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Planning and Endograft Related Variables Predisposing to Late Distal Type I Endoleaks

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WHAT THIS PAPER ADDS

This paper underlines that distal type I endoleak is not negligible during long term follow up after EVAR and re-intervention is always required but can be performed endovascularly in the most of cases. Moreover, in this experience we report that the presence of a distal oversize < 10% and a reduced coverage of the common iliac artery are risk factors for distal type I endoleak and it suggests that planning is crucial to reduce the development of this complication.

Objective: Late distal type I endoleak (ELIB) hampers the outcome of endovascular repair (EVAR) for abdominal aortic aneurysm (AAA); however, only few dedicated experiences have been reported in the literature. The aim of the study was to evaluate the incidence, presentation and treatment of late ELIB and to identify possible anatomical and technical predictors.

Methods: All patients undergoing elective EVAR between 2008 and 2013 were collected prospectively. Follow up was by post-operative computed tomography angiography (CTA) performed within 30 days and CTA and/or duplex ultrasound (DUS) at six or 12 months and yearly thereafter. Patients with late ELIB, defined as distal type I endoleak detected more than six months after the primary intervention without endoleak on the intra-operative completion angiogram and on the post-operative CTA, were retrospectively selected (G1) and compared with a control group with no ELIB (G2) homogeneous for clinical conditions, endograft implanted, and timing of follow up. The minimum follow up required for inclusion in the study was 24 months. Pre-operative morphological aorto-iliac features and EVAR implant details were evaluated, and measurements performed after centre lumen line reconstructions using dedicated software. The differences between G1 and G2 were analysed using the chi-square test, the Student *t* test, and logistic regression.

Results: Six hundred and sixteen patients were submitted to EVAR. ELIB was detected in 14 cases (2.3%) (G1) at a median follow up of 32.8 (IQR 48) months. In three of the 14 cases ELIB was symptomatic (AAA rupture, 2; pain, 1); in the remaining 11 cases it was asymptomatic and found incidentally at routine follow up. Treatment was by open repair in one case and by endovascular iliac leg extension in 13 cases. Hypogastric exclusion was necessary in two of 14 cases. Thirty patients were included in G2, with a median follow up of 41.2 (25) months. Common iliac artery length <4 cm (OR 5.3, 95% CI 1.1—29.5, $p = .05$), diameter > 15 mm (OR 3.5, 95% CI 1.2—10.9, $p = .03$), and severe thrombotic apposition (>50% of circumference) (OR 5, 95% CI 1.2—19.2, $p = .02$), at the iliac sealing zone were significant predictors of ELIB, on univariable analysis; oversizing of the iliac leg diameter < 10% and distal sealing > 1 cm above the hypogastric origin were independently associated with ELIB (OR 5.4, 95% CI 1.3—21.5, $p = .01$ and OR 6.6, 95% CI 1.1—39.3, $p = .03$, respectively), on multivariable analysis.

Conclusion: The present data underline that ELIB is a non-negligible occurrence during long term EVAR follow up and requires further interventions, most often by endovascular solutions. According to the ELIB risk factors identified in this study, an iliac leg diameter oversize >10% and extensive common iliac artery coverage (<1 cm above the hypogastric origin) would be suggested to prevent this complication.

Keywords: Abdominal aortic aneurysm repair, Endovascular procedures, Type I endoleak, Type IB endoleak, Type IB endoleak risk factors
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INTRODUCTION

Endovascular repair (EVAR) is accepted as the approach of choice for abdominal aortic aneurysms (AAAs) in most vascular centres worldwide; however, some problems are still unsolved, such as the high re-intervention rate.[1,2] Specifically, proximal and distal sealing zone complications may lead to aneurysm sac perfusion and subsequent AAA rupture.[3] However, while proximal sealing zone problems have been widely discussed,[4,5] only a few reports have been dedicated to the distal sealing zone.[6–8]

The distal sealing zone may be involved in different types of complications which can reduce EVAR efficacy, such as stenosis or occlusions and distal type I endoleak (ELIB), a clear predictor of post-EVAR AAA rupture[9] if not promptly corrected.

Several anatomical characteristics have been discussed in the literature as a potential cause of distal sealing problems,[10] such as the presence of dilated,[11–13] irregular, and tortuous iliac arteries,[14] but to date anatomical and procedural ELIB predictors have not been well defined.

The aim of this study was to analyse experience with late ELIB in order to describe the incidence, presentation, and treatment of this complication and to identify possible anatomical and technical predictors.

MATERIALS AND METHODS

Patient selection and inclusion criteria

Data of patients with infrarenal AAA undergoing elective EVAR with bifurcated endografts between 2008 and 2013 in a single centre were collected prospectively into the in house database. Pre-operative factors collected demographics (age, gender), comorbidities (coronary artery disease, hyperlipidaemia, hypertension, diabetes mellitus, smoking, body max index, chronic renal failure, American Society of Anaesthesiologists (ASA) score, antiplatelet therapy), anatomical details (pre-operative maximum aneurysm diameter, pre-operative neck characteristics, characteristics of the aortic bifurcation and of common iliac artery are reported in Table 1), and commercial endograft type and details.

Patients who developed late ELIB during follow up, in the absence of any other type of endoleaks, were retrospectively selected and clustered in Group 1 (G1).

Among the remaining patients, those who had a pre-operative and a post-operative CTA (performed in the hospital within one month), and a minimum follow up of 24 months with no evidence of type I endoleak or persistent type II endoleak were selected. The control group (Group 2, G2) was then randomly selected using a

Table 1. Pre-operative and post-operative measurements of patients and controls undergoing elective endovascular aneurysm repair for infrarenal abdominal aortic aneurysm and studied for distal type IB endoleak

Measurement	Definition
Pre-operative measurements	
Wide proximal aortic neck (PAN) diameter (> 28 mm)	
AAA maximum diameter	
Tight Aortic bifurcation diameter (< 21 mm)	
RCIA diameter (sealing zone)	
LCIA diameter (sealing zone)	
Short PAN length (< 15 mm)	
Aortic bifurcation length	Distance between LRA and aortic bifurcation
RCIA length	Distance between LRA and RH
LCIA length	Distance between LRA and LH
Severe PAN α angle (> 60°)	
Severe PAN β angle (> 60°)	
Severe CIA A angle (> 90°)	
Severe CIA B angle (> 90°)	
CIA circumferential calcification > 50%	
CIA circumferential thrombosis >50%	
Post-operative measurements	
Proximal aortic endograft (PN) oversize	
Right iliac limb (RIL) oversize	
Left iliac limb (LIL) oversize	
Uncovered RCIA	Distance between the distal end of the RIL and the RH
Uncovered LCIA	Distance between the distal end of the LIL and the LH

PAN = proximal aortic neck; AAA = abdominal aortic aneurysm; RCIA = right common iliac artery; LCIA = left common iliac artery; LRA = lower renal artery; RH = right hypogastric artery; LH = left hypogastric artery; CIA = common iliac artery; PN = proximal aortic endograft; RIL = right iliac limb; LIL = left iliac limb.

specific randomisation function (Excel 2007 [Microsoft Corporation, Redmond, WA, USA]: RANDBETWEEN [bottom-top0111983]) in order to increase the number of controls to a minimum of two controls for each G1 case and to compare each iliac leg with late ELIB to a minimum number of three iliac legs without late ELIB, increasing the chance of detecting important differences.[15] The patient selection flow chart is reported in Fig. 1. The two groups were compared in terms of pre-operative morphological aorto-iliac features and EVAR implant details of iliac limb.

Patients presenting with aneurysms involving the iliac arteries or with a history of previous aortic surgery were excluded.

The availability of a post-operative CTA was a mandatory inclusion criterion to include patients in each group (G1 and G2) in the study, in order to exclude the presence of post-operative distal type I endoleak caused by a planning or implant error.

The study was performed according to the rules of the ethics review board of the Institution.

Outcomes and definition

The incidence, presentation, and treatment of late ELIB were evaluated and the presence of pre-operative morphological aorto-iliac features and EVAR implant details, related to the presence of late ELIB, were investigated.

Endoleaks were defined according with the classification of White *et al*.[16] Late ELIB was defined as a distal type I endoleak detected more than six months after the primary intervention in patients with no endoleaks of any type on the intra-operative completion angiogram and post-operative computed tomography angiogram (CTA).

Technical success (TS) was defined as the successful sealing of the late ELIB, without persisting type I/III endoleak, presence of kinking or stenosis, conversion, intra-operative or 24 h death.

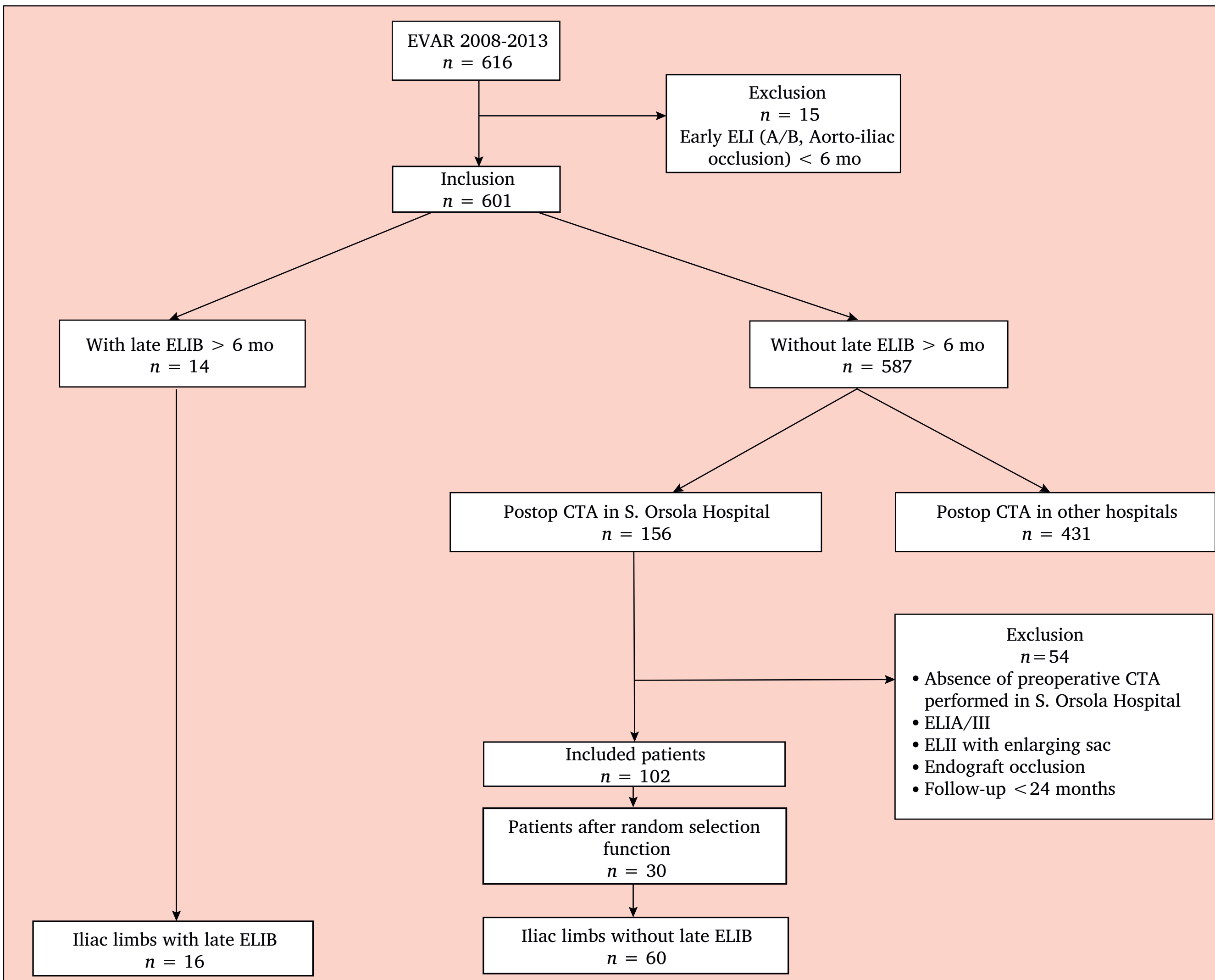

Figure 1. Flow chart for selection of 16 iliac limbs and 60 control iliac limbs of endovascular grafts to analyse late distal type I endoleak (ELIB) after endovascular repair of aortic aneurysm (EVAR). CTA = computed tomography angiography; ELIB = distal type I endoleak; ELI = type I endoleak; ELII = type II endoleak; ELIII = type III endoleak; EVAR = endovascular aneurysm repair.

Pre-operative imaging/planning

The aorto-iliac morphological factors were evaluated on pre-operative CTA performed within one month of the procedure by experienced vascular radiologists. Triple phase CTA (un-enhanced, arterial contrast enhanced, and delayed phases, 180 s) was acquired on a 32/64 slice CT scanner (GE Healthcare, Salt Lake City, UT, USA) from the thorax to the femoral artery bifurcations. Iodinated contrast (100—130 mL) (Iomeron 400; Bracco SA, Milan, Italy) was injected at rate of 4 mL/s for the first 100 mL and 2 mL/s for the last 30 mL. Contrast injection was followed by saline solution (.9% NaCl) at a rate of 2 mL/s. Reconstruction at 1 mm slice thickness was performed. The CTA was post-processed with dedicated software for visceral vessel analysis (3Mensio, Vascular Imaging, Bilthoeven, The Netherlands) and evaluated by vascular surgeons with specific experience in EVAR procedures.

All the procedures were planned and performed by the same surgical team of four senior vascular surgeons with an experience in EVAR procedures of more than 15 years.

All patients were treated with four different commercially available endografts, according to their instructions for use. Each case was discussed beforehand. The endograft was chosen according to the overall aorto-iliac anatomy of the patients. Usually, an infrarenal or suprarenal fixation endograft was used according to the length and characteristics of the proximal aortic neck, and the anatomy of the common and external iliac arteries (length, diameter, calcification, thrombus apposition, tortuosity) was also considered in the choice of the type of endograft (bi- or tri-modular, profile, flexibility, distal diameter, stent design of the iliac limb, radial force). However, for borderline anatomy the surgeon's preference was considered.

Endovascular procedure

As previously reported[4] the procedures were performed in the operating room, with a mobile angiographic C arm (OEC 9800 Plus; General Electric, Salt Lake City, UT, USA). Intravenous antibiotics and heparin, adjusted for the patient's weight, were always administered before the procedure. A bilateral common femoral artery cut down was performed in all cases under locoregional or general anaesthesia. According to the 3-Mensio angiographic reconstruction, diagnostic angiography (double magnification) was performed with the ideal C arm angulations to optimise visualisation of the origin of the lowest renal artery, of the infrarenal aortic neck during main body deployment, and of the hypogastric origin during iliac limb deployment. To optimise sealing of the endograft, angioplasty of the infrarenal neck and the docking zone, was always performed with a Coda (Cook Medical, Bloomington, IN, USA) or Reliant (Medtronic, Fridley, MN, USA) balloon. The iliac legs were treated subsequently, always with XXL (Boston Scientific, Natick, MA, USA) semi compliant balloons. According to the protocol,[17] completion angiography was always performed using three different C arm angulations (0°, 45° left anterior oblique, 45° right anterior oblique) to verify the absence of endoleaks or iliac limb stenosis. All patients underwent deep venous thrombosis prophylaxis and lifelong single antiplatelet therapy.

Follow up

All patients were entered into a dedicated EVAR follow up program after the procedure. Post-operative Doppler ultrasound (DUS) (before discharge) and CTA (within three months) were performed. DUS was performed at six and 12 months and yearly thereafter. Contrast enhanced ultrasound (CEUS) was also performed at the same stage in the absence of AAA sac shrinkage or in presence of any doubts about endoleak. A CTA was also performed for high flow endoleak, AAA sac growth, doubtful DUS/CEUS interpretation, or for planning a re-intervention.

CTA was the follow up method of choice in those patients who could not be followed by DUS/CEUS for some reasons (hostile abdomen, excessive meteorism, BMI $>$ 30, etc.).

Pre-operative/post-operative measurements

Measurements were performed after centre lumen line reconstructions of the pre-operative and post-operative CTA. The centre lumen line reconstructions were performed by two vascular surgeons (C.M., E.G.) with extensive experience of CTA post-processing analysis and EVAR planning.

The pre- and post-operative measurements were evaluated on the appropriate CTA and are summarised in Table 1. The right and left aorto-iliac axes lengths were defined as the distance between the lowest renal artery and the right and left hypogastric bifurcation, respectively. Common iliac artery lengths were measured as the distance between the aortic bifurcation and the hypogastric artery on both sides. Diameters at the proximal and distal sealing zones were measured as the linear outer wall distance in the orthogonal reformatted cuts. Parietal calcification and thrombosis were considered if involving $>$50% of the inner circumference at the common iliac artery sealing zone. The aorto-iliac axis length uncovered by the endograft was evaluated on the post-operative CTA calculated from the difference between the distal end of the iliac limb and the hypogastric bifurcation. The angulation between the AAA axis and the common iliac artery axis (A angle) and the angulation of the common iliac artery (B angle) (Fig. 2), were considered if $>$ 90°.

Anatomical characteristics of the proximal aortic neck, AAA diameter, and the aortic bifurcation were compared between patients who developed late ELIB (G1) and the control group (G2).

Anatomical characteristics of the common iliac artery, ipsilateral to the late ELIB (G1), were compared with each common iliac artery of patients of control group (G2).

Statistical analysis

Continuous data are presented as median and interquartile range (IQR). Categorical data are given as counts and percentages. Differences in categorical and continuous

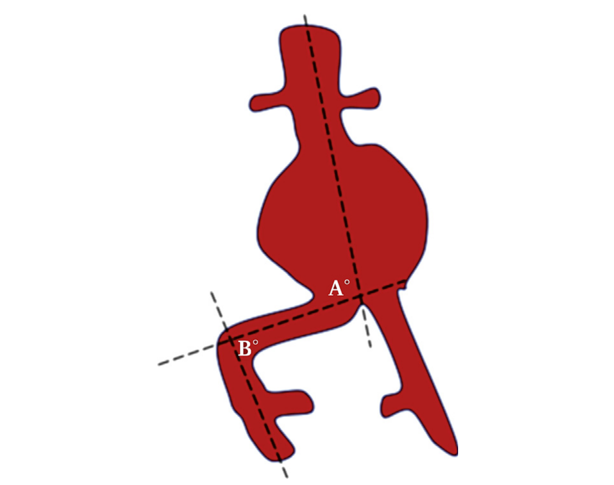

Figure 2. Common iliac artery angle. A° = the angle between the AAA and common iliac artery longitudinal axes. B° = the angulation of the common iliac artery. AAA = abdominal aortic aneurysm.

Table 2. Clinical characteristics of patients with (Group 1, G1) or without (Group 2, G2) late distal type I endoleak after endovascular repair for abdominal aortic aneurysm

Clinical characteristics	G1 (n = 14)	G2 (n = 30)	p
Age – y	73 (9)	73 (8)	.5
Body mass index – kg/m^2	27 (6)	28 (5)	.1
Sex – male	14 (100)	1 (97)	1.0
Hypertension	14 (100)	30 (100)	N/A
COPD	10 (71)	19 (63)	.7
Coronary artery disease	6 (43)	12 (40)	1.0
Atrial fibrillation	2 (14)	4 (13)	1.0
Dyslipidemia	9 (64)	21 (70)	.7
Chronic renal failure	7 (50)	11 (37)	.5
Smoke	3 (21)	13 (43)	.2
Diabetes	0 (0)	3 (10)	.5
Cerebro-vascular Insufficiency	2 (14)	4 (13)	1.0
ASA score ≥ 3	11 (79)	22 (73)	.3

Data are given as n (%) or median (interquartile range). COPD = chronic obstructive pulmonary disease; ASA score = American Society of Anaesthesiologists score; N/A = not available.

variables between the two groups were analysed using respectively the chi-square test (or Fisher exact test when appropriate) and Student t test (or Mann–Whitney test when appropriate). Univariable analysis, expressed by odds ratio (OR) and 95% confidence interval (CI), was performed to investigate factors affecting the presence of late ELIB. The multivariable analysis was performed using logistic regression. Factors in the univariable association with $p < .20$ were included in the multivariable analysis in order to evaluate the independent association with the presence of late ELIB. A p value $< .05$ was considered to be significant. Statistical analysis was performed using SPSS 21.0 software (SPSS Inc, Chicago, IL, USA).

RESULTS

Patient selection

During the study period, 616 patients underwent standard EVAR for AAA repair. A total of 14 patients (2.3%) developed late ELIB during follow up and they were clustered in G1. Among the remaining patients, 30 without any type of endoleaks at follow up were homogeneous with G1 for demographics and clinical characteristics, type of endograft implanted and timing of follow up; these patients were included in G2. The median follow up for G1 and G2 was 60.4 (41) and 41.2 (25) months, respectively ($p = .07$).

Demographics and clinical characteristics, pre-operative and post-implant morphological characteristics and type of endograft implanted, and timing of follow up are reported in Table 2, Table 3, and Table 4, respectively.

Outcomes

A late ELIB was detected in 14 patients (2.3% of G1). In two cases the late ELIB involved both iliac limbs, but was unilateral in the other 12/14 cases. The mean time of ELIB presentation was 37.4 ± 28 months. In 11 cases the ELIB was asymptomatic and detected during routine follow up. During follow up, six patients underwent to CTA at one year; all the other patients were followed by DUS/CEUS. An increase in common iliac artery diameter with no sign of ELIB was not considered. Three patients were symptomatic (AAA rupture in 1/14; abdominal pain in 2/14) and were treated urgently. The presence of late ELIB was detected by DUS/CEUS in eight patients and by CTA in six. When ELIB was detected by DUS/CEUS, a CTA was always performed in order to confirm the diagnosis and to plan the re-intervention.

The AAA rupture occurred in a patient who complied with the regular follow up program and did not show signs of endoleaks or AAA enlargement on the 24 month DUS. He was treated as an emergency at 30 months.

All patients were treated by open surgery (1/14) or EVAR (13/14). Technical and clinical success was achieved in all cases. Hypogastric exclusion was necessary in two cases, without any clinical consequences. Time of presentation, symptoms, and treatment details are summarised in Table 5.

Pre-operative and post-implant morphological characteristics that were the aim of the study are summarised in Table 6. Among them, a common iliac artery length <4 cm, a common iliac artery diameter >15 mm, severe thrombus (>50% of circumference) at the iliac sealing zone were associated with a higher risk of ELIB in the unadjusted analysis (Table 6); however, this finding was not confirmed in the adjusted analysis. Also, a severe common iliac artery A angle was not significantly correlated with the presence of a late ELIB; no cases with a severe B angle were observed in this series. Among the implant details, a <10% iliac leg oversize and a distal sealing >1 cm above the hypogastric origin were associated with ELIB both in the unadjusted and adjusted analysis (Table 6).

Table 3. Pre-operative and post-implant morphological characteristics of endografts with (Group 1, G1) or without (Group 2, G2) late distal type I endoleak (ELIB) after endovascular repair for abdominal aortic aneurysm

	G1 (n = 16)	G2 (n = 60)	p
Pre-operative neck characteristics			
PAN length < 15 mm	5 (36)	9 (30)	.77
PAN diameter > 28 mm	2 (14)	1 (3)	.29
PAN α angle > 60°	0 (0)	4 (13)	.34
PAN β angle > 60°	5 (36)	12 (40)	1.0
AAA diameter ≥ 60 mm	2 (14)	9 (30)	.37
Aortic bifurcation diameter < 21 mm	0 (0)	1 (3)	1.0
Characteristics of common iliac artery, ipsilateral to the ELIB			
CIA A angle > 90°	7 (44)	16 (27)	.22
CIA length < 40 mm	9 (56)	15 (25)	.02
CIA diameter > 15 mm	9 (56)	16 (27)	.03
CIA thrombosis >50%	5 (31)	4 (7)	.02
CIA calcification > 50%	4 (25)	15 (25)	1.0
Post-implant morphological characteristics, ipsilateral to the ELIB			
Distal oversize < 10%	9 (56)	14 (23)	.01
Distal sealing > 10 mm[a]	10 (63)	13 (22)	.004

Data are given as n (%). AAA = abdominal aortic aneurysm; PAN = proximal aortic neck; CIA = common iliac artery; ELIB = distal type I endoleak.

[a] Distal sealing >10 mm above the hypogastric origin.

Table 4. Endografts implanted in patients with (Group 1, G1) or without (Group 2, G2) late distal type I endoleak after endovascular repair for abdominal aortic aneurysm

Endografts	G1 (n = 14)	G2 (n = 30)	p
Endograft	5 (36)	11 (37)	.95
Anaconda™ (Vascutek)	3 (21)	7 (23)	.88
Endurant™ (Medtronic)	2 (14)	6 (20)	.64
Excluder™ (Gore)	4 (29)	6 (20)	.52
Follow-up time – mo	60 (41)	41 (25)	.07

Data are given as n (%) or median (interquartile range).

DISCUSSION

An overall ELIB incidence of 2.3% was found in the study, slightly lower than the reported range of 2.7—7% in other reports.[8,11,13] It should be noted that, unlike previous studies, late ELIB was the focus; moreover, the data were obtained only with currently available endografts. However, this incidence is not negligible, particularly if the timing and features of presentation are unpredictable. In this series, the majority of ELIB were detected more than 24 months after the original EVAR procedure, indicating that aneurysmal disease progression at the distal sealing zone may have played a role, as suggested in previous reports.[8,18] In those

Table 5. Timing of presentation, symptoms, and treatment of 14 studied late distal type I endoleaks (ELIB) after endovascular aneurysm repair

Patient number	Follow-up time (mo)	Symptoms	Treatment	Setting	Procedure	Results
1	6.7	None	EV	Elective	Iliac leg extension	Sealed
2	7.0	Abdominal pain	EV	Urgent	Iliac leg extension	Sealed
3	8.1	None	EV	Elective	Iliac leg extension	Sealed
4	11.2	None	EV	Elective	Iliac leg extension	Sealed
5	13.2	None	EV	Elective	Iliac leg extension	Sealed
6	30.1	AAA rupture	OR	Emergent	Bypass between iliac limb and native common iliac artery	Patency
7	30.3	None	EV	Elective	Iliac leg extension	Sealed
8	33.3	None	EV	Elective	Iliac leg extension	Sealed
9	41.8	Abdominal pain	EV	Urgent	Iliac leg extension, by using brachial approach/through and through technique	Sealed
10	51.7	None	EV	Elective	Iliac leg extension	Sealed
11	55.1	None	EV	Elective	Iliac leg extension	Sealed
12	63.5	None	EV	Elective	Bilateral iliac leg extension	Sealed
13	77.9	None	EV	Elective	Bilateral iliac leg extension	Sealed
14	83.8	None	EV	Elective	Iliac leg extension	Sealed

AAA = abdominal aortic aneurysm; EV = endovascular repair; OR = open repair.

Table 6. Morphological aorto-iliac features and endovascular aneurysm repair (EVAR) implant details associated with late distal type I endoleak (ELIB) in 16 iliac limbs in comparison to 60 control limbs

	ELIB (unadjusted)		ELIB (adjusted)	
	Odds Ratio (95% CI)	*p*	Odds ratio (95% CI)	*p*
AAA diameter ≥ 60 mm	0.4 (0.1–1.8)	.37	–	–
PAN length < 15 mm	1.2 (0.4–3.9)	.77	–	–
PAN diameter > 28 mm	2.4 (0.4–14.5)	.29	–	–
PAN α angle > 60°	0.8 (0.8–0.9)	.34	–	–
PAN β angle > 60°	0.9 (0.3–2.8)	1.0	–	–
Aortic bifurcation diameter < 21mm	0.9 (0.9–1.0)	1.0	–	–
CIA A angle > 90°	2.1 (0.7–6.6)	.22	–	–
CIA length < 40 mm	0.6 (0.2–1.8)	.02	5.3 (0.9–29.5	.06
CIA diameter > 15 mm	3.5 (1.1–10.9)	.03	2.8 (0.6–11.9)	.10
CIA thrombosis > 50 %	5.0 (1.2–19.2)	.02	4.4 (0.7–25.2)	.09
Distal oversize < 10%	4.1 (1.3–12.8)	.01	5.4 (1.3–21.5)	.01
Distal sealing > 10 mm[a]	5.0 (1.5–15.6)	.004	6.6 (1.1–39.3)	.03
CIA calcification > 50%	1.0 (0.3–3.7)	1.0	–	–

AAA = abdominal aortic aneurysm; PAN = proximal aortic neck; CIA = common iliac artery; ELIB = distal type I endoleak; EVAR = endovascular repair; CI = confidence interval.
Bold highlights factors with significative *P* value at univariate and multivariate analysis.
[a] Distal sealing > 10 mm above the hypogastric origin.

studies, the importance of the iliac seal zone dynamic was ascertained, as well as the late evolution of aneurysmal disease in the distal necks compared with proximal necks.[8,18]

In this series most ELIB were asymptomatic and were detected routinely during the follow up. Among the symptomatic cases, one case presented with frank rupture and required an emergency open repair, further confirming that ELIB is a clear cause of late EVAR failure leading to abdominal aortic aneurysm rupture.[3] However with a timely planned follow up, most cases of ELIB in this series were detected in an asymptomatic phase and re-interventions could be planned and performed electively, by an endovascular approach, with a 100% technical success rate.

These results seem in line with a recent literature review published by Bianchini *et al.*,[7] in which 50% of 30 ELIB occurred at least six months after the EVAR procedure, and underwent endovascular repair in 27 cases (90%).

In most cases, as stated in the new European guidelines,[3] this complication would be easily treatable by a minimally invasive approach, especially if detected during routine follow up. This further underlines the need for a long term dedicated surveillance protocol in patients undergoing EVAR, with timely adherence to the follow up schedule by all patients.

The study suggests that the presence of a common iliac artery <4 cm long, a common iliac artery diameter >15 mm, and severe thrombus (>50% of circumference) at the iliac sealing zone are associated with a higher risk of ELIB in the unadjusted analysis. Only few dedicated studies[5,10,13] on the anatomical and procedural risk factors for ELIB are reported in the literature. McDonnell *et al.*[11] analysed the impact of large iliac arteries as a risk factor for endograft failure and reported that iliac arteries between 16 and 22 mm in diameter may have a high index of suspicion for ELIB. According to the current results, it would appear that severe aorto-iliac angulation does not affect significantly the distal sealing zone. Conversely, by comparing a group of 33 patients with iliac problems (10 ELIB, 4 occlusions, and 16 iliac limb kinks) with a control group of 120 patients with no iliac complication at follow up, Coulston *et al.*[14] reported that increased aorto-iliac tortuosity was associated with an increased iliac failure rate after EVAR. In the current study no case of a severe common iliac artery A angle was associated with a severe B angle. Moreover, the A angle was at least 20 mm more proximal from the sealing zone. This could explain why severe angulation wouldn't appear to be a risk factor for late ELIB in the series. Other papers also reported a higher risk of ELIB in patients with AAA >65 mm in diameter.[7,8] However, that finding is not confirmed in the current study, since no correlation between AAA >60 mm and late ELIB was found.

Among the implant details, a distal seal >1 cm above the hypogastric origin and <10% oversize of the iliac leg diameter were associated with ELIB, both in the unadjusted and adjusted analysis in the current series. Heikkinen *et al.*[6] reported that patients with no migration had a greater iliac fixation length (30 ± 12 mm) than those with migration (22 ± 8 mm; $p = .01$) and that the distal end of the iliac limbs was closer to the iliac bifurcation compared with patients with migration (15 ± 12 mm vs. 25 ± 10 mm, respectively; $p = .001$). The authors[6] concluded that close proximity of the distal end of the stent graft to the iliac bifurcation seems to provide the greatest stability against migration. According with those previous reports and with the results here, a distal sealing as close as possible to the internal iliac bifurcation (distance < 1 cm) may be recommended in order to prevent the development of late ELIB, particularly if the iliac artery is relatively short (<4 cm). Similarly, an iliac limb oversize >10% could be suggested, especially if the iliac diameter at the distal sealing zone is > 15 mm.

According to the reported results, the current algorithm for distal sealing is to use bell-bottom iliac limbs when the distal sealing diameter is between 15 and 22 mm and the length of the common iliac artery is $\geq$ 4 cm; if the length of the iliac artery is $<$ 4 cm, other solutions should be considered. Torsello *et al.*[19] reported an incidence of 3.4% ELIB in 89 patients treated with a bell-bottom iliac limb, with 92% freedom from secondary interventions after five years. As a consequence of these analyses, the use of hypogastric side branch devices should be considered in good surgical risk patients with an ectatic common iliac artery, in order to preserve hypogastric artery patency.[3,20] For hypogastric side branch non-feasibility, a barrel technique could be also considered.[21,22] If the iliac artery is short but not dilated, it may be useful to consolidate the distal sealing by deploying an uncovered stent to the external iliac artery. The hypogastric artery exclusion with distal sealing in the external iliac artery can be considered in poor surgical risk patients with hostile hypogastric anatomy, particularly if a patent contralateral hypogastric artery is present, but taking into consideration the risk of pelvic complications[3,23] associated with this kind of approach.

Patients with hostile iliac artery features must be followed by a stricter follow up program,[3] due to the higher risk of developing iliac complications. A tailored follow up should be scheduled for patients with a large iliac diameter at the sealing zone or with a short iliac artery, due to the higher risk of late ELIB. However, if this complication is promptly diagnosed, an effective and safe treatment can be performed in the majority of cases.

This study has several limitations. The retrospective nature of the study may carry possible selection bias, and the sample is small. Although no correlation between the kind of device and late ELIB was observed, the small number of patients and the number of different endografts used did not allow any significant conclusion on this issue. Although the average follow up is appropriate for this analysis, a longer observation time would be useful for further consideration. Finally, the present study did not consider the impact of the clinical path on the development of late ELIB and this point should be worthy of further studies.

CONCLUSION

The present data underline that ELIB occurrence is not negligible during long term EVAR follow up, leading to the need for re-interventions, which can be performed safely and effectively endovascularly. According to the ELIB anatomical predictors, an iliac limb diameter oversize $>$10% and extensive coverage of the common iliac artery ($<$1 cm above the hypogastric origin) are suggested to prevent this complication.

CONFLICT OF INTEREST

None.

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COUP D'OEIL

A Brachial False Aneurysm Repair with Xeno-pericardium Bioconduit

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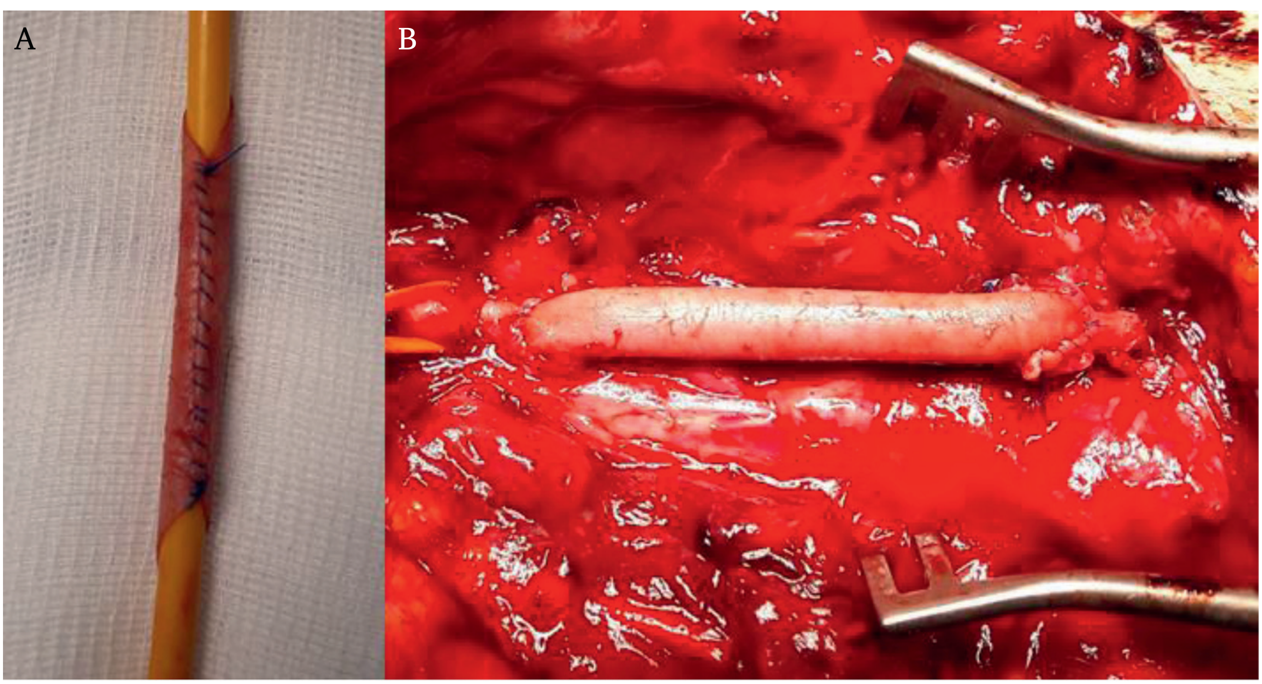

A 38 year old right handed male drug addict presented with a septic left brachial false aneurysm. After incision of the pseudoaneurysm, significant vessel wall disintegration was observed preventing primary repair. Therefore, a brachio-brachial bypass was performed using a homemade bioconduit made from a bovine pericardial patch (XenoSure Biologic Patch, LeMaitre, 6 × 8 cm). The length of the patch was first adapted to the arterial gap to be bridged, and then a tubular bioconduit was fashioned using a continuous suture with 5-0 polypropylene on a Foley catheter (panel A). Finally, two end to end anastomoses were performed by continuous suture with 6-0 propylene (panel B). Ten-month follow up was uneventful.

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