Eur J Vasc Endovasc Surg (2015) 50, 474—479

Internal Iliac Aneurysm Repair Outcomes Using a Modification of the Iliac Branch Graft

M. Noel-Lamy [*], J. Jaskolka, T.F. Lindsay, G.D. Oreopoulos, K.T. Tan

University Health Network, Vascular and Interventional Radiology, Toronto, Ontario, Canada

WHAT THIS PAPER ADDS

The data on aorto-iliac repair with iliac branch graft devices (IBGs) with concomitant internal iliac artery aneurysm (IIAA) are scarce in the literature. The majority of case series on IBG placement exclude patients with dilatation of the IIA. In two series that included patients with IIAA, associations with technical failure and endoleak were reported. However, in these studies the patient details, procedure, and outcome of patients with IIAAs were not detailed. The goal of this article is to report the experience covering long portions of the aneurysmal internal iliac artery with single vessel outflow and provide outcome and patency data to further validate the placement of IBGs in aneurysmal IIAs.

Objectives: Iliac branch grafts (IBGs) are a validated option for the treatment of aorto-iliac aneurysms preserving internal iliac artery (IIA) flow. IIA aneurysm (IIAA) is a relative contraindication to IBG placement. The goal of this study was to review experience in managing aorto-iliac aneurysms with concomitant IIAAs with extension of the IIA branch stent graft into the superior gluteal artery (SGA).

Methods: This retrospective study between May 2009 and November 2014 includes consecutive patients who underwent placement of an IBG (Cook, Bloomington, IN, USA) with extension of the internal iliac component of the branch stent graft into the SGA because of aneurysmal IIA (>15 mm). The stent grafts used were Viabahn (Gore, Karlsruhe, Germany), Fluency (Bard, Flagstaff, AZ, USA), or iCast (Atrium, Hudson, NH, USA) proximally. Imaging follow up was with computed tomography angiography (CTA) within 30 days of device insertion and then annually.

Results: The procedure was performed on 15 patients with a mean age of 76.8 years (SD 6.1 years). Twenty IIAAs were treated with a mean IIA and common iliac artery (CIA) diameter of 33 mm (SD 13 mm) and 35 mm (SD 11 mm) respectively. Technical success rate was 100%. One patient who underwent simultaneous IBG and three vessel fenestrated endovascular aneurysm repair died of mesenteric ischemia 2 days after the procedure. Mean imaging follow up with CTA was 18.3 months (SD 15.1 months). Primary patency of the SGA stent grafts was 100%. There was one case of type II endoleak. All patients were free from buttock claudication at follow up (mean: 19.7 months). Two patients who had IIA embolization contralateral to the IBG placement suffered from unilateral lower limb monoparesis.

Conclusions: Extension of the internal iliac component of IBGs into the SGA for distal seal is feasible and safe in the endovascular treatment of aorto-iliac aneurysms with concomitant IIAs. Long-term results are needed to further validate this technique.

Article history: Received 2 April 2015, Accepted 26 May 2015, Available online 15 July 2015

Keywords: Internal Iliac aneurysm, Endovascular procedures, Stents, Aortic abdominal aneurysm

INTRODUCTION

Iliac branch graft devices (IBGs) have emerged in the past decade as a tool to preserve internal iliac artery (IIA) flow during endovascular repair of common iliac artery aneurysms (CIAA). IBGs (Cook, Bloomington, IN, USA) have gained wide acceptance and multiple studies have reported favorable outcomes.[1—5] One of the challenges for IBG deployment is the presence of an internal iliac artery aneurysm (IIAA). This is commonly encountered, as 29% of patients with CIAA also have a dilatation of the IIA.[6] Dilatation of the main IIA trunk has been associated with technical failures.[2] In the absence of a distal landing zone in the proximal IIA trunk, one option is extension of the

* Corresponding author. Toronto General Hospital, Vascular and Interventional Radiology Division, 585, University Avenue, Toronto, Ontario, M5G 2N2, Canada.

E-mail address: maximenl@gmail.com (M. Noel-Lamy).

1078-5884/© 2015 European Society for Vascular Surgery. Published by Elsevier Ltd. All rights reserved.

http://dx.doi.org/10.1016/j.ejvs.2015.05.021

internal iliac branch stent graft into a divisional artery, such as the superior gluteal artery (SGA). Data in the literature on the outcome of placement of IBGs in patients with aneurysmal IIAs is limited.[1,2,7] The aim of the present study is to report the outcome of the extension of the IIA stent graft into the SGA in patients undergoing IBG placement for treatment of IIAA or of common iliac and aortic aneurysmal disease with concomitant IIAA.

MATERIALS AND METHODS

This is a retrospective study conducted at a tertiary academic center. The clinical investigation was approved by the institutional review board, with a waiver of informed consent. Patients were identified from the institutional advanced endovascular aneurysm repair (EVAR) database. From July 2007 to December 2014, 67 patients underwent placement of an IBG. From these IBG cases, patients with deployment of the internal iliac stent graft into the SGA were selected.

Clinical data were retrieved from the hospital's electronic medical records and imaging data were retrieved from the institution picture archiving and communication system (PACS). The decision to perform this procedure was made during the institution's weekly vascular rounds including vascular surgeons and interventional radiologists. The selection for treatment with an IBG was based on the activity level of the patient, comorbidities, and anatomic suitability for IBG placement, including a patent CIA lumen $\geq$14 mm for side branch deployment. Candidates for IBG placement with dilatation of the IIA trunk $\geq$15 mm with no distal landing zone in the IIA main trunk were then selected to have extension of the internal iliac stent graft into the SGA. This procedure was performed as an adaptation and extension of current techniques and skills.

Device and deployment

In all cases, the Zenith Iliac Branch Device (Cook, Bloomington, IN, USA) was used. Procedures were performed outside of the manufacturer's instruction for use. Procedures were performed under general or epidural anesthesia with surgical exposure of the common femoral arteries and/or axillary arteries. First steps of implantation for the IBG were similar to those described in the literature.[1] When the side branch was deployed and the IIA catheterized, a diagnostic angiogram was performed, showing the outflow IIA vessels and the IIA aneurysm (Fig. 1A). If the anterior IIA division was considered large enough to potentially cause a type II endoleak (more than 5 mm), it was embolized with coils. Then the posterior division of the IIA and the SGA were selected. Over a stiff wire, a stent graft was deployed from the SGA to the limb of the IBG (Fig. 1B). The stent graft was oversized 10% relative to the SGA diameter as measured on pre-operative computed tomography angiogram (CTA) and confirmed on fluoroscopy. If one stent graft was not adequate in length to reach the side-branch of the IBG, the distal stent was initially deployed and a second stent graft was deployed proximally. There was a minimum of 2–3 cm of overlap between the stent grafts. The distal landing zone in the SGA was at least 2 cm in length. Distally, the stent graft was not deployed beyond the greater sciatic foramen. Junctions between IIA stents were then sealed with an angioplasty balloon. In most cases the stent graft used was Viabahn (Gore, Karlsrhue, Germany). iCast (Atrium, Hudson, NH,

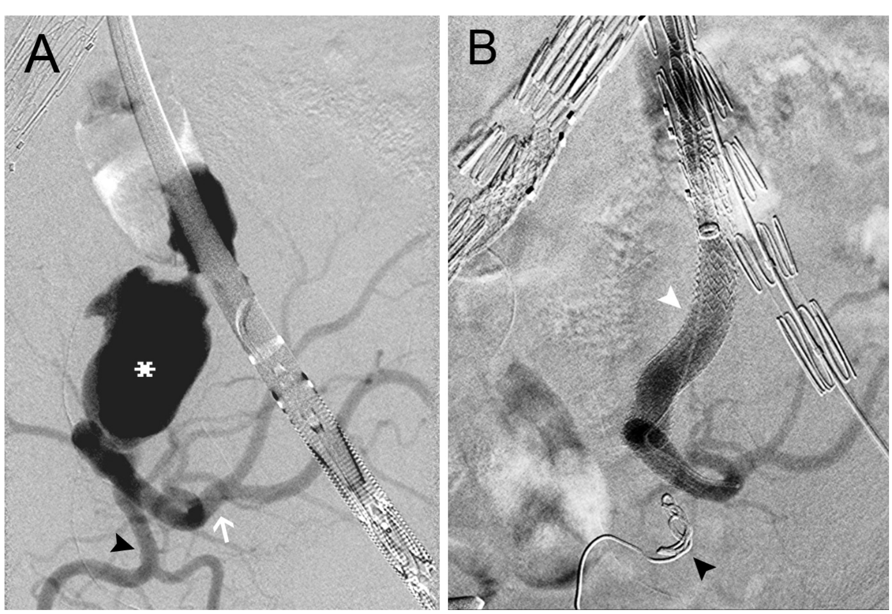

Figure 1. Angiogram pre and post device deployment. (A) Right anterior oblique (RAO) angiogram shows the internal iliac artery aneurysm (asterisk), the SGA (white arrow) and the anterior division of the IIA (black arrowhead). (B) Angiogram post stent graft deployment shows the Viabahn stent graft across the excluded internal iliac aneurysm (white arrow) and anterior division of the IIA occluded with coils (black arrowhead). The superior gluteal artery is widely patent.

Table 1. Patient comorbidities.

Comorbidities	No.	Percentage (%)
Hypertension	10	66.7
Diabetes mellitus	2	13.3
Dyslipidemia	12	80
Chronic renal insufficiency	2	13.3
Previous MI or documented CAD	7	46.7
Documented COPD	2	13.3
Active smoking	2	13.3
Past smoking history	10	66.7%

Note. CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; MI = myocardial infarction.

USA) was used as a proximal bridging stent in five cases (see Table 2). Fluency (Bard, Flagstaff, AZ, USA) stent graft was used primarily for the first patient, but as operators gained experience, Viabahn stent grafts became the stent of choice due to superior flexibility and ease of delivery. When the fluency stent was used in the SGA, the graft was lined with a self expanding bare metal stent for more conformability and less kinking.

Follow up

Clinical follow up was by vascular surgery clinic visits quarterly for the first year and biannually thereafter. During the first clinic visit at 1 month, all patients were asked specifically for the presence of buttock claudication. Imaging follow up was with triphasic CTA during the first month after intervention and annually thereafter. Grayscale and Doppler ultrasound were also performed at the time of the vascular clinic visit, between the CTA follow ups.

Study endpoints and variables

Technical success was defined as successful implantation of the IBG with preservation of antegrade flow in the SGA and absence of type I or type III endoleak on the immediate post-implantation angiogram. Buttock claudication, primary patency of the SGA stent graft on imaging, presence of endoleak, re-interventions, and 30 day mortality and morbidity were evaluated outcomes. Patients' variables included medical comorbidities, abdominal aortic aneurysm (AAA), CIAA, and IIAA sizes, and size of the SGA 3 cm before the greater sciatic foramen. All measurements were performed by a board certified radiologist of 2 years' experience with interpretation of CTA. Procedural variables included type and length of stent graft, presence of coil embolization of the IIA anterior division, fluoroscopy time, procedure time, contrast volume, and hospital length of stay. Measured values are reported as percentage and means ± standard deviations (SDs). The Fisher exact test was used to measure the association between binary variables. Data analysis was performed with Microsoft Excel (Redmond, CA, USA).

RESULTS

From May 2009 to November 2014, there were 67 IBG procedures; of these, 15 patients underwent IBG placement with distal seal in the SGA because of dilatation of the IIA main trunk. Five of those patients were treated bilaterally, with a total of 20 aneurysms treated. Patients were all male with a mean age of 76.8 years (SD 6.1, range 69.8–85.7 years). Patient comorbidities are summarized in Table 1. Mean pre-procedure IIAA diameter was 33 mm (SD 13.2, range 15–57 mm) and CIA diameter was 35 mm (SD 11.1, range 18–58 mm). Mean SGA diameter was 7.0 mm (SD 1.3, range 5.0–10.6 mm). Mean aortic diameter was 50 mm (SD 23, range 24–103 mm). AAA was one of the primary indications for the procedure in 12 patients (mean: 64 mm) and CIAA in 10 (mean: 41 mm). IIAA was the sole indication for repair in four patients (mean: 44 mm). Two of these patients had a previous history of aorto-bi-iliac bypass (ABIB) and underwent only iliac aneurysm repair where the IBG was landed proximally in a previously placed surgical limb. The other 13 patients (86.7%) underwent a concomitant aorto-iliac endovascular repair.

Technical success rate was 100%. Mean procedural fluoroscopy time was 72 min (SD 31 min) and the mean dose area product (DAP) was 296.3 Gy/cm^2 (SD 175.6 Gy/cm^2). Mean contrast volume (iodixanol 270 mg I/mL) was 208 mL (SD 59 mL) and mean procedure time 168 min (SD 64 min). Table 2 summarizes the patient characteristics and procedural details for each case. One stent graft was needed to extend from the SGA to the IBG device branch in 13 of the 20 cases performed (65%), and two were used in the other seven cases (35%). Embolization of the anterior division of the IIA prior to stent graft deployment was performed in 11 cases (55%). In three patients there was complete contralateral embolization of the proximal IIA to allow for endovascular treatment of CIAA with extension of the iliac limb into the external iliac artery. In two patients, the contralateral IIA was already occluded on pre-procedure CTA. Ten patients (66.7%) had bilateral antegrade IIA flow after the procedure.

The mean hospital length of stay was 7.4 days and 30 day mortality was 5% ($n = 1$). This patient died of mesenteric ischemia 2 days after the intervention, from a complication of a custom three vessel fenestrated abdominal aortic stent graft. This patient was therefore excluded from the subsequent analysis. Two patients (10.5%) experienced unilateral lower limb monoparesis post procedure. Both had undergone complete embolization of the proximal IIA with coils on the symptomatic side. The association between unilateral complete IIA embolization and presence of lower limb paresis was statistically significant ($p = .038$). One patient recuperated fully in the first week post procedure. The other patient recuperated partially and still needed a walker to ambulate outside the house. Re-intervention was performed in one case (5.2%) 6 days post procedure because of an asymptomatic stenosis from a kink in the external iliac artery (EIA) component of the graft, diagnosed on CTA. A balloon expandable stent was implanted in the EIA with a good result. For the 30 day morbidity, two patients (10.5%) suffered from myocardial infarction during the post-procedure hospital stay. One patient (5.2%) suffered from high grade atrio-ventricular heart block and had a pacemaker fitted. Two patients (10.4%) had new onset atrial fibrillation during the hospital stay. One patient (5.2%) suffered from pneumonia and *Clostridium difficile*.

Table 2. Aneurysm characteristics, procedural details, and outcomes.

Case	IIA size pre, mm	IIA size at follow up, mm	Contralateral IIA	Embolization of IIA branches	Stents used, prox./distal, mm	Buttock claudication	Primary patency	Endoleak	Complications
1	R: 24	R: 24	L: coiled	Yes	iCast 8 × 38/Viabahn 8 × 100	No	Yes	No	Left monoparesis, non-occlusive clot in branch, atrial Fibrillation
2	R: 25	R: 23	L: Patent	No	Viabahn 8 × 100	No	Yes	No	—
3	L: 21	L: 21	R: Patent	Yes	Viabahn 8 × 150	No	Yes	No	Pneumonia, *C. difficile*, atrial fibrillation
4	R: 43 L: 56	R: 32 L: 77	—	R: Yes L: No	R: Fluency 9 × 120 + Zilver 10 × 80 L: Fluency 9 × 60/ Viabahn 7 × 100	No	Yes	L: Yes, Type II	L: Type II endoleak L: Dehiscence of vascular anastomosis
5	R:35 L: 40	R: 35 L: 37	—	R: No L: Yes	R: Viabahn 10 × 100 L: Viabahn 10 × 100	No	Yes	No	Heart block, pacemaker fitted
6	R: 32	R:32	L: Occluded	No	Viabahn 8 × 100	No	Yes	No	—
7	L: 18	L: 17	Patent	No	Viabahn 8 × 100	No	Yes	No	Myocardial infarct Reintervention for occlusion of EIA graft
8	L: 28	L: 15	R: coiled	No	Viabahn 8 × 100	No	Yes	No	Myocardial infarct
9	R: 22	N/A	L: Occluded	Yes	iCast 7 × 22/ Viabahn 10 × 100	No	Yes	No	Death from mesenteric ischemia
10	R: 15 L: 24	R: 15 L: 18	—	R: Yes L: Yes	R: Viabahn 8 × 100 L: Viabahn 8 × 100	No	Yes	No	—
11	R: 45 L: 57	R:44 L: 57	—	R: Yes L: Yes	R: Viabahn 8 × 150 L: Viabahn 8 × 100/ Viabahn 8 × 150	No	Yes	No	—
12	L: 54	L: 51	Patent	No	Viabahn 9 × 100	No	Yes	No	—
13	R: 40	R: 30	Patent	No	iCast 8 × 38/ Viabahn 8 × 150	No	Yes	No	—
14	L: 33	L:33	R: coiled	Yes	Viabahn 8 × 100	No	Yes	No	Right monoparesis
15	R: 29 L: 31	R: 29 L: 31	—	R: No L: Yes	R: iCast 7 × 22/ Viabahn 8 × 100 L: iCast 7 × 38/ Viabahn 8 × 100	No	Yes	No	—

EIA = external iliac artery; IIA = internal iliac artery; L = left side; R = right side.

Figure 2. Volume rendering three dimensional reconstruction of follow up computed tomography angiography. White arrowhead = patent left superior gluteal artery; white arrow = junction of the stent graft with the iliac branch graft device side-branch.

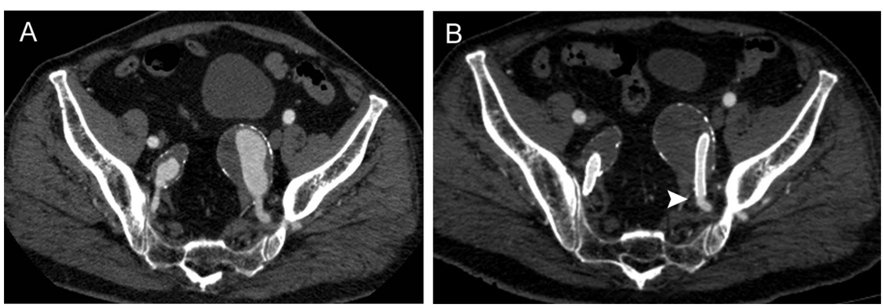

Figure 3. Pre- and post-procedure computed tomography angiography (CTA) (A) Bilateral internal iliac artery aneurysms with patent superior gluteal artery (SGA). (B) CTA 1 year post bilateral iliac branch graft device placement shows patent stent grafts and excluded internal iliac artery aneurysm. White arrowhead = transition between left stent graft and SGA.

At clinic follow up (mean: 19.7 months, SD 18.1 months), all patients were free from buttock claudication. Mean imaging follow up duration was 18.3 months (SD 15.1 months). At imaging follow up, the IIAA sac was stable or decreased (mean: 33 mm) in 95% of cases. Primary patency rate of the iliac branch and SGA was 100% (Fig. 2). In one patient, there was a non-occlusive clot in the IIA branch on CTA the day after surgery. The patient was anticoagulated with Coumadin for 3 months and the clot resolved at follow up imaging. A type II endoleak was present in one patient (5%) on CT follow up (Fig. 3). The IIA sac increased from 56 mm to 77 mm. This 91 year old patient refused treatment of the endoleak and is still undergoing follow up without rupture at 65 months.

DISCUSSION

IBGs are designed to preserve IIA flow in the endovascular treatment of CIA aneurysms. The alternative of IIA embolization is not harmless. The incidence of buttock claudication following bilateral IIA embolization has been reported as high as 42%.[8,9] In about one third of patients, buttock claudication does not regress and may lead to severe quality of life impairment.[10] When patients have a concomitant IIA aneurysm, preservation of pelvic blood flow provides an additional challenge. In these cases, extension of the IBG into the divisional iliac branches can provide a satisfactory distal seal. In the patients reported here, the stent graft was extended to the SGA, which is the larger IIA branch and the main blood supply to the gluteal muscles. Buttock claudication was successfully prevented.

In other published series, the presence of an aneurysm in the internal iliac artery main trunk has been shown to increase the difficulty of IBG deployment and has been potentially associated with an increased risk of endoleak. Wong et al.[2] in 2013 published a large series of IBG placement. Presence of an IIAA was responsible for one third of the technical failures and all the cases of endoleaks. Parlani et al.[1] published long-term outcomes of IBG for iliac aneurysms and reported that IIAA was a predictor of reintervention. In the current series, the technical success rate was excellent. The distal stent graft was always deployed first and extended proximally if required. The stent graft of choice was Viabahn, which conformed well to the tortuosity of the posterior division of the IIA. When a second stent graft was required proximally, both self expandable and balloon expandable stent grafts were used successfully as long as there was at least 2—3 cm of overlap between the stents. In the initial experience when the Viabahn stent graft was not available the Fluency stent graft was used.

In 2013, Austermann et al.[7] reported their technique for insertion of IBGs in IIAAs. Austermann et al.[7] proposed the use of a proximal balloon expandable covered stent deployed first, with subsequent deployment of a distal stent graft. A bare metal stent was used to reinforce and smooth the transition between the two stent grafts. In the series of 16 patients, an excellent primary patency rate of 95.3%, with no buttock claudication and no endoleak, was reported. The article suggests this specific stent combination might offer a better outcome.[7] This specific technique was not used in the patients reported here. The Viabahn was not routinely relined as described here, as it was found that this graft was kink resistant and relining was unnecessary. In addition, a single Viabahn stent was used for the procedure rather than the multiple stents described above. It is believed that a single stent graft is less likely to kink or dislocate and involves less wire and catheter exchanges. If the initial stent graft was too short, a second Viabahn or iCast stent graft would be used to extend proximally.

Considering the length of stent grafts (>10 cm) and the relatively small size of the SGA (mean: 7 mm), there is concern for thrombosis. This was not a clinical issue in this case series as only one patient presented with non-occlusive thrombus that resolved with anticoagulation alone. Other published series also reported an excellent patency for the branch stent graft in a divisional artery.[2,7]

One case of type II endoleak was observed. In this patient, the anterior division originated from the IIAA and measured 6 mm. Embolization was attempted, but was unsuccessful due to inability to select the anterior division. The endoleak originated from the branch that could not be occluded. In all cases, if small branches (<5 mm) arising from the IIAAs were seen, they were not embolized. There was no endoleak from these small uncoiled pelvic branches. Embolization of the anterior division of IIAA could be associated with a potential risk of ischemic pelvic symptoms. This was not seen in this patient group. However, patients were not specifically questioned for erectile dysfunction at follow up. In the literature, there is one case of mild erectile dysfunction reported secondary to embolization of the anterior division of the IIA alone.[7] The authors hypothesize that in most patients the collaterals between the superior and inferior gluteal arteries might help preserve flow in the anterior division. Buttock claudication was absent in all patients, but two of three patients who had unilateral complete IIA embolization suffered from ipsilateral lower limb monoparesis. This was thought to be secondary to lumbo-sacral plexus ischemia from the embolization, a previously described complication.[11] This underlines the potential morbidity of IIA embolization. The authors try to keep both IIAs patent if possible, and in this series one third of patients had an IBG placed on both sides.

Compared to the large series published by Parlani et al.[1] on IBGs, the mean procedure time, fluoroscopy time, and the contrast volume are higher in this series. This may be in part a result of the higher complexity of the procedure, and the need for embolization of the IIA division in more than half of the patients. No cases of acute renal failure or radiation induced 30 day complications were observed. There was a surprisingly large number of post-procedure adverse events in the patients, including death from mesenteric ischemia, arrhythmias, and myocardial infarction. These complications are partly secondary to patient age and multiple comorbidities. Advanced EVAR techniques require longer procedure times and this may have contributed to the high morbidity. Limitations of the study include its retrospective nature, the absence of a comparison group, the lack of a standardized assessment for buttock claudication, the small number of patients included, and the lack of long-term follow up.

In summary, IBGs can be used successfully to treat IIAAs by extending into the SGA for distal sealing. The patency rate is excellent and buttock claudication was successfully prevented. Studies with more patients and long-term follow up are needed to further validate this procedure.

CONFLICT OF INTEREST

None.

FUNDING

None.

ACKNOWLEDGMENTS

Research support from the Black Family Foundation, Peter Munk Cardiac Center, University Health Network.

REFERENCES

1 Parlani G, Verzini F, De rango P, Brambilla D, Coscarella C, Ferrer C, et al. Long-term results of iliac aneurysm repair with iliac branched endograft: a 5 year experience on 100 consecutive cases. *Eur J Vasc Endovasc Surg* 2012;**43**(3):287—92.
2 Wong S, Greenberg RK, Brown CR, Mastracci TM, Bena J, Eagleton MJ. Endovascular repair of aortoiliac aneurysmal disease with the helical iliac bifurcation device and the bifurcated-bifurcated iliac bifurcation device. *J Vasc Surg* 2013;**58**(4):861—9.
3 Pua U, Tan K, Rubin BB, Sniderman KW, Rajan DK, Oreopoulos GD, et al. Iliac branch graft in the treatment of complex aortoiliac aneurysms: early results from a North American institution. *J Vasc Interv Radiol* 2011;**22**(4):542—9.
4 Verzini F, Parlani G, Romano L, De rango P, Panuccio G, Cao P. Endovascular treatment of iliac aneurysm: concurrent comparison of side branch endograft versus hypogastric exclusion. *J Vasc Surg* 2009;**49**(5):1154—61.
5 Donas KP, Torsello G, Pitoulias GA, Austermann M, Papadimitriou DK. Surgical versus endovascular repair by iliac branch device of aneurysms involving the iliac bifurcation. *J Vasc Surg* 2011;**53**(5):1223—9.
6 Huang Y, Gloviczki P, Duncan AA, Kalra M, Hoskin TL, Oderich GS, et al. Common iliac artery aneurysm: expansion rate and results of open surgical and endovascular repair. *J Vasc Surg* 2008;**47**:1203—10.
7 Austermann M, Bisdas T, Torsello G, Bosiers MJ, Lazaridis K, Donas KP. Outcomes of a novel technique of endovascular repair of aneurysmal internal iliac arteries using iliac branch devices. *J Vasc Surg* 2013;**58**(5):1186—91.
8 Chun JY, Mailli L, Abbasi MA, Belli AM, Gonsalves M, Munneke G, et al. Embolization of the internal iliac artery before EVAR: is it effective? Is it safe? Which technique should be used? *Cardiovasc Intervent Radiol* 2014;**37**(2):329—36.
9 Lin P, Chen A, Vij A. Hypogastric artery preservation during endovascular aortic aneurysm repair: is it important? *Semin Vasc Surg* 2009;**22**:193—200.
10 Jean-baptiste E, Brizzi S, Bartoli MA, Sadaghianloo N, Baqué J, Magnan PE, et al. Pelvic ischemia and quality of life scores after interventional occlusion of the hypogastric artery in patients undergoing endovascular aortic aneurysm repair. *J Vasc Surg* 2014;**60**(1):40—9. 49.e1.
11 Abdellaoui A, West NJ, Tomlinson MA, Thomas MH, Browning N. Lower limb paralysis from ischaemic neuropathy of the lumbosacral plexus following aorto-iliac procedures. *Interact Cardiovasc Thorac Surg* 2007;**6**(4):501—2.