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Fenestrated Endovascular Grafting: The French Multicentre Experience☆

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Abstract *Purpose:* This study aims to evaluate the medium-term outcomes following aortic aneurysm repair using fenestrated endografts performed in 16 French academic centres.
Materials and methods: A retrospective analysis of prospectively collected data was carried out. This study included all patients treated with fenestrated endografts in France between May 2004 and January 2009. Patients were judged to be at high risk for open surgical repair. Fenestrated endografts were designed using computed tomography (CT) reconstructions performed on three-dimensional (3D) workstations. All patients were evaluated with CT, duplex ultrasound and plain film radiograph at discharge, 6, 12, 18 and 24 months, and annually thereafter.
Results: A total of 134 patients (129 males) were treated over the study period. Median age and aneurysm size were 73 years (range 48–91 years) and 56 mm (range 45–91 mm), respectively. A total of 403 visceral vessels were perfused through a fabric fenestration, including 265 renal arteries. One early conversion to open surgery was required. Completion angiography and discharge CT scan showed that 398/403 (99%) and 389/394 (99%) respective target vessels were patent. The 30-day mortality rate was 2% (3/134). Pre-discharge imaging identified 16 (12%) endoleaks: three type I, 12 type II and one type III. After the procedure, transient or permanent dialysis was required in four (3%) and two (1%) patients, respectively. The median duration of follow-up was 15 months (range 2–53 months). No aneurysms ruptured or required open

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conversion during the follow-up period. Twelve of 131 patients (9%) died during follow-up (actuarial survival at 12 and 24 months: 93% and 86%, respectively). Median time from procedure to death was 15 months. None of these deaths were aneurysm related. Aneurysm sac size decreased by more than 5 mm in 52%, 65.6% and 75% of patients at 1, 2 and 3 years, respectively. Three (4%) patients had sac enlargement within the first year, associated with a persistent endoleak. During follow-up, four renal artery occlusions were detected. A total of 12 procedure-related re-interventions were performed in 12 patients during follow-up, including six to correct endoleaks, and five to correct threatened visceral vessels.

Conclusions: The use of endovascular prostheses with graft material incorporating the visceral arteries is safe and effective in preventing rupture in the medium term. A predictable high mortality rate was depicted during follow-up in this high-risk cohort. Meticulous follow-up to assess sac behaviour and visceral ostia is critical to ensure optimal results.

In prospective randomised trials, endovascular aneurysm repair (EVAR) proved to have a lower early morbidity and mortality compared with open repair.[1,2] Nevertheless, an adequate proximal sealing zone is required to seal the aneurysm using conventional devices.[3] Advances in endovascular skills and technology offer the possibility of treating abdominal aneurysms with short necks (i.e., less than 10 mm long) or including visceral vessels.[4] Depending on the definition, the proportion of juxtarenal aneurysms (JRAs) ranges from 2% to 20% of abdominal aortic aneurysms (AAAs).[5–7] Some authors opine that there is no exact definition of JRA.[8] Others include intra-operative data in their definition of JRA.[9] According to reporting standards, short-neck infrarenal AAAs were classified as juxtarenal when extending to renal arteries without involving them.[10] Suprarenal aneurysms involve renal arteries or renal and splanchnic arteries. Type IV thoraco-abdominal aortic aneurysms extend on a variable abdominal length, and always involve the visceral aortic segment.[11] Fenestrated devices were designed to ensure the proximal sealing of these three aneurysm types and maintain antegrade perfusion of the vessels consequently included in the fabric. The purpose of this study was to evaluate the medium-term outcomes following aortic aneurysm repair using fenestrated endografts performed in 16 French academic centres. It is an update of our previous report evaluating the first 80 patients treated in France with fenestrated endografts.[12]

Material and methods

Aneurysms

All consecutive patients treated with fenestrated endografts in France between May 2004 and January 2009 were included. The aneurysms treated were juxtarenal, suprarenal and Crawford type IV thoraco-abdominal aneurysms. All aneurysms were asymptomatic. No patient had a prior EVAR. No fenestrated devices were implanted to treat infected or ruptured aneurysms. A visceral artery stenosis was considered significant when resulting in a more than 70% diameter reduction.

Co-morbidities

All patients were deemed to be at physiological high risk for open surgical repair. The high-risk criteria for open AAA repair have been determined by the Agence Française de Sécurité Sanitaire des Produits de Santé (AFSSAPS),[13] the French counterpart of the US Food and Drug Administration. Congestive cardiac failure was defined according to the New York Heart Association (NYHA) classification. A left ventricle ejection fraction (LVEF) of less than 40% was considered to be a high-risk criterion. Active and former smokers were included in the 'tobacco use' criterion. Lower limb atherosclerosis was defined by abolition of at least one lower limb pulse and/or an ankle—brachial index lower than 0.9. No patient had critical lower limb ischaemia. Each patient having a previous laparotomy, for any reason, was recorded as having a hostile abdomen. Using the Cockroft and Gault formula, we took an absolute cutoff at 60 ml min^{-1} for the estimated glomerular filtration rate (eGFR) to consider a patient having chronic renal insufficiency. A relative decrease and a relative increase were considered to be significant when respectively greater than 30% and 10%.[14] The need for transient or chronic postoperative haemodialysis was recorded.

Endografts

The platform of the CE-approved fenestrated endograft manufactured by Cook Inc. (Bloomington, IN, USA) was the one used in all patients. It is a three-component endograft, including a proximal tubular fenestrated body component (FBC), a bifurcated body and an iliac leg extension. The fenestrations are of three types: small, large and scallops. The design of these custom-built three-component fabrics requires high-resolution spiral computed tomography (CT) scans (0.75 mm reconstructions) and three-dimensional (3D) workstations. The design and implantation procedures have previously been described.[12] The size of the delivery system ranges from 20Fr to 24Fr. No 'homemade' devices were used.

Follow-up

Postoperative follow-up included a clinical and radiological evaluation with CT, renal duplex ultrasound and plain film radiograph at discharge, 6, 12, 18 and 24 months, and annually thereafter. A decrease or an increase in maximal aneurysm diameter was considered as significant when $>$5 mm. Serum level of creatinine and corresponding eGFR

were recorded. Early results included the period spreading from the day of procedure itself to the 30th postoperative day. Late results include the next steps of the follow-up.

Results

Patients

A total of 134 patients (129 men and five women) were treated. The median age was 73 years (range 48–91 years). The preoperative risk factors, including the high-risk criteria for open AAA surgery, are listed in Table 1. Chronic renal insufficiency was diagnosed in 40% of patients; none of them required chronic haemodialysis before the procedure. The eGFR was <30 ml min^{-1} in 11.1% of patients, and <40 ml min^{-1} in 22.2% of patients. A unilateral renal artery stenosis was diagnosed in 13 patients (9.7%), and bilateral renal artery stenosis in two patients (1.5%). Chronic renal insufficiency was found in eight of those with unilateral stenosis (62%) and in both patients with bilateral stenosis.

Aneurysms

The aneurysms were juxtarenal ($n = 99$, 73.9%), suprarenal ($n = 27$, 20.1%) and type IV thoraco-abdominal aneurysms ($n = 8$, 6%). Median maximum aortic diameter was 56 mm (range, 45–91 mm). A previous open AAA tube graft repair had been performed in five patients (3.7%).

Endografts

A three-component system was deployed in 125/134 patients (93.3%). In three patients (2.2%), a tapered aorto-uni-iliac distal component was implanted because of severe unilateral iliac atherosclerotic lesions. The five patients with previous AAA open-tube repair were treated with FBC alone. A single FBC was used to treat the only saccular aneurysm.

A total of 403 visceral vessels were incorporated in the prosthesis design. The median number of target vessels per patient was 3 (range: 2–5 vessels). Small fenestrations were used in 243 cases, large fenestrations in 26 cases and scallop fenestrations in 133 cases. One branch was designed to perfuse a 'downward pointing' coeliac trunk in a patient with a type IV thoraco-abdominal aortic aneurysm. The most frequent FBC configuration (64%) associated a scallop for the small mesenteric artery (SMA) and a small fenestration for each renal artery.

Table 1 Open surgery high-risk criteria and preoperative co-morbidities.

	Patients (n)	%
Age $>$ 80 years	12	9
CABG/coronary stent or previous MI[a]	74	55
Congestive cardiac failure[b]	24	18
LVEF $<$ 40%	22	16
COPD[c]	59	44
Chronic renal insufficiency	54	40
Hostile abdomen	49	37
Obesity (BMI $>$ 30)	23	17
Tobacco use	109	81
Lower limb atherosclerosis	27	20
Diabetes	21	16
Hypertension	81	60
Dyslipidemia	59	44
Previous stroke	19	14

[a] Patients with positive stress test and no possible new coronary revascularization (or no indication).
[b] Patients with clinical symptoms of CHF.
[c] COPD = PEFR $<$ 1.2 l/s, or VC $<$ 50% of predicted VC according to age, sex and weight, or baseline $PaCO_2 > 45$ mmHg or $PaO_2 < 60$ mmHg, or Home oxygen.

Procedures

The procedures were conducted in 16 French academic centres. Concomitant beating heart coronary artery bypass graft was performed in one patient. In two patients with severe external iliac artery atherosclerosis; a conduit to the common iliac artery was performed. In a third patient with unilateral severe iliac atherosclerosis, a specific one-side delivery system was used.

The median procedure time was 180 min (range 85–720 min), with a median of 40 min of fluoroscopy time (range 10–230 min). The median volume of contrast used was 160 ml (range 50–450 ml). The volume of contrast was more than 200 ml in 24 (18%) patients. Among patients with a preoperative GFR <40 ml min^{-1}, the median volume of contrast used was 192 ml (range 65–280 ml).

The procedure was performed under general anaesthesia in 129 cases (96.3%), and under loco-regional anaesthesia in five cases. These five patients had severe chronic obstructive pulmonary disease (COPD).

Conversion

Conversion to open surgery was required in one patient (1%). After successful implantation of the FBC component and of both renal stents, an occlusion of the native aortic bifurcation was identified. Through a left retroperitoneal approach, an aortobifemoral bypass graft was anastomosed to the fenestrated endograft.

Additional procedures

The following non-planned additional procedures were performed:

- Repair of femoral or external iliac artery rupture ($n = 6$);
- Repair of common femoral artery puncture-site dissections (short bypass) ($n = 2$);
- Stenting of iliac artery kink ($n = 3$) or dissection ($n = 2$);
- Giant Palmaz implantation to treat a proximal type I endoleak ($n = 1$);
- Femoro-popliteal embolectomy ($n = 1$);

- Implantation of an additional renal stent for renal stent occlusion ($n = 1$), renal stent migration ($n = 1$), type III endoleak ($n = 1$) and renal artery rupture ($n = 1$); and
- Implantation of an aortic extension to cover a coeliac trunk ($n = 1$).

Completion angiography

Completion angiography showed that 398/403 (99%) target vessels were patent.

The occlusion of four renal arteries and one coeliac trunk resulted from:

- Distal implantation of a covered renal stent occluding all renal branches;
- Erroneous implantation of a renal stent in an accessory polar renal artery instead of the main renal trunk;
- Failed catheterisation of a tight renal ostial stenosis ($n = 2$); and
- Failed catheterisation of a coeliac trunk with tight stenosis resulting from compression by a median arcuate ligament.

Another renal artery was not catheterised at the time of the initial procedure in a patient with a suprarenal aneurysm. This renal artery remained perfused by a type III endoleak through the small fenestration. A secondary procedure was successfully performed a few weeks later (implantation of a covered stent perfusing this renal artery and occluding the type III endoleak).

Early follow-up

The median length of stay in intensive care unit was 1 day (range 0—30 days). The median length of stay in hospital was 9 days (range 4—30 days). The 30-day mortality rate was 2% (3/134). Two patients died at days 4 and 5, respectively, after the initial procedure. Both ultimately died of multisystem organ failure, respectively, after major perioperative bleeding due to an external iliac artery rupture and after conversion to open surgery for acute aortic bifurcation occlusion. The third patient died from pulmonary oedema, at postoperative day 17. This patient had a history of coronary artery disease, with a preoperative LVEF estimated at 25%. He had been discharged at postoperative day 10, after an uneventful postoperative course.

Morbidity

The non-renal postoperative complications are reported in Table 2. The external iliac artery occlusion was asymptomatic. A negative laparotomy was performed the day following the procedure for suspected acute mesenteric ischaemia. A total of 22 complications were noted in 16 patients (12%). All of the non-renal early postoperative complications were successfully treated, except the paraparesis, which proved permanent. A magnetic resonance imaging (MRI) performed after the procedure demonstrated distal spinal cord ischaemia in this latter patient. A possible aetiology was the exclusion of large intercostals by the endograft. Regarding the two patients who suffered a stroke, MRI demonstrated

Table 2 Postoperative non-renal morbidity.

Patient	Cardiac and haemodynamic complications	Vascular complications	Neurological complications	Respiratory complications	Digestive complications
1				Respiratory insufficiency	Acute cholecystitis
2					Suspicion of acute mesenteric ischaemia
3	Cardiac arrest			Acute Respiratory Distress Syndrome	
4			Stroke, fully recovered		
5	Cardiac insufficiency			Respiratory insufficiency	
6			Stroke, fully recovered		
7	Cardiac insufficiency				
8	Myocardial infarction				
9	Cardiac insufficiency				
10			Paraparesis		
11	Myocardial infarction				
12	Cardiac insufficiency		Transient ischaemic attack	Pneumonia	
13				Pneumonia	
14				Respiratory insufficiency	
15	Atrial fibrillation				
16	Myocardial infarction	Iliac artery occlusion			

Table 3 Postoperative renal function (eGFR).

	Decrease *N* (%)	Increase *N* (%)	Stable *N* (%)	Temporary dialysis *N* (%)	Permanent dialysis *N* (%)
Preoperative renal insufficiency (eGFR < 60 ml/min) ($n = 53$, 40% of patients)	8 (15)	14 (26)	32 (59)	3 (5.5)	1 (2)
Normal preoperative renal function (eGFR> 60 ml/min) ($n = 81$, 60% of patients)	5 (6)	10 (12)	66 (82)	1 (1)	1 (1)
All	13 (10)	24 (17)	98 (73)	4 (3)	2 (1.5)

a right parietal cortical and infracortical infarct in one and a left capsular—thalamic infarct in the other patient. Neither of these patients had atherosclerotic disease of the arch. The aetiology remained unclear in both patients.

Renal function

Postoperative evolution of eGFR is reported in Table 3. Renal function showed a significant improvement or remained stable among 90% of the patients. After the procedure, a transient or permanent dialysis was required in four (3%) and two (1%) patients, respectively. Transient haemodialysis was required for the two patients with a multisystemic organ failure, the third patient had preoperative chronic renal insufficiency and the last one suffered from acute renal failure associated with cardiac and respiratory insufficiency. Permanent dialysis was required for a patient who had preoperative renal insufficiency and patent renal arteries after the procedure. This renal deterioration probably resulted from cholesterol emboli. The second case resulted from a perioperative renal artery thrombosis after failed catheterisation of this target vessel.

Secondary procedures

Additional four secondary procedures (3%) were performed in the early postoperative period for repair of two pseudoaneurysms (a brachial and a femoral), debridement of a groin wound and evacuation of a retroperitoneal haematoma in a patient with an iliac conduit.

Discharge CT

Before discharge, a CT was performed in all 131 patients. A total of 394 remaining target vessels were evaluated. The target vessels patency rate was 99% (389/394).

An endoleak was diagnosed in 16 (12%) patients: three type I (two proximal, one distal), 12 type II and one type III. A proximal type I endoleak was persistent despite implantation of a Palmaz stent in the immediate infrarenal segment. This endoleak spontaneously sealed on a CT performed 3 months later. The second proximal type I endoleak was considered very limited and no immediate treatment was performed. In the 6 months' control CT scan, the aneurysm diameter was unchanged and the endoleak had resolved. The distal type I endoleak was successfully treated by implantation of a Palmaz stent on the distal segment of the left leg. The type III endoleak arose from a renal fenestration that was not catheterised during the procedure. It was treated by the implantation of a covered renal artery stent 4 months later.

Late results

Follow-up

The median duration of follow-up was 15 months (range 2—53 months). No patient was lost during follow-up. No patient developed renal failure requiring dialysis during follow-up.

Mortality

During follow-up 12 patients died. The cumulative survival probability according to Kaplan—Meier analysis at 12 and 24 months were 93% and 86%, respectively (Fig. 1). The median time from procedure to death was 15 months. The median age of patients at the time of death was 75 years (range 62—91 years). None of these deaths was related to aneurysm. Carcinoma was the most frequent aetiology, affecting 5 of these 12 (42%) patients. Myocardial infarction affected three (25%) patients and the aetiology of one (8%) death remained

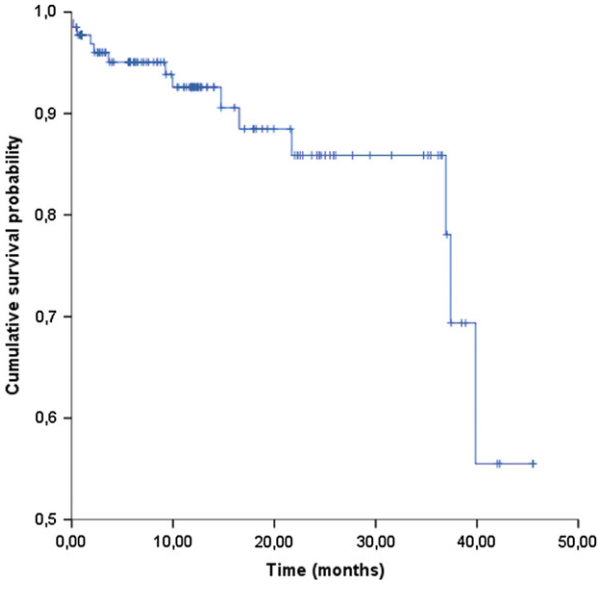

Figure 1 Kaplan—Meier cumulative survival probability.

Table 4 Secondary interventions during follow-up.

Complication diagnosed	Secondary intervention (*n*)	Delay from FEVAR (months)
Type IA endoleak	Chimney SMA covered stent + aortic cuff (1)	18
Type IB endoleak	Palmaz stent implantation (1)	2
Type II endoleak	Embolisation (2)	3 and 6
Type III endoleak	Covered renal stent (1)	4
Type III endoleak	Aortic cuff (1)	12
Renal stent fracture	Renal artery stenting (4)	6, 12, 18 and 18
Renal stent fracture	Hepato-renal bypass (1)	12
Ilio-femoral bypass proximal stenosis	Angioplasty (1)	6

unclear. This patient was suffering from coronary artery disease and had not shown any specific symptoms. He died 14 months after the procedure, and the last CT performed at 2 months demonstrated complete aneurysm exclusion, with patent target vessels and stable diameter aneurysm.

Re-interventions

No aneurysms ruptured or required open conversion during the follow-up period. A total of 12 procedure-related re-interventions were performed in 12 patients during follow-up, six to correct endoleaks, five to correct threatened visceral vessels and one to correct an ilio-femoral bypass, which had been performed to treat a per procedure external iliac artery rupture (Table 4):

- Type 2 endoleak embolisation ($n = 2$)
- Limb extension to treat a primary distal type I endoleak
- Covered renal stent implanted through a renal fenestration to treat a primary type III endoleak through an unstented renal fenestration
- Implantation of an aortic cuff to exclude a secondary type III endoleak
- Chimney technique with a covered stent in the SMA to treat a secondary proximal type I endoleak
- Complementary renal stenting in the setting of a renal stent fracture ($n = 4$)
- Hepato-renal bypass to treat a renal artery stenosis
- Stenting of a stenosis of a proximal anastomosis of an ilio-femoral bypass

During follow-up, five non-procedure-related re-interventions were performed in three patients:

- Recanalisation of superficial femoral artery ($n = 2$);
- Implantation of covered stent to exclude a false aneurysm of a previous aortobi-iliac bypass graft ($n = 2$); and
- Femoro-popliteal venous bypass and bipolar ligation to treat a symptomatic popliteal aneurysm.

Median delay for re-interventions was 10 months after the initial procedure (range, 2–30 months).

Aneurysm diameter

At each follow-up, the difference between the new and the initial aneurysm diameter was calculated. A significant aneurysm diameter decrease was depicted in 52%, 65.6% and 75% of patients at 1, 2 and 3 years, respectively. At 6 months, two (2%) patients had a significant increase in maximal aneurysm diameter, one of them without endoleak, and the other with a type II endoleak. This latter patient remained stable 6 months later. At 1 year of follow-up, three (4%) patients had sac enlargement, all associated with a persistent type II endoleak. No treatment was performed, and 6 months later, the three diameters had remained stable and the three endoleaks persisted. At 18 months, one (2.2%) patient had a sac enlargement. It was associated with a secondary type I endoleak that was treated by the chimney technique.

Endoleaks

During follow-up, 15 type II endoleaks (eight primary and seven secondary) were diagnosed (Table 5). Secondary type II endoleaks were diagnosed in seven cases, at 6 months ($n = 3$), 1 year ($n = 2$), 18 months ($n = 1$) and 2 years ($n = 1$). One of them, depicted at 6 months, was associated with a 5-mm increase in aneurysm diameter. It remained stable 6 months later. The other four endoleaks were not associated with a significant increase in maximal aneurysm diameter.

An increase in maximal aneurysm diameter was observed in the only patient with a secondary type I endoleak. This endoleak was treated by the chimney technique, with implantation of a proximal aortic cuff through a femoral approach and of a covered SMA stent through a brachial approach. A major reduction of the endoleak was diagnosed on the postoperative CT, and no further intervention was decided for this frail patient.

A secondary type III endoleak was diagnosed in one patient. This endoleak was perfused by a renal fenestration that had not been stented due to a failed catheterisation of a tight ostial renal stenosis. It was successfully treated by the implantation of an aortic cuff within the original FBC.

Table 5 Endoleaks diagnosed on CT scan during follow-up.

Follow-up (months)	6	12	18	24	30	36
Number of patients	97	74	45	31	29	19
Type I, *n* (%)	0	0	1 (2)	0	0	0
Type II, *n* (%)	13 (13)	6 (8)	2 (4)	1 (3)	0	0
Type III, *n* (%)	0	1 (1)	0	0	0	0

Target vessels patency

During follow-up, four renal artery occlusions were diagnosed (3%). One of each was found respectively at 6, 12, 24 and 36 months after the procedure (Table 6). A renal stent fracture in two cases and preoperative renal artery stenosis in the other two cases may explain these occlusions. One of these patients had a renal artery stenosis on the contralateral side to a renal artery occlusion that was treated by hepato-renal bypass. No coeliac trunk or SMA stenosis or occlusions were diagnosed during follow-up.

Discussion

The first EVAR was described by Parodi in 1991,[15] and the first use of a fenestrated device 8 years later by Faruqi.[16]Fenestrated endografts were initially designed to treat type I endoleaks complicating standard EVAR,[16] and mycotic aortic aneurysms.[17] The possibility of EVAR with a sealing zone including one or more visceral vessels allowed the treatment of complex aneurysms. Case reports were first published, and were followed by single-centre series. Australian,[18] Dutch,[19,20] American[4,14,21] and French[12] experiences have been published between 2004 and 2009. A decade after its introduction, fenestrated EVAR is an established technique: more than 2000 patients have been treated worldwide with fenestrated endovascular devices, by more than 150 physicians. The population of endovascular therapists using these custom-made endografts is following an exponential growth curve. We performed this nationwide multicentre trial to evaluate the results of fenestrated EVAR performed both within and outside of referral centres.

Series from referral centres have included between 38 and 119 patients, with 87—302 target vessels. A systematic review of 19 studies, totalling 715 target vessels, was published in 2006.[22] The 30-day mortality rates following fenestrated EVAR ranged from 0.84% to 3.4%. A more recent literature review has pooled eight studies, reporting a total of 368 patients, all treated with the Zenith fenestrated endograft.[8] In this review, a cumulative mortality following fenestrated EVAR of 5/368 (1.4%, 95% confidence interval (CI) 0.4—3.1) is reported. We report in this current study a 2% early mortality rate. A predictably high mortality rate was observed during follow-up in this high-risk cohort; however, it is interesting to note that the most frequent cause of death was not due to cardiovascular causes but rather due to carcinoma. No deaths occurred during follow-up from aneurysm-related causes.

The early visceral vessel patency rate in the literature ranges from 90.5% to 99.7%. Stenting of target vessels is highly recommended to avoid early visceral vessel occlusion. Stenting requires successful catheterisation of the target vessel through fenestration. Inadequate device design and target vessel ostial stenosis are predictors of per procedure catheterisation failure and target vessel thrombosis. The published 1-year target vessel patency rates range from 90.5% to 97% at 12 months.[8] Renal artery occlusion rate ranges from 2.3% to 4.3% in the literature. One case of chronic mesenteric ischaemia relating to a superior mesenteric artery stenosis has been described. This patient was successfully treated with a self-expanding stent.[14] In our study, we had no late mesenteric or coeliac artery occlusions at follow-up and found four renal artery occlusions.

Deterioration in renal function (eGFR) ranged from 11% to 25% (10% in our experience). Because the pathogenesis of deterioration in renal function is multifactorial and is also due to variations in reporting standards, assessment of the impact of these grafts on renal function is difficult to quantify. Nevertheless, renal impairment is statistically more severe in open repair than in fenestrated EVAR.[8]

In the current series, 12 patients underwent endovascular re-intervention for stent-related indications at a median interval of 10 months representing a 9% re-intervention rate. Six of these were for endoleaks and five to protect threatened visceral branches. Angioplasty of an anastamotic stenosis in an ileo-femoral bypass was also carried out. These figures compare favourably with the figure of 15% quoted in Nordon's review of 351 cases from various case series.[8] There was a similar distribution of indications for re-intervention in this review also, with 48% for endoleaks and 52% for branch vessel issues.

Depending on the series, the rate of patients with aneurysm diameter reduction ranges from 33% to 51% and 53% to 79% at 6 and 12 months, respectively. Similar results have not been reported with standard EVAR endografts. The proximal seal in a healthy and stable segment of the aorta (compared with the infrarenal neck in standard EVAR) may explain such findings.

To our knowledge, this current French multicentre study is the largest cohort of fenestrated EVAR ever published. The results of this study are concordant with previously published literature. We wish to emphasise that this current study has included every patient treated with fenestrated devices during the study period, and

Table 6 Target vessel occlusion during follow-up.

Patient	Vessel occluded	Preoperative stenosis	Stent fracture	Secondary procedure	Time from surgery to diagnosis	Preoperative GFR	Post-occlusion GFR	Haemodialysis
1	Right renal artery	Yes	Yes	No	6 months	52	57	No
2	Left renal artery	No	Yes	No	12 months	50	69	No
3	Left renal artery	No	No	Renal stenting 18 months after initial procedure	24 months	57	62	No
4	Left renal artery	Yes	Yes	No	36 months	120	34	No

consequently reflects a 'nationwide' learning curve. Hence, we suggest that the current study demonstrates fenestrated EVAR to be a technique whose role can be expanded for use in centres where there is reasonable endovascular experience and need not remain the preserve of referral centres only.

In our experience, concordant with the literature, the use of custom-made endografts with graft material incorporating the visceral arteries is safe and effective in preventing aneurysm rupture in the medium term.

Competing interests

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