**COMPLICATIONS AND REINTERVENTIONS AFTER FENESTRATED AND BRANCHED EVAR IN PATIENTS WITH PARAVISCERAL AND THORACOABDOMINAL ANEURYSMS**

**ABSTRACT**

The application of endovascular strategies to treat aneurysms involving the abdominal and thoracoabdominal aorta has evolved significantly since the inception of endovascular aneurysm repair. Advances in endograft technology and operator experience have enabled the management of a wider spectrum of challenging aortic anatomy. Fenestrated endovascular (FEVAR) and branched endovascular aneurysm repair (BEVAR) represent two technical innovations, which have expanded endovascular treatment options to include patients with paravisceral and thoracoabdominal aortic aneurysms. Although similar in many ways to standard aortic endografts, fenestrated and branched endografts have specific short and long term complications due to their unique modular endograft design and their sophisticated deployment mechanisms. This article aims to examine the commonly encountered complications with these devices and the endovascular reintervention strategies.

**INTRODUCTION**

Endovascular aortic repair (EVAR) for abdominal aortic aneurysm (AAA) has evolved significantly since the first case was reported in 1991[1]. It has become widely adopted as a method of treatment for infrarenal AAA. Open Surgical Repair (OSR) of AAA with hostile anatomy, such as those with short necks (<1.5cm) and/or highly angulated proximal aortic neck (>60°) have been associated with increased mortality and reduced renal function in the long-term, particularly in high risk patients[2]. The advantages of a minimally invasive endovascular treatment include reduced early perioperative morbidity and mortality rates, and shorter length of admission compared to OSR, as shown by several randomised controlled trials (RCT) and meta-analyses[3–6]. As such, EVAR has progressively become the preferred mode of treatment of AAA in high-risk patients.

The presence of a suitable proximal landing zone is one of the most important determining factor in the successful implantation of standard stent grafts in the treatment of AAA. Complex underlying anatomical configurations, such as absent, short or angulated proximal neck, involvement of visceral arteries, or thoracoabdominal aortic aneurysms (TAAA), are challenging in the endovascular treatment of aortic aneurysms. An estimated 45% of paravisceral and thoracoabdominal aortic aneurysms have these complex aortic anatomies [7,8]. As such, different minimally invasive endovascular treatment solutions are required. Fenestrated endovascular aneurysm repair (FEVAR) and branched endovascular aneurysm repair (BEVAR) were developed to overcome some of these difficulties[9–11]. The first FEVAR was performed by Park in 1996[12] and the first case of endovascular repair of a TAAA using BEVAR was performed by Chuter in 2001[13]. Since then, the indications of F/BEVAR, have been expanded progressively to encompass a wider spectrum of aortic aneurysms in patients who are high-risk surgical candidates and whose AAA anatomy precludes them from standard EVAR treatment. Technical and engineering advancements have resulted in a shift from physician-modified endovascular grafts to manufactured off-the-shelf or customised patient-specific endografts[9–15].

**PRINCIPLES OF FENESTRATED AND BRANCHED EVAR**

The aim of endovascular treatment of complex AAA and TAAA aortic aneurysms using F/BEVAR [16]is to move the proximal and, in limited pathoanatomy of Crawford type I, the distal sealing zone to a more suitable proximal or distal segment of the aorta. Fenestrations and branches are created to enable vascularisation of the visceral arteries after the main stent graft has been implanted. Fenestrations or scallops are reinforced, complete or partial holes in the stent graft fabric which allow perfusion to a target artery. They are suitable for use in nondilated aortic segments to allow contact of the fenestration against the aortic wall. In FEVAR, after partial deployment of the main body of the stent graft, the target arteries are cannulated through the specific fenestrations, followed by deployment of a balloon-expandable covered stent (BECS) into the target artery, which reaches into the lumen of the stent graft’s main body. Flaring of the proximal end of the covered stent with an oversized balloon against the main body is then performed to achieve a good seal around the fenestration leading to the branch artery[17–19].

In contrast, branched endografts have prefabricated branches for the visceral arteries integrated with the main body stent graft. Branched grafts are used in TAAA with a certain diameter of the aneurysm sac at the visceral arteries. The branches represent the proximal landing and sealing zone for coversed stents used to bridge the gap between the stent graft’s main body and the distal landing zone in the visceral artery. Thus, the covered stent facilitates perfusion of the target visceral artery.[16–18]. Most operators use self-expanding, rather than, balloon-expandable stentgrafts – in contrast to FEVAR [16–18].

Whilst F/BEVAR represent a technical and engineering evolution from conventional EVAR and thus share various similarities, as well as complications, there is a unique set of complications specific to F/BEVAR. This article aims to highlight those complications comprehensively and outline the main approaches to their management, periinterventionally and during follow-up.

**GENERAL COMPLICATIONS OF F/BEVAR**

There are some general complications, which are generic to EVAR and F/BEVAR, such as limb complications (e.g. limb occlusion, stenosis or kinks), contrast medium allergy, contrast induced nephropathy, spinal cord ischaemia, lower limb ischaemia and renal function deterioration. These complications are well recognised and are not within the scope of this article.

As the use of percutaneous access using large sheaths (20-24F) in F/BEVAR becomes more popular, one of the more pertinent general complications is access site complication, which has been reported in some series with a 9% to 16% incidence[20,21]. Although some studies have suggested percutaneous EVAR in obese patients and sheath size of ≥20F to be associated with post-operative complications[22–27], a systemic review of percutaneous femoral access for EVAR has shown a low access site complication rate of 4%[28]. These figures may be extrapolated to F/BEVAR as well.

The randomised Percutaneous Endovascular Aneurysm Repair (PEVAR) trial revealed that percutaneous access with the preclosure technique using the Perclose ProGlide devices (Abbott Vascular, Redwood City, Calif, USA) was noninferior to surgical cut-down in patients undergoing EVAR[29]. Moreover, studies on the safety and effectiveness of total percutaneous access for FEVAR demonstrate a successful percutaneous closure rate of 92%-95% and post-operative vascular access complication rate of 5%-12%[30,31]. Additional ProGlide device deployment has also been shown to reduce the rate of surgical repair after primary haemostasis failure in percutaneous EVAR, and the presence of anterior wall calcification within the common femoral artery (CFA) is a significant predictor for additional ProGlide device deployment[32].

**SPECIFIC COMPLICATIONS OF F/BEVAR**

Technical success of F/BEVAR is defined as a completed endovascular procedure with patent target vessels and successful exclusion of the aneurysm sac without any endoleaks at completion (exception being type II endoleaks)[33]. Compared with standard EVAR, F/BEVAR requires the deployment of additional covered stent grafts extending from the main body to the target arteries. Reports comparing standard EVAR and FEVAR[34] have shown that FEVAR is associated with an increased overall complication rate compared with standard EVAR. This is likely due to the higher morphological complexity and the requirement for visceral vessel cannulation, wire insertion and stenting, which risks target vessel occlusion, thrombosis and/or dissection and wire perforation. As such, specific complications exist in F/BEVAR relating to the main body and the additional stent graft fenestrations and branches. The specific complications of F/BEVAR may be identified during the procedure, or they may present at follow-up, either early (<3 months) or late (>3 months)

**Procedural complications of F/BEVAR – endograft specific**

***Endograft malplacement***

In FEVAR, in order to align the fenestration to the target vessel, accurate longitudinal positioning and rotational torque control of the delivery system must be achieved[35]. Malplacement of the proximal component or, in the rare situations of FEVAR in Crawford type I, of the distal component, the fenestrated endograft may result in back to front deployment of the endograft, high or low position of the endograft, or malrotation along the long axis of the endograft. This suboptimal positioning of the endograft may result in shuttering, defined as partial or complete misalignment of the fenestration with the target vessel ostium. Theoretically, shuttering could range from 0% (perfect alignment) to 100% (complete coverage of the fenestration)[36]. Minor shuttering may not have any clinical significance, but the complete covering of the ostium of an important arterial branch, such as the superior mesenteric artery (SMA), can have life-threatening consequences.

In a single-centre FEVAR experience using the Zenith fenestrated graft (Cook Medical, Bloomington, Ind., USA) [36], SMA shuttering of any amount measured on post-operative CT angiogram occurred in 50% of patients, and the range of SMA shuttering was reported between 12%-40%. However, no cases of acute or chronic mesenteric ischaemia were noted during follow-up. In the world’s largest experience with FEVAR from the Cleveland Clinic[37], concern was also raised about unsupported scallops for the SMA, and a recommendation was made to stent all scallop configurations to preserve patency of the visceral artery. Slow deployment of the partially constrained proximal component allows last-minute repositioning of the endograft to be made[38]. Cannulating and inserting wires in all target arteries and pre-loading covered stents in as many visceral arteries as possible may enable the most precise deployment of the main body with the most accurate alignment of the fenestrations and the arteries’ ostiums.

**Procedural complications of F/BEVAR – target organ specific**

***Unsuccessful target artery cannulation/stenting***

Stenting of a target vessel is technically successful when there is a <30% residual stenosis, and the stent is positioned within the target vessel[33]. Failure to catheterise and stent a target vessel may result in irreversible organ damage. Although F/BEVAR is a much more complex procedure than standard EVAR, the rate of unsuccessful catheterisation or stenting of a target visceral vessel is reported to be low (1%-2%)[39,40]. As such, the demanding nature of F/BEVAR has caused much debate as to whether it would be advisable to concentrate these procedures in a small number of high-volume, specialised centres with the necessary experience and required equipment to achieve better outcomes[41].

Contributing factors to technical failure include poor device design, adverse arterial anatomy and inadequate procedure planning[42]. Technical failure to cannulate and stent the target artery is minimised by careful assessment of the arterial anatomy on pre-operative CTA, good quality targeted intra-operative imaging and considerable expertise in endovascular techniques. Thus, it is of utmost importance that the operator is experienced in CT image reading and planning and measuring purposes, to choose the appropriate devices and to check the drafts of the specific manufacturers in custom-made F/BEVAR.

***Malplacement of a target artery endograft***

Malplacement of the target artery endograft can occur intraoperatively (Figure 1), which may go unnoticed and may only be discovered on the post-operative CTA. This may be due to poor angiographic visibility and low radioopacity of the balloon expandable covered stents (BECS) used (e.g. Advanta V12, Atrium Europe, The Netherlands). The most commonly encountered situation is a stent placed too far into the target visceral artery. This necessitates stenting of the fenestration using another covered stent to bridge the gap between the fenestration and the malpositioned endograft in order to prevent loss of organ perfusion[39].

***Guidewire perforation of target artery/organ***

Infrequently, a guidewire may cause inadvertent perforation of a target artery/organ intraoperatively. The renal artery is most commonly involved in perioperative vessel related complications (e.g. technical failure, vessel injuries and early occlusion)[42]. These injuries can result in perinephric haemorrhage, iatrogenic arteriovenous fistula or segmental renal infarction [43–45]. If left untreated, significant bleeding and organ injury may occur, jeopardising the overall success of the F/BEVAR procedure. Emergency embolisation is indicated to arrest potentially life-threatening haemorrhage (Figure 2). Consequently, it is of utmost importance during the procedure to keep the wire tip within the target vessel and in view at all times.

***Dissection/rupture of target artery***

Target artery dissection and pseudoaneurysm/aneurysm formation can also occur in the early post-procedural stage after F/BEVAR. The patient may complain of worsening abdominal pain (due to organ ischaemia or pseudoaneurysm enlargement), or haematuria (if a renal artery is involved). Plain target artery dissection can be treated by placement of a self-expanding bare-metal stent, and additional aneurysm formation secondary to occult renal artery injury can be treated by inserting another covered stent (Figure 3), such as the Viabahn endograft (Gore, Flagstaff, Ariz, USA)[46].

**Late complications F/BEVAR**

***Target vessel stenosis and occlusion***

Acute or chronic target vessel stenosis or occlusion are among the main complications of F/BEVAR accounting for up to 23.5% of all secondary procedures performed on F/BEVAR patients in one series[47]. As such, target vessel patency is one of the important issues of the success of the procedure. This is dependent on appropriate and timely reintervention, which is generally required once target vessel stenosis/occlusion, endoleak or an aortic/limb endograft complication has been detected.

Acute target vessel occlusion caused by acute thrombosis due to undelrying pre-existing stenosis or as acute thrombosis itself can potentially lead to life-changing, or even life-threatening, consequences, especially if in-stent occlusion occurs concurrently in a stented coeliac trunk and SMA[33]. Although acute occlusions may be attributed to an unrecognised kink in the stentgraft intraoperatively, in some cases, an underlying cause cannot be identified[48]. Occasionally, target stent graft occlusion produces acute symptoms leading to its discovery by imaging. In this situation, patients, can theoretically be treated by thrombolysis, thrombectomy and overstenting., although as is stated above, this scenario is unusual (Figure 4).

A more common situation is the diagnosis of a chronic stenosis or occlusion of a target vessel stent graft stenosis on follow-up imaging. In the majority of cases, target vessel stent graft occlusion is a silent phenomenon, likely occurring as a result of progressive occult stenosis of the target vessel stentgraft progressing to occlusion. These cases can usually be discovered on routine follow-up CTA. During normal respiration, the stented target artery motion can be significant[49,50], and the associated exertional forces may be transmitted to the target vessel endograft. This up and down movement may cause stent fracture or accelerated intimal hyperplasia at the stent graft’s distal edge. A stenosis of a target artery endograft is deemed haemodynamically significant when there is a reduction of >50% in the luminal diameter [51,52]. Positional stability of the F/BEVAR is important to ensure long-term procedural success. Over time, migration of the mainbody of the F/BEVAR can result in crushing of a target vessel stent and vessel occlusion [53]. Small migrations of <5mm have been reported to result in stent graft occlusions[39,54]. When visceral stentgraft stenosis and occlusion occurs, treatment with angioplasty and insertion of an additional supportive stentgraft into the visceral artery stent and across the site of the stenosis can be performed. An occlusion, or even a high grade in-stent stenosis, of any target artery endograft can be very challenging to treat. These may be approached optimally from a femoral or an upper limb access depending on the orientation of the specific stentgraft with the aorta (Figure 5).

***Type I and type III endoleaks***

In view of the modular nature of the device, out of the various types of endoleaks, type I and type III endoleaks are of special concern in F/BEVAR.

*Type 1 endoleaks:*

Failure to obtain a good seal resulting in an endoleak may lead to continued pressurisation of the aneurysm sac and eventual rupture. Compared with standard EVAR, the F/BEVAR endograft allows the operator to customise a stent with a more suitable and longer proximal sealing zone, thus mitigating the underlying hostile anatomy. The presence of a type Ia endoleak is reported in up to 5.8% in some series[55]. A proximal seal in the juxtarenal aorta has been associated with an increased risk of development of type 1a, which is associated with increased component instability and aortic-related deaths[56]. However, increasing graft coverage above the coeliac trunk is associated with a greater risk of spinal cord ischaemia and coeliac trunk occlusion[40]. Newer devices, such as the EndoAnchor (Aptus Endosystems, Sunnyvale, Calif, USA), have also been shown to have good short-term results in the treatment of type Ia endoleaks [57].

Type 1b endoleaks are generally easier to manage than 1a. Type 1b endoleak can be treated effectively with the use of extension stent grafts to achieve a better distal seal. Several commercially available iliac extender limbs and covered stents can be used to close the endoleak. If extension of the iliac limb across the internal iliac artery is necessary, embolisation of the internal iliac artery should be performed to avoid subsequent type 2 endoleak. Bilateral internal iliac artery embolisation should be avoided to prevent intractable buttock claudication. Type 1b endoleaks have also been successfully treated using liquid embolics such as NBCA glue (Trufill, Cordis, Miami, FL, USA)[58–60]. Type 1c endoleaks, defined as leaks that originated from lack of distal apposition of the visceral stents, can be effectively treated by additional covered stent implantation. However, care should be taken to preserve as many vital visceral branches as possible to avoid end organ ischaemia/infarct.

*Type 3 endoleaks*

Type 3 endoleaks specific to F/BEVAR may be caused by the following: a. A poor seal at the connection between the aortic fenestration or branch and the target vessel endograft, b. The target vessel endograft migrates out of the target artery, c. There is a poor seal between the target vessel endograft and the target vessel itself, d. There is a fabric tear in the target vessel endograft. Type 3 endoleak has a reported rate of 3.2% in a recent meta-analysis of FEVAR versus open repair[55]. If the problem is a poor seal at the fenestration or the branch, the first treatment to consider should be balloon dilatation of the connection between the fenestration/branch and the target vessel endograft(Figure 6). If this fails to abolish the endoleak, an additional oversized and overlapping BECS may be inserted to provide a better (Figure 7). Fabric tears are notoriously difficult to identify and are a diagnosis of exclusion. If there is concern about a possible fabric stear in the target artery stent graft, an additional overlapping endograft is the treatment of choice.

***Endograft migration***

Migration has been defined as any cranial or caudal movement of the main aortic endograft relative to a vascular landmark by ≥4mm[53]. Migration can occur at any time and may result in a separation of the endograft components. Migration is more often in an inferior direction than superiorly. Migration of the aortic endograft after F/BEVAR has been reported in 1 -7% of patients. In general, all detected migrations require reintervention[47,54,61]. Factors contributing to endograft migration include an insufficient landing zone or suboptimal planning of the original procedure[47]. The presence of barbs, bare proximal stent struts, higher fixation of stentgraft fabric and a separate proximal component help to prevent migration[53]. The motion of the aorta during respiration is considerable and the various longitudinal and radial forces exerted on the endovascular grafts may also contribute to the development complications, such as endograft migration[62,63].

Early detection of any migration enables appropriate intervention [64]. If left untreated, an adequate aortic seal may be lost, resulting in aneurysm sac pressurisation, enlargement and potential rupture (Figure 8). This can further lead to target vessel endograft kinking or occlusion, even with very small movements[65]. As the main body migrates, the target visceral vessel endografts may become kinked or stenosed, compromising the blood flow to the target organ. Further enlargement of the aneurysmal sac cranially can result in progressive dilatation of the aortic neck in the treated segment and may eventually result in loss of an adequate seal and relative inferior migration of the aortic endograft[65]. Relative inferior migration of the aortic endograft resulting in stenosis of a stented target vessel can be treated by additional covered stent insertion (Figure 9).

**OUTCOMES: TARGET VESSEL PATENCY AND REINTERVENTIONS AFTER FEVAR AND BEVAR**

In general, reinterventions are most commonly performed for target vessel stenosis, as well as endoleaks and graft limb complications. Selected target vessel patency rates and reintervention rates for FEVAR and BEVAR studies are shown in Table 1 and Table 2. Comparing FEVAR and BEVAR studies, patients who had BEVAR procedures appeared to have higher target vessel patency rates of 94% to 99.5% on follow-up (between 24 months and 60 months), as opposed to those who had FEVAR procedures with target vessel patency rats of 81% to 97% (follow-up between 12 months to 60 months).

Reintervention rates of FEVAR study cohorts being followed-up for 12 months to 60 months range between 12% to 44%[33,65–67], while the reintervention rate of patients who had BEVAR in one study was 24%[68]. In one FEVAR study, 29% of reinterventions were endoleak-related, 26% target vessel related and 13% graft limb related[67]. In another study comparing open surgery and FEVAR, significant numbers of reinterventions after F/BEVAR were performed to treat type III endoleaks, and FEVAR was found to require more reinterventions in the long-term, mostly for endoleak or vessel occlusion/stenosis during follow up[69]. Significantly, some FEVAR reinterventions for complications resulted in worse morbidity and mortality compared with open repair reinterventions [55].

In the largest FEVAR study, patients treated with a main body endograft which had a supracoeliac landing zone experienced higher branch reintervention rates compared to patient treated with other configurations[40]. In the largest series in Europe to report long-term outcomes of F/BEVAR including 166 patients[68], reintervention was required in 40% of patients. Although 17% of the patients required at least one reintervention within 2 to 3 years of the index procedure, more than 85% of these reinterventions involved minimally invasiave endovascular procedures with high technical success rates. The freedom from reintervention at 1 year and 3 years was 88% and 78%, respectively. Most of the late reinterventions (>30 days) are related to endoleak or endograft stenosis, which may be partly related to the lack of dedicated bridging stent grafts and other anciliary devices. However, the long-term 5 year target vessel stent patency rate remains impressive at around 95%.

**Conclusion**

The unique features of F/BEVAR provide an opportunity to expand endovascular treatment to include abdominal aortic aneurysms with challenging anatomy. However, the complex nature of F/BEVAR deployment demands a wide range of catheter/guidewire skills and experienced operators for successful deployment, as well as in the management of any associated complications. The factors paramount to successful F/BEVAR implantation, such as careful planning, high-resolution pre-procedural imaging, precise measurements, suitable patient and device selection, an experienced endovascular team executing the plan, and a dedicated multidiciplinary team managing the patient, cannot be emphasised enough. In general, procedural complications are more common than late complications. FEVAR appears to have slightly higher complication rates compared with BEVAR, while both procedures show higher reintervention rates compared to OSR at follow-up. As such, early recognition of problems and appropriate and timely reintervention are of paramount importance in ensuring a durable outcome using FEVAR or BEVAR techniques.

Conflict of interest statement:

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Figures

Figure 1. Malplacement of SMA endograft.   
Post-operative CT aortography in axial (A) and sagittal (B) planes showing a SMA endograft (white arrows; Advanta V12, Atrium Europe, Mijdrecht, The Netherlands) which was deployed too distally. This went unnoticed at the time of deployment due to the low radio-opacity of the stent used. Pre-and post-procedure angiography (C and D, respectively) during restenting procedure showed the deployment of an additional BECS (white arrowheads) across the SMA fenestration. The importance of visualisation and careful deployment of the stent cannot be stressed enough. If the stent proved “invisible” on fluoroscopy, the use of a more radio-opaque stent should be considered.

Figure 2. Hydrophilic guidewire perforation of right renal capsule.

Immediate post-procedural CTA of the kidneys in axial (A) and coronal (B) planes showed a large right perinephric haematoma (asterix) with only one active bleeding (white arrowheads). A left renal subcapsular haemorrhage was also noted on CTA but no active bleeding point was seen on left renal angiography. Emergency right renal angiography (C) demonstrated the point of active bleeding (white arrow). Post-embolisation right renal angiogram (D) showed successful coil embolisation and cessation of bleed.

Figure 3.Target artery aneurysm secondary to occult renal artery injury during FEVAR.

In another patient Post FEVAR, the patient experienced worsening abdominal pain. A left renal artery aneurysm (asterix) was detected on CTA (A,B and C) performed 3 months post FEVAR. The right kidney appeared normal and the right renal artery fenestrated graft was widely patent. No significant deterioration of renal function was noted clinically. Selective left renal angiography (D) confirmed the presence of a large left renal aneurysm, which was successfully treated by insertion of a Viabahn endograft (white arrows).

Figure 4. In-stent occlusion of a visceral artery endograft.

The CTA performed one day after FEVAR (A), showed an optimally positioned and patent endograft in the SMA. However, the CTA performed 6 months post-procedure (B) showed complete in-stent occlusion of the same endograft. Significant collateral blood flow via the coeliac trunk was present and the patient remained asymptomatic. The patient also declined further intervention at this stage. To date, there remains no reliable endovascular solution to treat this complication.

Figure 5. Visceral artery endograft stenosis and restenting.

Abdominal aortic angiogram (A) showed near complete stenosis of the mid portion of the right renal artery endograft (white arrowheads). Subsequent wire cannulation (B) followed by restenting of the stenosis using another covered stent (C) was performed. Selective right renal angiogram at completion (D) showed good results with minimal residual stenosis. Restenting of stenosed visceral artery endograft are technically challenging procedure, which demands high level of expertise of the operator.

Figure 6. Type III endoleak due to poor seal between the renal endograft and fenestration.

CTA in the axial plane (A and B) showed a type III endoleak (white arrowheads) between the left renal endograft and fenestration. The proximal aspect of the left renal endograft appeared constrained (white arrow). The type II endoleak (white arrowheads) was confirmed on a subsequent catheter aortogram (C and D), with the pinched proximal aspect of the left renal endograft again seen (white arrow). These complications were successfully treated with oversized balloon angioplasty of the visceral stent.

Figure 7. Type III endoleak due to poor seal between visceral endograft and target artery.

CTA in the axial (A) and coronal (B) planes showed a type III endoleak (asterix) around the SMA endograft and proximal component, which was confirmed on a subsequent selective catheter angiogram of the SMA. This was followed by wire cannulation of the SMA (D) and an additional overlapping, oversized endograft (white arrowheads) was deployed, successfully sealing the endoleak.

Figure 8. Aortic endograft migration.

Coronal CTA (A, B and C) showed distal migration of the main body of the aortic endograft (white arrowheads). In (B), the left renal artery fenestration has been pulled inferiorly, resulting in a kink (white arrow) in the left renal artery at the distal edge of the endograft and compromising blood flow to the left kidney. .

Figure 9. Aortic endograft migration (same patient as in Figure 8).

Aortic angiogram (A) confirmed the presence of a kink in the left renal artery (white arrowheads), distal to the left renal artery endograft component. Selective cannulation of the left renal artery followed by additional BECS deployment (B and C) was performed. Final left renal artery angiography (D) showed good results with no visible kink in the stented artery.

Table 1. Target vessel patency and reintervention rates – selected FEVAR studies

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| FEVAR | Year published | Number of patients | Target vessel patency  (Months of follow-up) | Reinterventions  (Months of follow-up) |
| Banno[66] | 2014 | 80 | 97% (24 months) | 29% (24 months) |
| Kristmundsson[67] | 2014 | 54 | 94% (12 months)  90% (60 months) | 12% (12 months)  44% (60 months) |
| Grimme/Verhoeven[33] | 2014 | 138 | 89% (48 months) | - |
| Oderich[65] | 2014 | 67 | 81% (60 months) | 22% (60 months) |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| BEVAR | Year published | Number of patients | Target vessel patency | Reinterventions |
| Greenberg[14] | 2010 | 172 | 99.5% (24 months) | - |
| Verhoeven [68]  (mixed BEVAR/FEVAR) | 2015 | 127 | 94% (60 months) | 24% |

Table 2. Target vessel patency and reintervention rates – selected BEVAR studies