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Clinical Research

Perioperative and Late Outcomes after Endovascular Treatment for Isolated Iliac Artery Aneurysms

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Background: The aim of the study is to report early and follow-up outcomes of the endovascular treatment with iliac endografts for isolated iliac artery aneurysms (IIAAs).

Methods: Records of patients who underwent elective endovascular repair for IIAA (both primary and para-anastomotic) from 2005 to 2015 in 2 Italian centers were retrospectively examined. Demographic data, preoperative patient comorbidities, iliac aneurysm characteristics, contralateral iliac axis involvement, patency of hypogastric arteries and inferior mesenteric artery (IMA), and data of endovascular treatment were obtained for analysis. Early end points were technical success (TS), perioperative morbidity, clinical success (CS), freedom from reintervention (FFR) and survival. Follow-up end points were CS, FFR, survival, evolution of the aneurysmal sac, and endoleak (EL).

Results: Thirty-two IIAAs were treated through an endovascular approach in 30 patients (male 96.7%; mean age 74.2 years ± 7.6, range 55–86). Aneurysms were para-anastomotic in 11 (34.4%) cases. Mean diameter was 42.9 ± 15.6 mm (range 30–100). Twenty (62.5%) aneurysms involved exclusively the common iliac artery, 7 (21.9%) the hypogastric, and 5 (15.6%) both arteries. Ipsilateral hypogastric artery was stenotic or occluded in 4 (12.5%) and 1 (3.1%) patient, respectively. Contralateral hypogastric artery was occluded in 2 (6.3%) cases. IMA was patent in 9 (30%) patients. The ostium of the hypogastric artery was preserved in 5 cases (15.6%) and voluntarily covered in 27 (84.4%). Endovascular embolization of hypogastric artery was obtained with a plug device in 8 cases (25%). Hypogastric surgical revascularization was performed in 2 cases (6.3%). TS was 96.9%. Thirty-day morbidity was 6.3% (2/32). CS was 96.9% (1 endograft limb stenosis). Thirty-day FFR was 90.6% (1 transluminal angioplasty, 2 inguinal revisions). Thirty-day survival was 100%. At 1, 3, and 6 years, CS was 93.4%, 85.6%, and 85.6%, respectively (1 endograft limb thrombosis, 1 endograft limb stenosis, 1 hypogastric type II EL with sac enlargement). At 1, 3, and 6 years, FFR was 87.5%, 76.8%, and 76.8%, respectively (1 fibrinolytic therapy and stenting, 1 stenting, 1 surgical ligation of hypogastric artery). At 1, 3, and 6 years, survival was 100%, 96.3%, and 81.3%, respectively. No IIAA-related deaths were reported. During follow-up, aneurysmal diameter was unchanged in 12 cases (37.5%), decreased in 19 (59.4%), and increased in 1 (3.1%). Type II EL from hypogastric artery was detected in 3 cases (9.4%) and led to sac enlargement requiring surgical treatment in 1 case.

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Conclusions: Endovascular treatment of isolated iliac aneurysm is safe and effective, providing that strict anatomical requirements are respected. Aneurysm embolization with vascular plugs was not associated with pelvic complications in this series. Endograft stenosis and thrombosis are the more frequent complications, which can be easily managed with endovascular approaches.

INTRODUCTION

Isolated iliac artery aneurysms (IIAAs) represent about 2% of all intra-abdominal aneurysms[1–3] with a prevalence of 0.03–0.1%.[4] The most frequent etiology is degenerative/atherosclerotic,[5] followed by para-anastomotic aneurysms secondary to bypass surgery (2–29%).[2,6–8] Isolated iliac aneurysms involve the common and the internal iliac artery in 70–90% and 10–30% of the cases, respectively. The external iliac artery is rarely involved.[9]

No univocal consensus on diameter threshold for treatment is reported. Some authors reported a growth rate of 4 mm/year, and suggested treatment when the diameter exceeds 30 mm.[1,10,11] Other authors[12] suggested 35 mm as threshold. Considering para-anastomotic aneurysms, the treatment is usually indicated with a diameter >40 mm.[13]

Surgical treatment may be challenging because of their deep pelvic localization and, in case of para-anastomotic aneurysms, for the presence of scar tissue. Thirty-day mortality and complication rate reach 10% and 16%, respectively.[14]

Endovascular treatment has been reported since 1994.[15] Patients with favorable iliac anatomy (presence of proximal and distal necks, absence of tortuosity, and adequate diameters) are good candidates for endovascular therapy. Elective endovascular treatment is associated with perioperative mortality <2% and perioperative morbidity about 20%.[6,14] Early results of endovascular treatment are encouraging,[7,16] but, at present, the literature about mid- and long-term clinical results is scarce.

The aim of the study is to report perioperative and late outcomes of the endovascular treatment for IIAAs.

METHODS

Study Design and Inclusion Criteria

This study is a retrospective analysis of prospectively collected database carried out from May 2005 to December 2015 in 2 Italian Centers of Vascular Surgery, considering patients who underwent elective endovascular treatment for primary or para-anastomotic IIAAs. Treatment indication was evaluated assessing risk/benefit ratio considering diameter ≥30 mm, according to the literature.[7,11] Infected etiology was preoperatively excluded by evaluating (1) the clinical status, (2) blood laboratory examinations (leucocyte count, erythrocyte sedimentation rate, C-reactive protein), and (3) labeled leukocyte scintigraphy or positron emission tomography (PET), where appropriate (in 1 center, PET was available only since 2007).

Inclusion criteria for the endovascular treatment of IIAAs were as follows: (1) proximal landing zone with diameter between 9 and 18 mm; (2) proximal landing zone with length ≥10 mm; and (3) distal landing zone with length ≥10 mm. Exclusion criteria were as follows: (1) suspected infected aneurysm and (2) urgent or emergent setting. Severe iliac angulation (≥90°) or severe arterial calcification (≥50% of arterial circumference) was not considered as exclusion criteria. The maximal aneurysm diameter was determined by centerline measurements. The iliac axis angulation was measured from three-dimensional data in 3 different arterial segments (proximal, distal common iliac, and external iliac artery) as a deviation from the straight path in degrees, as previously reported.[17]

Data Collection

Demographic data, preoperative patient comorbidities, and anesthesiological risk, according to the American Society of Anesthesiologists,[18] were collected. Considering the characteristics of IIAA treatment, localization of iliac aneurysm, anatomical features of proximal and distal neck (diameter and length), diameter of the aneurysm, and contralateral iliac axis involvement were gathered. Patency of hypogastric arteries and inferior mesenteric artery was assessed by preoperative computed tomography angiography (CTA).

Preoperative planning was performed at abdominal and pelvic CTA with slices <5 mm and, since 2009, a dedicated software (3Mensio™; Vascolare Immagine Software, Bilthoven, The Netherlands) Q3 was used. Anatomical features of proximal neck (diameter, tortuosity, angulation, calcification, and thrombosis), iliac axis, and access (tortuosity, stenosis, calcification) were evaluated.

During the procedure the following data were collected: type of anesthesia (general, locoregional,

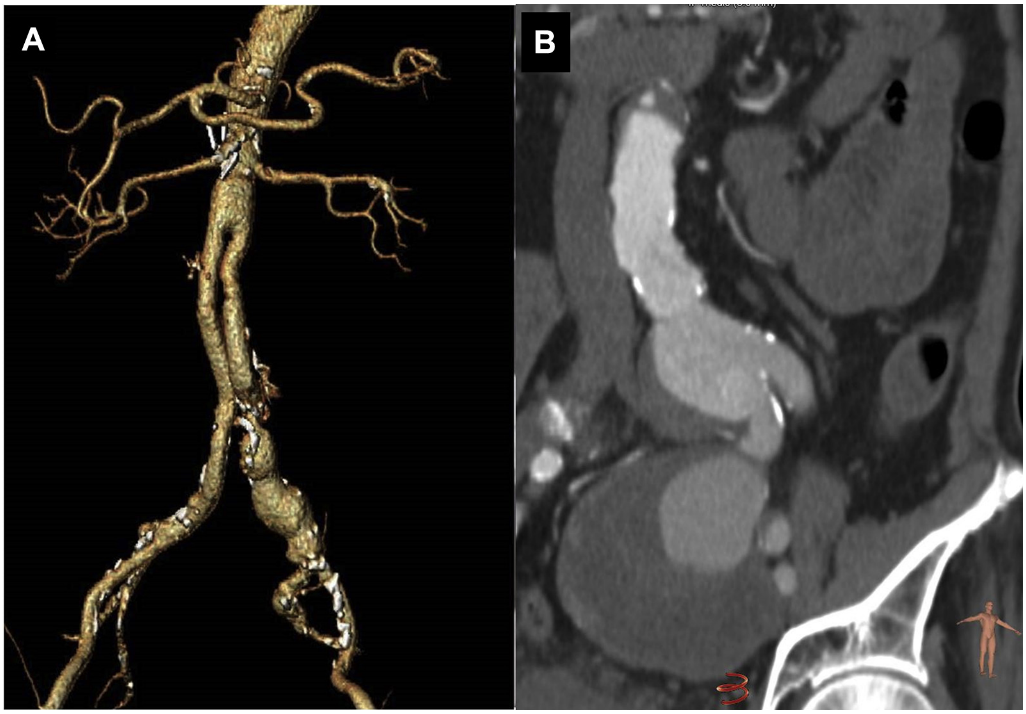

Fig. 1. Preoperative CTA imaging. **(A)** Three-dimensional reconstruction of isolated para-anastomotic aneurysm involving left common iliac artery and its bifurcation (type II). **(B)** Multiplanar rendering of degenerative/atherosclerotic aneurysms of common iliac and hypogastric artery (type III).

or local), access type and site, type of deployed endograft, contemporary treatment of hypogastric artery, bilateral treatment, length of the procedure, and amount of contrast medium.

IIAA Classification

Depending on localization and extension, IIAA has been classified into 4 categories: *type I*: involving common iliac artery with distal neck $\geq$1 cm in length; *type II*: involving common iliac artery and iliac bifurcation (hypogastric—external iliac artery) (Fig. 1A); *type III*: involving common iliac and hypogastric artery (Fig. 1B); and *type IV*: involving only the hypogastric artery.

Planning and Procedural Data

The type of treatment was planned during collegial assessment of preoperative CTA. The preservation of the hypogastric artery was considered in case of fit distal sealing zone in the common iliac artery (no coverage). In case of bilateral IIAA without appropriate distal sealing zones in the common iliac artery, we performed coverage on one side, and surgical revascularization in the contralateral side. The surgical revascularization of the hypogastric artery (external—internal iliac artery bypass) was performed in the same surgical session before stent-graft deployment. Isolated iliac branched endograft was deployed whenever anatomically possible. These parameters were considered independently from the nature of the aneurysm disease (atherosclerotic or para-anastomotic). Analyzing CTA imaging, the embolization was preoperative planned in case of the following: (1) type II iliac aneurysm with large diameter of common iliac artery above iliac bifurcation (prevision of no occlusion of the hypogastric artery origin with iliac endograft) and (2) type III or IV iliac aneurysm with maximum diameter >35 mm and patent gluteal arteries.

The site, number, and type of accesses (percutaneous versus surgical cutdown) were chosen in accordance with operator preference, considering the quality of the common femoral artery, preoperatively assessed at duplex ultrasound (DUS).

Procedures were classified into 5 types: (1) endografting of the sole common iliac artery (Fig. 2A); (2) endografting with distal landing zone in the external iliac artery without hypogastric embolization (Fig. 2B, right side); (3) endografting with distal landing zone in the external iliac artery

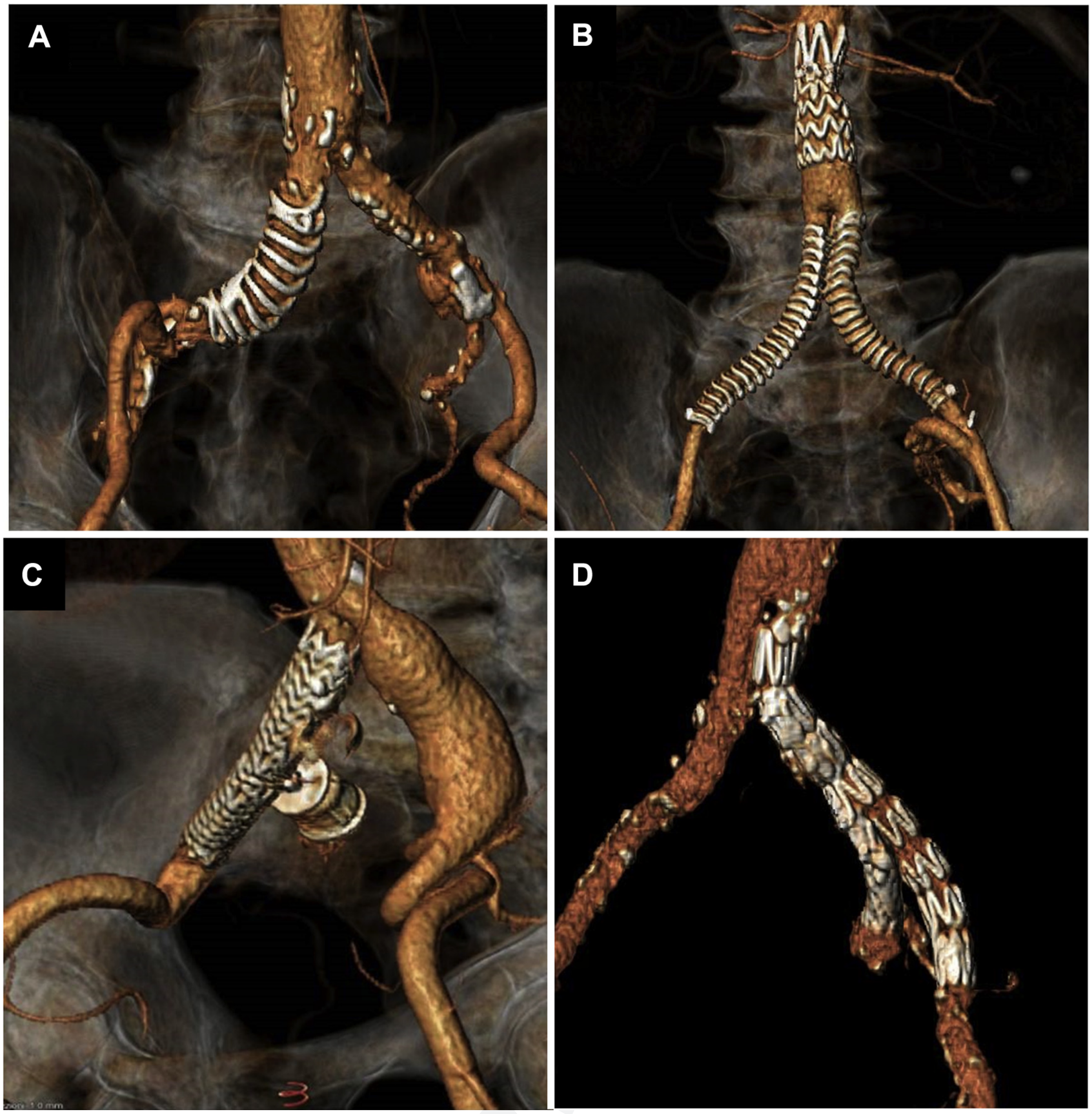

Fig. 2. Three-dimensional reconstruction of postoperative CTA. **(A)** Exclusion of isolated common iliac aneurysm (type I) with iliac endograft. **(B)** Exclusion of bilateral isolated common iliac aneurysms (type II) with iliac endografts and surgical revascularization of left hypogastric artery (previous deployment of tube aortic endograft for penetrating aortic ulcer). **(C)** Exclusion of right hypogastric aneurysm with iliac endograft and hypogastric embolization with plug. **(D)** Exclusion of aneurysm of left common iliac artery with iliac branched endograft.

with hypogastric embolization (Fig. 2C); (4) endografting with distal landing zone in the external iliac artery with surgical revascularization of hypogastric artery (Fig. 2B, left side); and (5) iliac branched endografting with endovascular revascularization of the external iliac and hypogastric artery (Fig. 2D).

After stent-graft deployment, ballooning of proximal and distal sealing zones was routinely performed. Intraprocedural adjunctive procedures (e.g., stenting) were collected as well.

Follow-up

Clinical and imaging follow-up protocol included the following: (1) clinical examination and DUS at 1, 6 months, and yearly thereafter; and (2) a CTA was performed at 1 year in all patients and, in case of nonthreatening endoleak (type II without sac enlargement), CTA was repeated yearly.

During imaging follow-up, maximum diameter of treated IIAA, thrombosis of the aneurysmal sac, patency of the endograft, and presence of endoleaks have been evaluated. The maximum diameter of the aneurysm was measured at center lumen line analysis. The diameter was considered to have increased or decreased in comparison with preoperative CTA with variation of +3 or −3 mm, respectively.

End Points

The end points were classified in early (within 30 postoperative days) and follow-up end points. Early end points were technical success (TS), perioperative morbidity, clinical success (CS), freedom from reintervention (FFR), and survival.

The follow-up end points were CS, FFR, survival, evolution of the aneurysmal sac, and endoleak (EL).

TS was defined as iliac endograft deployment with correct proximal and distal sealing, with exclusion of aneurysmal sac, no type I and III EL, or endograft stenosis >50% at completion angiography. Morbidity was defined as freedom from access site (hematoma, dehiscence, infection, lymphocele, lymphorrhea) or systemic complications (myocardial infarction, pneumonia, acute renal insufficiency). CS was defined as freedom from iliac aneurysm-related mortality, type I or III EL, endograft infection, endograft thrombosis or >50% stenosis, iliac aneurysm growth ≥5 mm or rupture, surgical conversion, and pelvic complications (buttock claudication, bowel ischemia, sexual impotence). FFR was defined as absence of vascular intervention secondary to the endograft deployment procedure.

Statistical Analysis

Descriptive statistics has been reported with mean and standard deviation for quantitative variables, while counts and percentage for qualitative variables. Follow-up results (CS, FFR, survival) were analyzed by Kaplan−Meier curves. Database and statistical analysis were performed with dedicated software (SPSS 13; SPSS Inc., Chicago, IL).

RESULTS

Preoperative

Thirty-two IIAAs in 30 patients (male 96.7%; mean age 74.2 years ± 7.6, range 55−86) were treated with an endovascular approach. Patients' comorbidities are reported in Table I. Iliac aneurysm was classified as primitive in 21 (65.6%) cases and secondary (para-anastomotic) in 11 (34.4%). The distribution of IIAA according to morphological classification is reported in Figure 3. Two patients (6.7%) underwent bilateral treatment for 2 type II and 2 type IV aneurysms. No isolated aneurysms involving the external iliac artery were detected. Mean diameter of iliac aneurysm was 42.9 ± 15.6 mm (range 30−100), mean diameter of proximal neck was 12.8 ± 2.7 mm (range 9−18), and mean diameter of distal neck was 10.8 ± 1.8 mm (range 9−15). Mean length of proximal and distal neck was 34.1 ± 24.1 mm (range 11−102) and 15 ± 11.2 mm (range 10−37), respectively. Ipsilateral hypogastric artery was completely patent, stenotic, and occluded in 27 (84.4%), 4 (12.5%), and 1 (3.1%) cases, respectively. Contralateral hypogastric artery was patent in 30 cases (93.7%) and occluded in 2 (6.3%) cases. Inferior mesenteric artery was occluded in 9 (30%) patients.

In the same period (May 2005 to December 2015), the total number of treated IIAAs was 38. Surgical approach was performed in 6 cases (15.8%) because the aneurysm was infected (3 cases) or considered unsuitable for endovascular repair according to anatomical parameters (3 cases).

Procedure

Prior to the endovascular repair, written informed consent was obtained from all patients. Procedure was performed under general, locoregional, and local anesthesia in 5 (16.7%), 16 (53.3%), and 9 (30%) of patients, respectively. Target artery was reached through ipsilateral surgical access in 9 patients (30%), bilateral surgical access in 4 cases (13.3%), ipsilateral surgical with contralateral percutaneous access in 15 cases (50%), surgical femoral access associated with contralateral pararectal cutdown in 1 case (3.3%), and surgical femoral access associated with ipsilateral pararectal cutdown in 1 case (3.3%).

Types of deployed endografts are reported in Table II. Mean proximal endograft diameter was 15.6 ± 3 mm (range 11−24), and distal mean diameter was 13.5 ± 2.2 mm (range 11−19 mm). Mean proximal and distal oversize of endograft was 22.2 ± 13.3% (range 7−50) and 26 ± 14.9% (range 6−67), respectively.

The hypogastric artery was treated according to the classification of IIAA as reported in Table III, and was covered in 27 (84.4%) cases, of whom 8 (29.6%) with concomitant endovascular embolization (Amplatzer vascular plug; St. Jude Medical, Saint Paul, MN). According to the preoperative planning, the embolization of hypogastric artery was not possible in 6 cases for technical inability to end the procedure (e.g., to cannulate the artery, to advance the sheath introducer).

Table I. Demographic data, preoperative comorbidities, and anesthesiological risk of included patients

Patients ($n = 30$)	n (%)
Male	29 (96)
Mean age (mean ± SD, range)	74.2 years ± 7.6 (55–86)
Arterial hypertension	29 (96)
Diabetes mellitus	4 (13)
Coronary artery disease	15 (50)
Chronic obstructive coronary disease	15 (30)
Dyslipidemia	18 (60)
Cerebrovascular disease	2 (7)
Chronic renal failure	6 (20)
ASA classification	
2	11 (37)
3	14 (47)
4	5 (16)

ASA, American Society of Anesthesiologists; SD, standard deviation.

Surgical revascularization of the hypogastric artery was performed in 2 cases (6.3%) with bilateral IIAA. In both cases, surgical revascularization was unilateral and the contralateral aneurysm was treated with simple coverage of hypogastric artery. Intraoperative adjunctive stenting was performed in 1 case (3.1%): a para-anastomotic aneurysm at the right distal anastomosis of an aortobi-iliac homograft was treated with iliac endograft, and a self-expandable stent was deployed at the proximal edge of the endograft to correct a homograft angulation.

Mean procedure time was 149 min (range 80–480). Mean amount of used contrast agent was 117.9 ± 25.5 cc (range 55–160). Mean length of postoperative hospital stay was 3.7 ± 2 days (median 3, range 1–8).

Mean follow-up was 48.3 ± 23.6 months (range 6.7–90.2).

Early End Points

TS was 96.9%. In 1 case, an endograft limb stenosis >50% remained undetected at completion uniplanar angiography but required a reintervention within the first 24 hr. Thirty-day morbidity was 6.3% (2/32). Two patients developed perioperative complications (access site-related): 1 common femoral artery intimal flap and 1 inguinal lymphorrhagia. No systemic complications were reported. CS was 96.9%, due to the abovementioned patient with endograft limb stenosis. No endograft thrombosis, distal embolization, or pelvic complications occurred. Thirty-day FFR was 90.6%. Reintervention was required in 3 cases. One transluminal angioplasty was performed in the abovementioned patient for iliac endograft stenosis (first postoperative day). The second patient required a femoral arteriotomy with correction of an intimal flap (first postoperative day). The latter was treated with inguinal surgical revision (28th postoperative day) for wound lymphorrhagia. Thirty-day survival was 100%.

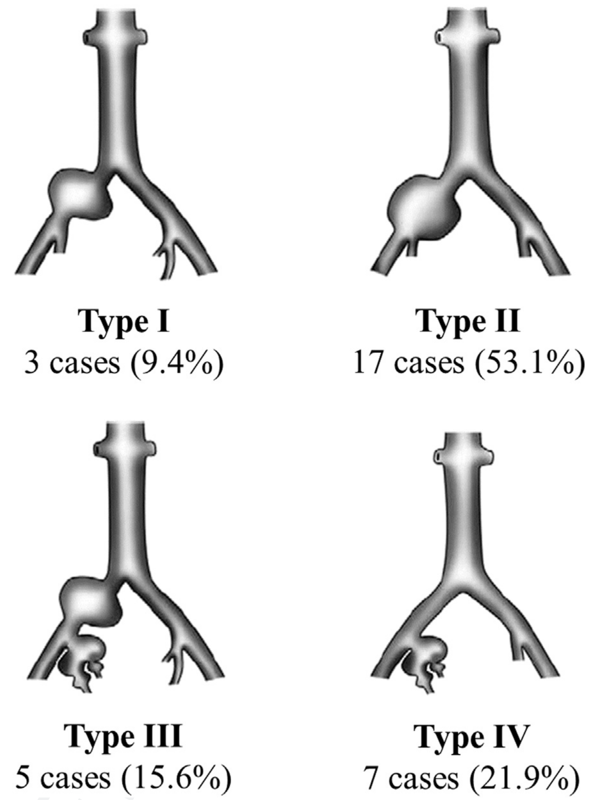

Fig. 3. Classification of IIAA, frequencies, and percentages.

Table II. Type of deployed iliac endograft Q4

	n (%)
Vascutek™ Anaconda™	14 (46.7)
Gore™ Excluder™	5 (16.7)
Medtronic™ Endurant™	3 (10)
Medtronic Talent™	3 (10)
Gore Viabahn™	2 (6.7)
Cook Zenith Converter™	2 (6.7)
Cook Iliac branched™	2 (6.7)
Cook Zenith Spiral™	1 (3.3)

Table III. Treatment of hypogastric artery

Type of aneurysm	Hypogastric arterial treatment: No coverage	Coverage without embolization	Coverage + embolization	EIA−HA bypass graft
Type I	3			
Type II	1[a]	9	5	2
Type III	1[a]	3	1	
Type IV		5	2	
Overall	5 (15.6%)	17 (53.1%)	8 (25%)	2 (6.3%)

EIA, external iliac artery; HA, hypogastric artery.
[a]Treated with iliac branched endograft.

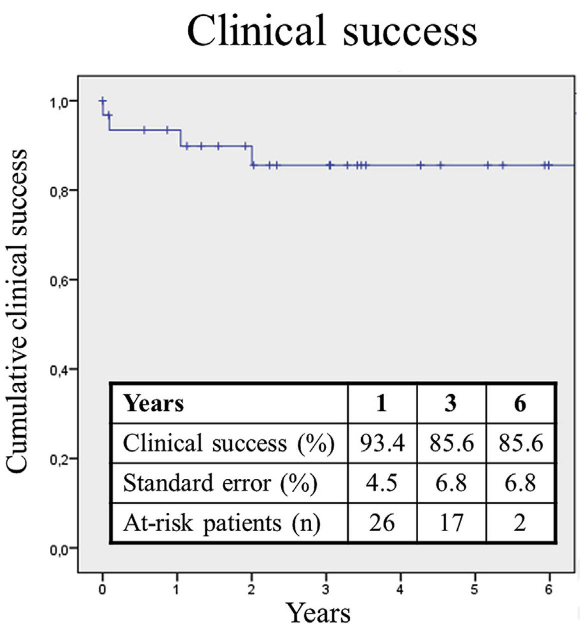

Fig. 4. Clinical success during follow-up according to Kaplan−Meier analysis.

Follow-up End Points

At 1, 3, and 6 years, CS was 93.4%, 85.6%, and 85.6%, respectively (Fig. 4). Clinical failures occurred in 3 cases. One patient had an endograft limb thrombosis at 32nd postoperative day (proximal and distal oversize of endograft was 7% and 44%, respectively). The second patient presented a distal endograft stenosis landing in the external iliac artery (proximal and distal endograft oversize was 20% and 50%, respectively) after 1 year. The latter developed a 60-mm hypogastric aneurysm with ≥5 mm enlargement for distal reperfusion. No type I or III EL, endograft infection, aneurysm rupture, or pelvic complications occurred.

At 1, 3, and 6 years, FFR was 87.5%, 76.8%, and 76.8%, respectively (Fig. 5). One patient underwent intra-arterial fibrinolytic therapy for endograft limb thrombosis due to proximal stenosis and endograft in-folding; iliac kissing stenting and stenting at distal edge of the endograft were required. The second patient was treated for endograft stenosis of distal edge with transluminal angioplasty and stenting. The latter patient underwent surgical ligation of the hypogastric artery for ≥5 mm enlargement of hypogastric aneurysm (during the first operation, endovascular embolization of aneurysm failed due to the impossibility of cannulating the gluteal arteries).

At 1, 3, and 6 years, survival was 100%, 96.3%, and 81.3%, respectively (Fig. 6). Late death occurred in 4 cases: 1 for myocardial infarction and 3 for cancer. No IIAA-related deaths were reported during follow-up.

Diameter of the iliac sac remained unchanged in 12 cases (37.5%), decreased in 19 (59.4%), and increased in 1 (3.1%). Sac evolution in the different types of IIAA is reported in Table IV.

During follow-up, type II EL from hypogastric artery was detected in 3 cases (9.4%). In these cases, iliac aneurysm diameter increased, remained unchanged, and decreased in 1 (3.1%) case each. The first patient, initially treated for a 54-mm type III IIAA with common and external iliac endografting without embolization, presented a 6-mm sac enlargement 2 years later. He successfully underwent surgery (ligation of hypogastric artery). In the remaining 2 patients, reintervention was not required and continued their follow-up. No type I or III EL was detected at follow-up. No pelvic complications occurred during follow-up.

DISCUSSION

In our series, considering the 10-year period of the study, 80% of IIAAs (32/38) underwent endovascular therapy. Endovascular iliac endografting has optimal TS, whereas CS and FFR are mostly influenced by endograft limb stenosis or occlusion. After hypogastric coverage, no pelvic complications

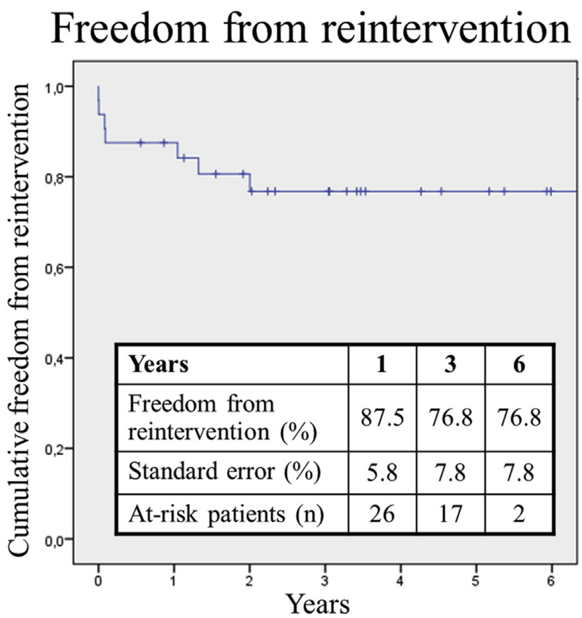

Fig. 5. FFR during follow-up according to Kaplan—Meier analysis.

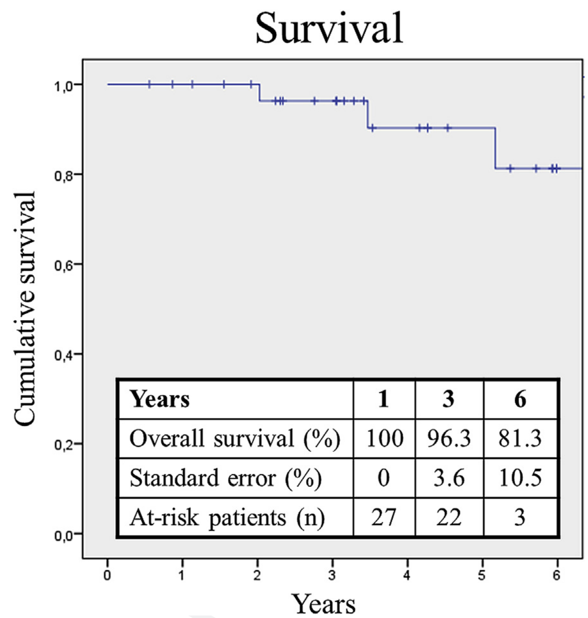

Fig. 6. Patient survival during follow-up according to Kaplan—Meier analysis.

occurred independently from hypogastric embolization.

In accordance with the literature, at present, endovascular aneurysm exclusion gained widespread acceptance as the first-choice treatment modality for IIAA.[18,19]

Endovascular procedure requires anatomical suitability in terms of diameter and length of proximal and distal sealing zone. In particular, proximal and distal neck lengths are not well defined. Some authors considered a sufficient proximal sealing zone in common iliac artery to be at least 5 mm in length,[7] others preferred more than 15 mm.[3] In case of common iliac artery aneurysm, distal neck (proximally to the iliac bifurcation) is considered fit for endovascular treatment in case of length ≥15[8] or ≥30 mm.[7] In our daily practice and for the inclusion criteria of this, a proximal and distal neck length ≥10 mm was considered fit for endovascular procedure.

Numerous and different endovascular procedures have been previously reported in literature as treatment for IIAA, depending on several factors: nature of the aneurysmal disease, localization and extension of the aneurysm, and characteristics of sealing zones. For common iliac artery, endograft iliac stent-graft deployment with/without hypogastric embolization is generally adopted, while, for hypogastric aneurysm, hypogastric embolization with/without endograft iliac stent-graft placement is described.[3,6,7] Normally, aorto-bifurcated stent graft is placed in case of unfit proximal neck or in case of bilateral IIAA.[3] In some cases, aortouni-iliac endograft was deployed with associated femoro-femoral supra-pubic bypass graft.[8] In this study, proximal sealing zone was obtained always in common iliac artery, without involvement of abdominal aorta. Zenith branch iliac endograft (Cook™, Bloomington, IN) was used without aortoiliac bifurcated module in 2 cases (6.3%). These 2 patients presented a common iliac aneurysm anatomically fit for bifurcated iliac branch (iliac bifurcation ≥16 mm in diameter; sealing zone in external iliac artery ≥20 mm in length and 8—11 mm in diameter; sealing zone in internal iliac artery ≥10 mm in length) and not dilated origin of common iliac artery that was used as proximal sealing zone.

Considering distal landing zone, only few cases presented an adequate length (at least 10 mm) in common iliac artery and a planned coverage of hypogastric artery was necessary in more than 80% of treatments. Differently from other studies,[3,6,7] no hypogastric aneurysm was treated by embolization alone, because the associate covering of the hypogastric ostium has been considered a safer procedure. However, bilateral occlusion of hypogastric artery is largely discouraged considering the high rate of pelvic complications (buttock claudication 42%, impotence 14%)[20]; Therefore, a revascularization of at least 1 hypogastric artery is suggested in case of bilateral aneurysm.[8]

Table IV. Shrinkage reported according to hypogastric artery treatment

Sac diameter evolution	Hypogastric arterial treatment: No coverage	Coverage without embolization	Coverage + embolization	Overall
Unchanged	1	6	5	12 (37.5%)
Decrease	4	8	7	19 (59.4%)
Increase	–	1	–	1 (3.1%)

Considering the high rate of TS reported in the literature,[6,8] the endovascular treatment of IIAA is considered a safe procedure.

In this study, in spite of high rate of hypogastric occlusion (78%) and high rate of para-anastomotic aneurysm (34%), no clinical consequences on pelvic vascularization (buttock claudication, pelvic ischemia, or sexual impotence) were reported after a mean period of 4 years.

On the contrary, literature data described a higher rate of buttock claudication (12–19%[6,18]; Table V)[3,6–8,18,21] and symptoms occurred particularly after the use of coil (22–30%).[6,18] Some literature data[8,22,23] suggest that coil embolization of hypogastric aneurysm in its distal branches leads to higher rate of buttock claudication. On the contrary, claudication is rarer without coil embolization or after coil deployment in the proximal portion of the vessel.[8,22,23] Coils deployment in the vascular district is not a precise procedure, and often the final coil position is changed by multiple forces (blood flow, arterial wall, coil bending). Coils may have been pushed distally by the flow, causing damage at distal arterial vascularization.

According to our strategy, iliac aneurysm embolization was performed in all cases with Amplatzer vascular plug (Vascular Plug or Vascular Plug II). After its release in the aneurysmal sac, its final conformation prevents displacement, limiting its thrombotic action in the dilated portion of the artery. Data concerning comparison between vascular plug and coils in iliac district are anecdotic[8,24,25] and further specific studies are necessary for ultimate conclusion.

In our series, the most frequent complications are stenosis or occlusion of iliac endograft limb (1 early stenosis, 1 late stenosis, and 1 late thrombosis). Grade of oversize probably plays a fundamental role in the genesis of these complications. In a patient who developed endograft limb thrombosis after 32 days, proximal and distal oversize were 7% (endograft 16 mm versus artery 15 mm) and 44% (endograft 13 mm versus artery 9 mm), respectively. In addition, stenotic iliac lesion diagnosed after 1 year involved an endograft with 20% of proximal and 50% of distal oversize. Excessive distal oversize may lead to in-folding (device compression and invagination)[26] of the distal edge of the stent graft and may lead to stenosis development and thrombosis of the graft. Even if in-folding has not been well defined and proved in iliac district, in our opinion this should be a valid explanation for the majority of iliac stenotic/occlusive events. To prevent these complications, an accurate endograft oversize must be calculated at the proximal and distal edge. A stenting of the edge of the endograft might prevent in-folding for excessive oversize.

Dealing with reintervention necessity, our data are comparable with literature data,[3] with 2-year FFR of about 80%. Reinterventions are mainly endovascular procedures and are generally effective. In the current series, only 1 case underwent open repair (hypogastric ligation) for a persistent type II EL from hypogastric artery.

Diameter reduction of isolated iliac aneurysm after endovascular exclusion has been already proven with diameter increment in about 2.9% (1/35) of aneurysms.[27] In accordance with these data, aneurysmal increase $\geq$5 mm was detected in only 3.1% of current case series.

Surgical treatment includes graft interposition for common or external iliac aneurysms. In case of hypogastric artery aneurysms, surgical treatment is quite complex due to the pelvic localization. In case of para-anastomotic aneurysms, surgery is challenging due to the scar caused by previous tissue dissection. In case of hypogastric artery aneurysm, surgical treatment includes ligature of hypogastric or aneurysmorrhaphy with or without graft interposition. In elective treatment, overall mortality ranged between 0% and 13% and, in case of emergency, reached higher rate (0–60%).[14] Possible complications include lower limb ischemia for embolism or thrombosis, bowel or pelvic ischemia for hypogastric ligation, graft infection, aortoenteric fistula, and lesion of ureter and iliac vein.

Thirty-day outcomes after endovascular treatment are superior to surgery in terms of survival and freedom from complications, with a

Table V. Outcome of endovascular treatment of isolated iliac artery aneurysm: revision of literature

First author	Year of publication	Number of patients	Mean diameter of IIAA (mm)	Thirty-day survival (%)	Reintervention (%), time of follow-up	Complication related with HA coverage (%)	EL (all types) (%)	Sac shrinkage (%)	Mean follow-up (months)
Boules[21]	2006	61	4.2 ± 1.7	100	11.9 (2 years)	20	13	87	22
Pitoulias[18]	2007	33	44.5 ± 15.5	100	NS	12	0	72	35
Chaer[3]	2008	52	42 ± 0.2	100	19 (2 years)	3.8	5.8	86	17
Power[7]	2009	11	4.3 ± 1.1	100	0 (1 year)	NS	8.3	NS	12
Patel[6]	2009	31	40 ± 1.1	100	NS	19	3.2	67	36
Chemelli[8]	2010	91	33 ± 1	80	13 (NS)	5.5	12	—	45
Current case series	—	25	39.6 ± 9.8	100	23.4 (4–6 years)	0	11	59	48

HA, hypogastric artery; NS, not specified.

significantly lower in-hospital stay after the procedure.[3,6] During follow-up, outcomes after iliac endografting is comparable with open surgery in terms of patency,[6] FFR,[2,3] pelvic claudication, and sexual complication,[3] with no statistically significant differences. In accordance with the literature, this study states that endovascular treatment can be considered the first-line treatment in case of elective treatment of IIAA.

CONCLUSION

Providing strict anatomical parameters are respected; endovascular iliac endografting for IIAA is a safe and effective procedure and follow-up outcomes are comparable with open surgery. Aneurysm embolization with Amplatzer vascular plug was not related with pelvic complications in our series. Endograft stenosis and thrombosis represent the main complications and are mostly re-treated successfully with endovascular approach. A careful assessment of oversizing is mandatory during preoperative planning. In case of common iliac aneurysm, type II EL from hypogastric artery is possible, but not necessarily associated with increase in sac diameter.

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