m².

The changes of eGFR over time were evaluated for each patient and compared to the pre-operative value. Renal deterioration was defined as a decrease of eGFR more than 25% compared to baseline in accordance with the RIFLE system (15).

The presence of a renal infarct and the patency of the renal arteries was evaluated on the post-operative injected CT-scan by a radiologist and a vascular surgeon. Injected CT-scan required a volume of contrast agent of 90 mL and was performed the days following the surgery.

Vascular complications were defined as any endoleak, stent or graft occlusion, limb or visceral ischemia, dissection or rupture and major bleeding (bleeding associated with a drop in the hemoglobin of at least 3 g/dL or requiring transfusion of 2 or more whole blood/ red blood cells or causing a permanent injury or requiring surgery). The patency of the stented vessels was evaluated on post-operative CT-scan.

Data collection

Data were collected using electronic and manuscript medical records, as well as the so-called Clinicom® computer software program. Imaging data were collected from the software called picture archiving and communication system (PACS-Carestream®).

129

130 *Study endpoints*

131 To evaluate the early impact of polar renal artery coverage after FEVAR, patients who had
132 polar renal artery coverage were compared to those who did not have polar renal artery. The
133 study endpoints were the early post-operative renal and vascular outcomes as well as the 30-
134 day post-operative mortality.

135

136 *Statistical analysis*

137 Categorical data were expressed as the number of patients and percentage and continuous
138 variables were expressed as the median with interquartile ranges. Group differences were
139 compared by a Mann-Whitney test. Fisher's exact test was used for categorical data. A two-
140 sided P value <0.05 was considered as significant. Statistical analyses were performed using
141 GraphPad Prism® software (version 7.00, La Jolla California USA).

142

143 **Results**

144 *Study population and baseline data*

145 In total, 51 patients deemed at high-risk for open repair underwent fenestrated endograft
146 during the study period (Figure 1). Were included in the current analysis, 43 patients (Table
147 1) who underwent FEVAR for a juxta-renal AAA in 35 cases (81.4%) or for a type IV
148 thoraco-abdominal aneurysm in 8 cases (18.6%). Eight patients with type II, III or type I
149 thoraco-abdominal aneurysms were excluded. The median age of the cohort was 76 years
150 (interquartile range: 69 – 83) and 95.4% were men. The body mass index was 23.9 kg/m²
151 (21.3 - 27.4). The left ventricle ejection fraction was 60% (50 – 67.3). Twenty-four patients
152 (55.8%) had a coronary artery disease, 8 (18.6%) a history of stroke, 9 (20.3%) a chronic
153 obstructive pulmonary disease and 11 (25.6%) a pre-operative chronic renal failure. Among

patients with pre-operative renal failure, 7 patients were graded as 3A, 3 patients as 3B and 1 patient as grade 4. The median ASA score was 3 (3 – 3).

Intraoperative data

Thirteen patients (30.2%) had a 2-fenestrations stent graft, 18 (41.9%) a 3-fenestrations graft and 12 (27.9%) had a 4-fenestrations graft. Stented vessels concerned the right renal artery in 40 patients (93%), the left renal artery in 40 (93%), the superior mesenteric artery in 32 (74.4%) and the celiac trunk in 16 patients (37.2%). Of note, 3 patients did not have a stent in both renal arteries as they had only one kidney. Vessel cannulation was successfully achieved in all patients for all target arteries. The intervention was successful in all patients, but one patient experienced a distal type I endoleak due to malposition of the right iliac limb. This last patient was endo-converted to an aorto-uni-iliac configuration and crossover femoral-femoral bypass at the 7th post-operative day.

The presence of a polar renal artery was observed in 10 patients (23.3%). Among them, 8 patients had a unique polar renal artery and 2 patients had 2 polar renal arteries. The mean diameter of the polar renal artery was 3.4 mm (3 – 4). The polar renal artery originated from the aorta for 8 patients (80%) and from the renal artery for 2 patients (20%). All of them were covered during the procedure. It was directed toward the superior pole, the inferior pole or the hilum of the kidney in respectively 3 cases (30%), 6 cases (60%) or 1 case (10%).

Early post-operative period

Patients who had a polar renal artery covered were compared to those without polar renal arteries (Table 2). Clinical characteristics including age, history of cardiovascular risk factors and comorbidities did not differ among the groups. The proportion of juxta-renal and type IV thoraco-abdominal aneurysms did not differ between the 2 groups (respectively 80% vs.

81.8%, $p=0.9999$ and 20% vs 18.2%, $p=0.9999$). The procedural characteristics were also comparable, with no significant difference on the proportion of the different types of fenestrated stent graft and stented vessels. The operative time did not differ between the 2 groups (respectively 240 vs 300 min, $p=0.4630$), neither the volume of contrast agent used (197 mL vs 135, $p=0.2107$).

The renal function was evaluated and the proportion of pre-operative chronic renal failure did not significantly differ: 1 patient (10%) vs 10 patients (30.3%), $p=0.4086$. The pre-operative eGFR did not differ among the groups ($77.7 \text{ mL/mn}/1.73\text{m}^2$ vs 71.6 , $p=0.4738$) and no significant differences were observed at 1 and 7 days following the intervention (respectively 69 vs $61.6 \text{ mL/mn}/1.73\text{m}^2$, $p=0.8708$ and $68.4 \text{ mL/mn}/1.73\text{m}^2$ vs 68 , $p=0.9440$). In patients who had polar renal arteries covered, even if the eGFR tended to decrease at 1 and 7 day-post-surgery compared to pre-operative values, the difference did not reach statistical significance (68.9 and 68.4 vs $77.7 \text{ mL/mn}/1.73\text{m}^2$ pre-operatively, $p=0.3926$).

Follow-up

The creatinine concentration and the eGFR obtained at the last follow-up were evaluated. The median follow-up was 233 days (14.3 – 1147.3). The creatinine concentration at the last follow-up was $159 \mu\text{mol/L}$ (111.8 – 253.3) in patients who had a polar renal artery covered and $102.5 \mu\text{mol/L}$ (81.3 – 126) in patients without a polar renal artery ($P=0.0572$). The eGFR was respectively $38 \text{ mL/mn}/1.73\text{m}^2$ (21.8 – 56.3) and $57 \text{ mL/mn}/1.73\text{m}^2$ (46.5 – 76), $P=0.0748$. The proportion of patients who had a post-operative decrease of eGFR ($>25\%$ compared to baseline) was respectively 4 patients (40%) and 7 patients (21.2%), $P=0.2477$.

As the presence of a pre-operative chronic renal failure can potentially impact on the results, we analyzed the changes of renal function in these patients. Compared to pre-operative

203 values, patients with chronic renal failure did not have a higher risk to have a post-operative
 204 decrease of eGFR at 1, 7 days and at the last follow-up (Supplemental Table).
 205 Patients who had polar renal artery coverage had significantly a higher proportion of post-
 206 operative kidney renal infarct compared to those without polar renal artery (60% vs 21.2%,
 207 $p=0.0441$). In patients who had a polar renal artery coverage, the renal infarct occurred in the
 208 territory of the covered vessel. In patients who did not have a polar renal artery, renal infarct
 209 was due to an occlusion of the renal stent for one patient, and to embolism or dissection of the
 210 renal parenchymal arteries for the other 6 patients. In patients who had polar renal artery
 211 coverage, the eGFR at the last follow-up post-intervention did not significantly differ between
 212 patients who developed a kidney renal infarct post-operatively and those who did not (69.5
 213 mL/mn/1.73m² vs 70.6, $p=0.9999$ and 64.7 mL/mn/1.73m² vs 68.4, $p=0.9048$). The diameter
 214 of the polar renal artery did not differ between patients who developed a renal infarct and
 215 those who did not (3.1 mm vs 3.8, $p=0.3810$).
 216 The 30-day post-operative mortality in the all cohort was 4.7% (2 patients) and was observed
 217 in patients who had polar renal artery covered ($P=0.0498$). The causes of the death were a
 218 multi-organ deficiency for the first patient and spinal cord ischemia for the second patient.
 219 The proportion of vascular complications did not differ between patients who had polar renal
 220 artery covered and those who did not (30% vs 30.3%, $p=0.9999$). The presence of type II
 221 endoleak was checked on the post-operative CT-scan. The median time when the CT-scan
 222 was performed was 5 days (2.8 – 7) after the surgery. Type II endoleaks were observed in 1
 223 patient (10%) in the group with polar renal artery coverage and 3 patients (9.1%) without
 224 polar renal artery ($p=0.9999$). None of the endoleaks were related to the polar renal artery
 225 coverage. Lower limb ischemia occurred respectively in 1 patient (10%) with polar renal
 226 artery covered and 2 patients (6.1%) without polar renal artery ($p=0.5579$). Major bleeding
 227 was observed in 1 patient (10%) who had polar renal artery covered and 2 patients (6.1%)

without polar renal artery ($p=0.5579$). An asymptomatic dissection involving the celiac trunk and the common femoral artery was observed in one patient from the group who did not have polar renal artery.

Discussion

Our results revealed that the eGFR did not differ at 1 and 7-day post-surgery between patients who had polar renal artery covered and those without polar renal artery. Even though the proportion of renal infarct was significantly higher in patients who had polar renal artery covered, the eGFR did not differ between those who developed renal infarct and those who did not. However, follow-up on a longer period revealed that patients who had polar renal artery coverage tended to have a lower eGFR compared to those without polar renal artery. Patients who had a polar renal artery covered also tended to have a higher proportion of post-operative decrease of eGFR at the latest follow-up. Taken together our results suggest that the coverage of polar renal artery during FEVAR has a limited impact on early renal function but could affect renal function on longer term. Post-operative renal impairment represents one of the major complications following the treatment of complex aneurysm. A systematic review reported an incidence of early transient renal failure varying between 5 and 25% following FEVAR, with a pool estimated rate of 14.9% (16). FEVAR can potentially impact on renal function as well as renal volumes and several events can occur including renal stent occlusion, dissection, fracture, stenosis, kink or renal stent related endoleak (17). As FEVAR can impact on renal function, prevention strategies should be taken to prevent acute kidney injury (18). Several factors can also affect renal function during FEVAR including the operative time, the placement of stents in the renal artery, the variation of blood pressure and the amount of contrast media used during the intervention.

While the consequences on renal function appears as a major challenge during FEVAR, the impact of polar renal artery coverage has been so far poorly investigated. In our cohort, 23.3% of patients had a polar renal artery. This is in accordance with the literature, reporting a prevalence of polar renal artery between 12 and 25% of the population (7-9). The polar renal artery originated from the abdominal aorta and was oriented to the renal inferior pole in the majority of cases. This represents a classic anatomic variation which has previously been described (7). Several studies addressed the changes of renal function following EVAR and the majority of them did not report any significant difference on post-operative creatinine concentrations and/or eGFR between patients who had polar renal artery covered and those who did not (19-24). Only a few studies reported an early transient impairment of renal function following polar renal artery coverage after EVAR (21, 25). The occurrence of renal infarct following polar renal artery coverage during EVAR has been described in several studies, with ranges varying from 20% to 84% of patients (20-24, 26). The consequences of the occurrence of renal infarct on renal function in context of polar renal artery coverage during EVAR are heterogeneous. A first study reported a significant decrease of renal function in patients who developed renal infarct compared to those who did not (26), whereas another study did not find any correlation between the extent of kidney infarction and the changes in renal function (21). We found similar results in our cohort involving patients who had FEVAR; 54.5% of patients who had polar renal artery coverage developed a renal infarct and this was not associated with a significant impairment of early renal function. At last, we did not observe any significant difference on polar artery diameter between patients who developed renal infarct and those who did not. Similar findings were reported by Sadeghi-Azandaryani et al. (26).

We found that the 30-day post-operative mortality after FEVAR was 4.7% in this cohort deemed at high risk for open surgery. This rate is in accordance with other studies which

reported a 30-day mortality after FEVAR varying between 0.5% and 9.5% (27-30). Even if we reported 2 deaths in the group of patients who had polar renal artery covered, the causes of the deaths were not related to the coverage of the polar renal artery.

At last, the rate of vascular complications did not differ between patients who had polar renal artery coverage and those who did not. No endoleak related to the vessel covered was reported. These results suggest that polar renal artery thrombosed after coverage and have poor collateralization, which is in accordance with the fact that they represent end-arteries (20). Similar findings were reported by other investigators who did not observe any endoleaks related to accessory renal artery coverage during endovascular aneurysm repair (20, 22-25). However, one study reported the occurrence of type II endoleaks in 3 of 18 patients (17%) who had polar renal artery coverage (21). Note that in our study, the presence of type II endoleak was detected on early post-operative CT-scan and this could explain why no type II endoleak was observed on this short follow-up period.

The consequences of the polar renal coverage on post-operative outcomes are still incompletely understood and there is a lack of consensus on whether the polar renal artery should be preserved or covered. In our cohort, no patient had a revascularization of the polar renal artery. Several authors have proposed the use of chimney grafts as well as commercially or home-made fenestrated endografts to preserve the polar renal artery (31-34). Besides, open and/or hybrid surgery with re-implantation of polar renal arteries remain therapeutic options to preserve renal vascularization. Currently, there is no consensus on the criteria that should be taken into account to preserve or not the polar renal artery. Criteria to choose the most appropriate approach should take in consideration the polar renal artery configuration, patients clinical and anatomic characteristics as well as material available, the experience and the training of the operators (35).

Several prospects of improvement can be suggested. This was a single-center retrospective study and given the prevalence of polar renal artery, the number of patients analyzed was small and limited the power of the statistical analysis. The renal function was evaluated on a short post-operative period. It would be worth extending this study to other centers and to prospectively include patients. This would allow us to obtain larger cohorts on a longer follow-up period to evaluate the long-term impact of polar renal artery coverage on renal and vascular function after FEVAR.

Conclusion

To the best of our knowledge this is the first study to address the impact of polar renal artery coverage after FEVAR for juxta-renal and type IV thoraco-abdominal aneurysms. Patients who had polar renal artery coverage had a higher proportion of post-operative renal infarct. Polar renal artery coverage did not impair early post-operative renal function but can affect renal function on a longer follow-up period. The occurrence of vascular complications at 30-day post-surgery did not differ among the groups. Further studies are required to better understand the long-term impact of polar renal artery coverage and clearly define the criteria that should be taken in consideration to choose to cover or preserve it.

Author contribution

All authors confirm they contributed to the intellectual content of this article including conception and design. They revised the manuscript and approved the final version.

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328

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330

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Tables and figure legends:

Table 1: General characteristics of patients who underwent FEVAR

Values are median (interquartile range) or n (%). % are expressed compared to the number of patients. P value was calculated comparing patients who had polar renal artery covered and patients without polar renal artery.

Table 2: Procedural and anatomic characteristics of patients who underwent FEVAR

Values are median (interquartile range) or n (%). % are expressed compared to the number of patients. P value was calculated comparing patients who had polar renal artery covered and patients without polar renal artery.

NA: not applicable

Table 3: Post-operative outcomes of patients who underwent FEVAR

Values are median (interquartile range) or n (%). % are expressed compared to the number of patients. P value was calculated comparing patients who had polar renal artery covered and patients without polar renal artery. For each patient, post-operative decrease of eGFR was estimated as compared to pre-operative values.

Figure 1: Flow chart of the study population

Figure 1: Flow chart of the study population

General characteristics	Whole cohort (n=43)	Patients who had polar renal artery covered (n=10)	Patients without polar renal artery (n=33)	P value
Age	76 (69 – 83)	73 (68 – 82)	71 (71 – 84)	0.5278
Male sex	41 (95.4%)	10 (100%)	31 (93.9%)	0.9999
Body mass index (kg/m ²)	23.9 (21.3 – 27.4)	24.4 (20.5 – 27)	23.9 (21.3 – 28.7)	0.8415
Diabetes	5 (11.6%)	1 (10%)	4 (12.1%)	0.9999
Arterial hypertension	26 (60.5%)	5 (50%)	21 (63.6%)	0.4809
Dyslipidemia	14 (32.6%)	4 (40%)	10 (30.3%)	0.7037
Smoking	34 (79.1%)	9 (90%)	25 (75.8%)	0.6591
Coronary artery disease	24 (55.8%)	5 (50%)	19 (57.6%)	0.7279
Prior myocardial infarction	17 (39.5%)	3 (30%)	14 (42.4%)	0.7142
Atrial fibrillation	6 (14%)	1 (10%)	5 (15.2%)	0.9999
Left ventricle ejection fraction (%)	60 (50 – 67.3)	60 (50 – 62.5)	60 (50 – 70)	0.4358
History of stroke	8 (18.6%)	3 (30%)	5 (15.2%)	0.3617
Chronic obstructive pulmonary disease	9 (20.3%)	2 (20%)	8 (24.2%)	0.9999
Chronic renal failure	11 (25.6%)	1 (10%)	10 (30.3%)	0.4086
American Society of Anesthesiologists (ASA) score	3 (3 – 3)	3 (3 – 3)	3 (3 – 3)	0.2894
Pre-operative creatinine concentration (µmol/L)	88 (75 – 108)	91 (74.8 – 109.8)	88 (73.5 – 108.4)	0.9155
Pre-operative eGFR (mL/mn/1.73m ²)	71 (59.2 – 85.6)	76 (61.5 – 91.1)	71 (56.4 – 85.4)	0.3865
Pre-operative treatment				
. Angiotensin II converting enzyme inhibitor	16 (37.2%)	5 (50%)	11 (33.3%)	0.4596
. Beta-blocker	17 (39.5%)	4 (40%)	13 (39.4%)	0.9999
. Angiotensin II receptor blocker	3 (7%)	0 (0%)	3 (9.1%)	0.9999
. Calcium inhibitor	7 (16.3%)	1 (10%)	6 (18.2%)	0.9999
. Diuretics	11 (25.6%)	1 (10%)	10 (30.3%)	0.4086
. Antiplatelet therapy	38 (88.4%)	10 (100%)	28 (84.8%)	0.3198
. Oral anti-diabetic	4 (9.3%)	0 (0%)	4 (12.1%)	0.5579

. Anticoagulant	6 (14%)	1 (10%)	5 (15.2%)	0.9999
. Statin	26 (60.5%)	5 (50%)	21 (63.6%)	0.4809

Table 1: General characteristics of patients who underwent FEVAR

Values are median (interquartile range) or n (%). % are expressed compared to the number of patients. P value was calculated comparing patients who had polar renal artery covered and patients without polar renal artery.

Procedural and anatomic characteristics	Whole cohort (n=43)	Patients who had polar renal artery covered (n=10)	Patients without polar renal artery (n=33)	P value
Juxta-renal aneurysm	35 (81.4%)	8 (80%)	27 (81.8%)	0.9999
Type IV thoraco-abdominal aneurysm	8 (18.6%)	2 (20%)	6 (18.2%)	0.9999
Number of fenestrations	3 (2 -4)	3 (2 – 3)	3 (2 – 4)	0.2401
Type of fenestrated stent graft				
. 2 fenestrations	13 (30.2%)	4 (40%)	9 (27.3%)	0.4582
. 3 fenestrations	18 (41.9%)	5 (50%)	13 (39.4%)	0.7174
. 4 fenestrations	12 (27.9%)	1 (10%)	11 (33.3%)	0.2366
Type of stented vessels				
. Right renal artery	40 (93%)	10 (100%)	30 (90.9%)	0.9999
. Left renal artery	40 (93%)	10 (100%)	30 (90.9%)	0.9999
. Superior mesenteric artery	32 (74.4%)	6 (60%)	26 (78.8%)	0.2477
. Celiac trunk	16 (37.2%)	1 (10%)	15 (45.5%)	0.0635
Operative time (min)	300 (202.5 – 360)	240 (180 – 420)	300 (240 – 360)	0.4630
Volume of contrast agent (mL)	132.5 (112 – 187.5)	197 (125 – 285)	135 (113 – 195)	0.2107
Vascular filling volume (mL)	2000 (1500 – 2500)	2500 (2000 – 2500)	2000 (1500 – 2750)	0.7774
Use of vaso-active drugs during the intervention	28 (65.1%)	6 (60%)	22 (66.7%)	0.7190

Anatomic characteristics of the polar renal arteries	NA	3.4 (3 – 4)	NA	NA
Diameter (mm)	NA	8 (80%)	NA	NA
Origin	NA	2 (20%)	NA	NA
. Aorta				
. Renal artery	NA	3 (30%)	NA	NA
Localization	NA	6 (60%)	NA	NA
. Superior pole	NA	1 (10%)	NA	NA
. Inferior pole				
. Hilum				

Table 2: Procedural and anatomic characteristics of patients who underwent FEVAR

Values are median (interquartile range) or n (%). % are expressed compared to the number of patients. P value was calculated comparing patients who had polar renal artery covered and patients without polar renal artery.

NA: not applicable

Post-operative outcomes	Whole cohort (n=43)	Patients who had polar renal artery covered (n=10)	Patients without polar renal artery (n=33)	P value
Change of medical treatment	7 (16.3%)	3 (30%)	4 (12.1%)	0.3249
1-day post-operative creatinine concentration (μmol/L)	97 (79 – 118)	93.5 (79.8 – 108)	97 (74.5 – 129)	0.8931
1-day post-operative eGFR (mL/mn/1.73m ²)	62.5 (48.3 – 82.1)	69 (55.5 – 83.8)	62 (44.2 – 80.9)	0.5097
7-day post-operative creatinine concentration (μmol/L)	93 (78 – 126)	99.5 (78.3 – 127.5)	91 (77.5 – 126.5)	0.6352

7-day post-operative eGFR (mL/mn/1.73m ²)	71 (47.2 – 81.3)	68 (46.7 – 84.2)	71 (46.9 – 82)	0.9877
Post-operative creatinine concentration at the latest follow-up (μmol/L)	110.5 (86 – 175)	159 (111.8 – 253.3)	102.5 (81.3 – 126)	0.0572
Post-operative eGFR at the latest follow- up (mL/mn/1.73m ²)	54 (34.5 – 71.8)	38 (21.8 – 56.3)	57 (46.5 – 76)	0.0748
Post-operative decrease of eGFR (>25%) at 1-day	8 (18.6%)	2 (20%)	6 (18.2%)	0.9999
Post-operative decrease of eGFR (>25%) at 7-day	9 (21%)	2 (20%)	7 (21.2%)	0.9999
Post-operative decrease of eGFR (>25%) at the latest follow-up	11 (25.6%)	4 (40%)	7 (21.2%)	0.2477
Kidney renal infarct	15 (34.9%)	6 (60%)	7 (21.2%)	0.0441
30-day post-operative mortality	2 (4.7%)	2 (20%)	0 (0%)	0.0498
30-day post-operative vascular complications	13 (30.2%)	3 (30%)	10 (30.3%)	0.9999

Table 3: Post-operative outcomes of patients who underwent FEVAR

Values are median (interquartile range) or n (%). % are expressed compared to the number of patients. P value was calculated comparing patients who had polar renal artery covered and patients without polar renal artery. For each patient, post-operative decrease of eGFR was estimated as compared to pre-operative values.