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Hellenic Society of Vascular and Endovascular Surgery

# Hellenic Journal of Vascular and Endovascular Surgery

## HOT TOPICS



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# Hellenic Journal of Vascular and Endovascular Surgery

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- Follow the guidelines in the AMA Manual of Style (10th ed., 2007). Do NOT use endnotes or other bibliographic style function for reference lists.
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Giannoukas AD, Chabok M, Spanos K, Nicolaides A. Screening for Asymptomatic Carotid Plaques with Ultrasound. Eur J Vasc Endovasc Surg. 2016;52:309-12.

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# Contents




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Hellenic Journal of Vascular and Endovascular Surgery

# Letter from the Editors

Dear colleagues,

The Hellenic Society of Vascular and Endovascular Surgery in an effort to re-publish and upgrade the Society's official scientific journal evolved us in this task. The first issue of this new international journal entitled "**Hellenic Journal of Vascular and Endovascular Surgery**" is now a reality. It will be published in English every three months, in order to have a greater scientific impact and reach beyond the borders of Greece.

**HJVES** is aimed at any specialty dealing with patients with arterial, venous and lymphatic diseases. Thus, contribution from the fields of vascular surgery, interventional radiology, anesthesiology, angiology, diabetology, cardiology and any other that involves some kind of vascular pathology is welcomed. We therefore invite everyone that is interested to submit his/her scientific work, including original studies, systematic reviews, interesting cases, technical aspects or any other interesting article in the field of vascular surgery, vascular imaging, intravascular techniques as well as in the prevention and treatment of vascular diseases. In particular, endovascular techniques and reports on the emerging technology are also encouraged.

The journal is published by the Publisher Press "ROTONDA", based in Thessaloniki, and will be **available free of charge in electronic form (pdf),** through its' website. **Submission and publication of articles will be also free of charge.** All articles will be subjected to "peer review" by external peer reviewers who are specialized in the field of the subject in order to improve and harmonize them with the structure of the journal. The thematic and lead publishers will make the final decision for publication, while the Journal is committed decisions not to delay more than 40 days from submission. The process of "peer review" is considered necessary both to ensure the quality of the magazine and its possible future acceptance by international databases and PubMed in particular.

We call all members of the Hellenic Society of Vascular and Endovascular Surgery, as well as all Greek vascular surgeons and other vascular specialties working abroad to actively contribute in this new scientific effort of the Society. We hope our non-Greek colleagues all around the world to consider our Journal for submission of their scientific work. We, all Editors, promise to work hard in order to continually publish a journal with good scientific quality that will be indexed in most known international databases in the near future.

Prof. Miltos Matsagkas
Editor in Chief

Prof. John Kakisis
Senior Editor

Hellenic Journal of Vascular and Endovascular Surgery

# Letter from the President of Hellenic Society of Vascular and Endovascular surgery

The Hellenic Society of Vascular and Endovascular Surgery (HSVES) is one of the leading scientific organizations in Greece committed to support scientists and clinicians in Vascular Medicine and Vascular Surgery. With this main objective, our Society has been at the epicentre of developments regarding the introduction of new technologies and new forms of diagnosis and treatment options in this field over the last few decades.

In spite of the financial situation of our country, our members are highly active both in research and in clinical practice with the application of new technologies regarding endovascular surgery, nanomedicine, 3D - reconstruction, 3D- printing and newly developed models for the study of cardiovascular haemodynamics.

Thanks to these creative efforts and excellent cooperation with domestic and international centres, it is noted that the Greek Vascular Society contributes significantly to the promotion of scientific knowledge and its dissemination through scientific events and publications. Our highly skilled members excel internationally with high-quality scientific publications in international prestigious journals. .

As the President of the Hellenic Society of Vascular and Endovascular Surgery, I have repeatedly urged, both our society members and other members of the scientific community, to join the Society Journal ("Hellenic Vascular Surgery" or "Ελληνική Αγγειοχειρουργική"), which is now going to be republished. After many discussions between the members and the administration council of the society we decided in the last general assembly, that took place in our last Annual Meeting in March 2018 in Thessaloniki, to reprint the journal in a revised english form under the new title "**Hellenic Journal of Vascular and Endovascular Surgery**". I am pleased to inform the society members that the publication of the journal is financially secured for the next years.

Professor Miltiadis Matsagkas is assigned as Editor in Chief while Professor Ioannis Kakissis as Senior Editor. All assistant editors and members of the editorial board members are internationally distinguished prestigious scientists. The journal is being published by the Publisher Press "ROTONDA" based in Thessaloniki and will be available in electronic form, through its website, under the policy of open access making it accessible on-line and free of cost or other barriers. Our objective is the future acceptance of our journal by international databases.

I would like to thank Prof. Matsagkas and Prof. Kakisis for their huge and great effort, as well as all members of the editorial office including the highly motivated team of reviewers. Last but not least, I would like to thank the medical companies for supporting our Society's Journal.

I would like to invite all members and colleagues from various related specialties to contribute to the new Journal by submitting original articles, interesting case reports, short communications, critical reviews, surveys, opinions, commentaries and essays in the field of Vascular Medicine and Surgery.

I expect our vision to flourish and our Journal to receive further recognition among the members of the scientific community.

Prof. Kyriakos D. Ktenidis
President of HSVES

# HJVES Reviewers 2018

The Editors would like to thank the Reviewers of the Journal for their support during the year 2018. Their contribution was constant and invaluable for achieving the aims of the Journal.

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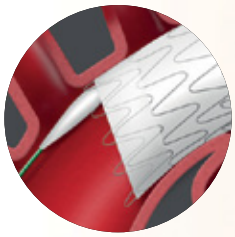

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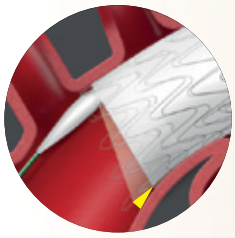

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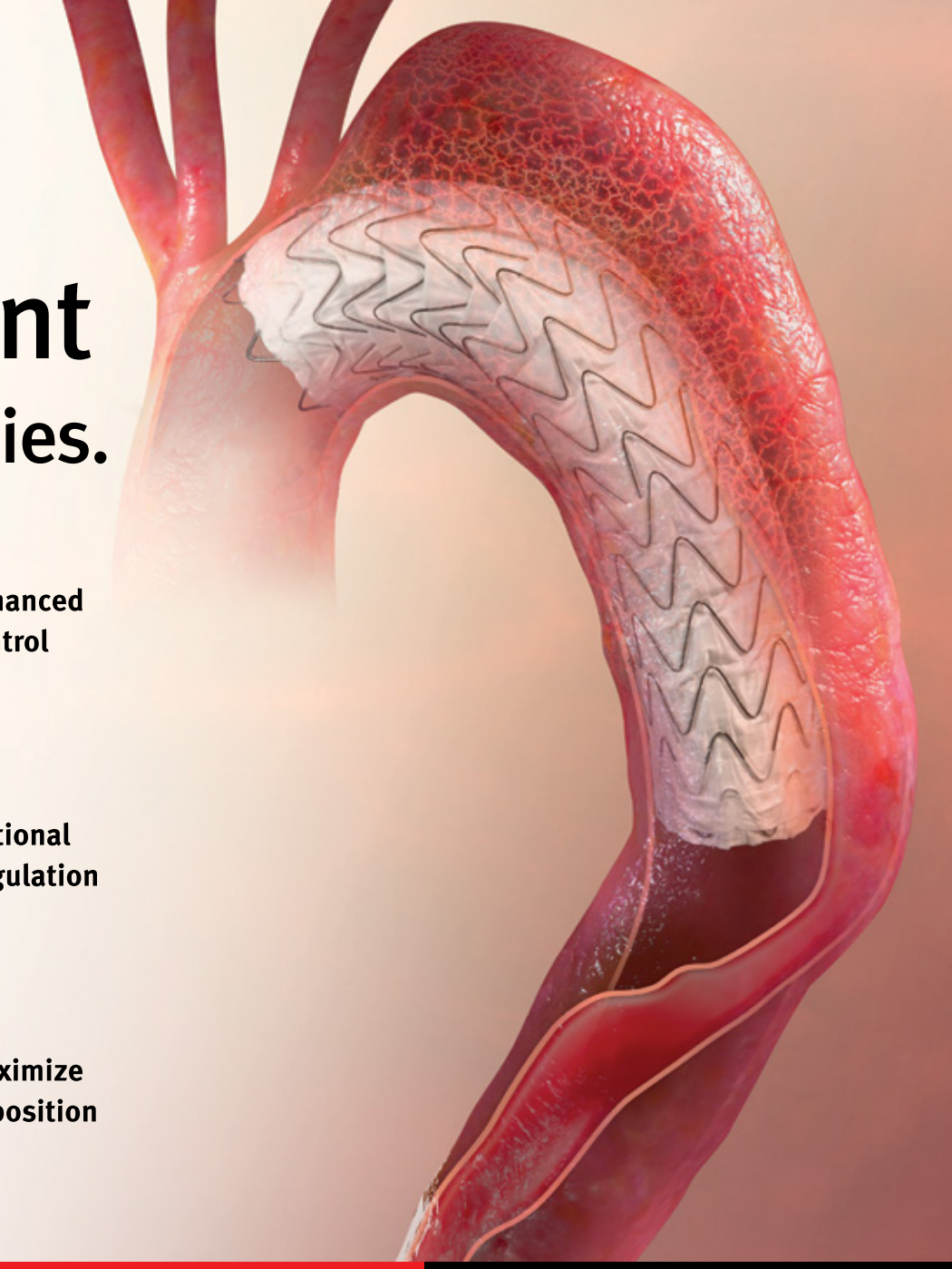

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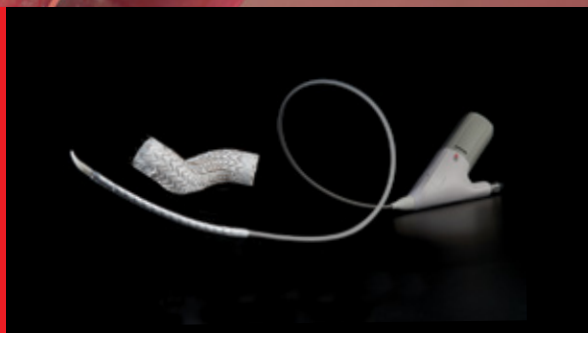

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EDITORIAL

# Intentional targeted false lumen occlusion after aortic type B dissection: Where do we stand?

**Konstantinos Spanos[1,2], Nikolaos Tsilimparis[1,3], Fiona Rohlffs[1], Tilo Kölbel[1]**

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[3]Department of Vascular Surgery, Ludwig Maximilian University of Munich, Germany

The incidence of aortic dissection (AD) has been increased from previously estimated at 3.5/ 100,000 patient-years to 14/100,000.[1,2] Patients with thoracic ADs not involving the ascending aorta and arch are defined as Stanford B (Debakey IIIa, IIIb).[3] Thoracic endovascular aortic repair (TEVAR) has been increasingly used for the treatment of type B aortic dissection (TBAD) offering better outcome in terms of mortality and morbidity compared to open surgical repair.[4]

However, after standard TEVAR, complete false lumen thrombosis is only achieved in around 40% of the patients by covering the proximal tear entry point alone.[5] Persistent perfusion from distal entry-tears may cause the lack of false lumen thrombosis, which can lead to late false lumen expansion during follow up in 30% of patients being treated with TEVAR requiring additional re-interventions.[6] False lumen patency is independently associated with poor long-term survival in chronic TBAD (cTBAD), while thrombosis of the false lumen may be an independent predictor of no further growth.[7]

Many techniques have been applied for the induction of complete false lumen thrombosis after TEVAR such as Candy-plug, the Knickerbocker, vascular and iliac plugs, coils and liquid embolization techniques.[8] Kölbel group[9] were the first ones to describe the Candy-plug technique in 2013 using a back-table modification of a Zenith thoracic TX2 Pro-Form stent-graft by adding a diameter-reducing suture to restrict the opening to a maximum diameter of ~10 mm still allowing for retraction of the dilator tip. A 20-mm Amplatzer Vascular Plug II (AVP; St. Jude Medical, St. Paul, MN, USA) was deployed in the waist of the candy-wrapper shaped pluginto the false lumen in a distal segment of the descending thoracic aorta and simultaneously a thoracic stent-graft was placed at the level of the celiac artery into the true lumen. Recently, Rohlffs et al.[9] presented the results of Candy plug technique in 18 consecutive patients showing that this technique is a feasible endovascular method to achieve false lumen occlusion and aortic remodeling in chronic aortic dissection patients and it is associated with low morbidity and mortality.

Knickerbocker technique is another option, which is based on the dilation of the middle part of a large diameter stent-graft that is placed in the true lumen.[10] In this technique, a short segment of the stent-graft is dilated with excessive force using a compliant balloon to rupture the dissection membrane and extending the stent-graft to the false lumen. The main advantage of this technique is that an access of the false lumen is not needed which may become a complicated procedure and additionally of other materials are required.

A large variety of devices along with solid as well as liquid embolization materials have been developed to occlude the false lumen such as coils, onyx, glue, iliac occluder devices, and various other vascular plugs.[8] The diameter of the false lumen still remains a limitation for most of the materials as most of these are commercially available up to 24mm, having as a result using more than one device or a lot of adjunctive embolization material.

Induction of false lumen thrombosis after endovascular treatment of type B aortic dissection is not commonly performed in Vascular Centers. However, a recent systematic review of the literature highlighted that those procedures achieve high technical success rate irrespectively of the technique (99%, 60/61 in one case it was not possible to introduce a covered stent into the celiac trunk and a persistent flow into the FL was present at the level of the attempted sealing), with low percentages of mortality (0%, 0/61), while it was also shown that the false lumen may remain completely thrombosed up to 62% during follow up.[8]

The time of the intervention remains a matter of debate as currently there is no hard evidence on the preferred timing for the induction of false lumen thrombosis. In the literature, patients were treated either under elective circumstances (false lumen expansion >5 mm expansion per 6 months; false lumen aneurysm >5.5 cm) or presence of symptoms/ or rupture.[8] Most of false lumen occlusion techniques demand experienced operators with a high technical skills level, which may be currently a limitation for those techniques. The development of referral centers and may increase the experience on these techniques producing even better outcomes.

*Conflict of interest*

*N. Tsilimparis is proctor for Cook Medical*

*Tilo Kölbel has intellectual property with Cook Medical*

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## REFERENCES


1 Clouse WD, Hallett JW Jr, Schaff HV, Spittell PC, Rowland CM, Ilstrup DM, et al. Acute aortic dissection: population based incidence compared with degenerative aortic aneurysm rupture. Mayo Clin Proc. 2004;79:176-80.

2 Olsson C, Thelin S, Ståhle E, Ekbom A, Granath F. Thoracic aortic aneurysm and dissection: increasing prevalence and improved outcomes reported in a nationwide population-based study of more than 14,000 cases from 1987 to 2002. Circulation. 2006;114:2611-8.

3 Rohlffs F, Tsilimparis N, Diener H, Larena-Avellaneda A, Von Kodolitsch Y, Wipper S, et al. Chronic type B aortic dissection: indications and strategies for treatment. J Cardiovasc Surg (Torino). 2015;56:231-8.

4 Kusagawa H, Shimono T, Ishida M, Suzuki T, Yasuda F, Yuasa U, et al. Changes in false lumen after transluminal stent-graft placement inaortic dissections: six years' experience. Circulation 2005; 111: 2951-7.

5 Fattori R, Tsai TT, Myrmel T, Evangelista A, Cooper JV, Trimarchi S, et al. Complicated acute type B dissection: is surgery still the best option? A report from the International Registry of Acute Aortic Dissection. JACC Cardiovasc Interv 2008; 1: 395-402.

6 Tanaka A, Sakakibara M, Ishii H, Hayashida R, Jinno Y, Okumura S, et al. Influence of the false lumen status on clinical outcomes in patients with acute type B aortic dissection. J Vasc Surg 2014; 59: 321-6.

7 Li D, Ye L, He Y, Cao X, Liu J, Zhong W, et al. False Lumen Status in Patients With Acute Aortic Dissection: A Systematic Review and Meta-Analysis. J Am Heart Assoc. 2016 10;5.

8 Spanos K, Kölbel T, Rohlffs F, Heidemann F, Giannoukas AD,Debus SE, et al. Intentional targeted false lumen occlusion after aortic dissection: a systematic review of the literature. Ann Vasc Surg. (In press)

9 Rohlffs F, Tsilimparis N, Fiorucci B, Heidemann F, Debus ES, Kölbel T. The Candy-Plug Technique: Technical Aspects and Early Results of a New Endovascular Methodfor False Lumen Occlusion in Chronic Aortic Dissection. J Endovasc Ther. 2017;24:549-55.

10 Kölbel T, Carpenter SW, Lohrenz C, Tsilimparis N, Larena-Avellaneda A, Debus ES. Addressing persistent false lumen flow in chronic aortic dissection: the knickerbocker technique. J Endovasc Ther. 2014; 21: 117-22

# Reinterventions after endovascular abdominal aortic aneurysm repair

**John D. Kakisis[1], Konstantinos G. Moulakakis[1], George Sfyroeras[1], Andreas M. Lazaris[1], Christos D. Liapis[1], Stavros Spiliopoulos[2], Elias Brountzos[2], George Geroulakos[1]**

[1]Department of Vascular Surgery, School of Medicine, National and Kapodistrian University of Athens, "Attikon" University Hospital, Athens, Greece
[2]2nd Department of Radiology, School of Medicine, National and Kapodistrian University of Athens, "Attikon" University Hospital, Athens, Greece

**Abstract:**

**Objectives:** To record all the complications after endovascular abdominal aortic aneurysm repair (EVAR) treated invasively, to summarize the treatment methods that were used and assess the safety and efficacy of these methods.

**Patients and Methods:** Between 1/2010 and 12/2017, 628 patients underwent EVAR. Patients were followed by CT angiography on the 1st and 12th postoperative month and annually thereafter by color duplex. The records of all patients undergoing reoperation, either open or endovascular, were reviewed from a prospectively kept database.

**Results:** One hundred and eight reinterventions were performed in 90 patients (14.3%). The most frequent cause of reoperation was type II endoleak: 43 reoperations in 35 patients (5.6%). Of these reoperations, 21 were transarterial (9) or translumbar (12) embolizations, 20 were open surgical ligations and 2 were interventions for complications of embolization. Technical success of transarterial embolization was 78% and of translumbar 67%. The second cause of reintervention was endograft limb occlusion (32 re-operations in 23 patients, 3.6%). Of these reinterventions, 13 were stentings (92.3% technical success), 17 bypasses and 2 thrombectomies with angioplasty. The third cause of re-intervention was type I endoleak (18 reinterventions in 17 patients, 2.7%). All Ib endoleaks (6 patients) were treated by extension of the endograft to the common or external iliac artery, while Ia (11 patients) endoleaks were treated by open conversion (5), proximal cuff (3), Palmaz stent (3) or embolization (1). More rare causes of re-intervention included endograft infection (8 patients), type III endoleak (3), aneurysm rupture (1) and sigmoid (2) or buttock ischemia (1).

**Conclusions:** The most frequent complication after EVAR requiring intervention was type II endoleak followed by endograft limb occlusion and type I endoleak. About half of these complications were treated by endovascular means with a success rate of 67-100% whereas the other half required open surgical repair.

Once considered as a surgical alternative for high risk patients with abdominal aortic aneurysms (AAAs), endovascular AAA repair (EVAR) has now outnumbered open AAA repair in most vascular centers, being applied in most patients in whom it is technically feasible, irrespective of surgical risk. That is due to the well documented low perioperative mortality ranging between 0.5-1.7%, whereas the respective rate in patients submitted to open repair is about 3-fold higher, ranging between 1.3-4.7%.[1-4] Nevertheless, reinterventions remain the Achilles heel of the technique, with a reported incidence of up to 38% after 12 years of follow-up, with the respective incidence in patients submitted to open AAA repair being less than 21%.[5] Endoleaks, migration, limb occlusion, aneurysm rupture, endograft infection, graft-enteric fistula, bowel ischemia and access site problems represent the wide spectrum of complications that may require reintervention.

The aim of our study was to record all the complications after EVAR that required interventional treatment, to summarize the treatment methods that were used and assess the safety and efficacy of these methods.

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## PATIENTS AND METHODS

The medical records of all patients undergoing EVAR in our Department between January 2010 and December 2017 were retrospectively reviewed to identify patients who underwent any type of reintervention. The initial decision between open and endovascular repair was based on anatomic suitability, medical fitness and patient's preference. The selection of endograft type was an individual surgeon's decision and was based on the anatomic characteristics of the aneurysm and the instructions for use of the various endografts. Informed consent was obtained from all patients that their anonymous data could be used in the future for research purposes.

All patients were followed with routine physical examination and computed tomography angiography (CTA) on the 1st and 12th postoperative month and, in the absence of endoleak, with duplex ultrasound (DUS) imaging and physical examination yearly thereafter. In the presence of type II endoleak, patients were followed with DUS every 6 months.

### *Outcome measures*

The main outcomes that were recorded included the type, the cause and the success rate of reinterventions. A reintervention was defined as any open surgical or endovascular procedure that was performed after the initial EVAR procedure and was either directly or indirectly related to it. Technical success was defined as uncomplicated completion of the preplanned procedure with elimination of the problem for which it was performed.

## RESULTS

During the study period, 628 patients underwent EVAR in our Department with commercially available endografts: Gore Excluder (n=187), Cook Zenith (n=251), Vascutek Anaconda (n=118), Medtronic Endurant (n=54), Bolton TREO (n=6), Jotec E-Vita (n=4), Cordis Incraft (n=4), Trivascular Ovation (n=3) and Endologix AFX (n=1). The majority of the procedures were elective (606 procedures, 96.5%), whereas 22 (3.5%) procedures were performed for ruptured AAAs. The median follow-up time was 48 months (range: 1-96). Follow-up compliance over the first year was 100%, whereas 72 patients (11.5%) were lost to follow-up at some time point thereafter. Of these, 90 patients (14.3%) underwent 108 reinterventions. The causes of reinterventions along with their incidence are depicted in Table 1.

| Cause of reintervention | Number of reinterventions | Number of patients | % patients |
|---|---|---|---|
| Endoleak type II | 43 | 35 | 5.6 |
| Endograft limb occlusion | 32 | 23 | 3.6 |
| Endoleak type I | 18 | 17 | 2.7 |
| Endograft infection | 8 | 8 | 1.3 |
| Endoleak type III | 3 | 3 | 0.5 |
| Sigmoid ischemia | 2 | 2 | 0.3 |
| Buttock ischemia | 1 | 1 | 0.2 |
| Aneurysm rupture | 1 | 1 | 0.2 |
| Total | 108 | 90 | 14.3% |

**Table 1.** Causes and incidence of reinterventions

### *Endoleak type II*

Forty three reinterventions were performed in 35 patients (5.6%) for the management of a type II endoleak that caused asymptomatic expansion of the aneurysm sac >5mm. Mean aneurysm sac expansion was 10.8 ± 2.5 mm and the mean maximum diameter of the aneurysm at the time of embolization was 6.7±1.3 cm. Mean time from EVAR to embolization was 30.7 ± 19.8 months.

Twenty one patients were treated by embolization either transarterial (9 patients) or translumbar (12 patients). The transarterial route was the access of choice in patients in whom the inferior mesenteric artery (IMA) was patent (8 patients). Embolization was performed via the common femoral artery. The IMA was catheterized from the superior mesenteric artery (SMA) via the marginal artery (Figure 1). In one patient with a large middle sacral artery (MSA) feeding a type II endoleak, the MSA was accessed from the left internal iliac artery (IIA) via the iliolumbar artery. In all 9 patients, the endoleak nidus within the aneurysm sac was reached with the use of microcatheter. Digital Subtraction Angiography (DSA) was performed to depict the inflow and outflow arteries and embolization followed with n-butyl-cyanoacrylate (Glubran 2, GEM SRL, Viareggio, Italy) and lipiodol mixture (1:3 to 1:5).

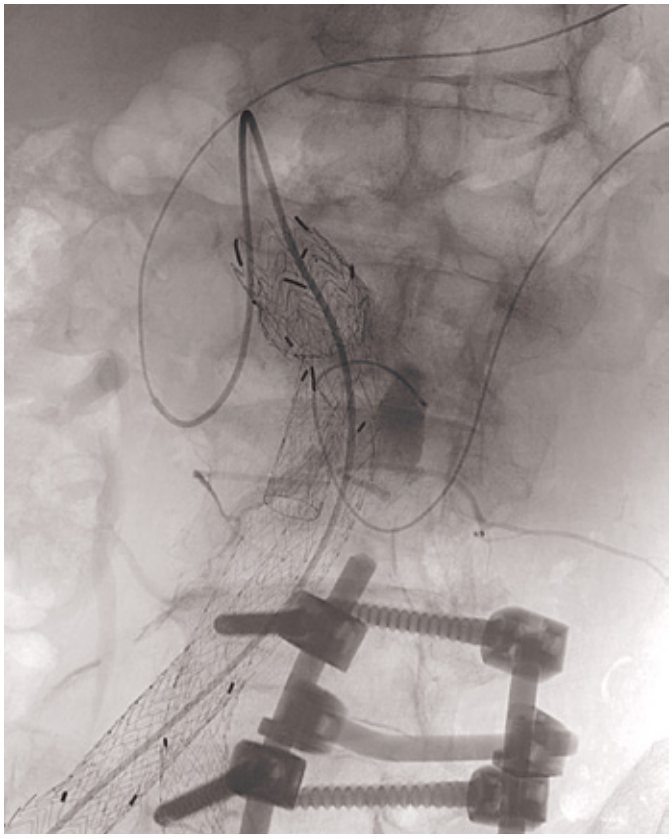

**Figure 1.** Transarterial embolization of a type II endoleak. A Simmons catheter is inserted through the right common femoral artery to the superior mesenteric artery and a microcatheter through the middle colic artery, the left branch of the middle colic artery, the superior branch of the left colic artery, the left colic artery and the inferior mesenteric artery to the endoleak nidus, where glue was infused.

Translumbar embolization was performed from a left-sided translumbar approach under CT guidance. The patient was then transferred prone to the angiosuite table and the procedure was completed there under fluoroscopic guidance. A standard angiographic catheter was introduced into the sac at the point of the endoleak and embolization was performed as described in the previous paragraph.

Technical success of transarterial embolization was 78% (7 out of 9 patients). In one patient, the type II endoleak persisted after completion of the procedure and was treated with open surgical ligation at a second stage. In another patient, shortly after the embolization procedure, sigmoid necrosis developed and was treated by left colectomy and proximal colostomy (Hartman operation). The continuity of the colon was restored three months later.

Technical success of translumbar embolization was 67% (8 out of 12 patients). In 4 patients, a persisting type II endoleak was observed after the completion of the embolization procedure and was treated with open surgical ligation.

In total, 21 patients required open surgery, with the surgical technique of choice being ligation of the lumbar arteries (18 patients) with preservation of the endograft and tight

suturing of the aneurysm sac around it. In 2 patients the endograft was replaced by a Dacron tube graft because of displacement of the endograft during manipulations to expose and ligate the orifice of the lumbar arteries. One more patient required 2 open surgical reinterventions for the treatment of sigmoid necrosis, as already mentioned.

### *Endograft limb occlusion*

Overall, 32 reinterventions for 31 endograft limb occlusions were performed in 23 patients (3.6%) during the study period. One patient had 2 reinterventions in the same limb to restore perfusion, whereas 8 (1.3%) patients were treated for sequential (in different time) bilateral limb occlusion.

There was one case of limb occlusion during the first post-operative week, three cases of endograft limb occlusion between the first and the fourth post-operative week, while in the remaining 27 cases (87%) limb occlusion occurred after 2-96 months.

The majority of these reinterventions (29/32; 90.6%) were performed for short-distance buttock claudication (Rutherford-Becker classification 3), whereas 3 reinterventions (9.4%) were performed for the treatment of rest pain. Although the exact cause of limb occlusion could not always be determined with certainty, in 12 cases (38.7%) an ipsilateral iliac artery angulation of >60° was noted, in 10 cases (32.3%) an excessive endograft limb over sizing >15% and in 20 (64.5%) cases an iliac calcification of >50% of the vessel circumference. In 5 patients (16.1%), however, no causal factor could be identified.

Thirteen limb occlusions were treated by either stent grafts (9 cases) or nitinol bare stents (4 cases) (Figure 2).

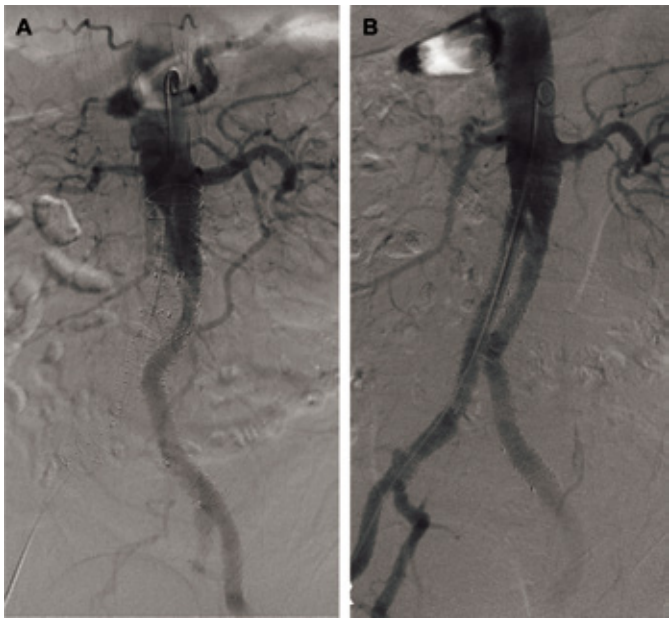


**Figure 2.** Endograft right limb occlusion (A), treated by percutaneous placement of two nitinol, self-expandable stents (B).

Median diameter of stent grafts deployed was 13.5mm (range: 10-13.5mm). Median diameter of bare self-expandable stents deployed was 12mm (range: 9-14mm). Mean number of stents used per limb was 2 (range: 2-3 stents). Mean occlusion length that had to be covered was 132.0 ± 17.1mm). Technical success was 92.3% (12/13 cases). There was only one technical failure to cross a long-standing, 12-months old occlusion, in a patient suffering from Rutherford 3 intermittent claudication. The patient was treated with a femorofemoral bypass.

Seventeen limb occlusions were treated by open surgery: femoro-femoral (10), aortobifemoral (4) or axillofemoral (3) bypass, whereas 2 more patients were treated by a hybrid approach consisting of open surgical thrombectomy plus intraoperative angioplasty to correct the underlying iliac stenosis.

### *Endoleak type I*

Eighteen reinterventions in 17 patients (2.7%) were performed for the management of a type I endoleak. Six type Ib endoleaks, occurring 1-5 years after the initial EVAR procedure, were successfully treated by coil embolization of the internal iliac artery plus endograft extension to the external iliac artery (4) or by endograft extension to the common iliac artery in two patients with upward migration of the endograft limbs within the aneurysm sac. Two type Ia endoleaks were recognized in the first postoperative CTA and 5 after 1-4 years. All of the type Ia endoleaks were treated percutaneously by an aortic cuff (3), a Palmaz stent (3) or by coil and glue embolization (1). Aortic cuffs were placed when the distance between the lowest renal artery and the main body of the endograft was more than 5 mm. Palmaz stents were placed when the distance between the lowest renal artery and the endograft was less than 5 mm (Figure 3). Coil and glue embolization was performed when the Palmaz stent failed to seal the endoleak.

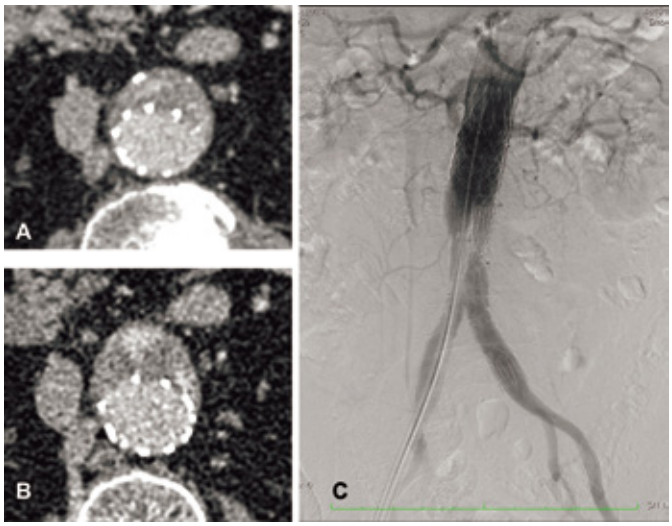


**Figure 3. A, B:** CTA revealing the presence of a type Ia endoleak. C: DSA revealing elimination of the endoleak by placement of a Palmaz XL stent.

Percutaneous treatment was successful in 85.7% (6/7 patients). In one patient, placement of a Palmaz stent, followed by coil and glue embolization failed to eliminate the endoleak and the patient was treated by open conversion (Figure 4). In total, 5 conversions were performed for the management of a type Ia endoleak, in cases where endovascular treatment was either impossible or failed. Endovascular treatment was considered impossible when the diameter of the aortic neck had exceeded the diameter of the main body of the endograft.

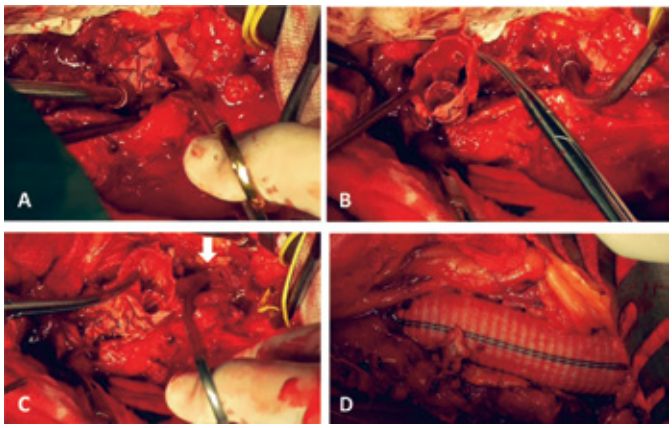


**Figure 4.** Open conversion due to type Ia endoleak. The main body of the endograft is cut between the first and the second stent (A, B). A Palmaz stent that had been placed in an attempt to seal the endoleak is being removed (C). The endograft is excised and replaced by a straight Dacron graft with the sutures of the proximal anastomosis passing through both the fabric of the remaining proximal stent and the aortic wall (D).

### *Endograft infection*

Eight patients (1.3%) presented with fever, low back pain, leukocytosis, and increased C-reactive protein. A CTA showed the presence of gas in the aneurysm sac, verifying the diagnosis of endograft infection. The treatment of choice was endograft excision followed by either axillofemoral bypass (2 patients) or neoaortoiliac system (NAIS) procedure (3 patients). One of the 3 patients treated by NAIS died 1 month after the procedure because of vein graft rupture, probably due to recalcitrant infection by Klebsiella pneumoniae.

In the remaining 3 patients, a more conservative approach with preservation of the endograft was selected due to the poor clinical status of the patients. A laparotomy was performed, the aneurysmal sac was opened, the endograft was exposed and debridement of the area, local irrigation with antibiotics according to antibiogram and omentoplasty followed. One of these patients died on the 2nd postoperative day due to pulmonary embolism, whereas in the other 2 patients infection recurred 11 months and 3 years, respectively, after laparotomy, despite lifelong treatment with antibiotics.

### *Less common causes of reinterventions*

Three type III endoleaks were diagnosed during the study period, all of which were invasively treated with either relining of the endograft (2 patients) or open conversion (1 patient).

One patient presented with aneurysm rupture and was submitted to open conversion.

Two patients developed sigmoid necrosis which was diagnosed on the first postoperative day. Both patients were submitted to left colectomy and proximal colostomy (Hartman operation) but they both died of multiorgan failure 1 and 3 days later.

One patient developed buttock ischemia with skin necrosis after intended coverage of the ipsilateral internal iliac artery (IIA), while the contralateral IIA was patent but heavily calcified. The patient was treated by external to internal iliac bypass via a retroperitoneal approach.

## DISCUSSION

The results of our study, showing a 14.3% reintervention rate, confirm that secondary procedures after EVAR are still a problem despite the unequivocal improvements in endografts as well as in imaging and sizing methods. The EVAR trial 1, having recruited patients between 1999 and 2004, has recently shown a 26% reintervention rate after a mean follow-up of 12.7 years.[6] Re-interventions occurred throughout the study follow-up, including in patients who were free from re-intervention after 2 years or even 5 years. These late reinterventions have led the authors of the EVAR trial 1 to the conclusion that it is not safe to stop follow-up for patients with EVAR. The OVER trial has also shown a high rate of reinterventions, with 22.1% of the patients having at least one reintervention after a mean follow-up of 5.2 years after EVAR.[7] In the ACE trial, the percentage of reinterventions was 16% in the EVAR group, after a mean follow-up of 3 years.[4] This percentage was significantly higher than the 2.4% reintervention rate in the open AAA repair group and has led the authors of the ACE trial to the conclusion that open repair of AAA remains a more durable therapeutic option.

In accordance with the findings of our study, a systematic review of 23 studies published between 2010 and 2017 and reporting on 83,307 patients showed that endoleak type II was the most common indication for re-intervention.[8] Type II endoleaks occurred in 14-25.3% after EVAR, but the majority resolved without intervention. Reintervention was required in 3.5-22.5% of them. Consequently, about 2.6-7.3% of the patients submitted to EVAR required reintervention for a type II endoleak.[9,10] The success rate of transarterial embolization is reported to be 20-80%.[11-14] The reason why transarterial embolization may fail to seal the endoleak is that these endoleaks are usually fed by a network of arteries instead of a single vessel. Embolization of the endoleak cavity and not only of the feeding artery is therefore recommended and is reported to increase the success rate of the transarterial embolization to 78%.[15] Incomplete embolization of the endoleak cavity accounts for the remaining cases of failure to seal the endoleak.

Endograft limb occlusion is reported to occur in 2.6-7.4% of patients after EVAR.[16-18] Several anatomical risk factors have been proposed including common iliac artery diameter, calcification, angulation and the presence of thrombus, whereas procedure related risk factors for limb thrombosis include endograft oversizing and extension to the external iliac artery.[19-20] In a previous study from our center on 579 patients treated by EVAR, we had shown that endograft limb occlusion was associated with iliac artery angulation ≥60%, perimeter calcification ≥50% and ≥15% endograft oversizing in the common iliac artery. No other risk factors for limb occlusion were recognized.[21,22] Although frequently avoided for the fear of thromboembolic complications, percutaneous stenting is nowadays the treatment of choice in our department, with zero complications in the first 13 cases and only one failure to recanalise a chronic occlusion of more than 12 months old.[23]

Type Ia endoleaks have been reported in 0.6%-13% of the patients after EVAR and are more frequent in patients with short and heavily calcified aneurysmal necks and large aneurysms.[8,24] Aortic cuffs, when the distance between the lowest renal artery and the endograft is more than 5 mm, and Palmaz stents, when the distance is less than 5 mm, are associated

with a success rate of 86-100% in sealing the endoleak.[25,26] Recently, self-expandable nitinol stents with a diameter of up to 36 mm have been manufactured and used for the treatment of type Ia endoleaks.[27] When aortic cuffs and Palmaz stents fail to seal the endoleak, coil and/or glue embolization is the next step, associated with a success rate of about 85%.[28,29] The chimney graft technique,[30,31] fenestrated cuffs[32] and endostaples[33] represent additional options that are included in the minimally invasive armamentarium against a type Ia endoleak, whereas aortic neck banding[34] and open conversion[35] are the two open surgical alternatives for cases refractory to multiple attempts at endovascular repair.

The incidence of endograft infection ranges between 0.2-3%.[36] Although rare, it is a life-threatening disease with mortality rates ranging between 25-100%. Roughly one-third present as chronic sepsis, one-third as severe acute sepsis, and one-third as aortoenteric fistulas. The primary treatment objective in such cases is to remove the infected stent graft and to reestablish vascular continuity with an extraanatomic bypass or in situ graft replacement. Nevertheless, this approach is associated with high mortality rates, ranging from 28% to 83%, especially when undertaken in unstable, septic patients with severe comorbidities.[37,38] Open laparotomy with debridement without removal of the endograft, or CT-guided percutaneous drainage, followed by lifelong antibiotic therapy, could be an alternative in such cases.[36]

In conclusion, despite significant improvements in endograft design as well as in imaging and sizing methods, complications after EVAR continue to be a problem and required re-intervention in 14.3% of our patients. The most frequent complication requiring intervention was type II endoleak with an increasing aneurysm sac diameter, followed by endograft limb occlusion and type I endoleak. About half of these complications were treated percutaneously with a success rate of 67-100% whereas the other half required open surgical repair.

## REFERENCES


1 Prinssen M, Verhoeven EL, Buth J, Cuypers PW, van Sambeek MR, Balm R, et al. A randomized trial comparing conventional and endovascular repair of abdominal aortic aneurysms. N Engl J Med 2004;351:1607-18.

2 Greenhalgh RM, Brown LC, Kwong GP, Powell JT, Thompson SG; EVAR trial participants. Comparison of endovascular aneurysm repair with open repair in patients with abdominal aortic aneurysm (EVAR trial 1), 30-day operative mortality results: randomized controlled trial. Lancet 2004;364:843-8.

3 Lederle FA, Freischlag JA, Kyriakides TC, Padberg FT Jr, Matsumura JS, Kohler TR, et al; Open Versus Endovascular Repair (OVER) Veterans Affairs Cooperative Study Group. Outcomes following endovascular vs open repair of abdominal aortic aneurysm: a randomized trial. JAMA 2009;302:1535-42.

4 Becquemin JP, Pillet JC, Lescalie F, Sapoval M, Goueffic Y, Lermusiaux P, et al. A randomized controlled trial of endovascular aneurysm repair versus open surgery for abdominal aortic aneurysms in low- to moderate-risk patients. J Vasc Surg 2011;53:1167-73.

5 van Schaik TG, Yeung KK, Verhagen HJ, de Bruin JL, van Sambeek MRHM, Balm R, et al; DREAM trial participants. Long-term survival and secondary procedures after open or endovascular repair of abdominal aortic aneurysms. J Vasc Surg 2017;66:1379-89.

6 Patel R, Sweeting MJ, Powell JT, Greenhalgh RM; EVAR trial investigators. Endovascular versus open repair of abdominal aortic aneurysm in 15-years' follow-up of the UK endovascular aneurysm repair trial 1 (EVAR trial 1): a randomised controlled trial. Lancet 2016;388:2366-74.

7 Lederle FA, Freischlag JA, Kyriakides TC, Matsumura JS, Padberg FT Jr, Kohler TR, et al; OVER Veterans Affairs Cooperative Study Group. Long-term comparison of endovascular and open repair of abdominal aortic aneurysm. N Engl J Med 2012;367:1988-97.

8 de la Motte L, Falkenberg M, Koelemay MJ, Lönn L. Is EVAR a durable solution? Indications for reinterventions. J Cardiovasc Surg (Torino) 2018;59:201-12.

9 Maleux G, Poorteman L, Laenen A, Saint-Lèbes B, Houthoofd S, Fourneau I, et al. Incidence, etiology, and management of type III endoleak after endovascular aortic repair. J Vasc Surg 2017;66:1056-64.

10 Lal BK, Zhou W, Li Z, Kyriakides T, Matsumura J, Lederle FAFA, et al. Predictors and outcomes of endoleaks in the Veterans Affairs Open Versus Endovascular Repair (OVER ) Trial of Abdominal Aortic Aneurysms. J Vasc Surg 2015;62:1394-404.

11 Nolz R, Teufelsbauer H, Asenbaum U, Beitzke D, Funovics M, Wibmer A, et al. Type II endoleaks after endovascular repair of abdominal aortic aneurysms: fate of the aneurysm sac and neck changes during long-term follow-up. J Endovasc Ther 2012;19:193-9.

12 Sheehan MK, Barbato J, Compton CN, Zajko A, Rhee R, Makaroun MS. Effectiveness of coiling in the treatment of endoleaks after endovascular repair. J Vasc Surg. 2004;40:430-4.

13 Baum RA, Carpenter JP, Golden MA, Velazquez OC, Clark TW, Stavropoulos SWl. Treatment of type 2 endoleaks after endovascular repair of abdominal aortic aneurysms: comparison of transarterial and translumbar techniques. J Vasc Surg 2002;35:23-9.

14 Moulakakis KG, Klonaris C, Kakisis J, Antonopoulos CN, Lazaris A, Sfyroeras GS, et al. Treatment of Type II Endoleak and Aneurysm Expansion after EVAR. Ann Vasc Surg. 2017 Feb;39:56-66.

15 Stavropoulos SW, Park J, Fairman R, Carpenter J. Type 2 endoleak embolization comparison: translumbar embolization versus modified transarterial embolization. J Vasc Interv Radiol 2009;20:1299-302.

16 Sampram ES, Karafa MT, Mascha EJ, Clair DG, Greenberg RK, Lyden SP, et al. Nature, frequency, and predictors of secondary procedures after endovascular repair of abdominal aortic aneurysm. J Vasc Surg 2003;37:930-7.

17 Fairman RM, Baum RA, Carpenter JP, Deaton DH, Makaroun MS, Velazquez OC, et al. Limb interventions in patients undergoing treatment with an unsupported bifurcated aortic endograft system: a review of the Phase II EVT Trial. J Vasc Surg 2002;36:118-26.

18 Ronsivalle S, Faresin F, Franz F, Pedon L, Rettore C, Zonta L, et al. A new management for limb graft occlusion

after endovascular aneurysm repair adding a vollmar ring stripper: the unclogging technique. Ann Vasc Surg 2013;27:1216-22.

19 Wyss TR, Dick F, Brown LC, Greenhalgh RM. The influence of thrombus, calcification, angulation, and tortuosity of attachment sites on the time to the first graft-related complication after endovascular aneurysm repair. J Vasc Surg 2011;54:965-71.

20 Carroccio A, Faries PL, Morrissey NJ, Teodorescu V, Burks JA, Gravereaux EC, et al. Predicting iliac limb occlusions after bifurcated aortic stent grafting: anatomic and device-related causes. J Vasc Surg 2002;36:679-84.

21 Mantas GK, Antonopoulos CN, Sfyroeras GS, Moulakakis KG, Kakisis JD, Mylonas SN, et al. Factors Predisposing to Endograft Limb Occlusion after Endovascular Aortic Repair. Eur J Vasc Endovasc Surg 2015;49:39-44.

22 Moulakakis KG, Antonopoulos CN, Klonaris C, Kakisis J, Lazaris AM, Sfyroeras GS, et al. Bilateral Endograft Limb Occlusion after Endovascular Aortic Repair: Predictive Factors of Occurrence. Ann Vasc Surg 2018;46:299-306.

23 Spiliopoulos S, Moulakakis K, Palialexis K, Konstantos C, Reppas L, Kakisis I, et al. Long-Term Outcomes of Percutaneous Stenting of Aortic Endograft Limb Occlusion. Ann Vasc Surg 2018 (in press).

24 Sampaio SM, Panneton JM, Mozes GI, Andrews JC, Bower TC, Karla M, et al. Proximal type I endoleak after endovascular abdominal aortic aneurysm repair: predictive factors. Ann Vasc Surg 2004;18:621-8.

25 Rajani RR, Arthurs ZM, Srivastava SD, Lyden SP, Clair DG, Eagleton MJ. Repairing immediate proximal endoleaks during abdominal aortic aneurysm repair. J Vasc Surg 2011;53:1174-7.

26 Byrne J, Mehta M, Dominguez I, Paty PS, Roddy SP, Feustel P, et al. Does Palmaz XL stent deployment for type 1 endoleak during elective or emergency endovascular aneurysm repair predict poor outcome? A multivariate analysis of 1470 patients. Ann Vasc Surg 2013;27:401-11.

27 Chisci E, Ventoruzzo G, Alamanni N, Bellandi G, Michelagnoli S. Transrenal E-XL stenting to resolve or prevent type Ia endoleak in the case of severe neck angulation during endovascular abdominal aortic aneurysm repair. J Vasc Surg 2013;57:1383-6.

28 Choi SY, Lee DY, Lee KH, Ko YG, Choi D, Shim WH, et al. Treatment of type I endoleaks after endovascular aneurysm repair of infrarenal abdominal aortic aneurysm: usefulness of N-butyl cyanoacrylate embolization in cases of failed secondary endovascular intervention. J Vasc Interv Radiol 2011;22:155-62.

29 Graif A, Vance AZ, Garcia MJ, Lie KT, McGarry MK, Leung DA. Transcatheter Embolization of Type I Endoleaks Associated With Endovascular Abdominal Aortic Aneurysm Repair Using Ethylene Vinyl Alcohol Copolymer. Vasc Endovascular Surg 2017;51:28-32.

30 Mylonas SN, Moulakakis KG, Kakisis JD, Brountzos EN, Liapis CD. New Chimney after Chimney EVAR for the Treatment of Type Ia Endoleak. Int J Angiol 2016;25:126-30.

31 Quintas A, Alves G. Three-vessel Chimney Technique Combined with Endovascular Aortic Sealing Device for the Treatment of a Type Ia Endoleak. Eur J Vasc Endovasc Surg 2017;53:379.

32 Oikonomou K, Botos B, Bracale UM, Verhoeven EL. Proximal type I endoleak after previous EVAR with Palmaz stents crossing the renal arteries: treatment using a fenestrated cuff. J Endovasc Ther 2012;19:672-6.

33 Jordan WD Jr, Mehta M, Varnagy D, Moore WM Jr, Arko FR, Joye J, et al; Aneurysm Treatment using the Heli-FX Aortic Securement System Global Registry (ANCHOR) Workgroup Members. Results of the ANCHOR prospective, multicenter registry of EndoAnchors for type Ia endoleaks and endograft migration in patients with challenging anatomy. J Vasc Surg 2014;60:885-92.

34 Younis G, Messner G, Gregoric I, Krajcer Z. Aortic wrap as a novel technique of type I endoleak repair. Ann Vasc Surg 2006;20:690-5.

35 Moulakakis KG, Dalainas I, Mylonas S, Giannakopoulos TG, Avgerinos ED, Liapis CD. Conversion to open repair after endografting for abdominal aortic aneurysm: a review of causes, incidence, results, and surgical techniques of reconstruction. J Endovasc Ther 2010;17:694-702.

36 Moulakakis KG, Sfyroeras GS, Kakisis JD, Papapetrou A, Antonopoulos CN, Mantas G, et al. Endograft infection and treatment with preservation of the endograft: early results in 3 cases. Ann Vasc Surg 2014;28:1789.e1-7.

37 Setacci C, De Donato G, Setacci F, Chisci E, Perulli A, Galzerano G, et al. Management of abdominal endograft infection. J Cardiovasc Surg (Torino) 2010;51:33e41.

38 Arya S, Coleman DM, Knepper J, Henke PK, Upchurch GR, Rectenwald JE, et al. Outcomes after late explantation of aortic endografts depend on indication for explantation. Ann Vasc Surg 2013;27:865-73.

INVITED COMMENTARY

# Aneurysm-related complications and life-long reinterventions after endovascular abdominal aortic aneurysm repair

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Abdominal aortic aneurysm (AAA) patients treated by endovascular aneurysm repair (EVAR) are more likely to experience aortic complications and reinterventions than those operated on by open surgery. In this issue of the journal, Kakisis and colleagues[1] present a large modern experience of 628 EVAR patients that were treated in the vascular department of a large university hospital. The authors studied the reinterventions after EVAR.

EVAR revolutionized our practice and transformed our specialty over the last two decades. As our knowledge and experience increased and stent-graft technology evolved, EVAR became part of everyday aneurysm practice. Vascular surgeons had to master the procedure and refine the technique. However, unlike open repair patients, the EVAR patient will have to be followed carefully for life because the long-term results are not well known. During the follow-up, there will be stent-graft failures or aneurysm-related complications that may require re-interventions and vascular surgeons should familiarize themselves to deal with such problems in a variety of elective and emergency scenarios.

In the present series, 108 reinterventions were performed in 90 patients (14.3%). Type II endoleak was the most frequent cause of reintervention and resulted in 43 reoperations in 35 patients (5.6%). Of these reoperations, 21 were transarterial (9) or translumbar (12) embolizations, 20 were open surgical ligations and 2 were interventions for complications of embolization. Technical success of transarterial embolization was 78% and of translumbar 67%. Most type II endoleaks are considered as being benign. Nevertheless, aneurysm rupture has been described due to a type II endoleak. When to intervene is not entirely clear, but according to the 2019 ESVS guidelines on the AAA management, re-intervention for type II endoleak after EVAR (primarily by endovascular means) should be considered in the presence of significant aneurysm growth (class IIa, level B recommendation).[2] Significant growth is expansion of sac diameter 1 cm or more detected during follow-up using the same imaging modality and measurement method. Various treatment options exist. Endovascular treatment consists of transarterial, translumbar, transcaval, or transsealing (between iliac graft and iliac arterial wall) embolisation of the aneurysm sac and feeding vessels and is successful in 60-80% of cases. On the other hand, surgical options include laparoscopic or open ligation of side branches feeding the endoleak, suturing of the ostia of the leaking branch from the inside after opening the aneurysm sac or stent graft explantation with open conversion. The latter, being more invasive, is reserved for cases where endovascular intervention has failed.

The second most common reason for reintervention in the series was endograft limb occlusion. This required 32 reoperations in 23 patients (3.6%). Of these reinterventions, 13 required stent placement, 17 bypass and 2 thrombectomy combined with angioplasty. Post-EVAR reoperation for limb occlusion or kinking occurs in about 1.4-8% of patients in modern series. Reoperation will require a variety of open surgical or endovascular options. There is no evidence in the literature regarding superiority of one treatment option over the other, so the treatment strategy should be individualized depending on local preference and experience as well as patient factors.

The third cause of reintervention was type I endoleak (18 reinterventions in 17 patients, 2.7%). All Ib endoleaks (6 patients) were treated by extension of the endograft to the common or external iliac artery, while Ia (11 patients) endoleaks were treated by open conversion (5), proximal cuff (3), Palmaz stent (3) or embolization (1). Type 1 endoleak should be corrected promptly aiming to exclude the aneurysm sac for the systemic arterial pressure. Endovascular options include dilation with a molding balloon, placement of a balloon expandable stent (i.e. Palmaz type) or fixation with endovascular staples against the aortic wall if the graft is adequately sized, has not migrated, and there is an appropriate landing zone to achieve a seal.[2] If the latter is not the case, extension of the landing zone is required with proximal tubular or fenestrated cuff insertion, or distal iliac extension. If an endovascular option is not available and the patient is fit for open surgery, open conversion is an alternative.

Last but not least, less common causes of reintervention in the series included endograft infection (8 patients), type III endoleak (3), aneurysm rupture (1) and sigmoid (2) or buttock ischemia (1), all complex problems with significant risks for morbidity and mortality. Based on the recently published ESVS guidelines on the management of AAA patients, table 1 summarizes the literature data on the expected 5-year frequency of stent-graft complications post-EVAR.[2] This could help and guide practicing vascular surgeons through the patient informed consent process and related medicolegal issues.

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| Complications | % during 5-year follow up |
|---|---|
| Type I endoleak | 5% |
| Type II endoleak | 20-40%, 10% persistent at 2 years |
| Type III endoleak | 1-3% |
| Type IV endoleak | 1% |
| Endotension | <1% |
| Migration | 1% |
| Limb kinking/occlusion | 4-8% |
| Infection | 0.5-1% |
| Rupture | 1-5% |

**Table 1.** Long-term stent-graft complications post-EVAR.

The authors are to be congratulated both for the skillful management of these complications in such a demanding group of patients and for documenting the frequency and results of their reinterventions. The take home message from this large experience is that we should follow our EVAR patients carefully for life, because problems may arise in a proportion of patients that will require additional procedures. Expertise with the management of such complications will grow with experience and appropriate training. Both open and endovascular techniques should be part of the armamentarium of the modern vascular surgeon.

## REFERENCES

1 Kakisis J, Moulakakis G, Sfyroeras G, Lazaris A, Liapis C, Spiliopoulos S et al. Reinterventions after endovascular abdominal aortic aneurysm repair. Hel J Vasc Endovasc Surg 2019; 1: 3-8.

2 Wanhainen A, Verzini F, Van Herzeele I, Allaire E, Bown M, Cohnert T, et al. European Society for Vascular Surgery (ESVS) 2019 Clinical Practice Guidelines on the Management of Abdominal Aorto-iliac Artery Aneurysms. Eur J Vasc Endovasc Surg 2018 Dec 4. pii: S1078-5884(18)30698-1. doi: 10.1016/j.ejvs.2018.09.020. [Epub ahead of print] PubMed PMID: 30528142.

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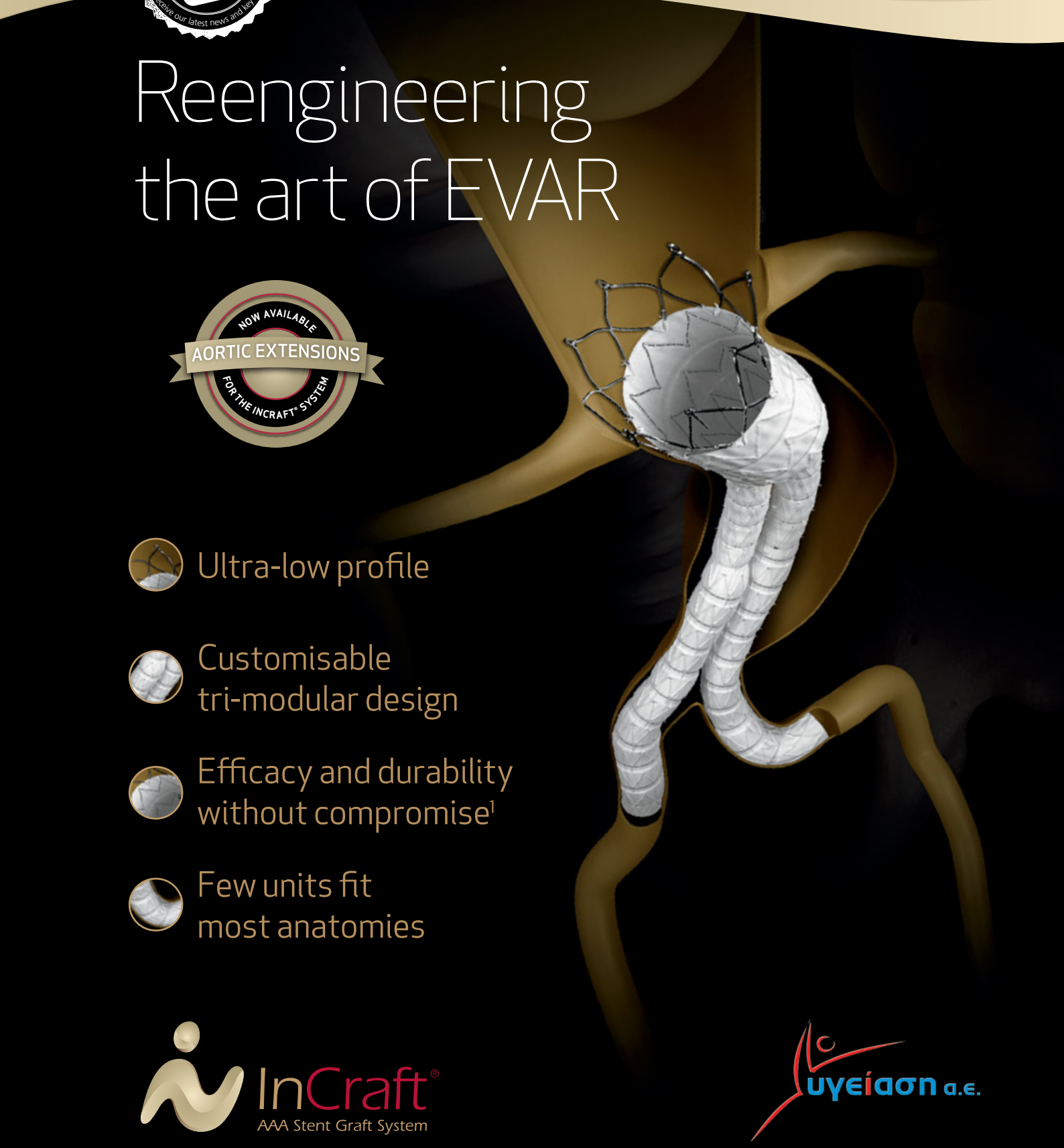


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[1] Torsello et al. Safety and effectiveness of the INCRAFT® AAA Stent Graft for endovascular repair of Abdominal aortic aneurysms. JOURNAL OF VASCULAR SURGERY; January 2015, Volume 61, Number 1. Pages 1-8.

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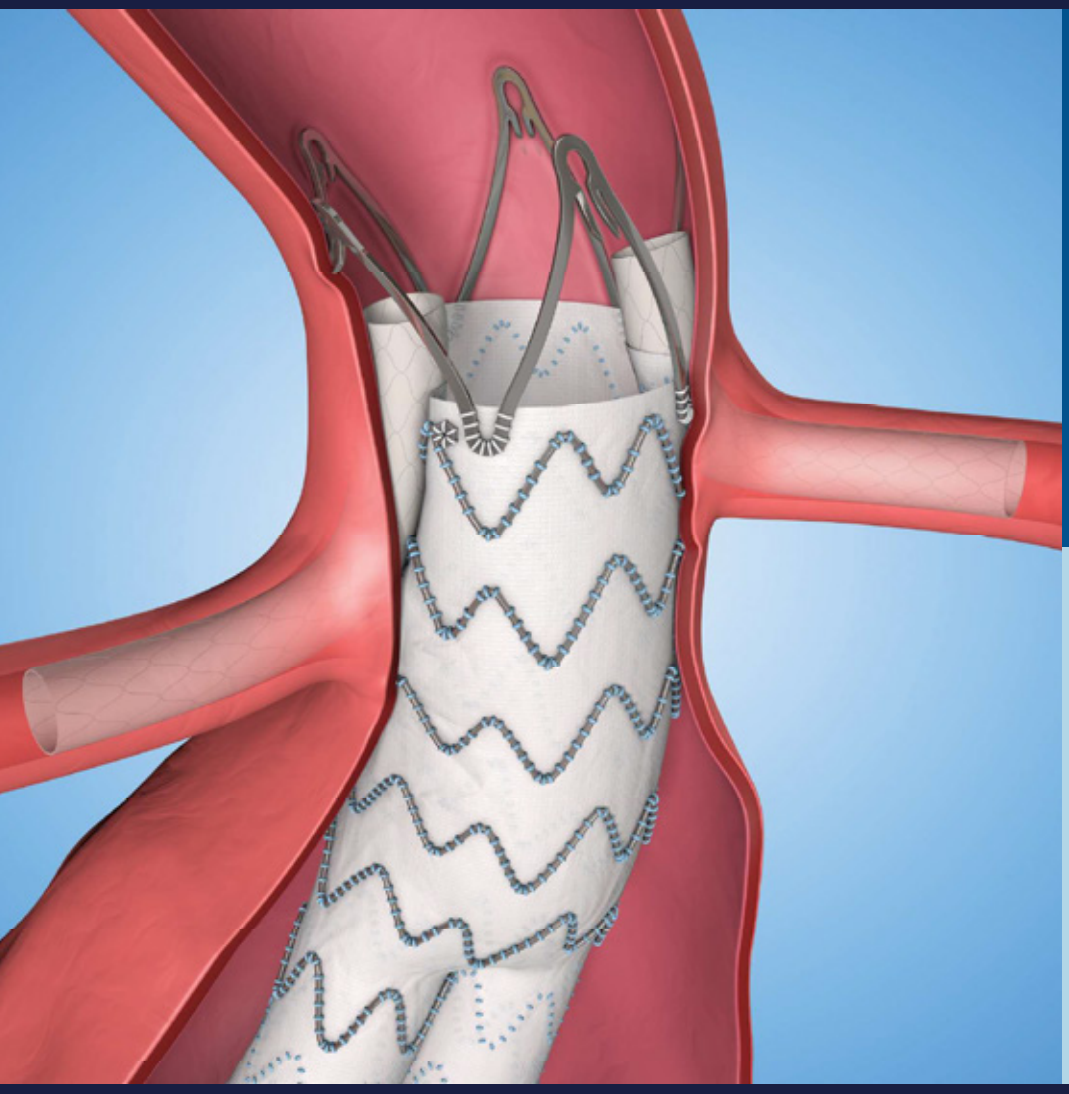

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# Preservation of internal iliac artery during endovascular repair of abdominal aneurysmal disease

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**Abstract:**

**Objective:** The overstenting of the internal iliac artery (IIA) in patients with concomitant aortic and common iliac artery (CIA) aneurysm has been sometimes associated with significant complications. The aim of this study was to report a single center experience during a 7 years period on preservation of IIA during endovascular aneurysm repair (EVAR).

**Methods:** From January 2006 till Jun 2014, all patients who underwent a revascularization additive procedure, open or endovascular, for IIA preservation during EVAR were registered in a prospectively maintained database and included in this study. Aneurysm morphology and the need for revascularization were determined on preoperative computed tomography angiography. During follow-up all patients were interviewed for the presence of symptoms, while occurrence of endoleak and the evolution of the aneurysms were recorded.

**Results:** A total of 11 patients (10 males, mean age 73.5±5.6 years) underwent an adjunctive revascularization procedure for IIA preservation during EVAR. Mean maximum CIA diameter at the side of revascularization was 40.6±15.6 mm, while at the contralateral side was 44.3±18.3 mm. In nine patients IIA revascularization was performed to preserve at least the patency of one IIA, one patient underwent bilateral IIA preservation, while in one patient the CIA was accidentally covered during the deployment of the contralateral limb. Three patients underwent an IIA transposition, while 2 patients had an external iliac artery-IIA by-pass. In three patients an iliac branch device was deployed, while in three the "sandwich technique" was applied. The overall 30-day mortality was null. During a mean follow-up of 48±21.7 months early buttock claudication was observed in 1 patient (9.1%) at the contralateral side from the preservation that was resolved three months after. Two occlusions, one IBD and one sandwich, occurred. Both occlusions were asymptomatic and no reinterventions were needed. The cumulative free from reintervention rate was 100%.

**Conclusion:** Preservation of one or both hypogastric arteries can be accomplished through various open or endovascular techniques. These techniques represent a significant improvement in the treatment of aortoiliac aneurysms by allowing preservation of pelvic flow. A trend towards more endovascular procedures for IIA preservation has been noted during the last years. However considering the lack of long-term data, therapeutic strategy should be tailored for each individual patient, according to anatomical criteria and the presence of significant comorbidities.

## INTRODUCTION

A significant proportion (up to 40%) of patients with abdominal aortic aneurysm have an ectatic or aneurysmal common iliac artery (CIA).[1-7] The presence of concomitant iliac artery aneurysm has been associated with worse outcome regarding type I endoleak, limb thrombosis and aneurysm rupture.[8] Whenever possible the CIA may serve as a distal landing zone, thus avoiding coverage of the internal iliac artery (IIA) during endovascular aneurysm repair (EVAR). However only iliac limbs up to 28mm are commercially available, that can be used for iliac aneurysms up to 24 mm, according to manufacturer's instructions.[9]

In cases of larger iliac aneurysms, EVAR requires exclusion of one or both internal iliac arteries (IIA) and extension of the stent graft to the external iliac artery. In a proportion of these patients embolization of one or both IIAs is often required. The overstenting of the IIA has been sometimes associated with significant complications including buttock claudication, gluteal necrosis, ischemic colitis, erectile dysfunction and spinal cord injury.[2] The group of patients at increased risk for such complications has not been well defined. Coverage of a single IIA is generally well tolerated, although an incidence up to 28% of buttock claudication has been reported.[3, 4] Reports of bilateral IIA embolization show that bilateral IIA overstenting might be safe for the majority of patients, although there is an increased risk of serious life-threatening consequences.[2-4] Clearly some patients at high risk for developing adverse complications might benefit from preservation of IIA perfusion and therefore most physicians attempt to preserve flow at least to one IIA whenever possible.[5,6]

Several open and endovascular techniques have been described to maintain pelvic perfusion during EVAR. The aim of

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the present study was to report our single center experience in preservation of IIA and analyze technical and clinical outcome.

## METHODS

*Study population*: From January 2006 till Jun 2014, all patients who underwent a revascularization additive procedure, open or endovascular, for IIA preservation during EVAR were registered in a prospectively maintained database and included in this study. We also retrospectively reviewed all EVAR procedures to identify cases in which overstenting of the IIA and perhaps embolization occurred and defined their frequency.

All patients underwent preoperative computed tomography angiography (CTA) to determine anatomical suitability for endovascular treatment and evaluate the need for a revascularization procedure for IIA preservation. All procedures were performed in a fully equipped operating room with the patient under general or regional anesthesia. All patients were treated by the same surgical and anesthesiology team. Every effort was made to follow the selection criteria recommended by the manufacturer of the device. However, the decision as to which device to use was based on surgeon's critical preference, according to the anatomic characteristics of the proximal neck, the iliac configuration, and the presence of thrombus or calcification. The grafts deployed were Excluder (W. L. Gore & Associates, Flagstaff, Ariz), Talent and Endurant (Medtronic Corp, Minneapolis, Minn), Zenith (Cook Inc, Bloomington, IN, USA). The choice of the revascularization procedure for IIA preservation was based on anatomical criteria as depicted from the preoperative CTA as well as on the surgeon's preference. The decision on the best approach when IIA preservation was considered was tailored to each patient specifically. There were patients that could be treated successfully by different therapeutic options, open or endovascular. An endovascular-first strategy was considered in every patient, while an open approach was followed in patients that could not be treated endovascular or in accidental coverage of the IIA. The use of an iliac branched device is restricted by certain anatomic properties inside the instructions of use for each endograft mostly regarding the length of the common iliac artery and the distal landing zone of the IIA. The sandwich technique can be applied in patients with a short CIA that cannot be treated with an IBD.

*Description of procedures performed (Figures 1-4)*:

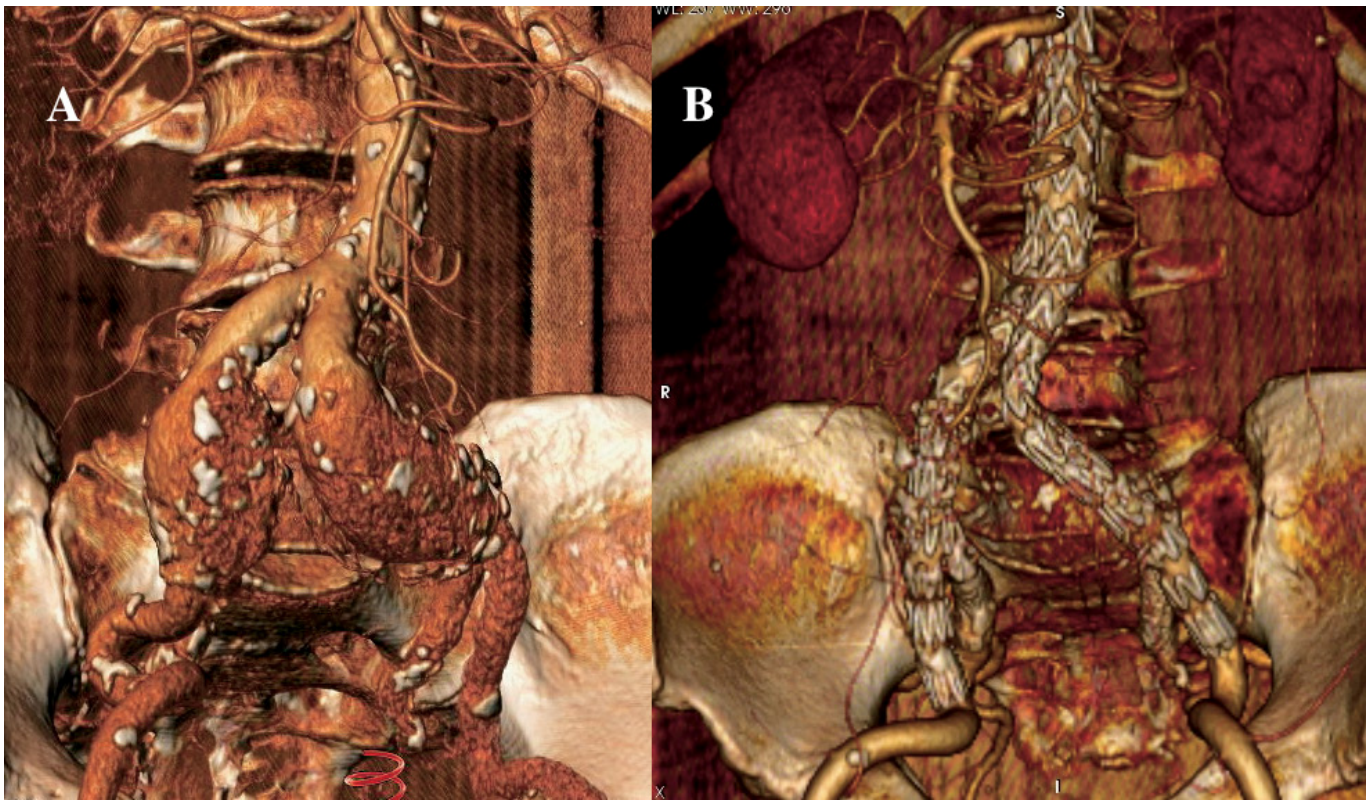


**Figure 1.** A. CTA showing large bilateral iliac artery aneurysms, B. CTA at 1 year after the deployment of bilateral IBDs showing patency of both IIAs and complete exclusion of both aneurysms

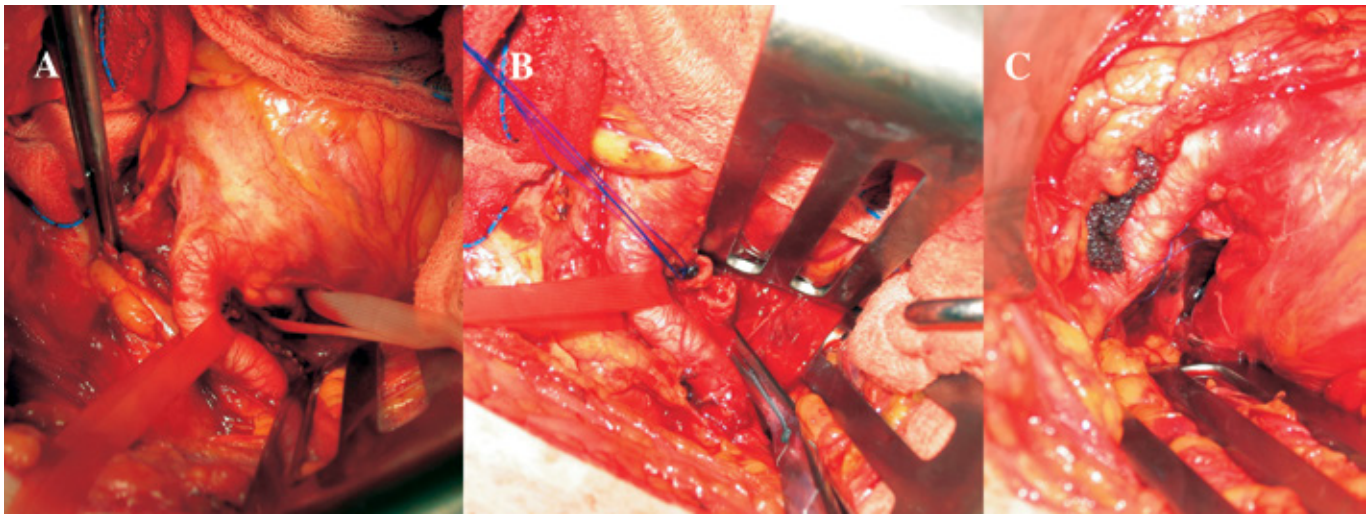


**Figure 2.** A. Exposure of the iliac bifurcation in a patient with a large CIA aneurysm, B,C. Preservation of the IIA by transposition to the ipsilateral IIA

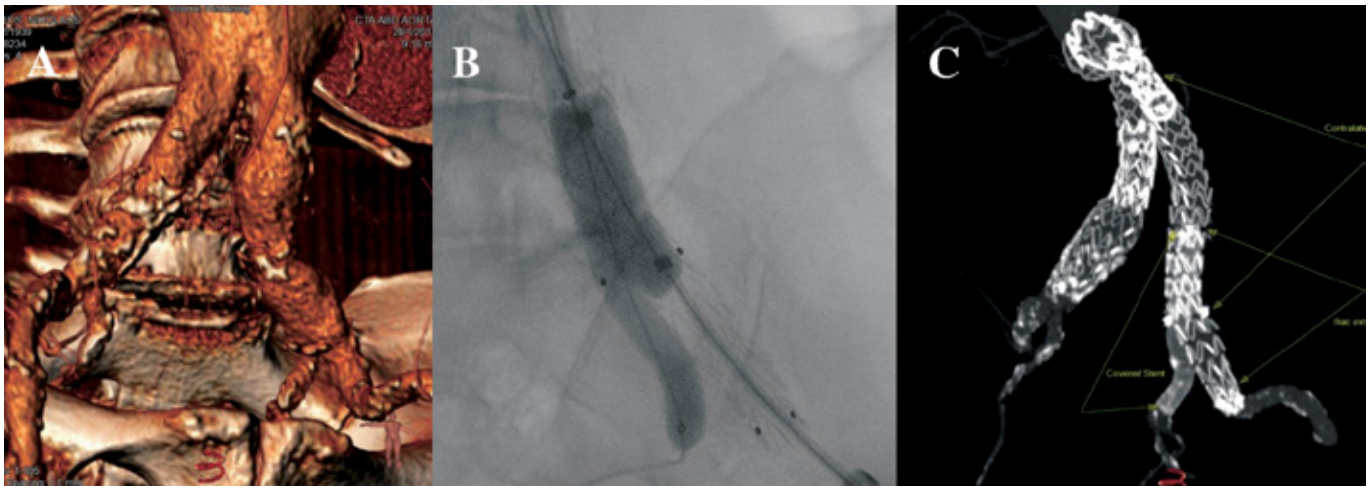


**Figure 3.** A. CTA showing a large Lt CIA aneurysm with insufficient landing zone, B. Intraoperative image showing the kissing-balloning during the sandwich technique, C. CTA at 2 years after the procedure showing the endografts' configuration after the sandwich technique

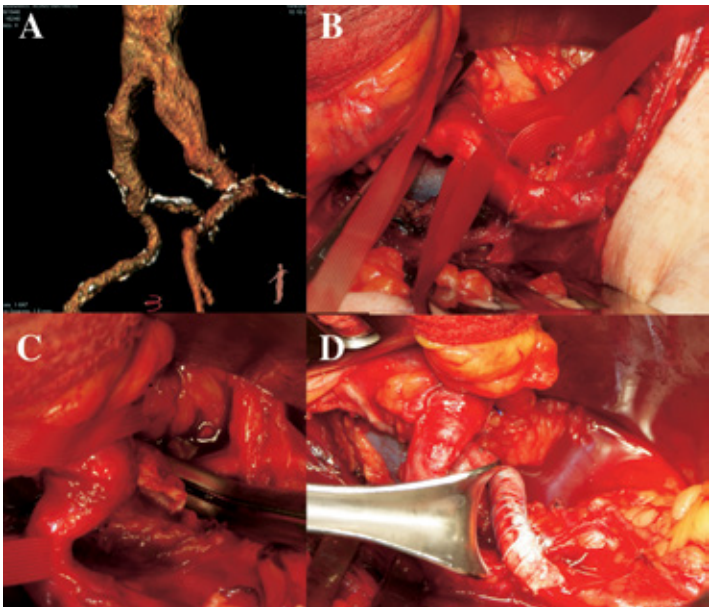


**Figure 4.** A. CTA showing a patient with CIA aneurysms, B,C,D. Intraoperative images showing the exposure of the iliac bifurcation and the completion of an EIA to IIA by-pass

*IIA bypass/transposition*: Standard surgical techniques were used to accomplish retroperitoneal exposure of the CIA, IIA and EIA via a relative short oblique incision in the lower quadrant of the abdomen. The level of iliac bifurcation was identified and the IIA was carefully exposed and controlled a few cm from its origin. The proximal anastomosis of a 6 mm PTFE graft to the IIA was accomplished at a first step, followed by the distal anastomosis to the distal part of the EIA in an end to side fashion. The IIA was ligated proximally to avoid retrograde filing of the aneurysm sac after endovascular repair. Alternatively, the IIA after being transected close to its origin was transpositioned on the EIA and directly anastomosed in an end-to-side fashion.

*Sandwich-technique*: A detailed description of this technique has been reported elsewhere.[10,11] Using an ipsilateral femoral approach the main body of a bifurcated stent graft was deployed with the distal end of the iliac limb positioned 1 cm above the iliac bifurcation. The ipsilateral IIA was cannulated using a left brachial access and a self-expandable covered stent was deployed at least 1 cm inside the nondiseased IIA, with at least 5 cm overlapping into the iliac limb extension. The iliac limb extension was positioned 1 cm below the covered stent proximal end, deployed and accommodated with a balloon prior to deploying the covered stent.

*Iliac Branched Device*: One IBD stent graft model was used (Cook Inc, Bloomington, IN, USA). This model comes with a preloaded indwelling catheter and guidewire through the side branch. This guidewire was snared from a contralateral or brachial approach and guides the introduction of a sheath that will enter the main body of the device and exit through the side branch. The IIA was catheterized and a bridging covered stent was deployed, connecting the side branch to the IIA and excluding flow into the sac of the CIAA.

In open IIA revascularization single antiplatelet therapy was given during and after the procedure. In endovascular procedures for IIA preservation, the patient was given dual antiplatelet therapy (aspirin plus clopidogrel) after the procedure and for at least one month during follow-up. After the first month the patient remained on single antiplatelet therapy.

All patients underwent a postoperative surveillance protocol, which included physical examination, blood pressure measurement, and CTA at 1, 6, and 12 months postoperatively and yearly thereafter.

Statistical analysis: Data are expressed as mean±standard deviation, except for non-Gaussian parameters, which are presented as median (range). Categorical data are represented by number (n) and percentage (%). Kaplan- Maier analysis was used to estimate survival rates. Statistical analyses were performed using SPSS 20.0 statistics software (SPSS Inc, Chicago, Ill). A p value of $<.05$ was considered as statistically significant.

## RESULTS

During a time period of 7 years 380 patients underwent EVAR with modular devices in our institution. Concomitant unilateral iliac aneurysms were found in 125 (33.1%) patients, while 63 (16.7%) had bilateral iliac aneurysms. Exclusion of one IIA with the extension of the stent graft to the external iliac artery was performed in 53 (14%) patients, while embolization of the IIA in 23 (6%) patients. 124 patients were treated with a wide iliac limb landing on the common iliac artery (bell-bottom technique). Eleven of the patients that had the IIA overstented had an IIA aneurysm. None of these patients needed any IIA preservation procedure and were treated with an endograft landing on the EIA.

Our study population consisted of a total of 11 patients (10 males, mean age 73.5±5·6 years, range 64-82 years) who underwent an adjunctive revascularization procedure for IIA preservation during EVAR. Patients' demographics and preoperative and postoperative data are shown in Table I, and a summary of all cases reported herein is delineated in Table II. None of these patients were operated on emergency setting. Mean maximum abdominal aortic diameter was 60±19 mm (range 26-99 mm). Three patients had no abdominal aortic aneurysm, but a bifurcated endovascular graft was deployed due to inadequate CIA landing zone. Ten patients had bilateral CIA aneurysms above 3cm, while 1 patient had a unilateral CIA aneurysm >3cm. Mean maximum CIA diameter at the side of revascularization was 40.6±15.6 mm.

| Variables | No. (%) |
|---|---|
| Age, years | 73.5±5.6 |
| Gender (male) | 9 (81.8) |
| Risk factors | |
| Hypertension | 11 (100) |
| Hyperlipidemia | 8 (72.7) |
| Coronary artery disease | 5 (45.5) |
| Chronic Obstructive Pulmonary Disease | 6 (54.5) |
| Diabetes mellitus | 3 (27.3) |
| Cardiac insufficiency | 3 (27.3) |
| Smoker | 5 (45.5) |
| Abdominal aorta maximum diameter, cm | 6±1.9 |
| Time to discharge, median/days | 5 |

**Table 1.** Patient demographics and comorbidities

| No | Year | Age | Gender | AAA (mm) | RCIA | LCIA | IIA occlusion | IIA embolization | IIA preservation | Procedure | Follow-up | Complications |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2008 | 67 | F | 50 | 31 | 12 | RIIA | | LIIA | Transposition | 62 | |
| 2 | 2008 | 70 | M | 65 | 32 | 36 | LIIA | | RIIA | By-pass | 58 | |
| 3 | 2009 | 73 | M | 28 | 70 | 55 | LIIA | | RIIA | Transposition | 46 | |
| 4 | 2010 | 64 | M | 98 | 38 | 50 | | LIIA | RIIA | By-pass | 38 | |
| 5 | 2011 | 69 | M | 59 | 35 | 33 | RIIA | | LIIA | Transposition | 27 | |
| 6 | 2012 | 79 | M | 53 | 36 | 93 | | LIIA | RIIA | IBD | 15 | Thrombosis at 1st month |
| 7 | 2012 | 82 | M | 26 | 41 | 73 | | | RIIA-LIIA | IBD | 12 | |
| 8 | 2013 | 76 | M | 64 | 39 | 44 | | LIIA | RIIA | "Sandwich" | 6 | |
| 9 | 2013 | 74 | M | 72 | 32 | 36 | | | LIIA | "Sandwich" | 6 | |
| 10 | 2013 | 74 | M | 71 | 36 | 25 | | | RIIA | "Sandwich" | 3 | Thrombosis at 1st month |
| 11 | 2013 | 80 | F | 73 | 37 | 42 | | LIIA | RIIA | IBD | 3 | |

No: number, F: Female, M: Male, AAA: abdominal aortic aneurysm, RCIA: Right common iliac artery, LCIA: Left common iliac artery, IIA: Internal iliac artery, IBD: iliac branch device

**Table 2.** Summary of all cases undergoing internal iliac artery preservation during endovascular aneurysm repair.

**Indications**: In nine patients IIA revascularization was performed to preserve at least the patency of one IIA. One patient underwent bilateral IIA preservation. This patient had large bilateral CIA aneurysms (4.1 and 7.3 cm respectively) and severe atherosclerosis of the whole aortic tree. Bilateral IIA preservation was deemed appropriate for paraplegia prevention. In one patient the IIA was accidentally covered during the deployment of the contralateral limb and since the other IIA was deliberately covered with a limb extending to the EIA, preservation of the contralateral IIA was necessary.

**Procedures:** Six patients underwent an endovascular procedure for IIA preservation, while in 5 patients an open procedure was performed. Three patients underwent an IIA transposition, while 2 patients had an EIA-IIA by-pass. In three patients the iliac branch device (IBD) (Cook Medical Inc, Bloomington, IN, USA), in two unilateral and one bilateral, was deployed, while in three patients the "sandwich technique" was applied. IIA revascularization was accomplished successfully in all cases and no reoperation was required in the postoperative period. The overall 30-day mortality was null. The median hospital stay was 5 days (range, 4-7 days).

During a mean follow-up of 48±21.7 months (range 15-90 months; median, 26 months) early buttock claudication was observed in 1 patient (9.1%) at the contralateral side from the preservation that was resolved conservatively three months after the procedure. There were no cases of ischemic colitis, buttock necrosis or late buttock claudication. Two occlusions occurred during the follow-up period, both found at the first month visit after the procedure. One IBD was occluded, probably as a result of severe atherosclerotic disease and very poor outflow. One sandwich was also thrombosed, due to significant compression of the iliac limb extension. Both occlusions were asymptomatic and were found incidentally at the 1st month follow-up visit. No reinterventions were needed for these occlusions. The cumulative free from reintervention rate was 100%.

## DISCUSSION

The clinical impact of IIA overstenting with or without embolization has been controversial. Complications predominantly comprise buttock claudication and erectile dysfunction but may even involve spinal, bowel ischemia or buttock necrosis.[4] Papazoglou et al reported a 13% incidence of buttock claudication after IIA coverage that was significantly ameliorated or resolved within the first 6 months postoperatively in all patients.[12] However, a recent review identified the development of buttock claudication in 29.2% of patients after unilateral IIA embolization prior to EVAR, while new onset erectile dysfunction was evident in 12.7% of the male population.[4] Bilateral IIA occlusion has been associated with a higher incidence of buttock claudication as well as other presentations of pelvic ischemia.[4] These complication rates should be interpreted cautiously, since several complications after IIA interruption might be underreported leading to significant publication bias.[3] Although current data are coming mostly from retrospective not randomized case series, these relatively high complication rates after single or bilateral IIA sacrifice raises certain questions about the necessity for IIA preservation even when unilateral coverage is involved.

Current evidence regarding the subset of patients that may benefit from an IIA revascularization procedure during EVAR has not been well defined. The presence of certain circumstances, as contralateral IIA occlusion, large inferior mesenteric artery or the need for concomitant thoracic endograft, may exert the need for a revascularization procedure; although not enough data exist.[1-10] Furthermore, the presence of severe atherosclerosis resulting in significant stenosis of the contralateral IIA's orifice consist an indication that has to be considered. Therefore in such cases it is of utmost importance always to evaluate meticulously both IIAs during the preoperative planning. In our practice we try to preserve the flow to at least to one IIA, if possible.

The bell-bottom technique has been proven safe and effective in treating common iliac aneurysm of moderate size over a long-term period.[1] However, this technique, although is easy to perform even in emergency situations, is limited by the commercially available sizes of iliac limbs (28mm) and the high risk of secondary procedures. Various techniques, open or endovascular, have been developed to exclude the CIA and minimize the risk of a type IIa endoleak from the IIA without raising the chance for pelvic ischemia.[2-4]

An open surgical procedure for IIA revascularization was used in nearly half of our patients. Open interventions, as it is shown from our report, was the first choice in the early years of EVAR, when IIA maintenance was deemed necessary. They can be safely and successfully applied in emergent setting, as in one of our patients, in case of inadvertent coverage of the IIA. Lee et al by retrospectively studying patients treated with an hypogastric by-pass found only 4% of new onset buttock claudication ipsilateral to the hypogastric by-pass, while they also reported a 90% patency rate at 36 months.[2] In our series there were no ischemic complications while both bypasses were patent at 3 years. These excellent associated results should not come to any surprise given the relatively large diameter and short length of the by-pass. However, the procedure itself is technically demanding given the anatomic location of the IIA, especially in obese patients and those with large aneurysms.

Furthermore, the transposition of the hypogastric artery was performed in three of our patients and consist a good alternative therapeutic option, though an adequate length of IIA is mandatory. Nevertheless, the exposure of the CIA bifurcation and the isolation of the proximal segment of the IIA through a small lower quadrant incision, especially in obese individuals, require a high-level of surgical training, considering the limited and deep surgical field.[13,14]

A trend towards more endovascular procedures for IIA revascularization during EVAR in recent years is evident.[4] This shift was also evident in our practice. In half of the patients an iliac branch device was deployed, while in the other half the "sandwich technique" was applied. Iliac branch devices (IBD) extend from a conventional bifurcated stent-graft into the EIA whilst preserving flow into the ipsilateral IIA using a side branch.[3] This procedure can be performed with high technical success rate and have been associated with encouraging mid-term results, very low endoleak rate, although a significant reocclusion rate (10%) that required reintervention has been reported.[3] In our series one IBD was occluded, though no reintervention was needed.

The sandwich endograft technique involves deployment of two parallel endografts side by side into an existing iliac limb to create a bifurcated iliac component.[15] This technique allows for iliac preservation by using commercially available grafts in an off label manner. Lobato et al by studying 40 patients undergoing "sandwich technique" for treatment of complex aortoiliac or isolated iliac aneurysms reported a 100% and 93.8% technical success and primary patency rate respectively.[16] There were three occlusions, occurring early in the study probably, as the authors stated, because of the technique's learning curve. Nevertheless, the lack of long-term data and the potential risk for type III endoleak and limb thrombosis should be acknowledged. In our practice we always deploy the bridge stent graft through a brachial access, that has enable a successful catheterization in all cases. Furthermore, in this technique an overlap of at least 40mm is considered mandatory to avoid undesirable endoleaks and succeed the best sealing. Therefore, we always use the Viabahn stent graft, due to its flexibility and length (available in length >100mm).

Several other endovascular techniques have been proposed over the past decade for IIA revascularization during EVAR. Minion et al used two bifurcated endovascular prostheses to preserve IIA patency.[17] However the need for a large enough aortic diameter to fit the three limbs and the high cost of a second bifurcated graft has limited the applicability of the procedure. External iliac-to-internal iliac artery "cross stenting" has also been recommended.[18] This technique however warrants further investigation, considering the potential high risk of graft kinking and the lack of adequate literature data.

A very important issue with IIA preservation is the cost, particularly as the overall budget of the endovascular procedure is compared with AAA open repair. Stroupe et al recently by studying the 881 patients of the Open Versus Endovascular Repair (OVER) Veterans Affairs (VA) Cooperative Study reported a lower cost for EVAR when compared with open repair after the initial hospitalization, which eventually became not significantly different after the first two years.[19] It has been reported that IIA embolization can be achieved at a cost of approximately $470.[20] Undoubtedly, all the endovascular interventions for IIA preservation performed in our series raise the total cost of the procedure. The use of Zenith bifurcated Iliac Side device (Cook Inc, Bloomington, IN) adds $6000 to the cost of standard EVAR, without taking into account the additional cost of the bridging stent graft.[3] The sandwich technique consists a more economic option; though the cost of the iliac extension limb and the bridge cover stent should be acknowledged. Open surgical procedures for IIA revascularization seem to consist the most economic solution, however the logistic impact of certain parameters as the perioperative morbidity and the hospital stay prolongation have not been evaluated. The cost-effectiveness of IIA preservation during EVAR remains open to question and certainly a formal cost-effectiveness appraisal is mandatory.

In conclusion, the option of unilateral or bilateral internal iliac artery occlusion during EVAR may have a significant risk of complications in certain patients. Preservation of one or both hypogastric arteries can be accomplished through various open or endovascular techniques. These techniques represent a significant improvement in the treatment of aortoiliac aneurysms by allowing preservation of pelvic flow. A trend towards more endovascular procedures for IIA preservation has been noted during the last years. However considering the lack of long-term data, therapeutic strategy should be tailored for each individual patient, according to anatomical criteria and the presence of significant comorbidities.

## REFERENCES


1 Torsello G, Schönefeld E, Osada N, Austermann M, Pennekamp C, Donas KP. Endovascular treatment of common iliac artery aneurysms using the bell-bottom technique: long-term results. J Endovasc Ther 2010;17:504-9

2 Lee WA, Nelson PR, Berceli SA, Seeger JM, Huber TS. Outcome after hypogastric artery bypass and embolization during endovascular aneurysm repair. J Vasc Surg 2006;44:1162-8

3 Karthikesalingam A, Hinchliffe RJ, Holt PJ, Boyle JR, Loftus IM, Thompson MM. Endovascular aneurysm repair with preservation of the internal iliac artery using the iliac branch graft device. Eur J Vasc Endovasc Surg 2010;39:285-94

4 Kouvelos GN, Katsargyris A, Antoniou GA, Oikonomou K, Verhoeven EL. Outcome after Interruption or Preservation of Internal Iliac Artery Flow During Endovascular Repair of Abdominal Aorto-iliac Aneurysms. Eur J Vasc Endovasc Surg.2016;52:621-634

5 Moll FL, Powell JT, Fraedrich G, Verzini F, Haulon S, Waltham M, et al; European Society for Vascular Surgery. Management of abdominal aortic aneurysms clinical practice guidelines of the European society for vascular surgery. Eur J Vasc Endovasc Surg. 2011;41:S1-S58

6 Chaikof EL, Dalman RL, Eskandari MK, Jackson BM, Lee WA, Mansour MA, et al. The Society for Vascular Surgery practice guidelines on the care of patients with an abdominal aortic aneurysm. J Vasc Surg. 2018;67:2-77

7 Smith M, Gupta R, Jazaeri O, Rochon P, Ray C. Preservation of internal iliac arterial flow during endovascular aortic aneurysm repair using the "sandwich" technique. Semin Intervent Radiol 2013;30:82-86

8 Hobo R, Sybrandy JE, Harris PL, Buth J; EUROSTAR Collaborators. Endovascular repair of abdominal aortic aneurysms with concomitant common iliac artery aneurysm: outcome analysis of the EUROSTAR Experience. J Endovasc Ther 2008;15:12-22

9 Stokmans RA, Willigendael EM, Teijink JA, Ten Bosch JA, van Sambeek MR, Cuypers PW. Challenging the evidence for pre-emptive coil embolisation of the internal iliac artery during endovascular aneurysm repair. Eur J Vasc Endovasc Surg 2013;45:220-6

10 Smith M, Gupta R, Jazaeri O, Rochon P, Ray C. Preservation of internal iliac arterial flow during endovascular aortic aneurysm repair using the "sandwich" technique. Semin Intervent Radiol 2013; 30:82-86

11 Lobato AC, Camacho-Lobato L. The sandwich technique to treat complex aortoiliac or isolated iliac aneurysms: results of midterm follow-up. J Vasc Surg 2013; 57:26S-34S

12 Papazoglou KO, Sfyroeras GS, Zambas N, Konstantinidis K, Kakkos SK, Mitka M. Outcomes of endovascular aneurysm

repair with selective internal iliac artery coverage without coil embolization. J Vasc Surg 2012; 56:298-303

13 Criado FJ. Iliac bifurcation relocation: more complex and controversial. J Endovasc Surg 1999;6:348-9

14 Parodi JC, Ferreira M. Relocation of the iliac artery bifurcation to facilitate endoluminal treatment of abdominal aortic aneurysms. J Endovasc Surg. 1999;6:342-7

15 Smith M, Gupta R, Jazaeri O, Rochon P, Ray C. Preservation of internal iliac arterial flow during endovascular aortic aneurysm repair using the "sandwich" technique. Semin Intervent Radiol 2013; 30:82-86

16 Lobato AC, Camacho-Lobato L. The sandwich technique to treat complex aortoiliac or isolated iliac aneurysms: results of midterm follow-up. J Vasc Surg 2013;57:26-34

17 Minion DJ, Xenos E, Sorial E, Saha S, Endean ED. The trifurcated endograft technique for hypogastric preservation during endovascular aneurysm repair. J Vasc Surg 2008;47:658-61

18 Silingardi R, Tasselli S, Gennai S, Saitta G, Coppi G. Endovascular preservation of pelvic circulation with external iliac-to-internal iliac artery "cross-stenting" in patients with aorto-iliac aneurysms: a case report and literature review. J Cardiovasc Surg (Torino) 2012; 53:651-5

19 Stroupe KT, Lederle FA, Matsumura JS, Kyriakides TC, Jonk YC, Ge L, et al; Open Versus Endovascular Repair (OVER) Veterans Affairs Cooperative Study Group. Cost-effectiveness of open versus endovascular repair of abdominal aortic aneurysm in the OVER trial. J Vasc Surg 2012;56:901-9

20 Vandy F, Criado E, Upchurch GR Jr, Williams DM, Rectenwald J, Eliason J. Transluminal hypogastric artery occlusion with an Amplatzer vascular plug during endovascular aortic aneurysm repair. J Vasc Surg 2008; 48:1121-4

INVITED COMMENTARY

# Endovascular techniques for preserving hypogastric arteries

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Up to 30% of abdominal aortic aneurysms (AAAs) have concomitant common iliac artery aneurysms. Isolated iliac artery aneurysms occurring in the absence of AAA, are relatively rare and account for 0.4% to 1.9% of intra-abdominal aneurysms. They are located in the common iliac artery in 70% to 90% of cases and in the internal iliac artery (IIA) in 10-20% of cases.[1,2] Bilateral common iliac artery aneurysms are identified in approximately 30 to 50% of cases.[2] An important issue in endovascular treatment of aortoiliac and isolated iliac aneurysms is the preservation of pelvic flow. Planned or unintentional coverage of internal iliac arteries may result in symptomatic pelvic ischemia. It is usually well tolerated but in certain cases pelvic ischemia may present as recalcitrant buttock claudication and vasculogenic impotence whereas in more severe cases of compromised pelvic arterial flow, gluteal necrosis, colonic ischemia, and spinal ischemia can occur.

Kouvelos et al.[3] in this interesting single center study reported their experience in preservation of internal iliac arteries (IIAs) and analyzed the technical success and the clinical outcome of the techniques used. In consistency with the literature data, the authors reported concomitant unilateral iliac aneurysms in 33.1% of patients and bilateral iliac aneurysms in 16.7%. Remarkably, in this study several hybrid and novel endovascular techniques were applied in order to maintain adequate pelvic perfusion, including IIA bypass/transposition, external iliac artery to IIA bypass, the "sandwich or double-barrel" technique and iliac branch devices (IBDs). Overall, 6 patients were treated totally endovascularly -3 with IBD and 3 with "sandwich technique"- and 5 with hybrid procedures (combining EVAR with open revascularization of the IIA) with no reported deaths. Two early occlusions, one of an IBD and one sandwich, occurred. Buttock claudication was observed in 1 patient (9.1%).

Three important issues should be underlined:

**a.** Typical strategies utilized during standard endovascular repair of aortoiliac aneurysms involve sacrifice via embolization of unilateral or bilateral hypogastric arteries. A recent systematic review found that buttock claudication occurs in 27% of patients undergoing unilateral IIA interruption and in 36.5% of patients with bilateral IIA interruption.[4] A metanalysis showed that erectile dysfunction occurs in 10.2% of males, with higher rates after coiling.[5] So, it is self-evident why in the last years, we have moved forward from intentional embolic occlusion of the internal iliac artery to advanced endovascular options.

**b** The IBDs have been increasingly used for treating aortoiliac aneurysms with encouraging results. In March 2016, the US Food and Drug Administration approved the GORE EXCLUDER Iliac Branch Endoprosthesis (IBE). Other IBDs have been commercially available in Europe and include versions of the Zenith IBD (Cook Medical, Brisbane, Australia) and the Jotec E-iliac device (Jotec, Hechingen, Germany). In a recent metanalysis the pooled technical success rate of IBD was 93%, the 30-day mortality rate 2%, the follow-up patency 86%, the endoleak rate 12%, the buttock claudication rate 6% and the IBD-associated re-intervention rate was 11%.[6] Interestingly, the pELVIS Registry investigators analyzing the results of 227 patients with isolated common iliac artery aneurysms treated with IBDs showed a 35% reintervention rate at 60 months demonstrating that the occurrence of secondary procedures in patients treated with iliac branch devices is not negligible.[7] So, it should be emphasized that although these encouraging results are strongly related to anatomical feasibility and proper patient selection, certain concerns regarding the durability and the clinical outcome still exist.[8]

**c.** The "sandwich" or "chimney" technique is a feasible alternative to IBDs. Due to strict anatomic inclusion criteria associated with IBDs, only 35% of patients have anatomy suitable for repair.[7] Lobato et al. evaluating the safety and efficiency of the sandwich technique for internal iliac artery revascularization in 40 patients described a 100% technical success rate and a 93.8% primary patency rate.[9] Three IIA occlusions occurred early in this study. Although this innovative method of iliac aneurysm repair is technically feasible and with promising results, the "off-label" use of these devices poses skepticism about the patency and gutter-related endoleaks. Long-term data are needed to prove the efficacy and durability of the technique.

In conclusion, in this interesting paper the authors provided their experience in treating patients with hybrid or totally endovascular means. The preservation of hypogastric arteries should be offered to all patients when technically achievable. Iliac branch devices have high technical success rate without serious complications. More data are needed to prove the efficacy and durability of the "sandwich" or "parallel" grafts technique.

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## REFERENCES


1 Dix FP, Titi M, Al-Khaffaf H. The isolated internal iliac artery aneurysm--a review. Eur J Vasc Endovasc Surg. 2005;30:119-29.

2 Brunkwall J, Hauksson H, Bengtsson H, Bergqvist D, Takolander R, Bergentz SE. Solitary aneurysms of the iliac arterial system: an estimate of their frequency of occurrence. J Vasc Surg. 1989;10:381-4.

3 G. Kouvelos, P. Nana, D. Xanthopoulos, M. Peroulis, E. Arnaoutoglou, S. Koutsias, et al. Preservation of internal iliac artery during endovascular repair of abdominal aneurysmal disease. Hel J Vasc Endovasc Surg 2019; 1: 13-9.

4 Kouvelos GN, Katsargyris A, Antoniou GA, Oikonomou K, Verhoeven EL. Outcome after Interruption or Preservation of Internal Iliac Artery Flow During Endovascular Repair of Abdominal Aorto-iliac Aneurysms. Eur J Vasc Endovasc Surg.2016;52:621-634.

5 Bosanquet DC, Wilcox C, Whitehurst L, Cox A, Williams IM, Twine CP; British Society of Endovascular therapy (BSET). Systematic Review and Meta-analysis of the Effect of Internal Iliac Artery Exclusion for Patients Undergoing EVAR. Eur J Vasc Endovasc Surg. 2017;53:534-548.

6 Li Y, Hu Z, Zhang J, Zheng H, Wang J, Chen Z, et al. Iliac Aneurysms Treated with Endovascular Iliac Branch Device: A Systematic Review and Meta-Analysis. Ann Vasc Surg. 2018 Oct 1.

7 Fargion AT, Masciello F, Pratesi C, Pratesi G, Torsello G, Donas KP; pELVIS Registry collaborators. Results of the multicenter pELVIS Registry for isolated common iliac aneurysms treated by the iliac branch device. J Vasc Surg. 2018;68:1367-1373

8 Pearce BJ, Varu VN, Glocker R, Novak Z, Jordan WD, Lee JT. Anatomic suitability of aortoiliac aneurysms for next generation branched systems. Ann Vasc Surg 2015;29:69-75.

9 Lobato AC, Camacho-Lobato L. The sandwich technique to treat complex aortoiliac or isolated iliac aneurysms: results of midterm follow-up. J Vasc Surg. 2013;57:26S-34S.

# Female gender may be a predictor of poor clinical outcome after infrainguinal bypass surgery in patients with foot gangrene

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**Abstract:**

**Introduction:** The effect of gender on the outcome of peripheral bypass surgery remains unclear. Aim of the study was to assess the impact of gender on clinical outcome of infrainguinal bypass procedures, in patients suffering by limb ischemia with foot gangrene.

**Patients and methods:** A retrospective study was designed. All consecutive patients who suffered by severe lower limb ischemia with foot necrosis (Rutherford 5 or 6), and had an infrainguinal bypass surgery with a venous or synthetic graft in a 3-year period were included in the study. We examined the effect of gender on early graft failure, 12-month graft overall (secondary) patency, and 36-month amputation-free survival and mortality. To reduce the effect of various factors that could potentially interfere with the results, propensity score matching was additionally applied.

**Results:** Sixty-seven patients were included (41 males, 26 females). Overall, females presented an increased risk of early graft failure (38.5% vs. 14.6%, p=0.039). Similarly, the 12-month patency appeared lower in females (35% vs. 66.3% in male group, p=0.040). Mortality and amputation-free survival at 36 months post the procedure were not statistically different between the two groups. In propensity score matched subsamples, the early graft failure was worse in the female group, 39% vs. 6% (p=0.022). Similarly, female patients presented inferior results regarding amputation-free survival (32.1% vs. 68.5%, p=0.034) at 36 months post the procedure.

**Conclusion:** Female patients seem to have an increased risk of early graft failure as compared to males, when they have an infrainguinal bypass graft for severe critical limb ischemia with foot tissue loss. Additionally they present worse patency, and potentially amputation free survival rates. Nevertheless, no difference exists with regard their long-term mortality.

**Keywords**

Peripheral arterial disease, arterial occlusive disease, blood vessel prosthesis, lower limb bypass, foot gangrene, gender

## INTRODUCTION

Despite the advances of endovascular techniques, infrainguinal bypass procedures remain the cornerstone of lower limb revascularization. Although technical factors are known to be critical for the success of surgical revascularization, the effect of patient's gender has been controversial [1]. Female gender has been proposed as a potential predictor of poor results especially in terms of postoperative mobility [2], and perioperative complications including mortality and amputations [3]. In the PREVENT III trial, female gender was found to be associated with an increased rate of bypass loss [4]. However, a nationwide study in Taiwan, considered males to be at risk of future lower extremity amputation [5]. In contrast, from a study that analyzed the infrainguinal arterial revascularization over a 15 years period in more than 1450 procedures, Ballotta et al. concluded that gender did not seem to influence patency, limb salvage, and survival rate [6]. In the BASIL trial, the only one randomized controlled trial comparing open surgical bypass and angioplasty in patients suffering from critical limb ischemia, no effect of gender on outcome was reported [7].

It is considered that patients with foot sepsis or gangrene, (Rutherford 5 or 6), have an increased need of foot arterial blood flow in order to heal tissue loss areas, as compared to patients with critical limb ischemia without tissue loss [8]. Nevertheless, scarce reports exist regarding the effect of various factors on the outcome of revascularization in this subgroup of critical ischemia patients. Aim of this study was to investigate the effect of gender on clinical outcomes of infrainguinal open revascularization procedures, in patients suffering from severe lower limb ischemia with foot tissue loss or gangrene.

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## PATIENTS AND METHODS

A retrospective single-institutional clinical study was undertaken. The study was approved by Ethical Committee of the Attikon Teaching Hospital. All consecutive patients suffering by severe limb ischemia characterized by foot gangrene (Rutherford 5 or 6) and received an infrainguinal open arterial reconstruction within a 3-year period (2011 - 2013) were included. Patients who had a lower limb bypass for any other reason but foot gangrene were excluded from the study (i.e. patients suffering by intermittent claudication or critical limb ischemia without foot tissue loss, or patients with popliteal artery aneurysms that had a femoropopliteal bypass). Similarly, all the patients that were treated only with an angioplasty were excluded from the study. Data were retrieved from the electronic database of the hospital. Whenever data were missing, an additional research of the medical records was performed. Follow-up information were gathered either by patients' medical records of the outpatient clinics or by direct communication with the patients at the time of data collection.

Patients were divided in two groups based on their gender, the female and male groups. Various parameters were recorded as potential risk factors that could affect the outcome of revascularization (Table 1). These parameters included baseline characteristics (age, atherosclerosis predisposing factors), clinical characteristics (size of foot necrosis, urgency of the procedure, primary operation or operation after a failed bypass or a failed angioplasty), and various technical details (graft type, level of proximal and distal anastomosis). Males and females were compared across these potential covariates to assess whether the groups were similar enough and thus a univariate analysis on gender would be meaningful.

### *Surgical technique and patients' surveillance*

All patients had a standard infrainguinal revascularization procedure. In case of existence of a concomitant aortoiliac component of ischemia, this had been dealt either before with an open or endovascular approach, or at the same time with a hybrid approach if this had been considered feasible. The proximal anastomosis was either at the femoral artery (including the superficial femoral artery or the profunda femoris artery) or at the popliteal artery (at a supra- or infra-genicular level). In case of severe stenosis of the inflow artery mostly the common femoral artery (CFA) and/or the profunda femoris artery (PFA), an endarterectomy was performed at the time of the procedure. The distal anastomosis was at a good quality vessel, which had an inline continuation to the plantar arteries (popliteal or any tibial or pedal artery). The graft was mainly a venous graft when a proper vein was available, as seen in the preoperative ultrasound vein-mapping scan. As proper vein was considered the vein with a diameter greater than 3 mm; whenever a single segment vein was not available, two or more pieces of proper veins of lower or upper limbs were sewn together to form a single vein graft. When a vein graft was unavailable a synthetic graft (PTFE), sized 6 to 8 mm on surgeon's preference, was used. Patients who had either a combined vein-PTFE graft or a venous collar at the distal anastomosis of a PTFE graft were considered to have a synthetic graft in the analysis. Debridement of the foot necrosis (including local amputation if necessary) was performed after revascularization, unless the lesion was considered grossly infected and the patient was septic. In the latter situation the debridement was performed prior to the vascularization. After the procedure, all patients received long-term single standard antiplatelet therapy, as well as statin therapy targeting to a level of serum low-density lipoproteins less than 100 mg/dl. Patients who had an infrapopliteal synthetic graft received dual antiplatelet treatment for at least 12 months after the procedure. After bypass, patients entered a strict ultrasound and clinical surveillance program for 12 months.

Patients were advised to visit the outpatient clinic at 1, 6 and 12 months after the procedure, or when they developed a sudden significant deterioration of their condition indicating graft occlusion (acute onset of numbness, coldness or pain on their limb). In the latter situation, if patients had to be hospitalized in another hospital, they were advised to communicate with us and inform us about their situation the soonest possible. Subsequently, they were followed-up annually up to 36 months after the procedure.

### *Study endpoints*

The study endpoints of the study were chosen based on those used in the BASIL trial [7]. The amputation-free-survival was the primary endpoint of the study. Amputation-free-survival was described the situation that the patient was alive with intact limb (without having undergone a major amputation).) Early graft failure, graft patency, and patients' survival were the secondary endpoints of the study. As early graft failure was defined the situation where the graft was occluded within the first 30 days after implantation. If a patient with an early graft failure underwent immediately a graft repair and following this the graft remained patent after the 30-day postoperative period, the initial procedure was not considered a failure. Graft patency was considered the secondary patency. Amputation free survival and mortality were calculated at a 36-month interval after the index procedure, while the grafts patency at a 12-month interval, a period when the patients were under the ultrasound surveillance program.

### *Propensity Score Analysis*

To minimize a possible effect of the various baseline characteristics to the outcomes, a further analysis using propensity score matching (PSM) was performed using the "one-to-one matching technique" [9]. PSM allows the analysis of observational non-randomized data, thus mimicking some of the characteristics of a randomized controlled trial [9]. Following PSM, two new female and male groups of equal size were created, both similar regarding the various baseline characteristics. Thus, any difference found regarding outcome could be attributed only on gender and not to any other factor. Then, the two new groups were compared towards the same endpoints as the original groups.

### *Statistical analysis*

Non-parametric descriptive statistics were used for the description of the patients in the two groups (median, range). Life table analysis techniques (Kaplan-Meier and Peto's log-rank test) were used for the assessment of graft patency, limb salvage or amputation rate, patients' survival, and amputation-free-survival. The early graft failure between the two groups was assessed using the Fisher's Exact test. The comparison of the different baseline characteristics between the two groups was performed using parametric or non-parametric techniques (Unpaired t-test, Fisher's Exact test). Logistic

regression analysis, stepwise method, was used for the calculation of the propensity scores. The level of statistical significance of 0.05 (two-sided) was used throughout. The StatsDirect software package was used for the statistical analysis.

## RESULTS

During the 3-year study period, 209 patients were treated for various degrees of lower limb ischemia. One hundred eight patients had an endovascular treatment, while 101 had a surgical bypass procedure. Among the patients who underwent a surgical bypass, 67 suffered by severe ischemia with foot tissue loss (Rutherford 5 or 6), these being our study group. Forty-one patients were males (male group, 61%), and 26 females (female group, 39%).

### *Comparison of the two original groups*

The two original groups were not similar regarding specific baseline characteristics (Table 1). The median age of the patients was 69 years (range 32 to 87), similar in both groups (69.5 in the female and 68.7 in the male group, p=0.61). However, the portion of patients aged above 75 years was lower in females (19% vs. 32%, p=0.035). The two groups did not appear to differ significantly in chronic renal failure needing dialysis (4% in female, 15% in male group, p=0.159), or diabetes mellitus (58% in female and 66% in male group). However, men tended to be current smokers more often compared to women (88% vs. 65%, respectively, p=0.028). Regarding the various clinical details, female and male groups were not different in the extent of foot necrosis (p=0.245) or the urgency of the procedure (p=0.431). As it regards the technical details, female patients needed more often a PTFE graft due to unavailability of a vein (50% vs. 27%, p=0.054). Additionally, the two groups were similar regarding the locations of proximal and distal anastomoses. Finally, there was no difference between the number of forefoot amputations (digits or transmetatarsal) in the two groups (16/26, 61.5% in females vs. 28/41, 68.3% in males, p=0.61)

### *Primary and secondary endpoints*

At 36-month post the procedure the amputation-free survival was 30.4% in female and 52.9% in male patients (p=0.107) (Figure 1). The early graft failure was superior in the female group (38.5% vs. 14.6% in male group, p=0.039) (Figure 2). The 12-month patency-rate was 35.0% in the female group, as compared to 66.3% in the male group (p=0.040) (Figure 3). Finally, no difference was found in overall survival at 36 months post the procedure (63.9% in females and 69.4% in males, p=0.541) (Figure 4).

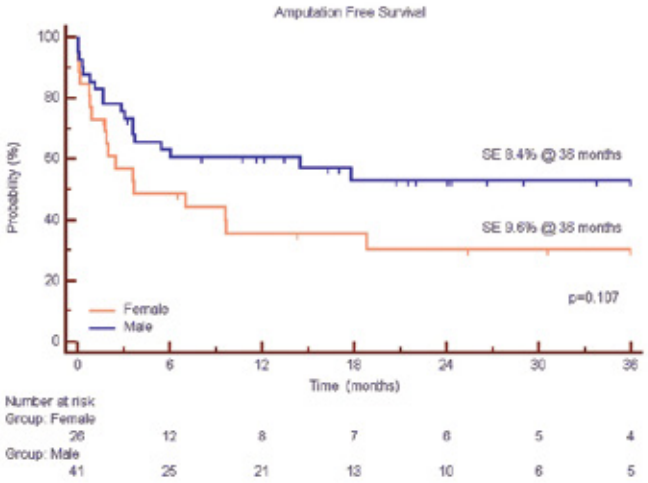


**Figure 1.** Amputation-free survival (@ 36 months) in the total cohort of patients.

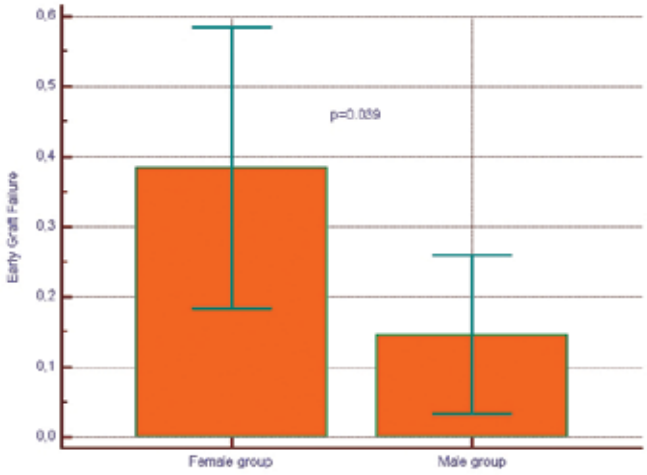


**Figure 2.** Early graft failure rates in the two groups

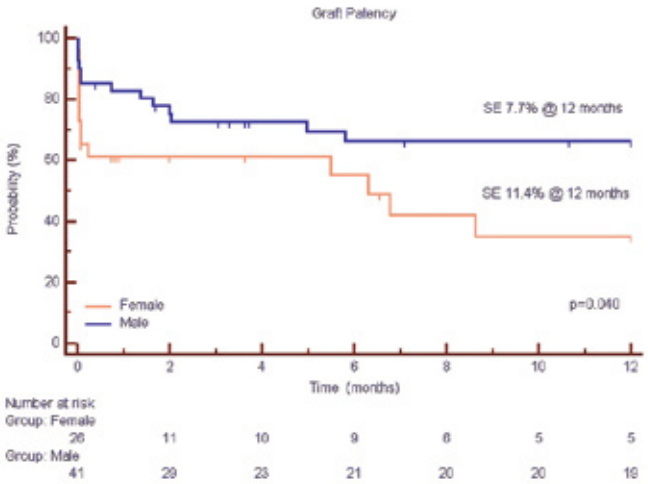


**Figure 3.** Graft patency (@ 12 months) in the total cohort of patients

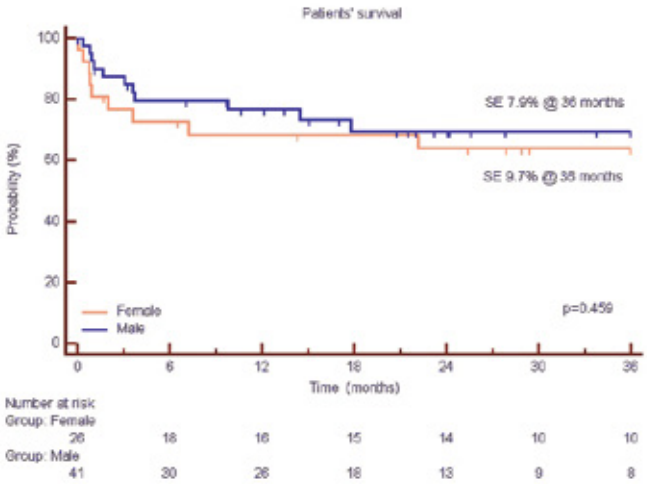


**Figure 4.** Patients' survival (@ 36 months) in the total cohort of patients

### *Propensity score analysis*

Following propensity score matching, 36 patients were selected from the original group, 18 males and 18 females. These two new groups, similar regarding the various baseline characteristics (Table 1), were examined towards the originally predefined endpoints (Table 2). The 36-month amputation-free-survival was found worse in the female group (32.1% versus 68.5% in males, p=0.034). Early graft failure was worse in the female group, 38.9% vs. 5.6% (p=0.022). Similarly, the 12-month graft patency was 31.4% in females vs. 75.1% in males (p=0.028). No difference was found in the 36-month patients' survival (63.6% vs. 72.3%, p=0.525).

| | Overall series | | | Propensity score-matched pairs | | |
|---|---|---|---|---|---|---|
| | Female group 26 patients | Male group 41 patients | *p-value (two-sided)* | Female group 18 patients | Male group 18 patients | *p-value (two-sided)* |
| Age | | | | | | |
| Median (range) | 69.5 (48-87) | 68.7 (32-87) | 0.611 | 67.3 (48-87) | 59.8 {32-75) | 0.116 |
| Age > 75 years | 6 (19%) | 20 (32%) | 0.035 | 1 (6%) | 0 (0%) | 0.311 |
| History of active smoking | 17 (65%) | 36 (88%) | 0.028 | 14 (78%) | 16 (89%) | 0.371 |
| Chronic Renal Failure (end-stage) | 1 (4%) | 6 (15%) | 0.159 | 1 (6%) | 0 (0%) | 0.311 |
| Diabetes Mellitus | 15 (58%) | 27 (66%) | 0.501 | 11 (61%) | 12 (67%) | 0.729 |
| Size of foot necrosis | | | | | | |
| Digital | 20 (77%) | 26 (63%) | 0.245 | 14 (78%) | 14 (78%) | >0.999 |
| Extensive | 6 (23%) | 15 (37%) | | 4 (22%) | 4 (22%) | |
| Urgency of procedure | | | | | | |
| Elective | 21 (81%) | 36 (88%) | 0.431 | 16 (89%) | 15 (83%) | 0.630 |
| Urgent | 5 (19%) | 5 (12%) | | 2 (11%) | 3 (17%) | |
| Type of procedure | | | | | | |
| Primary bypass | 16 (61%) | 23 (56%) | 0.660 | 12 (67%) | 13 (72%) | 0.717 |
| Bypass after previous angioplasty | 10 (39%) | 18 (44%) | | 6 (33%) | 5 (28%) | |
| Type of graft | | | | | | |
| Vein | 13 (50%) | 30 (73%) | 0.054 | 13 (72%) | 14 (78%) | 0.700 |
| PTFE | 13 (50%) | 11 (27%) | | 5 (28%) | 4 (22%) | |
| Proximal anastomosis | | | | | | |
| Femoral | 22 (85%) | 38 (93%) | 0.293 | 14 (78%) | 16 (89%) | 0.371 |
| Popliteal | 4 (15%) | 3 (7%) | | 4 (22%) | 2 (11%) | |
| Distal anastomosis I | | | | | | |
| Popliteal | 12 (46%) | 25 (61%) | 0.234 | 6 (33%) | 8 (44%) | 0.494 |
| Distal | 14 (54%) | 16 (39%) | | 12 (67%) | 10 (56%) | |
| Distal anastomosis II | | | | | | |
| Supragenicular | 6 (23%) | 6 (15%) | 0.380 | 3 (17%) | 2 (11%) | 0.630 |
| Infragenicular | 20 (77%) | 35 (85%) | | 15 (83%) | 16 (89%) | |
| Minor amputations | 16 (61%) | 28 (68%) | 0.606 | 11 (61%) | 12 (67%) | >0.999 |
| Propensity score (median) | 0.322 | 0.691 | <0.0001 | 0.691 | 0.691 | 0.676 |

| Propensity Score Analysis | | | | |
|---|---|---|---|---|
| | | Female (N=18) | Male (N=18) | *p-value* |
| Amputation Free Survival @ 36 months | (%) | 32.1 | 68.5 | 0.034 |
| Early Graft Failure | (%) | 38.9 | 5.6 | 0.022 |
| Graft Patency @ 12 months | (%) | 31.4 | 75.1 | 0.028 |
| Patients Survival @ 36 months | (%) | 63.6 | 72.3 | 0.525 |

## DISCUSSION

In this retrospective analysis of consecutive lower limb infrainguinal bypasses performed in patients with severe limb ischemia with foot gangrene, females seemed to experience superior early graft failure as compared to male patients and similarly, short-term (12-month) graft patency. Additionally, the long-term (36-month) amputation-free survival although tends to be worse than in male patients although the difference is not significant. Similar results were found also in propensity score matched groups. On the contrary, long-term (36-month) mortality seemed to be similar in male and female patients.

The increased early graft failure among female patients after an infrainguinal bypass seems to be a consistent finding in the literature [10 11]. On an analysis of the possible factors that might be related to an early graft failure after infrainguinal bypass, our group found that female gender is one of them, the rest factors being a previous ipsilateral angioplasty, a redo procedure and a distal bypass [12]. All these factors were included as the components of FARP2 score used for the prediction of early graft failure of infrainguinal bypass surgery [12]. Of interest is that Sahin and El [13] validated externally this model, this indicating that in their group also female gender was an independent predictor of early graft failure. The smaller size of lower limb arteries in females has been proposed as a possible cause. Women with peripheral artery disease seem have smaller tibial arteries, which may be perceived as a factor that increases the technical difficulty associated with lower limb revascularization [14].

Several studies have shown inferior patency of a surgical lower extremity revascularization procedure in women [15 16]. Green et al [17] found that the 5-year cumulative patency rates were 69.1% for men and 45% for women. Nguyen et al [4] observed that black women have the greatest disadvantages in terms of a higher extremity saphenous vein bypass loss at 1 year. Although these reports suggest an inferior patency in the female population, some studies have not identified significant gender effects on patency among patients treated with endovascular procedures, surgical bypass, or hybrid techniques [18]. In our study, female patients present worse patency rates as compared to male patients at a statistically significant level. We attribute this result to the increased early graft failure in females rather than on a continuous effect later on.

The worse patency rates in female population with PAD, does not seem to translate always into differences in limb salvage [19]. This seemed to be the situation in our cohort where the amputation free survival, although lower in the female group, did not reach a statistical significance. If this is not real, then the small number of patients in our cohort may explain this finding. The overall amputation-free-survival (AFS) in the total group of our patients was 44.4%, which is lower than the results shown in the BASIL trial [7] at the same interval (AFS about 50%). However, the BASIL trial cohort cannot be considered identical to our group. BASIL trial included patients with critical limb ischemia, while our study was limited in patients that had foot gangrene, excluding patients suffering by rest pain without tissue loss..Limb salvage has not been widely related to gender. Most authors agree that gender has no effect on limb salvage [1 20]. Of note, Watson et al. reported a worse limb salvage rate in women (74% vs. 83%) at 12 months after femorodistal bypass [21]. Similarly, Nguyen et al, after proper patients matching using propensity score analysis from the PREVENT III trial, found that black women had an increased amputation rate at one year compared with black men [4]. On the contrary, Malmstedt et al noted that male diabetic patients were at relatively higher risk of limb amputation than females [22].

Various factors have been considered as potential predictors of the infrainguinal arterial revacularization outcome. The type of antithrombotic treatment is one of them. All our patients received single antiplatelet treatment (Clopidogrel 75 mg od or Aspirin 100 mg od), except patients with infrapopliteal synthetic grafts who received double antiplatelet treatment. A combination of antiplatelet and anticoagulant was not used. Data in the literature indicate a possible beneficial effect of vitamin K antagonists in the venous [23] or prosthetic [24] lower limbs bypass grafts. On the other hand, dual antiplatelet treatment is considered to improve the outcome of infragenicular synthetic bypass grafts [25]. A potential positive effect of direct oral anticoagulant on this population has been documented [26], however randomized controlled studies are still ongoing [27]. Futhermore, smoking has been considered to negatively affect the outcome of an infrainguinal bypass [28]. In our group, smoking was not examined as a possible factor of graft occlusion. Although more active smokers were in the male group, they had a better outcome. This might be explained by the fact that males had more vein grafts than females. Finally, the type of graft (vein or synthetic) definitely has an impact in infrainguinal revascularization. Without doubt, vein graft and mainly a unique saphenous vein of good size and quality is the best graft that offers both instant effectiveness and longevity [29]. Of note was the finding that our female group had more synthetic grafts as compared to males. This was also described recently by Arhuidese et al [30] in a population of hemodialysis patients suffering by peripheral artery disease who had a lower extremity bypass surgery.

The association between gender and patient' survival after lower extremity revascularization for peripheral artery disease is complex and appears to be influenced by differences in age, comorbidities, and procedural factors. Controversial evidence exists in the literature. Magnant et al reported similar perioperative mortality rates among men and women undergoing infrainguinal bypass for lower extremity ischemia, but an increased mortality in diabetic women [31]. Egorova et al. [32] also noted an increased hospital mortality rate in women with peripheral artery disease. On the contrary, in their retrospective study of lower extremity saphenous vein bypasses, Belkin et al. [33] reported lower perioperative mortality in women. Hultgren et al. [34] identified an interaction between female gender and age as predictors of perioperative mortality among patients undergoing surgical or endovascular procedures for lower extremity ischemia. In their multivariate analysis, female gender was associated with improved long-term survival. Others have reported no gender effect on survival after treatment with endovascular [35] or open surgical techniques (4), as also seen in our study too.

The study suffers of various limitations. This is a single-institutional study with a small number of patients and therefore it is only powered to detect large differences between the two groups. In order to reduce the heterogeneity due to the diversity of the baseline characteristics (different levels of

distal anastomosis, different types of grafts, etc), propensity score matching was used so as to create comparable groups . Nevertheless hidden bias through unmeasured confounding may still remain. A subgroup analysis on specific sub-populations might be feasible only in large scale, possibly multicenter trials. Additionally, due to the small number of patients, the values of standard errors of the survival analysis exceeded the level of 10% in some instances. This confirms the necessity to assess the results of the study with caution. Another weakness of the study has to do with the results per se. All examined parameters, mainly the early graft failure and patency rates, are inferior to what is reported in the literature. There are two reasons for that. First, our cohort consisted only of Rutherford 5 and 6 patients where one can expect worse clinical outcome as opposed to those patients who do not suffer by that severe limb ischemia. This has been seen in our hands too. Within those of our patients who had a surgical bypass without a foot necrosis, the early graft failure was only 4.8% (unpublished data). As opposed to the current study, most results in the literature refer to mixed groups of peripheral vascular disease patients (including claudicants, and / or those suffering by critical limb ischemia but without foot necrosis). Secondly, today, as the majority of cases are treated endovascularly leaving only the most challenging cases to be treated with open procedures, surgical bypass could be expected to have worse results compared to the results of previous studies when the studied groups contained both “easy” and “difficult” cases together.. Finally, no specific information regarding the quality of runoff is available. However, the two groups seem to have similar patterns of disease as this can be seen by the levels of proximal and distal anastomoses, which were similar in the two groups (Table 1).

## CONCLUSIONS

Gender seems to may have a significant effect on early graft failure after open infainguinal revascularization procedures in patients with foot necrosis due to severe limb ischemia. Female patients present higher early graft failure and subsequently, they suffer a worse short-term overall patency as well as a potential worse long-term limb salvage and amputation-free survival as compared to males. This difference seems to be attributed to the fundamental difference of early graft failure between males and females, rather than on a continuous effect later on. The improvement of instant technical success and the decrease of early graft failure in female patients with peripheral vascular disease will possibly refine the long-term clinical results of lower limbs bypass surgery, offering comparable long-term clinical results as in male patients.

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## REFERENCES

1 Seymour KA, Sadowitz B, Amankwah KS, Gahtan V. Outcome of lower extremity revascularization for peripheral artery occlusive disease: is there a difference between men and women? Vascular. 2011 Apr;19(2):59-67.

2 Ambler GK, Dapaah A, Al Zuhir N, Hayes PD, Gohel MS, Boyle JR, et al. A United Kingdom perspective on independence and mobility after infrainguinal lower limb bypass surgery for critical limb ischemia. J Vasc Surg. 2013 Dec 21.

3 Vouyouka AG, Egorova NN, Salloum A, Kleinman L, Marin M, Faries PL, et al. Lessons learned from the analysis of gender effect on risk factors and procedural outcomes of lower extremity arterial disease. J Vasc Surg. 2010 Nov;52(5):1196-202.

4 Nguyen LL, Hevelone N, Rogers SO, Bandyk DF, Clowes AW, Moneta GL, et al. Disparity in outcomes of surgical revascularization for limb salvage: race and gender are synergistic determinants of vein graft failure and limb loss. Circulation. 2009 Jan 6;119(1):123-30.

5 Chen JJ, Lin LY, Lee CH, Liau CS. Age, male gender, and atrial fibrillation predict lower extremity amputation or revascularization in patients with peripheral artery diseases: a population-based investigation. Int J Angiol. 2012 Mar;21(1):35-40.

6 Ballotta E, Gruppo M, Lorenzetti R, Piatto G, DaGiau G, Toniato A. The impact of gender on outcome after infrainguinal arterial reconstructions for peripheral occlusive disease. J Vasc Surg. 2012 Aug;56(2):343-52.

7 Bradbury AW, Adam DJ, Bell J, Forbes JF, Fowkes FG, Gillespie I, et al. Bypass versus Angioplasty in Severe Ischaemia of the Leg (BASIL) trial: An intention-to-treat analysis of amputation-free and overall survival in patients randomized to a bypass surgery-first or a balloon angioplasty-first revascularization strategy. J Vasc Surg. 2010 May;51(5 Suppl):5S-17S.

8 Lawrence PF, Chandra A. When should open surgery be the initial option for critical limb ischaemia? Eur J Vasc Endovasc Surg. 2010 Mar;39 Suppl 1:S32-7.

9 Austin PC. An Introduction to Propensity Score Methods for Reducing the Effects of Confounding in Observational Studies. Multivariate Behav Res. 2011 May;46(3):399-424.

10 Lancaster RT, Conrad MF, Patel VI, Cambria RP, LaMuraglia GM. Predictors of early graft failure after infrainguinal bypass surgery: a risk-adjusted analysis from the NSQIP. Eur J Vasc Endovasc Surg. 2012 May;43(5):549-55.

11 Luther M, Lepantalo M. Femorotibial reconstructions for chronic critical leg ischaemia: influence on outcome by diabetes, gender and age. Eur J Vasc Endovasc Surg. 1997 Jun;13(6):569-77.

12 Lazaris AM, Mastoraki S, Kontopantelis E, Seretis K, Karouki M, Moulakakis K, et al. Development of a Scoring System for the Prediction of Early Graft Failure after Peripheral Arterial Bypass Surgery. Ann Vasc Surg. 2017 Apr;40:206-15.

13 Sahin M, El H. External Validation and Evaluation of Reliability of the FARP2 Score to Predict Early Graft Failure after

Infrainguinal Bypass. Ann Vasc Surg. 2018 Aug;51:72-7.

14 AhChong AK, Chiu KM, Wong M, Yip AW. The influence of gender difference on the outcomes of infrainguinal bypass for critical limb ischaemia in Chinese patients. Eur J Vasc Endovasc Surg. 2002 Feb;23(2):134-9.

15 Abbott WM, Green RM, Matsumoto T, Wheeler JR, Miller N, Veith FJ, et al. Prosthetic above-knee femoropopliteal bypass grafting: results of a multicenter randomized prospective trial. Above-Knee Femoropopliteal Study Group. J Vasc Surg. 1997 Jan;25(1):19-28.

16 Feinglass J, McDermott MM, Foroohar M, Pearce WH. Gender differences in interventional management of peripheral vascular disease: evidence from a blood flow laboratory population. Ann Vasc Surg. 1994 Jul;8(4):343-9.

17 Green RM, Abbott WM, Matsumoto T, Wheeler JR, Miller N, Veith FJ, et al. Prosthetic above-knee femoropopliteal bypass grafting: five-year results of a randomized trial. J Vasc Surg. 2000 Mar;31(3):417-25.

18 Kashyap VS, Pavkov ML, Bena JF, Sarac TP, O'Hara PJ, Lyden SP, et al. The management of severe aortoiliac occlusive disease: endovascular therapy rivals open reconstruction. J Vasc Surg. 2008 Dec;48(6):1451-7, 7 e1-3.

19 Duffy RP, Adams JE, Callas PW, Schanzer A, Goodney PP, Ricci MA, et al. The influence of gender on functional outcomes of lower extremity bypass. J Vasc Surg. 2014 Nov;60(5):1282-90 e1.

20 Roddy SP, Darling RC, 3rd, Maharaj D, Chang BB, Paty PS, Kreienberg PB, et al. Gender-related differences in outcome: an analysis of 5880 infrainguinal arterial reconstructions. J Vasc Surg. 2003 Feb;37(2):399-402.

21 Watson HR, Schroeder TV, Simms MH, Horrocks M. Association of sex with patency of femorodistal bypass grafts. Eur J Vasc Endovasc Surg. 2000 Jul;20(1):61-6.

22 Malmstedt J, Leander K, Wahlberg E, Karlstrom L, Alfredsson L, Swedenborg J. Outcome after leg bypass surgery for critical limb ischemia is poor in patients with diabetes: a population-based cohort study. Diabetes Care. 2008 May;31(5):887-92.

23 Efficacy of oral anticoagulants compared with aspirin after infrainguinal bypass surgery (The Dutch Bypass Oral Anticoagulants or Aspirin Study): a randomised trial. Lancet. 2000 Jan 29;355(9201):346-51.

24 Brumberg RS, Back MR, Armstrong PA, Cuthbertson D, Shames ML, Johnson BL, et al. The relative importance of graft surveillance and warfarin therapy in infrainguinal prosthetic bypass failure. J Vasc Surg. 2007 Dec;46(6):1160-6.

25 Belch JJ, Dormandy J, Biasi GM, Cairols M, Diehm C, Eikelboom B, et al. Results of the randomized, placebo-controlled clopidogrel and acetylsalicylic acid in bypass surgery for peripheral arterial disease (CASPAR) trial. J Vasc Surg. 2010 Oct;52(4):825-33, 33 e1-2.

26 Vos CG, Vahl AC. Anticoagulation and antiplatelet therapy in patients with peripheral arterial disease of the femoropopliteal arteries. J Cardiovasc Surg (Torino). 2018 Apr;59(2):164-71.

27 Capell WH, Bonaca MP, Nehler MR, Chen E, Kittelson JM, Anand SS, et al. Rationale and design for the Vascular Outcomes study of ASA along with rivaroxaban in endovascular or surgical limb revascularization for peripheral artery disease (VOYAGER PAD). Am Heart J. 2018 May;199:83-91.

28 Kalbaugh CA, Gonzalez NJ, Luckett DJ, Fine J, Brothers TE, Farber MA, et al. The impact of current smoking on outcomes after infrainguinal bypass for claudication. J Vasc Surg. 2018 Aug;68(2):495-502 e1.

29 Ambler GK, Twine CP. Graft type for femoro-popliteal bypass surgery. Cochrane Database Syst Rev. 2018 Feb 11;2:CD001487.

30 Arhuidese I, Kernodle A, Nejim B, Locham S, Hicks C, Malas MB. Sex-based outcomes of lower extremity bypass surgery in hemodialysis patients. J Vasc Surg. 2018 Jul;68(1):153-60.

31 Magnant JG, Cronenwett JL, Walsh DB, Schneider JR, Besso SR, Zwolak RM. Surgical treatment of infrainguinal arterial occlusive disease in women. J Vasc Surg. 1993 Jan;17(1):67-76; discussion -8.

32 Egorova N, Vouyouka AG, Quin J, Guillerme S, Moskowitz A, Marin M, et al. Analysis of gender-related differences in lower extremity peripheral arterial disease. J Vasc Surg. 2010 Feb;51(2):372-8 e1; discussion 8-9.

33 Belkin M, Conte MS, Donaldson MC, Mannick JA, Whittemore AD. The impact of gender on the results of arterial bypass with in situ greater saphenous vein. Am J Surg. 1995 Aug;170(2):97-102.

34 Hultgren R, Olofsson P, Wahlberg E. Sex-related differences in outcome after vascular interventions for lower limb ischemia. J Vasc Surg. 2002 Mar;35(3):510-6.

35 DeRubertis BG, Vouyouka A, Rhee SJ, Califano J, Karwowski J, Angle N, et al. Percutaneous intervention for infrainguinal occlusive disease in women: equivalent outcomes despite increased severity of disease compared with men. J Vasc Surg. 2008 Jul;48(1):150-7; discussion 7-8.

REVIEW

# Identifying the right patient for iliofemoral venous stenting

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**Abstract:**

Venous iliofemoral and caval stenting are increasingly used as more evidence accumulates supporting the open vein hypothesis, the safety, efficacy, and durability of these interventions. The indications are still evolving, but there is little doubt that certain patients with iliofemoral venous occlusive disease, acute or chronic, can avoid or abolish pain, swelling and chronic non-healing ulcers to enjoy a better quality of life. Knowing the right indications, following standardized protocols and technical steps are all critical components of a successful outcome and vascular surgeons will be increasingly asked to get involved.

**Keywords**

Deep vein thrombosis, chronic venous insufficiency, venous stenting, post-thrombotic syndrome, iliac vein compression

## INTRODUCTION

Iliofemoral venous obstruction is a common condition that may have been underestimated as a major cause of disability and has been traditionally managed conservatively. Venous obstruction can occur because of extrinsic compression (malignancy or anatomic variants), because of acute or chronic deep vein thrombosis (DVT).[1-3] Patient symptoms are variable and largely dependent on the cause, extent of venous obstruction, and disease duration.[1-3]

While for the majority of iliofemoral occlusive venous disease cases compression and/or anticoagulation may be optimal, certain patients will have symptoms that interfere with their quality of life. These patients may benefit from catheter-based therapies and iliofemoral stenting, a growing field that vascular surgeons will be increasingly asked to get involved. During the last decade, the endovascular management of iliofemoral or iliocaval obstruction has superseded open venous reconstructions. The safety, efficacy and durability of indicated endovascular interventions for iliocaval obstruction have been extensively demonstrated.[2,3] Knowing the right indications, following standardized protocols and technical steps are all critical components of a successful outcome.[1-5]

### *Extrinsic Iliac Vein Compression*

Iliac vein compression syndrome (IVCS), also called May-Thurner or Cockett syndrome is an anatomic variant manifesting with symptoms of chronic venous insufficiency, mainly lower extremity swelling, pain, varicosities and in its extreme form acute DVT. In its most frequent anatomic pattern there is compression of the left common iliac vein against the lumbar spine by the overlying right common iliac artery, but right sided syndrome can also occur. The traditional nomenclature may be confusing so the term nonthrombotic iliac vein lesion (NIVL) has been suggested.[6] Anatomic studies in cadavers and CT imaging reviews of asymptomatic patients indicate that ~25% have an at least 50% stenosis of the left common iliac vein by the overlying right iliac artery.[7,8]

Despite its high incidence in the general population, NIVL remains largely silent and we do not really know why not everybody develops symptoms. It is believed that NIVLs are permissive lesions meaning that additional pathologies such as trauma, cellulitis, distal thrombosis, lymphatic exhaustion, or reflux will trigger the symptoms.[6] The typical symptomatic patient is a young woman 20-40 years old. The rational for treatment in these young female patients is to offer relief from swelling, venous claudication, varices (leg and pubis) and why not for cosmesis. Iliac vein stenting can abolish external compression, provide venous outflow and symptom relief.

In 2003, the Raju group demonstrated that 50% of patients with pain and 55% with venous ulceration reported improvement following stent placement in NIVL.[9] In 2006, the same group reported a cohort of 316 patients treated for NIVL of which 82% and 77% with and without venous reflux, respectively, reported resolution of their lower-extremity edema.[6] In the largest systematic review to date, iliac vein stenting for NIVL provided the best outcomes against any other indication for stenting (acute or chronic DVT): 5 year primary and secondary patency 90% and 98% respectively.[2] Based on such robust evidence, in today's practice iliac vein stenting is the standard of care for symptomatic NIVL and this has been reflected in the most recent European Society for Vascular Surgery guidelines (Class IIa, Level B).[10]

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### *Acute DVT*

Catheter-directed thrombolysis (CDT) for acute iliofemoral deep venous thrombosis (DVT) has been increasingly used over the past decade targeting severe acute symptomatology and potentially prevention of post-thrombotic syndrome (PTS). The results of various retrospective and prospective randomized studies have been inconsistent, but there is little doubt that CDT will remain in the treatment armamentarium for patients with symptomatic iliofemoral DVT with good life expectancy and low bleeding risk.[11-15]

The long-anticipated results of the ATTRACT trial have challenged the expectations of CDT believers, demonstrating a relatively high post-thrombotic rate irrespective of treatment modality (47% for CDT vs 48% for anticoagulation (AC) at 2 years, P=.56).[16] In addition to the invasive nature of CDT, higher (though still low (1.7%)) major bleeding complications were seen. However, CDT reduced early DVT symptoms and the severity of post-thrombotic syndrome (PTS). While the study is unique and sets the benchmark for the treatment of acute iliofemoral DVT, there should be caution in the interpretation as selection bias and dilution of the sample with softly indicated cases (e.g femoropopliteal DVTs may have skewed the results).[17] The significant reduction of PTS severity with CDT should not be underestimated (risk ratio, 0.73; 95% CI, 0.54 to 0.98; P = 0.04). PTS was defined as Villalta score >4. As such, patients with mild symptoms (itching, mild edema etc.) were as frequent in the CDT group as in the AC group. When assessing an invasive vs. a non-invasive DVT treatment, moderate to severe PTS might have been a more appropriate primary endpoint.

The main advantages of catheter-based interventions are re-establishment of iliofemoral inline flow, faster symptom resolution, valve function preservation and reduction of PTS severity. Interventional success rates are high, with reported 2 and 5-year patency rates between 65-90%.[5, 14,18-22] Stenting of iliac vein narrowing or obstruction noted to be present following thrombolysis seems to be a critically important component of a successful procedure.[5,12] (Figure 1) This is currently recommended by both the American Venous Forum (Grade 1, Level C) and CIRSE (no Grade or level of evidence reported) guidelines.[23,24]

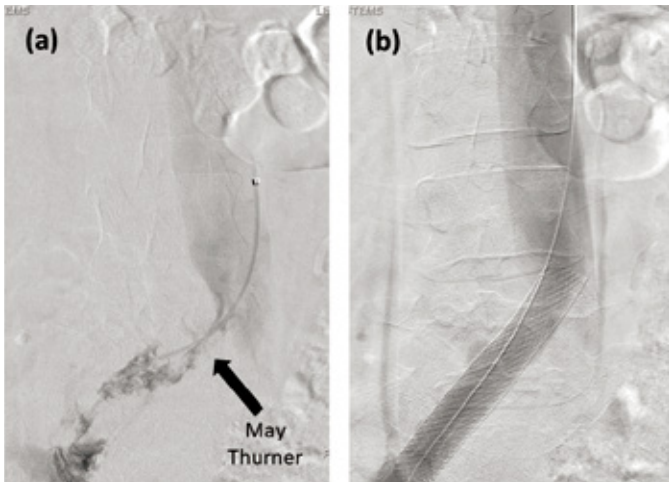


**Figure 1.** 28 year old female with acute left iliofemoral deep vein thrombosis undergoing thrombolysis (patient is in prone position). (a) notice the thrombus and the tight common iliac vein compression/stenosis; (b) final result after completion of thrombolysis and iliac vein stenting with a 16mm Wallstent (Boston Scientific, Nantick, MA) extending into the inferior vena cava.

### *Chronic DVT*

The PTS represents the constellation of symptoms seen with chronic venous disease (CVD) and is regarded as the single most common DVT complication occurring in 20% to 50% of cases.[25]

The diagnosis of PTS is predominantly supported by clinical signs (pain on calf compression, skin edema, induration, pigmentation, erythema, venous ectasia, and ulcers) and clinical symptoms (leg pain, cramps, heaviness, paresthesia, and itching). Initial conservative management of CVD includes lifestyle modifications (moderate physical activity and leg elevation), compression therapy, and pharmacologic therapy. When these fail interventional options may be beneficial.[10,23,24]

Venous reflux but not obstruction, has been the "central theme in CVD" for the last half century. However, the advances in diagnosis and imaging techniques, mainly the intravascular ultrasound scan (IVUS), have allowed us to better understand the obstructive pathophysiology of venous disease. Although the combination of obstruction and deep reflux is present in most CVD, the Raju group demonstrated that resolving the obstructive pathologic condition alone (through stenting) among patients with deep venous system reflux offered complete or partial pain relief (78% at 5 years).[26] The anticipated primary and secondary stent patency at 5 years should be anticipated to exceed 60% and 85%.[2]

As such, stent treatment has been recommended for patients with CEAP (clinical, etiology, anatomic, pathophysiology) IV-VI and occlusive iliac venous disease,[27] yet the guidelines' recommendation is weak.[10,24] Level one evidence will be available once the C-TRACT trial is complete. C-TRACT is an NIH-funded trial: 374 subjects with established PTS will be randomized in a 1:1 ratio to either endovascular therapy (plus optimal compression) or optimal compression only. Subjects are currently enrolling in 20-40 U.S. centers and will be followed for 24 months.

### *Identifying the right patient for venous stenting*

Identifying the right candidate for venous stenting is founded within the basics of an appropriate medical history and physical exam. (Figure 2)

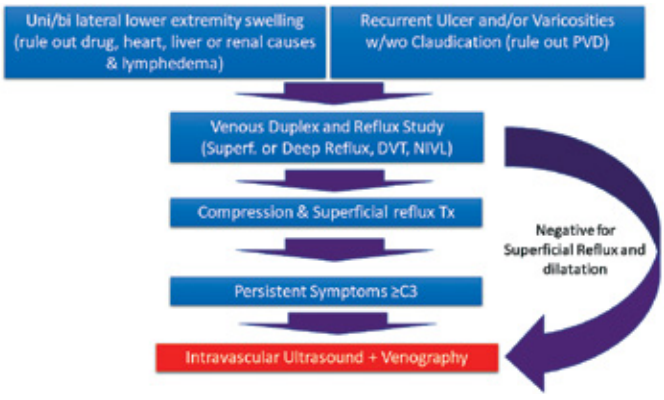


**Figure 2.** Clinical algorithm to identify and patients who might benefit from iliac vein stenting
PVD: Peripheral vascular diseases; DVT: Deep vein thrombosis, NIVL: Non thrombotic iliac vein lesion

The acute DVT patient will typically have more intense recent onset symptomatology while the chronic DVT or NIVL

patients will report long lasting symptoms. The patient whom we should suspect having iliac occlusive disease should be one complaining of leg swelling and/or pain, manifesting early or late signs of chronic venous insufficiency (skin discoloration, varicosities or non-healing ulcers). Symptomatology at the thighs should raise suspicion of iliac venous disease. Physical exam beyond the legs should always include inspection of the pubic area, pelvis and abdomen for enlarged veins that will indicate underlying central venous occlusion. If no prior DVT is clearly known, careful history taking will reveal an old event that might have involved a silent DVT (e.g. major surgery or trauma, temporary swelling or pain, cellulitis etc). Unilateral edema alone should of course include a differential diagnosis of lymphedema and associated pathologies (e.g. abdominal malignancy). Bilateral edema should raise concerns for heart, liver or renal causes and drug induced edema (e.g calcium channel blockers), but IVC occlusion should remain as a possible diagnosis. Presence of an ulcer should also include ruling out peripheral arterial disease. Classification per the CEAP (Clinical presentation, Etiologic factors, Anatomic location, Pathologic process) system and venous clinical severity or Villalta scoring will help in classify chronic venous disease and guide the pretreatment and post-treatment assessments.[28-30]

Venous duplex ultrasound should be the first imaging study; it is easy to obtain, cheap and reliable in the hands of appropriate operators. Venous duplex will offer information on superficial or deep reflux, acute or chronic DVT and on non-thrombotic obstructing iliac vein lesions. The criteria for the diagnosis of iliac vein stenosis or occlusion include: loss of phasicity in the contralateral common femoral vein and/or contralateral asymmetry, mosaic color at the exit of the stenosis, poor flow augmentation, low amplitude signals and peak vein velocity ratio (post/pre stenotic) >2.5.[31]

If superficial reflux with dilatation is identified, its treatment (ablation) should be prioritized as it is much simpler, cheaper, low risk and can be at least partially efficient in symptom resolution and ulcer healing in patients with combined superficial and deep vein reflux.[26, 32-34] Significant leg swelling, pain disproportionate to the superficial reflux, presence of deep reflux only or persistent ulcer despite endovenous ablation are good indicators to pursue intravascular ultrasound and consider iliac vein stenting. At all times, implementation of appropriate compression is of outmost importance.

The decision to proceed to further assessment or interventional management of central vein obstructive lesions, has to be rationalized based on the patient's age and life expectancy, level of activity and degree of disability (physical or emotional) his or her symptoms cause. As a general rule young, active good risk patients will benefit the most from iliac vein stenting (along with thrombolysis for those with acute DVT). Still, older good risk patients with chronic non-healing leg wounds that do not respond to compression will likely benefit by their tremendous improvement in their quality of life. (Figure 3) The rational for iliac vein stenting is not much different from the rational of treating peripheral vascular disease in claudicants: it's about quality of life. Alongside, a failed venous intervention (e.g. stent rethrombosis) will most likely be benign compared to a failed arterial intervention that may lead to critical limb ischemia.

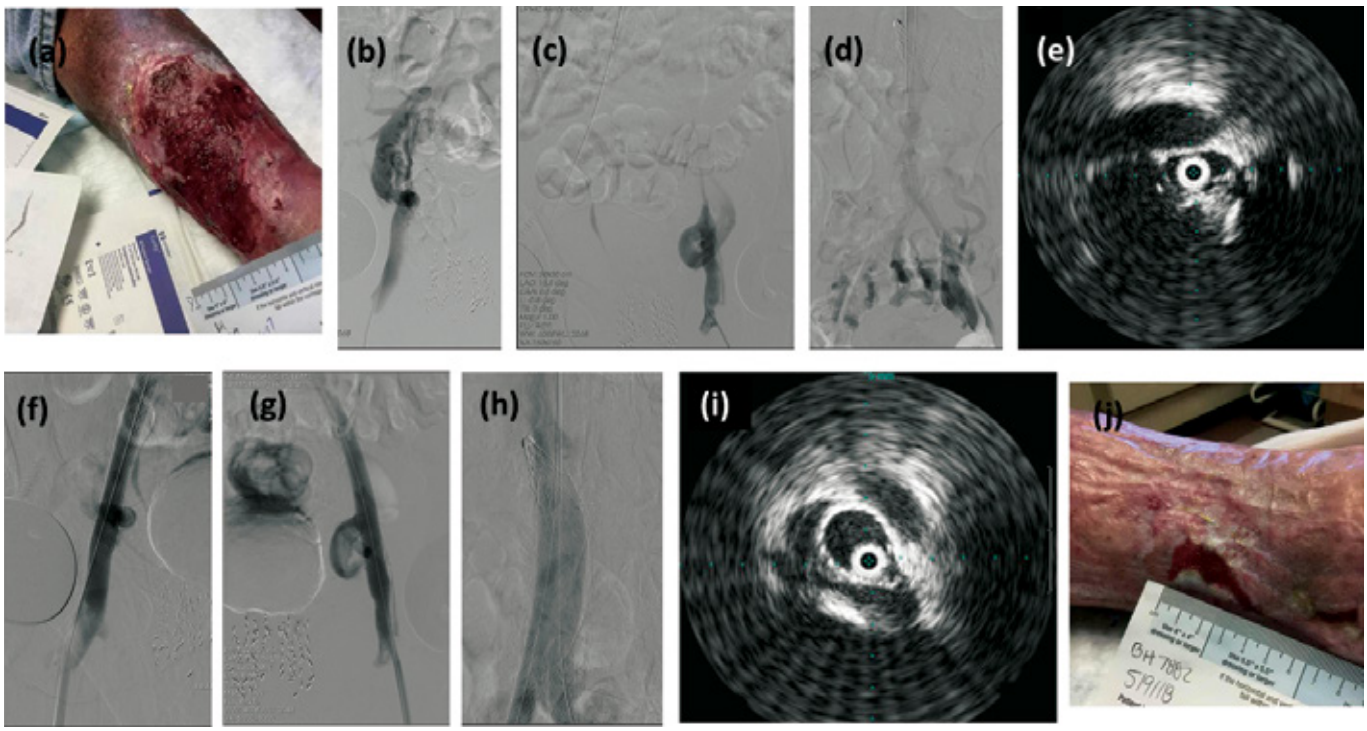


**Figure 3.** 78 year old male with chronic non healing left leg ulcer (a), known history of DVT and filter placement 10 years ago. (b), (c) right and left femoral vein access, multiple collaterals and occluded right and left iliac vein; (d) bilateral iliac vein occlusions have been crossed, notice there is caval disease up to the level of the filter; (e) intravascular ultrasound, right common iliac vein almost completely collapsed around the IVUS catheter; (f) (g) (h) right and left iliac veins stented down to the level of the inguinal ligaments and proximal to the level of the filter; (i) widely patent right common iliac vein stent; (j) ulcer status 6-months after the procedure

For those patients whose symptoms persist despite appropriate compression and/or superficial reflux elimination, and we have decided that they might benefit from iliac stenting, further assessment with venography and intravascular ultrasound is required. Preoperative CT or MR venogram can have a role for patients who are anticipated to have complex lesions for better planning, for patients whom we are unsure if they have any lesion at all (e.g. obese patients, poor ultrasound quality).[35-37] CT and MR venogram can accurately identify external arterial compression and also exclude extravascular disease causing obstruction, such as neoplasms or retroperitoneal fibrosis. Still, there is insufficient scientific evidence to adequately judge the true effectiveness of both techniques for visualization of the venous vasculature. The decision of whether to perform MRV or CTV is mainly dependent on the local expertise. (Figure 4)

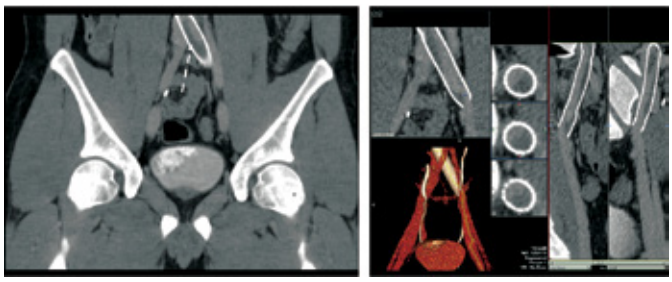

**Figure 4.** CT venography in a patient with recurrent left leg swelling a year after left common iliac vein stenting for May Thurner Syndrome. Notice the subocclusive thrombus within the stent. Venous Duplex was inconclusive.

In our practice, CTV or MRV will only be obtained selectively (uncertainty for the pathology, anticipated complex case), as ascending phlebography can be used both for diagnostic and therapeutic purposes. Intravascular ultrasound is otherwise emerging as the gold standard for the diagnosis of vein stenosis as it was recently shown that it is more sensitive, compared to stand alone venography, in identifying and quantifying iliofemoral vein obstructive lesions.[38]

### *Technical Considerations*

Deep venous procedures that involve iliofemoral stenting can have good outcomes with excellent patency, provided that they are done not only by interventionalists with appropriate expertise, but with appropriate resources too. Since these procedures are mostly done for non-life or limb threatening conditions, optimizing the outcomes is of paramount importance. Procedures can be done under local anesthesia and mild sedation or under general anesthesia. Stenting and ballooning of chronic occlusion may sometimes cause significant pain and discomfort and another important factor that needs to be taken into consideration is the anticipated length of the procedure. Some cases (e.g. chronic iliocaval occlusions) should be anticipated to last more than 2 hours.

Inferior vena cava filters, even when acute DVT is treated, are rarely needed.[39]

### *Access*

Ultrasound-guided access to the deep venous system is commonly performed through the ipsilateral femoral or deep femoral vein in the upper thigh or midthigh. Some interventionalists may choose jugular access, but this will require very long sheaths and catheters and access to the deep femoral or femoral veins may be cumbersome. For acute iliofemoral DVT that commonly extends to the femoropopliteal level, popliteal or tibial access (patient prone) will be required.

### *Crossing the lesion*

Traversing nonobstructive venous lesions is usually straightforward using standard techniques. In the setting of acute DVT, crossing through the thrombus is typically easy. Thrombolysis or suction thrombectomy will be required before evaluating the underlying lesion for stenting. There are various thrombolysis protocols, the detailed description of which goes beyond the scope of this article.[5]

Chronic total occlusions of the iliocaval system will require more advanced skills. Typically, a stiff or floppy hydrophilic guide wire with a straight or angled tip along with a supporting catheter will work through the trabeculations of the chronic thrombus. (Figure 3) The use of crossing sets (e.g TriForce kit (Cook Medical, Bloomington, IN)) and even re-entry devices can be helpful in tight chronic lesions. Not infrequently, 0.035" catheters may be too large to cross tight lesions; 0.018" and even 0.014" systems may be used for crossing and predilating the lesions (4-6 mm balloons) before switching to an 0.035 platform for IVUS and stenting. Whenever perforation is suspected, the wire is withdrawn and re-advanced without the need for aborting the procedure because of the low venous pressures and the perivenous fibrosis.

After crossing the lesion and before initiating balloon venoplasty, IVUS is essential to decide the length of the lesion that will guide the length of the stent(s). If unavailable, venography using anteroposterior, $45^0$ and $60^0$ oblique projections are recommended to better delineate the stenosis.

### *Stenting*

Venous balloon angioplasty alone is a suboptimal intervention, and the lesion almost always recurs.[10,23,24,27] Cephalad landing zones include the IVC up to the level but not including the right atrium. Caudad landing zones include crossing the inguinal ligament down to the common femoral vein without jailing the deep femoral vein. Caval filters that may have been left behind for many years, are stented across to optimize outflow. (Figure 3) Some interventionalists may attempt a challenging retrieval opting to not displace the filter. This may prevent longer term unknown complications but comes at the cost of a much longer and higher risk procedure.

After traversing, predilating and evaluating (with IVUS) the lesion, the entire track is dilated using 14- to 18-mm high pressure balloons depending on the involved vein segment. The common femoral vein can accept up to a 14-mm, the external iliac vein a 16-mm, the common iliac an 18-mm and the IVC an 18- to 24-mm balloon. Subsequent stenting usually corresponds to the size of the balloon. In general, self-expanding stents are used and it is essential to postdilate the stents to allow full expansion. With regard to the extent of stenting, all lesions should be stented without leaving skip areas behind. As previously mentioned it is acceptable to stent below the inguinal ligament into the common femoral vein as stent fracture in the venous system is infrequently encountered. Patency is highly related to an unobstructed inflow to the stent.[5]

The iliocaval junction is another critical and common failure point that needs to be traversed and stented in iliac compression syndrome, otherwise stent compression and restenosis are to be expected; the radial force of the frequently used in U.S. Wallstent (Boston Scientific, Nantick, MA) is high at its main body and lower towards its edges. Extension of the stent into the vena cava to avoid this problem may render subsequent contralateral stenting technically difficult and possibly contribute to partial jailing of contralateral flow. Acute jailing of the contralateral iliac is less of a concern compared with chronic subclinical jailing. Stent extension into the IVC has raised concerns about contralateral limb outflow obstruction in a chronic fashion. The interstices of the venous stent covering the contralateral iliac become lined up with neointima that eventually occlude the outflow. Techniques to circumvent this occurrence have been proposed including using the Gianturco Z stent (Cook Medical, Bloomington, IN) that has wider interstices, or more recently dedicated open cell or oblique stents.[27, 40-41] The double-barrel technique works for bi-iliac stenting and is optimal whenever bilateral or iliocaval disease is present. (Figure 3) Others prefer inverted Y techniques, deploying a single barrel inside the IVC and then extending the iliac stents into this.[1, 27, 42, 43] Re-assessing after stenting with IVUS is also advisable to ensure appropriate expansion and apposition.

### *Anticoagulation and Stent Surveillance*

The relative importance of antiplatelet agents versus anticoagulants has never been evaluated and is largely based on extrapolation from the arterial system and an understanding of the venous system. Without any hard evidence available, a reasonable antithrombotic plan is anticoagulation (DVT protocol using any approved agent) plus aspirin 81-100mg for 3 months and then aspirin (or clopidogrel) only. Chronic anticoagulation (DVT protocol using any approved agent) should be maintained for higher risk patients (e.g. thrombophilia, unporovoked DVT) and complex post-thrombotic iliocaval reconstructions. Venous stent surveillance aims at detecting stent thrombosis or restenosis. Duplex surveillance at 1 month, 3 months and yearly there after is a reasonable surveillance program. If a greater than 50% restenosis is identified balloon venoplasty is recommended to maintain patency regardless of symptoms.[10, 23, 24, 44]

## CONCLUSION

Venous iliofemoral and caval stenting are increasingly used as more evidence accumulates supporting the open vein hypothesis, the safety, efficacy, and durability of these interventions. The indications are still evolving, but there is little doubt that certain patients with iliofemoral venous occlusive disease, acute or chronic, can avoid or abolish pain, swelling and chronic non-healing ulcers to enjoy a better quality of life. Thoughtful patient selection and appropriate team expertise are critical components of a successful outcome.

## REFERENCES


1 Abou Ali AN, Avgerinos ED, Chaer RA. Role of venous stenting for iliofemoral and vena cava venous obstruction. Clin North Amer 2018;98:361-71

2 Razavi M, Jaff M, Miller LE. Effectiveness of stent placement for iliofemoral venous outflow obstruction. Circ Cardiovasc Interv 2015;8:e002772

3 Seager MJ, Busuttil A, Dharmarajah B, Davies AH. A systematic review of endovenous stenting for venous disease secondary to iliac vein obstruction. Eur J Vasc Endovasc Surg 2016;51:100-120

4 Hager ES, Yuo T, Tahara R, Dillavou E, Al-Khoury G, Marone L, et al. Outcomes of endovascular intervention for May-Thurner syndrome. J Vasc Surg 2013;1:270-275

5 Avgerinos ED, Saadeddin Z, Abou Ali AN, Pandya Y, Hager E, Singh M, et al. Outcomes and predictors of failure of iliac vein stenting following catheter directed thrombolysis for acute iliofemoral thrombosis. J Vasc Surg Vein Lymph 2019 in press

6 Raju S, Neglen P. High prevalence of nonthrombotic iliac vein lesions in chronic venous disease: a permissive role in pathogenicity. J Vasc Surg 2006;44:136-43

7 May R, Thurner J. The cause of the predominantly sinistral occurrence of thrombosis of the pelvic veins. Angiology 1957;8:419-427

8 Kibbe MR, Ujiki M, Goodwin AL, Eskandari M, Yao J, Matsumura J. Iliac vein compression in an asymptomatic patient population. J Vasc Surg 2004; 39:937-943.

9 Neglen P, Thrasher TL, Raju S. Venous outflow obstruction: an underestimated contributor to chronic venous disease. J Vasc Surg 2003;38:879-85.

10 Wittens C, Davies AH, Baekgaard N, et al. Management of chronic venous disease: clinical practice guidelines of the European Society for Vascular Surgery. Eur J Vasc Endovasc Surg 2015;49:678-737

11 Bashir R, Zack C, Zhao H, Comerota A, Bove A. Comparative Outcomes of Catheter-Directed Thrombolysis Plus Anticoagulation vs Anticoagulation Alone to Treat Lower-Extremity Proximal Deep Vein Thrombosis. JAMA Intern Med. 2014;174:1494.

12 Mewissen MW, Seabrook GR, Meissner MH, Cynamon J, Labropoulos N, Haughton SH. Catheter-directed thrombolysis for lower extremity deep venous thrombosis: report of a national multicenter registry. Radiology 1999;211:39-49.

13 Enden T, Haig Y, Klow NE, Slagsvold CE, Sandvik L, Ghanima W, et al. Long-term outcome after additional catheter-directed thrombolysis versus standard treatment for acute iliofemoral deep vein thrombosis (the CaVenT study): a randomised controlled trial. Lancet 2012;379:31-8.

14 Haig Y, Enden T, Grøtta O, Kløw N, Slagsvold C, Ghanima W, et al. Post-thrombotic syndrome after catheter-directed thrombolysis for deep vein thrombosis (CaVenT): 5-year follow-up results of an open-label, randomised controlled trial. The Lancet Haematology. 2016;3:e64-e71

15 Vedantham S. Catheter-directed thrombolysis to avoid late consequences of acute deep vein thrombosis. Thromb Res. 2018;164:125-128

16 Vedanham S, Goldhaber SZ, Julian JA, Kahn SR, Jaff MR, Cohen DJ et al. Pharmacomechanical catheter directed thrombolysis for deep-vein thrombosis. N Engl J Med 2017;377:2240-2252

17 Avgerinos ED, Chaer RA. The ATTRACTiveness of catheter directed thrombolysis. J Vasc Surg Venous Lymphat Dis-

ord 2018;6:303

18 Aziz F, Comerota AJ. Quantity of residual thrombus after successful catheter-directed thrombolysis for iliofemoral deep venous thrombosis correlates with recurrence. Eur J Vasc Endovasc Surg 2012;44:210-3.

19 Baekgaard N, Broholm R, Just S, Jorgensen M, Jensen LP. Long-term results using catheter-directed thrombolysis in 103 lower limbs with acute iliofemoral venous thrombosis. Eur J Vasc Endovasc Surg 2010;39:112-7.

20 Protack CD, Bakken AM, Patel N, Saad WE, Waldman DL, Davies MG. Long-term outcomes of catheter directed thrombolysis for lower extremity deep venous thrombosis without prophylactic inferior vena cava filter placement. J Vasc Surg 2007;45:992-7; discussion 7.

21 Lin PH, Zhou W, Dardik A, Mussa F, Kougias P, Hedayati N, et al. Catheter-direct thrombolysis versus pharmacomechanical thrombectomy for treatment of symptomatic lower extremity deep venous thrombosis. Am J Surg 2006;192:782-8.

22 Xue G, Huang X, Ye M, Liang W, Zhang H, Zhang J, et al. Catheter-directed Thrombolysis and Stenting in the Treatment of Iliac Vein Compression Syndrome with Acute Iliofemoral Deep Vein Thrombosis: Outcome and Follow-up. Ann Vasc Surg 2014;28:957-963.

23 Meissner MH, Gloviczki P, Comerota AJ, Dalsing MC, Eklof BG, Gillespie D L, et al. Early thrombus removal strategies for acute deep venous thrombosis: clinical practice guidelines of the Society for Vascular Surgery and the American Venous Forum. J Vasc Surg 2012;55:1449-62.

24 Mahnken A, Thomson K, de Haan M, O'Sullivan G. CIRSE Standards of Practice Guidelines on Iliocaval Stenting. Cardiovasc Intervent Radiol. 2014;37(4):889-97

25 Kahn SR. The post-thrombotic syndrome: the forgotten morbidity of deep venous thrombosis. J Thromb Thrombolysis 2006;21:41-8

26 Raju S, Darcey R, Neglén P, Flowood J. Unexpected major role for venous stenting in deep reflux disease. J Vasc Surg 2010;51:401-8; discussion: 408.

27 Raju S. Treatment of iliac-caval outflow obstruction. Semin Vasc Surg 2015;28:47-53.

28 Eklof B, Rutherford RB, Bergan JJ, Carpentier PH, Gloviczki P, Kistner RL, et al. Revision of the CEAP classification for chronic venous disorders: Consensus statement. Journal of Vascular Surgery 2004;40:1248-1252.

29 Vasquez MA, Rabe E, McLafferty RB, Shortell CK, Marston WA, Gillespie D, et al., American Venous Forum Ad Hoc Outcomes Working Group. Revision of the venous clinical severity score: Venous outcomes consensus statement: Special communication of the American Venous Forum Ad Hoc Outcomes Working Group. Journal of Vascular Surgery, 2010;52:1387-1396.

30 Kahn SR. Measurement properties of the Villalta scale to define and classify the severity of the post-thrombotic syndrome. J Thromb Haemost 2009;7:884-888

31 Labropoulos N, Borge M, Pierce K, Pappas PJ. Criteria for defining significant central vein stenosis with duplex ultrasound. J Vasc Surg 2007;46(1):101-7

32 Gohel MS, Barwell JR, Taylor M, Chant T, Foy C, Earnshaw JJ, et al. Long term results of compression therapy alone versus compression plus surgery in chronic venous ulceration (ESCHAR): randomised controlled trial. BMJ 2007;335:83.

33 Montminy ML, Jayaraj A, Raju S. A systematic review of the efficacy and limitations of venous intervention in stasis ulceration. J Vasc Surg Venous Lymphat Disoed 2018:6:376-98

34 Gohel MS, Heatley F, Liu X, et al. A randomized trial of early endovenous ablation in venous ulceration. N Engl J Med 2018;378(22):2105-2114

35 Choi JW, Jae HJ, Kim HC, Min SI, Min SKm Lee W, Chung JW. CT venography for deep venous thrombosis: can it predict catheter-directed thrombolysis prognosis in patients with iliac vein compression syndrome? Int J Cardiovasc Imaging 2015;31(2):417-26

36 Fraser DG, Moody AR, Martel A, Morgan PS. Re-evaluation of iliac compression syndrome using magnetic resonance imaging in patients with acute deep venous thromboses. J Vasc Surg 2004;40:604-611

37 McDermott S, Oliveira G, Ergu¨l E, Brazeau N, Wicky S, Oklu R. May-Thurner syndrome: can it be diagnosed by a single MR venography study? Diagn Interv Radiol 2013;19:44-48

38 Gagne PJ, Tahara R, Fastabend CP, et al. Venography versus intravascular ultrasound for diagnosing and treating iliofemoral vein obstruction. J Vasc Surg Vein Lymph 2017;5(5):678-687

39 Avgerinos ED, Hager ES, Jeyabalan G Marone L, et al. Inferior vena cava filter placement during thrombolysis for acute iliofemoral deep venous thrombosis. J Vasc Surg Venous Lymphat Disord 2014;2: 274-81

40 Murphy EH, Johns B, Buck W, et al. Deep venous thrombosis associated with caval extension of iliac stents. J Vasc Surg Venous Lymphat Disord 2017;5(1):8-2017

41 Stuck AK, Kunz S, Baumgardner I, et al. Patency and clinical outcomes of a dedicated self-expanding, hybrid oblique stent used in the treatment of common iliac vein compression. J Endovasc Therapy 2017;24:159-166

42 Erben Y, Bjarnason H, Oladottir GL, et al. Endovascular recanalization for nonmalignant obstruction of the inferior vena cava. J Vasc Surg Venous Lymphat 2018;6:173-82

43 Chick JFB, Srinivasa RN, Cooper KJ. Endovascular iliocaval reconstruction for chronic iliocaval thrombosis: the data, where we are, and how it is done. Tech Vasc Interv Radiol 2018;21:92-104

44 Raju S, Tackett PJ, Neglen P. Reinterventions for nonocclusive iliofemoral venous stent malfunctions. J Vasc Surg 2009;49:511-8.

# CONTINUUM OF CARE

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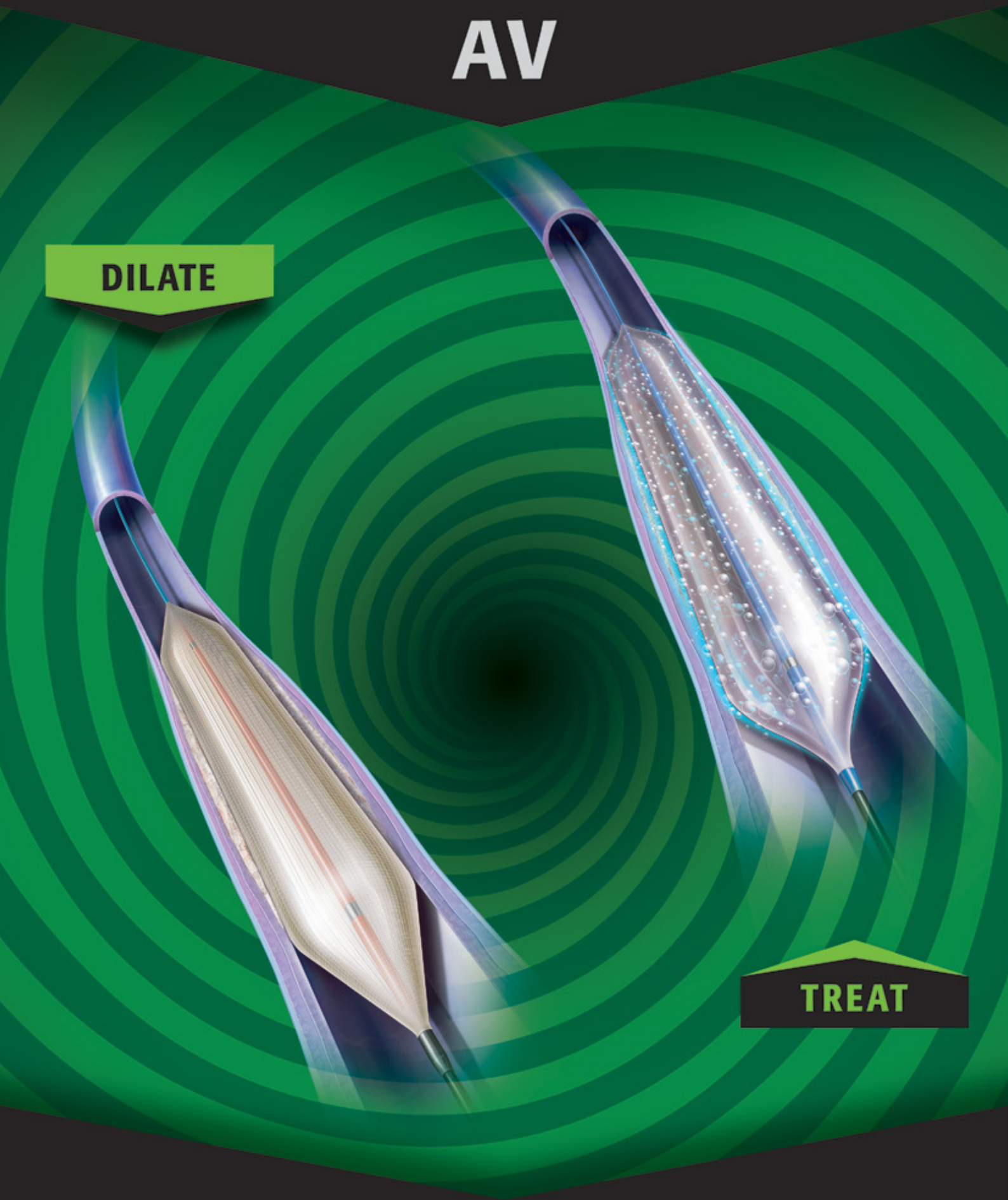


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EDUCATION

# Applied statistics in vascular surgery Part 1: Choosing between parametric and non-parametric tests

**Constantine N. Antonopoulos, John D. Kakisis**

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**Abstract:**

The interest for studying and performing surgical research has grown during the last decades. Among its fundamental principles is the understanding of statistical tools that will allow an appropriate analysis and interpretation of the data. The aim of our study is to present the basic concepts of parametric and non-parametric statistical tests for assessing differences when comparing two or more groups. A basic understanding of normal vs non-normal distribution is presented, along with definitions of the most appropriate statistical test to be used based on the type of the variables, the data distribution, the number of groups and the independence between groups.

## INTRODUCTION

The interest in surgical research has vastly increased over the last 30 years, accounting for an increasing number in published articles, conference presentations and citations counts in peer reviewed journals [1]. Among the integral parts of surgical research is the appropriate statistical analysis. As a result, it is of utmost importance, especially for young surgeons to properly work on statistics when performing their research or studying the work of other colleagues. However, a surgeon may often feel overwhelmed when trying to decide which statistical method to use when conducting a research. Currently, there are statistical teams that work on medical data, however it is recommended that surgeons may also have to acquire some level of statistical understanding. Determining what type of data to collect and what hypothesis test to formulate is among the fundamental principles of surgical research. The aim of this article is to present a general understanding of the basic statistical concepts when facing the dilemma of which statistical test to use.

### *Data distribution and samples' independence*

Collecting data for all patients who ever had a vascular operation is time consuming and usually not feasible. For that reason, we often pick up a representative study sample and formulate a hypothesis. The *a priori* hypothesis is the null hypothesis ($H_0$), which assumes that no significant difference is expected between specified populations. For example, when comparing the age of patients treated with endovascular and open repair of abdominal aneurysms, the null hypothesis assumes that there is no statistically significant difference. If the null hypothesis is rejected, then the alternative hypothesis ($H_1$) is true and thus, there is difference in the age of patients treated with the two techniques. The first step when analysing data is to decide whether it is continuous or categorical. In our case, age of study participants can take all values within a measurement scale and thus it can be considered as a continuous variable. On the contrary, categorical variables contain a finite number of categories or distinct groups (e.g. gender). When dealing with variables, in general, the researcher should firstly apply descriptive techniques, namely frequency distributions and graphical displays (Figure 1) in order to get acquainted with the data.

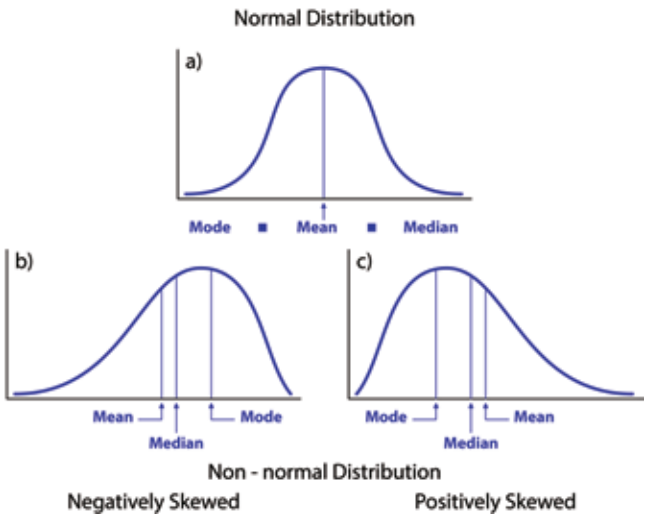


**Figure 1.** Examples of normal and non-normal distributions: a) the upper curve represents a symmetrical, bell shaped (normal) distribution, in which mean = median = mode, b) the left curve represents a negatively skewed distribution with mean ≤ median ≤ mode and shows an elongated tail at its left, in which more observations are present compared to normal distribution curve, c) the right curve represent a positively skewed distribution with mean ≥ median ≥ mode and shows an elongated tail at its right, in which more observations are present compared to normal distribution curve.

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In case of a continuous variable, the next step is to decide about the distribution of the data. When data follow a symmetric and bell-shaped curve around the mean value then a parametric test can be used. Parametric are methods that use distributional assumptions, they assume that the data follow a normal distribution and also that the spread of the data (variance) is uniform either between groups or across the range being studied [2]. On the contrary, the non-parametric tests do not require the data to follow a particular distribution and they apply by using the rank order of observations rather than the measurements themselves [2,3]. As it is important to clearly assess whether data come from a normal distribution or not, the researcher can apply a more mathematical way, which is the "*Kolmogorov-Smirnov goodness-of-fit test*". After assessing the normality of study variables, the researcher should assess samples' independence. Two or more samples/groups are independent if the values of one sample/group do not depend on the values of the other sample/group. In our case patients who were treated with endovascular repair are different from those who were treated with open repair and as a result samples are independent.

### *Choosing the appropriate statistical test*

Appropriateness of a statistical test when examining for difference of a continuous variable (i.e. age of participants) among different groups (i.e. endovascular and open repair) depends on the variables' distribution (normal vs. non-normal) and the independence of groups. In case of normal distribution, mean and standard deviation (SD) should be reported, while in case of skewed distribution, median with inter-quartile range is appropriate for reporting the average of the continuous variable. A statistical algorithm depicting which statistical test to use when dealing with data based on the type of the variable, the distribution, the number of groups and the independence between groups is shown in Table 1. It should be highlighted that using a parametric test when the data deviate strongly from normal distribution, could lead to incorrect conclusions. Furthermore, when analyzing small study samples (n<30 patients), the parametric assumption of normality is particularly worrisome and non-parametric tests should be used instead. On the contrary, if data are not skewed, use of non-parametric procedures will have generally less power to detect statistically significant difference for the same samples[4].

When dealing with categorical data (e.g. gender) *chi-square test* is used if the sample size contains more than 20 observations in total and more than five observations in each group. In case of small study sample, *Fisher's exact test* is used instead, while *McNemar's test* can be used for paired categorical data [5]. Dealing with the statistical tests can be performed by using many different commercially available statistical packages with various specifications and costs, such as SPSS (IBM), STATA (StataCorp), SAS (SAS Institute), R (R Core Team), Minitab (Minitab Inc.) and others.

In conclusion, research in vascular surgery has expanded together with rapid advances in endovascular technology and increasing complexity of patient's care. To support this demand, the vascular researcher should make proper use of statistical techniques to analyze primary data in order to correctly drive decision-making.

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## REFERENCES

1 Pallot JM, Choonara H, Gerrard E, Gnanalingham KK, Davies BM. Trends in the quality of work presented at the society of british neurological surgeons meetings: 1975 to 2010. Br J Neurosurg. 2018;32(3):231-6.

2 Altman DG, Bland JM. Parametric v non-parametric methods for data analysis. BMJ. 2009;338:a3167.

3 Cassidy LD. Basic concepts of statistical analysis for surgical research. J Surg Res. 2005;128(2):199-206.

4 Rosner B. Fundamentals of Biostatistics. California: Duxbury Press; 2000.

5 Flikkema RM, Toledo AH, Anaya-Prado R, Toledo-Pereyra LH. Principles of statistics in surgery. J Invest Surg. 2011;24(6):237-42.

| TYPE OF VARIABLE | Continuous | | | | | | | | | | | Categorical |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DISTRIBUTION | Normal distribution | | | | | Skewed distribution | | | | | | |
| No of GROUPS | 1 group | 2 groups | | >2 groups | | 1 group | 2 groups | | >2 groups | | | |
| Independence between GROUPS | | Independent | Dependent | Independent | Dependent | | Independent | Dependent | Independent | Dependent | Independent | Dependent |
| STATISTICAL TEST | 1-sample t-test | Independent sample t-test | Paired sample t-test | ANOVA | Repeated-measures ANOVA | Sign test, Wilcoxon signed ranks test | Mann-Whitney U test | Sign test, Wilcoxon signed ranks test | Kruskal-Wallis H test | Friedman test | Chi-square test, Fischer exact test | McNemar's test |
| EXAMPLE | Mean age of all patients with AAA | Mean age of AAA patients treated with OSR vs. EVAR | Difference in aortic diameter in patients before vs. after EVAR | Mean age of AAA patients treated with OSR vs. EVAR vs. conservative treatment | Difference in aortic diameter in patients before vs. after 6 months vs. after 1 year of EVAR | Mean age of all patients with AAA | Mean age of AAA patients treated with OSR vs. EVAR | Difference in aortic diameter in patients before vs. after EVAR | Mean age of AAA patients treated with OSR vs. EVAR vs. conservative treatment | Difference in aortic diameter in patients before vs. after 6 months vs. after 1 year of EVAR | Difference in males/females among patients treated with OSR vs. EVAR | Difference in number of patients with excluded/non-excluded aneurysmal sac after 6 months vs. after 1 year of EVAR |

**Table 1**. A statistical algorithm depicting which test to use, based on the type of variable, data distribution, number of groups and independence between groups

**Abbreviations:** AAA: Abdominal Aortic Aneurysm, ANOVA: Analysis of Variance, EVAR: Endovascular Aortic Repair, OSR: Open Surgical Repair

# Popliteal artery cystic adventitial disease: A case report and a review of the current literature

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**Abstract:**

Cystic adventitial disease is a rare condition affecting mostly the popliteal artery, associated to non-atherosclerotic intermittent claudication. We report a case of a 59-year-old male patient, with mild atherosclerotic risk factors, complaining of intermittent claudication in his left calf. Duplex ultrasonography and computed tomography angiography revealed a cystic lesion highly adhered to the popliteal artery, causing a critical stenosis. The patient treated with an excision of the P1 segment of the diseased artery and a venous by-pass grafting. Nowadays, less than 250 cases of popliteal artery cystic adventitial disease are recorded in the literature. Surgical treatment with excision of the cyst and by-pass grafting with autologous vein graft is the treatment of choice.

## INTRODUCTION

Cystic adventitial disease (CAD) is a rare condition associated to non-atherosclerotic intermittent claudication in young patients. A cystic lesion could be found in any vessel with a higher predominance at the popliteal artery (PACAD). It concerns a unilocular or multilocular mucin-filled cyst in the vessel's adventitia which may result in arterial stenosis or thrombosis.[1] In the literature, almost 250 cases of cystic adventitial disease of the popliteal artery have been recorded, mostly in case reports and small series.[2] Most of the patients underwent a surgical excision of the cyst, accomplished with an artery reconstruction, with a low recurrence rate.[3] We report a case of a 59-year-old male patient treated in our department for a PACAD and we present a review of the current literature. This case presentation was approved by the Ethical committee of our Hospital..

## CASE PRESENTATION

The patient presented to the Vascular Outpatient Service complaining of intermittent claudication in his left calf at 300 meters, during the past 6 months. He was an ex-smoker (tobacco cessation 5 years ago) and hypertensive under treatment. No trauma or other atherosclerotic risk factors were recorded in his medical history. Clinical examination revealed an absent dorsalis pedis and posterior tibial pulse at his left limb. Resting ankle brachial index (ABI) was 1.1 on the right and 0.7 on the left limb. The patient underwent a duplex ultrasonography (DUS) with extremity in complete extension and during knee flexion initially, and subsequently a computed tomography angiography (CTA) of lower limbs which revealed a cyst of 3cm diameter, highly adhered to the popliteal artery, causing a stenosis >90% (Figure 1).

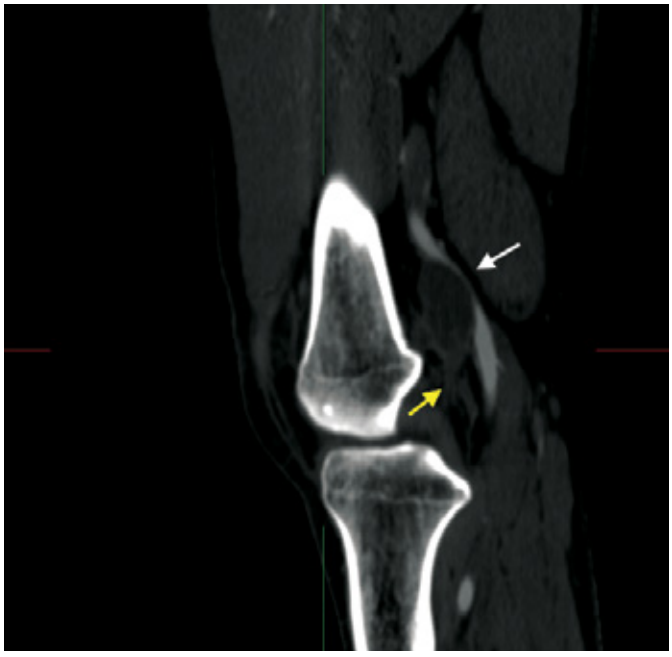

**Figure 1.** Preoperative CTA image with scimitar sign, the cystic lesion of the popliteal artery (white arrow) and the ligament connecting it to the knee joint (yellow arrow)

Peripheral arteries were all patent with no atheromatosis. The patient was scheduled for surgical treatment. Through a medial approach, the above the knee popliteal artery was dissected, and a cystic formation was revealed at the P1 segment of the popliteal artery. A ligamentous band between the cystic part of the artery and the knee joint was found, ligated and cut (Figure 2).

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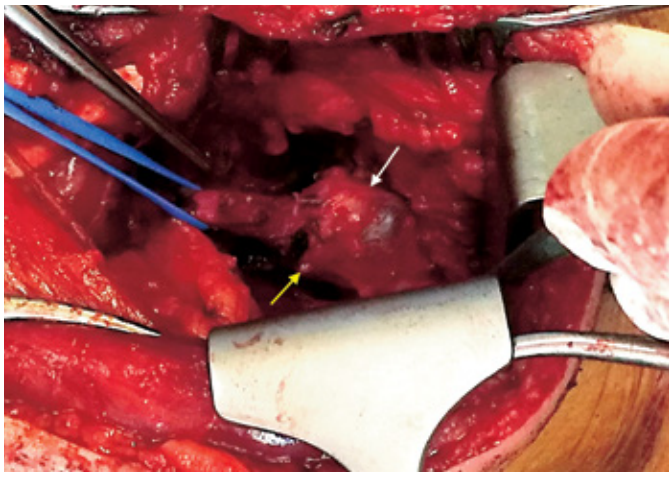

**Figure 2.** Anatomical exposure, the cystic lesion of the popliteal artery (yellow arrow) and the ligament connecting it to the knee joint (white arrow)

A complete excision of the diseased part of the artery was performed (Figure 3).

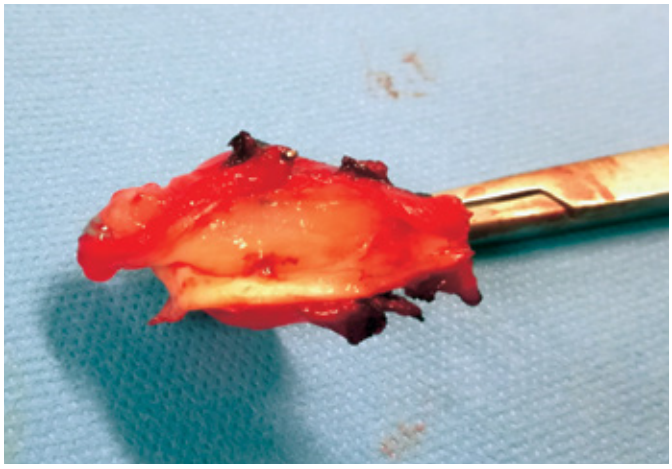

**Figure 3.** The diseased artery with the cyst after the excision

Subsequently, a short interposition venous bypass graft was used to restore the vessel continuity, using a reversed segment of the adjacent great saphenous vein (Figure 4).

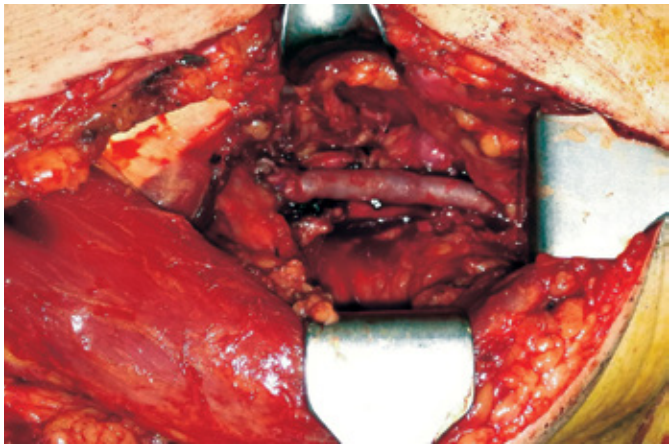

**Figure 4.** The short femoropopliteal bypass with a reversed vein graft (ipsilateral great saphenous vein)

Post-operatively, the pulses on the left dorsalis pedis and posterior tibial arteries were restored, and ABI was measured at 1.1. The patient was discharged on the 4th post-operative day under a lifelong treatment of aspirin 100mg once daily. The histological report confirmed a cystic lesion firmly attached to the popliteal adventitia. At the 6th month follow-up, the patient was asymptomatic, with complete recovery of his daily routine activities, and the graft was patent on the DUS.

## DISCUSSION

PACAD is an uncommon nonatherosclerotic cause of intermittent claudication, with an incidence of 1 in 1200 cases of claudication.[1] It is characterized by unilocular or multilocular myxomatous cysts, situated in the adventia. The majority of CAD occurs in males (ratio 4:1), during the 4th and 5th decade of life, with no or minor atherosclerotic risk factors, as in this case. Almost all patients suffer from intermittent claudication of the calf, with a period of symptoms' recovery longer than in typical atherosclerotic claudication. Nowadays, less than 250 cases of PACAD are recorded in the literature.[2]

CAD pathogenesis has not been clearly defined. Various theories have been suggested.[3] According to the trauma theory, repetitive microtraumatic mechanisms of the nearby joints may provoke the destruction and cystic degeneration of the adventitia. In the developmental theory, stem cells from joints migrate into the adventitia during embryonic development. The systemic disorder theory, which is the most popular, incriminates a systemic connective tissue disease. According to the gaglion theory, adjacent synovial cells of the nearby joints migrate through a low-pressure pathway and form cysts. In many cases, as in this case, a "ligament" between the cyst and the joint is revealed. According to the ligament theory, there is a consistent fluid communication between the knee joint and the cyst.[4]

The typical profile of PACAD is that of a middle-aged male patient with no severe comorbidities or atherosclerotic risk factors who presents with a new onset intermittent calf claudication. Initially, the symptoms could be sudden or insidious. Intermittent claudication tends to wax and wane as the cyst may resolve spontaneously.[4] In the literature, spontaneous resolve of the symptomatology has been associated with spontaneous rupture of the cyst.[5] Peripheral limb pulses are generally palpable in rest but diminished after exercise. Disappearance of the foot pulses during knee flexion could be seen in PACAD, a phenomenon described as the Ishikawa's sign. This sign facilitates the differential diagnosis between popliteal cystic adventia disease and the popliteal entrapment syndrome, where foot pulses disappear in ankle plantar flexion. ABI measurement is not pathognomonic for the disease.[6]

DUS is a useful, non-invasive diagnostic media for PACAD.[7] When performed by an experienced radiologist, it is usually the first imaging test that reveals the cystic nature of the lesion and the pre-occlusion stenosis. The hypoechoic characteristics of the cyst facilitates its differential diagnosis over a popliteal aneurysm. An echogenic thin line separating the vessel lumen and the cyst can be imaged. On color DUS, a scimitar sign could be seen at the narrowed lumen, producing high velocity. Intravascular ultrasound, computed tomography (CT) and magnetic resonance imaging have also been advocated in the diagnosis of CAD.[7,8] In angiography, an eccentric narrow-

ing of the lumen (scimitar sign), hourglass narrowing of the lumen, or complete occlusion with a lack of post-stenotic dilatation may be detected. However, the differential diagnosis between the PACAD and atherosclerotic stenosis occasionally remains quite difficult.[8]

Surgical treatment with bypass grafting, using an autologous vein graft (great or small saphenous vein), after the cyst excision constitutes the intervention of choice in most of symptomatic patients.[2,3,9] Otherwise, cyst evacuation followed by a patch angioplasty can also be performed. Simple resection of the cyst, and CT-guided or ultrasound-guided percutaneous aspiration have also been described and used in monocular cysts without cyst-artery adhesion. Aspiration of the cyst could be inefficient in multilocular cyst disease and in high viscosity cyst content. Simple cyst excision and ligation of the cyst-joint connections has been proposed in cases where the intima preservation was possible.[6] Complete excision of the diseased popliteal artery has shown a low recurrence rate (0-10%) compared to the partial cyst excision with remaining lesions (10-34% recurrence rate).[9] Endovascular techniques have no clear place in the treatment of PACAD, because of the compressional nature of the disease. Even if they are described in the literature, they are associated with a high rate of recurrence and a possibility of arterial thrombosis. Conservative treatment is proposed only for asymptomatic patients.[10]

## CONCLUSION

PACAD is an uncommon non-atherosclerotic vascular disease associated with intermittent claudication. A high clinical suspicion and an appropriate imaging investigation are very important to set diagnosis. Excision of the cyst and bypass grafting with autologous vein graft is, generally, the preferred treatment, with a low incidence of recurrence.

*Acknowledgements: None*

*No conflict of interest.*

## REFERENCES

1 Hennessy MM, McGreal G, O'Brien GC. Two Cases Of Popliteal Cystic Adventitial Disease Treated with Excision And Primary Bypass Graft: A Review Of The Literature. Vascular and Endovascular Surgery. 2017, 51(7): 480-484

2 Baxter AR1, Garg K, Lamparello PJ, Mussa FF, Cayne NS, Berland T. Cystic adventitial disease of the popliteal artery: is there a consensus in management? Vascular. 2011, 19 (3): 163-166

3 Motaganahalli RL, Smeds MR, Harlander-Locke MP, Lawrence PF, Fujimura N, DeMartino RR, et al.. Vascular Low-Frequency Disease Consortium, A multi-institutional experience in adventitial cystic disease. J Vasc Surg. 2017;65:157-61

4 Cassar K, Engeset J, Cystic Adventitial Disease: A Trap for the Unwary. Eur J Vasc Endovasc Surg, 2005, 29: 93-96

5 Lossef SV, Rajan S, Calcagno D, Jelinger E, Patt R, Barth KH. Spontaneous rupture of an adventitial cyst of the popliteal artery: confirmation with MR imaging. Journal of Vascular and Interventional Radiology 1992, 3(1):95-97

6 Li S, King BN, Velasco N, Kumar Y, Gupta N. Cystic adventitial disease-case series and review of literature. Annals of Translational Medicine. 2017, Vol. 5 (16): 327

7 Koppensteiner R., Katzenchlager R., Ehringer H., Cystic adventitial disease of the popliteal artery demonstrated by intravascular ultrasound imaging, Abstract. 17th World Congress of the International Union of Angiology, 1995; 14

8 Zhang H, Zhang Y, Wang Q, Zhao WG, Wang JJ, Cystic adventitial disease of the popliteal artery: report of two cases, Surg Today ,2014, Vol. 44: 1760-1763

9 Miyake K, Sawamura N, Ikegaya Y Isogai N, Kawachi J, Shimoyama R, et al. Adventitial cystic disease of the popliteal artery treated by bypass graft utilizing the short saphenous vein: A case report. Int J Surg Case Rep. 2017, 38: 154-157

10 Takizawa K, Osawa H, Kojima A, Abraham SJK, Hosaka S. Cystic Adventitial Disease of Popliteal Artery with Venous Aneurysm of Popliteal Vein: Two-Year Follow-Up after Surgery. Case Rep Vasc Med. 2017: 4873474

# Traumatic superficial temporal artery pseudoaneurysm in a patient under DOAC: a case report

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**Abstract:**

Pseudoaneurysm of the superficial temporal artery (STA) is an uncommon vascular complication, usually, with a traumatic or iatrogenic etiology and a delayed appearance. Diagnostic imaging with duplex ultrasound, computed tomography or magnetic resonance angiography is useful to confirm the diagnosis. Surgical excision is the treatment of choice, especially in patients under anticoagulant treatment. In this case, a direct oral anticoagulant (DOAC) factor may have a role in the expansion of the pseudoaneurysm. An 88-year-old male patient, under long-term anticoagulant therapy with rivaroxaban, developed a STA false aneurysm after a minor head blunt trauma, which was treated successfully by surgical excision.

## INTRODUCTION

Pseudoaneurysm of the superficial temporal artery (STA) is an uncommon vascular complication, following blunt head trauma or face and head procedures (iatrogenic). It is estimated that 400 cases of pseudoaneurysms have been reported, comprising 1% of all traumatic aneurysms.[1] True temporal artery aneurysms are even rarer and usually have an atherosclerotic or congenital etiology.[1] Herein we report a case of an 88-year-old male under long-term anticoagulant therapy with rivaroxaban suffering from a traumatic pseudoaneurysm of the superficial temporal artery. This report has been approved by the Ethics Committee of the Hospital.

## CASE REPORT

An 88-year old male patient with a history of atrial fibrillation under treatment with Rivaroxaban (15mg per day) presented to the outpatient department because of a frontal painless mass. He referred a minor blunt head trauma due to a fall 3 months ago. The mass started to develop 3 weeks after the fall and continued to expand thereafter. No other regional or neurological symptoms were reported. Clinical examination revealed a pulsatile, non-tender, subcutaneous, mobile mass measuring approximately 3 cm in diameter, located to the left frontal-temporal region. A color duplex ultrasound confirmed the diagnosis of a pseudoaneurysm of the frontal branch of the left superficial temporal artery. A surgical treatment was decided. Anticoagulant treatment with Rivaroxaban was interrupted 48 hours before surgery. An excision and ligation of the branches took place under local anesthesia. The patient was discharged the same day and restarted his oral anticoagulant therapy the first postoperative day. Histopathological examination was conclusive of a pseudoaneurysm. At 6-month follow up the patient was well having a normal life.

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## DISCUSSION

Superficial temporal artery is the terminal branch of the external carotid artery, responsible for the vascularization of the temporal scalp. It is situated between the temporal fascia and the temporal muscle. The aneurysms of the temporal artery are rare and usually concern its superficial branch. Most of the aneurysms (95%) are pseudoaneurysms caused by blunt head trauma during sports activity in young patients or falls in elder patients.[2] Iatrogenic injury during neurosurgical procedures has also been described.[3]

Most aneurysms are clinically revealed a few days to months after trauma. Diagnosis could be made only on history and physical examination. As in this patient, typical history involves a minor head blunt trauma, followed by the delayed appearance of a mass. A compressible, tender or pulsatile mass located to the frontal scalp is apparent. A bruit or thrill may be detected. Neurological symptoms are uncommon and may include headache, dizziness, ear discomfort, or facial droop due to cranial nerve VII compression.[1] The differential diagnosis includes cyst, lipoma, abscess, simple hematoma, arteriovenous fistula, tumor and aneurysms of the middle meningeal artery with bone erosion.[4] Temporal artery pseudoaneurysms are under risk for a spontaneous or traumatic rupture.[5]

Diagnostic imaging is useful to confirm the diagnosis and differentiate it from other pathologies. In our case, color duplex ultrasound was used. Other reports describe computed tomography angiography to confirm diagnosis. Duplex ultrasound is the imaging modality of choice since it can provide detailed information about the vascular anatomy, without the need for any radiation exposure.[6] Usually, a normal waveform is

presented in the artery. "Ying-yang" sign and "swirling pattern" waveform can be detected during DUS and help in differential diagnosis from other pathologies as arteriovenous fistula.[7] CT or magnetic resonance (MR) angiography could be needed in cases where a concomitant intracranial pathology is suspected.[7]

Conservative treatment of these pseudoaneurysms has not been proposed, as there is always the risk of rupture. Surgical excision is the treatment of choice with a low rate of post-operative complications.[8] Continuous pressure over small aneurysms, percutaneous ultrasound-guided injection of thrombin and micro-coil embolization are alternative treatment methods, especially when the aneurysm is located at the proximal superficial temporal artery. Allergic reactions due to thrombin, recanalization and distal ischemia are common complications of those. Follow-up with duplex ultrasound is mandatory in these cases.[9]

Nowadays, the percentage of elder patients under treatment with DOACs is increasing. This is the first report of a patient under treatment with a DOAC presenting with a temporal artery pseudoaneurysm. In the presence of a pseudoaneurysm, a conservative treatment with compression and observation usually fails in this group of patients and an intervention is required.[10] In this case, the pseudoaneurysm continued to expand, while the patient was under a lower dose of rivaroxaban. DOAC may have a role in sac expansion in this case, preventing a likely thrombosis of the aneurysm. Sac expansion is associated with a higher risk of rupture which would be related to an important hemorrhage, especially in a case of a patient under anticoagulant treatment. The careful perioperative use of DOACs was associated with no perioperative complication in our case.

## CONCLUSION

Superficial temporal artery aneurysms are a rare complication after blunt head trauma. Careful clinical examination can conclude to a correct diagnosis. Duplex sonography is a useful tool to clarify diagnosis. Surgical treatment is the gold standard of care and minimal invasive approach an alternative in aneurysms of proximal temporal artery. Anticoagulant treatment in elder patients may be associated with larger diameter pseudoaneurysm and a higher risk of rupture. Careful perioperative use of DOACs could lead to avoidance of postoperative complications.

*Acknowledgements: None*

*No conflict of interest*

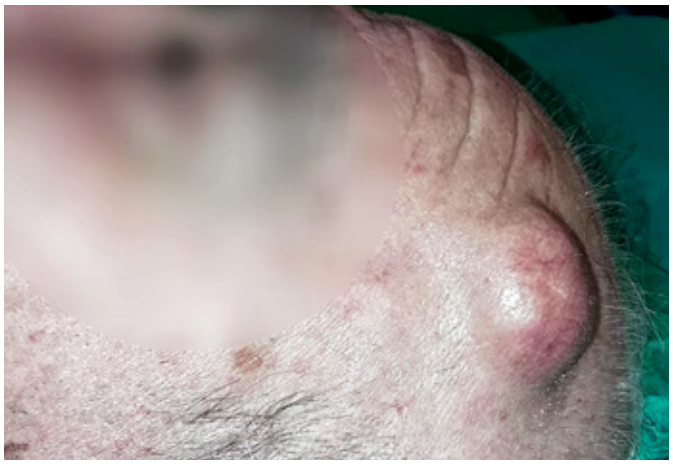

**Figure 1.** A pseudoaneurysm of the superficial temporal artery after a blunt cranial trauma

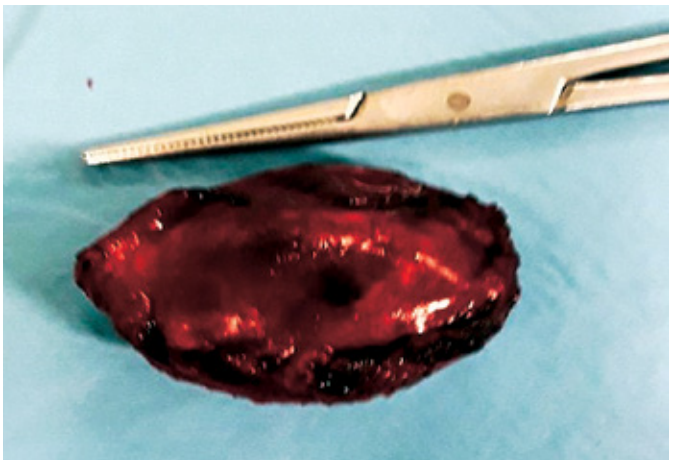

**Figure 2.** The excised pseudoaneurysm of the superficial temporal artery

## REFERENCES

1 O. Ayling, A. Martin, G. Roche-Nagle, Primary Repair of a Traumatic Superficial Temporal Artery Pseudoaneurysm: Case Report and Literature Review, Vascular and Endovascular Surgery, 2014, Vol. 48(4): 346-348

2 D. Lebas, P. Modiano, T. Wiart, Superficial temporal artery pseudoaneurysm: 2 cases, Annales de dermatologie et vénéréologie, 2018 Apr, Vol. 145(4):257-260

3 M. Benyachou, A. Echchaoui, A. El Hankari, S. El Mazouz, N. Gharib, A. Abbassi, Traumatic Pseudoaneurysm of the Superficial Temporal Artery: A New Case Report, Focus on Sciences, 2017 Feb, Vol. 3 (1)

4 H. Joswig, Wai P. Ng, Traumatic pseudoaneurysm of the superficial temporal artery, CMAJ, 2017 June, Vol. 189(24): 837

5 B. Tekin, E. S. Denli Yalvac, T. Zenginkinet, Image Gallery: Traumatic pseudoaneurysm of the superficial temporal artery, British Journal of Dermatology, 2017 Sep, Vol. 177(3): 70

6 A. L. Peick, W. Kirt Nichols, J. J. Curtis, D. Silver, Aneurysms and pseudoaneurysms of the superficial temporal artery caused by trauma, Journal of Vascular Surgery, 1988 Nov, Vol. 8(5): 606-610

7 P. Khandelwal, F. Akkara, V. Dhupar, A. Louis, Traumatic pseudoaneurysm of the superficial temporal artery, National Journal of Maxillofacial Surgery, 2018, Vol. 9(1): 74-77

8 M. Czihal, A. Sturm, U. Hoffmann, P. J. Kuhlencordt, Painful nodule of the forehead after blunt trauma: Superficial temporal artery pseudoaneurysm, Vascular Medicine, 2015, Vol. 20(1) 86-87

9 A. Domen, P. De Vleeschauwer, K. Goossens, Y. Deruyver, Palpable Pulsatile Mass of the Forehead: A Case Series of Superficial Temporal Artery Pseudoaneurysms, J Angiol Vasc Surg 2017, Vol. 2: 10

10 P.A. Stone, M. Martinez, S.N. Thompson, D. Masinter, J.E. Campbell, J. Campbell et al, Ten year experience of Vascular Surgeon Management of Iatrogenic Pseudoaneurysms: Do Anticoagulant/Antiplatelet Medications Matter?, Annals of Vascular Surgery, 2016 Jan, Vol 30:45-51


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VASCULAR IMAGE

# Lymphocele after AV graft; a rare complication

**Konstantinos Spanos, MD, MSc, PhD, Ioannis Vasilopoulos, MD, MSc, Athanasios D. Giannoukas, MD, MSc, PhD, FEBVS**

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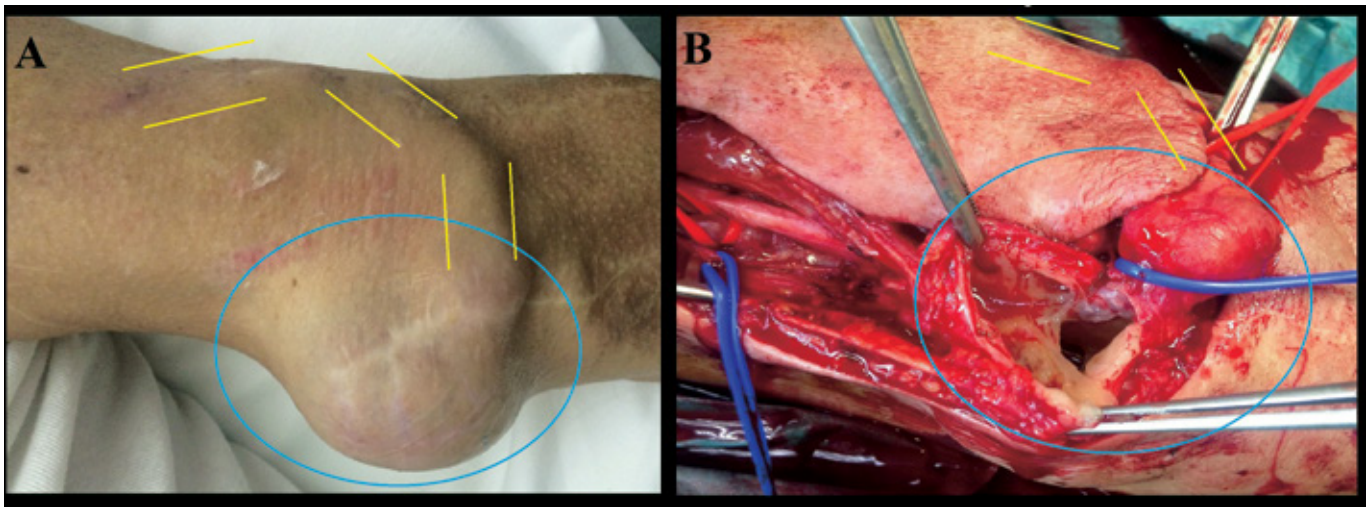


A 54-year old male with end-stage renal disease, presented with pain, numbness and chronic swelling (circle) in the area of arterial anastomosis two years after an arterio-venous (AV) brachial-axillary prosthetic graft (lines), without receiving any immune-suppressant medication. All upper extremity pulses were intact, and the graft had a positive thrill. The duplex scan suggested the presence of a suspected thrombosed pseudoaneurysm of the arterial anastomosis with patent graft. An operation was decided to relieve the symptoms, however, intra-operatively a lyphocele was identified (image 2) and removed with mechanical lavage of the graft, the tissue cultures were negative. The av graft remains patent and functional during 6=month follow up, without any other fluid collection or re-intervention.

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VASCULAR IMAGE

# Endoleak imitation after EVAR

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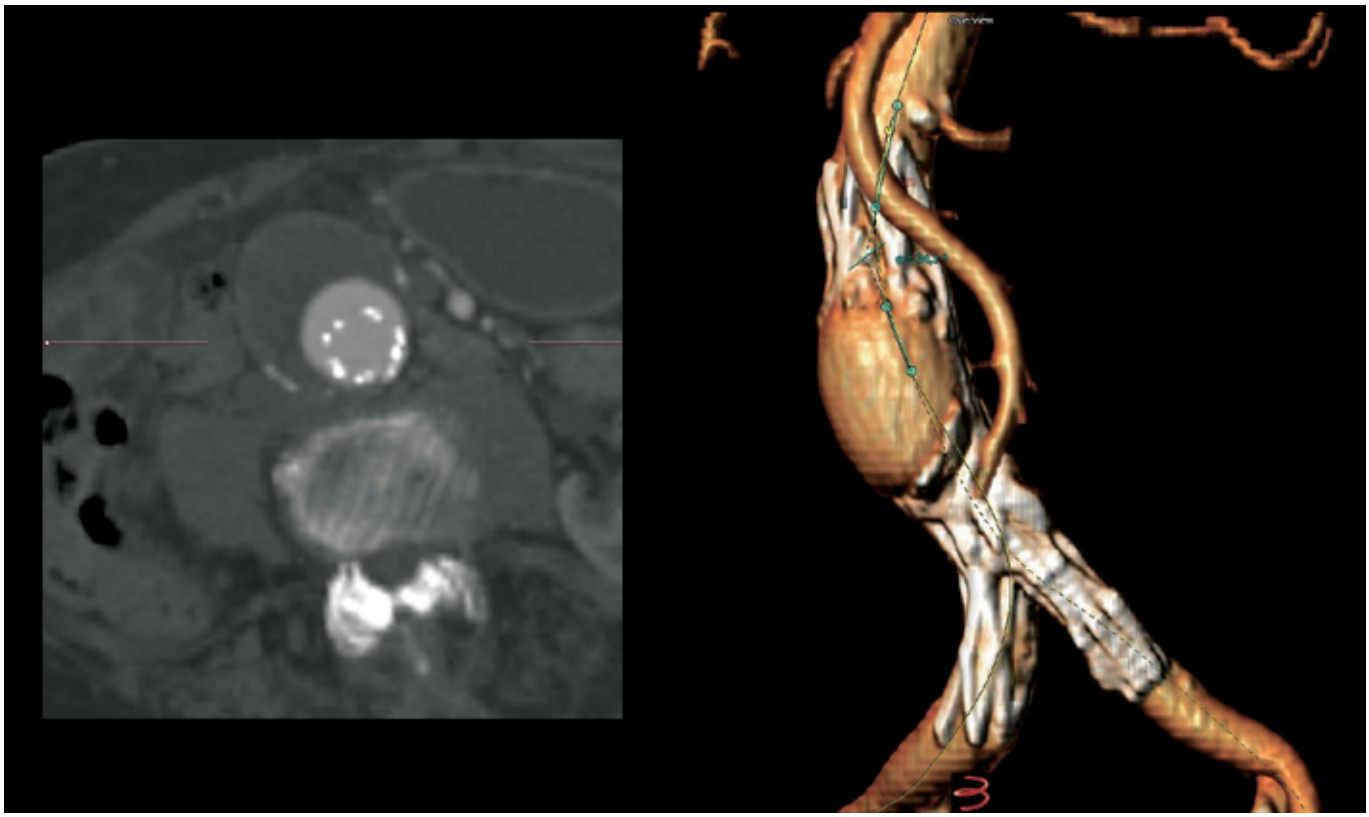

An 85-year-old female patient treated electively for a 5.9cm abdominal aortic aneurysm using a two pieces, second generation, AFX endograft (Endologix, CA). Pre-operatively, an infrarenal proximal neck angulation of 58° was present. At 1st month follow-up an important quantity of contrast was observed between the proximal endoskeleton and the graft material, imitating a well delimited, "smooth" saccular endoleak. The proximal neck angulation after EVAR was reduced, but still measured at 34° and probably is responsible for this exceeding finding. This phenomenon has been described as billowing and it concerns a benign imaging finding which can be incorrectly considered as an endoleak. A closer follow-up is mandatory in these cases, as there is an association in billowing and late sac expansion and aneurysm rupture.

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Leipzig, Germany

**Controversies & Updates in Vascular Surgery**
February 7-9, 2019
Marriott Rive Gauche Hotel
Paris, France

**EVC 2019**
March 10-12, 2019
Maastricht, Netherlands

**18th Panhellenic Congress of Angiology, Vascular and Endovascular Surgery**
March 14-16, 2019
Megaron, Athens, Greece

**Critical Limb Ischemia Course (CLIC) 2019**
March 21-22, 2019
Padua, Italy

**ALPIC 2019 (Advanced Learning on Platelets & Thrombosis International Course)**
March 22-24, 2019
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Metsovo, Greece

**11th Congress of the Vascular Access Society**
April 11-13, 2019
De Doelen International Congress Centre
Rotterdam, The Netherlands

**Charing Cross Symposium 2019**
April 15-18, 2019
Olympia London
London, United Kingdom

**LIVE 2019**
May 9-11, 2019
Larissa Imperial Hotel
Larissa, Greece

**68th Congress of the European Society of Cardiovascular and Endovascular Surgery (ESCVS)**
May 22-25, 2019
The University Medical Center Groningen
Groningen, The Netherlands

**Critical Issues in Aortic Endografting 2019**
May 23-24, 2019
Hilton Liverpool City Centre
Liverpool, UK

**SVS/VAM 2019**
June 12-15, 2019
Gaylord National Resort & Convention Center
National Harbor, MD

**20th European Venous Forum Meeting**
June 27-29, 2019
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**ISTH 2019**
July 6-10, 2019
Melbourne, Australia

**CIRSE 2019**
September 7-11, 2019
Barcelona, Spain

**ESVS 2019 - The 33rd European Society for Vascular Surgery Annual Meeting**
September 23-27, 2019
Hamburg, Germany

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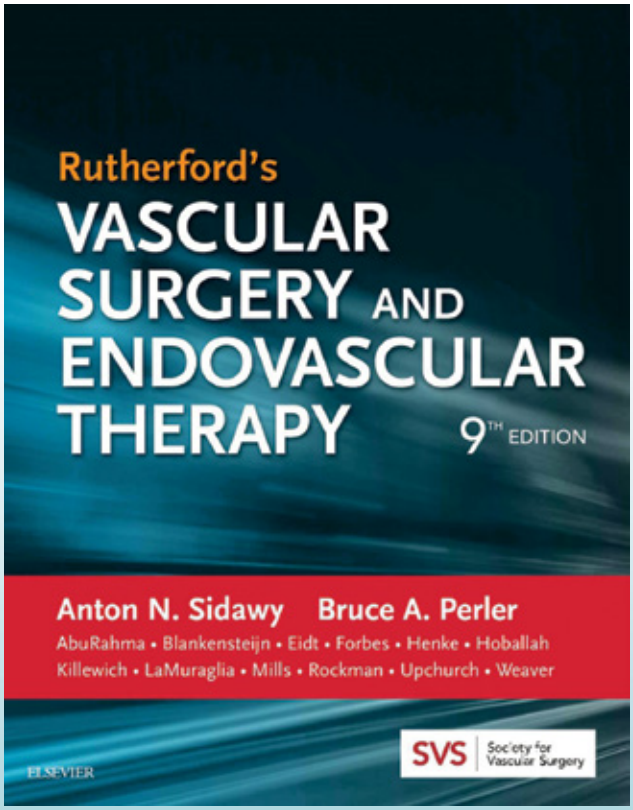


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