Experience with a novel custom-made fenestrated stent graft in the repair of juxtarenal and type IV thoracoabdominal aneurysms

Alexander E. Rolls, MRCS,[a] Michael Jenkins, MS, FRCS,[a] Colin D. Bicknell, MD, FRCS,[a] Celia V. Riga, MD, MRCS,[a] Nick J. Cheshire, MD, FRCS,[a] Nick Burfitt, FRCR,[b] and Mohamad Hamady, MD, FRCR,[b] *London, United Kingdom*

Objective: **Fenestrated stent grafting has become increasingly popular as a means to manage complex aortic pathology, including juxta- and pararenal aneurysms. The design of a recently developed custom-made fenestrated stent graft, in theory, confers advantages when managing anatomically challenging aortic morphology. This study evaluated its feasibility in anatomically challenging scenarios.**

Methods: **Over a 12-month period, 20 patients received fenestrated stent grafts. Among those, 13 patients with juxtarenal or type IV thoracoabdominal aortic aneurysms underwent endovascular repair with the novel fenestrated stent graft at a single UK institution. Data on aneurysm morphology and immediate and short-term results were collected prospectively.**

Results: **The mean aneurysmal sac size was 7.3 cm (range, 5.5-10.0 cm). The mean infrarenal neck length was 4.4 mm (range, 0-9 mm), and in three cases was lined by a pre-existing infrarenal stent graft. Nine cases had an infrarenal neck angulation of 60° or more in either the anteroposterior or coronal planes. Five cases had ≥50% thrombus at the proximal landing zone. A total of 35 target vessels were cannulated, of which six right renal and four left renal arteries were angulated ≥120°. Two-thirds of cannulated celiac trunks were angulated ≥120°, and one cannulated superior mesenteric artery was angulated ≥ 140°. Seven of the cannulated targets were stenosed more than 60%. One patient had two right renal arteries arising 3 mm from each other. Four right and four left common iliac arteries were angulated ≥90° in relation to the infrarenal aorta. Technical success was 100%. Median time from date of procedure to most recent follow-up with computed tomography scanning was 33 weeks. There was no type I or III endoleak. One type II endoleak was observed at the time of most recent computed tomography scanning and treated expectantly. There was a single incident of left renal artery occlusion. One patient required repair of a brachial artery, fasciotomies, and temporary haemofiltration. One patient died from ischemic heart disease 77 weeks after the procedure.**

Conclusions: **The use of the novel fenestrated stent graft system in patients with hostile aortic aneurysmal morphology is feasible with acceptable short-term outcomes. (J Vasc Surg 2014;59:615-22.)**

Since the introduction of endovascular aneurysm exclusion by Parodi et al, stent graft design has undergone constant evolution, largely driven by recognition of graft-associated complications including endoleaks, stent migration, infection, and iliac limb kinking and occlusion.[1] Despite improvements in graft and fabric technology and demonstrated improvements in morbidity and mortality, hostile anatomic factors including short (<15 mm) and angulated (>60°) proximal aneurysmal neck, inclusion of visceral branches, tortuous and narrow access vessels prevent more extensive use of this technique.[2] In addition, late data from endovascular aneurysm repair (EVAR) trials have shown that using infrarenal abdominal aortic aneurysm (IRAAA) EVAR stents outside instructions-for-use may result in significantly more late complications and graft-related adverse events.[3-5] In order to overcome these anatomical restrictions and decrease long-term complication rates, fenestrated stent grafting was developed; allowing use of the visceral segment as a landing zone if the aneurysmal neck is deemed too short, or actual exclusion of an aneurysm that involves visceral target vessels. Subsequent studies have demonstrated fenestrated endovascular aortic repair (FEVAR) as a reliable means to treat aneurysms with complex morphology involving visceral aortic segments, with lower overall mortality as compared to open repair and with high short- and mid-term target vessel patency rates.[6-9]

Nevertheless, the suitability for this technology is hampered by planning and technical difficulties secondary to hostile anatomy. In a study of 70 patients with complex aortic aneurysms, only 60% of patients were deemed suitable for mainstream fenestration technology.[10] New designs of FEVAR devices have been developed to address the current limitations.[11]

From the Imperial Vascular Unit,[a] and Department of Interventional Radiology,[b] Imperial College Healthcare National Health Service Trust.
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Reprint requests: Alexander E. Rolls, MRCS, Imperial Vascular Unit, Imperial College Healthcare National Health Service Trust, Vascular Secretaries Office, Waller Cardiac Building, St. Mary's Hospital, Praed Street, London W2 1NY, UK (e-mail: alex.rolls1981@googlemail.com).
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Table I. Patient demographics

Patient No.	*Sex*	*Age, years*	*Comorbidities*	*ASA*
1	F	87	Hypertension, osteoarthritis	III
2	M	69	Hypertension, smoker, hypercholesterolemia, COPD, pancreatitis, peptic ulcer disease	III
3	M	83	Hypertension, smoker, colorectal Ca	III
4	M	69	Type II diabetes, hypertension, ischemic heart disease, obesity	III
5	F	73	Type II diabetes, hypertension, smoker, ischemic heart disease, hypercholesterolemia, COPD	III
6	F	72	Hypertension, smoker, breast Ca, uterine Ca, single functioning right kidney	III
7	M	87	Hypertension, smoker, diabetes	III
8	M	75	Hypertension, hypercholesterolaemia	IV
9	F	77	Smoker, hypertension, congestive cardiac failure, COPD	III
10	M	84	Smoker, hypertension, cerebro-vascular accident	III
11	F	86	Paroxysmal AF, TIA, hypertension, ischemic heart disease	III
12	M	72	Smoker, hypertension, AF, ischemic heart disease	III
13	M	68	Smoker, hypertension, AF	III

AF, Atrial fibrillation; *ASA,* American Society of Anesthesiologists; *Ca,* cancer; *COPD,* chronic obstructive pulmonary disease; *TIA,* transient ischemic attack.

The purpose of this article was to describe our experience with the custom-made Anaconda fenestrated stent graft system (Vascutek, Inchinnan, United Kingdom) in a series of patients with complex anatomy best suited to this stent graft system. In particular, emphasis is placed on the anatomical challenges presented by each case in this series, encompassing short and angulated aneurysmal necks, re-do endovascular procedures with existing stent grafts in place, excessively tortuous iliacs, and stenosed or aberrant target vessel anatomy in some cases. The authors have no relationship with Vascutek, and the company did not sponsor this article.

METHODS

Patient selection. Between August 2011 and August 2012, 20 patients received fenestrated stent grafts; 13 of them were included in this study. Over the same time period, 18 patients underwent open repair for juxtarenal or thoracoabdominal aortic aneurysms. Patients were selected on the basis of having two or more of the challenging anatomical features described below, which, in a number of cases, required the use of a graft outside the instructions-for-use for existing fenestrated devices. The design of the fenestrated Anaconda stent graft system was determined to be appropriate in these cases, given its repositionable and unsupported body, which afforded flexibility when aligning fenestrations in cases of severe proximal angulation or challenging access vessels. The ability to cannulate fenestrations via a proximal brachial approach further facilitated cannulation of caudally oriented target vessels. Data were prospectively collected on patient demographics and comorbidities (Table I), and abdominal aortic aneurysm and target vessel anatomy. All computed tomographies (CTs) were examined by a single radiologist and angulation measured according to the scheme given in Fig 1. Stent graft, procedural, and follow-up data including CT examinations were collated. Our normal threshold for treating standard infrarenal aneurysms is 5.5 cm. Indications for fenestrated stenting in complex aneurysms were aneurysm size above or equal to 6 cm or growth exceeding 1 cm per year, together with unsuitable proximal necks (<1 cm, conical) or an aneurysm that involved the visceral segment. The specific indications for treatment of patients with complex aneurysms below 6 cm were: Female gender, rapid growth, and patient anxiety.

All patients underwent preoperative high-resolution computed tomographic angiography (CTA) and selective preoperative cardiac and pulmonary assessment including stress-echocardiography, pulmonary function testing, and MAG-III scanning. Three-dimensional and multiplanar workstation (Phillips Healthcare, Andover, Mass) reconstructions were performed in order to assess aneurysm morphology and plan graft dimensions. Following multidisciplinary team discussion, devices were customized to include all those vessels deemed essential for target organ function. Unfavorable anatomy in this series was defined as cases having two or more of the following characteristics: Infrarenal neck angulation $\geq 60^\circ$, down-stream angulation of renal arteries and celiac trunk $\geq 120^\circ$, angulation of superior mesenteric artery (SMA) $\geq 140^\circ$ and common iliac artery angulation $\geq 90^\circ$, ostial stenosis >60%, multiple targets in close proximity ≤ 3 mm (eg, two right renals), and pre-existing infrarenal aortic stents with suprarenal fixation.[10]

Anaconda abdominal aortic aneurysm stent graft system. The custom fenestrated Anaconda system has previously been described in detail.[2] The Anaconda system consists of three separate components; the aortic endograft and two separate iliac legs. The proximal end of the main body of the aortic endograft has two separate nitinol ring stents separated from each other by a distance of 8 to 11 mm. Four "pairs" of nitinol hooks protrude in a caudal direction from the inferior ring described above and provide a positive sealing function. The body itself is unsupported by ring stents, which maximizes the available area through which fenestrations can be made. The combination of the proximal sealing rings and the unsupported body facilitates treatment of angulated necks. One of the principal advantages of this stent graft system is its repositionability; the "control collar" allows the

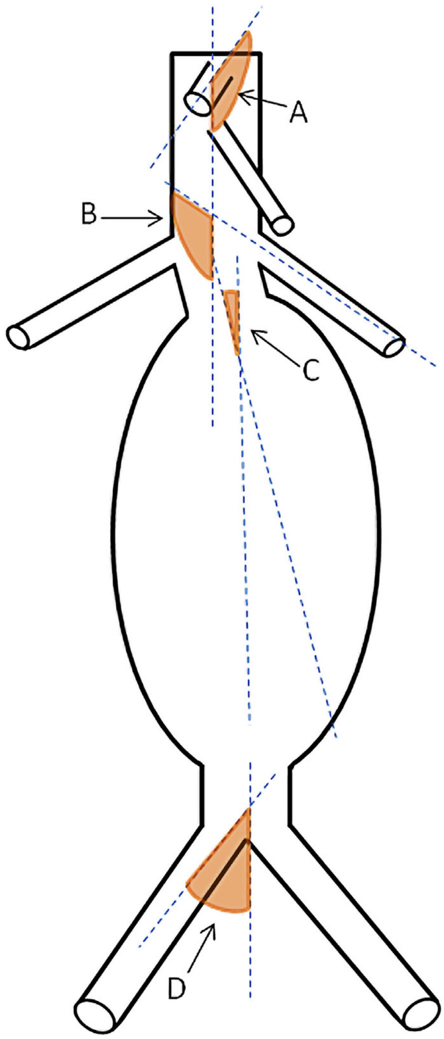

Fig 1. Angles measured in preoperative planning. All angles were measured in relation to the long-axis of the aorta. **A,** Celiac trunk angle. **B,** Renal artery angle. **C,** Infrarenal neck angle. **D,** Common iliac artery angle. Superior mesenteric artery (SMA) angle measured the same way as computed tomography (CT) angle.

interventionalist to collapse, rotate, advance, retract, and ultimately redeploy the graft. The stent graft system allows for cannulation of caudally angulated target vessels from above, immediately following unsheathing of the stent graft in a partially deployed state, but remains redeployable. No other currently available device allows this.

Stent graft planning. CTA digital imaging and communications in medicine data were imported into a Phillips workstation (Phillips Healthcare) for 3D reconstruction and for detailed assessment and measurement of aneurysm morphology in order to facilitate graft planning. Position, angulation, and size of target vessel ostia, aneurysm neck length, diameter, and angulation, and position of aortic bifurcation with respect to aneurysm sac as well as iliac tortuosity were taken into account. All angulation measurements were taken in relation to the midline of the aorta, as seen in Fig 1. Additionally, proximal landing zone calcification and mural thrombus were taken into account. In order to confirm correct position of the fenestrations with respect to ostia and to provide a preprocedure rehearsal opportunity for the primary operator, prototype stents were developed and deployed in silicone aortic models based on the each individual patient's CTA data.

Graft deployment. All procedures were performed in the hybrid operating suite following induction of general anesthesia. Bilateral common femoral arteries were exposed surgically in all cases, and additional access was obtained through the brachial arteries in order to facilitate target vessel cannulation in cases where the latter were significantly caudally angulated. In some cases, where external iliac arteries were found to be <7 mm in diameter, a Dacron conduit was fashioned to facilitate passage of the delivery system. A dosage of 100 IU/kg body-weight of unfractionated heparin was administered systemically immediately prior to accessing the arterial system, and boluses were administered throughout to keep the activated clotting time at 250 to 300 seconds.

The main body was then positioned according to target vessels; the position of the renals was used to determine the craniocaudal position of the graft, and the "valleys" of the proximal end of the main body were oriented anteroposteriorly in order to accommodate the superior mesenteric or celiac arteries. In selected cases, fenestrations were used to accommodate the SMA, and the "valley" was therefore used to allow inflow into the celiac artery. Therefore "peaks" are oriented laterally and above the renals in most cases. Target vessels were then cannulated with a combination of preshaped conventional catheters or robotic (Hansen Medical, Mountain View, Calif) catheters. After selective angiography to confirm adequate target vessel cannulation, V12 Advanta balloon-expandable covered stents (Atrium Medical Corporation, Hudson, NH) of suitable sizes were deployed through Ansel sheaths (Cook Peripheral Intervention, Bloomington, Ind) and flared proximally. The iliac legs were subsequently deployed with the aid of the magnetic cannulation system for the contralateral limb and all junctions expanded with a moulding balloon. Completion angiography was performed to confirm the absence of immediate complications such as endoleak or target-vessel obstruction.

Follow-up and postoperative care. After completion of the procedure, all patients were transferred to a specialist vascular high-dependency unit, where invasive arterial and central venous monitoring could be continued. The unit has the capacity for systems support in the form of noninvasive ventilation and inotrope/vasopressor circulatory support if required. Following discharge, all patients were placed on a surveillance program consisting of CTA and renal function testing at less than 1 month, 6 months, and yearly thereafter. Specifically, reconstructions were performed to identify branch stent stenoses.

Table II. Aneurysm morphology

Patient No.	*Sac size, cm*	*Infrarenal neck angulation Coronal/AP, degrees*	*Aortic diameter at renal level, mm*	*Aortic diameter at sealing zone, mm*	*Degree of thrombus*	*Degree of calcification*	*Neck length, mm*	*Operative approach*[a]
1	5.7	4/8	26	27	50%	Minimal	5	Juxtarenal
2	6.4	49/64	22	26	45%	Negative	9	Juxtarenal
3	8.8	24/65	26	23	Negative	Negative	0	Juxtarenal
4	7.6	66/25	26	25	50%	Negative	7.6	Juxtarenal
5	6.0	16/65	21	27	50%	Negative	0	Type IV
6	5.9	47/20	24	26	Negative	Negative	6.9	Juxtarenal
7	6.6	78/15	27	24	50%	Negative	1	Juxtarenal
8	10.0	29/42	30	28	50%	Negative	Pre-exisiting stent	Type IV
9	5.5	80/36	25	25	Negative	Negative	5	Juxtarenal
10	9.0	73/53	23	27	Negative	Negative	Pre-existing stent	Type IV
11	8.0	70/50	27	22	Negative	Negative	2	Juxtarenal
12	7.7	32/23	29	26	Negative	Negative	Pre-existing stent	Type IV
13	7.3	81/36	26	22	Negative	Negative	7.1	Juxtarenal

[a]For the purposes of this article, anatomical variants were classified by the operative approach that would have been required in open surgery: *Juxtarenal*, clamp placed above renals; *Type IV*, medial visceral rotation with clamp placed above celiac axis.

RESULTS

Demographics and indications. Over a period of 12 months, 13 fenestrated EVARs were performed on patients who met appropriate indications for fenestrated stenting and had two or more hostile anatomic features using the Anaconda device. The cohort included five females and eight males; median age was 75 years (range, 68-87 years). Patient American Society of Anesthesiologists status ranged from III to IV, and comorbidities are listed in Table I. Patient 1 demonstrated rapid growth (7 mm) in the 6 months prior to intervention.

Aneurysm morphology. The mean aneurysmal sac size was 7.3 cm (range, 5.5-10.0 cm). The mean infrarenal neck length was 4.4 mm (range, 0-9 mm), and in three cases was lined by a pre-existing stent and had type Ia endoleaks (Table II). Nine cases had an infrarenal neck angulation of at least 60° in either the AP or coronal planes; three in the AP plane and six in the coronal plane. Mean aortic diameter at the sealing zone was 25.1 mm (range, 22-27.7 mm) and at the level of the renal vessels 25.5 mm (range, 22-30 mm). Five cases had 50% thrombosis at the proximal landing zone. Three-dimensional reconstructions of two of the cases are given as examples in Fig 2.

Target vessels. Thirty-five target vessels were cannulated; two patients had one target vessel treated, three had two vessels treated, five had three vessels treated, and three had four vessels treated (Supplementary Table, online only). The adverse anatomical features were six right and six left renal artery ostial stenoses (≥60%), six right and four left renal arteries were angulated >120°, eight celiac axes were likewise angulated >120°. One of the cannulated SMAs was angulated >140°. Two-thirds of cannulated CTs were angulated >120°, while one was stenotic.

Access vessels. Four right common iliac- and four left common iliac arteries were angulated >90°. In three cases, both common iliac arteries were angulated >90°. The Supplementary Table (online only) gives common iliac artery angulations encountered in each case. Only three patients (1, 8, 12) did not have significant neck or iliac tortuosity.

Technical success. The stent graft was successfully deployed in all patients, and there were no technical issues with the control or release mechanisms. Two patients required repositioning of the main body before complete deployment in order to align renal fenestrations with the corresponding target vessels. In addition, this repositioning feature was utilized to ‘restrain’ the stent graft from the aortic wall, in order to aid cannulation of a fenestration in the presence of a stenosed target vessel (Patient 3). A total of 35 target vessels were cannulated successfully through fenestrations, and there were no instances of branch-stent occlusion or kinking on predischarge follow-up scanning. One left renal artery was found to be occluded on CT scan at 30 weeks. There was one instance of a single iliac limb kink that did not result in significant hemodynamic or symptomatic consequences. Two endoleaks were identified on intraprocedural angiography: one type III endoleak was identified arising from the junction between the right renal stent and the corresponding fenestration, and was managed intraoperatively by flaring the proximal portion of the stent with a 12 mm balloon. In another patient, check angiography showed evidence of a proximal type Ia endoleak: the anterior valley (accommodating the SMA) was held off the aorta by an irregularity in the aortic wall, and stenting and flaring the SMA allowed apposition and seal, eliminating the type I endoleak. Early CT scanning (median duration from procedure, 4 days) demonstrated four type II endoleaks, as seen in Table III. One early scan was delayed due to contrast nephropathy and was subsequently performed at the patient’s local hospital. Eleven patients had subsequent CT scans (median duration to most recent scan, 33 weeks), at which point one type II endoleak was observed. There were no type I or type III endoleaks. There was concern regarding graft infection in one patient who was

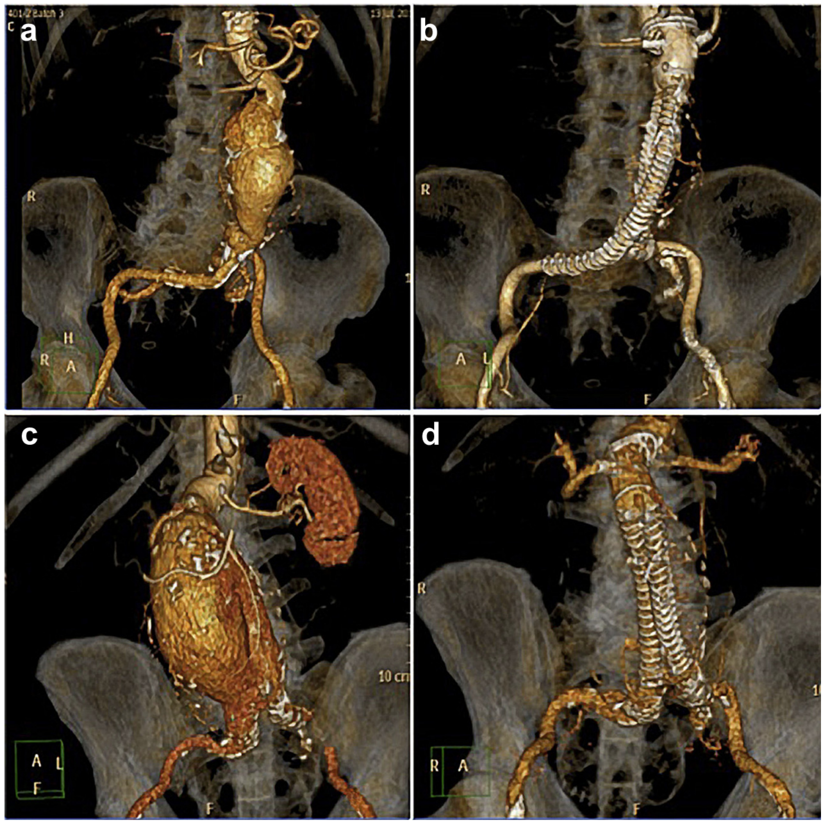

Fig 2. Three-dimensional reconstructions demonstrating adverse adverse anatomical features. **a,** Angulated neck, narrowing of the aorta at the renal level, difficult course of left renal artery, and angulated right common iliac artery. **b,** Same patient post-treatment. **c,** Angulated neck, difficult right renal artery take-off, caudally oriented left renal artery, and tortuous iliacs bilaterally. **d,** Same patient post-treatment.

subsequently treated with aggressive intravenous antibiotic therapy. Subsequently, all investigations have proven negative for an infected graft, and the patient is now off antibiotics and remains well. Two patients demonstrated aneurysm growth following the procedure, although no endoleak was demonstrated, and both were closely observed. One of these patients (Patient 2) underwent ultraselective angiography of his lumbar arteries, which failed to demonstrate endoleak despite a growing sac size; this patient is awaiting further urgent imaging with MRI followed by multidisciplinary discussion.

Morbidity and mortality. Mortality at 30 days was 0%. Mean estimated blood loss was 650 mL (range, 400-1000 mL). Mean length of stay was 8.5 days (range, 4-20 days), and there was no significant difference between preprocedure and predischarge creatinine ($P = .24$; Wilcoxon signed rank test). One patient experienced a transected left brachial artery, requiring repair with a vein graft in the same operative session. Prolonged left leg ischemia resulted in compartment syndrome and fasciotomy, and subsequent acute renal failure required a 7-day intensive care unit stay for hemofiltration. Shortly prior to discharge to a rehabilitation unit, blood culture revealed Gram-negative rods, requiring placement of a peripherally inserted central catheter and a 6-week course of ertapenem. This patient's renal function returned to baseline. One patient had asymptomatic infarction of the tip of inferior pole of the right kidney as a result of coverage of an accessory right renal vessel by a renal stent that was deployed in the dominant vessel. Renal function in this patient deteriorated transiently but then returned to baseline levels. No patients remained dialysis-dependent.

DISCUSSION

This article describes the use of the Anaconda fenestrated stent graft in complicated anatomical scenarios and is, to our knowledge, the largest series documenting its use. This patient cohort included patients with juxta- and pararenal, as well as type IV thoracoabdominal morphological configurations, and all these patients had two or more anatomical features that were considered unfavorable. The most widely recognized fenestrated device is the Cook Zenith (Cook Medical), with which we have significant experience.[9] For patients either unsuitable for the Cook graft or where we felt significant advantage could be gained in particularly challenging anatomical configurations, we used the Anaconda fenestrated device. These advantages included the ability to cannulate from a brachial approach

Table III. Short-term outcomes

Patient No.	*Estimated blood loss, mL*	*Length of stay, days*	*Discharge disposition*	*Preop creatinine, μmol/L*	*Predischarge creatinine, μmol/L*	*Time to initial scan, days*
1	750	12	Rehab Unit	145	186	8
2	400	6	Home	80	136	252 (delayed −impaired renal function)
3	550	5	Home	83	71	3
4	550	9	Home	169	228	5
5	500	20	Home	109	277	2
6	450	8	Home	78	91	1
7	800	9	Home	101	95	7
8	1000	5	Home	64	55	5
9	500	8	Home	55	56	3
10	650	5	Home	79	88	2
11	800	8	Home	72	56	7
12	1000	4	Home	81	73	3
13	500	11	Home	62	50	4

LRA, left renal artery.

in cases of severe downward angulation (seven patients), significant iliac tortuosity, and/or severe infrarenal neck angulation (10 patients), all of which may hinder cannulation attempts. The unsupported main body places fewer restrictions in terms of the fenestration site, which in this series facilitated cannulation of two renal targets that were very close to each other. Additionally, the graft was repositionable in two cases where aligning renal fenestrations with target vessels was complicated by neck angulation. This early series seems to be successful in terms of aneurysm exclusion; there were no type I or III endoleaks despite significant neck angulation in nine patients.

The use of the Anaconda fenestrated stent graft system has been described in a series describing its application and immediate as well as short-term outcomes (1 month) in four patients with short-neck infrarenal and juxtarenal aneurysms.[2] In the present series, the longest period of follow-up was 65 weeks. The largest two series of fenestrated stent grafting to date describe the use of the Cook fenestrated stent graft, with a maximum of 8 and 4.4 years of follow-up, respectively.[12,13] Although a direct comparison of this data with the present series is therefore not ideal, in both of these series, predischarge endoleaks were a composite of types I, II, and III. Two endoleaks were identified in this series on intraprocedural angiography that required adjunctive measures to obtain a better seal. Four type II endoleaks were noted on discharge, and one type II endoleak at the date of most recent CTA (median, 33 weeks). We identified a single left renal artery occlusion on CTA at 30 weeks that was not present at predischarge scanning. We fully appreciate that these results are difficult to interpret and put into context of existing literature owing to small numbers and short follow-up period. Reports vary in terms of when the majority of occlusions occur, ranging from mainly within the first year and up to 36 months in the French multicenter experience.[13,14] All occlusions in their single-center experience occurred within the first year.[14] In the present series, none of the 13 stenosed vessels required reintervention following the initial bridging stent.

The emphasis of this work is on the utility of a novel fenestrated stent graft system in overcoming challenging anatomical scenarios. Planning of successful fenestrated endovascular intervention needs to bear in mind multiple anatomical factors including aortic morphology, target vessel angulation and diameter, and access vessel tortuosity. Rodd et al describe an anatomical scoring system for thoracoabdominal aortic aneurysms in order to determine suitability for repair by pure endovascular means.[10] Some components of this assessment tool can be applied to the anatomical scenarios described in this study, including target vessel angulation and stenosis and length of proximal and distal landing zones. However, the authors emphasize angulation of the arch itself and the junction between the aortic arch and descending thoracic aorta. Of interest in this study were advantages that a repositionable stent graft system with an unsupported main body might confer during cannulation of challenging targets, which were on occasion positioned on or adjacent to an angulated infrarenal neck. The added advantage of this system is the ability to cannulate the target vessel antegradely while the system is still partially deployed and adjustable. Numerous studies have correlated anatomical complexity in this regard with clinical outcome in standard EVAR in IRAAA; severe neck angulation has been defined previously as angle $\geq 60^\circ$ of the long axis of the aneurysm sac in relation to the abdominal aorta and has been identified as an independent prognostic indicator of adverse outcomes.[15-18]

A combination of main body flexibility and high proximal fixation strength in theory provides a means of overcoming this anatomical problem, and manufacturers have focused on the development of such devices. The standard nonfenestrated Anaconda graft, in addition to the flexibility of its main body, has demonstrated superior proximal fixation strength as opposed other grafts and has delivered promising results in initial studies.[19-21] We identified two

Table III. Continued.

Radiological findings at initial scan	*Time to most recent scan, weeks*	*Preop sac size, cm*	*Sac size at final scan, cm*	*Radiological findings at final scan*
No endoleak	Emigrated prior to follow-up	5.7	5.5	-
8.7 cm sac	61	6.4	9.1	Increasing sac size, no endoleak
Type II endoleak	Died ischemic heart disease 77 weeks	8.8	9.0	-
Type II endoleak	30	7.6	7.3	No endoleak, occluded LRA
No endoleak	42	6.0	5.8	No endoleak
No endoleak	69	5.9	5.1	No endoleak
Type II endoleak	65	6.6	4.9	No endoleak
No endoleak	37	10	10	Type II endoleak
No endoleak	33	5.5	4.7	No endoleak
No endoleak	25	9.0	8.9	No endoleak
No endoleak	32	8.0	7.4	No endoleak
Type II endoleak	39	7.7	8.3	Increasing sac size, no endoleak
No endoleak	48	7.3	7.0	No endoleak

single occurrences of type I and type III endoleak intraoperatively. We did not observe any delayed type I or III endoleaks despite severe neck angulation in 69% of cases, although we acknowledge limited follow-up times in some cases of this series.

There is a paucity of data relating to endoleak rates in FEVAR. EUROSTAR (European Collaborators on Stent-Graft Techniques for Abdominal Aortic Aneurysm Repair Registry) data suggest that standard infrarenal EVAR patients with necks <15 mm in length experienced significantly higher rates of type I endoleaks within 30 days.[22] In theory, this risk is obviated by the ability to land the fenestrated graft on a suprarenal landing zone. Three patients in this series who had previously developed delayed type Ia endoleaks following EVAR underwent relining of the proximal portion of a pre-existing stent graft using fenestrated Anaconda cuff extensions. Vourliotakis et al describe a positive experience with Cook fenestrated grafts for the management of juxta- and pararenal aneurysmal degeneration following previous EVAR in a series of nine patients.[23] To our knowledge, the data presented in this study are the first to describe the use of the Anaconda graft in this particular setting. The redeployable nature of the graft and the unsupported main body facilitated cannulation of the target vessels, and we did not encounter additional difficulties as a result of the pre-existing stents.

CONCLUSIONS

The deployment of the fenestrated Anaconda stent graft system was technically feasible in cases with anatomical complexity. This was facilitated by the unsupported and repositionable main body, as well as antegrade cannulation of target vessels early on in the procedure when the system is still under the operator's control. Short-term results are encouraging in terms of endoleak, target vessel, and iliac limb patency rates. Longer follow-up is warranted to identify durability of this system in terms of late complications such as graft migration and component separation.

AUTHOR CONTRIBUTIONS

Conception and design: NB, MH
Analysis and interpretation: AR, MJ, CB, NB, MH
Data collection: AR
Writing the article: AR, MH
Critical revision of the article: AR, MJ, CB, CR, NC, NB, MH
Final approval of the article: AR, NB, MH
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Supplementary Table (online only). Target/access vessels

Patient	*Vessels fenestrated*	*RRA diameter, mm*	*RRA angulation, degrees*	*LRA diameter, mm*	*LRA angulation, degrees*	*SMA diameter, mm*	*SMA angulation, degrees*	*CT diameter, mm*	*CT angulation, degrees*	*LCIA angulation, degrees*	*RCIA (angulation, degrees)*
1	2 (LRA, RRA)	4 (S)	-	4.5 (S)	150	-	-	-	-	-	-
2	2 (LRA, RRA)	-	129	-	-	-	-	-	-	-	-
3	1 (RRA)	-	128	-	134	-	-	-	-	-	-
4	4 (LRA, RRA, SMA, CT)	-	123	-	-	-	-	7.9 (S)	125	-	-
5	3 (LRA, RRA, SMA)	5 (S)	137	5 (S)	-	-	-	-	-	95	-
6	1 (RRA)	-	127	-	-	-	-	-	-	98	93
7	2 (LRA, RRA)	5.8 (S)	-	5 (S)	-	-	-	-	-	-	90
8	4 (LRA, RRA, SMA, CT)	6.8 (S)	-	6 (S)	-	-	-	-	130	-	-
9	3 (LRA, RRA, SMA)	-	-	-	140	-	-	-	-	-	-
10	3 (LRA, RRA, SMA)	4.5 (S)	129	-	-	-	-	-	-	-	-
11	3 (LRA, RRA, SMA)	-	-	5 (S)	150	-	149	-	-	108	103
12	4 (LRA, RRA, SMA, CT)	5 (S)	-	5.5 (S)	-	-	-	-	-	-	-
13	3 (2x RRA, LRA)	-	-	-	-	-	-	-	-	105	98

CT, Celiac trunk; *LCIA,* left common iliac artery; *LRA,* left renal artery; *RCIA,* right common iliac artery; *RRA,* right renal artery; *SMA,* superior mesenteric artery.

Values are given only for those target vessels that were classified as anatomically challenging.