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REVIEW

Clinical and anatomical variables associated in the literature to limb graft occlusion after endovascular aneurysm repair compared to the experience of a tertiary referral center

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ABSTRACT

INTRODUCTION: Limb graft occlusion (LGO) is the third reason for hospital readmission after endovascular aneurysm repair (EVAR) for abdominal aortic aneurysm. We reviewed the clinical features, incidence, anatomical and devices related predictive factors for LGO after EVAR, and compared them with our experience.
EVIDENCE ACQUISITION: EVAR between 2010-2017 were included. Patients with LGO (LGO group) were matched for age and type of endograft with the rest of the entire cohort without LGO (control group). Clinical, anatomical, operative, outcome, and follow-up data were collected.
EVIDENCE SYNTHESIS: Two hundred seventy-six EVAR, (30 aorto-uniliac), 276 patients. The incidence of LGO was 2.5% (seven limbs, seven patients) at 27±24.6 days. Symptomatic patients were successfully treated. No mortality, limb loss, critical limb ischemia or residual claudication due to LGO was observed. Fifty patients resulted from the matching. Among the predictive factors of LGO between the two groups, significant differences were observed in graft limb oversizing ≥15% (57.1% *vs.* 8%, P=0.005), or kinking (42.9% *vs.* 2%, P=0.01), and diameter of the aortic bifurcation <20 mm (71.4% *vs.* 20%, P=0.01). Logistic regression analysis showed that these three variables increased the risk of LGO (P=0.003, P=0.006, and P=0.01, respectively).
CONCLUSIONS: The strongest predictive factors of LGO issued from our review were: extension in the external iliac artery, or small diameter; tortuous, angled, and calcific iliac axis; excessive oversizing of the limb graft, or kinking; use of old generation devices; EVAR performed outside the instructions for use. Limb graft oversizing >15%, or kinking, and aortic bifurcation <20 mm appear to be independent predictive factors of LGO.

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KEY WORDS: Vascular surgical procedures; Abdominal aortic aneurysm; Endovascular procedures; Vascular graft occlusion.

Introduction

Endovascular aneurysm repair (EVAR) has become the treatment of choice for most abdominal aortic aneurysms (AAA). Wider instructions for use (IFU) for EVAR have emerged, including complex aortic anatomies, which might have led to increased complication rates (*e.g.*, endoleaks, migration or detachment of the graft, and infection).[1, 2] Limb graft occlusion (LGO) represents a not so rare complication, as well as the third most important cause of hospital readmission after EVAR.[3, 4] Anatomical and technical factors associated with LGO should be clearly detected to prevent graft failure.

The purpose of our work was aimed at reviewing the clinical features, anatomical and devices related predicting factors for LGO after EVAR starting from review of the literature and comparing it with the experience at the University Hospital of Sassari, referral Center of North-Sardinia.

Evidence acquisition

A literature search on PubMed and Embase was performed using “limb graft occlusion” and “endovascular aneurysm repair” as key words. Additional references identified were used to expand the search, limited to English articles and single and multi-center studies were included. Data were extracted independently and any discrepancies adjudicated by two investigators (V.C. and E.M.). The initial article search identified 234 articles. All articles were separately reviewed by the same two investigators. We contacted authors for additional data or clarification when required. Articles with no sufficient information regarding causes, predictive factors and treatment of LGO were excluded. The final search comprising eleven articles: 5681 patients from 2001 to 2017.

In our analysis we considered all causes and predictive factors of LGO that were statistically significant in the studies reviewed from the literature (Table I).[3-13] Among them, unsupported and older generation devices were not considered, being not prescribed in our cohort. Similarly, technical errors and low radial force of the graft were excluded, being in our opinion not quantifiable. The following variables were included in our analysis: extension of the limb graft in external iliac artery (EIA), limb graft diameter less than or equal to 14 mm, age <70 years, limb graft kinking (referred to graft deformation due to an acute localized angulation of the graft or graft limb >90°, detected at final

TABLE I.—*Predictive factors and causes of LGO in the literature.*[3-13]

Study	Graft	N. patients	LGO	Predictive factors and causes of LGO
Carpenter *et al.*[3]	Mixed	173	7.7%	Unsupported limb graft
Carroccio *et al.*[8]	Mixed	351	3.7%	Extension to the EIA Limb graft diameter <14 mm
Erzurum *et al.*[9]	Mixed	823	2.7%	Unsupported limb graft Extension to the EIA
Cochennec *et al.*[5]	Mixed	460	7.2%	Younger age Older generation devices Limb graft kinking
Abbruzzese *et al.*[10]	Mixed	565	6%	Outside of the IFU
Conway *et al.*[11]	Mixed	661	4.6%	Extension to the EIA Tortuous iliac with small diameter.
van Zeggeren *et al.*[12]	Endurant	496	4%	Technical error
Taudorf *et al.*[6]	Zenith	504	3.5%	Iliac tortuosity BMI≥28.9 kg/m^2
Faure *et al.*[7]	Endurant	1143	3.4%	Extension to the EIA or diameter <10 mm; AAA diameter <59 mm; Limb graft kinking.
Mantas *et al.*[13]	Mixed	439	4.1%	Iliac angle >60°; Iliac calcification >50%; Graft limb oversizing >15%.
Wang *et al.*[4]	Mixed	66	10.6%	Anatomic factors [a] Device-related factors [b] Combined (anatomic and device) factors

LGO: limb graft occlusion; EIA: external iliac artery; IFU: instructions for use; BMI: Body Mass Index; AAA: abdominal aortic aneurysm.
[a] Anatomic factors: small artery size, aneurysm angulation ≥60°, calcified and narrowed aortic bifurcation, tortuous iliac artery and iliac artery dissection; [b] device factors: graft migration, insufficient graft size and low radial force. Categorical data are given as the counts (percentage).

procedure angiogram or during control CTA),[14] procedure outside of the IFU (considered as the device-specific parameters of aneurysm morphology and graft sizing, included each device's instructions for use), body mass index (BMI) less than or equal to 28.9, EIA diameter less than or equal to 10 mm, AAA maximum diameter <59 mm, iliac angle greater than or equal to 60°, iliac artery calcification greater than or equal to 50% of its circumference, AAA's neck angulation greater than or equal to 60°, graft limb oversizing (measured at the end of the graft — sealing zone diameter — ≥15% of the diameter of the landing zone target vessel), narrow aortic bifurcation (<20 mm), presence of iliac artery dissection, and graft migration. Diameter of the vessels was defined as the maximum distance length between the adventitia and the opposite adventitia of the arterial wall, measured perpendicular to the center lumen line. Angulation was measured considering the maximum arterial angulation calculated with a processing images software centerline, taking into account the entire length of the vessel. All the analysis and measurements of AAA characteristics were performed on CTA scan images with Osirix MD software (Pixmeo SARL, Geneva, Switzerland).

Patients who underwent EVAR for AAA, aorto-common iliac aneurysm (ACIAA), and isolated or bilateral common iliac aneurysm (CIAA) in the University Hospital of Sassari, Italy, between January 2010 and December 2017 were selected. Patients who were treated with EVAR for pseudoaneurysm from any causes or penetrating aortic ulcer (PAU), were excluded. EVAR procedures were performed in the operating room (OR), with general or loco-regional anesthesia based on patient general conditions. Uni- or bi-lateral surgical femoral access was performed. The following grafts were implanted: Excluder (W.L. Gore & Associates, Newark, DE, USA), Endurant (Medtronic Inc., Minneapolis, MN, USA), Treovance (Bolton Medical, Barcelona, Spain), Anaconda AAA Stent Graft System (Vascutek Ltd, Inchinnan, UK), and INCRAFT (Cordis Corporation, Fremont, CA, USA). In the postoperative period, all patients received 100 mg of acetylsalicylic acid per day and lifelong. Diagnosis of LGO was clinical and confirmed by imaging duplex ultrasound scan (DUS) or computed tomography angiography (CTA) findings. Systematic postoperative and long-term follow-up was carried out, including a 30-day physical examination, a 3 and 6-months DUS and a 1-year CTA. In case of any diagnostic doubt with DUS, the CTA was anticipated. LGO patients (LGO group) were compared with a control group of patients who did not show LGO, extrapolated from the entire cohort after matching for age and type of endograft implanted. Our treatment and follow-up algorithm remained uniform throughout the study period. Clinical and anatomical information, operative management, outcomes, and follow-up data were prospectively collected in an electronic database and analyzed.

Formal ethical approval, as well as patient informed consent, was not needed. The current Italian legislation on observational studies (our study is the case) does not request the above-mentioned documents when clinical data are anonymized (G.U.R.I. # 76, March 31, 2008).

Statistical analysis

Continuous data were described as means and standard deviations, whereas categorical characteristics were described as absolute and relative frequencies. The χ^2 or Fisher's Exact and Student's *t*-tests were used to assess differences for categorical and continuous variables. A logistic regression analysis was performed to assess the role of clinical and epidemiological factors in the occurrence of LGO. P values<0.05 were considered statistically significant. All statistical analyses were performed using the software STATA version 15 (StataCorp LLC, College Station, TX, USA).

Evidence synthesis

Two hundred seventy-six EVAR, of which 30 were aorto-uni-iliac (AUI) endografts, in 276 patients were carried out. Two hundred sixty-one (94.5%) patients showed an AAA or uni- or bilateral ACIAA, whereas 15 (5.5%) an isolated or bilateral CIAA. A total of 522 graft limbs were recruited. The mean size of the aneurysms was 52.7±13.5 mm and 26.3±9.2 mm for AAA and CIAA, respectively. The most frequently implanted grafts were Excluder and Endurant in 165 (59.7%) and 103 (37.3%) patients; 2.8% were treated with other devices (four Treovance, two Anaconda, and two Incraft). The mean follow-up time of the entire cohort was 32.3±25.2 months. The incidence of LGO after EVAR was 2.5%, related to seven limbs in seven patients (five males, whose mean age was 75.6±6.4 years); mean time of occurrence of LGO was 27±24.6 postoperative days (POD). Five patients showed an AAA (2 of them had a saccular aneurysm), one an unilateral ACIAA, and one a bilateral CIAA. The mean size of the LGO aneurysms was 52.7±1.0 mm. Six patients were treated with an Endurant bifurcated stent graft, whereas in one patient we used 2 out of IFU isolated Excluder iliac stent graft to treat bilateral CIAA. Clinical presentation of the LGOs was heterogeneous: five patients presented with acute limb ischemia of grade 2A (N.=2) and 2B (N.=3), 1 developed claudication, and one was asymptomatic. Six patients were promptly treated. Three individuals had a successful thrombolysis followed by iliac stent placement (two cases) and angioplasty alone (one case). Our thrombolysis protocol provides a catheter directed intra-arterial continuous urokinase infusion, through a 4-Fr side holes catheter by left brachial or femoral (ipsilateral to LGO) access, with a bolus of 200,000 units of thrombolytic agent followed by urokinase at 70,000 units/hour, associated to a continuous intravenous infusion of heparin at 25,000/24 hours. Usually,

TABLE II.—*Specific features of the seven cases of LGO.*

Case #	Gender	Age (years)	AAA type	AAA size (mm)	Graft type	Time to LGO (days)	Causes of LGO	Clinical Presentation	Treatment
1	M	65	Bilateral Iliac	33	Excluder (2 isolated graft limbs)	8	Younger age (<70 years) Outside of IFU BMI≥28.9 kg/m² AAA diameter <59 mm Iliac angle ≥60° Graft limb oversizing ≥15% Aortic bifurcation <20 mm	Acute ischemia	Thrombolysis + covered stent
2	M	74	Aortic	61	Endurant (bifurcated graft)	12	Limb graft kinking; Aortic bifurcation < 20 mm	Acute ischemia	Thrombolysis + Covered stent
3	F	76	Saccular aortic	48	Endurant (bifurcated graft)	1	BMI≥28.9 kg/m² EIA≤10 mm AAA diameter <59 mm Iliac angle ≥60° AAA angulation ≥60° Aortic bifurcation <20 mm	Acute ischemia	Thrombectomy + covered stent + femoral artery patch
4	M	81	Aortic	60	Endurant (bifurcated graft)	11	Limb graft diameter ≤14 mm Limb graft kinking BMI≥28.9 kg/m² Iliac angle ≥60° AAA angulation ≥60° Iliac calcification ≥50%	Acute ischemia	Covered stent
5	M	82	Aortic	59	Endurant (bifurcated graft)	53	Limb graft diameter ≤14 mm EIA≤10 mm Graft limb oversizing ≥15% Aortic bifurcation <20 mm	Asymptomatic	Covered stent
6	M	81	Aortic + right iliac	51	Endurant (bifurcated graft)	62	Extension to the EIA EIA≤10 mm AAA diameter <59 mm Iliac angle ≥60° Graft limb oversizing ≥15%	Claudication	Conservative therapy (LMWH)
7	F	70	Saccular aortic	57	Endurant (bifurcated graft)	42	Limb graft diameter ≤14 mm Limb graft kinking BMI≥28.9 kg/m² AAA diameter <59 mm Graft limb oversizing ≥15% Aortic bifurcation <20 mm	Acute ischemia	Thrombolysis + angioplasty

LGO: limb graft occlusion; AAA: abdominal aortic aneurysm; IFU: instructions for use; BMI: Body Mass Index; EIA: external iliac artery; LMWH: low-molecular-weight heparin.

the angiographic control was performed after 12 hours of therapy. No bleeding complications related to thrombolysis were observed in patients with recent groin surgical incision. One patient was treated with surgical thrombectomy and iliac covered stent (Fluency, C.R. Bard, New Providence, NJ, USA) placement followed by patch angioplasty of the common femoral artery. Two patients required an iliac covered stent placement without thrombolysis or surgical thrombectomy: both cases required a primary self-expandable covered stenting with Viabahn (W.L. Gore & Associates) 13×10 mm and 13×15 mm. The asymptomatic patient received conservative management with low-molecular-weight heparin (LMWH). Characteristics of LGO cases are summarized in Table II. No mortality, no limb loss, no critical limb ischemia or residual claudication due to LGO was observed in a mean follow-up time of 39.3 months. Fifty patients resulted after matching between the seven patients with LGO and the rest of the entire cohort. The seven patients with LGO (LGO group) and 50 matched controls (control group), extrapolated from the entire cohort, were included in the analysis. Table III shows differences between the LGO and the control group. No statistically significant differences were found for gender, aneurysm type, and preoperative aneurysm size. Statistically significant differences were observed in the limb graft oversizing ≥15% (57.1% *vs.* 8%; P=0.005), limb graft kinking (42.9% *vs.* 2%; P=0.01), and preoperative size of aortic bifurcation (aortic bifurcation <20 mm: 71.4% *vs.* 20%; P=0.01). The logistic regression analysis, aimed to assess the relationship between epidemiological and clinical variables and LGO, showed that limb graft oversizing ≥15% (OR: 15.3, 95% CI: 2.5-93.9; P=0.003), limb graft kinking (OR: 18.0, 95% CI: 2.3-141.2; P=0.006), and aortic bifurcation <20 mm (OR: 10.0, 95% CI: 1.7-59.3; P=0.01) increased the risk of LGO (Table IV). The CTAs in Figure 1 and Figure 2 show right and left limb graft occlusion due to right limb graft kinking and narrow aortic bifurcation, respectively.

Table III.—*Comparison between the groups (LGO versus control).*

Variables	LGO group (N.=7)	Control group (N.=50)	P value
Sex, male	5 (71.4%)	47 (94.0%)	0.11
Mean age, years	75.6±6.4	75.7±6.4	Matched variable
AAA type			0.29
Aortic	31 (62.0%)	3 (48.9%)	
Saccular aortic	6 (12.0%)	2 (28.6%)	
Aorto-monoiliac	3 (6.0%)	1 (14.3%)	
Aorto-bi-iliac	4 (8.0%)	0 (0.0%)	
Isolated mono-iliac	4 (8.0%)	0 (0.0%)	
Isolated bi-iliac	2 (4.0%)	1 (14.3%)	
Mean aneurysm size, mm	52.7±1.0	55.1±13.8	0.66
Endograft type			Matched variable
Excluder	32 (64.0%)	1 (14.3%)	
Endurant	18 (36.0%)	6 (85.7%)	
Extension to the EIA	1 (14.3%)	13 (26.0%)	0.67
Limb graft diameter ≤14 mm	3 (42.9%)	26 (52.0%)	0.71
Age <70 years	1 (14.3%)	9 (18.0%)	1.0
Limb graft kinking	3 (42.9%)	2 (4.0%)	0.01
Outside of the IFU	1 (14.3%)	1 (2.0%)	0.23
BMI >28.9 kg/m^2	4 (57.1%)	10 (20.0%)	0.05
EIA ≤10 mm	3 (42.9%)	15 (30.0%)	0.67
AAA diameter <59 mm	4 (57.1%)	31 (62.0%)	1.0
Iliac angle ≥60°	4 (57.1%)	13 (26.0%)	0.18
Iliac calcification ≥50%	1 (14.3%)	6 (12.0%)	1.0
AAA angulation ≥60°	2 (28.6%)	9 (18.0%)	0.61
Graft limb oversizing ≥15%	4 (57.1%)	4 (8.0%)	0.005
Aortic bifurcation <20 mm	5 (71.4%)	10 (20.0%)	0.01
Iliac artery dissection	0 (0.0%)	4 (8.0%)	1.0
Graft migration	0 (0.0%)	0 (0.0%)	–

LGO: limb graft occlusion; AAA: abdominal aortic aneurysm; EIA: external iliac artery; IFU: instructions for use; BMI: Body Mass Index.

Discussion

LGO is a serious and frequent complication of EVAR. Cochennec *et al.* evaluated 460 patients who underwent EVAR from 1995 to 2005 and reported a 7.2% incidence of LGO.[5] In a recently described cohort of 504 patients who underwent EVAR, with several newest stent grafts, LGO occurred in 3.6% of the cases.[6] Faure *et al.* followed-up 1143 patients of The Endurant Stent Graft Natural Selection Global Postmarket Registry (ENGAGE), and described a 3.4% incidence of LGO.[7] The incidence of LGO in our study was lower (2.5%), which is in the range of up to 10.6% reported in the literature.[3-13, 15-40] Despite of widely different stent graft commercially available, similar outcomes occurred in large multi- and single-center studies performed

TABLE IV.—*Logistic regression analysis to assess the relationship between the clinical variables and the presence of LGO.*

Variables	Univariate analysis	
	OR (95% CI)	P value
Extension to the EIA	0.5 (0.1-4.3)	0.51
Limb graft diameter ≤14 mm	0.7 (0.1-3.4)	0.65
Age <70 years	0.8 (0.1-7.1)	0.81
Limb graft kinking	18.0 (2.3-141.2)	0.006
Outside of the IFU	8.2 (0.5-148.2)	0.16
BMI ≥28.9 kg/m^2	5.3 (1.0-27.8)	0.047
EIA ≤10 mm	1.8 (0.4-8.8)	0.50
AAA diameter <59 mm	0.8 (1.2-4.1)	0.81
Iliac angle ≥60°	3.8 (0.8-19.3)	0.11
Iliac calcification ≥50%	1.2 (0.1-12.0)	0.86
AAA angulation ≥60°	1.8 (0.3-10.9)	0.51
Graft limb oversizing ≥15%	15.3 (2.5-93.9)	0.003
Aortic bifurcation <20 mm	10.0 (1.7-59.3)	0.01

LGO: limb graft occlusion; EIA: external iliac artery; IFU: instructions for use; BMI: Body Mass Index; AAA: abdominal aortic aneurysm.

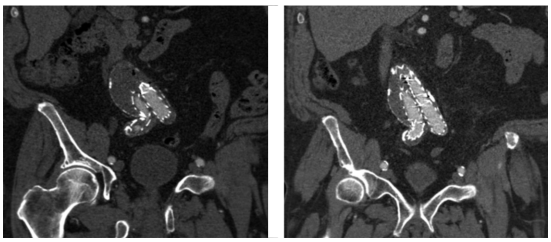

Figure 1.—Occlusion of right limb graft due to limb graft kinking, and post-treatment control.

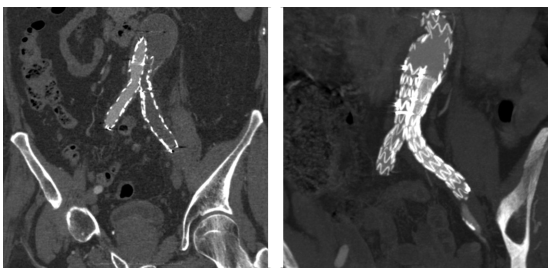

Figure 2.—Occlusion of left limb graft due to narrow aortic bifurcation, and post-treatment control.

with single or mixed devices.[10-13, 36-41] In our cohort the most frequently implanted device was the Excluder (59.7%); however, the majority (six of seven) of the LGO cases were found in patients treated with Endurant. We did not find any device-related features predicting LGO, although we might infer that a possible explanation can be the fact that we treated the most challenging cases with Endurant. The clinical presentation included acute limb ischemia in five out of seven of patients, and LGO occurred only in the first 6 months after EVAR, in agreement with previous series.[4-6] LGO after EVAR can be caused by numerous factors and only a few studies addressed their role, as shown in Table II.[3-13] Carpenter *et al*. stated that fully supported AAA endografts provide superior endograft limb patency compared with an unsupported design; however, only older generation devices, such as Ancure EVT, were included in that study.[3] LGO with older generation graft devices has been described several times.[5, 42, 43] In our series we used new generation devices, and no association between supported or unsupported graft-design and graft-patency was found. In a recent series from Wang *et al*., causes of LGO were divided into 3 major categories: anatomical (small artery size, aneurysm angulation ≥60°, calcified and narrowed aortic bifurcation, tortuous iliac artery and iliac artery dissection), device-related (graft migration, insufficient graft size and low radial force), and combined (anatomical and device-related) factors.[4] Anatomical, such as narrow aortic bifurcation, and device-related, such as the excessive limb graft oversizing, factors, seem to increase the risk of LGO in our cohort. Mantas *et al.* studied 439 patients who underwent elective EVAR with various device-grafts and stated that significant angulation (iliac angle >60°) and calcification (>50%) of the iliac arteries, as well as excessive limb oversizing (>15%) were independent predictive factors of LGO. Taudorf *et al.* found that three iliac artery tortuosity indices based on the preoperative CTA (the pelvic artery index of tortuosity, PAI; the common iliac artery index of tortuosity, CAI; the double iliac sign, DIS) and body mass index (BMI) can have a role in graft patency.[6] To our knowledge, no other studies reported association between BMI and higher LGO rate. In our personal series, iliac tortuosity was not calculated with these three iliac artery tortuosity indices, but it was simplified as excessive iliac angle (iliac angle >60°) and did not result to be a significant predictive factor of LGO. However, a potential result of iliac tortuosity can be the limb graft kinking, which was an independent factor of LGO after EVAR in our study, as confirmed by other authors.[5, 7] Abbruzzese *et al.* described a higher incidence of limb graft stenosis when implantation was performed outside at least one IFU.[10] On the other hand, van Zeggeren *et al.* showed that technical errors can cause LGO in 60% of the cases.[12] In our study, we excluded any variable related to technical errors due to the high volume and tertiary referring center characteristics; EVAR performed outside of IFU was not a significant predictive factor of LGO. Finally, in the ENGAGE registry the Authors classified patients at high and low risk according to an algorithm. A high-risk patient was identified in three steps: placement of distal end of the device, including extensions in the EIA; diameter of external iliac artery <10 mm in the presence of kinking; correction of endoleak or maximum diameter of aneurysm <59 mm. When the response was negative to all three checks, the patient was evaluated as low risk. Most of the LGOs occurred in the high-risk patients (38 of 42, 90.4%), even if they used only one stent graft type.[7] Other authors described the extension of the limb graft to the EIA as a significant predictive factor of LGO; these data were not confirmed in our cohort. Similarly, diameter of EIA <10 mm and AAA diameter <59 mm are not associated with LGO occurrence.[5, 8, 9, 11]

According to our review, therapeutic interventions after LGO can be identified in four types: endovascular (angioplasty alone, or with covered or bare metal stent; thrombolysis alone, or as adjuvant treatment), surgical (thrombectomy or extra-anatomic bypass), hybrid (*i.e.*, thrombectomy and iliac stent), and conservative (anticoagulant therapy). Some Authors reported that extra-anatomical bypass is an effective alternative with patency rates >90%.[5, 44] Ronsivalle *et al*. showed an unclogging technique adding a Vollmar ring stripper with promising results.[45] In our series, LGO cases were successfully treated with endovascular interventions in the majority of the cases (five of seven) and three required an additional thrombolysis. Thrombolysis has been shown to be an effective option in restoring patency in LGO.[46] One patient was treated with a hybrid procedure and one with a conservative approach (LMWH). Nevertheless, the best treatment should be prevention. Some Authors suggested that adjunctive iliac stents in angled iliac arteries reduce the LGO risk.[11, 47, 48] However, accurate measurement of iliac tortuosity is difficult, and the use of adjuvant iliac stents is based on subjective assessment of the iliac artery anatomy. Faure *et al.* proposed a decision tree based on clinical, anatomic, device, and operative conditions to classify patients as at high or low risk for LGO. Although it could be mighty helpful, its implementation is limited to the Endurant stent graft.[8]

Conclusions

LGO after EVAR is a serious complication and efforts should be adopted to prevent it. The incidence of LGO after EVAR was low (2.5% in our series). The most frequently detected factors associated with LGO were the extension of the limb graft in the EIA, small diameter of EIA, a tortuous, angled and calcific iliac axis, excessive oversizing of the limb graft, limb graft kinking, use of old generation devices, and EVAR performed outside of IFU. We confirmed the role played by aortic bifurcation <20 mm, limb graft kinking, and limb graft oversizing >15%. Treatment of this complication can be carried out with endovascular solutions; however, surgical and hybrid options can be effective. One pressing need is the classification of patients at risk of LGO. New multi-center studies, based on an appropriate design, could address this clinical unmet need.

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