Volume 6 Issue 2 April 2024 ISSN 2732-7175

Hellenic Society of Vascular and Endovascular Surgery

Hellenic Journal of Vascular and Endovascular Surgery

HOT TOPICS

Contemporary Role of IVC Filters and Advanced Retrieval Techniques
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The Practice of Ultrasound Guided Foam Sclerotherapy in Varicose Veins of Lower Limbs in Greece During the Years of Economic Crisis, Compared with Today: Have Things Changed?
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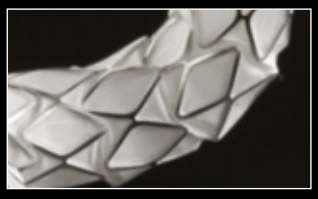

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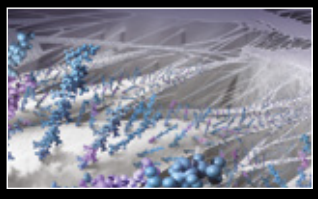

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EDITORIAL

Women in vascular surgery: Every coin has two sides

Nana Petroula, Kölbel Tilo

German Aortic Center, Department of Vascular Medicine, University Heart and Vascular Center, UKE, Hamburg, Germany

Female sex has been considered as a factor of increased mortality and morbidity after endovascular and open repair of diseases affecting any segment of the aorta.[1,2] From the ascending down to the abdominal aorta, females present higher risk for early death and severe complications compared to males, including stroke and acute kidney injury; with both being related to decreased survival during follow-up.[2,3] However, when endovascular repair is feasible among female patients, it tends to provide significant benefits in terms of mortality and early morbidity compared to open procedures.[1,3] A variety of factors have been related to worse outcomes among females, beginning with anatomic characteristics, as target and access vessels diameter, presence of atherosclerosis, and continuing with higher rates of underdiagnosed comorbidities, including cardiac disease.[3]

Similarly, despite that the prevalence of peripheral arterial disease (PAD) is higher among women, female patients remain undertreated, as they are less likely to be evaluated by a vascular specialist and receive appropriate medical management, as suggested in the current recommendations, compared to men.[4,5] The different patterns of the disease, including higher rates of asymptomatic PAD or PAD with atypical presentation may affect adequate management in women and could explain the worse outcomes among females with PAD.[5] Even when treatment is provided, female patients with PAD tend to report a lower quality of life after repair compared to males, while they present higher rates of depression and cardiovascular mortality during follow-up.[5] Carotid interventions, including carotid endarterectomy and stenting, for symptomatic carotid stenosis have been also related to worse outcomes in female patients, with a higher incidence of neurologic and cardiac adverse events.[6] No difference has been found though between males and females managed for asymptomatic carotid atherosclerosis, setting rationally the question for potential earlier intervention in females.[6]

In addition to physiologic and biological parameters, social factors may also contribute and affect outcomes when reporting on female populations. Despite being under-investigated, economic status and social and family roles may lead female patients to lower and/or later access to health facilities, and timely appropriate management.[7] Despite that, according to the World Health Organization, cardiovascular diseases are the main cause of mortality among women, their importance seems to be still undervalued from both health providers and female patients.[8] On one hand, health providers often lack awareness on sex and gender related research findings and clinical parameters while female patients remain under-informed about the presentation, symptoms and signs of vascular diseases.[8] Understanding the impact of biological, social, and cultural aspects on health behavior and disease patterns may assist providing a more holistic approach and further, ameliorate the short and long-term outcomes in female patients suffering from vascular diseases.

Passing from patients' aspect to professional matters, women remain an underrepresented group in vascular societies.[9] As presented a few years ago by Prof. Mastracci, women represent a minority in the largest vascular meetings, with 23.3% of the chair and panel positions being administrated to them.[9] While these numbers signify the need for changes from societies' side to strengthen diversity, parameters as lacking role models and the complexity of women's social role potentially affect their decision and make vascular surgery an unattractive field of practice. Even in general terms, medicine, which has become a popular professional choice among women, seems to be at the end an unfriendly environment, with recent mental health data showing that female health providers present 7.5% higher rate to commit suicide compared to the general female population.[10]

Measures to increase awareness on vascular diseases and their associated risks among female patients and their environment could be a first step to improve diagnosis and management. The investigation of data focusing on female populations, including the total spectrum of vascular diseases, can highlight the pitfalls of the currently provided treatments and allow to direct our efforts to improved outcomes. Endovascular aortic repair findings show that we are probably on the right path to manage female patients with aortic diseases, even if further steps are needed to optimize management.[3] However, the awareness should extend also within the working environment. Accepting the differences related to biological and social factors, in addition to stronger role models and support from the official organizations, would encourage young female colleagues to become active part of the vascular

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doi: 10.59037/wz669330
ISSN 2732-7175 / 2024 Hellenic Society of Vascular and Endovascular Surgery Published by Rotonda Publications

community. Through the years vascular surgery is becoming a field, where womens' creativity can be expressed and appreciated.

Conflict of interest: Tilo Kölbel is a consultant and proctor for and has intellectual property with Cook Medical, receiving royalties, speaking fees, and research, travel, and educational grants. Both authors declare no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work; no other relationships or activities that could appear to have influenced the submitted work.

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The Practice of Ultrasound Guided Foam Sclerotherapy in Varicose Veins of Lower Limbs in Greece During the Years of Economic Crisis, Compared with Today: Have Things Changed

Konstantinos Seretis, Sophia Tzamtzidou, Dimitra Manou, Nikolaos Giannakopoulos, Konstantinos Roditis, Theofanis Papas

Department of Vascular Surgery, Korgialenio - Benakio Hellenic Red Cross General Hospital, Athens, Greece

Abstract:

Introduction: Thermal tumescent interventions emerged during the years of economic crisis in Greece, whereas ultrasound-guided foam sclerotherapy (UGFS) and other endovenous treatments were not widely adopted in Greece because of their increased cost. The aim of this study is to compare the practice of UGFS during the years of economic crisis and today, and find out if there are any changes in terms of technical, medical and economical settings.

Methods: A questionnaire was sent to the members of the Hellenic Phlebological Society and the Hellenic Society of Vascular Surgery, including questions about the technical, medical and economical settings. The collected data were verified, responses were analyzed, and a comparison between the responses given before and after the economic crisis was conducted accordingly.

Results: Technical settings questions were almost the same between the two time periods examined, and it seems that economic crisis didn't affect the way that the method was applied. Medical settings had some minor changes, and there was a notable increase in the number of cases performed in public hospitals. The greatest difference between the two time periods was found in the economical settings, with a shift from open surgery that was mainly applied in the years of economic crisis, to endovenous procedures that are mainly applied in the post crisis period.

Conclusion: In the years of crisis, endovenous treatments were offered mainly in private hospitals, and open surgery was the method of choice in public hospitals. This treatment strategy has now changed, with modern treatment methods being the 1st line of treatment in both the public and the private sector.

Keywords: vein insufficiency; thermal tumescent interventions; laser ablation, radiofrequency ablation; ultrasound-guided foam sclerotherapy.

INTRODUCTION

The traditional treatment of Great Saphenous Vein (GSV) incompetence is open surgery, but in the last two decades, endovenous procedures for treating superficial venous insufficiency have emerged. Endovenous procedures aim to occlude the incompetent GSV by means of thermal energy, chemical irritation, or adhesion, and have gained popularity over open surgery because of their minimal invasive nature. Procedures that utilize thermal energy are called thermal tumescent interventions (EVLA/RFA/EVSA), and are performed using tumescent anesthesia and thermal energy to occlude the incompetent GSV[1]. More recently, there has been an increasing use of non- thermal treatments for GSV insufficiency that do not require the use of tumescence anesthesia and do not subject individuals to the risk of thermal injury. These techniques are therefore known as non-tumescent non-thermal (NTNT) techniques[2], and the initial technique of non-thermal interventions for GSV incompetence was that of ultrasound-guided foam sclerotherapy (UGFS). Mechanochemical ablation (MOCA) is another NTNT technique which obliterates the venous lumen through the use of a rotating catheter tip that causes mechanical damage, and concomitant injection of a liquid sclerosant that causes chemical injury[3]. Another NTNT technique is cyanoacrylate embolisation, where occlusion of the incompetent GSV is achieved by means of adhesion after the injection of cyanoacrylate glue within the vein via a handheld delivery gun[4].

Thermal tumescent interventions are the recommended 1st line treatment techniques and UGFS is the recommended second line treatment technique for the treatment of GSV incompetence in the United Kingdom (UK), as per the latest NICE guidance[5]. Since these techniques emerged during the years of economic crisis in Greece, UGFS and other endovenous treatments were not widely adopted in Greece because of their increased cost. The aim of this study is to compare the practice of UGFS during the years of economic crisis and today, and find out if there are any changes in terms of technical, medical and economical settings.

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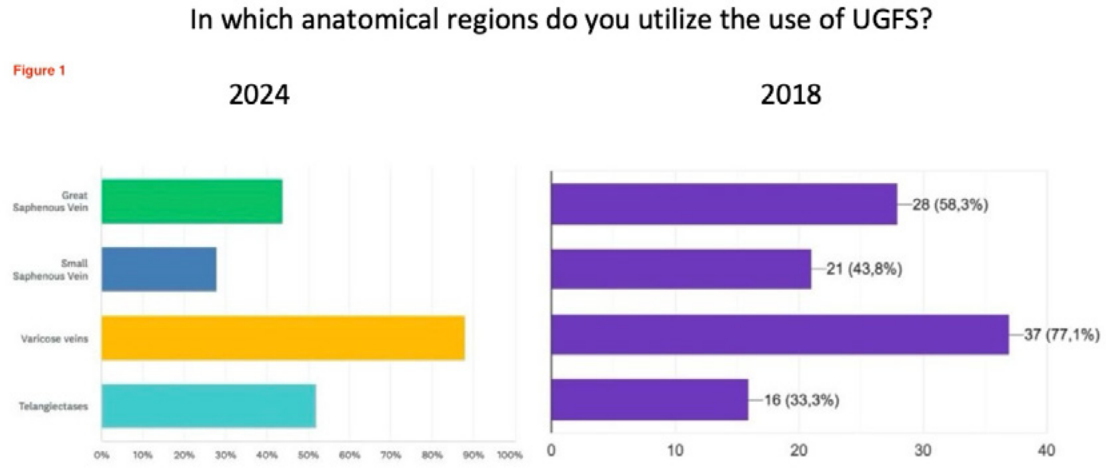
doi: 10.59037/h3avke72
ISSN 2732-7175 / 2024 Hellenic Society of Vascular and Endovascular Surgery Published by Rotonda Publications

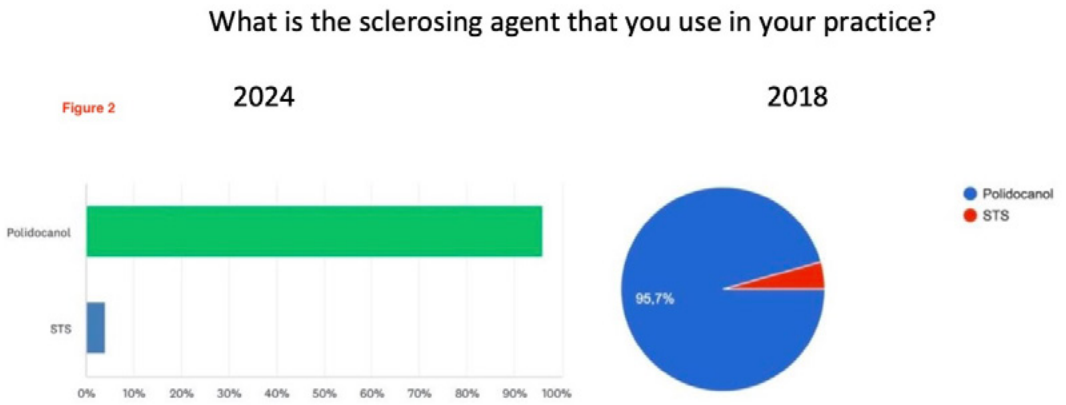
METHODOLOGY

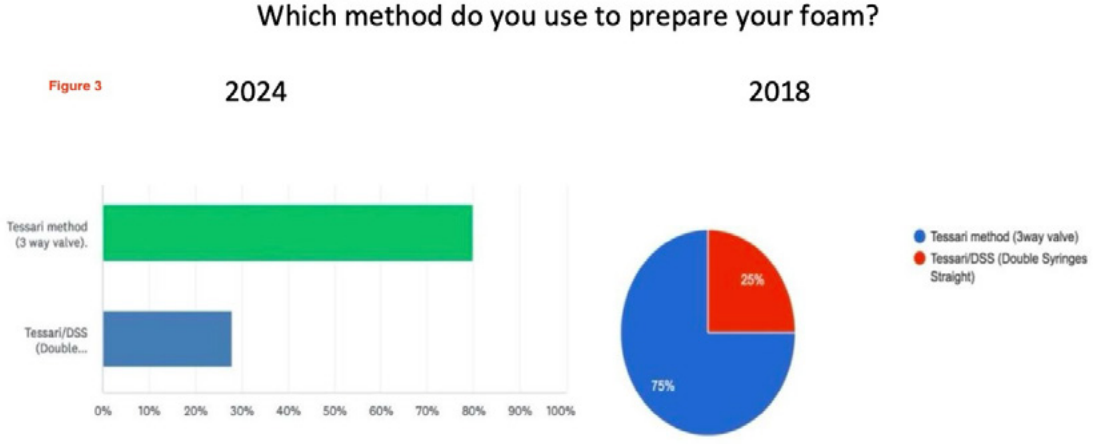
This is a comparison of the findings depicted in a previous study conducted in 2018 under the auspices of Hellenic Phlebological Society and presented in the annual congress of Societe Francaise de Phlebologie, and a recent study with the same study design applied in today's every day practice by phlebologists in Greece. According to the study design, a questionnaire was sent to the members of the Hellenic PHlebological Society (*HPHS*) and the members of the Hellenic Society of Vascular Surgery (*HSVS*), and included questions about the technical, medical and economical settings. The collected data were verified, responses were analyzed, and a comparison between the two sets of study questions was conducted accordingly.

RESULTS

Technical settings questions were almost the same between the two time periods examined, and it seems that economic crisis didn't affect the way that the method was applied (Figure 1-6).

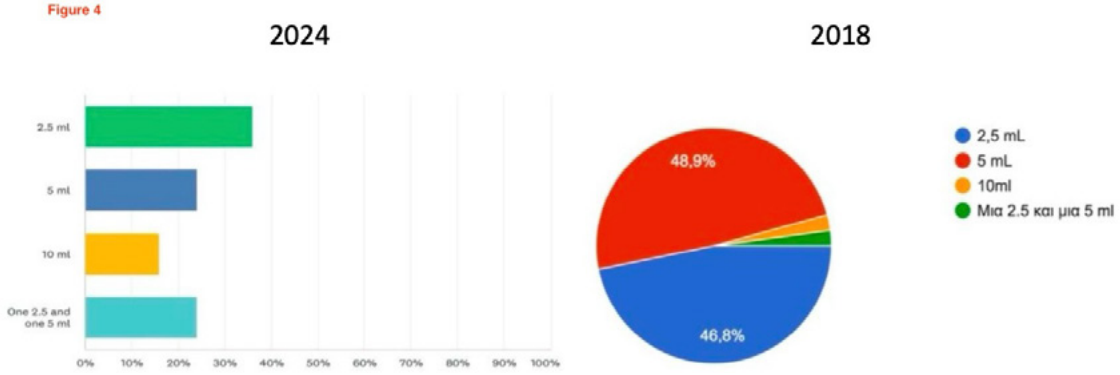






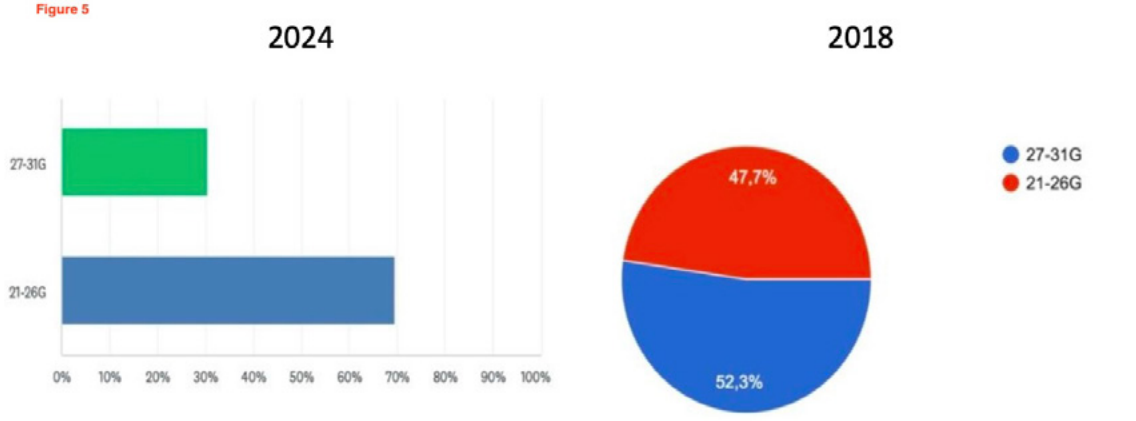
Which is the size of syringes that you use?

Figure 4



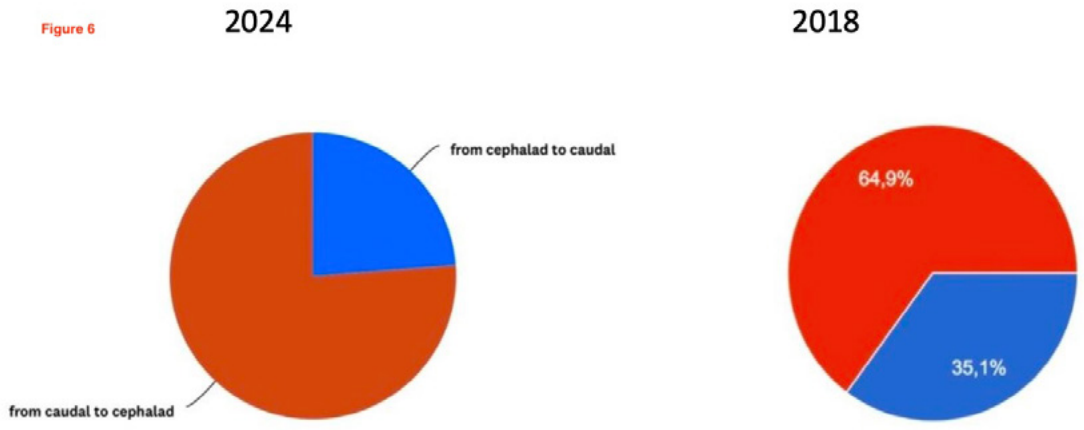
Which is the size of the needle that you use to treat Great Saphenous Vein?

Figure 5



When you perform UGFS for Great Saphenous Vein, you begin to inject...

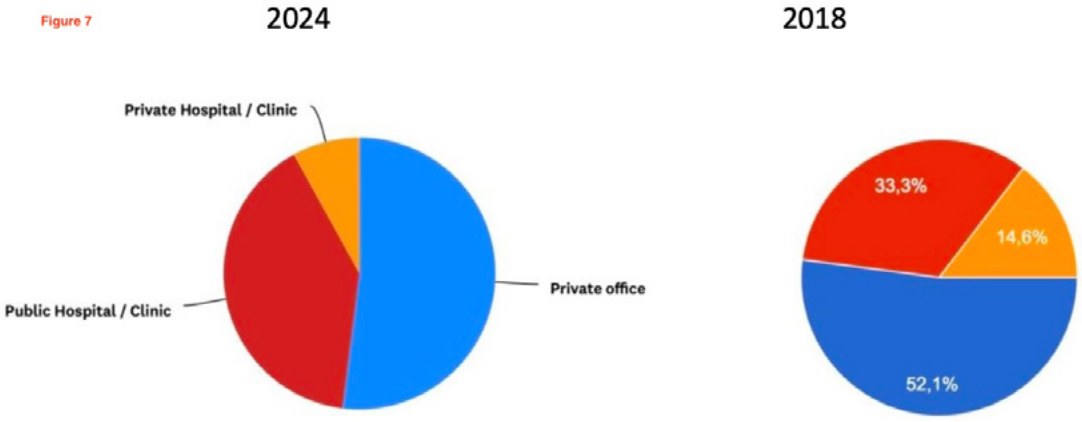
Figure 6



Medical settings had some minor changes, and there was a notable increase in the number of cases performed in public hospitals (Figures 7-8).

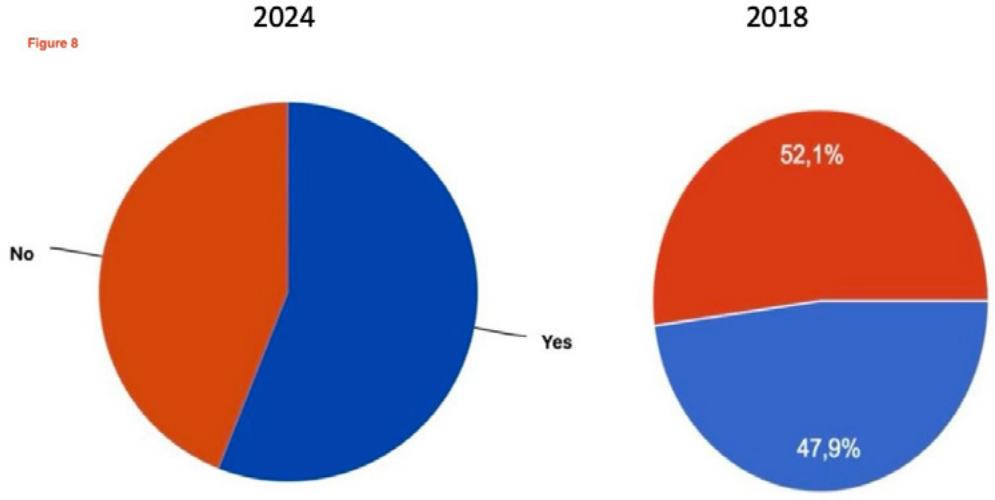
Where do you practice UGFS in varicose veins of the lower limbs?

Figure 7



Have you been certified by the Ministry of Health to perform vascular U/S?

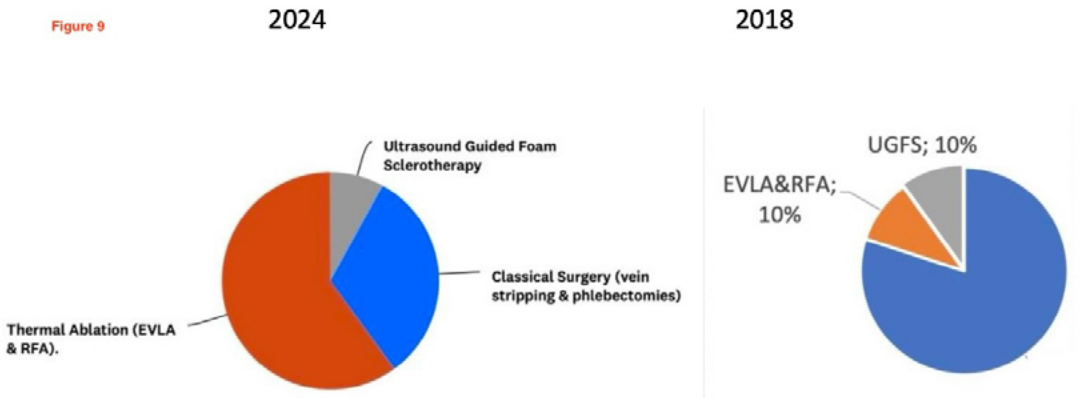
Figure 8



The greatest difference between the two time periods was found in the economical settings, as it was expected. There has been a shift from open surgery that was mainly applied in the years of economic crisis, to endovenous procedures that are mainly applied in the post crisis period (Figure 9).

What is your preferred treatment strategy that you have utilized mainly to treat Primary Truncal Varicose Veins (GSV) during the last 3 yrs?

Figure 9



Nowadays, the vast majority of treatments for primary truncal varicose veins incompetence is carried out with thermal tumescent techniques, while in the years of crisis open surgery accounted for the 80% of the total cases. NTNT techniques share the same quota in both time periods examined, although UGFS and MOCA, and more recently cyanoacrylate embolization, are the preferred endovenous treatment in an increasing number of physicians because of the lower complication rate that is associated with these techniques.

CONCLUSIONS

Economic crisis deprived modern treatment strategies from Greek patients suffering from chronic venous insufficiency. In the years of crisis, endovenous treatments were offered mainly in private hospitals/clinics, and open surgery was the method of choice in public hospitals. This treatment strategy has now changed, and now that the economic crisis has past, we have aligned with other European Countries and modern treatment methods are now offered to Greek patients as the 1st line of treatment.

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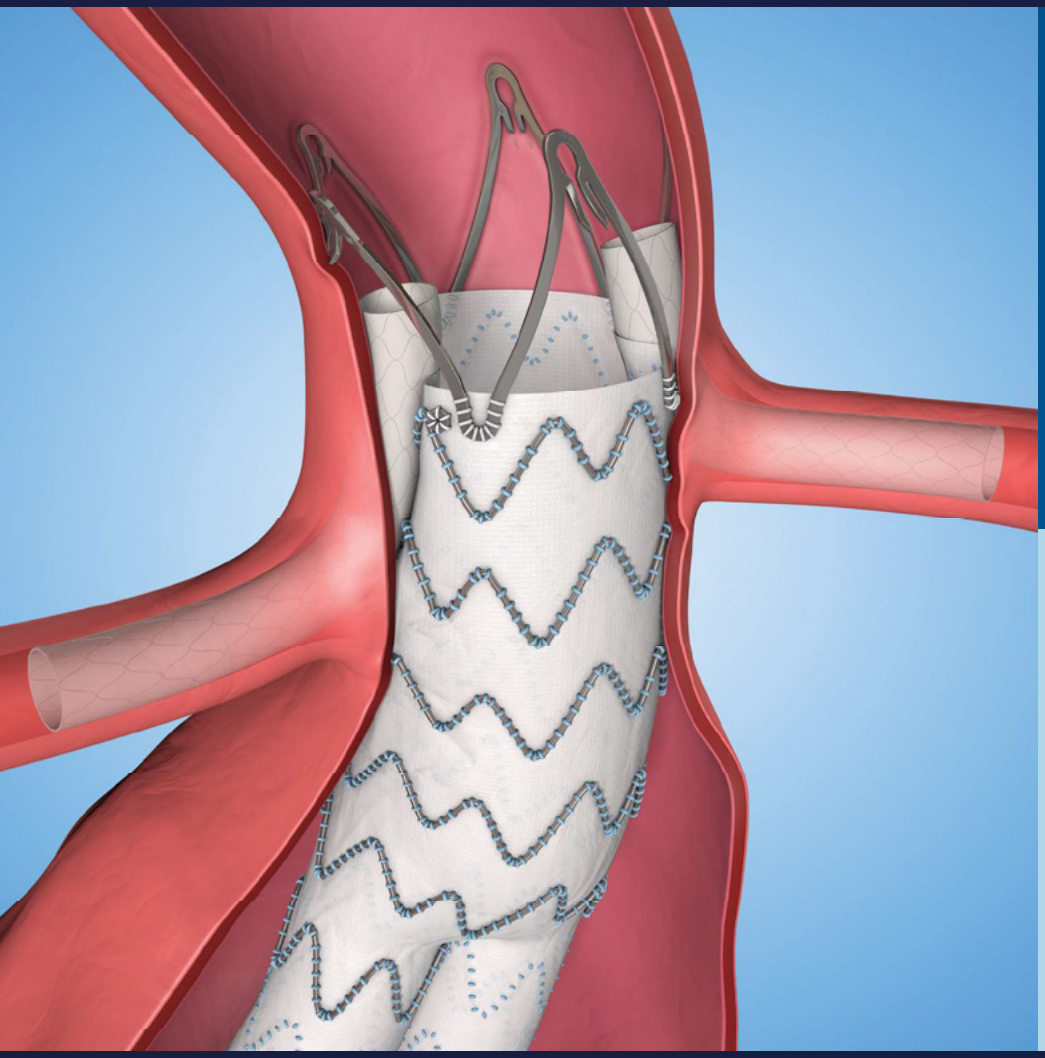

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Contemporary Role of IVC Filters and Advanced Retrieval Techniques

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Abstract:

The role of inferior vena cava filters (IVCF) has been controversial over the years, due to concerns regarding their overuse for non-specific indications. Current guidelines recommend their use for patients with proximal deep vein thrombosis who have contraindications or have failed anticoagulation therapy. Prophylactic placement while occasionally justified, remains controversial as robust evidence is lacking. Decision making regarding any IVCF application should be based on a thorough patient selection, 'cost-effectiveness' evaluation of the procedure and a proper follow-up protocol needs to be in place for retrieval. A variety of different types and designs of mainly retrievable IVCF is available. The IVCF should be removed when their use is no longer indicated. Prolonged dwell time is not only linked with filter-related complications, but can also lead to a challenging retrieval and/or failure. Advanced filter retrieval techniques are currently available with excellent results, even under complicated circumstances, when performed by experienced physicians.

Keywords: IVC filter, IVC filter complications, IVC filter indications, IVC filter retrieval, Pulmonary embolism, Deep vein thrombosis

INTRODUCTION

Deep vein thrombosis (DVT) and pulmonary embolism (PE), combined known as venous thromboembolism (VTE) are the third cause of cardiovascular death after myocardial infarction and stroke.[1] The reported annual incidence of DVT in the United States is 80 cases per 100,000 people, more than 60% of which, will develop PE. Although PE is usually asymptomatic, it is a complication of DVT that can lead in hospitalization, with high morbidity and mortality rates.[2] The "gold standard" treatment for patients with DVT and/or PE, is anticoagulation (AC) therapy. However, for a high-hemorrhagic risk patient with existing or at risk of VTE, AC therapy is contraindicated.[3] In particular, in cases of intracranial bleeding or other major bleeding, active gastrointestinal bleeding, threatened abortion, preeclampsia and eclampsia, malignant hypertension, brain surgery and spinal surgery, AC therapy is contraindicated, as identified by ICD-9-CM diagnosis or procedure codes.[3] The need to prevent the occurrence of PE in those patients, supports the use of either permanent or retrievable inferior vena cava filters (IVCF).[1]

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doi: 10.59037/1h40xk83
ISSN 2732-7175 / 2024 Hellenic Society of Vascular and Endovascular Surgery Published by Rotonda Publications

The American Heart Association[4], the Society of Interventional Radiology (SIR)[5,6], and the American College of Radiology[7] have supported the use of IVC filters over the years. However, with only a few studies of adequate strength proving evidence for their efficacy, controversy amongst medical communities and experts has been provoked.[8] More recently, the SIR and the Society for Vascular Surgery (SVS) jointly announced the publication of the "Predicting the Safety and Effectiveness of Inferior Vena Cava Filters (PRESERVE)" study, the largest prospective study undertaken regarding outcomes with contemporary IVCF use. The results demonstrated that IVCF are safe and effective for the treatment of VTE, able to prevent DVT from developing into PE.[9]

However, the main concern of experts and scientific boards remains on whether the advantages of the placement of an IVCF, can outweigh potential complications particularly when filters dwell for long periods; and then which is the safest choice for the patient: to perform a challenging IVCF retrieval or rather leave it behind.

Aim of this review is to summarize the current evidence regarding the use of IVCF, and report the latest trends in IVCF retrieval techniques highlighting potential challenging parameters of the procedure.

IVCF STUDIES

PREPIC studies

According to the first ever randomized controlled trial PREPIC and its 8-year follow up, the placement of an IVCF to a patient that can receive proper AC therapy, does not benefit neither the short nor the long term patients' survival. More specifically, in a series of 400 patients with acute PE and a

high risk of recurrence, the PREPIC study compared the safety of retrievable vena cava filters plus AC, to AC therapy alone. After a two-year follow up period, no significant differences in symptomatic PE or survival between the two groups were observed, apart from a higher rate of DVT recurrence in the patients of the IVCF group (20.8% vs. 11.6%, P=0.02). At 8 years of follow-up, patients with IVCF had a smaller rate of symptomatic PE (6.2% vs. 15.1%, P=0.008) but a significantly higher incidence of DVT (35.7% vs. 27.5%, P=0.042). The overall incidence of VTE, post-thrombotic syndrome and mortality was similar among the 2 groups. Authors came to conclusion, that systematic use of IVCF in patients with VTE who can be treated with anticoagulants, is not recommended. It is suggested though, only in case of failure or contraindication of AC therapy.[10,11]

PREPIC2 a randomized, open-label, blinded end point trial with 6-month follow-up, conducted from August 2006 to January 2013 compared the results from hospitalized patients with acute, symptomatic pulmonary embolism associated with lower-limb vein thrombosis and at least 1 criterion for severity that underwent to retrievable inferior vena cava filter (RIVCF) implantation plus AC (filter group; n = 200), with patients that received AC therapy alone with no filter implantation (control group; n = 199). In the filter group, the filter was successfully inserted in 193 patients and was retrieved in 153 of the 164 patients in whom retrieval was attempted. Follow-up after 3 months showed recurrent pulmonary embolism occurrence in 6 patients (3.0%; all fatal) in the filter group and in 3 patients (1.5%; 2 fatal) in the control group (relative risk with filter, 2.00 [95% CI, 0.51-7.89]; P = .50). The results were similar at 6 months and indicated that the use of a RIVCF plus AC compared with AC therapy alone did not reduced the risk of symptomatic recurrent pulmonary embolism at 3 months and therefore a RIVCF is not recommended for patients who can be treated properly with AC.[11]

Further investigation however, needs to be done towards the placement of temporary IVCF, in selected patient groups, that are prone to develop VTE and unable to receive prophylactic AC therapy.

PRESERVE study

Recently, the "PREdicting the Safety and Effectiveness of InferioR VEna cava filters (PRESERVE)", a prospective, nonrandomized study at 54 sites in the United States between October 10, 2015, and March 31, 2019, demonstrated that the IVC filters are both safe and effective when used to prevent the clinically significant PE. The study enrolled 1429 participants (53.3% male), IVCF were implanted in 1421 patients and were evaluated at baseline and at 3, 6, 12, 18, and 24 months. The follow up for the patients whose IVCF were removed, was for 1 month after retrieval. Of these, 71.7% had current DVT and/or PE. AC therapy in 81.6% was contraindicated or had failed. 8.9% of the implanted IVCFs were prophylactic. IVCF were removed from 44.5% of the patients at a median 86.3 days following implantation, of which 96.8% at first attempt. The primary safety endpoints (freedom from perioperative serious adverse events (AE) and from clinically significant perforation, VCF embolization, caval thrombotic occlusion, and/or new deep vein thrombosis DVT within 12-months) and primary effectiveness endpoints (composite comprising procedural and technical success and freedom from new symptomatic PE confirmed by imaging at 12-months in situ or 1 month postretrieval) were both achieved.

Procedural AEs were rare and not severe and VCF-related AEs were uncommon. One patient died during attempted IVCF removal. Postfilter, venous thromboembolic events (none fatal) occurred in 6.5%, including DVT (5.2%), PE (1.6%), and/or caval thrombotic occlusions (1.1%). No PE occurred in patients following prophylactic placement.

These results might at first seem in favor of the use of IVCF, taking also into consideration the high rate of IVCF removal, however they are overshadowed by study's limitations. It is worth mentioning that the PRESERVE study is not randomized and the majority of the enrolled patients were in severe health state, with limited therapeutic alternatives and contraindication to the optimal AC therapy. As the authors state *"withholding AC therapy from control groups with VTE is an unethical deviation from standard of care".*[9]

Moreover, the broad inclusion criteria used in the study don't clarify the potential effect of concomitant AC therapy, the patients may have received prior, at the time and after the placement of IVCF and also the severity of VTE of the patients at presentation. VTE events or PE that occurred only a short period of time after the IVCF placement can be attributed to pre-existing DVT or PE. In other words, the study does not separate high and low risk patients, and how this might have impacted the results, was not sufficiently considered in the analysis.

It is challenging to determine if the placement of an IVCF generates any net benefits without a control group. Whereas there is no proven evidence for claiming the success of the intervention (filter implantation) without comparing it to optimal medical care and other forms of thromboprophylaxis. Yet, despite these limitations, placement of an IVCF was deemed relatively safe and effective.

IVC Filter Indications

According to the **ESVS (2021) Clinical Practice Guidelines**, temporary inferior vena cava filter insertion is recommended and constitutes the only viable treatment option, for patients with proximal deep vein thrombosis who have contraindications to anticoagulation during the initial or principal treatment phase (Class I / Level C).[12] Nevertheless, for a patient properly receiving AC treatment, the routine use of an IVCF is not recommended (Class III / Level B).[12] IVCF can't treat and prevent VTE, but they can prevent the serious complication of PE.

As a relative indication an IVC filter can also be considered in AC treatment failures[8,12] and selectively in percutaneous endovenous interventions.[13,14,15]

Prophylactic use (absence of active VTE) in high risk groups (e.g. polytrauma, spine or bariatric surgery) has also expanded over the past several years given their ease of use, howev-

Table 1. Filter Indications

Classic Indications / Patients with documented VTE	Relative / Extended indications	Prophylactic / Patients without VTE
1..Contraindication to AC therapy	2.a. Failure and/or complication of AC therapy	3.a. Trauma patient at high risk for VTE not cleared to receive prophylactic AC due the risk of bleeding (e.g., long bone fractures, immobility)
	2.b. Percutaneous endovenous interventions	3.b. Surgical procedure in a patient at high risk for VTE who cannot receive prophylactic AC
		3.c. Patients with paraplegia or other high-risk patients who cannot receive prophylactic AC

er it remains highly controversial. A multidisciplinary decision weighing costs and benefits is necessary. As awareness on IVC filter potential complications has increased, the prophylactic use is declining.[16,17,18]

All indications are summarized in Table 1.

Role of Permanent vs Retrievable IVCF

Permanent IVCF currently in use include Vena Tech LP (B. Braun IS, Bethlehem, PA), titanium Greenfield (Boston Scientific, Watertown, MA), Trap Ease (Cordis, Bridgewater, NJ), Simon Nitinol (Bard Peripheral Vascular Inc., Tempe AZ), and Bird's Nest (Cook Group, Bloomington, IN) filters. Although permanent IVCF are not designed to be removed from a percutaneous approach, they can be removed, if needed, at specialized centers capable to perform advanced retrieval techniques (ART).

Retrievable IVCF on the other hand, permit percutaneous removal if and when the risk of PE resolves. They are designed to be maintained in place in the IVC by hooks, barbs, or radial pressure. Among many examples are Celect (CookMedical Inc, Bloomington, IN), Günther-Tulip (Cook Medical Inc), Option (Argon Medical Devices, Athens, TX), ALN (ALN Implants Chirurgicaux, Ghisonaccia, France), Denali (and predecessors Meridian, Eclipse, and G2) (Bard Peripheral Vascular Inc.), Tempofilter II (B. Braun, Melsungen, AG), G2 and G2x (Bard Access Systems Inc., Salt Lake City, UT, USA) and Crux (Volcano Corp, SanDiego, CA).[19]

All IVCF have FDA approval for permanent use. This only constitutes one parameter of the low retrieval rates, not matched by the corresponding growth in removable IVCF implantation.[19] RIVCF and their flexible indications may sound appealing given the operators ability to postpone decision-making, regarding the optimal removal time, however permanent IVCF for a patient with a prolonged or lifelong need for protection may seem to be a better choice (Figure 1).[19] According to Brothers et al. analysis, permanent filters had greater predicted effectiveness compared with RIVCF implantation (5.41 quality-adjusted life-years [QALY] vs 5.33 QALY) at a lower cost ($2070 vs $4650).[20] Also the implantation of RIVCF according to the literature has a higher rate of complications and greater percentage of adverse events after prolonged dwell time. A retrospective single center study of 1234 IVCF placed from 2005 to 2010 explored the differences in patients' characteristics and complications between those with retrievable (group A) and those with permanent filters (group B). The complication rates were significantly higher in the group of indwelling RIVCF, than the group with permanent filters (9% vs 3.0%; P <

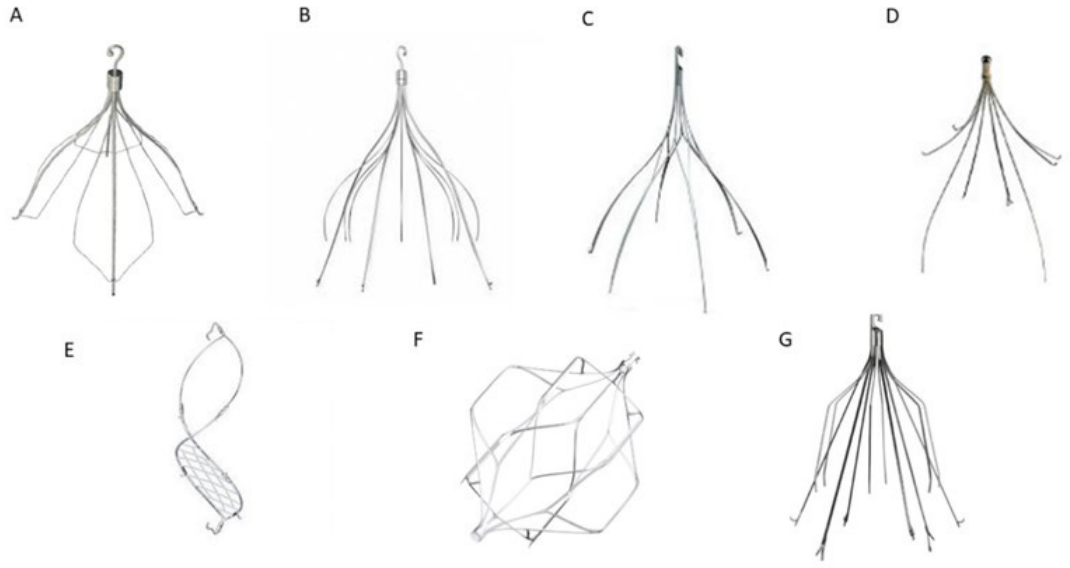

Figure 1: Variety of retrieval IVC filters. COOK Gunther Tulip (A). COOK Celect (B). Rex Medical Option (C). ALN (D). Volacano Crux (E). Cordis Optease (F). Bard Denali (G).

.0001) after mean follow-up of 20 months. Both thrombotic and device-related complications were more common with retrievable filters, and therefore their long term use should be avoided.[21]

According to an analysis of filter data from a single institution, whether an optional IVCF can become permanent can be quantitatively predicted from patient parameters. Advanced age, male sex, history of underlying malignancy, and history of anticoagulation failure are positively correlated with optional filters being declared permanent.[22] It is important to emphasize that retrievable filter use should be limited to patients with appropriate indication for filter placement in whom retrieval is highly likely and feasible. Retrievable filters are designed to allow the filter to be easily collapsed during retrieval like an umbrella, in comparison with permanent filter designs characterized of a more durable structure.[21] Physicians should make their decisions regarding the placement of a permanent IVCF based on each patients' individual criteria, their risk for PE, and their potential need of life-long protection. Since there are no RCTs published yet to compare permanent and retrievable filters, widely acceptable guidelines and recommendations are still not available.[19]

Filter related Complications

Whether the benefits from an IVCF placement can outweigh potential complications, is in association with the patients' unique characteristics and available treatment options. As already mentioned in the PREPIC study, the patients at the IVCF plus anticoagulation group showed a higher rate of DVT recurrence comparing to those treated only with anticoagulation alone.[11] A retrospective cohort study, of 126 030 patients with VTE, 45 771 (36.3%) were treated with an IVCF, whereas 80 259 (63.7%) did not receive a filter, after adjustment for immortal time bias, showed that IVCF placement in patients with venous thromboembolic disease and a contraindication to anticoagulation was associated with a significantly increased hazard ratio of 30-day mortality (1.18; 95%CI, 1.13-1.22; P < .001).[3]

Prolonged IVCF dwell time can cause IVC thrombosis, IVC penetration, filter migration, DVT and filter fracture.[23] The FDA-approved IVCF types have device-specific risks. Better understanding of the complications each filter may cause, can help identify patients who may benefit from ongoing follow-up instead of a filter retrieval.[24] Risk of penetration is higher with purely conical filters (90-100%). Filters with cylindrical or umbrella elements are associated with the highest reported risk of IVC thrombosis (30-50%), whereas earlier generation filters are associated with high risk of fracture (40%).[24] A limitation of the reported device-specific complications, is the lack of equal follow up duration for the used devices among the available studies, considering also that complications tend to increase after longer dwell times.[24]

Optimal time for retrieval

IVCF with prolonged dwell time that are no longer indicated for use, should be evaluated for removal, in view of the risk of long-term IVCF complications described in the previous section.

Considering the FDAs' recommendations, a retrievable filter should be removed when protection for PE is no longer indicated. In fact, only a small percentage of them are removed, which varies between studies, but the majority of RIVCF are left in place permanently, with early reported retrieval rates as low as 8.5%.[25] This can be attributed to physician oversight and patients' noncompliance with the follow up protocol. However, according to Avgerinos et al., appropriate rigorous follow up protocols have improved retrieval rates to 60-70% at best.[26]

Prolonged dwell time is associated with a potentially challenging retrieval procedure. Filter retrieval is defined as challenging when retrieval is unsuccessful due to technical failure or when adjunctive endovascular maneuvers or access sites are necessary to achieve filter removal.[26] According to Avgerinos et al. filter retrieval can be challenging or fail when the dwell time is >50 days and >90 days, respectively, and when the filter hook opposes the caval wall.[26] Desai et al. suggested that patients with RIVCF in place beyond 7 months, may face difficulties during retrieval, with a calculated risk of standard technique failure at 40.9%, and a referral to centers with expertise in advanced filter retrieval techniques is the best option.[27] In a single center study of 648 retrievals, technical success was achieved with standard retrieval techniques in 536 procedures (82.7%); with adjunctive techniques, 631 (97.4%) whereas dwell time (52/648 with dwell time > 6 months) did not affect technical success (OR, 0.98 [95% CI, 0.95-1.01]; P = .12).[28]

Filter retrieval techniques

Standard retrieval technique (SRT) is performed with the use of a snare and a coaxial sheath.[29] The endovascular snare device is used in order to capture the filter apex/hook. Firstly, a cavography is performed in order to examine potential in situ filter thrombus, then telescopic sheaths are placed right adjacent to the filter. When the hook is captured, opposite traction is applied to both the snare and sheath to remove the RIVCF from the caval wall.[30]

Any other technique that requires additional tools to achieve filter removal is considered advanced.[29] In the literature ART were classified as stiff wire displacement, loop snare realignment, wire loop and snare sling technique, wire and snare flossing, balloon displacement, parallel wire and dual sheath, and dissection with off-label tools (endobronchial forceps).[29] Avgerinos et al. reported an overall success rate of 91.5% and a 71.1% success rate with advanced techniques. Al-Hakim et al. reported 73.2% success using standard techniques and 94.7% success with advanced techniques. Dowell et al. also reported a 65% success rate using advanced techniques and overall success rate of 96.5%. This can be attributed to the operator's comfort using the optimal ART.[29] Limitations of the published studies are among others, that the type of each ART used in not objectively assigned and is utilized based on the operators skills and preference.[29]

Advanced retrieval technique vs difficult retrieval scenario

Curved inner sheath

The majority of the available filter designs have a conical shape, which allows them to adjust to the caval wall, at one "circle" formed by the peripheral ends of the device. Filter tilt occurs when external anti-parallel force is applied to the long axis of the filter.[25] As a result of the tilt, the filter may not be adequate to capture a thrombus or its position will lead to easier thrombus formation. Standard straight sheaths and snare devices are often unable to successfully capture the filter hook in order to achieve retrieval. A curved inner sheath can facilitate successful snaring of a hook that is significantly deviated from the central axis of the IVC. Desai et al. suggests the use of a Flexor Ansel Guiding Sheath with Ansel 2 modification (Cook Medical) to provide additional directionality in securing a tilted filter.[25]

Loop - snare technique

In case of filter tilt, the filters hook/apex is located in close apposition with the caval wall which results to significant blood flow disruption, leading to development of intimal hyperplasia and endothelialization.[25] As a result, the hyperplastic tissue which is formed and covers the hook constitutes a challenging retrieval. The basic principle of the loop-snare technique is to capture a tilted or embedded filter via forming a wire loop through the main body of the RIVCF,[30] by passing a wire between at least two filter legs/struts and then snaring it superiorly to create the loop, which engages the filter for retrieval (Figure 2).[31] This technique may fail in cases with an embedded hook.[31] According to Desai et al., a modified technique that targets the fibrin cap is used, in which a reverse-curve catheter aids to engage the radiolucent hyperplastic cap encasing the filter apex. A hydrophilic wire is then passed cranially and snared, forming a wire loop through the tissue cap. The sheath is then advanced coaxially over the wire loop, resulting in either capture and collapse of the filter or disruption of the tissue cap. Then, a standard snare is used to capture and retrieve the filter.[25]

The modified loop-snare technique that creates a wire loop between the filter neck and the IVC wall, for release of embedded filter hooks is referred to as "The hangman technique".[32] The Hangman technique is described by Al-Hakim et al. and is performed as follows; A right-sided internal jugular vein approach is used with placement of a 14-F x 45 cm sheath (special order; Cook, Inc). A 16 or even an 18Fr sheath can be more efficient. Through this sheath, a 5-F reverse curve catheter (SOS Omni Selective Catheter; AngioDynamics, Latham, New York) is advanced distal to the filter and a glidewire is brought down, around and up above the filter neck to be snared using a 25-mm Amplatz GooseNeck Snare (ev3 Endovascular, Inc, Plymouth, Minnesota) and with-drawn through the sheath. The reverse curve catheter is withdrawn, and cranially directed tension is applied to both the leading end and the trailing end of the wire to release the embedded filter hook from the IVC wall and align it with the sheath and remove it. In cases when filter neck cannot align with the sheath, the double wire system can be rotated creating a spiral that aligns the filter with the sheath and then the sheath can be pushed down and filter can be removed. It is important to understand that high forces may be needed to remove the filter and this is safe provided that these forces are applied against the sheath and not against the IVC wall.

Al-Hakim et al. reported a retrieval success rate of 81.9% (9 of 11 cases; mean tilt, 13.3 degrees +/- 3.9 and an embedded hook (mean dwell time, 194.5d)) and no associated complications.[31] A low-profile hangman technique, with the use of a standard 11 Fr Cook filter retrieval sheath, in 23 patients was successful on initial attempt in 22 cases (96%), median dwell time was 196 days, and no procedure-related complications occurred.[32]

Endobronchial forceps

Rigid Endobronchial forceps are used off-label for filter retrieval; however, they can be safely and reliably used to remove not only embedded, but also fractured, or tilted RIVCF from patients in whom SRT were unsuccessful.[33] Endobronchial for-

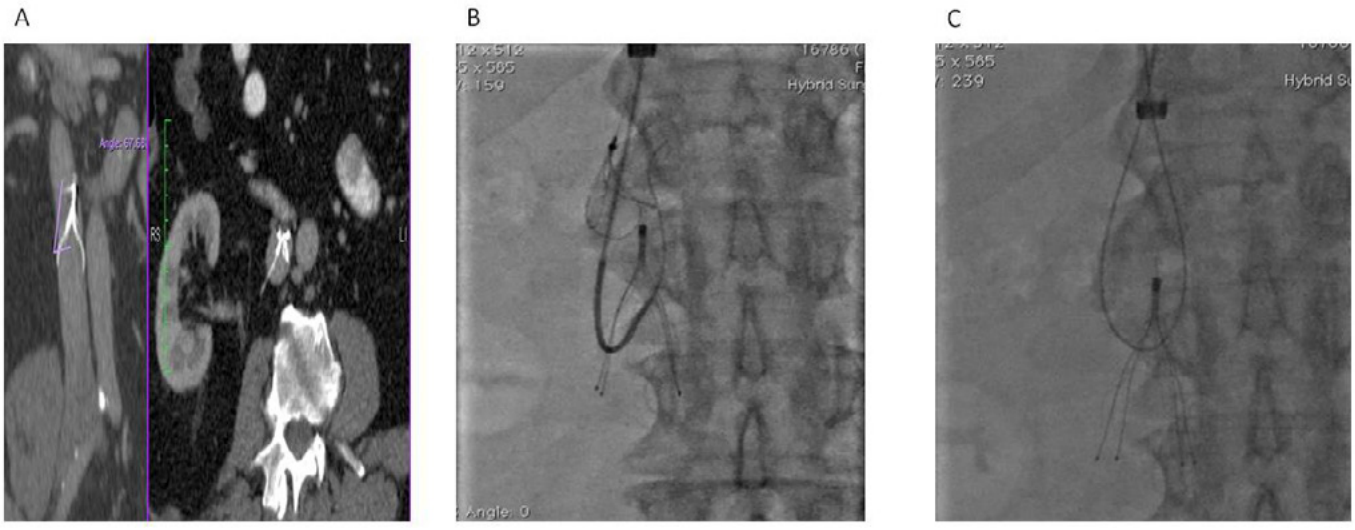

Figure 2: Loop - snare technique for an embedded Filter apex. Filter apex tilted and embedded in the IVC wall (A). Curved catheter around the filter apex (B). Wire looped around the filter and back in to the large bore access sheath (C).

ceps are usually malleable and can be shaped to provide the appropriate degree of curvature to reach an embedded filter hook, achieve dissection of the tissue from the filter apex and finally centering the filter and allow retrieval with a standard snare or alternatively with the forceps itself.[25] With the use of forceps, physicians should be careful for potential caval distention or laceration of the caval wall.

According to a single-center retrospective review, in 60 consecutive patients, 58 IVCF were successfully retrieved with rigid endobronchial forceps. Filter fractures intra-operatively occurred in 10 patients, and four complications were reported, including 1 retroperitoneal hemorrhage, 1 IVC flap, and 2 filter component migrations, both of which were retrieved with a snare device.[33] Another single-center retrospective series reported 114 patients with tip-embedded optional IVCF of a variety of models, with median dwell times 465 days. Filter retrieval was successfully achieved in 109 of 114 (96%) patients with the use of a 12-14Fr sheath combination.[34] The same institution in a subsequent study evaluated the use of a larger 16Fr sheath, for retrieving "closed-cell" filters, which have a higher incidence of strut and wall-embedment, in 35 patients and found 100% technical success rate in retrieving Gunther Tulip (CookInc,Bloomington,IN), Option (Argon Medical Devices, Plano, TX), and Opt Ease (Cordis Endovascular, Warren, NJ) IVCF.[35] Insignificant caval spasm and filling defects were observed in 17 of 34 patients, but there were no major adverse events, which further highlights the benefits of the stiffer and larger 16-Fr sheath for dissecting the heavily embedded filter elements from the caval wall, providing stable forward counterforce.[35] After more than a decade since the first description of forceps-assisted IVCF retrieval in 2006, with increased operator experience, the fluoroscopy times required for the retrieval have dropped to less than a median of 10 minutes. As endobronchial forceps can be sterilized and reused, the cost of a forceps-assisted retrieval is much less compared to many other advanced retrieval techniques.[36]

Laser ablation sheaths

RIVCF with prolonged dwell times can become embedded to the caval wall, due to vascular remodeling and neo-intimal hyperplasia. As a result, the filter cannot be removed with a standard sheath and the use of additional force could cause more damage.[30] Laser ablation sheaths, originally designed for pacemaker lead extraction, have been successfully used "off-label" to photothermally ablate neointimal tissue encasing the filter struts within the caval wall, allowing filter removal.[25] Kuo et al. after failed retrieval using 3X standard force, were able to remove 98% of embedded filters utilizing the laser sheath technique. In particular, by placing a laser sheath (Spectranetics) connected to a 308-nm XeCl excimer laser generator (CVX-300, Spectranetics), to achieve fibrotic tissue ablation.[37] The major complication rate was 2.0%, and all were successfully treated with either medical management and/or percutaneous endovascular therapy. IVC hemorrhage occurred in three patients (0.6%) (3/500) and was attributed to laser activation, at the time when the laser sheath wasn't safely centered within IVC lumen.[37] Desai et al. reported that filters with a "Closed-cell" design (Gunther Tulip (Cook, Inc, Bloomington, IN), Option and Option Elite (Argon Medical Devices, Inc, Plano, TX), OptEase and TrapEase, and Simon Nitinol (Bard Peripheral Vascular, Tempe, AZ), may necessitate the use of the laser sheath for higher rates of successful and safe retrieval when compared with "open-cell" filters (odds ratio, 20.1). In their study the laser sheath was required in 143/441 cases in total (mean dwell times for all filters was 56.6 months) with technical success 96% (134/143). To achieve successful retrieval of closed-cell filters, laser-sheath assistance was necessary in 127 of 210 (60.5%) of cases as compared with open-cell filters that requiring the laser sheath in 16 of 231 (7.0%).[38] One complication occurred among laser sheath retrievals and required short admission for a femoral access site hemorrhage.[38]

Novel Filter Designs

New and improved retrievable VCF devices are constantly developed targeting smaller delivery systems, non-tilting configurations, improved stability, safety while indwelling, aiming to reduce complication rates and reassure an easier retrieval procedure. New designs have recently been made commercially available in Europe (e.g. VIDI Vena Cava Filter, Veniti Inc, MO, USA; Angel Catheter, BiO2Medical Inc, CO, USA).

An innovation and potentially the future of IVCF, is the creation of absorbable filters. Studies have been made regarding the development and in vitro testing of several absorbable vascular filter designs and materials that could possibly erase the long-term complications of conventional IVCF and eliminate filter retrieval.[39] The feasibility, effects, and complications of a resolvable IVCF also was tested in vivo to animal models, but further research of bioabsorbable polymers, absorption mechanics in the vascular system, and absorption times needed to be done.[40]

In a recent non-randomized prospective multicenter trial, the Sentry bioconvertible IVCF was implanted in 129 patients with documented DVT and/or PE (67.5%) or who were at temporary risk of developing DVT/PE (32.6%). The filter is designed to bioconvert at 60 days after implantation. At the time of bioconversion, the device's nitinol arms retract from the filtering position into the caval wall and the stable stent-like nitinol frame is endothelialized. The composite primary 6-month endpoint of clinical success was achieved in 97.4%, no other filter-related symptomatic complications occurred, also no filter tilting, migration, embolization, fracture, or caval perforation and no filter-related deaths through 2 years. The rate of new symptomatic PE was 0% (n = 126) through 1 year. During the second year of follow up, 2 cases of new PE occurred, but it was after the bioconversion of the filter and at a timing that doesn't imply the release of an entrapped thrombus. During the 24 months of follow-up, the bioconversion was successful to 96.5% (82/85) of patients and there was no evidence of late-stage IVC obstruction or thrombosis.[41] The availability and use of a bioconvertible filter constitutes a step forward. Although short-term outcomes are promising, further investigation is needed regarding any effect of the long-term presence of the bioconverted and endothelialized Sentry device.

CONCLUSION

It is widely acceptable among physicians that AC therapy is well established as the treatment of choice for VTE. IVCF have an important adjunctive role to prevent a potentially fatal PE, particularly when AC is contraindicated or has failed. Which IVCF to use, when to use them, for how long they should remain in place, and which is the most effective removal technique remains a highly complex process with many variables to consider. Decision making should be based on a thorough patient selection, balancing costs and benefits. It is important to clarify the cases in which the placement of an IVFC to a patient who already receives AC therapy is beneficial or constitutes a risk factor, due to the potential complications. Patients' unique characteristics will aid to determine on a permanent or a retrievable filter placement. The majority of eligible patients should be considered for a retrievable filter but they should be rigorously followed up for removal as soon as they are not needed anymore to prevent long term complications. While most frequently IVCFs can be easily removed, advanced retrieval techniques may sometimes be necessary. These should be attempted in the hands of experienced physicians to minimize the risk of retrieval related complications and permit retrieval regardless of their implantation time. Further research is mandatory, to support the current evidence guidelines and optimize filter utilization in the future.

Financial Disclosure:

None reported

Declaration of Conflict of interests:

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article

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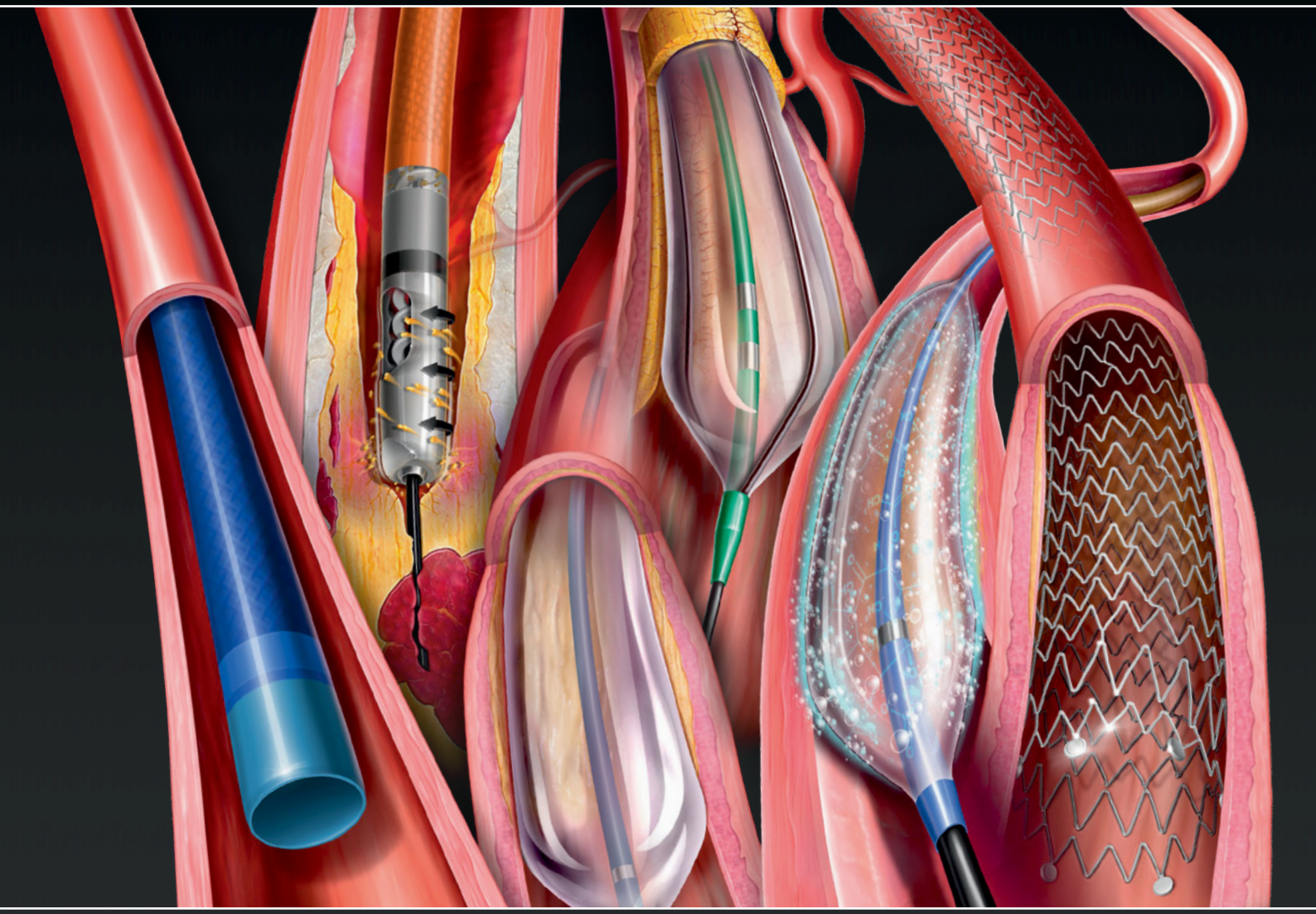

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Use of hybrid techniques for the treatment of Leriche syndrome with repeated occlusions of the infrarenal aorta, after failed endovascular and open repairs

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Abstract:

Leriche syndrome, known as aortoiliac occlusive disease, is a rare pathological entity that manifests with a triad of symptoms: claudication of both legs, reduction of peripheral pulses of both legs and erectile dysfunction. We present a case of a 55-year-old female patient with acute aortoiliac occlusion and complex surgical history, including both endovascular and open techniques. After initial diagnosis and extensive consideration of the complexity of the surgical history, the therapeutic choices who were left were the following: completely endovascular approach, open repair and finally a hybrid approach. The hybrid approach was elected and a hybrid aorto-iliac reconstruction, with redo-exposure of the right femoral artery, over the wire embolectomy of the right axis and of the proximal anastomosis and implantation of a covered 16x38mm stent at the proximal anastomosis as well as new crossover bypass was performed. Due to embolization of the right renal artery, caused by the deployment of the covered stent, deployment of another 4mm grafted stent in the right renal artery was neccessary. The 8-month follow-up revealed primary patency of the whole reconstruction. Patient was free of symptoms and both limps were salvaged.

In conclusion despite the complexity and severity of the case, a hybrid combination of both open and endovascular techniques managed to completely restore the perfusion of both legs and pelvis.

Keywords: Leriche Syndrome, Hybrid, Acute aortoiliac occlusion, Limb salvage

INTRODUCTION

Leriche syndrome represents a progressive aortoiliac disease which may lead to the thrombotic occlusion of the infrarenal aorta.[1]

Clinically it manifests as a triad of symptoms, which includes erectile dysfunction for male patients, claudication and reduction or absence of femoral pulses.[1,2] Although an exact prevalence and incidence can not be found, it is stated that the rates are getting higher with the ever ageing population.[2] Usually it affects heavy smoker males in their sixties although female patients have also been reported.[3] The main therapeutic solution is an open repair, including aortobifemoral or axillobifemoral bypass. Perioperative mortality and morbidity rates are 5% and 18% respectively and secondary patency at 10years mark reaches 92%.[3,4] With the progress of the endovascular techniques in the latest years more and more vascular surgeons tend to choose an endovascular approach in order to deal with Leriche Syndrome. There are studies that documented technical success rate between 96 and 98%, primary patency rates between 85 and 91% at >3years mark and secondary patency rates between 95 and 100% respectively.[5,6]

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doi: 10.59037/w26xvh03

ISSN 2732-7175 / 2024 Hellenic Society of Vascular and Endovascular Surgery Published by Rotonda Publications

CASE

A 55-year-old female with a quite complex vascular surgical history presented to our emergency department with symptoms of acute bilateral leg ischemia, including resting pain affecting both legs as well as sensory and motor deficit. Considering the patient's atherosclerotic risk factors, she had positive history of smoking, hypertension, hyperlipidemia as well as positive family history for cardiovascular disease. Peripheral arterial disease (PAD) was also known to be present on the patient, as she had previously described claudication at stage III according to Rutherford's classification. Clinical examination revealed absence of both femoral pulses, a necrotic lesion at her left toe, a postoperative infected wound at her left groin and ankle systolic pressure of 20mmHg with an Ankle-Branchial Index (ABI) of 0,15. This combination of clinical signs and the patient's history of PAD were suggesting acute on chronic ischemia of both limbs, likely due to occlusion of the aortic bifurcation. Through careful examination of her surgical history we extracted the following informations. Firstly, she was treated in another hospital in 2018 with a kissing stenting angioplasty in order to deal with an acute thrombotic occlusion of both common iliac arteries. The colleagues there decided to use self-expanding stents. A week later both stents

were occluded and she received a re-stenting angioplasty of both iliac arteries with bilateral stent extension, leading to coverage of the left internal iliac artery. After an unknown period of time, she suffered another acute thrombotic occlusion of the aortoiliac bifurcation. This time an open repair with an aortobifemoral bypass was elected. In October of 2022 the aortobifemoral bypass was occluded. This occlusion was treated with thromboembolectomy of the right bypass axis and a crossover bypass from the right femoral artery to the left, due to a failed thromboembolectomy of the left axis. A day later the whole reconstruction was once more compromised and another thromboembolectomy was performed. An endarterectomy with bovine patch for the right femoral bifurcation was also performed. Due to a suspicion of a stenosis at the proximal anastomosis as the main reason for all those occlusions a stent was implanted right below the renal arteries. Then 2 months later and with progressively worsening of her symptoms, she was presented to our medical care. Computed tomography angiography revealed the magnitude of the reduced, almost absent, limp and pelvis perfusion and the complexity of the case (figure 1). An extensive screening control revealed neither thrombophilia nor any other blood disorder, which could explain the repeated occlusions. Other thromboembolic sources, such as aortic aneurysm, plaque rupture, cardiac arrythmias, malignancies, blood clots in left heart ventricle, etc. were also ruled out by external medical specialists. Conservative therapy with Heparin and Prostaglandins managed to stabilize the situation and secure valuable time in order to review the therapeutic options and elect an approach. Of the 3 therapeutic options: open repair with a redo-aortobifemoral or a new axillobifemoral bypass, a completely endovascular attempt and a hybrid approach from the right groin, the later was elected. Firstly, a redo-exposure of the right femoral artery was performed and then over the wire embolectomy of the right axis and of the proximal anastomosis followed. Then and due to residual stenosis followed the implantation of a covered 16x38mm stent at the proximal anastomosis. Due to embolisation of the right renal artery, caused by the deployment of the covered stent, deployment of another 4mm grafted stent in the right renal artery was also performed. After the conclusion of the endovascular part a final angiography was performed that revealed the patency of bypass and both stents, as well as the unobstructed perfusion of both kidneys. Subsequently, due to the suboptimal intramuscular course of the old crossover bypass, which included kinking and compression points, there was a high risk of re-occlusion and failure of the entire vascular reconstruction. Therefore, a new crossover bypass was necessary. Due to the inadequate vessel wall of the right femoral artery after all these operations, a short interposition bypass from the right common femoral artery to the right profunda and superficial femoral artery was also necessary. For the crossover bypass and due to the infected wound at the left groin, and therefore an increased risk for graft infection, an 8mm Rifambicin soaked Dacron graft was used. Postoperative, femoral and popliteal pulses were palpable for both legs and ABI reached 0.8. After 12 postoperative days the patient was discharged with Clopidogrel due to stent implantation and Phenprocoumon due to the extensive thrombotic history as anticoagu-

Figure 1: 3D reconstruction of preoperative computed tomography angiography, that shows total occlusion of aortoiliac Bifurcation.

Figure 2: 3D reconstruction of postoperative computed tomography angiography, that shows primary patency of the hybrid vascular reconstruction and complete perfusion of pelvis, kidneys and both legs.

lation. At 8 month follow-up we were happy to see that our patient was free of symptoms, both limbs were salvaged and both groin-wounds were healed. The postoperative computed tomography angiography at 8 month mark revealed the complete patency of the whole vascular reconstruction, including both stents, the right axis of the old aortobifemoral bypass and the new short interposition and crossover bypass. (figure 2). Consent for publication was given by the patient.

DISCUSSION

Leriche syndrome, or aortoiliac occlusive disease is a rare form of peripheral artery disease.[2] With the imminent danger of major amputation, the necessity of surgery or intervention is quite evident.[7] Traditionally the first operative option is an aortobifemoral bypass in anatomical position.[8,9] With the evolution of endovascular surgery in later years, some studies[5,10] suggest a complete endovascular approach as a safe alternative to the traditional open repair, with good early and mid-term results. In our case the history of consecutive thrombotic occlusions in combination with the young age of the patient made the completely endovascular approach unappealing. Also, the previously implanted stent at the proximal anastomosis of the aortobifemoral bypass, right below the renal arteries made the open repair with laparotomy and a redo-aortobifemoral bypass quite risky. Therefore, the hybrid approach was elected. During the intervention and by the deployment of a covered stent the adverse event of the thromboembolic occlusion of the right renal artery occurred. That was a calculated and realistic risk in order to secure the proximal patency of the whole vascular reconstruction. The risk of a potential embolization of the superior mesenteric artery was also evident, which did not occur. By securing the adequate blood-perfusion of both kidneys, by stent implantation in the right renal artery, as well as the perfusion of intestines, the endovascular part of this hybrid approach was concluded and the open-repair part followed, with the implantation of a short interposition bypass and of a Rifambicin soaked crossover bypass. Although an adept surgical technique and the election of the right procedural approach are responsible for the primary patency of the revascularization, the longevity of the reconstruction depends on the right and adequate anticoagulation, which highlights the importance of right postoperative medication. This issue was evident in our case involving a young female patient who underwent numerous interventions and surgeries, all of which ended in failure. The reasons for these repeated occlusions are multifactorial and can only be speculated upon. With hypercoagulopathy and other thrombotic sources ruled out, one potential reason could be the underestimation of atherosclerotic disease both proximally and distally to the aortic bifurcation, leading to suboptimal treatment with kissing stenting. Another possible cause could be inadequate surgical technique. Given that a stent was placed at the proximal anastomosis of the initial aortobifemoral bypass, it is plausible that this anastomosis was sutured too low from the renal arteries, leaving a segment of the infrarenal aorta susceptible to thrombosis due to hemodynamic changes. Myointimal hyperplasia could also impact the longevity of these vascular reconstructions and play a significant role in the repeated occlusions. Finally, the patient's noncompliance with her anticoagulation medication should not be ruled out as a contributing factor. So a combination of technical mistakes, underestimation of the disease and patient's incompliance should be attributed to the repeated failures and patient's ordeal. For patients with a series of consecutive thrombotic occlusions, without diagnosed blood disorder or thrombophilia, the anticoagulation with Vitamin-K antagonists is suggested.[11,12] In conclusion hybrid techniques as the one mentioned above offer a great variety of solutions for the more complex vascular cases and should be part of the repertoire of the modern vascular surgeon. Although both completely endovascular reconstruction and aortobifemoral bypass are proven through studies[13] to be feasible for the treatment of Leriche syndrome, there are no studies that support the usage of hybrid techniques. After the successful treatment of this complex case we suggest and encourage the usage and documentation of such techniques in order to study the long-term postoperative results and validate their place in the treatment algorithm of AOD.

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Isolated visceral arteries dissection: Report of three cases and literature review

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Abstract:

Spontaneous, isolated visceral artery dissection represents an infrequent clinical occurrence. Over the past decade, there has been a notable rise in reported cases within the medical literature. There is no optimal therapy for this condition, nevertheless, conservative therapy and close follow-up for uncomplicated cases is accepted. Computed tomography angiography is the diagnostic tool of choice, whereas blood tests usually have no specifical abnormalities. Nowadays, endovascular therapy is therapy of choice for complicated cases, especially where exploration of the abdomen is not necessary. We report three cases of successful conservative therapy and we present a literature review.

Keywords: visceral, dissection, spontaneous, isolated, celiac artery, superior mesenteric artery

INTRODUCTION

Isolated visceral artery dissection represents an infrequent clinical occurrence. Over the past decade, there has been a notable rise in reported cases within the medical literature. This increase is primarily ascribed to the growing utilization of computed tomography angiography (CTA), although it may also be linked to an overall elevation in the incidence of visceral artery dissections. The precise pathophysiology of this condition remains unclear. Common risk factors identified among affected individuals encompass smoking and hypertension, implying that atherosclerosis and heightened shear stress may significantly contribute to the pathophysiological mechanisms. In this context, we present three cases of isolated visceral artery dissection managed conservatively, accompanied by a comprehensive literature review elucidating the characteristics of this uncommon medical phenomenon. Informed consent has been obtained from the patients for publication of the case report and accompanying images. Also, approval was obtained from the local ethics committee.

CASE 1

A 52-year old woman presented to the emergency department complaining of abdominal pain radiating to her back. The pain was characterized as postprandial, commencing four weeks prior and intensifying over the last twenty-four hours. Clinical assessment disclosed a supple abdomen with generalized tenderness. The patient's medical history disclosed inadequately controlled arterial hypertension. Laboratory investigations demonstrated values within the normal range. CTA revealed a celiac artery (CA) dissection with an intimal flap originating approximately 1.2cm from the celiac artery ostium for a length of 1.7cm. (fig.1) Hepatic, splenic and gastric artery were patent with no signs of flow limitation, thrombosis, aneurysm formation or intestinal ischemia. Conservative management was initiated. Subsequently, the pain was effectively alleviated, and the patient has remained asymptomatic for a duration of two years. (fig.2)

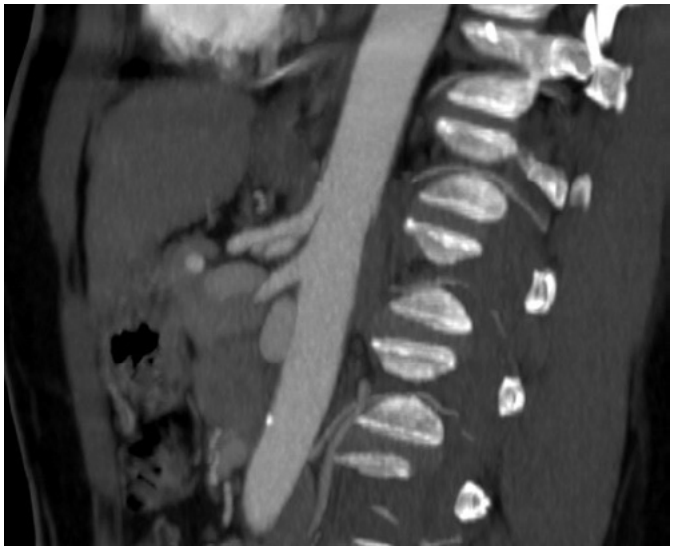

Fig. 1: Celiac artery dissection

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doi: 10.59037/me0nkk18
ISSN 2732-7175 / 2024 Hellenic Society of Vascular and Endovascular Surgery Published by Rotonda Publications

Fig. 2: Stable findings two years after discharge. CA dissection until trifurcation.

CASE 2

A-64-year-old man presented to the emergency department with recurrence of his abdominal pain and indigestion. He had been hospitalized two weeks prior at a different medical facility, where he received treatment involving antibiotics and proton pump inhibitors. The patient's medical background comprised a history of hypertension, coronary artery disease, and diabetes mellitus. Physical examination revealed a diffused, mild abdominal tenderness. Platelets and white blood count deviated from the normal range. X-rays and ultrasonography were normal. CTA revealed stenosis at the celiac artery ostium with post-stenotic dilatation (fig.3) as well as a dissection of superior mesenteric artery (SMA) with a flap originated at 1.2cm from its ostium, with a length of 8.5cm and re-entry point with patent branches of the SMA. (fig.4) The patient was successfully managed conservatively. A CT scan performed three months post the incident exhibited consistent and unchanging results.

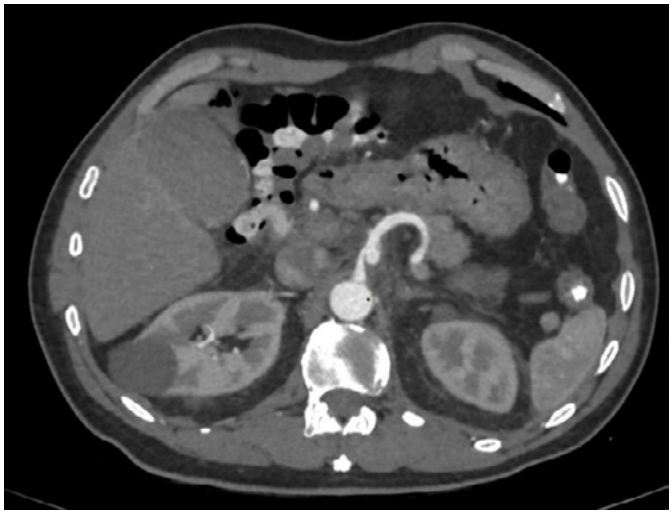

Fig. 3: CA post stenotic dilatation

Fig. 4: SMA dissection (length ~8cm), entry and re-entry points

CASE 3

A 51-year-old man presented to the emergency department reporting acute abdominal and left flank pain. The patient's medical history encompassed inadequately controlled hypertension, dyslipidaemia, and a history of tobacco use. CTA revealed dissection of the celiac artery and flow limitation to its branches. The patient was admitted to the hospital and was successfully treated conservatively, including bowel rest, antiplatelet and anticoagulation therapy. Ten days later, he underwent a repeated CTA which revealed patent left gastric artery. (fig.5) He remained asymptomatic, with stable CT scan findings even 7 years after this incident.

All three patients were treated conservatively in the acute phase and the therapy included anticoagulation, antiplatelet, b-blocker medications and bowel rest. Enteral nutrition was incrementally introduced starting from the sixth day of their hospitalization . Upon discharge, they were prescribed antiplatelet agents, and the follow-up period ranged from three months to 7 years.

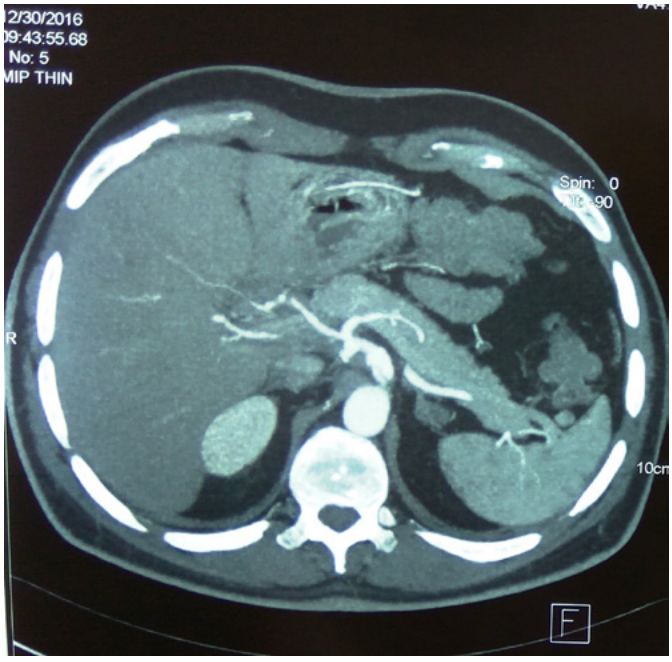

Fig. 5: Ct scan before discharge, CA dissection, patent left gastric artery

DISCUSSION

Spontaneous dissection of visceral arteries was traditionally considered an exceedingly rare condition, given an estimated incidence of approximately 0.08% whereas synchronous dissection of more than one visceral artery is even more extraordinary.[1-7] A comprehensive review of published articles within the PubMed database (2012-2022) was conducted to investigate isolated visceral artery dissection. The search yielded information on more than 600 cases. The augmented identification of spontaneous visceral artery dissection is attributed either to a genuine increase in the prevalence of such cases or to the enhanced detectability, facilitated by contemporary imaging modalities.[8] The demographic profile of affected individuals typically comprises middle-aged, Asian men. Upon presentation, these patients commonly exhibit a history of smoking and hypertensive urgency.[2,4,9-12] The superior mesenteric artery is most often affected, with the celiac artery following as the next most commonly affected vessel.[10,13,14]

Bax et al, in a very interesting article, discuss on pathophysiology of arterial dissections.[15] Various factors including hypertension, age, gender, connective tissue diseases, atherosclerosis, arterial cystic necrosis, trauma and smoking are considered to be associated with the disease. An intriguing pathophysiologic mechanism was suggested by Wu et al, proposing that SMA is more susceptible to shear stress in the transition zone from fixed retropancreatic to relatively mobile segment in the mesenteric root, analogous to what is seen at the ligamentum arteriosum in thoracic aortic dissection.[16] Celiac artery dissection should include investigation for median arcuate ligament syndrome.[17-19] An additional finding identified in this study, is that pancreatic enzymes released during pancreatitis can erode adjacent arterial wall and thus, the presence of acute pancreatitis might have triggered arterial dissection.[6,20]

Clinical presentation most often includes acute abdominal or flank pain. However, it could be present in a more indolent fashion, with an insidious onset, lasting days or weeks before the pain becomes more severe.[5] Yamaguchi et al reported a case where a patient presented with acalculous cholecystitis as a result of hepatomesenteric trunk dissection.[21] The pain can be postprandially or irrelevant with food intake, and the character may be sharp or dull. Some patients remained totally asymptomatic, and they were diagnosed incidentally or they were misdiagnosed.[5,14,19,22] Abdominal pain may be implying bowel ischemia, perforation and peritonitis or aneurysmal formation with imminent rupture of the artery. Nevertheless, the abdominal pain could alternatively be explained as an inflammatory response triggered by the dissection, thereby provoking pain through stimulation of the visceral nerve plexus. Current literature supports that the degree of pain is positively correlated with the length of the dissected blood vessel.[23] An author suggests that there were no significant differences in medical history or medications between symptomatic and asymptomatic patients. However, patients with abdominal symptoms tended to be younger and were more frequently hospitalized.[24] Nevertheless, in another study, it was noted that asymptomatic patients were younger (53.9±11.4 vs 58.7±11.2, p = 0.032) and that no significant differences were presented between the artery which was involved (CA vs SMA) in patients with or without symptoms, however there was a trend towards SMA involvement in symptomatic patients (23 (46%) vs 7 (26%), p = 0.085).[25]

The literature documents that many patients were misdiagnosed. Radiologic modalities are determinant of an accurate diagnosis.[26] CT angiography is the preferred diagnostic tool, as it is a rapid, non-invasive, and high resolution examination, which contributes to the visualization of the vessels and of complications from abdominal organs such as necrosis and perforation.[5,13] Regarding laboratory blood tests, coagulation markers, such as fibrin degradation products, are known to increase in acute aortic dissection. However, these markers were not markedly elevated in this condition, even in symptomatic patients, possibly because the amount of thrombus in SIVAD is smaller, due to the size of the vessel.[24] According to the same study, there were significant differences between symptomatic and asymptomatic patients in white blood cell count and creatine kinase levels, but not in FDPs or d-dimer levels.[24]

There are no specific guidelines regarding the ideal treatment of visceral dissection. However, a reasonable algorithm is the following: Surgery (open/endo/hybrid) is recommended if the patient in the acute phase presents with rupture, signs of end-organ ischemia, enlargement of the artery (>2cm) or blood flow limitation, in correlation with pain not responding to medication. If none of these conditions exists, the physician can choose conservative therapy (medication, bowel rest). Our strategy includes bowel rest for 5 to 6 days, staged nutrition, anti-hypertensive medication, antiplatelet therapy, low molecular weight heparin at a prophylactic dose, repeated

laboratory blood tests including arterial blood gases, and CT angiography on the day of the admission, before discharge, at 3 and at 12 months after patients' discharge. After the first year, patients are followed up with duplex scan in turn with CT scan to avoid exposure to radiation. Although there is an ongoing debate regarding the efficacy of antithrombotic therapy (anticoagulation and antiplatelet medication), studies revealed that they do not demonstrate any advantages in terms of clinical or morphological outcomes.[7,27] Endovascular therapy includes bare metal stent, coil assisting bare stent therapy, coil embolization[3,6,18,28,29], whereas open surgical therapy is preferred in cases where exploration of the abdomen is mandatory. Patch angioplasty or bypass is still an option, but endovascular therapy is the preferred method because of its high technical success and low complication rate.[30] Nowadays, hybrid approach is almost always available, however there is still no case report announced in Pubmed database.

Regarding prognosis, dissection can progress in various ways. It may exhibit a self-limited course with symptom resolution, progress to involve distal branches, develop into aneurysmal dilatation, or, in more severe cases, culminate in rupture.[19] Current literature supports that approximately 20% of patients who were treated conservatively, developed aneurysmal dilatation requiring intervention during the follow-up period.[31,32] In a review by Wang it is reported that 8% of the symptomatic celiac artery dissection patients and 12% of the symptomatic superior mesenteric artery dissection patients who were managed conservatively, required secondary intervention during follow-up, whereas none of the asymptomatic patients needed further intervention.[33] Superior mesenteric artery seems to fail to achieve complete remodeling, and therefore, it is correlated with more complications.[33] Moreover, comparing visceral artery dissection with renal artery dissection it can be supported that the latter has worst prognosis, since it is correlated with increased complications and mortality.[34,35] Patients who have visceral artery dissection with otherwise normal appearing arteries carry a higher risk of major adverse arterial events compared with those with fibromuscular dysplasia, primarily because of recurrent dissections.[36,37]

In conclusion, given the heightened frequency of case series and reports in the literature over the past decade, one may infer a probable contemporary escalation in the prevalence of isolated visceral artery dissection. This condition poses challenges in the emergency department where its symptoms, encompassing abdominal and back pain, are commonplace, and clinical presentation may mimic other gastrointestinal or musculoskeletal disorders, potentially leading to misdiagnosis. While conservative management during the acute phase is often feasible, further comprehensive data on mid and long-term outcomes and management are needed.

ACKNOWLEDGMENTS

None.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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author	year	country	patients	age	gender	symptomatic/ asymptomatic	vessel	risk factors	therapy	in hospital regimen	home prescription	fup
Aciu et al	2022	USA	1	57	male		CA extended to splenic (Segmental splenic infarction)	hypertension	conservative	antihypertensive + dual antiplatelet	antihypertensive + antiplatelet	6 months
Yamaguchi et al	2022	Japan	1	48	male		hepatomesenteric trunk (acalculous cholecystitis)	none	conservative	n/a	n/a	n/a
Ialani et al	2021	India	1	60	male		CA, SMA	hypertension	conservative	hep 5000u three times daily	anticoagulation	3 months
He et al	2021	China	27	24-77	24 male, 3 women		16 sma, 6 abdominal, 3 splenic, 2 renal	n/a	n/a	n/a	n/a	n/a
Yamaguchi et al	2021	Japan	1	80	male		SMA	hypertension	false lumen coiling	n/a	n/a	
Gao et al	2021	China	28	43-68	23 male, 5 women		CA, SMA	smoking, hypertension, drinking, diabetes, cancer, gastrointestinal, cerebrovascular disease	Bare metal stents	anticoagulation + antiplatelet	anticoagulation + antiplatelet	3-77months
Mkangala et al	2020	Chine	62	52.55 ±7.22	83.9% male		SMA	hypertension 41.9% (n = 26, atherosclerosis 41.9% (n = 26), smoking 25.8 (n = 16)	14 concervative, 48 endovarscular	hep 1mg/kg twice daily and aspirin 100mg	dual antiplatelet in endovascular group	28.76 ±12.87
Yokoyama et al	2020	Japan	1	41	male		SMA, renal	hypertension	conservative, endovascular	anticoagulation + antiplatelet	antiplatelet	6 months
Shiraki et al	2020	Japan	36 (2010-2016)	mean age 54.6	29male/7female		26 SMA, 9 CA, 2 splenic, 1 common hepatic, 1 gastroduodenal, 1 left gastric	hypertension, smoking	94.4% conservatively, 5.6% endovascularly	anticoagulation + antiplatelet	n/a	n/a
Hoglund et al	2020	USA	1	54	male		CA extended to common hepatic, proper hepatic, right and left hepatic arteries, as well as the proximal gastroduodenal artery	hypertension	conservative	anticoagulation	apixaban	3 months
Moran et al	2020	USA	1	middle aged	male		CA, 2 renals	variant of transforming growth factor beta receptor 1 gene (TGFBR1).	Bare metal stents	anticoagulation	n/a	5 months
Komem et al	2019	Israel	1	51	female	symptomatic	CA, splenic, IMA, right renal , both external iliac, right internal carotid artery	COL3A1 subtype mutation (c.3199A>T, Ser1067Cys variant), smoking, migraines	endovascular (Stenting)	anticoagulation	dual antiplatelet	12 months
Jeong et al	2018	Korea	23+40 (2010-2016)	48 (25-82)	91% male	symptomatic	23 renals (results compared with 40 SMA)	Diabetes mellitus 13%, Hypertension 17%, Smoking 70%	35% endovascular (stent, coil, stent+coil)	iv heparin 78%	warfarin for 6 months	median fup 20 months (range 0-63)
Yamaguchi et al	2018	Japan	47 (2005-2016)	mean, 62.8 ± 12.6 years; range, 35-88 years	43 male, 4female	22 pts symptomatic, 25 asymptomatic	SMA 37, 10 CA	hypertension (n=21, 44.7%); hyperlipidemia (n=11, 23.4%); diabetes mellitus (n=8, 17.0%); smoking (n=29, 61.7%); Ehlers-Danlos syndrome(n=1, 2.1%); and segmental arterial mediolysis (SAM) (n=1, 2.1%)	conservatively, 1 pt endo, 5 pts endo during fup	antiplatelet or anticoagulation, prostaglandin E1	antiplatelet 6-10 months	mean follow-up 925.1 ± 383.0 days for the symptomatic group (n=21: 1 patient died of sepsis during hospitalization) and 710.4 ± 737.6 days for the asymptomatic group
Morgan et al	2018	USA	77 (2006-2016)	56 years (range 26 - 86)	80% male	64% symptomatic, 36% asymptomatic	CA, SMA, 18% combined CA+SMA	13% connective tissue disorder	4 pts open surgical repair,1 pt stenting, the rest conservatively	anticoagulation 52%, 30% antiplatelet, 13% observation	3-5 months anticoagulation, indefinite antiplatelet	mean fup 21 months
Tanaka et al	2018	Japan	39 (2007-2016)	median age 52	94.9% male		CA, SMA	hypertension (48.7%), smoking (79.5%)	32pts conservative, 7pts open or endo	anticoagulation or antiplatelet	n/a	median fup 11 months
Heo et al	2017	Korea	116 (2001-2016)	mean age, 54.7±10.8 years	92% male	76% symptomatic	SMA	hypertension, smoking, connective tissue disorder, cancer	83pts conservatively, 6 open surgical repair or endovascularly	anticoagulation or antiplatelet or none	n/a	53±39 months (range:1-173 months)
Otsuka et al	2017	Japan	32 (2005-2015)	mean age 54 years (30-85)	28male, 4 female	symptomatic	10 CA, 15 SMA, 5 CA+SMA	13 pts hypertension	29 pts conservatively, 1pt open surgical repair, 3pts embolization	six pts took heparin 10,000 unit/day	no antiplatelet/ anticoagulation	3.8 ±2.6 (1-10) years
Melnychuk et al	2017	USA	1	37	male		CA extented to hepatic artery	hypertension, smoking, possible fibromuscular dysplasia	conservative	heparin infusion	antiplatelet	2 months
Binh Le et al	2016	Korea	1	55	male		CA, SMA, both renals	hypertension	conservative (CA,renal) + endovascular (stenting SMA, 1 renal)	heparin infusion	anticoagulation + antiplatelet	84 months
Nonami et al	2016	Japan	56 (2004-2015)	54 years (range, 32-86 years)	89.3% male		40 SMA, 16 CA	hypertension, smoking, DM, ischemic disease, other visceral dissection, dyslipidemia	conservative, 3 endo, 2 open	12.5% anticoagulation, 0% antiplatelet		median fup 22.5 months (1-112)
Su et al	2016	Australia	1	43	female		hepatic artery	fibromuscular dysplasia, hypertension	conservative	dual antiplatelet	dual antiplatelet	four months
Ichiba et al	2016	Japan	1	51	female		left gastric	hypertension	pseudoaneurysm coil embolization	none	none	6 months
Sun et al	2016	China	23 (2009-2014)	median age 50 (30-82)	83%male, 17% female		CA	48% hypertension, 48% smokers	15 endo (stenting or embolization), 8 conservatively	n/a	n/a	mean fup 21 months (6-70 months)
Hee Ko et al	2015	USA	23 (2005-2014)	58.4 (31-80)	78%male	78% symptomatic	CA, SMA	65.2% hypertension, Hyperlipidemia 56.5%, Smoking 21.7%, Diabetes 8.7%	observation in 4, anticoagulation in 13, endovascular stenting in 6 patients	13 pts anticoagulation or antiplatelet	antiplatetel those treated	23.8 months
Alcantara et al	2015	USA	10 (2009-2013)	mean age 61.5 ± 10.3 (range 41-77 years)	90% male	6pts asymptomatic, 4 symptomatic	CA,SMA	hypertension, smoking,	observation without anticoagulation in 8 pts (80%), anticoagulation in 1 pt (10%), endovascular stenting in 1 pt (10%)	antiplatelet	antiplatelet	fup 14.7 ± 11.6 (1-31 months)
Galastri et al	2015	Brazil	10 (2009-2014)	44.8 (35-55)	90%male	symptomatic	CA	hypertension 40%, polyarteritis nodosa 30%	conservative 9pts , 1 pt stent + coil embolization	anticoagulation	anticoagulation (+antiplatelet in 5 pts)	mean fup 19 months (2-59)
Black et al	2014	UK	1	51	male	symptomatic	CA	none significant	conservative	n/a	n/a	n/a
Perini et al	2013	Brazil	4 (2010-2011)	mean age, 51 years; range, 43-65 years	male	symptomatic	CA	n/a	coil embolization, plug	n/a	n/a	median, 4.5 months; range, 3-24 months

Open surgical repair of a giant iatrogenic pseudoaneurysm of the profunda femoral artery. A case report and review of the literature

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Abstract:

We report the case of a 92-year-old male patient who suffered from a 9-cm iatrogenic pseudo-aneurysm of the left profunda femoris artery (pr.FA) and managed surgically by excision and interposition of an autologous bypass. Femoral artery (FA) pseudoaneurysms are the most common iatrogenic arterial injuries caused by FA catheterizations. In particular, they can remain clinically silent but are potentially lethal if not diagnosed or treated promptly. Endovascular or minimally invasive techniques are the predominant first-line treatment options, however in challenging cases surgical reconstruction remains the most successful definitive treatment.

Keywords: deep femoral artery peudoaneurysm, iatrogenic arterial pseudoaneurysm, surgical repair.

INTRODUCTION

Femoral artery (FA) pseudoaneurysm results from a variety of mechanisms including blood-borne infections, trauma, injection of illegal substances, arterial access for diagnostic and endovascular procedures, closure devices, synthetic graft infections and chronic anastomotic degeneration of bypass grafts. Iatrogenic FA pseudoaneurysm is a classical complication of arterial percutaneous diagnostic angiography or interventional procedures which occurs in 0.2-2.6% of cases.[1] During the recent years there is a gradual increase in their diagnosis and treatment due to the increase in endovascular catheterizations and medical interventions, both diagnostic and therapeutic.[2]

On the other hand, profunda FA (pr.FA) pseudoaneurysms pose a larger challenge in respect to its diagnosis and management, being more "silent" in terms of clinical examination and potentially lethal if they remain underdiagnosed. Surgery is considered the traditional revascularization option whereas endovascular and minimally invasive procedures have become attractive alternative treatment strategies and promising first-line therapeutic options.[3] We describe the case of a 92-year-old male patient who suffered from a giant 9-cm in length iatrogenic pseudoaneurysm of the pr.FA and managed surgically.

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doi: 10.59037/a2f3nn16
ISSN 2732-7175 / 2024 Hellenic Society of Vascular and Endovascular Surgery Published by Rotonda Publications

CASE

A 92-year-old male patient was admitted to the Cardiology department of our district hospital for suspected endocarditis following a 14-day period of fever of unknown etiology. Trans-esophageal echocardiogram and positive blood cultures for gram-positive cocci (*staphylococcus aureus*) confirmed the diagnosis. The patient had a medical history of transcatheter aortic valve replacement in a tertiary referral hospital with left femoral access three months ago and atrial fibrillation under anticoagulant treatment. Other clinical information of his past cardiac intervention could not be retrieved. At his admission to the hospital, the patient reported an increasing discomfort in his left mid-thigh, initially started as vague pain since he was at home but gradually turned into a worsening, non-remitting pain during the course of his hospitalization. At clinical examination, a pulsating painful mass in the suspected region was palpated. Ankle-brachial index was approximately 0.55 on the suspected leg due to concomitant femoropopliteal occlusive disease. Ultrasound color-duplex scanning using a 5-MHZ convex array transducer revealed a giant (9-cm in diameter, 5-cm in length) expanding pr.FA pseudoaneurysm, located approximately 5-cm distal to the femoral bifurcation, between the 2nd and 3rd perforating artery (Figures 1-3). While an endovascular option was initially considered as an attractive solution due to its minimally invasive nature, the advanced patient's age and

his current anticoagulation treatment, we opted for open surgical repair. Our treatment strategy was principally technically defined due to the broad base without neck expanding pr.FA pseudoaneurysm and also clinically driven to minimize the possibility of establishing permanent neuropathy by surgical evacuation of the hematoma causing compressive symptoms. An additional significant parameter in decision making was the lack of an established diagnosis by the time of intervention, with possible diagnoses including iatrogenic or infected pseudoaneurysm. In the latter case we would prefer to avoid placement of endovascular materials in infected areas.

Therefore, through an extended anteromedial left groin surgical approach exposing the femoral bifurcation and its branches, the culprit branch of the pr.FA pseudoaneurysm was dissected and excised while reconstruction was completed by interposition of an autologous bypass using segment of the distal ipsilateral greater saphenous vein (Figure 4). Perioperatively, 3 units of packed red blood cells were transfused. The patient had an uneventful recovery, having a mild wound lymphorrhea treated conservatively with elastic compression, completely resolving at 3 months post-operatively. Pseudoaneurysm and arterial wall microbiology cultures were negative for any infectious organism. Follow-up at 6 months revealed no complications.

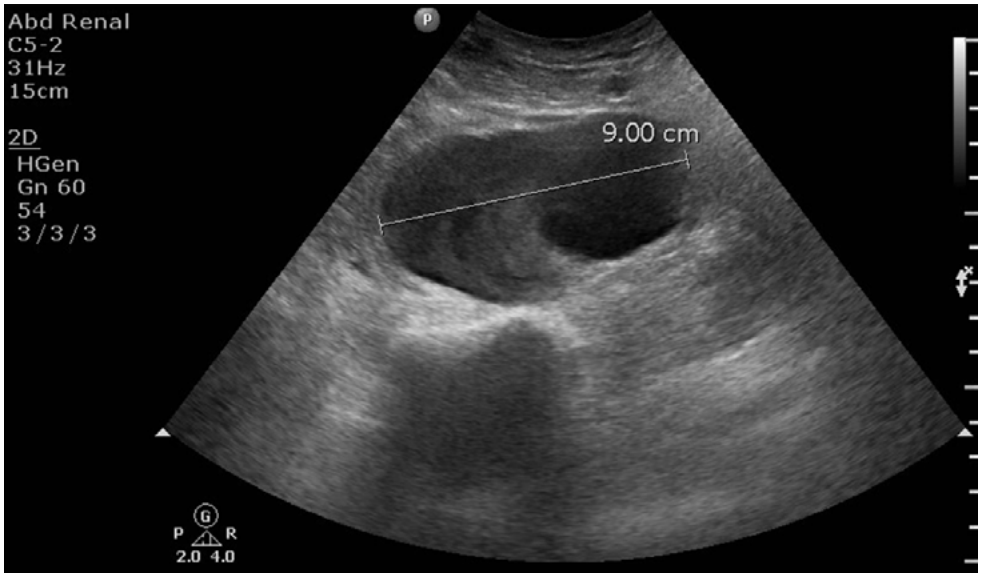

Figure 1: Gray scale ultrasound longitudinal scan of the left upper thigh reveals a 9cm intramuscular unilocular cystic lesion with floating echogenic particles in it.

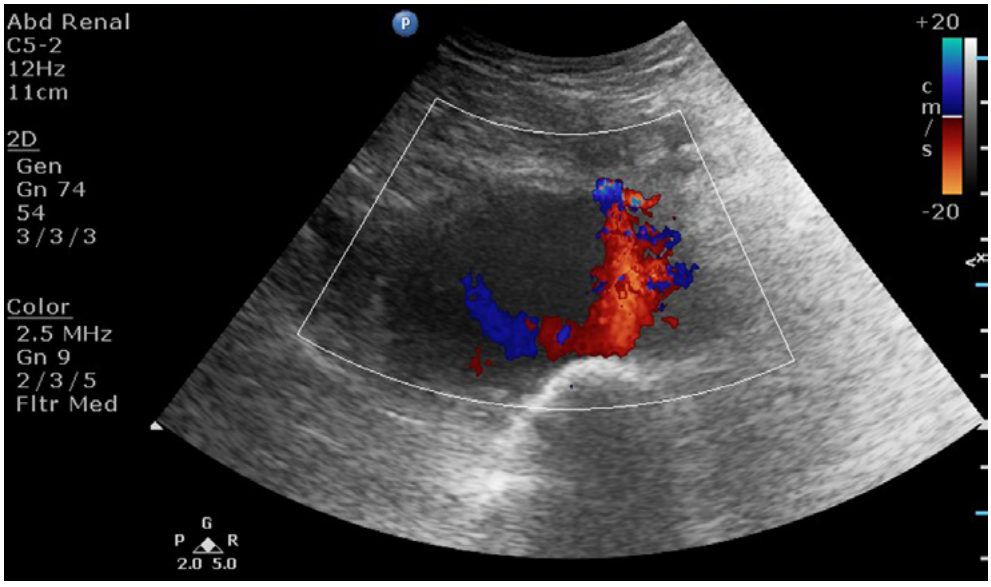

Figure 2: Color Doppler ultrasound longitudinal scan of the left upper thigh reveals bidirectonal flow inside the aforementioned lesion typical of aneurysm/pseudoaneurysm (the yin-yang sign). It also depicts the feeding artery (a branch of the profunda femoral artery (pr.FA)).

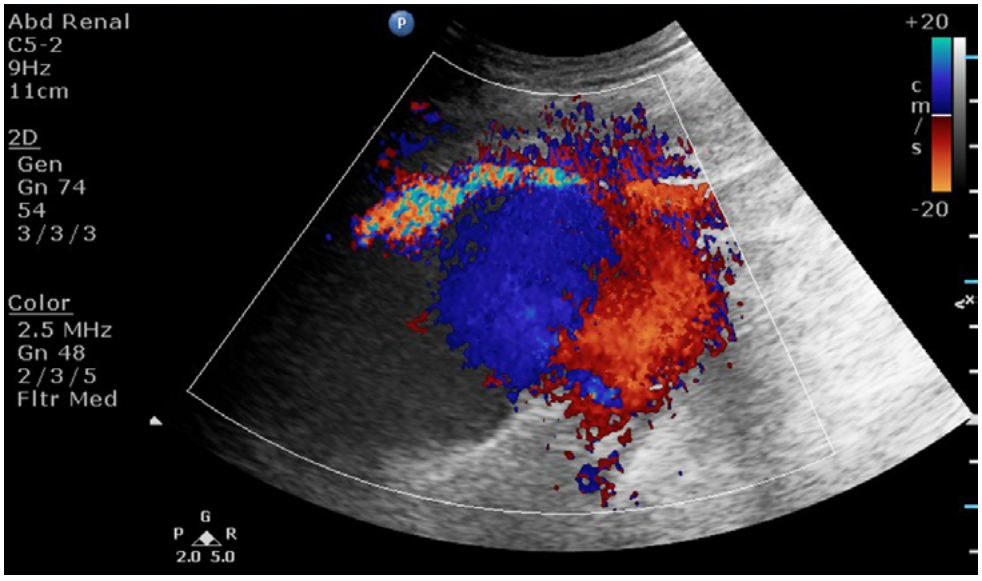

Figure 3: Color Doppler ultrasound transverse scan of the left upper thigh depicts the high-velocity jet of blood entering the pseudoaneurysm.

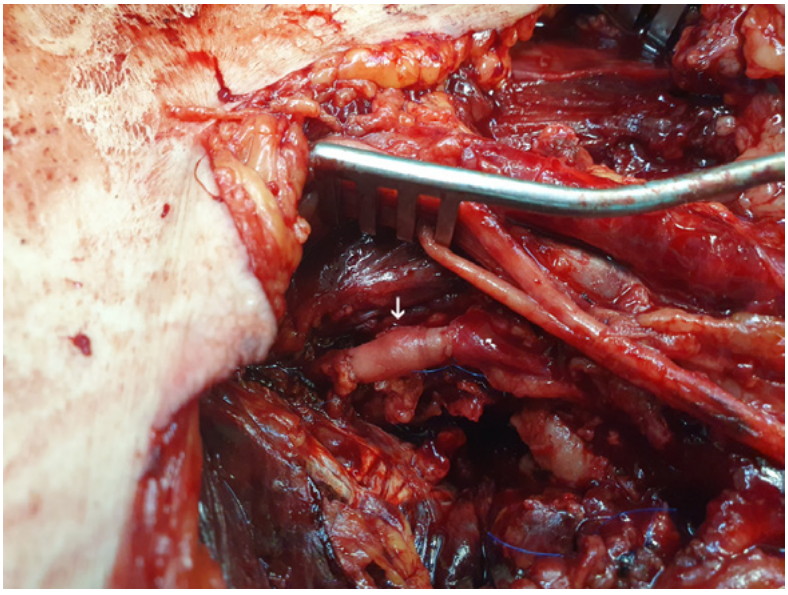

Figure 4: Aneurysm excision and vein interposition grafting (arrow) between the 3rd and 4th perforating branch of the pr.FA.

DISCUSSION

The common FA is the most common access site for endovascular procedures, and it is therefore essential for interventionists to know how to recognize and manage iatrogenic complications associated with this type of access. Pseudoaneurysms are reported to occur in 1% of diagnostic arteriograms and up to 8% of therapeutic endovascular interventions.[4] The most frequent complications range from 0.5% to 8% and include hematoma, uncontrollable groin and/ or retroperitoneal bleeding, Pseudoaneurysm formation, arteriovenous fistula, and in situ arterial dissection with or without associated thrombosis.[5] Less frequent complications include distal embolization, nerve damage, abscess, and lymphocele.[5] In recent years, a number of percutaneous closure devices have been developed, with the hope of reducing the frequency of local complications and allowing early patient mobilization post endovascular intervention. Large clinical trials have indeed demonstrated patients' preference for the use of these closure devices compared to the long bedrest associated with the more traditional method of manual compression. However, these studies failed to demonstrate a reduction in local complications associated with the use of these devices.[6]

Coronary angiography, angioplasty and stenting are recognized risk factors for FA pseudoaneurysm formation.[7] Procedural factors, which mostly influence risk of complications include use of a sheath size greater than 8 Fr. and faulty puncture technique, either puncture above the inguinal ligament or puncture of the superficial FA or pr.FA.[8,9] The latter occurs

more frequently if the origin of pr.FA originates behind or even above the inguinal ligament, an anatomical variation observed in 25% of cases.[10] Patient-specific risk factors include arterial hypertension, female gender, coagulopathy, severe peripheral arterial disease, hostile groin anatomy, high femoral bifurcation, nonflexible hip, advanced age, obesity, erythematous skin, intertrigo and anticoagulation, antiplatelet or fibrinolytic medication.[11]

Endovascular repair of femoral arterial access complications is considered an attractive solution in patients who cannot tolerate vascular reconstruction and bleeding due to advanced cardiovascular disease.[12] The number of percutaneous endovascular interventions performed worldwide has been growing rapidly due to important technological advances, improved long-term clinical outcomes, and, also, the lower morbidity associated with these procedures compared with traditional surgical techniques.[13] Endovascular procedures can be performed under local anesthesia, are well tolerated by the patient, and are associated with a short hospitalization time. Nitinol stent technology allows for safe stent and stent-graft extension at the common FA level, due to increased resistance to external compression and bending stress.[14] Thalhammer et al included 26 patients after repair of iatrogenic pseudoaneurysms of the femoral bifurcation, reporting high technical and clinical success, concluding that stent-graft placement is an effective, low-risk procedure, especially in high-risk patients.[12] Despite absence of long-term results for the covered stent technology in the literature, relative contraindications for the endovascular approach could include young patients who are good candidates for open surgery, extreme elongation and tortuosity of the femoral vessels, short femoral bifurcation and increased cost of the device.[13]

Ultrasound-guided compression is an effective treatment for FA pseudoaneurysms, with success rates of ranging from 70% to 90% in patients without anticoagulation therapy.[15] Nevertheless, this method has significant limitations. It is painful and time-consuming, with suboptimal results in patients who are obese and under anticoagulant treatment.[16] As an alternative, direct percutaneous embolization of the pseudoaneurysm sac with different embolic materials has been reported. Thrombin is the most popular embolic agent used for percutaneous occlusion of FA pseudoaneurysms because it causes fast and efficient thrombosis in the aneurysmal sac without filling it with foreign material.[17] However, some complications may occur with this agent, including allergic reaction and distal thrombosis of the parent artery by leakage through the pseudoaneurysm neck.[18] Kurzawski et al. prospectively studied 353 patients treated by thrombin injection and reported 53 (15%) arterial microembolizations and 1 (0.3%) pulmonary embolism in a case of concomitant arterial-venous fistula.[19] Comparing these two methods, the only randomized clinical trial existing in the literature concluded that percutaneous thrombin injection appeared to be more effective than ultrasound-guided compression in achieving primary thrombosis of a pseudoaneurysm, although other case series in the literature have reported higher pseudoaneurysm sac thrombosis rates with compression compared to previous case series.[14,20]

N-butyl-2 cyanocrylate glue is a potential alternative to thrombin, initially described or treating arterio-venous malformations amenable to endovascular interventions.[21] However, its main drawback is the risk of direct percutaneous distal embolization due to escape of the material from the pseudoaneurysmal sac before it is completely polymerized.[22] For this reason, Griviau et al described the technique of inflating an angioplasty balloon at the orifice of the pseudoaneurysm during glue injection and to avoid blood backflow and reflux of glue into the native artery.[23] Potentially less effective method for reducing the risk of distal ischemia or recurrence of the pseudoaneurysm is manual effective methods to decrease the risk of distal embolization is manual compression of the either neck or the sac of the pseudoaneurysm by ultrasound until no sac flow is observed in the pseudoaneurysm, followed by glue injection. However, these techniques are more technically challenging to identify the no-flow pseudoaneurysm after compression by ultrasound, especially if the patient is obese or the hematoma is large.[24,25]

In the era of endovascular evolution, surgical treatment of FA pseudoaneurysms is less common but can be life-saving, especially when other modes of intervention are more likely to fail or are contraindicated. Major indications that favor surgical management over endovascular management are infected pseudoaneurysms, rapid sac expansion, skin necrosis and compressive symptoms such as neuropathy, claudication and critical limb ischemia.[3] Among the surgical solutions, interposition bypass, saphenous vein patch angioplasty and vessel ligation are included. On the other hand, surgical reconstruction leads to increased local complications and prolonged hospitalization. Although there are no large clinical series or comparative studies existing in the literature, the implementation of endovascular or minimally invasive techniques could theoretically provide an advantage in terms of morbidity and mortality compared to open surgery. This avoids the need for a general anesthetic in a group of patients with significant comorbidities who cannot tolerate vascular general reconstruction with concomitant blood loss.[14]

In our patient, obesity, a small-neck with a large diameter pr.FA pseudoaneurysm surrounded by an extended hematoma and the crucial loss of the only outflow vessel (pr.FA) in the leg applying risky procedures were unsuitable factors for endovascular or minimally invasive strategy. Further selection criteria for open surgical reconstruction were the rapidly expanding pseudoaneurysm from the continuous intrasac bleeding and worsening neuropathy due to local compression symptoms of the femoral nerve. In this regard, resolution of the symptoms would be improved only after surgical decompression of the hematoma, reducing also the risk of a future infected hematoma in the groin region.

CONCLUSION

Femoral PAs are relatively common iatrogenic injuries following therapeutic and diagnostic catheterization procedures. In particular, pr.FA pseudoaneurysms are clinically silent but potentially lethal, especially if remain underdiagnosed or left untreated. Although endovascular or minimally invasive

techniques have been evolving and transforming into the gold-standard treatment option, surgical reconstruction still remains the sine qua non of vascular repair, especially in selected cases not amenable to endovascular solutions.

The Authors state that

(1) there has been no duplicate publication or submission of any part of the revised work;

(2) all have read and approved the revised manuscript; and

(3) This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sector

(4) there is no conflict of interest within the manuscript

(5) Informed consent has been obtained from the patient for publication of the case report and accompanying images.

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Penetrating carotid artery injury

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A 27-year-old male presented with a left cervical pulsative mass after penetrating trauma with a knife. No external bleeding was observed despite the presence of an open skin incision over the sternocleidomastoid muscle. Urgent Computed Tomography Angiography (CTA) revealed a partial transverse transection of the left common carotid artery (CCA) and the adjacent internal jugular vein (IJV) surrounded with a cervical hematoma due to gross extravasation from both vessels (Figure). In operating theatre, after a standard open approach for carotid endarterectomy, the CCA and IJV were clamped. The CCA was totally transected at the injury site, trimmed and re-anastomosed in an end-to-end fashion. The IJV was primarily sutured, and the hematoma was evacuated. The postoperative care was uneventful, and the patient was discharged on the 4th postoperative day. She was prescribed single antiplatelet and antibiotic treatment.

Carotid artery injury is a rare event, which may manifest as a true or false aneurysm, arteriovenous fistulae, dissection or thrombotic occlusion. It can result from blunt or penetrating trauma, atherosclerosis, infections, iatrogenic interventions, fibromuscular dysplasia or from more innocent causes as minor neck trauma, coughing or vomiting, chiropractor manipulation or prolonged telephone usage with flexion of the neck. Common symptoms include cervical pain, a pulsatile (or non-pulsative) neck mass, carotidynia, hoarseness, dysarthria, headache, syncope, Horner's syndrome or cranial palsy. In most cases intervention is warranted to prevent rupture, exsanguination or cerebral embolization. Depending on CTA findings, alternative treatment options include open repair with primary suturing or end-to-end anastomosis, endovascular repair with insertion of bare or covered stents and embolization with coils in bleeding side branches. In many cases blunt dissections or thrombotic occlusions may be treated conservatively with antithrombotic therapy.

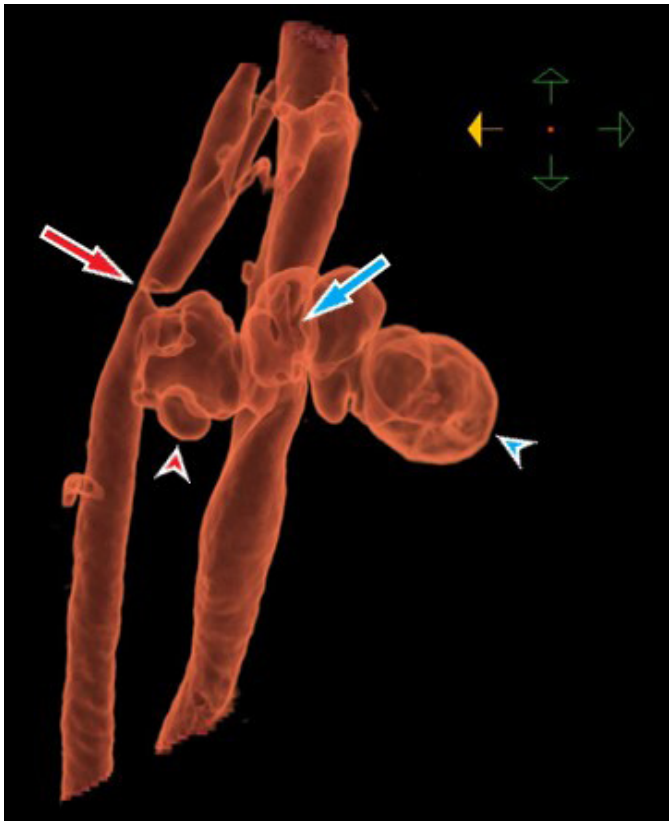

Figure: An urgent Computed Tomography Angiogram (CTA) with 3D VRT reconstruction of the cervical vessels depicted almost complete transection of left common carotid artery (red arrow), with formation of a traumatic pseudoaneurysm (red arrowhead). Additionally, a concurrent traumatic rupture of the left internal jugular vein (blue arrow), with formation of a similar traumatic pseudoaneurysm is also depicted (blue arrowhead).

CONFLICT OF INTERESTS

None

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doi: 10.59037/pwd17k22
ISSN 2732-7175 / 2024 Hellenic Society of Vascular and Endovascular Surgery Published by Rotonda Publications

Ruptured Degenerative Common Femoral Artery Aneurysm

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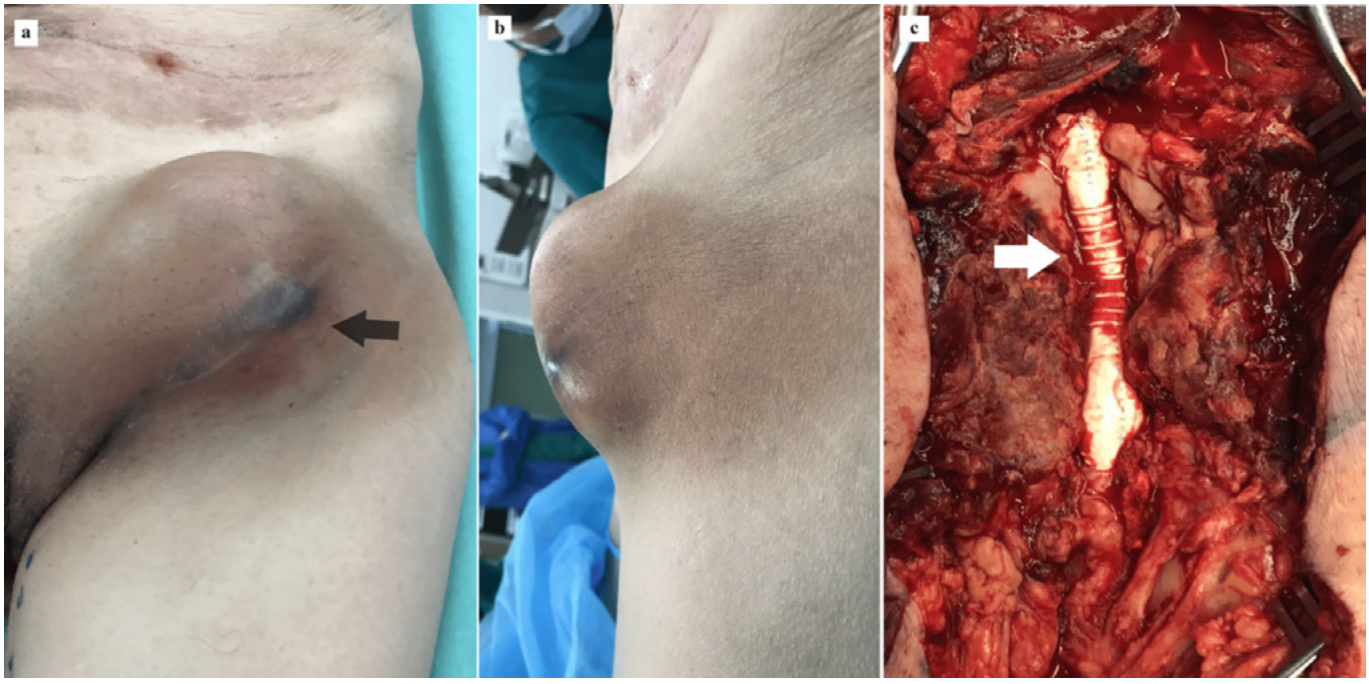

Figure 1. a) Frontal view of the extensive inguinal mass. Spot of imminent skin necrosis is pointed by black arrow. b) Lateral view of the same lesion also helps to appreciate the size and extension of the inguinal mass. c) Intraoperative image of the arterial reconstruction where an 8mm polytetrafluoroethylene (PTFE) graft (white arrow) has been end-to-end anastomosed to the external iliac artery proximally and femoral bifurcation distally.

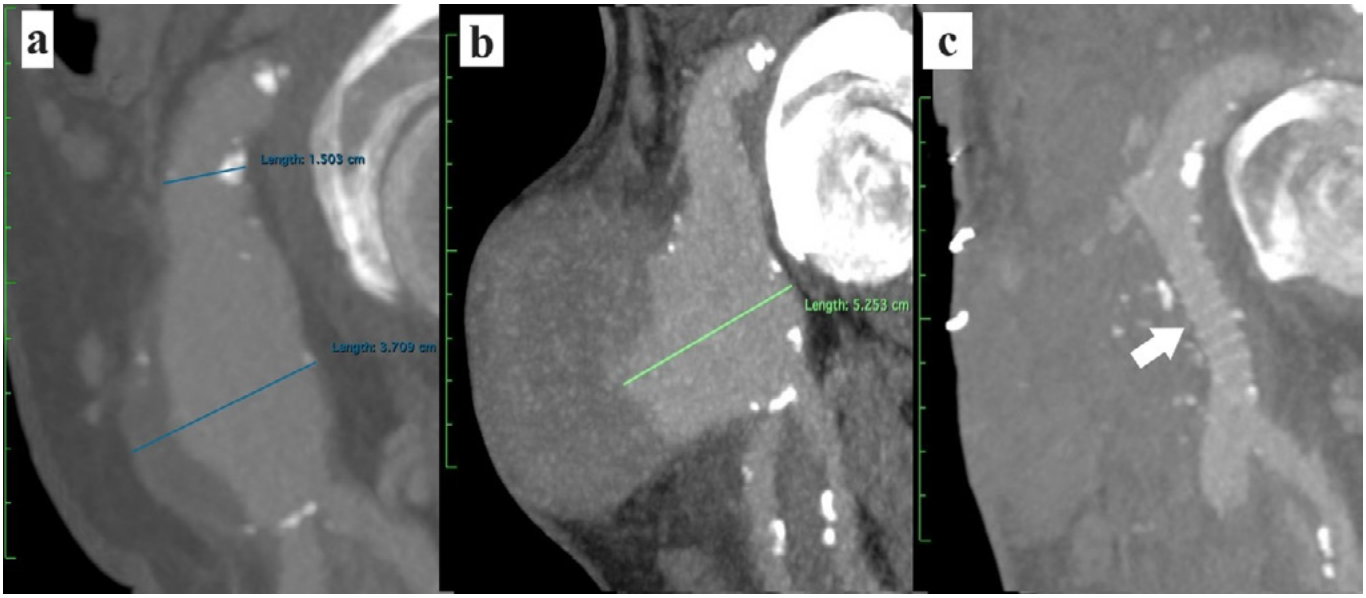

Figure 2. a) Computed Tomography Angiography (CTA) image on a sagittal plane, performed almost a year ago, showing a degenerative left Common Femoral Artery Aneurysm (CFAA) with mural thrombus, measuring 3.7cm. b) CTA image performed at current presentation showing a contained rupture of the ipsilateral CFAA. c) Postoperative CTA image showing the arterial reconstruction. White arrow indicates the 8mm PTFE graft.

A 75-year-old male patient presented acutely complaining of a painful and increased in size left inguinal mass. Being haemodynamical stable, physical examination revealed a severe palpable inguinal mass where the overlying skin was erythematous with spots of imminent necrosis (Figure 1a and b). He had a history of Endovascular aortic Aneurysm Repair (EVAR) eight years ago on the background of aneurysmatic disease progression following an initial open repair of his abdominal aortic aneurysm seventeen years ago. Urgent Computed Tomography Angiography revealed an isolated ruptured Common Femoral Artery Aneurysm (CFAA) (Figure 2b). Right afterwards, under general anaesthesia proximal control was obtained by exposing, through a longitudinal incision, the very distal left External Iliac Artery (EIA) right above the inguinal ligament and distal control by exposing the proximal superficial femoral artery. Following haematoma and aneurysmatic sac evacuation, back-bleeding from the profunda was halted by inflating a 3Fr Fogarty catheter. Then, arterial reconstruction was succeeded by an 8mm polytetrafluoroethylene graft (Gore Propaten, Flagstaff, AZ, USA) anastomosed proximally to the EIA and distally to the common femoral bifurcation (Figure 1c). Recovery was successful, patient was discharged and returned in three-weeks-time for an endovascular repair of his bilateral type Ib endoleaks. True isolated CFAA is rare with an incidence of five patients per 100,000[1]. Up to 60% of the cases are asymptomatic and recent data suggest that risk of complications like rupture (6%) or thrombosis (4%) are rare for those smaller than 3.5cm[2]. Our patient had a CTA a year ago which showed a left CFA measuring 3.7cm but was not picked up (Figure 2a). Clearly our case shows how aneurysmatic disease progresses with time and sets a high suspicion for an underlying connective tissue disease.

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doi: 10.59037/32r6wf96
ISSN 2732-7175 / 2024 Hellenic Society of Vascular and Endovascular Surgery Published by Rotonda Publications

ACKNOWLEDGEMENTS

None

CONFLICT OF INTEREST

None declared.

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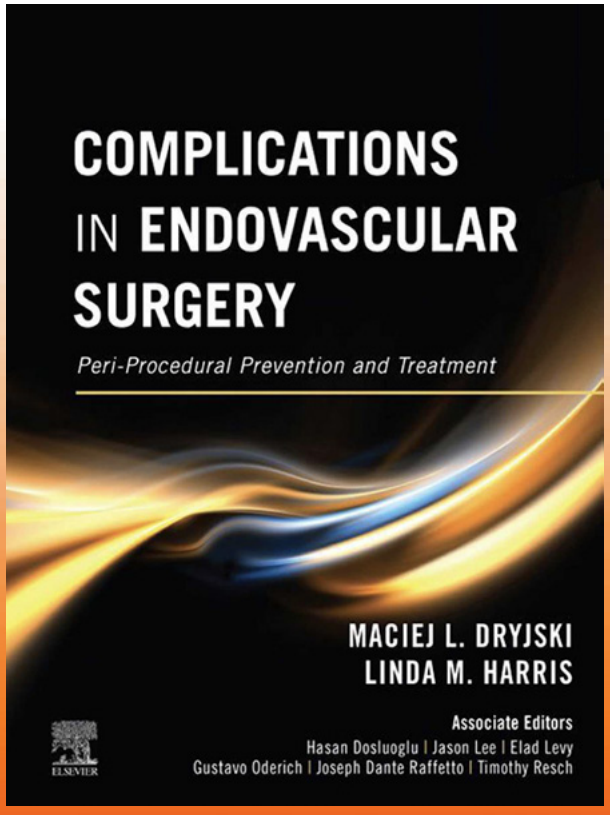

Publication Date: 04/2021
PRICE: 190€

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