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Nikolaos Kontopodis, Christos V. Ioannou

Vascular Surgery Unit, Department of Cardiothoracic and Vascular Surgery, University of Crete Medical School, Heraklion, Greece


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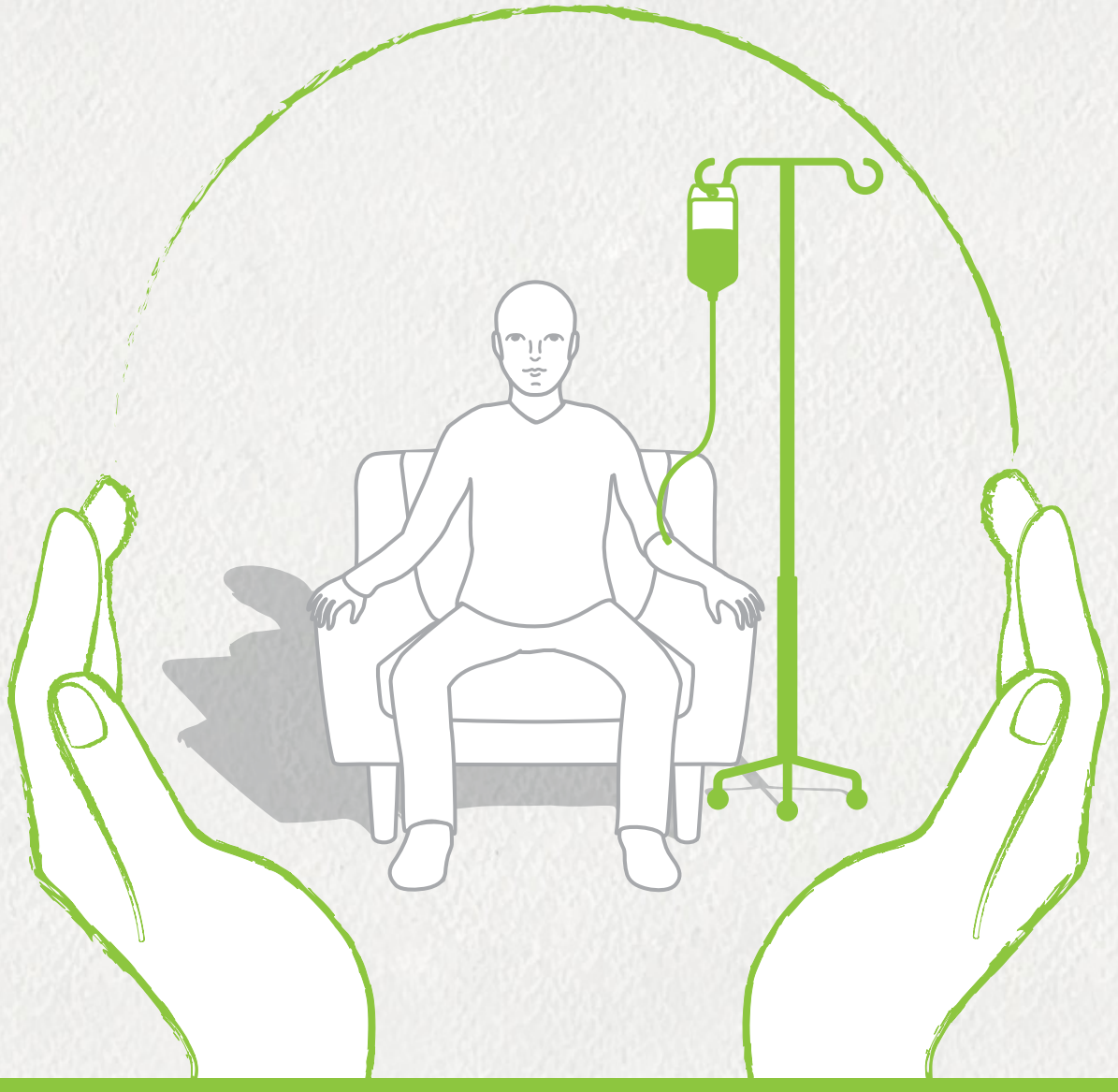

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EDITORIAL

Which PAD patients will probably benefit more from a COMPASS strategy?

Miltos Matsagkas, Petroula Nana, Konstantinos Spanos

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Peripheral arterial disease (PAD) affects more than 100 million people worldwide, while 65% of these patients remain asymptomatic.[1] It is estimated that probably just 5% of patients suffering from PAD, have the typical clinical symptoms of intermittent claudication.[1] The REACH registry (including 8322 patients with PAD) has demonstrated that 3 out of 5 patients with PAD have also concomitant coronary artery disease (CAD) and/or other cardiovascular disease.[2] Almost 40% of the REACH population had concomitant PAD and CAD, while 13% of them suffered from poly-vascular disease affecting more than 2 vascular beds.[2] Symptomatic PAD patients are in higher risk not only for major cardiovascular events (myocardial infarction and stroke, 20%) but also, for PAD progression and limb amputation (4-27%/year).[3] In this group of patients, all-cause mortality and cardiovascular mortality is estimated between 10-37% and 9-25%, respectively.[3]

The European Society of Vascular Surgery (ESVS) Guidelines published in 2017 in collaboration with the European Society of Cardiology (ESC) for the management of PAD recommended that symptomatic PAD patients should be under treatment with single antiplatelet therapy with clopidogrel or aspirin (Class I A), showing a slight preference to clopidogrel.[4] However, at the time being, more than 20 years after the publication of CAPRIE trial[5], aspirin is the antiplatelet drug mostly used for these patients.[6] These guidelines also recommend no antiplatelet therapy for the asymptomatic PAD patients (Class III A).[4] For asymptomatic patients, antiplatelet therapy with aspirin seems to offer no clear benefit in diabetic and/or non-diabetic populations.[7,8] Double antiplatelet therapy (DAPT) may offer a slight benefit in very high risk patients in the prevention of cardiovascular events, significantly increasing at the same time the risk of major bleeding.[9] Thus, the indications of DAPT are doubtful and restricted only to patients at very high risk for cardiovascular events and limb loss, if they are at low risk for bleeding.[10] Oral anticoagulation with vitamin K antagonists has been proved inadequate for PAD patients, offering no benefit, while leading in excessive bleeding and should not be used.[4]

In late 2017, the COMPASS trial evaluated the role of low dose rivaroxaban (2.5mg x 2) in combination with aspirin (100mg x 1), in comparison to aspirin alone, in the prevention of secondary cardiovascular events in almost 27000 stable atherosclerotic cardiovascular patients.[11] The rationale was that this dual inhibition pathway stopping platelets activation and aggregation through aspirin and at the same time reducing thrombin generation though low-dose rivaroxaban, would probably have more favorable results in reducing secondary cardiovascular end-points.[11] The primary outcome was a composite of cardiovascular death, stroke or MI. The study was stopped due to low dose rivaroxaban-plus aspirin superiority after a mean follow-up of 23 months.[11] Dual inhibition pathway (low-dose rivaroxaban plus aspirin) had significantly better cardiovascular outcomes, reducing major adverse cardiovascular events (MACE) among patients with stable atherosclerosis, being also the first study documenting a significantly 22% reduction in cardiovascular mortality in such patients.[11] Although intracranial and fatal bleeding were not significantly increased,[11] more major bleeding events occurred in the dual inhibition pathway group than in the aspirin alone group.[11] However, a significant net clinical benefit was reported for patients receiving this novel dual antithrombotic therapy. A pre-defined analysis of PAD sub-population in COMPASS trial, including 7470 patients, has further confirmed the benefit on MACE and mortality prevention.[12] Furthermore, a substantial reduction in major adverse limb events (MALE) and an incredible 70% decline in major amputations, was recorded in the group treated with low-dose rivaroxaban plus aspirin compared to aspirin alone.[12] However, although fatal or critical organ bleeding was not increased, major bleeding was also significantly higher in the dual path group.[12] Keeping in mind that bleeding risk in PAD patients is rationally increased, the higher bleeding rate in this group of patients is usually expected.

In 2018, a sub-analysis of the COMPASS PAD population for MALE confirmed the role of dual-path inhibition in reducing amputations and re-interventions.[13] In this sub-analysis, patients that had undergone revascularization (with bypass and/or angioplasty), amputation or had severe progressive limb ischemia (Fontaine Class 3 or 4) were at higher risk for event recurrence with a total vascular amputation rate at 23%.[13] Low-dose rivaroxaban plus aspirin treatment was associated with a reduction in MALE incidence at 43% and a decrease in total

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vascular amputations at 58%.[13] A more recent risk stratification analysis, confirmed the initial COMPASS PAD study findings. Using the REACH registry risk score and the Classification and Regression Trees survival analysis, Anand *et al*. stratified PAD COMPASS trial population in higher and lower risk for vascular event recurrence.[14] In the higher risk group, dual COMPASS therapy had favorable outcomes with a reduction of 30 events per 1000 patients in 30 months of follow-up.[14] Additionally, over time, dual inhibition pathway treatment was associated with a considerable reduction in event recurrence.[14] In terms of major bleeding, an absolute overall risk was estimated at less than 1% in 30 months.[14] It seems that in those higher risk group, the absolute risk of severe bleeding is low and the net clinical benefit even more favorable for patients treated with low-dose rivaroxaban plus aspirin compared with aspirin alone. This analysis showed also that patients with poly-vascular disease and especially those suffering from PAD and CAD are at highest risk for cardiovascular events and are these who benefit more from a COMPASS strategy, with only a small increase in bleeding risk.[14] Furthermore the authors confirmed that PAD patients suffering also from heart failure (HF), renal impairment with moderate affected eGFR (30-50 ml/min) and diabetes mellitus (DM) were also in higher cardiovascular risk and had a substantial reduction of cardiovascular and limb events if they received the dual pathway inhibition therapy.[14] These findings were even more strengthened with the simultaneous publication of the COMPASS-eligible PAD population included in the REACH registry analysis, which confirmed that PAD patients with concomitant CAD disease and those with co-morbidities such as HF, renal impairment and DM are at higher risk for cardiovascular events and also showed that adding more co-morbidities in a single patient the cardiovascular risk is exacerbating, while the bleeding risk is slightly increasing.[15] On the other hand in the COMPASS PAD analysis 22% of PAD patients were asymptomatic and these presented just 0.5% of major adverse cardiovascular and limb events during the follow-up period (in fact only 5 events in absolute numbers).[16] Therefore it is quite obvious that these asymptomatic PAD patients do not have something to earn from a dual inhibition strategy, while they will be at increased risk for bleeding.

Taking into consideration the above mentioned findings, it is important in clinical practice to identify the specific group of PAD patients that are at higher risk for MACE or MALE and will benefit the most from a dual-inhibition pathway treatment. It seems that asymptomatic patients with PAD and patients that are at high bleeding risk will not benefit by dual antithrombotic therapy. On the other hand, PAD patients with poly-vascular disease (≥ 2 vascular beds and especially these having concomitant CAD), as well as PAD patients with certain co-morbidities as heart failure, renal insufficiency and diabetes mellitus are very likely to benefit more from this novel combination anti-thrombotic treatment. Last but not least, PAD patients with prior revascularization or amputation, as well as symptomatic PAD patients (especially these presenting with severe disease deterioration), seems to also benefit from dual inhibition therapy.[14,17] It has to be mentioned that for the time being this novel strategy has not been included in any PAD guidelines as the publication of COMPASS studies came out after the most recent guidelines had been published. However in the very recent ESC guidelines regarding cardiovascular patients with diabetes, the dual pathway inhibition strategy is suggested for the first time for PAD patients with DM with a class IIa recommendation.[18]

In conclusion, the "ideal" PAD patient that should receive dual-path inhibition treatment is that having the highest risk for cardiovascular and limb events and an acceptable bleeding risk; such a patient would probably have the greatest absolute benefit. The clinician has in any case to estimate individually for each patient the benefit and the risks of this novel dual antithrombotic therapy and personalize the optimal medical treatment. For sure this novel strategy opens new horizons in cardiovascular medicine and PAD in particular, for the secondary prevention of cardiovascular and limb events, while it would be of great interest to see in the future direct comparisons of this approach with clopidogrel alone or with clopidogrel plus aspirin.

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Preoperative prediction of type II endoleak following standard EVAR

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Abstract:

Introduction: Type II endoleak (T2EL) consists the most common complication after the endovascular repair of an abdominal aortic aneurysm (EVAR). Despite been generally considered as a benign condition, aortic sac expansion is possible, and for this reason patients should be kept under close surveillance. Aim of the study was to identify preoperative parameters that are related with a T2EL and create a predicting-scoring model.

Methods: A prospective clinical study was made. All patients who underwent EVAR throughout a 12-month period in two hospitals, were included. Patients were followed for 12 months using a pre-specified protocol. Various clinical, anatomical and device specific parameters were examined as potential factors of T2EL, using univariate and multivariable analysis.

Results: Overall, 73 patients were included. Three patients were excluded due to Type I endoleak. From the rest 70 patients, 17 (24.3%) developed a T2EL (Endoleak group). These patients were compared to the patients who did not develop a T2EL (No-Endoleak group, N=53). The analysis demonstrated that 3 parameters were related with the development of T2EL: the preoperative anticoagulant treatment, the number of patent arteries in the preoperative CT scan, and the nitinol skeleton of the endograft. Based on the multivariable analysis, the ***ABS-10*** risk scoring system for the preoperative prediction of a T2EL was created as following: 4 points for prior chronic use of ***A***nticoagulants, 1 point for each patent arterial ***B***ranch from the aneurysm sac, and 5 points for a nitinol endograft ***S***keleton. A score of 7 presented sensitivity 88%, specificity 62%, positive predictive value 43%, and negative predictive value 94%.

Conclusions: A risk scoring system for the prediction of T2EL after standard EVAR was created. A score of less than 7 practically excludes the possibility of T2EL. External validation in larger populations is needed.

INTRODUCTION

Endovascular aortic aneurysm repair (EVAR) of infrarenal abdominal aortic aneurysms has been established as an accepted alternative to open surgery. EVAR is associated with lower rates of surgical mortality and morbidity, less invasiveness, and shorter hospital stay[1]. An inherent problem of the method is the development of endoleaks due to persistent, post-interventional perfusion of the aneurysmal sac[1].

Although it has been agreed that type I and type III endoleaks require urgent treatment[2], there is no such consensus at this time regarding treatment of type II endoleaks (T2EL). However, this is the most frequently occurring endoleak in approximately 10-25 % of patients who undergo EVAR[2,3]. This type of endoleak is related to retrograde filling of the aneurysm sac from aortic side branches. Typical sources of T2EL are the inferior mesenteric artery (IMA), one or more lumbar arteries, the median sacral artery, or even accessory renal arteries. These endoleaks are usually transient and get thrombosed spontaneously within the first 6 months in up to 80% of cases[4,5].

However, T2EL that persist longer than 6 months are associated with a higher probability of a complicated course[3] and, despite being small, the risk of aneurysm rupture due to an increasing intrasaccular pressure exists. Data from the EUROSTAR registry on 2463 patients suggested a cumulative 2-year incidence of rupture after T2EL of 1.8%, although this rate was no different in patients without any detected endoleak (0.9%)[6]. The increase of the aneurysmal sac size is observed significantly more often in patients with a persistent T2EL (24-52%) than in patients without it (13%)[4,5,7-9]. In the follow-up period of patients after EVAR, the increase of the aneurysmal sac size is a matter of concern and generally is an accepted criterion for reintervention[10]. In patients with a T2EL after EVAR, about a quarter will need to be treated due to aortic aneurys-

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mal sac enlargement[11], although the treatment of T2EL without changes of the aneurysmal sac remains controversial[12-19].

Little is known about the factors that can predict a T2EL preoperatively. A high suspicion of a postoperative T2EL after EVAR would be helpful for the proper selection of patients regarding the proper type of treatment they would receive including open repair. On the contrary, a minimal risk of T2EL will allow treating physicians choosing patients who will benefit of an EVAR without the question of a potential long-term hazard. Aim of this study was to determine factors that may be potentially predictive of early T2EL after standard EVAR, taking into consideration patients' clinical data, aneurysm anatomic features, and endograft details.

METHODS

A prospective clinical study was designed. The study population included all consecutive patients with AAA disease who underwent a standard EVAR throughout a 12-month period in two tertiary care hospitals in Athens area (G. Gennimatas Athens General Hospital, and Attikon University Hospital). Patients who underwent an endovascular treatment for complex aortic cases such as fenestrated grafts, parallels grafts, or iliac-branch devices were excluded from the study. All patients consented, and the Ethics Commitees of both hospitals approved the study. Patients who developed a type I endoleak were excluded from the study. The rest patients were divided in two groups: the No-endoleak group (N=53), which consisted of the patients who did not develop a T2EL, and the Endoleak group (N=17), which consisted of the patients who developed a T2EL.

The primary outcome was the existence or absence of a T2EL. All patients underwent a high-resolution multislice computed tomography angiography (CTA) with 0.5 - 1.5 mm thickness, preoperatively. Postoperatively, they entered a strict follow-up protocol, which included clinical examination and an aorta CTA scan at previously specified time-intervals (1, 6 and 12 months). A patient was considered to have a T2EL if this was diagnosed in one of the postoperative CT scans. For each patient, the endoleak type was classified according to the EVAR reporting criteria[20].

Specific sets of variables regarding the patient, the aneurysm and the endograft were examined as possible factors that could relate to the outcome (Tables 1, 2, 3). The study of the anatomic characteristics of the aneurysm was based on the preoperative aortic CTA. The CTAs were analyzed using the 3mensio Medical Imaging / Pie Medical Imaging (Bilthoven, The Netherlands) software. Two authors (DD, AML) examined independently the CT scan and when a disagreement was found this was dealt with a consensus of both.

Statistical analysis

Means and standard deviations were used for the description of the continuous data, while percentages for the description of the binary data. Each of the parameters / variables was examined as a potential factor for a T2EL on a univariable analysis using various tests based on the type of parameter (continuous or binary), and its distribution (normal or abnormal) when it regarded continuous data. A normal distribution for a continuous variable was assumed when the two-sided F test between the two groups for this specific parameter was not statistically significant ($p>.05$). The tests used for the univariable analysis were: Unpaired t test, Mann Whitney U test, Chi-square test, Yates corrected Chi-square test, and Fisher's Exact test. Descriptive statistics were presented as mean with standard deviation or rates.

Variables that were found to have a statistically significant difference between the two groups ($p< .05$) were considered as potential predictors of T2EL and were entered into a multivariable analysis as independent variables, using the outcome (endoleak or no-endoleak) as the dependent variable. Using a logistic regression analysis, the most significant factors ($p< .05$) were extracted and presumed as the definitive predicting factors for a T2EL.

Based on this logistic regression equation, a simplified risk-scoring model for the prediction of a T2EL was created. The extracted simplified risk-scoring model was subsequently tested for calibration or good-fitness (Hosmer & Lemeshow test) and discrimination (Harrell's c statistic). The ROC curve of the risk-scoring model was designed, the area under the curve was calculated, and sensitivity, specificity, and positive and negative predictive values at the relevant score cut-off levels were measured.

The Statsdirect Software for medical statistics (version 2.8.0)[10], and the MedCalc Medical Statistical software (version 12.5.0; Broekstraat, Mariakerke, Belgium) were used for the statistical analyses.

RESULTS

From a total of 73 patients, 3 patients (4.1%) developed a type 1 endoleak and were excluded from the analysis. Overall, 17 patients (23.3%) developed a T2EL. The patients were divided in two groups: the No-Endoleak group (N=53), and the Endoleak group (N=17).

Most of the patients were male (94%) and their mean age was 73±9.3 years. Regarding atherosclerosis risk factors, 76% were smokers, 84% ⅝ suffered by arterial hypertension, 79% by dyslipidemia, 44% were diabetic, and 39% had any degree of renal impairment. Nine patients (13%) were on therapeutic anticoagulant treatment on admission, whereas 46% were on antiplatelet, and 47% on lipid control treatment (Table 1). As it regards the aneurysm characteristics, the mean diameter of the aneurysm was 62.2±17.6 mm, while 26% of them had an abnormal proximal aortic neck, either due to large angulation or short length. Thirty three percent of the patients had a patent inferior mesenteric artery on the preoperative CT scan while the mean number of patent lumbar arteries from the aneurysmal sac was 3.1 (Table 2). Six different types of endografts were used: Cook Zenith™, Metronic Endurant™, Vascutek Anaconda ™, Gore Excluder ™, Bolton Treo ™, and Cordis Incraft ™. Two different types of Cook Zenith ™ endografts were used, Cook Zenith Flex and Cook Zenith LP, the skeleton of which are different: stainless steel for the Flex™ and nitinol for the LP™. Overall, nitinol skeleton was used in 61% of the cases. Additionally, most of the grafts used, 84%, had suprarenal fixation (Table 3).

In the total cohort of patients, there was no perioperative death, and not any other significant morbidity apart endoleak was noted.

		No--endoleak N=53	Endoleak N=17	p (two--sided)
Demographic data				
Age (years)	mean ± SD	72.7 ± 9.7	73.8 ± 7.8	.682 a
Gender: male	N (%)	49 (92%)	17 (100%)	.568 e
Risk factors				
Tobacco use	N (%)	41 (77%)	12 (71%)	.746 e
Arterial hypertension	N (%)	45 (85%)	14 (82%)	>.999 e
Dislipidemia	N (%)	41 (77%)	14 (82%)	>.999 e
Diabetes Mellitus	N (%)	22 (42%)	9 (53%)	.586 d
Chronic Renal Failure	N (%)	20 (38%)	7 (41%)	>.999 d
Blood tests on admission				
CRP (mg/L)	mean ± SD	12.2 ± 18.6	17.6 ± 44.8	.662 b
Hemoglobin (g/L)	mean ± SD	13.3 ± 2	13.2 ± 2	.768 a
White blood cells (x 10^3 /mm^3)	mean ± SD	8.9 ± 3.8	8.4 ± 2.6	.611 a
Platelets (x 10^3 /mm^3)	mean ± SD	231 ± 86	222 ± 47	.906 b
Abnormal coagulation tests	N (%)	5 (9%)	2 (12%)	>.999 e
Medications on admission				
Anticoagulants	N (%)	4 (8%)	5 (29%)	.033 e
Antiplatelets	N (%)	25 (47%)	7 (41%)	.879 d
Statins	N (%)	25 (47%)	8 (47%)	>.999 d

Table 1. Patients' characteristics include demographic data, atherosclerosis risk factors, blood test examinations, and patients' medications (a: Unpaired t-test, b: Mann Whitney U test, c: Uncorrected Chi^2, d: Yates-corrected Chi^2, e: Fisher's Exact test).

		No--endoleak N=53	Endoleak N=17	p (two--sided)
AAA measurements				
Abnormal suprarenal angle	N (%)	1 (2%)	1 (6%)	.429 e
Abnormal infrarenal angle	N (%)	4 (8%)	3 (18%)	.349 e
Abnormal proximal angle	N (%)	5 (9%)	3 (18%)	.387 e
Abnormal length of proximal neck	N (%)	8 (15%)	5 (29%)	.283 e
AAA diameter (mm)	mean ± SD	61.4 ± 16.7	64.8 ± 20.6	.489 a
AAA lumen diameter (mm)	mean ± SD	38.8 ± 12.6	41.1 ± 12.5	.516 a
Aortic bifurcation diameter (mm)	mean ± SD	35.9 ± 11.8	37.4 ± 16.6	.694 a
Patent any lumbar artery	N (%)	37 (70%)	17 (100%)	.008 e
Number of patent lumbar arteries	mean ± SD	2.7 ± 2.1	4.1 ± 1.3	.030 b
Patent IMA	N (%)	14 (26%)	9 (53%)	.115 d
Number of patent arterial branches	mean ± SD	3 ± 2.3	4.6 ± 1.5	.008 a
AAA volume (mL)	mean ± SD	208.6 ± 137.4	269.9 ± 204.5	.392 b
Lumen volume (mL)	mean ± SD	94.7 ± 65.1	105.5 ± 66	.567 a
Thrombus volume (mL)	mean ± SD	103.2 ± 98	154.7 ± 151.4	.308 b
Volumes ratio: Thrombus / AAA (%)	mean ± SD	51.3 ± 18.7	52.7 ± 23.6	.825 a
Volumes ratio: Thrombus / Lumen (%)	mean ± SD	140.3 ± 103.2	154.9 ± 105.1	.629 a
Volumes ratio: Lumen / AAA (%)	mean ± SD	48.6 ± 18.7	47.3 ± 23.6	.825 a

Table 2. Aneurysms' details (a: Unpaired t-test, b: Mann Whitney U test, c: Uncorrected Chi^2, d: Yates-corrected Chi^2, e: Fisher's Exact test).

		No--endoleak N=53	Endoleak N=17	p (two--sided)
Endograft characteristics				
Suprarenal fixation	N (%)	44 (83%)	15 (88%)	>.999 e
Fabric type: polyester	N (%)	51 (96%)	16 (94%)	>.999 e
Skeleton type: Nitinol	N (%)	28 (53%)	15 (88%)	.020 d
Endograft type				
Cook Zenith™	N (%)	39 (74%)	11 (65%)	.543 e
Medtronic Endurant™	N (%)	1 (2%)	2 (12%)	.144 e
Vascutek Anaconda™	N (%)	7 (13%)	1 (6%)	.669 e
Gore Excluder™	N (%)	2 (4%)	1 (6%)	>.999 e
Bolton Treo™	N (%)	4 (8%)	1 (6%)	>.999 e
Cordis Incraft™	N (%)	0 (0%)	1 (6%)	.243 a

Table 3. Devices' specifications (a: Unpaired t-test, b: Mann Whitney U test, c: Uncorrected Chi^2, d: Yates-corrected Chi^2, e: Fisher's Exact test).

Univariate analysis

Initially, the two groups were compared regarding each one of the variables on a univariable analysis (Tables 1, 2, and 3). The most statistically significant factors (p<.05) found were patient been on chronic anticoagulant treatment (8% in the No-Endoleak group versus 29% in the Endoleak group, p=.033), the existence of at least one patent lumbar artery in the pre-operative CT scan (70% in the No-endoleak group versus 100% in the Endoleak group, p=.008), the number of patent lumbar arteries (2.7 in the No-endoleak group versus 4.1 in the Endoleak group, p=.030), the total number of any patent arterial branch from the aortic sac, lumbar artery, or inferior mesenteric artery (3 in the No-endoleak group versus 4.6 in the Endoleak group, p=.008), and a Nitinol skeleton on the endograft (29% in the No-endoleak group versus 88% in the Endoleak group, p=.028).

Mutlivariable analysis / risk model creation

After the multivariable analysis, the variables found to be statistically significant were the chronic use of anticoagulants, the total number of any patent arterial branch from the aortic sac on the preoperative CT scan, and the type of skeleton material of the endograft (Table 4). These parameters were included in a risk scoring model, the ABS-10 risk scoring for the prediction of T2EL after standard EVAR. On this scoring model, each of the parameters scores as follows:

Chronic use of ***A***nticoagulants: 4 points

Patent arterial ***B***ranch from the aortic sac on the preoperative CT scan: 1 point / each patent artery

Nitinol ***S***keleton of the endograft: 5 points

The ABS-10 predicting score model was well-fitted (Hosmer & Lemeshow test 3.5, p=0.75) and presented a good discriminative ability (Harrell's c statistic 0.81, 95% CI 0.70 - 0.89, at an optimum cut-off score of 7) (Figure 1). Overall, 25 patients had a score above 7 in the No-endoleak group (47%) and 16 (94%) in the Endoleak group (Figure 2). At this score level, the model presented 88% sensitivity, 62% specificity, 43% positive predictive value, and 94% negative predictive value.

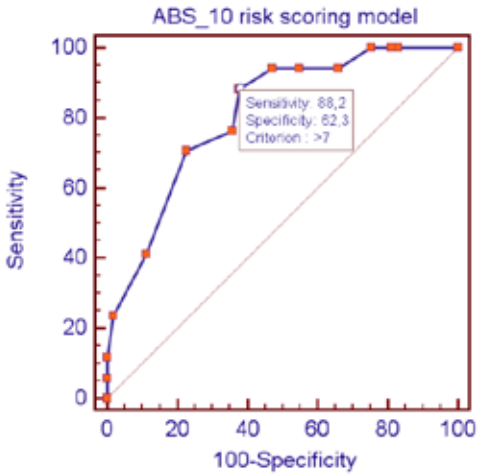

Figure 1. ROC analysis of the ABS-10 risk-scoring model. A value of 7 consists the optimum cut-off point, giving the best combination of sensitivity and specificity.

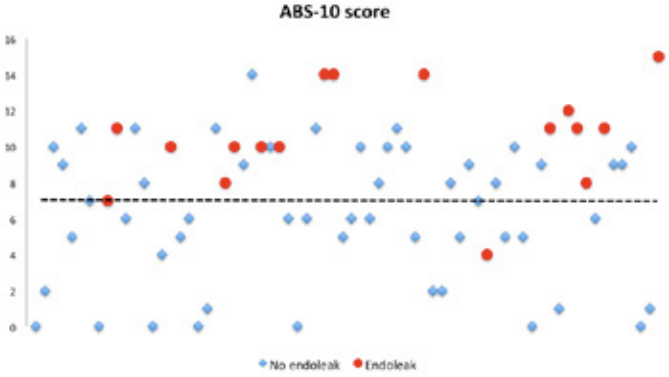

Figure 2. Scatterplot indicates the value of ABS-10 score for each of the patients of the study. Almost no patient with a value of ABS-10 less than 7 had a type II endoleak (red points).

DISCUSSION

In the current study of patients with AAA disease, being treated with a standard EVAR procedure, T2EL occured in 23.3% of the population. According to the analysis, three variables were related with the T2EL: the preoperative chronic use of anticoagulant treatment, the number of patent arterial branches from the aortic sac in the preoperative CT scan, and the nitinol skeleton of the endograft. Based on these findings, the ***ABS-10*** risk scoring system for the preoperative prediction of a T2EL was created as following: 4 points for prior chronic use of ***A***nticoagulants, 1 point for each patent arterial ***B***ranch from the aortic sac, and 5 points for nitinol endograft ***S***keleton.

Atherosclerosis risk factors were not found to be associated with T2EL. Current use of tobacco, arterial hypertension, and dislipidemia did not show any statistically significant difference between the two groups. In a meta-analysis regarding the possible risk factors associated with T2EL, gender, diabetes, hypertension, and dyslipidemia were not found to have a role[21]. On the contrary, smoking was considered to act protectively, something that was not seen in the current study.

The use of anticoagulant treatment has been considered as a potential predisposing factor for T2EL after EVAR[22,23], but this is not a constant finding. In a study of 127 patients with AAA s who underwent EVAR, Bobadilla et al.[24] reported that anticoagulation with warfarin appears to be linked to an increased risk for the development of endoleak after EVAR, specifically type II. Similarly, previous reports have demonstrated that the chronic anticoagulation drugs' use can lead to a long-term poor outcome[25,26]. This is consistent with our univariate and multivariable analysis, which found that patients been on ongoing treatment with anticoagulants were in higher risk for T2EL (8% in the No-Endoleak group vs. 29% in the Endoleak group, p=.033).

The existence of patent arterial branches from the aneurysm sac seems to be related to the development of T2EL[27-30]. The patent lumbar arteries, the inferior mesenteric artery, or any accessory renal arteries are such arterial branches. Each of them has been described as a potential risk factor for the development of a T2EL[27-29]. In our study, although in the unviariate analysis both the number of patent lumbar arter-

ies and the patent IMA were found to be associated with the T2EL, both were excluded in the multivariable analysis. On the contrary, the total number of patent arterial branches from the aneurysm sac, either lumbar arteries or IMA, was found to be a risk factor for a T2EL. It seems reasonable to consider that the existence of any patent branch is important and not any particular vessel, either named IMA or lumbar artery[30].

In the present analysis, we were not able to confirm any relationship between aneurysmal thrombus and T2EL. No thrombus-associated parameter of the AAA such as thrombus volume, thrombus-to-AAA ratio, thrombus-to-lumen ratio proved to be a predictive factor for the development of T2EL. Brountzos et al[30] have reported that the percentage of aortic perimeter covered by thrombus at the level of the sac lumbar arteries' ostia is an independent predictor of T2EL. Similarly, no relation between the material of the endograft (polyester or PTFE) and T2EL was found.

However, the material of the endograft skeleton was significantly associated with T2EL (nitinol skeleton was found in 29% in the No-endoleak group versus 88% in the Endoleak group, p=.028). Nitinol, an approximately equiatomic alloy of nickel and titanium, belongs to a group of materials named as shape-memory alloys, due to its remarkable properties of thermal shape-memory[31]. It is more compliant than other alloys such as stainless steel, and has a broad array of applications in vascular surgery[32]. Nitinol is considered to produce a limited inflammatory response[33] but there are conflicting reports with regard to the effect of inflammation magnitude to the development of endoleaks. Some authors support that that an increased inflammatory reaction post EVAR increases the possibility of T2EL[34], while other studies have shown that an increased inflammation after EVAR is associated with a decreased incidence of T2EL[35]. In our study, there was no specific investigation with regard to inflammation markers, nevertheless CRP was found similar in both groups (Table 1). Irrespective to the controversial effect on inflammation, it seems that nitinol exhibits reduced thrombogenicity as compared to stainless steel stents. In an animal study of Thierry et al[36], nitinol stents were found to present lower thrombogenicity as compared to stainless steel stents. This was proven by assessing the local fibrinogen absorption and was confirmed by scanning electron observations showing different thrombus morphologies between nitinol and stainless steel. As the metallic skeleton of the aortic graft usually lies outside the fabric, it is in constant contact to the content of the aneurysmal sac. The decreased thrombogenicity of nitinol can be considered an advantage when it regards bare metal stents as it may reduce the possibility of stent thrombosis. However, in aortic stent grafts, as it lies (in most devices) on the outer surface of the graft, its constant contact with the aortic sac content might be considered a factor for decreased aortic sac thrombosis and thus a risk factor for T2EL development. Nevertheless, today this finding has literally a theoretical value and no clinical impact, since the skeletons of most endografts existing in the market today are made of nitinol. The only company still using stainless steel on grafts exoskeleton is Cook Medical™, which uses skeletons made of stainless steel in a small portion of its AAA products (Zenith® Flex and Zenith® Fenestrated AAA Endovascular Graft™).

This study has several limitations. Despite being a prospective study, the number of patients was small, and limited the general relevance of the results. Additionally, as the decision for the selection of the graft type was made per surgeons' preference, the number of the various types of endografts used varied. Thus, the potential effect of specific devices could not been tested. Another limitation concerns the methodology for measuring the morphological characteristics of the aneurysm based on the CTA images. Although the measurements were performed by two independent researchers (DD, AML,) intraobserver or interobserver variability may exist[37]. Definitely, external validation of the model in large cohorts of patients is needed in order to accept of reject the results of the study. Finally, the ABS-10 prediction model does not identify the T2EL that would need intervention, as this definitely would need further follow-up.

CONCLUSIONS

Three variables were found to be related to the development of T2EL after standard EVAR: the preoperative chronic use of anticoagulants, the number of patent lumbar arteries in the preoperative CT scan, and the nitinol skeleton of the endograft. The produced ABS-10 predicting score model could be used to potentially identify low-risk patients for the development of this complication. Further studies involving larger numbers of patients will improve our understanding on T2EL.

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Ultrasonography guided percutaneous EVAR using the ProGlide® Perclose device. Single center preliminary results

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Abstract:

Introduction: Percutaneous EVAR (p-EVAR) has gained popularity after the introduction of arteriotomy closure devices, as it facilitates a totally minimal invasive technique having a lot of advantages. Duplex ultrasonography (DUS) guided arterial puncture could be mandatory in complications' prevention. The aim of this study was to evaluate the initial experience of p-EVAR in a tertiary vascular center.

Methods: A retrospective study (2017- 2019) with prospectively collected data was undertaken, including all consecutive AAA patients treated using completely percutaneous access. Demographics, pre-operative anatomic parameters and postoperative outcomes were collected. All patients underwent DUS pre- and post-operatively, while the percutaneous femoral access was also achieved under DUS guidance. The femoral artery out-wall diameter, the presence of atherosclerosis and the distance from the skin were recorded. The technical success, use of additional closure devices, volume of blood transfusion, site-related complications and open femoral artery conversions were recorded and analyzed.

Results: Thirty patients underwent p-EVAR (mean age 71 years, all men). Mean body mass index (BMI) was 26.5 kg/m^2. The mean common femoral artery (CFA) diameter was 11mm at the right (range 9-14mm) and 9mm (8-12mm) at the left side and the mean distance from the skin was 13mm (range 10-35mm). Sheath diameter was ranging between 7-18Fr. In 44 CFAs, 2 ProGlide® devices (Abbott, Santa Clara, California, USA) were applied vs 1 device in 16 access sites. The mean duration of operation was 115 min. Percutaneous closure primary technical success was 92% (55/60). Only 1 additional device was used to achieve accurate hemostasis in 1 patient. In 5 femoral arteries, an open conversion was performed. The median post-operative in-hospital stay was 1 day. Three patients presented a small inguinal hematoma and treated conservatively. Mean blood transfusion was 150cc. During the follow-up period (1-30 months), no further access site complication was recorded.

Conclusion: Percutaneous US guided access using the Proglide device was a safe and effective approach in many AAA patients treated with EVAR even at an initial experience level. Careful patient pre-operative evaluation and selection could lead in even better results in the future.

INTRODUCTION

Endovascular aortic aneurysm repair (EVAR) has been established as the standard of care in the management of abdominal aortic aneurysm (AAA) worldwide.[1] Fast-track EVAR protocols have been implemented in well-selected patients with a high clinical success rate and associated decrease in intensive care unit (ICU) admission and in-hospital length of stay. No negative effect on the peri-operative morbidity and mortality has been recorded so far in the literature.[2] The extensive use of EVAR in the daily practice has increased surgeon's experience, while the introduction of new generation endografts with much lower profile and the use of innovative arteriotomy closure devices made easier and safer the percutaneous access.[3]

Percutaneous EVAR (p-EVAR) has gained popularity during the recent years with a lower post-operative complication rate in comparison to conventional exposure, while closure device failure has been limited within an acceptable rate.[4,5] P-EVAR has permitted the wider use of local anesthesia and decreased the total operation time along with the need for blood transfusion, as well as wound infections of the groin.[4] Despite these encouraging data, failed access closure in p-EVAR is associated with the need of additional closure devices and higher cardiac adverse event rate.[4,6] Patients' selection according to body mass index and the adequacy of the femoral arteries seems to play a mandatory role in the prevention of complications.[4] A detailed pre-operative access vessels assessment is important to confirm the feasibility and safety of the technique.[4] Despite

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that duplex ultrasound is not obligatory during percutaneous access and there is no comparison study between ultrasound guided and unguided procedures, current literature confirm its wide use in percutaneous interventions.[1,4]

The aim of this study is to report and analyze the initial experience of p-EVAR using the ProGlide® Perclose closure device under duplex ultrasound (DUS) guidance in a single tertiary vascular center.

METHODS

Study Cohort

A retrospective study with prospectively collected data was undertaken including patients that were treated using completely percutaneous access from June 2017 to September 2019. Except two cases that were treated for a previous failed EVAR, all patients underwent a primary intervention. Demographics, pre-operative femoral artery anatomic parameters and post-operative outcomes were collected prospectively. Informed consent was obtained from all patients. The study was approved by the Institutional Review Board.

Imaging evaluation

Computed tomography angiography (CTA) of the abdominal aorta down to femoral arteries was performed as a part of the pre-operative assessment. Sizing and planning were performed based on the CTA using a workstation with 3Mensio dedicated reconstruction software (Medical Imaging B.V., Bilthoven, Netherlands). If the patient did not have diffuse calcification in the femoral arteries in CTA evaluation, the femoral bifurcation was below the inguinal ligament and the device planned needed introduction sheaths up to 18Fr (outer diameter of about 20Fr), he was considered a potential candidate for percutaneous access. All candidates for p-EVAR underwent DUS from an expertise vascular surgeon. Femoral access site was evaluated the day before the operation as well as the 1st post-operative day to confirm the successful deployment of the closure devices and possible site complications. The femoral artery out-wall diameter, the presence of atherosclerotic plaque (anterior and posterior) and the distance from the skin were also recorded.

Access and closure devices

All patients were treated in an adequately equipped operating room using a moveable radiolucent surgical table and a mobile digital angiographic system (Philips BV Endura, Philips Medical Systems, Release 2.2.3, the Netherlands). Bi-femoral access was used for the insertion of the main endograft and the contralateral limb extension. Previous intervention with femoral cut-down was not a criterion of exclusion for p-EVAR. Perclose ProGlide® (Abbott, Santa Clara, CA, USA) was used in all cases under DUS guidance in order to achieve a safe insertion of the device. With the US probe in transverse position to the underlining femoral artery, the artery was visualized from the femoral bifurcation and upwards ending at the level of the inguinal ligament (Figure 1A). Then the most adequate point for puncture was chosen in terms of the quality of the artery wall (at least no anterior atherosclerotic plaque) and the diameter of the artery (at least 8-9mm for large sheaths). Having the artery in the middle of the US image, direct puncture was then achieved with a large bore needle. After successful catheterization of the femoral artery, a standard J-shape guidewire was inserted and followed with the US up to the external iliac artery to ensure the uncomplicated, adequate position inside the artery (Figure 1B-D). Afterwards a standard 6F sheath was inserted, blood was withdrawn and finally local heparinization was performed. The sheath was withdrawn and one or two Proglide® devices inserted (depending on the diameter of the largest sheath that would be needed to pass through), according to the instructions for use (Figure 2A and B). One closure device was used for sheaths up to 11F and two devices for larger sheaths (Figure 2C). Upon the bilateral completion of the insertion of the closure devices, standard sheaths were inserted in the arteriotomies, arteriotomy sutures were carefully isolated and secured and the main procedure was started after systemic heparinization (Figure 2D). At the end of the main endovascular procedure, large sheaths and stiff guidewires were replaced by smaller sheaths and short standard J-type guidewires and after small sheaths removal, the Proglide® sutures were tighten with the guidewire in place (Figure 3A and B). If a satisfactory hemostasis was achieved the guidewire was removed, the knot was tightened again, locked and secured and the sutures were cut short, leaving just a small hole in the skin (Figure 3C and D). The need for any additional closure device was decided during the suture tightening process at the end of the operation according to hemostasis achieved at the arteriotomy closure (Figure 4). After the successful arteriotomy closure, mechanical compression was applied, which remained at the recovery room and until the patient was transferred to the ward. The compression was then removed and the patient was able to stand up after 3 additional hours. Thereafter, full mobilization was allowed.

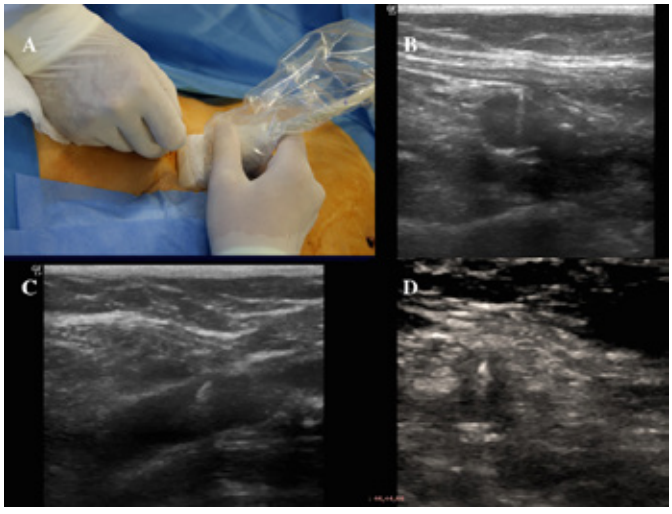

Figure 1. With the US probe in transverse position to the underlining femoral artery, the artery was visualized from the femoral bifurcation and upwards ending at the level of the inguinal ligament (A). The most adequate point of puncture was chosen and having the artery in the middle of the US image, direct puncture was achieved with a large bore needle (B). After catheterization of the femoral artery, the position of the guidewire was confirmed in the longitudinal (C) and transverse (D) view.

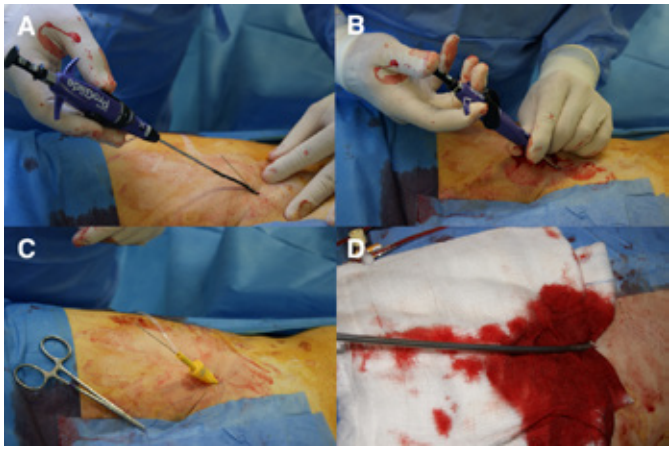

Figure 2. The Proglide® device inserted over the guidewire (A), and the suturing of the artery (B). Positioning of a standard sheath over the guidewire at the end of the Proglide® initial procedure (C). The main body of the endograft inserted via the puncture site during the procedure (D).

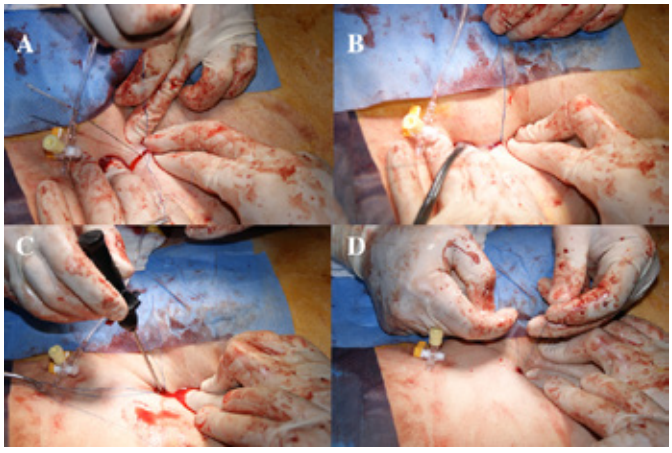

Figure 3. At the end of the procedure, large sheaths and stiff guidewires were replaced by smaller sheaths and short standard J-type guidewires (A). After small sheaths removal, the Proglide® sutures were tighten with the guidewire in place (B). If a satisfactory hemostasis was achieved the guidewire was removed, the knot was tightened again using the trimmer device (C), locked and secured (D) and cut short.

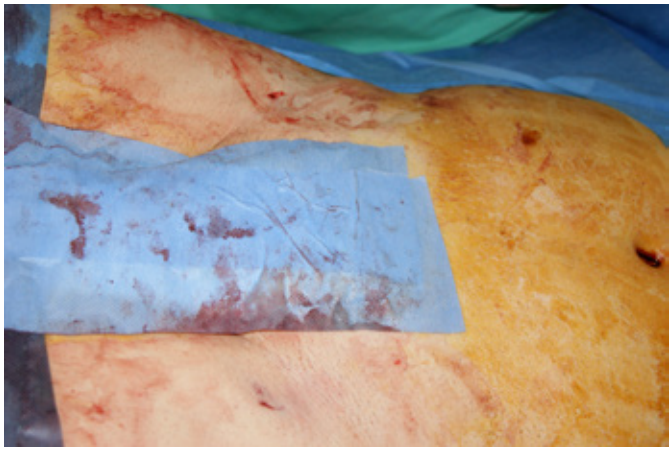

Figure 4. At the end of the operation, two small puncture holes are present at the access sites.

Type of sheaths and endografts

A bifurcated endograft was applied in all patients. Percutaneous technique was preferred initially in lower profile endografts, mainly Incraft (Cardinal Health, Ohio, USA) that needs a 14-16Fr sheath for the main graft and 11-12Fr for the contralateral side, depending on the diameter of the limb. As surgeon's experience became higher, different type of grafts with wider insertion sheaths were used, as AFX 2 (Endologix, California, USA) that needs a 17Fr sheath for the main graft and just 7Fr sheath for the contralateral side, Nellix (Endologix, California, USA) that needs 17Fr sheaths on both sides, Excluder C3 with or without Excluder IBE (W. L. Gore & Associates, Delaware, USA) that needs 16-18Fr for the main graft and 12-14Fr for the contralateral side and Altura (Lombart Medical, California, USA) hat needs 14Fr sheaths bilaterally.

Follow-up

All patients underwent DUS evaluation the 1st post-operative day in order to control the complete closure of the artery wall and to diagnose any further complication (pseudo-aneurysm formation, inguinal hematoma and leak). A standardized EVAR follow-up protocol including CTA of the abdominal aorta, iliac and femoral arteries as well as laboratory testing was performed at 1 and 12 months and yearly, thereafter. DUS was used as standard follow-up method at 6-month follow-up. Any complications from access sites were recorded during standard evaluation.

Outcomes

The primary technical arteriotomy closure success, use of additional devices, volume of blood loss, site-related complications as well as need for open access conversion were recorded and analyzed.

Statistical Analysis

Continuous data were reported as a mean ± standard deviation. Categorical data were expressed as absolute numbers and percentage of prevalence (%) in the study cohort. In the statistical analysis for continuous variables the independent t-test for normally distributed data and the Mann-Whitney U test for nonparametric data were used. The Pearson x^2 test or the Fisher exact test was used for categorical variables, as appropriate. P value was considered significant at <0.05. Statistical analysis was performed by SPSS 22.0 for Windows software (IBM Corp, Armonk, NY).

RESULTS

Thirty patients underwent p-EVAR (mean age 71 years, all men). Patients' mean body mass index (BMI) was estimated at 26.5kg/m^2 (range 18-34.4kg/m^2). Patients' demographics are presented in Table I. The mean AAA diameter was 68 mm (range 55-82mm), while the mean femoral artery diameter was calculated at 11mm (range 9-14mm) at the right and 9mm (8-12mm) at the left side. The mean distance between the anterior wall of the common femoral artery (CFA) and the skin was 13mm (range 11-38mm) in both access sites.

Demographic characteristics	
Age (mean)	71
Male	100%
BMI (mean, kg/m^2)	26.5
Comorbidities	**Number of patients (%)**
Obesity (BMI>25kg/m^2)	19 (63)
Hypertension	30 (100)
Dyslipidemia	27 (90)
Diabetes Mellitus	16 (53)
COPD	25 (83)
Tobacco use (current or previous)	26 (86)
CAD	19 (63)
Previous EVAR	2 (6.7)

Table I. Patients' demographic characteristics and comorbidities. BMI: body mass index; COPD: chronic obstructive pulmonary disease; CAD: coronary artery disease; EVAR: endovascular aneurysm repair

Sheath diameter was ranging between 7-18Fr. The distribution of sheath diameters is presented in Table II. In 44 femoral arteries, 2 ProGlide® devices were applied to achieve hemostasis, versus 16 access sites were 1 device was used. In most cases, a low profile endograft was applied. Fourteen patients were treated with Incraft, 2 with AFX 2 and 1 with Altura device (Lombart Medical, California, USA). In 9 cases, a Nellix sealing device was applied while in 3 cases, a bifurcated Excluder device was used. In one of these cases, an Internal Branch Endoprothesis (IBE) was also used to preserve internal iliac artery flow. In this case, a bilateral percutaneous access was achieved without any complication.

Sheath inner diameter (in Fr)	Number of sheaths used
7	2
11	14
14	17
16	3
17	19
18	5

Table II. The distribution of sheath size in femoral artery access sites

Primary technical success was 92% (55/60 access sites). In three cases (5 access sites), a conversion to conventional exposure was performed. In the first patient, even percutaneous access was achieved; the adequate insertion of the closure device was incomplete due to severe posterior plaque and distal iliac artery tortuosity. The presence of posterior plaque was not included in standard contraindications for p-EVAR. Although in this case, the remaining lumen did not permit the smooth insertion of the closure device. Including that this event occurred during the very initial experience, a conversion to open exposure was chosen to accomplish the intervention. In the second patient, who was obese with a BMI of 31kg/m2, an adequate catheterization was initially achieved in a very deep situated femoral artery on both sides. The depth of the artery made impossible for the closure device to be inserted properly in a manner that would allow the suturing of it. Thus, both sides were converted to open exposure. This was the only case of technical failure recorded in the group of patients with BMI>25kg/m2 (overweight). In the last case, the malposition of the ProGlide® device during puncture (lateral to the CFA wall because of atherosclerosis in the anterior part of the artery) provoked a left CFA occlusion after closure. The patient was treated immediately with endarterectomy and patch-closure. During the same procedure, a third ProGlide® device was applied at the contralateral site in order to achieve complete hemostasis. It is remarkable that this patient had a very low BMI (18kg/m^2) and suffered a post-operative coagulopathy, fortunately without any serious consequences.

The median post-operative in-hospital stay was calculated at 1 day (1-5 days). Three patients presented a small inguinal hematoma. All cases were treated conservatively without any further intervention. No trauma infection was detected during hospitalization or early follow-up. Mean blood transfusion was recorded at 150cc (range 0-500cc) without any difference between converted and percutaneous cases. During the follow-up period (range 1-30 months), no further access site complication was recorded.

DISCUSSION

Percutaneous procedures, highlighting even more the minimal invasive approach of endovascular techniques, gain more and more popularity in vascular surgery. Percutaneous approach seems as safe and efficient as open trans-femoral exposure for the treatment of AAA, with a high technical success rate up to 95%.[7,8] In cases of failed percutaneous access, additional device usage or even transfemoral cut-down is needed to achieve a successful arteriotomy closure, but still the rate remains low.[4,5] During early post-operative follow-up, the re-admission rate for access complications after pEVAR is estimated at 4%. All re-admissions are due to access vessel stenosis or pseudoaneurysm formation.[9] In this study, the technical success rate was 92% (55/60). In 2 patients (4 CFAs), an open conversion was decided intra-operatively to achieve access because of the failure of the device to adequately inserted for different reasons, because of excessive BMI in one case and calcification along with tortuosity of the external iliac artery in the second case. One has to keep in mind that the Proglide® device is very smooth having also a significant length and so needs a quite healthy long segment in the distal external iliac artery for adequate placement. Additionally, CFA depth may hamper the insertion and suturing of the artery. Only in one case, there was a malposition of the Proglide® device during puncture, even if it was done under DUS guidance. In the remaining femoral artery, an additional 3rd device was used to achieve hemostasis. In this particular patient, we might have underestimated the atherosclerosis on the anterior wall of both femoral arteries, because of the very small BMI of the patient. In any case it is quite obvious that careful evaluation of the femoral arteries not only pre-operatively but also during the procedure is crucial for a successful p-EVAR.

Meta-analyses have shown that p-EVAR has a shorter procedural time and a lower complication rate than conventional exposure.[7,8] In the present analysis, the mean duration of op-

eration was estimated at 115min, which is highly acceptable. The reduction of post-operative in-hospital length of stay is established in many case series of percutaneous approach.[10,1110] The post-operative in-hospital stay was 1 day in this study. In terms of puncture site complications, it seems that p-EVAR is associated with a lower or at least equal site infection rate and reduced blood loss. [3,7,8,12,13] No infection was recorded during follow-up in this study while the mean blood transfusion was limited at 150cc. Furthermore, percutaneous approach as a primary access in EVAR seems to be technically beneficial in terms of re-intervention. As femoral artery stays intact after p-EVAR, an open transfemoral approach during a secondary operation would be easier and safer.

Furthermore, percutaneous approach offers a better quality of life in patients by reducing the peri-operative pain and the post-operative wound inflammatory reaction.[12] In our experience, there is no need for opioids post-operatively. Paracetamol on demand according to pain estimation was used for pain relief. Patients were allowed to walk since the day of operation, 6-8 hours after the accomplishment of the procedure, according to their general status. For the rest of site complications, there are controversial results comparing percutaneous and open access. [6,7,8] In a case study comparing TAVI and EVAR procedures, the use of percutaneous access with ProGlide® in AAA repair was associated with a higher bleeding and device failure rate than in aortic valve replacement, which looks quite strange having in mind the nature of these two different diseases.[14] This result may reflect different experience with closure devices between the two operative teams, as well as the different diameters of the devices used that are usually wider in the EVAR case.

Pre-operative assessment of the femoral bifurcation with ultrasonography has an important role in patients' selection and furthermore, a mandatory impact in reduction of systematic and site complications.[13,15] Factors independently associated with percutaneous access failure are femoral artery diameter, femoral artery stenosis>50% and emergent interventions.[1] The role of atherosclerosis, especially of an anterior plaque, may be dominant in the Perclose-Proglide® technique and is associated with a higher usage of additional closure devices.[6] A pre-operative DUS evaluation can identify all these risk factors, while predictive score systems are created in order to avoid technical failure.[1] On the other hand, the distance from the skin may not have an impact in puncture site outcome.[6] In obese patients, p-EVAR seems safe and feasible with a lower infection rate and a decrease in operative duration.[11] In this study, there was only one technical failure recorded in the group of patients with BMI>25 (overweight).

The low complication rate as well as the reduced post-operative length of stay may have a beneficial economic impact. Unfortunately, in our country there are not financial data to calculate the cost effectiveness of p-EVAR. Percutaneous aneurysm repair even though was associated with increased closure device cost, lead in reductions in procedural duration, hospitalization and complications and thus offset the additional device cost, confirming that p-EVAR may be a cost-effective option.[9,16] In Europe, financial data have shown that p-EVAR, even in cases of access failure where an additional device is needed, is a cost-effective technique with a low complication rate.[17] Future studies, and broader use of percutaneous approach in EVAR patients will lead to more objective outcomes.

Conclusion

Percutaneous US guided access using the Proglide® device was a safe and effective approach in many AAA patients treated with EVAR even at an initial experience level. Careful patient pre-operative evaluation and selection could lead in even better results in the future.

Disclosures: None

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BY EXAMPLE

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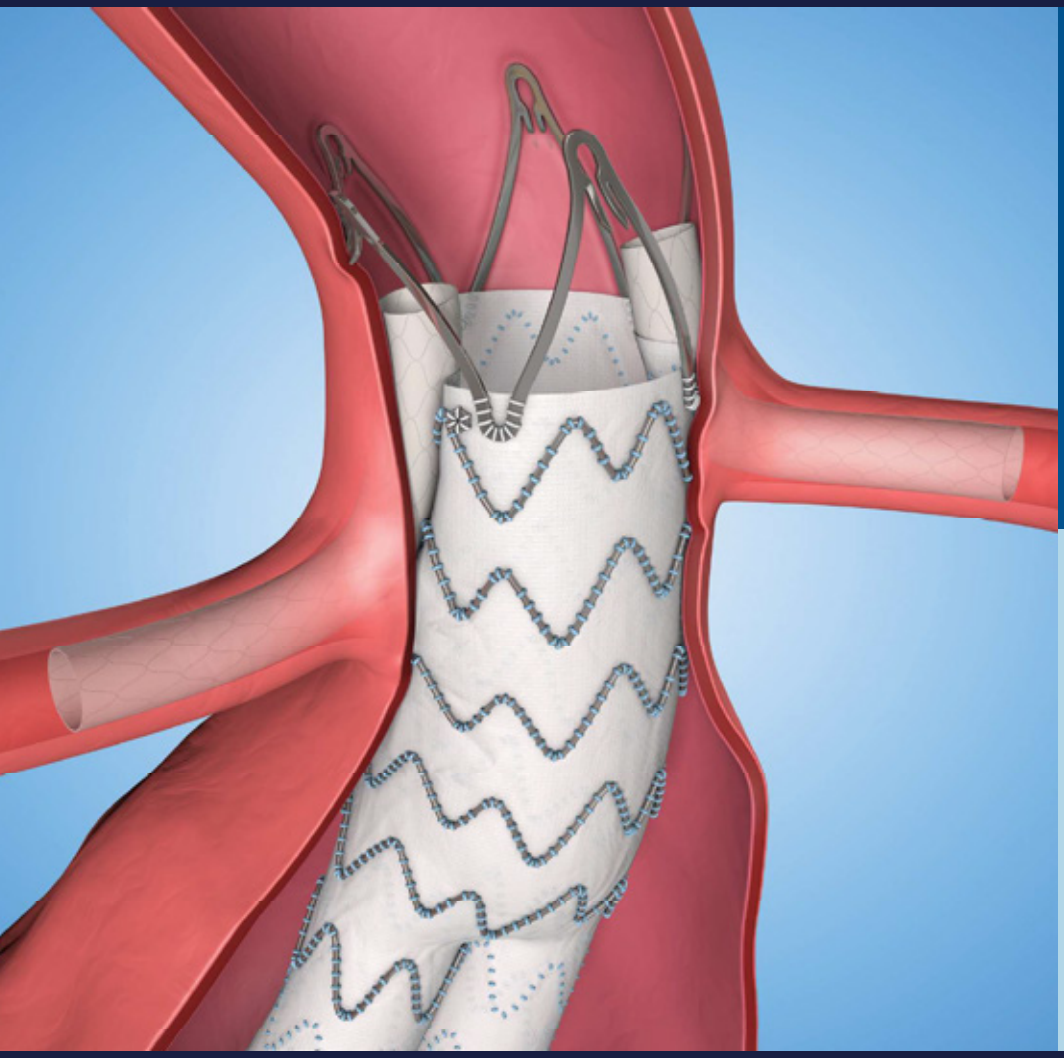

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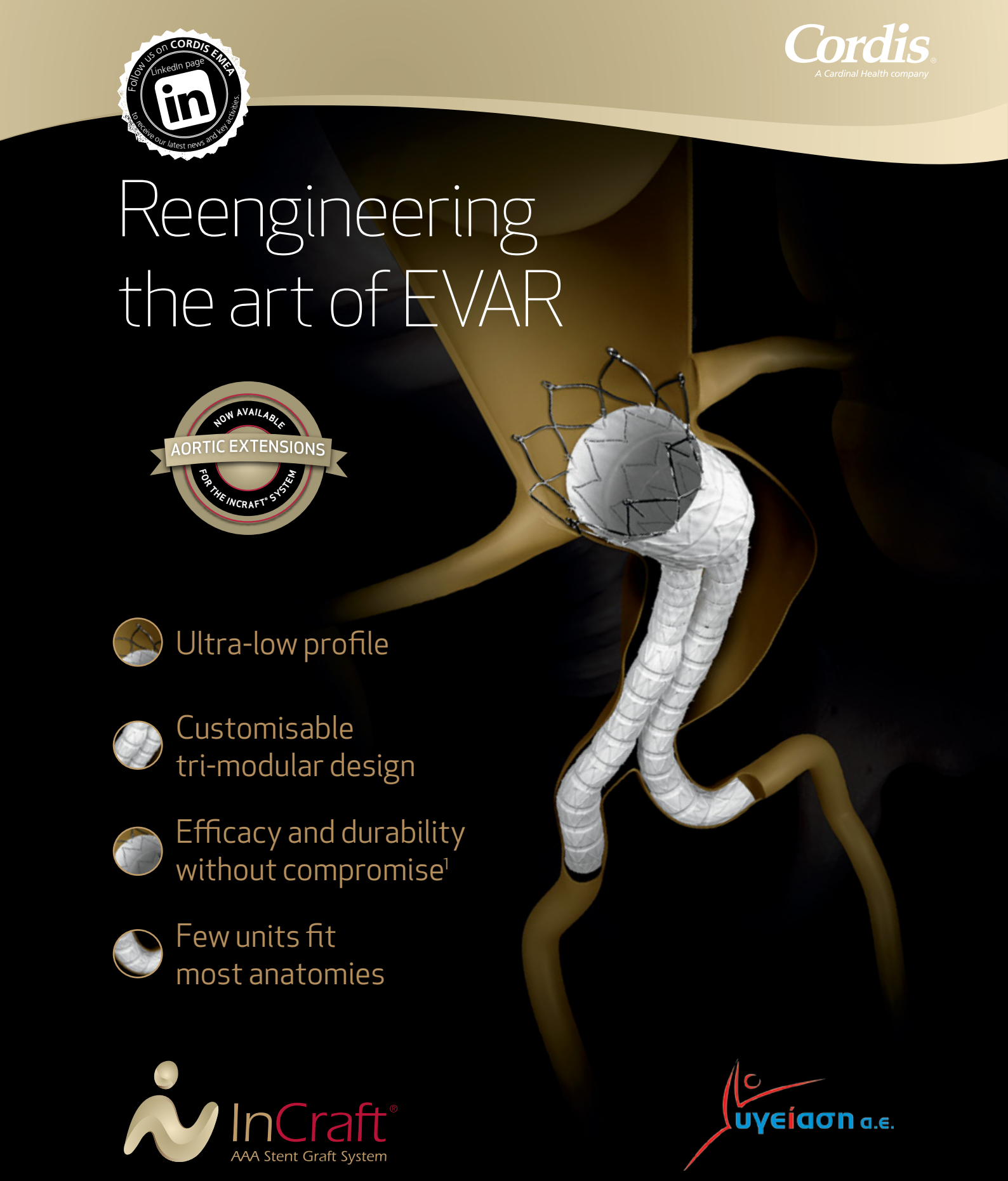

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Initial experience with the CERAB technique: case series

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Abstract:

Open surgical repair with aorto-bifemoral bypass grafting is considered as the standard of care for the aorto-iliac occlusive disease involving the abdominal aorta, at least in fit patients. On the other hand, substantial risk of peri-operative morbidity and mortality may tarnish the good technical outcomes in higher risk patients. The covered endovascular reconstruction of aorto-iliac bifurcation (CERAB) is a novel minimal invasive approach for aorto-iliac occlusive disease treatment, offering good early- and mid-term outcomes so far. The procedure consists of the implantation of a wide diameter aortic stent graft and the expansion of two iliac covered stents according to the kissing-technique inside the aortic graft. We report an initial case series of 4 patients treated with the CERAB technique for aorto-iliac occlusive disease treatment.

INTRODUCTION

Current ESVS guidelines recommend the endovascular approach as a first line treatment for occlusions extending to the infrarenal aorta (IIb, B).[1] However, traditionally open surgical repair with aorto-bifemoral bypass grafting has been considered as the standard of care for the aorto-iliac occlusive disease involving the abdominal aorta, at least in fit patients. Recently, the covered endovascular reconstruction of aortic bifurcation (CERAB) has been considered as a novel and viable solution for aorto-iliac occlusive disease treatment, especially in high-risk patients.[1] Evidence has shown that the two-year primary patency rate may be estimated at 82% in patients treated using the CERAB technique for such lesions.[2] Despite the minimal approach, in these cases, the peri-operative morbidity and mortality risk exists as well as the risk of long-term restenosis or occlusion.[1]

In terms of anatomical and hemodynamic characteristics, it seems that the CERAB configuration is, geometrically, more similar with the native aortic bifurcation in comparison to kissing stents alone.[3] The configuration of the iliac kissing stents is associated with a lower mismatch rate when they are tapered by an aortic cuff.[3] While kissing stents technique with self or balloon expandable stents is reported to be related with flow disturbances, the CERAB technique is associated with less flow perturbations, diminishing in this way the risk of stent thrombosis or distal embolization.[4]

Herein, the aim of the study was to evaluate our initial experience of CERAB technique for the treatment of high-risk patients with aorto-occlusive arterial disease.

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METHODS

Patients' characteristics and pre-operative evaluation

Between September 2018 and September 2019, 4 patients were treated using the CERAB technique. All patients suffered from restrictive intermittent claudication. All patients were considered as high-risk for conventional aorto-bifemoral reconstruction (ASA IV). Considering their anatomical aspects and the risk of an aorto-bifemoral bypass, an endovascular approach was decided in all cases. Demographics, clinical evaluation, anatomical characteristics, intra-operative details and patients' outcomes were recorded prospectively. Pre-operative evaluation included computed tomography angiography (CTA) of the abdominal aorta down to the tibial arteries, in order to verify in and outflow lesions. Sizing and planning were performed using a workstation with 3Mensio dedicated reconstruction software (Medical Imaging B.V., Bilthoven, Netherlands). Pre-operative CTA confirmed the presence of aorto-iliac occlusive disease extended up to the infra-renal aorta.

Technical details

All patients were treated in an adequately equipped operating room using a mobile digital angiographic system (Philips BV Endura, Philips Medical Systems, Release 2.2.3, the Netherlands). Access was achieved with open trans-femoral exposure or ultrasound-guided percutaneous puncture (5:3 femoral artery access sites), according to the need for simultaneous common femoral endarterectomy or the presence of anterior

atherosclerotic plaque in the common femoral artery, which was considered as a contraindication for percutaneous access.

A hydrophilic 0.035'' or/and 0.014'' and 0.018'' guidewire was inserted to overcome bilateral iliac occlusions or stenoses and it was exchanged with a standard PTFE guidewire after accessing the abdominal aorta. A 0.014'' and 0.018'' guidewire was initially used as a step of the standard procedure in order to achieve intra-luminal access. In case where a sub-intimal access was demanded to complete the intervention, a hydrophilic 0.035'' was preferred. An upper access site from the left brachial artery was also available in all patients, in case of failure of passage the lesion through femoral access. After the insertion of an 8Fr x 45cm sheath (Arrow, Teleflex, USA) into the aorta, a diagnostic arteriography was accomplished. A balloon expandable aortic stent graft (Be-Graft, Aortic, Bentley, Innomed, Germany) was, then, deployed into the infrarenal aorta down to the bifurcation through a 12Fr x 33cm sheath over a stiff guidewire (Gore, W.L. Gore & Associates Inc. Delaware, USA). Two balloon-expandable covered stents (Be-Graft, Aortic, Bentley, Innomed, Germany) were then deployed with the kissing stent technique starting 10-20mm into the aortic stent graft, creating a new aortic bifurcation. In case of extended disease, down to the external iliac arteries, self-expandable stents or just balloon angioplasty was used to complete the procedure. Final angiography was used to confirm adequate placement and patency intra-operatively.

Post-operative surveillance and follow-up

Double anti-platelet therapy was initiated the day of the procedure. Clinical evaluation and ankle-brachial pressure index (ABPI) measurements were assessed the first post-operative day. 30-day, 6-month and 1st-year follow-up was undertaken with CTA at the first instance and duplex ultrasonography in subsequent ones in order to evaluate the flow and any stent-graft malformation or other complication (Figures 3 and 4).

RESULTS

All patients were males with a mean age 65 years (range 58-69 years). The clinical presentation was restrictive intermittent claudication at 100m or lower (Rutherford Classification 3 and 4), affecting their daily routine. Femoral artery pulses were absent during clinical evaluation. Pre-operative ABPIs were ranging between 0.36-0.54 (Table I). Comorbidities and pre-operative antithrombotic treatment are presented in Table II. All patients were previous smokers. All of them were presented with significant coronary artery disease. The first patient had a severe infrarenal aortic stenosis and concomitant bilateral common iliac and right common femoral artery stenosis (Figure 1A-D).

The second and third cases were treated for an occlusion of the aorto-iliac bifurcation extending to bilateral common iliac arteries. The second patient had a concomitant severe stenosis of the right external iliac and both common femoral arteries while the third patient suffered a unilateral common femoral artery stenosis. The last case was the most challenging as an infrarenal aortic and bilateral common iliac arteries occlusion was diagnosed. Furthermore, both external iliac and left common femoral arteries had severe atheromatosis; the left external iliac artery with important stenosis of its lumen while the right one was totally occluded (Figure 2A-D). Patients' pre-operative characteristics are summarized in Table III.

Patients	ABPI pre-operatively	ABPI post-operatively
No 1	(R) 0.54 (L) 0.5	(R) 1.00 (L) 1.12
No 2	(R) 0.53 (L) 0.53	(R) 1.08 (L) 1.16
No 3	(R) 0.36 (L) 0.45	(R) 0.95 (L) 1.00
No 4	(R) 0.45 (L) 0.37	(R) 1.20 (L) 0.90

Table I. ABPI measurements pre and post-operatively

Comorbidities	No of patients
Tobacco use	4
Hypertension	4
Dyslipidemia	4
Coronary artery disease (CAD)	4
Coronary artery bypass grafting (CABG)	0
Percutaneous coronary angioplasty (PTCA)	2
Previous ischemic stroke	1
Chronic obstructive pulmonary disease (COPD)	4
Diabetes Mellitus	1
Renal insufficiency (GFR<30ml/min/1.73m^2)	1
Antiplatelet treatment	4
Aspirin 100mg once daily	2
Clopidogrel 75mg once daily	1
Aspirin 100mg plus Clopidogrel 75mg once daily *due to recent PTCA	1

Table II. Patients' comorbidities

Patients	Pre-operative anatomic characteristics	Access sites	Stent grafts
No 1	Severe infrarenal aortic & bilateral CIA and right CFA artery stenosis	Percutaneous LCFA RCFA endarterectomy	14x57mm aortic stent-graft & 8x38mm covered balloon expandable at CIAs (Be-Graft, Bentley, Innomed, Germany)
No 2	*Occlusion* of the aorto-iliac bifurcation extending to bilateral CIAs & right EIA and CFA stenosis	Bilateral CFA endarterectomy	Pre-dilatation of REIA with 7x80mm angioplasty balloon; 16x38mm aortic stent-graft & 9x57mm & 8x57mm balloon expandable covered stents at the right and left CIA, respectively (Be-Graft, Bentley, Innomed, Germany)
No 3	*Occlusion* of the aorto-iliac bifurcation extending to bilateral CIA & unilateral CFA stenosis	Percutaneous LCFA RCFA endarterectomy	16x38mm aortic stent-graft & 8x57mm balloon expandable covered stents at CIAs (Be-Graft, Bentley, Innomed, Germany)
No 4	*Occlusion* of the infrarenal aorta, bilateral CIA & right EIA and CFA artery; diffused severe atheromatosis	Percutaneous RCFA LCFA endarterectomy	14x38mm aortic stent-graft & 8x57mm balloon expandable covered stents at CIAs (Be-Graft, Bentley, Innomed, Germany); *sub-intimal re-canalization* of right EIA with self-expanding stents 8x60mm& 8x40mm (E-Luminexx, Bard Peripheral Vascular, Arizona, USA)

Table III. Pre-operative anatomical and intra-operative patients' characteristics. CFA: common femoral artery; CIA: common iliac artery; EIA: external iliac artery

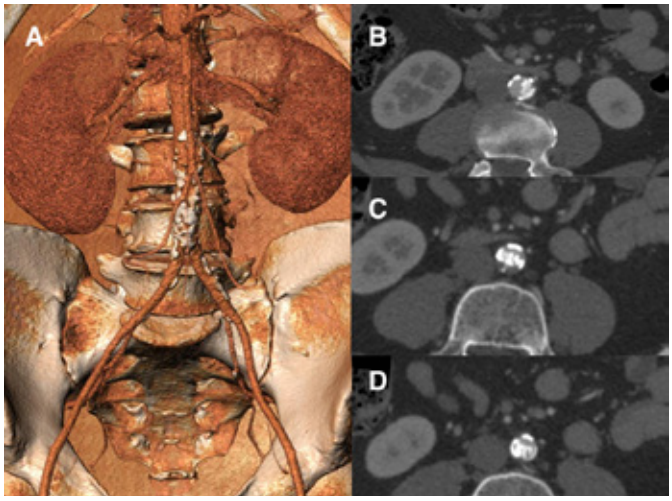

Figure 1. The first patient had a severe infrarenal aortic stenosis and concomitant common iliac artery stenosis bilaterally. In Panel A, 3D reconstruction and in B-D, axial view of the aortic stenosis.

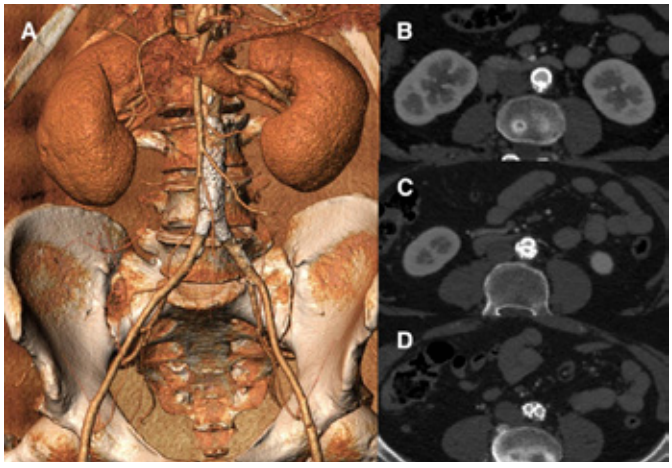

Figure 2. The fourth case suffered from an infra-renal aortic and bilateral common iliac arteries occlusion. Furthermore, both external iliac arteries had severe atheromatosis; the left one with important stenosis of its lumen while the right one was totally occluded. In Panel A, 3D reconstruction and in B-D, axial view of the aortic and iliac occlusions.

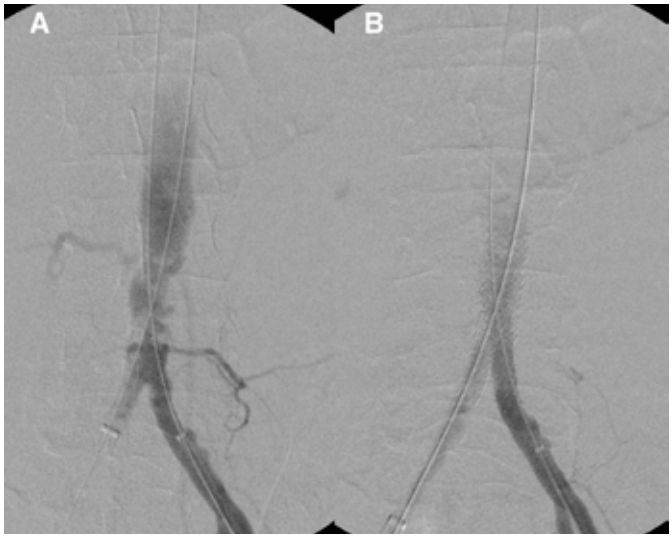

Figure 3. Aortic stenosis is confirmed during diagnostic angiography intra-operatively (A), revealing important collateral vessel (A). Completion angiography confirmed the patency of aortic reconstruction (B).

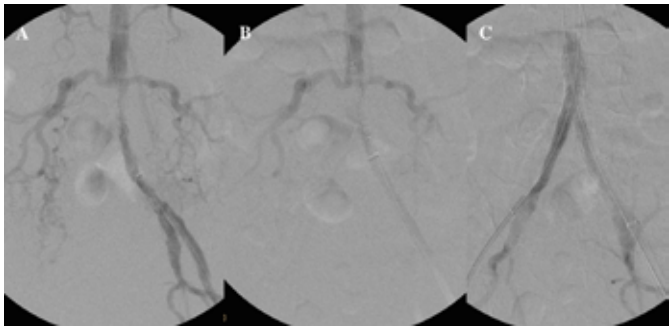

Figure 4. The intra-operative angiography confirmed the occlusion of the infra-renal aorta (A) while an impressive collateral net of lumbar arteries was revealed (B). The completion angiography showed stent patency of the aortic reconstruction (C).

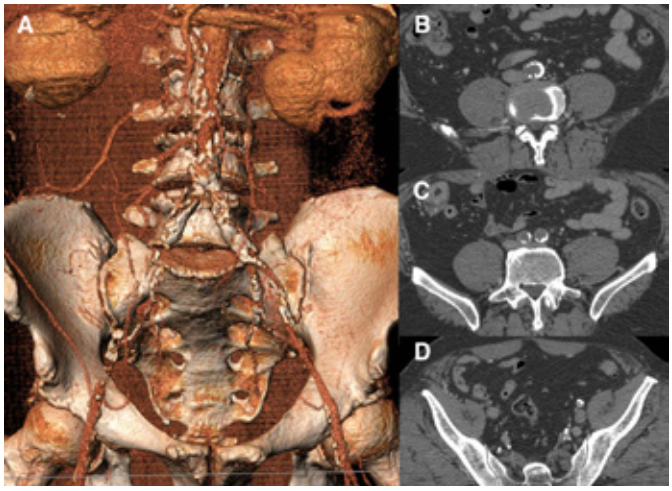

Figure 5. Post-operative CTA of the 1st patient treated with the CERAB technique; Panel A, 3D reconstruction and B-D, axial views.

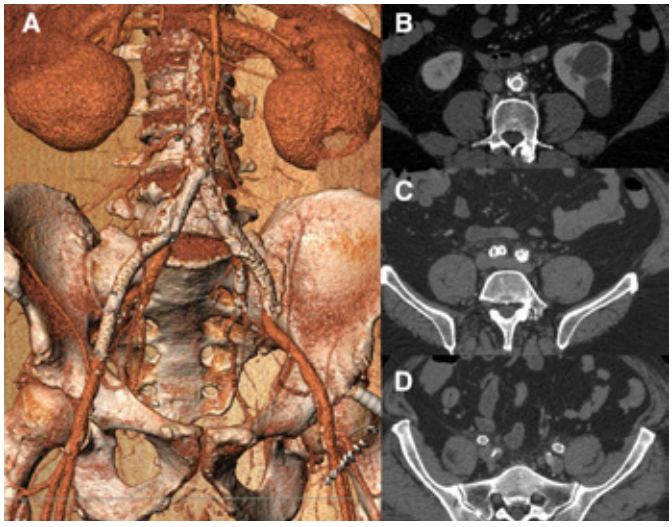

Figure 6. Post-operative CTA of the 4th patient treated with the CERAB technique. Right external iliac artery stenting was accomplished to treat a residual stenosis; Panel A, 3D reconstruction and B-D, axial views.

All cases were undertaken under general anesthesia. Systemic heparinization was administrated in all patients after sheath insertion (50-100IU/kg). In the first case, an ultrasound-guided percutaneous approach was used for the left femoral access while an open transfemoral exposure was used on the right side. Using the technique described above, an aortic stent-graft 14x57mm (Be-Graft, Bentley, Innomed, Germany) was deployed while two balloon expandable covered stents (Be-Graft, Bentley, Innomed Germany) 8x38mm were deployed like kissing stents in the common iliac arteries. In the second patient, after a bilateral femoral artery endarterectomy, endovascular access of the aortic bifurcation was achieved. In this case, a pre-dilatation of the right external iliac artery was performed using a 7x80mm angioplasty balloon. An aortic graft of 16x38mm and 2 covered balloon expandable stents, 9x57mm at the left and 8x57mm at the right common iliac artery were deployed (all Be-Grafts, Bentley, Innomed, Germany). In the third case, a right femoral artery endarterectomy was performed initially; while an aortic-bifurcation reconstruction was achieved using a 16x38mm aortic stent-graft and two 8x57mm balloon expandable covered stents (all Be-Grafts, Bentley, Innomed, Germany). In the last case, a percutaneous approach was used for the right femoral access. An open transfemoral exposure, associated with endarterectomy and patch closure was performed at the left common femoral artery. For the aortic occlusion, an aortic stent-graft 14x38mm was used, while balloon expandable covered stents 8x57mm were deployed in the common iliac arteries (all Be-Grafts, Bentley, Innomed, Germany). A sub-intimal re-canalization of the right external iliac artery was treated using two self-expanding stents 8x60mm and 8x40mm (E-Luminexx, Bard Peripheral Vascular, Arizona, USA) (Figure 3A-C). All intra-operative details are summarized in Table III. The mean operational time was 95 min (90-120), while the mean contrast volume was 45ml (40-50ml) and the mean dose area product was 48mGy (21 min). Technical success was 100%. One patient underwent a synchronous bilateral common femoral artery endarterectomy, while another one a unilateral one. All patients were transferred post-operatively to the ward. Post-operative ABPIs are presented in Table I. Pulses were detected in all femoral arteries post-operatively. All patients became asymptomatic after treatment (Rutherford's 0 from Rutherford's 3and 4). Two patients discharged home the 1st and the other two the 2nd post-operative day in a good general status.

Follow-up was ranging between 1 and 12 months. All patients remained asymptomatic (0 Rutherford's Class) and ABPIs were stable. No renal function deterioration or colonic ischemia event was record. No re-intervention, limb adverse event, major cardiovascular adverse event or death was recorded. One patient suffered from a clopidogrel allergic reaction; presenting only severe exanthema without systemic complications; clopidogrel was withdrawn and patient has been continuing only on aspirin. All patients underwent a 30-day CTA which revealed no complication while one completed the 6-month and another the 12-month follow-up using DUS. Flow patterns were within normal limits and no restenosis was detected so far. No stent compression, restenosis or migration was revealed in CTAs.

DISCUSSION

Aorto-bi-femoral bypass grafting has been used as the treatment of choice in patients with aorto-iliac occlusive disease involving the abdominal aorta during the last decades. The endovascular treatment of this complex disease was initially presented as an alternative option to open surgical repair in high comorbid patients.[5] The latest ESVS guidelines recommend that the endovascular approach may be the first line treatment for the aorto-iliac occlusive disease, preserving the open repair only for fit patients.[1] In 2016, the initial results of CERAB, presented by Dijkstra et al[6]., fostered the widespread use of endovascular procedures for aortoiliac recanalization for TASC C and D lesions using covered balloon-expandable stents. High technical success and 12-month patency rate presented in these series offered an alternative viable endovascular approach for this group of patients.[6] In our opinion, when there is a substantial distal aortic lesion (severe stenosis or occlusion), or severe lesions on both iliac arteries, aortic bifurcation reconstruction with the use of covered balloon expandable stents may be more safe and durable. Along this line, in this small study the technical success was 100% with good outcomes in terms of morbidity and mortality.

The technical success rate has been demonstrated to be high in different case series, ranging between 76% (in initial experience studies) up to 100%, as in this analysis.[3,7,8] Primary, primary assisted and secondary patency are highly acceptable and estimated at 86%, 91%, and 97% at 1 year; and 82%, 87%, and 97% at 3 years of follow-up.[8] Restenosis was observed in rates up to 20%, with a successful re-vascularization in 85% of them while distal embolization was present in up to 8%.[3,7] At 5-year follow-up, primary patency was estimated at 70% and secondary patency rate at 77%.[9] In this study, no restenosis, thrombosis or stent compression was revealed during a very early follow-up. Additionally, no intervention was needed during this follow up period. In the literature, factors that have been associated with lower patency rate are age, subsequent tobacco use and\ previous aorto-iliac interventions.[10] At least theoretically; the decreased radial mismatch presented in covered stent reconstruction of the aortic bifurcation is expected to be associated with an improved flow pattern and subsequent better clinical outcome.[11,12]

The low mortality and morbidity rate of the endovascular aortic reconstruction enforces the application of the technique in high risk patients.[13] There was no early post-operative mortality using the CERAB technique, reported so far in the literature.[2] The lack of high quality data comparing endovascular and open surgery precludes any strict conclusion at the moment. Real-world data are encouraging in terms of early and mid-term follow-up. The 30-day major complication rate was highly acceptable (1-7%).[2,8] Concerning local complications, groin hematoma is present in 15% of patients while the evolution of post-operative pseudo-aneurysm rate was abscent.[2] In terms of systematic morbidity; major complication rate is expected at 2%.[2] In this study, no major complication was recorded post-operatively. A patient suffered an allergic reaction to clopidogrel with exanthema which was treated successfully by discontinuation of the drug. Renal insufficiency is a rare complication after CERAB.[7] Inferior mesenteric artery (IMA) and lumbar arteries occlusion, when is required, seems to have no impact in the post-operative period.[6] No colonic ischemic events were recorded in the current literature, affirming the safety of the technique in case of pre-operatively

patent IMA.[5] However, there is no evidence to indicate the preservation or over-stenting of an IMA >3-4 mm (very rare in any case), while the risk of peri and post-operative complications during endovascular canalization and stenting should not be ignored.[5]

Concerning clinical improvement, in a small case series, an improvement by 2 categories in more than 50% of patients has been recorded.[14] In mid-term follow-up, 96% of the patients are expected to improve at least one more Rutherford's category.[8] In this case series, all patients were asymptomatic after treatment (Rutherford's 0 from Rutherford's 3-4). Following this clinical improvement, ABPI was also significantly increased.[8,14] In patients treated with endovascular means for TASC C and D lesions, the overall survival without restenosis, amputation, or surgery was acceptable (62.8±1.9%) but significantly lower than type A and B lesions (69.6±1.5%).[15] The estimated limb salvage rate was 98% and 97% at 1 and 3 years of follow-up, respectively.[8] During the early follow-up of this case-series, no major adverse limb event was recorded.

Despite the encouraging patency and morbidity-mortality rates, the cost-effectiveness of the technique is still controversial. Endovascular materials and sophisticated covered balloon expandable stents are more expensive than standard stents and conventional Dacron or PTFE grafts.[2] The need for re-interventions may increase the costs in the long-term.[2] However, the low morbidity and mortality rate and the minimal duration of hospitalization and ICU admission may decrease the total cost of the procedure.[2] It is difficult to evaluate accurate this cost because a direct comparison of those two options is not available nowadays. In this case series, the total duration of hospitalization was 2-3 days and no patient was transferred to the ICU. Financial data cannot be extracted in our country in order to support the hypothesis of the cost-effectiveness.

CONCLUSION

The CERAB technique seems to be safe and feasible in patients with aorto-iliac occlusive disease. Early patency rates as well as patients' clinical improvement demonstrated favorable outcomes of endovascular approach in TASC C and D lesions.

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A systematic review of endovascular management of chronic iliofemoral venous thrombosis

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Abstract:

Introduction. Although endovascular management of acute iliofemoral venous thrombosis has been reported as a promising and effective treatment option in recently published societal guidelines, its role on chronic venous disease (CVD) management has not been adequately justified.

Methods. A retrospective systematic review was performed for the efficacy of endovascular stenting in patients with chronic post-thrombotic syndrome in terms of venous patency and QoL measurement of these patients in relevant studies.

Results. We identified 22 observational cohort studies reporting a total of 2288 participants. Primary outcome measures were technical success, primary, primary-assisted and secondary patency rates of the endovascular intervention of the lesions. Secondary outcome measure was improvement of QoL of life scales before and after the procedure. Primary patency rates at the 1st, 2nd and 3rd year of follow up ranged from 57% to 98%, 65% to 91% and 43% to 96% respectively. Similarly, primary-assisted patency rates ranged from 71% to 99%, 68%-90% and 65%-90% at 1st, 2nd and 3rd year of follow up respectively. Secondary patency rates ranged from 85% to 100%, 79% to 95% and 75% to 94% at the 1st, 2nd and 3rd year respectively. QoL measurements were improved after the intervention compared to preoperative values.

Conclusion. Our study indicated that the use of endovascular stenting is associated with a high patency rates and a trend towards a reduced incidence of post-thrombotic syndrome. More well-designed randomized clinical trials will clarify and strengthen the efficacy of endovascular stenting in CVTs.

Key-words: iliofemoral thrombosis, venous stenting, stent patency, QoL measures/

INTRODUCTION

Chronic iliofemoral venous thrombosis (CVT) is a major health problem worldwide, frequently resulting in chronic venous insufficiency and in the development of the post-thrombotic syndrome (PTS), at the same time having a great economic social and psychological impact worldwide.[1] Chronic venous disease is associated with various etiologic factors including external pressure, anatomical diversities (May-Turner syndrome), acute or chronic deep venous thrombosis (DVT) whereas the symptomatology depends on the cause, extent and duration of the disease.[2] Among the most serious complications of the disease is the development of the PTS which appears in 20% to 100% of patients despite contemporary treatment, having a negative influence on the Quality of Life (QoL) of involved patients.[3] Historically, surgical venous thrombectomy firstly described by Leriche in 1948, represented an alternative treatment choice compared to conservative treatment with controversial short-term results regarding the recanalization of the iliofemoral venous segment and the improvement of the post thrombotic syndrome.[4,5] Therapeutic anticoagulation for CVT currently represents the gold-standard treatment and is a globally accepted as the treatment of choice despite high morbidity rates. Although endovascular management of acute iliofemoral venous thrombosis has been reported as a promising and effective treatment option in recently published societal guidelines[6] its role on CVT management has not been adequately justified. In the present study, we conducted a systematic review and meta-analysis of the current literature for the efficacy of endovascular stenting in CVT in terms of venous patency and its effect on the QoL of these patients.

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METHODS

Design and study selection

This review was carried out according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement standards.[7] We included observational studies and case series including more than five patients who underwent endovascular intervention for iliofemoral CVT suffering from PTS. Studies had to report at least one of the outcomes of interest: technical success and patency rates.

Search strategy

A systematic review of relevant studies between January 1992 and December 2018. Searches of the Ovid Medline, Scopus and Cochrane Library were performed using a combination of the following search terms: venous thrombosis with either iliofemoral, endovascular, stenting and post-thrombotic syndrome to identify articles published in English language. In relevant studies we calculated Quality-of-Life (QoL) measurements with the SF-36[8] and VEINES-QOL[9] questionnaires whereas clinical examination was also recorded according to the C of the CEAP classification[10] (scores C4-6), the Venous Clinical Severity Score (VCSS)[11] and the Villalta scale[12].

Eligibility criteria

We excluded studies involving endovascular intervention relating to acute iliofemoral venous thrombosis and those with mixed groups of acute and chronic venous disease in cases that relevant data could not be safely extracted. Furthermore, we excluded patients from studies who underwent endovascular intervention due to other venous pathologies such as iliac vein compression syndromes (May-Turner Syndrome) or non-thrombotic etiology of venous occlusion. The detailed search is provided in figure 1.

Study records

Primary outcome measures were technical success, primary, primary-assisted and secondary patency rates of the endovascular intervention of the lesions. Secondary outcome measure was improvement of QoL of life scales before and after the procedure. Post-operative (30-day) complications as well as stent thrombosis were recorded. All data were calculated as ratios. Major complications included death and major bleeding whereas minor complications were minor bleeding, back pain persisting after stent deployment and venous perforation caused by catheter or guidewire injury. Eligibility assessment of identified studies was performed by two review authors (CA, LM). We developed a data extraction sheet, pilot tested it in randomly selected studies that met our inclusion criteria and refined it accordingly. One author (CA) extracted relevant information from selected studies. A second review author (GG) cross-checked the data that were extracted from the studies. We collected study-related information, such as study design and year of publication; baseline demographics and clinical characteristics of the entire screened population (Table 1).

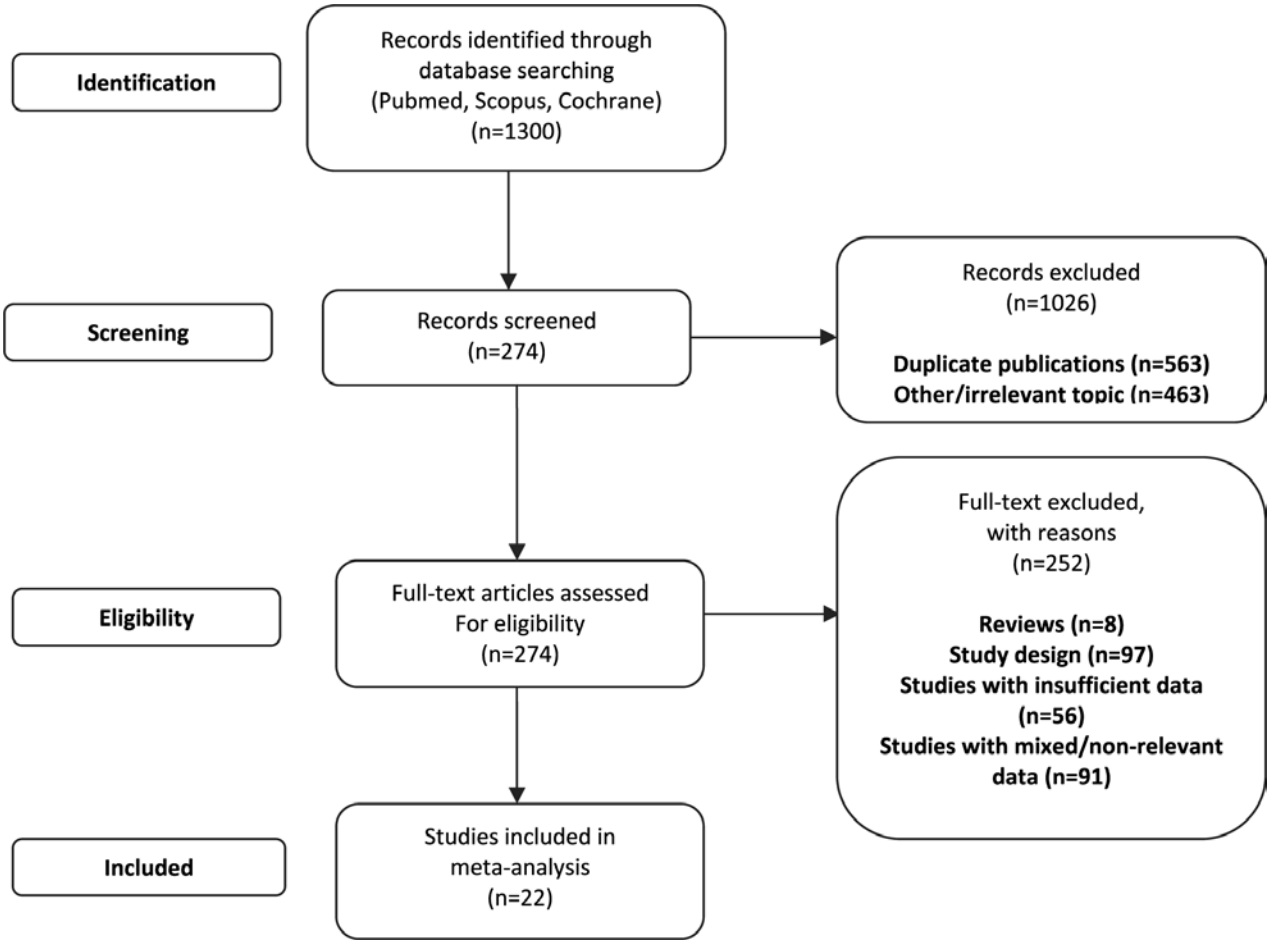

Figure 1. Study flow diagram showing the number of studies that were screened, assessed for eligibility and included/excluded from the systematic review (along with reasons for exclusion)

Author	Demographics					
	Type of study	Pts	Limbs	Age range (yrs)	Sex male pts N (%)	Positive Thrombophilia screen pts(%)
Ye, 2014[12]	RT, SC	110	118	32-81	44(40)	NR
Sang, 2014[13]	RT, SC	67	67	mean 44 range 24-72	36(54)	4(6)
Rosales, 2010[34]	RT, SC	34	34	median 41 range 15-63	15(44)	17(50)
Raju, 2009[35]	RT, SC	159	167	median 53 range 18-84	80(50)	44(34)
Falcoz, 2016[16]	RT, SC	21	21	mean 41 range 32-60	10(50)	NR
Raju, 2002[44]	RT, SC	292	304	median 52 range 14-83	97(33)	48(16)
Neglen, 2007[14]	RT, SC	870	982	median 54 range 14-90	450(55)	173/454 (38)
Hartung, 2009[17]	RT, SC	89	96	median 43 range 16-79	17(19)	17/89(19)
de Wolf, 2015[2]	RT, SC	75	NR	median 45 range 15-77	26(35)	NR
Catarinella, 2015[36]	RT, SC	153	NR	mean 43.5 range 17-77	46(30)	NR
Alerany, 2014[18]	RT, SC	36	41	mean 50 range 19-83	16(44)	17/36 (47)
Kurklisnsky, 2012[37]	RT, SC	89	91	median 46.2	27(30)	27/89 (30)
George, 2014[38]	RT, SC	38	44	median 45 range 25-67	20(52)	NR
Ruihua, 2017[19]	RT, SC	81	81	mean 57 range 29-82	37(46)	NR
Kolbel, 2009[20]	RT, SC	62	66	mean 39 range 18-69	21(36)	32(67)
Nayak, 2012[39]	RT, SC	44	45	mean 42.2 range 20-77	20(45)	7/54(15.9)
Oguzkurt, 2008[40]	RT, SC	16	NR	NR	NR	NR
Lou, 2009[41]	RT, SC	34	NR	NR	NR	NR
Blattler, 1999[21]	RT, SC	42	NR	mean 48.8 range 22-75	3(7)	NR
O'Sullivan, 2013[22]	RT, SC	20	NR	NR	NR	NR
Sarici, 2013[42]	RT, SC	52	59	median 58 range 23-76	15(25)	21/52(40)
Meng, 2011[43]	RT, SC	296	NR	median 43 range 15-63	136(46)	NR

NR; not reported, Pts;patients, RT;retrospective study, SC;Single-cener study, Yrs;years

Table 1. Demographics

RESULTS

Our search identified 1300 articles. After duplicate (n=563) and non-relevant (n=463) studies were excluded, we screened 274 studies which were considered eligible for inclusion. Finally, we identified 22 observational cohort studies reporting a total of 2288 participants (709 men and 1579 women) (Figure 1). The mean age of participants ranged across the studies from 18 to 85 years. Mean follow up was 18 months and positive thrombophilia screen was noted in 35% of included patients. Mean intervention time of endovascular intervention was 7.3 years, technical success ranged from 93% to 97%, 30-day stent occlusion and stent restenosis rates ranged from 3% to 5% and 14% to 18% respectively. Primary patency rates at the 1st, 2nd and 3rd year of follow up ranged from 57% to 98%, 65% to 91% and 43% to 96% respectively. Similarly, primary-assisted patency rates ranged from 71% to 99%, 68%-90% and 65%-90% at 1st, 2nd and 3rd year of follow up. Secondary patency rates ranged from 85% to 100%, 79% to 95% and 75% to 94% at the 1st, 2nd and 3rd year respectively. (Table 2). Six studies[12,14,19,36,40,41] reported QoL measurements and these represented 55.5% of the overall patient pool. QoL measurements were improved after the intervention compared to preoperative values but did not reach statistical significance (p<.051). Clinical venous scales were not calculated to the heterogeneity of the data. There were no major 30-day post-operative complications (major bleeding, death due to operation-related causes)[12-22]. Minor complications were recorded, including venous perforation occurring in 23% of recorded patients[12,13,19], back pain with restricted retroperitoneal bleeding in 37% of recorded studies.[12,15,19,20] Posto-operative (30-day) stent thrombosis occurred in 2.8% (42/1503) of the overall stent placement.

Author	Intervention					
	Mean Intervention time range (yrs)	Technical success % (pts/L)	Primary patency (%)	Primary assisted patency (%)	Secondary patency (%)	Stent size (mm)
Ye, 2014[12]	range 1-40	95(112/118 L)	3yr (70)	3yr (90)	3yr (94)	D 4-16 L 60-220
Sang, 2014[13]	range 12-36	94(63/67 pts)	1yr (87.9) 3yr (70.7)	NR	1yr (93.3) 3yr (82.8)	NR
Rosales, 2010[34]	NR	94(32/34 pts)	2yr (67)	2yr (76)	2yr (90)	NR
Raju, 2009[35]	NR	83(139/167 limbs)	1yr (57) 2yr (45) 3yr (43)	1yr (75) 2yr (68) 3yr (65)	1yr (85) 2yr (79) 3yr (76)	NR
Falcoz, 2016[16]	2 (range 1-8.5)	100 (21/21pts)	1yr (90.5) 2yr (90.5)	NR	NR	D 8-18 L 40-80
Raju, 2002[44]	NR	100(292/292pts)	1yr 71	1yr 71	1yr 97	D 14-16
Neglen, 2007[14]	NR	NR	1yr (90) 2yr (86) 3yr (79) 6yr (67)	1yr (95) 2yr (90) 3yr (90) 6yr (89)	1yr (95) 2yr (95) 3yr (95) 6yr (93)	D 10-20 L 40-260
Hartung, 2009[17]	NR	98 (87/91pts)	30day (96) 1yr (89) 3yrs (83)	1yr (94) 3yr(89)	30day (97) 1yr (96) 3yr (93)	D 12-16 L40-90
de Wolf, 2015[2]	6 (1-37)	100 (75/75pts)	1yr (90)	1yr (99)	1yr (100)	NR
Catarinella, 2015[36]	NR	NR	2yr (65)	2yr (78)	2yr (89)	NR
Alerany, 2014[18]	8.8 (2-48)	NR	2yr (74)	2yr (87)	2yr (89)	D 12-24
Kurklisnsky, 2012[37]	NR	NR	1yr (81) 3yr (71)	1yr (94) 3yr (90)	1yr (95) 3yr (95)	NR
George, 2014[38]	NR	NR	1yr (94)	1 yr (97)	NR	D 6-24 L 40-120
Ruihua, 2017[19]	7.8 (2-35)	77/81 (95)	2yr (81.5)	2yr (91.4)	2yr (93.8)	D 10-12
Kolbel, 2009[20]	NR	59/62 (92)	5yr (70)	5yr (73)	5yr (80)	D 12-22
Nayak, 2012[39]	5±5.9	39/44 (89)	NR	NR	NR	D 12-16
Oguzkurt, 2008[40]	1 (2-5)	NR	1yr 80 2yr 72 3yr 72	NR	1yr 93 2yr 86 3yr 75	D 12-16 L 40-90
Lou, 2009[41]	NR	NR	6mon 50	NR	NR	D 10-16 L 60-90
Blattler, 1999[21]	mean 18.3 (range 1.7-46)	25/42(60)	1yr 11(79)	NR	NR	NR
O'Sullivan, 2013[22]	mean 0.5 (range 1-15)	NR	1yr 93.9	NR	NR	NR
Sarici, 2013[42]	NR	52/52 (100)	NR	NR	NR	D 6-14
Meng, 2011[43]	NR	285/296 (96)	1yr 98 3yr 96 5yr 95	NR	NR	L 40-80 D 10-20

NR; not reported, Pts;patients, RT;retrospective study, SC;Single-cener study, Yrs;years

Table 2. Results

DISCUSSION

Since 1990s, endovascular intervention for deep venous pathology has gained increased popularity in managing the severe clinical manifestations of post-thrombotic syndrome (PTS).[23] Common manifestations of PTS include pain, calf swelling, heaviness, edema, skin pigmentation, or venous ulceration of the affected leg, with symptoms becoming apparent usually within the first 2 years after the thrombotic event.[24] The present meta-analysis has demonstrated that endovascular treatment of chronic iliofemoral venous disease is a durable and effective option in treating symptomatic patients with PTS, having a high technical and clinical success. In particular, endovascular stenting has resulted in major symptom relief in patients with chronic venous disease however this was not consistently reflected in all aspects of QoL measurements and it nearly reached statistical significance(p<.051). In respect to the acute phase of deep venous thrombosis, the most recent CHEST guidelines state that "anticoagulation therapy alone is an acceptable alternative to Catheter-directed Thrombolysis (CDT) in all patients with acute lower extremity DVT," citing unacceptable risk of bleeding.[25] In contrast to the CHEST guidelines, the American Heart Association does recommend CDT as first-line therapy for patients at low bleeding risk with lower extremity DVT.[26]

The CaVenT study was the first randomised controlled trial to evaluate the clinically relevant effect of additional cathe-

ter-directed thrombolysis for proximal deep vein thrombosis. The results after 5 years of follow-up showed a continued and increased reduction in development of post-thrombotic syndrome in patients assigned to catheter-directed thrombolysis compared with those assigned to anticoagulation and compression therapy alone as well as reducing post-thrombotic syndrome after extensive DVT.[27] The ATTRACT Trial was a 56 centre, randomised controlled trial (RCT) that evaluated pharmaco-mechanical catheter directed thrombolysis (PCDT) for prevention of PTS in patients with acute proximal deep vein thrombosis (DVT). The study found that PCDT did not prevent PTS over 2 years (primary outcome); increased major bleeding; did not influence health related quality of life (QOL) or recurrent venous thromboembolism; improved leg pain and swelling over30 days; and reduced the severity of PTS.[28] However these randomized clinical trials included patients only in the acute phase of deep venous thrombosis whereas the recommendation for endovascular stenting of chronic deep venous thrombosis relies on low levels of evidence.[24]

On the other hand, several reviews and meta-analyses have postulated the effectiveness of endovascular stenting on CVD and PTS.[29-31] However these studies have included data of patients with CVD due to thrombotic and non-thrombotic etiology, thus limiting the clarity of the results since these different groups of patient diseases have been associated with different outcomes and results due to different pathological mechanisms.[32] In the present meta-analysis, only patients with post-thrombotic syndrome due ro thrombotic occlusion of the iliofemoral segment were included. Based on this parameter, the fact that the relief rate of PTS in these patients from the QoL scales did not reach statistical significance could partly be attributed to two reasons. Firstly, patients with PTS due to valvular insufficiency could maintain symptoms of leg edema and pain even if venous obstruction would have improved by stenting. Second, the recanalization of a completely thrombosed venous segment is highly dependent on distinct venous disease pathogenesis, on the degree of vein collaterals and venous recanalization, on the quality of inflow and outflow and rigor of anticoagulant treatment resulting in distinct clinical outcomes in each of the treated patients.

The results of our study show a high technical success of the endovascular intervention and high primary, primary-assisted and secondary patency rates. These results further support the trend of endovascular stenting as an option in patients with CVT suffering from PTS despite the wide application of alternative conservative measures such as pharmacologic treatment, compression therapy and exercise therapy.[33] Technical factors limiting or altering the technical success and stent patency results of the present meta-analysis are venous stenting extending below the inguinal ligament and iliofemoral thrombosis of non-thrombotic etiologies.[12,29] Indeed, in numerous studies, extension of the stenting below the level of the inguinal ligament has been associated with worse patencies whereas other studies have not shown this correlation.[14,34,17,20] Other anatomical criteria playing a substantial role in the management and outcome of the disease are the location of the venous occlusion and the disease pathology. Neglen et al in their study have shown that stent patency was better correlated with the disease pathology, better patency achieving patients with non-thrombotic iliac vein lesions compared to chronic total occlusions.[14]

Limitations of the study include the statistical gaps in categorizing and estimating values of QoL tools and the fact that no QoL tools exist specifically for estimating venous diseases. Duration of follow-up and outcomes for the QoL measures was inconsistently reported. We made no attempt to compare group of patients with different disease pathogenesis due to the fact that most studies were retrospective and single centres and additionally pooled data were insufficient as to reach any definitive conclusions or suggestions. Furthermore, quality of the results are possibly hindered by the fact that different stent sizes and designs were used making impossible the comparator from the reported data. Patient characteristics, physician experience and periprocedural protocols used in each center are possible confounders influencing the credibility of outcomes. Quality results for the homogeneity of the included studies are lacking.

CONCLUSION

Endovascular management of chronic iliofemoral venous thrombosis is an emerging therapeutic option in managing patients with chronic iliofemoral venous thrombosis and PTS and should be considered an attractive option to alternative management strategies since it combines safety, technical success and negligible morbidity rates. However, in terms of QoL scales, possibly further studies could further support the efficacy in the improvement if the patient's symptoms.

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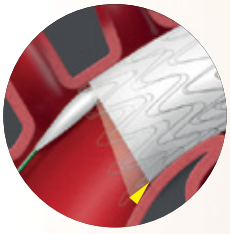

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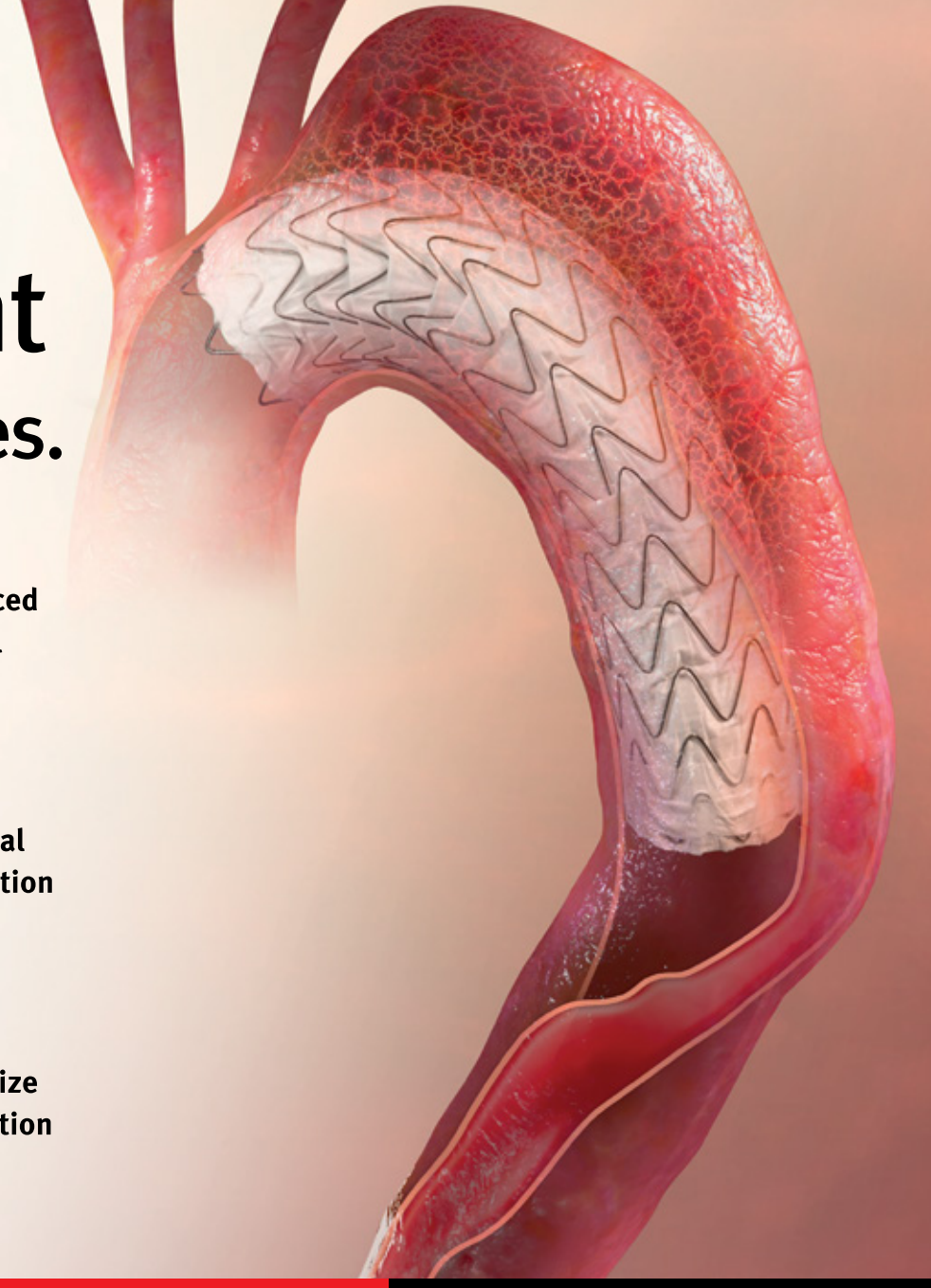

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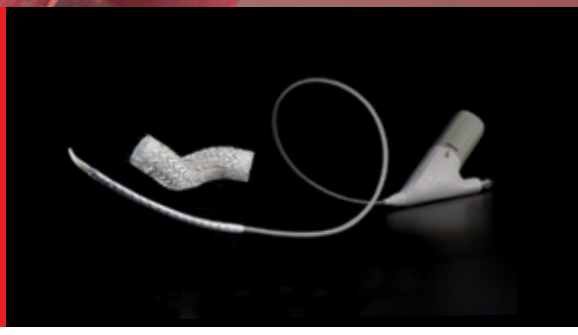

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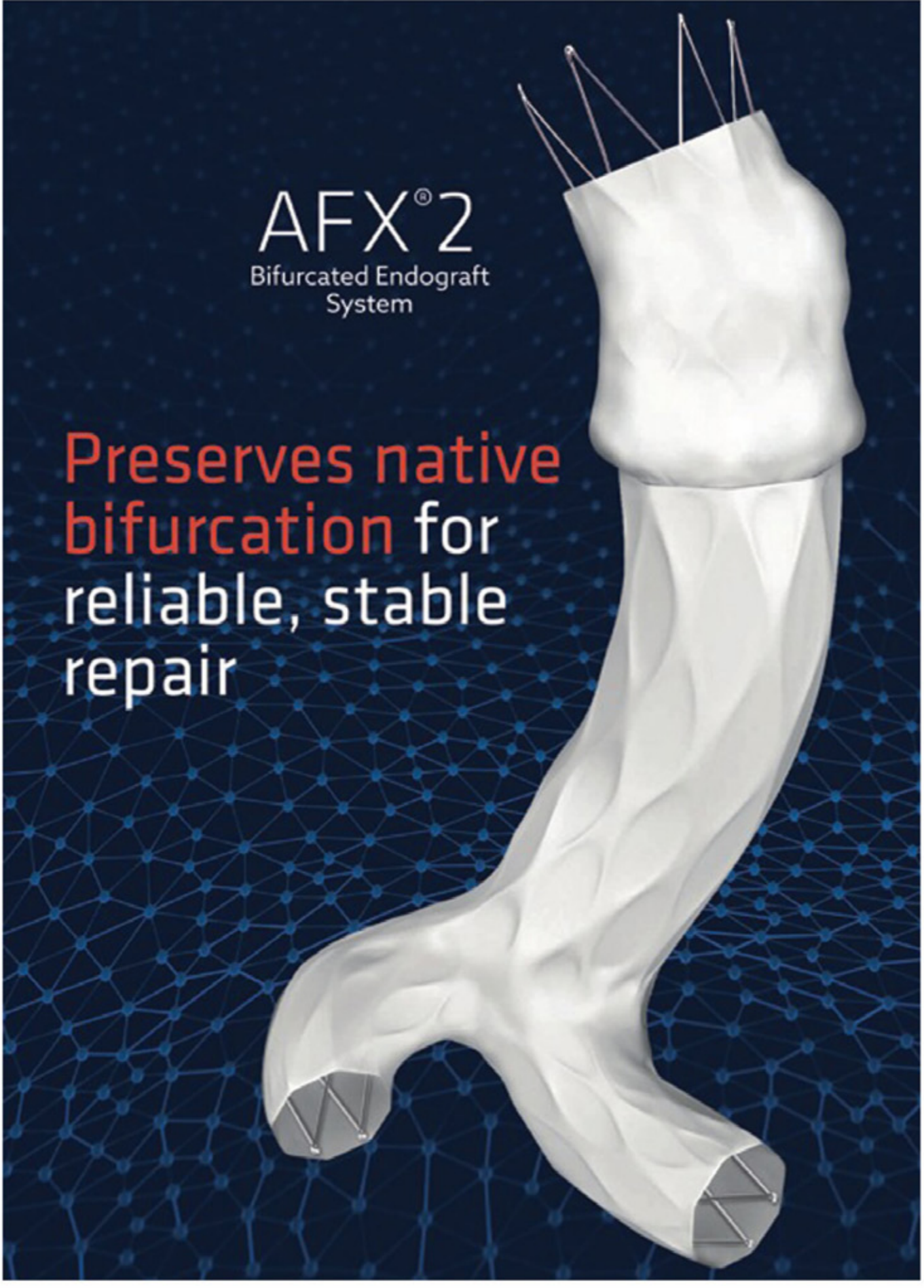

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Hellenic Vascular Registry (HEVAR): structure, perspectives and scopes

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INTRODUCTION

The term registry although it is widely used in medical literature, it is not well defined. The MeSH (Medical Subject Headings), defines registries as the "systems and processes involved in the establishment, support, management, and operation of registers [sic], e.g., disease registers."[1]

Many developed countries have regional and national clinical registries. Clinical registries are organized systems that use observational study methods to collect uniform data to evaluate specified outcomes for a population defined by a particular disease or clinical condition. In many cases, researchers and physicians attempting to assess a group of patients, search a "registry" of these patients. A PubMed search for the term "registry" in June 2019 returns almost 21.717 title hits, the oldest citation in 1936, revealing the timeless definitive role of registries in clinical practice and research.

The scope of the registries is to analyze the epidemiology, to improve the health outcomes of patients diagnosed with particular diseases and also to monitor the quality of care. The recent published guidelines from European Society for Vascular and Endovascular Surgery on the Management of Abdominal Aorto-iliac Artery Aneurysms, emphasize the importance of quality control in vascular surgery.[2] The guidelines recommend that centers performing aortic surgery should enter cases in a validated prospective registry to allow for monitoring of changes in practice and outcomes.[2]

ESTABLISHMENT AND STRUCTURE OF THE HEVAR

The creation of the Vascular Surgery Registry (HEVAR - The Hellenic Vascular Registry) has been a desire of the Hellenic Vascular Surgery community almost from its foundation. Several times, elected members of the Hellenic Vascular Surgery tried to achieve this goal but the result was disappointing.

Hopefully, the Hellenic Vascular Registry (HEVAR, https://vascularregistry.gr) was established in March 2019. HEVAR runs under the auspices of the Hellenic Society of Vascular and Endovascular Surgery (HSVES, https://www.vascularsociety.gr). HSVES is the leading scientific organization in Greece committed to support scientists and clinicians in Vascular Medicine and Vascular Surgery. HSVES, in an effort to evaluate and register the occurrence of vascular diseases and also to analyze the clinical outcome and care of patient treated in Greece, created a governing committee appointed to two members of the Board of the society with the task to organize this project for the duration of 3 years.

In April 2019, HEVAR became a full member of the Vascunet (https://vascunet.org). Vascunet is a collaboration of vascular registries, administered and partly funded by the European Society of Vascular Surgery (ESVS). It was established to improve the quality, safety and effectiveness of vascular healthcare in Europe and Australasia. Currently, Vascunet connects the national vascular registries of 23 different countries in Europe and Australasia.

SCOPE OF HEVAR

The primary scope of HEVAR is the collection of information regarding the total spectrum of vascular diseases throughout Greece. It aims to analyze the data deriving from treatment of vascular diseases over time and to create an objective evaluation assembly of treatment effectiveness that will shape the quality of healthcare service for vascular diseases in Greece. As part of the Vascunet, HEVAR will collaborate with international registries to increase its knowledge and understanding of vascular disease, and to promote excellence in vascular surgery, by means of international vascular audit and collaboration.

Finally, HEVAR will invite physicians-users to participate in future national and international clinical research projects. HEVAR may lead to research projects and suggestions that are also welcomed by institution participants. The governing committee will evaluate with transparency, objectivity and no exclusions research projects from all departments and institutions participating in HEVAR, guarantying the confidentiality and accuracy of data and the ethics.

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Figure 1. The official webpage of the Hellenic Vascular Registry (HEVAR, VascularRegistry.gr)

HOW THE REGISTRY IS SET UP?

Specialized board certified physicians working in public and private Greek hospitals, involved in vascular diseases treatment, can apply in the electronic platform to become members of HEVAR (Figure 1). The governing committee evaluates the application and activates the registration if the member fulfils the above-mentioned criteria. The electronic consists of a data entry system which currently comprises of 3 modules:

The Aortic aneurysm disease module, in which patients with aneurysm disease of the thoracic, abdominal or thoracoabdominal aorta can be registered. Furthemore another type of diseases regarding aorta can be recorded in this modules, such as aortic graft infection and aortoenteric fisula, acute aortic syndrome (dissection, intramural hematoma, atherosclerotic ulcer) and open conversion after endovascular aortic repair. Personal patient's data, details regarding comorbidities, aneurysm anatomy, type of treatment (endovascular or open), postoperative complications, outcome and follow-up information have to be provided for each patient. (please add an image of the registry how it looks on the computer)

The Carotid artery disease module, in which patients with carotid disease are registered. Acute carotid dissection, carotid aneurysms and carotid body tumors can be also recorded in this module. In the same manner with the aortic module, personal patient's data, comorbidities, neurological symptoms if present, type of treatment [endovascular stenting (CAS) or carotid endarterectomy (CEA)], postoperative complications, outcome and follow-up information are recorded.

The Lower limb Ischemia module, in which patients with chronic and acute limb ischemia are registered. Additionally, patients suffering by lower limb aneurysmal disease (popliteal, femoral), Buerger's disease, and vascular trauma of lower limbs can be included. Similarly to the previous modules, patient's and disease's data can be recorded.

Intention of the HEVAR governing committee is to add more modules in the electronic platform so as the total spectrum of vascular procedures to be finally included.

CONFIDENTIALITY, DISCRETION AND DATA PROTECTION

Patients' data are highly confidential. Improper disclosure of these data could result in emotional or psychological harm to patients and their families. Therefore, one of the most important responsibilities of HEVAR registry governing committee was to ensure and protect the confidentiality of patient's information. All institutions and hospitals participating in this registry have to receive an Institutional Review Board (IRB) and Ethics committee approval. In order to protect the rights and keep confidential the personal data an electronic system of registration has been generated compliant with the General Data Protection regulations (GDPR) requirements. Individuals are asked to give consent and provide information about their disease on a voluntary basis and are permitted to withdraw at any time they want. In order to protect data privacy, each participating physician can have access (view and edit) only on his personal patients' data. Data are highly confidential and no access to the registry data is permitted to the members of the registry. Data of the electronic database are highly encrypted this ensured and certified by Secure Sockets Layer (SSL) technology.

HEVAR SPONSORING AND OWNING OF REGISTRY DATA

HEVAR is exclusively sponsored by the Hellenic Society of Vascular and Endovascular Surgery. In order to enhance its credibility and extend its activity, HEVAR in future will apply for grants, sponsorship and donations.

The data collected belong to the Hellenic Society of Vascular and Endovascular Surgery. A statistical analysis of data will be performed and a detailed report will be shared with the physicians, participants and their families if they ask, and approved health care professionals and researchers. Personal, identifying information will be kept private. Currently, the HEVAR governing committee is responsible for providing data upon request. A dedicated Patients Data Management Committee will be created. This committee will be responsible for sharing data outside HEVAR

COMMUNICATION WITH HEVAR AND ANNUAL REPORT

An official webpage has been created - https://vascularregistry.gr- which informs physicians, participants, health care professionals, researchers and web users about the establishment and scope of the Registry. All participant Departments, Units and institutions are described in detail. HEVAR is also registered in popular mobile messaging applications and a periodical newsletter is provided electronically in all members.

An annual report emphasizing into the outcomes from different treatments in aortic aneurysmal disease, carotid artery disease and peripheral occlusive disease with epidemiological data around Greece will be presented and discussed in a special section in the annual Vascular Meetings of the Hellenic Society of Vascular and Endovascular Surgery.

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Applied statistics in vascular surgery Part IV: Introduction to survival analysis

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Abstract:

Survival or 'time to event' analysis is used to estimate the lifespan of a particular population under study. The goal is to estimate the time for an individual or a group of individuals to experience an event of interest. In this paper, we present the basic concepts of survival analysis.

INTRODUCTION

When conducting a clinical study, the type of the experimental design and the type of the variables which should be analyzed are important factors highlighting the type of statistical analysis needed. It is evident that mortality after open repair of abdominal aortic aneurysm (AAA) is a binary outcome variable (equal to 1 if the patient died and 0 if the patient survived). In that case, the researcher can estimate the odds of experiencing the outcome of death within a specific time frame (eg, 30-day mortality after surgery), when one or more covariates are present by conducting logistic regression analysis.[1] However, if we want to estimate the lifespan of this particular population, the time to death is the observed outcome and this type of analysis is not appropriate.

In the last scenario, the research question involves the length of time until death occurs, and one might think that length of time is a continuous outcome variable and as a result, linear regression analysis might be appropriate. However, in this case, death will usually have occurred only in some, but not in all patients, by the time the study ends. Furthermore, for those who are lost to follow-up before the end of the observation period or those who haven't yet reached the reported time endpoint, full survival times are unknown. It seems that when length of time until death is the outcome of interest, a combination of whether death has occurred (binary outcome) and when death has occurred (continuous outcome) should be taken into consideration[1] and the appropriate analysis is called "survival analysis". However, it should be highlighted that despite the name ''survival analysis,'' this method can be used in any time-to-event outcome analysis, such as the time until a patient experiences a stroke, a myocardial infarction, a bypass or stent failure etc.[2]

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WHICH ARE THE BASIC COMPONENTS OF SURVIVAL ANALYSIS?

Firstly, a clear definition of the outcome of interest defined as "event" (eg. death after open repair of AAA) and the exact starting point (eg. time of open AAA repair) are crucial. The length of follow-up should be enough to ensure that a sufficient number of events are observed, but at the same time not too long to allow changes to the variable under investigation during the study period, due to uncontrolled factors (eg change in a surgical technique over time, changes in endograft design which cause improvements in endograft performance etc).[1,3]

SURVIVAL TIME AND CENSORING

After defining the event and the starting point, the time until it occurs, (eg. the time interval between the open AAA repair and death) should be captured. This is also a synonym for "survival time" or "failure time" or "time-to-event" or "freedom from the event" depending on the definition of the event. For some patients, the event (eg. death) occurred, and we were able to measure when it occurred (eg. three months after AAA repair). However, for some patients, the event was not observed during follow-up and the researcher does not know the exact time of the event (if happened), or the patients were lost to follow-up or not have reached the reported follow up. This is called "censoring". In this case, we have incomplete observation of survival times and the subjects with the incomplete observation are referred to as "censored". There are many types of censoring. In one of the most frequent types patients do not complete the follow-up, because they are lost to follow-up, or they are uncooperative and refuse to remain in the study. This is called "random censoring" and it occurs when follow-up ends for reasons that are not controlled by the investigator. Another type is when the patient is known to have experienced the event (eg. death) before the start of the observation period (eg. the patient died, while he was waiting for open AAA repair). This is called "left censoring". In another situation, we know that the event occurred (or will

occur) sometime after the date of last follow-up, but the observation of the patient is terminated before the event occurs, which means that the actual time-to-event, if it were to occur, is longer than the observation time. This is called "right censoring". In other words, for some patients the event did not occur during the time we observed the individual, and we only know the total number of days in which it did not occur (eg. we do not kwon the exact time of death for a patient with AAA repair; we only know that the patient was followed up for 6 months, during which he was alive). There are two types of right censoring; type I and II. In type I censoring, the study stops at a predetermined time, at which point any subjects remaining are right-censored, while in type II censoring, the study stops when a predetermined number of patients are observed to have failed; the remaining subjects are then right-censored.[3]

ASSUMPTIONS OF SURVIVAL ANALYSIS

Before conducting a survival analysis, the researcher should check if specific assumptions are fulfilled.[4] Firstly, the outcome for a patient can either be censored or the event has occurred; it cannot be both. For example, the patient is either dead or censored at the end of follow-up and at least one of these two states have occurred. Secondly, the "survival time" should be measured with precision (eg. the researcher should know the exact time of death or censorship after open AAA repair for each study participant). Thirdly, left censorship should be as low as possible. Moreover, independence of censoring and event is required. This means that a patient is "censored" not because he/she is at greater risk for the event (eg. death). This is based on the assumption that the reasons for someone to quit follow-up are unrelated to whether the event occurs or not. For example, some patients become too ill during the study and then withdraw and then die. These patients will skew survival analysis, as they will be counted as non-events without ever contributing an event when in fact they should have counted as an event. Furthermore, the observation period should not be too long to introduce bias by allowing confounders to affect the likelihood of the event; this is called "secular trend". Lastly, in case of comparison of survival between two or more groups, the possibility and pattern of censorship should be similar among the different groups.[5,6]

CONCLUSION

Survival or "time-to-event" analysis is a set of methods to measure the time until a specific event occurs in a study sample. Due to the fact that not everyone in the sample will experience the event, either because the study ended before they had the event or because they were lost to follow-up, there is incomplete observation of time-to-event and the subjects with the incomplete observations are referred to as "censored". Unlike regression models, survival methods correctly incorporate information from both censored and uncensored observations in estimating important model parameters.

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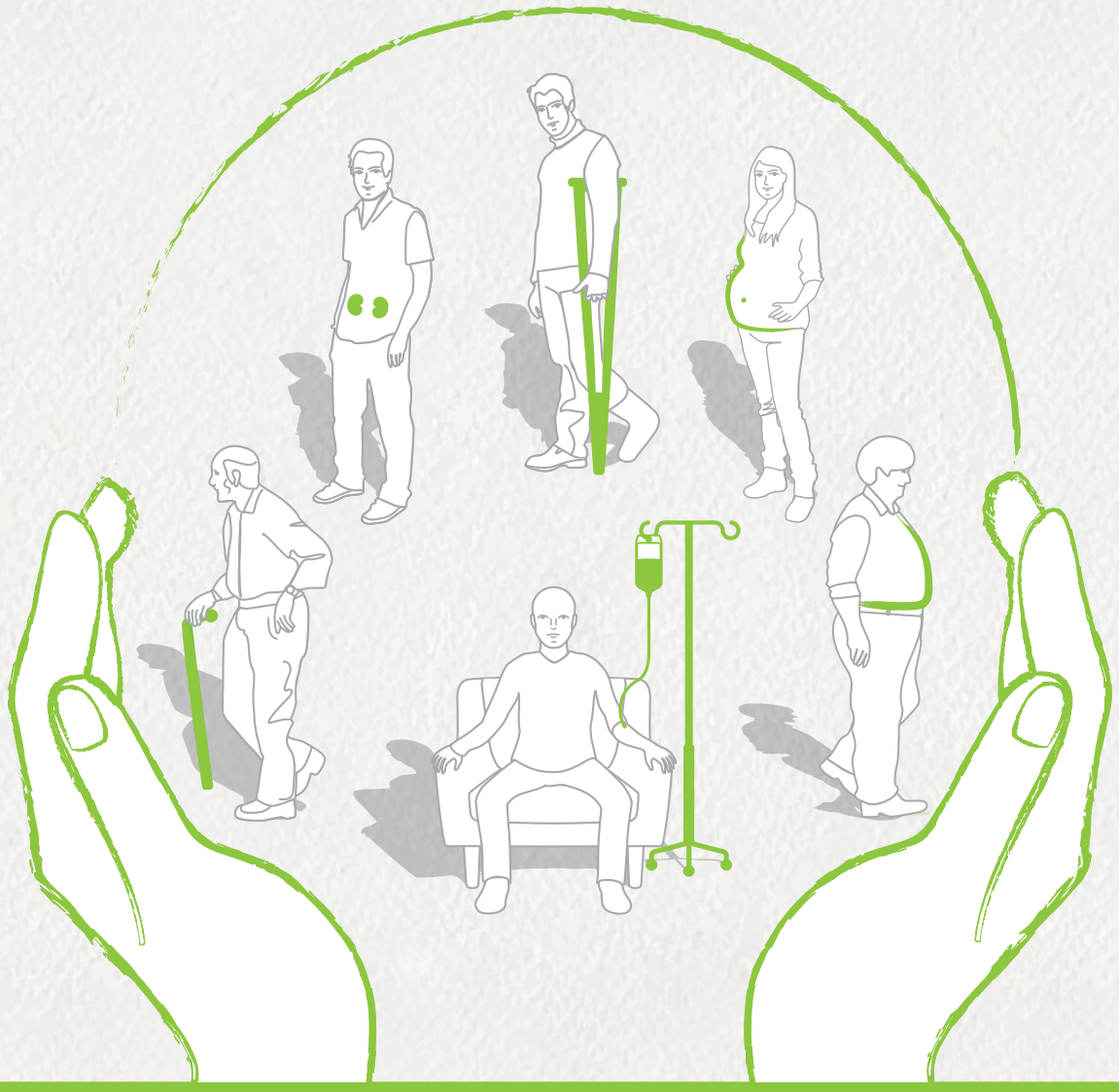

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False lumen occlusion in chronic type B aortic dissection using the candy-plug technique

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Abstract:

Endovascular repair has become the treatment of choice for type B aortic dissections (mainly acute, and in specific indication in chronic too). However, the persistent false lumen patency represents the Achilles heel of this method. Herein we describe the successful use of the candy-plug technique in a patient with residual chronic type B aortic dissection after thoracic endovascular repair and a false lumen aneurysm of an increasing diameter due to persistent false lumen backflow. A custom-made candy-plug device was used to seal the false lumen. Computed tomography angiography one month after the procedure revealed complete thrombosis of the false lumen.

INTRODUCTION

According to the latest European Society for Vascular Surgery (ESVS) guidelines on the management of descending thoracic aorta diseases, in patients with chronic aortic dissection, an aortic diameter greater than 60 mm should be considered as an indication for treatment in patients at reasonable surgical risk (Class IIa, Level of evidence C).[1] Endovascular repair should be considered in such patients, provided that the anatomy is suitable for endografting and that the centre is dedicated (Class IIa, Level of evidence C).[1] The efficacy of the procedure is determined by the ability of the endograft to induce false lumen thrombosis, with persistent false lumen patency representing the Achilles heel of the method. Patency of the false lumen despite endovascular repair has been unequivocally recognized as a predictor of both false lumen expansion as well as expansion of the visceral segment of the aorta during follow-up.[2,3]

Recently, several techniques have been introduced for the induction of complete false lumen thrombosis after thoracic endovascular aneurysm repair (TEVAR) including the Candy-plug, the Knickerbocker, vascular and iliac plugs, coils and liquid embolization.[4,5] Herein we describe the successful use of the candy-plug technique in a patient with residual chronic aortic dissection after TEVAR and thoracic false lumen aneurysm of an increasing diameter due to false lumen backflow.

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CASE REPORT

A 55-year-old male with history of a chronic type B aortic dissection presented to the outpatient clinic of our Department. The dissection had occurred 8 years before and was being treated conservatively. A few days before his appointment, the patient had been submitted to a computed tomography angiography (CTA) which verified the presence of the type B aortic dissection with the entry tear located 7.5 cm below the left subclavian artery (Figure 1A). All splanchnic branches of the aorta originated from the true lumen as well as both internal iliac arteries. The true lumen was completely compressed in both external iliac arteries and both legs were supplied from the false lumen. The diameter of the descending thoracic aorta (DTA) at the widest point was 75 mm, the diameter of the abdominal aorta 3 cm, the right common iliac artery (CIA) 5 cm, the left CIA 4.4 cm and the left external iliac artery 4 cm (Figures 1A and B).

The patient had history of hypertension, dyslipidemia, hypothyroidism and benign prostatic hyperplasia. He did not report any thoracic or abdominal pain over the past 8 years.

A staged therapeutic approach with TEVAR followed by open repair of the iliac aneurysms was hindered by the chronic, complete occlusion of the true lumen at the level of both external iliac arteries, so a reverse staged procedure was planned. The patient was submitted to open surgical reconstruction of the infrarenal aorta and two iliac arteries with an aorto-bi-iliac Dacron graft with an end-to-end proximal anastomosis below the renal arteries and two end-to-end distal anastomoses at the internal iliac arteries. Two jump-grafts were then placed between the limbs of the bifurcated graft and the common femoral arteries. Two months later, the patient underwent endovascular repair of the dissecting aneurysm of the thoracic aorta with the implantation of a 20 cm in length and 34 mm in diameter Bolton RelayNBS Plus endograft (Bolton Medical, FL, USA).

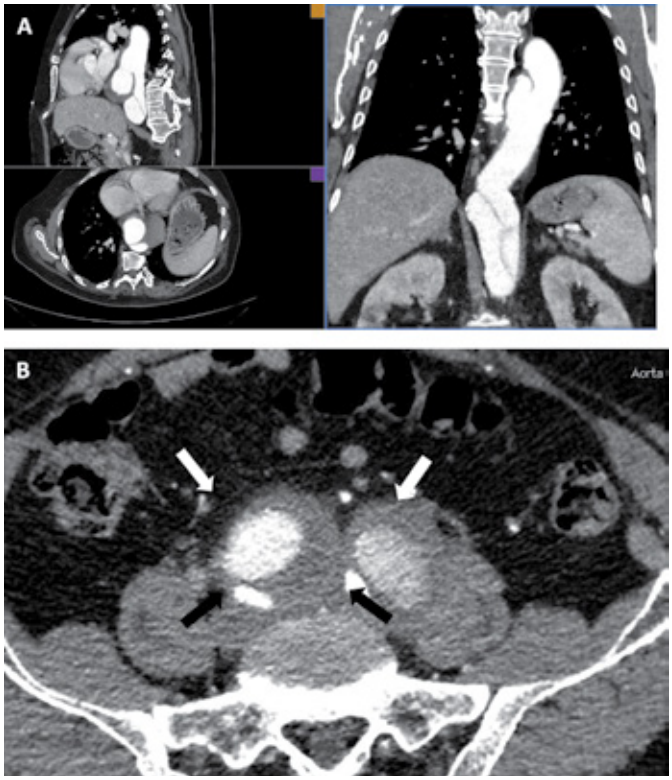

Figure 1. (A) CTA showing a type B aortic dissection with the entry tear located 7.5 cm below the left subclavian artery. The diameter of the descending thoracic aorta at the widest point was 75 mm. (B) at the level of the common iliac arteries there were two narrow true lumens supplying the internal iliac arteries (black arrows) and two dilated false lumens supplying the external iliac arteries (white arrows). The diameter of the right CIA was 5 cm and of the left 4.4 cm.

One month after this procedure, a CTA revealed thrombosis of the thoracic aneurysm but with some retrograde flow in the false lumen next to the last stent of the endograft (Figure 2).

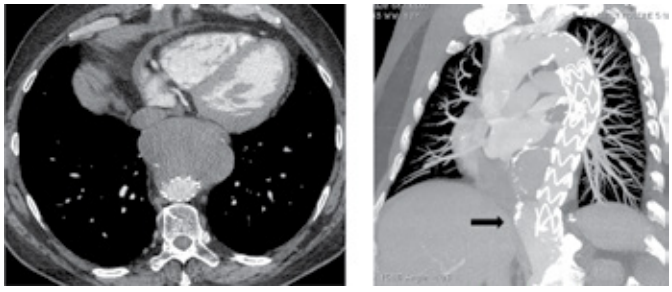

Figure 2. Post-TEVAR CTA showing thrombosis of the thoracic aneurysm but with some retrograde flow in the false lumen next to the last stent of the endograft (arrow).

Follow-up CTA 1 year later revealed a type Ib endoleak within the aneurysm, the diameter of which had gone up to 9.7 cm (Figure 3). The diameter of the false lumen at the level of the supraceliac aorta was 3.8 x 2 cm. Occlusion of the false lumen with the candy-plug technique was decided. A custom-made, double-tapered endograft (candy-plug) with a 42 mm proximal and distal diameter, a 16 mm diameter at the narrow part and a 105 mm length was prepared by Bolton Medical, FL, USA. The procedure was performed in the operating room with the use of a Philips BV Endura mobile C-arm. Under general anesthesia, the jump-grafts from the aorto-bi-iliac graft limbs to the femoral arteries were exposed just above the femoral anastomoses. The false lumen was cannulated through the right ilio-femoral jump-graft and the true lumen through the left ilio-femoral jump-graft (Figure 4A). The celiac artery was catheterized with a Cobra catheter and the level of its orifice was marked on the screen of the C-arm (Figure 4B). A 36 x 100 mm Bolton RelayNBS Plus endograft was implanted in the true lumen from within the previous endograft down to the orifice of the celiac artery and the candy-plug was implanted in the false lumen at the same level. A 22-mm Amplatzer Vascular Plug II (St. Jude Medical, St. Paul, MN, USA) was then deployed in the waist of the candy-plug (Figure 4C and D). Completion angiography showed absence of retrograde flow to the false lumen and unrestricted patency of the celiac trunk (Figure 4E).

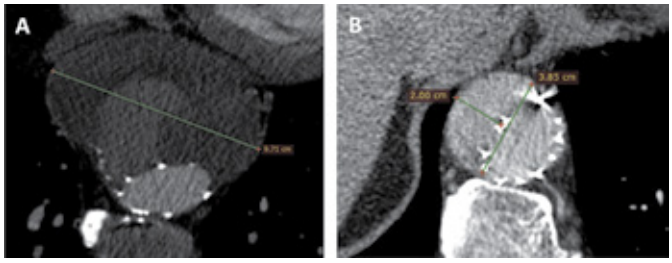

Figure 3. (A) CTA 1 year post-TEVAR revealing a type 1b endoleak and a thoracic aneurysm of 9.7 cm in diameter. (B) The diameter of the false lumen at the level of the supraceliac aorta was 3.8 x 2 cm.

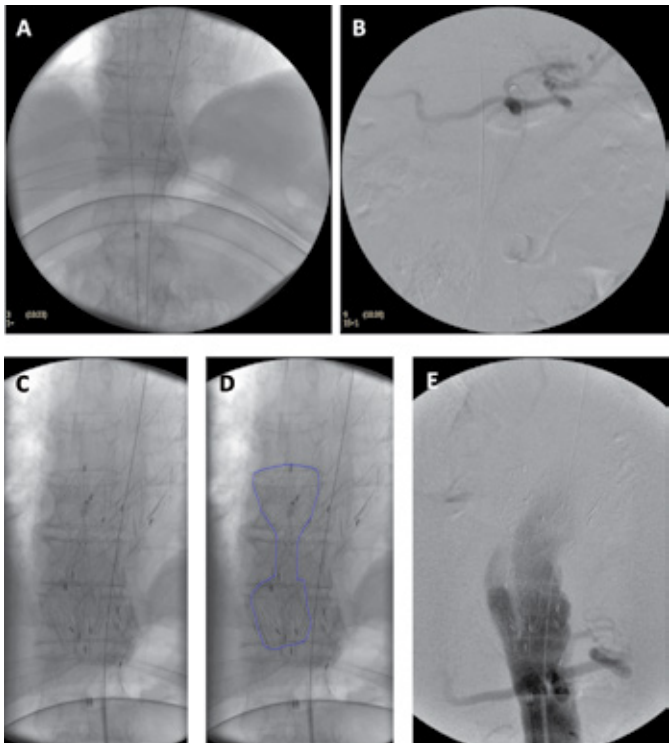

Figure 4. (A) Cannulation of the false and the true lumen and (B) catheterization of the celiac artery. (C, D) Implantation of a standard thoracic endograft in the true lumen and a candy-plug in the false lumen above the level of the celiac trunk. (D) Completion angiography showing absence of retrograde flow to the false lumen.

The patient was discharged on the fifth postoperative day. CTA at 1 month showed no endoleaks and complete thrombosis of the false lumen and the dissecting thoracic aneurysm above the candy-plug device (Figure 5).

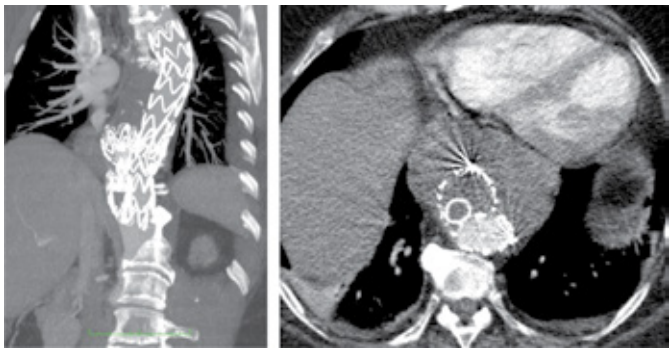

Figure 5. CTA 1 month post-TEVAR showing no endoleaks and complete thrombosis of the dissecting thoracic aneurysm above the candy-plug device.

DISCUSSION

The candy-plug technique was described for the first time in 2013 by Kölbel et al who modified a 42 mm Cook Zenith TX2 thoracic endograft (Cook Medical, Bloomington, IN, USA) to a large diameter vascular plug by partial unloading the stent-graft and adding a diameter-reducing suture between the third and fourth Gianturco Z-stents to restrict the opening of the stent-graft at this point to about 10 mm.[6] The customized stent-graft was implanted in the false lumen of a chronic type B aortic dissection and its waist was occluded with an Amplatzer vascular plug. Completion angiography as well as CTA at 1 week and 3 months verified the complete thrombosis of the false lumen. Ogawa et al described the applicability of the candy-plug technique to another type of stent-graft, the Excluder aortic extender (W.L. Gore & Associates, Flagstaff, AZ, USA), which offers the advantage of an easier modification since it does not have to be unloaded from a delivery sheath.[7]

Another interesting modification of the candy-plug technique was described by Marone et al, who used two commercially available stent grafts released side by side in the false lumen: a 32 to 12 mm converter aortouniliac stent-graft and a 13 to 24 mm bell bottom iliac extender stent-graft in order to obtain an adequate oversizing sufficient to allow false lumen occlusion.[8] Both stent-grafts were occluded using two Zenith and two Amplatzer vascular plugs.

Nowadays, the candy-plug endograft is available as a custom-made device with a maximum diameter of 50 mm and a mid-section of 16 or 18 mm, whereas the latest development has been the production of a candy-plug endograft, the central portion of which closes itself as soon as the dilator tip is removed.[9] This new design obviates the additional placement of a plug to occlude the mid-section of the endograft.

Rohlffs et al have published a series of 18 consecutive patients in whom the Candy-Plug technique was applied.[10] Technical success was 100%. Complete distal false lumen occlusion was present on postoperative CTA in 15 patients, while 3 had minor contrast enhancement in the distal false lumen. Over a mean 9-month follow-up, 1 patient died due to rupture. Follow-up >6 months was available in 10 patients: 7 patients showed aortic remodeling, while aneurysm size was stable in 3 patients.

A subsequent study by the same group reported on a consecutive series of 14 patients who were treated with the self-sealing Candy-Plug generation II (CP II) device (Cook Medical, Bloomington, IN, USA).[11] Immediate complete false lumen occlusion was achieved in 12 patients; the other 2 required reintervention. One patient died due to retrograde type A aortic dissection that was not related to CP II placement. Over a mean 8-month follow-up (range 3-12), 9 patients had CTA; 8 patients had evidence of aortic remodeling, while 1 aneurysm sac was stable.

Author	Year	No of patients	Candy-Plug Device	Vascular Plug	Follow-up
Kolbel[6]	2013	1	Cook Zenith TX2	Amplatzer	3 months: complete thrombosis of the false lumen
Ogawa[7]	2016	1	Gore Excluder	Amplatzer	14 months: decreased maximum diameter, greater expansion of the true lumen, and volume reduction of the thrombosed false lumen
Marone[8]	2017	1	Cook Zenith converter + bell-bottom iliac extension	Cook Zenith vascular plug + Amplatzer	18 days: complete thrombosis of the false lumen
Kotani[12]	2017	1	Gore Excluder	Amplatzer	1 year: complete thrombosis of the false lumen
Rohlffs[10]	2017	18	Cook Zenith TX2	Amplatzer	Mean follow-up of 14.7 months: 1 patient died due to rupture, 7 patients showed aortic remodeling, while aneurysm size was stable in 3 patients.
Branzan[13]	2018	1	Medtronic Valiant Captivia	Fractured tip of the delivery system	6 months: complete thrombosis of the false lumen and shrinkage of the aneurysm
		2	Cook Candy-Plug II	-	
Lin[14]	2018	1	Gore Excluder	Amplatzer	Postoperative CTA: complete thrombosis of the false lumen
Wu[15]	2018	1	Medtronic Valiant Captivia	Amplatzer	6 months: complete thrombosis of the false lumen
Furukawa[16]	2018	1	Cook Zenith TX2	Amplatzer	1 year: complete thrombosis of the false lumen
Yap[17]	2019	1	Zenith Alpha	Amplatzer	2.5 years: no endoleak, the thrombosed false lumen in the thoracic aorta was reduced in size
Morisaki[18]	2019	1	Gore Excluder	Amplatzer	3 months: shrinkage of the thrombosed false lumen
Hasegawa[19]	2019	1	Cook Zenith TX2	Coils	1 month: complete thrombosis of the false lumen
Eleshra[11]	2019	14	Cook Candy-Plug II	-	Mean follow-up of 8 months: 9 patients had CTA; 8 patients had evidence of aortic remodeling, while 1 aneurysm sac was stable.

Table. Summary of studies reporting on the use of the Candy-Plug technique

A literature search reveals that until the 6th of October 2019 there had been 45 reported cases of the application of the Candy-Plug technique to achieve false lumen thrombosis (Table). Our report adds another case of a successful treatment of a residual chronic type B aortic dissection after TEVAR using the candy-plug technique. Implantation of the candy-plug was uneventful and short-term outcome was excellent, though long-term results are still awaited.

In conclusion, the candy-plug technique appears to be a safe and effective endovascular method to achieve thoracic false lumen occlusion in chronic aortic dissection. However, long-term terms results are needed before a robust conclusion is reached.

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Crossed limb (Ballerina) Endovascular Aneurysm Repair: Presentation of a case and Literature review

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Abstract:

In modern era of endovascular procedures, the aortic anatomy may influence the potential success of the endovascular abdominal aortic repair (EVAR). To overcome some of these limitations, the crossed-limb (CxL) technique was developed, where catheterization of the contralateral limb performed from the ipsilateral side. This report present a rare case of a 65-years old male patient who treated in our department for a large 7.5 cm infrarenal abdominal aortic aneurysm (AAA) using the CxL technique with an unexpected result, the almost 'double crossing' of the limbs. This resulted from over-rotation of the main body during the deployment with no impact on the blood flow. Two years thereafter the aneurysm sac has been shrinked and both limbs are patent without endoleak. We also contact a literature review regarding the CxL technique and the short and midterm outcome of the method.

INTRODUCTION

Endovascular aneurysm repair (EVAR) have changed the therapeutic approach in abdominal aortic aneurysms (AAAs) over the last decades[1]. New commercially available devices have increased the safety and success of the method[2]. However, anatomic factors may limit the availability of the method[3]. The crossed-limb (CxL) or 'ballerina position' technique was developed first from Ramaiah VG et al in 2002 for cases where the conventional EVAR configuration were not feasible[4]. In these cases, the deployment of an AneuRx stent-graft made with the contralateral gate of the main body facing the ipsilateral side after rotation of the device.

This report presents an interesting case of a patient treated endovascularly for a 7.5 cm infrarenal AAA using the CxL technique, where over-rotation of the main body had an unexpected result; the almost 'double' CxL configuration which illustrated patent in the two years follow-up. We also contact a literature review concerning the efficacy of this method.

CASE REPORT

A 65-years old male patient presented in the emergency department due to acute left calf swelling. His medical history included hypertension, hyperlipidemia, diabetes mellitus, coronary artery disease and obesity (BMI>30). A vein duplex examination revealed an unprovoked deep vein thrombosis (DVT) extending from left popliteal to left external iliac vein and an incidental finding of a large 7.5 cm infrarenal AAA not associated with the thrombosis. Emergency Computer Tomography angiography (CTA) verified the diagnosis. The aneurysm was suitable for standard - EVAR, although the big size of the aneurysm and the extended mural thrombus were concerns for extra consideration (Figures 1a). We also observed the tortuosity of the left external iliac artery with mild angulation of both common iliac arteries (Figure 1b). The patient operated in an emergency setting and we implanted a Zenith Flex® AAA endograft (Cook medical, Bloomington, USA). A right main access was selected. Considering the size of the aneurysm and the high volume of mural thrombus into the sac we decided to use the CxL technique. Nevertheless, over-rotation of the main body during deployment resulted in a little bit additional torsion of the main body. This led to the double crossing of the limbs position which had no impact on the blood flow in both limbs. We also hypothesize that winding of the contralateral guide wire to the ipsilateral one may affect the final position of the endograft. Total operative time was 153 minutes and blood loss of 240 mL. The patient was discharged during the fourth post-operative day with no complications under therapeutic doses of low-molecular-weight heparin (LMWH) for six months and an antiplatelet agent for lifetime. Two years thereafter the aneurysm sac has been shrinked and both limbs are patent without endoleak (Figure 2).

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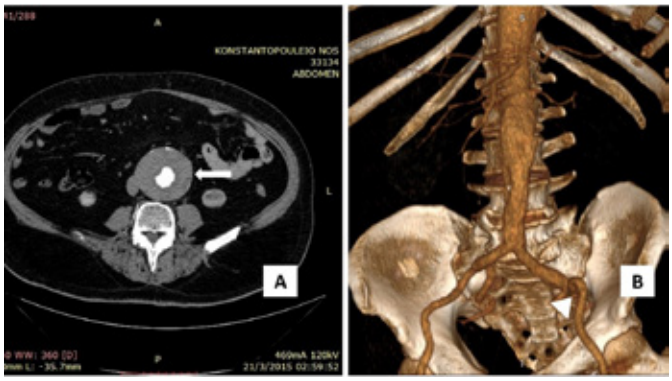

Figure 1. a. Pre-operative Computed Tomography Angiography (CTA) revealed the 7.5 cm infra-renal abdominal aortic aneurysm with extended mural thrombus (arrow). **b.** 3-D reconstruction of the pre-operative CTA showing the small patent lumen with the angulated left common iliac artery and the tortuous left external iliac artery (arrowhead).

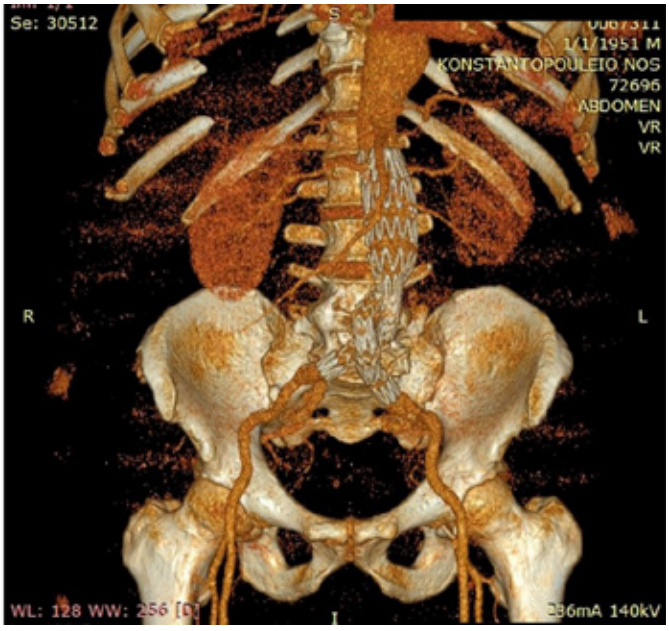

Figure 2. Two years follow-up CTA revealed the patent cross-limbed endograft in antero-posterior view.

DISCUSSION

In modern era of endovascular procedures, the aortic anatomy may influence the potential success of the endovascular abdominal aortic repair (EVAR) technique[5]. In cases with severely splayed iliac arteries, large aneurysm sac, severe proximal or distal neck angulation and increased or absent mural thrombus catheterization of the short limb via the contralateral access is difficult[4,6,7]. To overcome this barrier, the crossed-limb (CxL) technique was developed where the short limb gate of main body faces the ipsilateral side, to facilitate catheterization of short limb via contralateral access. Ramaiah et al. reported the use of this technique in 1.6% oh their patients treated with EVAR in 2002[4]. This technique does not seem to affect hemodynamic behavior compared to a typically positioned endograft, although it seems to increase forces exert on the limbs[6]. There is no increased risk of graft limb occlusion or of clinically significant endoleaks for the CxL configuration compared to conventional endograft position, but there is lacking evidence to support this view. Our case fulfils two anatomic criteria introduced from Georgiadis et al[7] considering the presence of a large aneurysm with increased mural thrombus. This maneuver reduced the difficulties of a straight catheterization and the possibility of the contralateral limb to be deployed inside the thrombus, but over-rotation resulted in the twisted position of the device. Furthermore, we observed that operative time was higher from the average time of 116.3 minutes that previous report mentioned, making it a time-consuming procedure for non-familiar practicioners[7].

Finally, we conducted a cross-sectional literature review concerning the use of this technique in patients treated for AAAs. We used the terms “EVAR”, “crossing the limbs technique”, “ballerina EVAR”, “AAA”. Three case series isolated from this search[4,7,8]. The first one described the first use of the technique in patients with an extremely angled aortic neck[4]. Georgiadis et al. reported a case-controlled analysis of 54 patients from 2007 to 2012 who treated by the same EVAR endograft using either the CxL or straight-limb (SL) technique[6]. The authors measured the primary outcomes of both methods in a time – period ranging from 6 – 59 months. There were no difference in short- and midterm outcomes between the two methods, apart from the mean procedural time which were significantly longer in the CxL group (116.3 vs 90.7 minutes). Dattani et al. retrospectively reviewed 312 EVAR patients treated with the crossed (n=43) and uncrossed (n=269) technique at a tertiary vascular center for a 5 years period[7]. The authors concluded that there was no difference in both groups for two years follow – up apart from type II endoleaks which were higher in the crossed group, but it was not associated with sac expansion. They also observed that the main indication for the crossed-limb technique was angulation on the distal portion of the aorta. The two series have some limitations and differences concerning the selected anatomic and exclusion criteria, but both showed similar results.

CONCLUSION

Crossing the limbs technique (CxL) is a possible option for patients treated for AAA with specific anatomic criteria. This can be planned in a pre – operative planning process for elective repair cases or it can be an option decided during the procedure with acceptable mid-term results compared with the straight-limb (SL) EVAR procedure.

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Conflicts of interest: The Authors declare that there is no conflict of interest with respect to the research, authorship, and/or publication of this article.

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Endovascular repair of a thoraco-abdominal aneurysm using the sandwich technique

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Abstract:

Endovascular repair of thoraco-abdominal aneurysms has gained popularity due to custom-made devices such as fenestrated and branched ones. However, these devices may not be applicable in the emergent setting and/or in specific anatomical conditions. Sandwich technique using parallel grafts, may be a valid alternative in some of these cases. We report a case of a 73-year-old male patient, who was considered unfit for open repair and unsuitable for fenestrated/branched devices, presenting with a large type II thoraco-abdominal aneurysm. The patient has been treated in two stages using the sandwich technique.

INTRODUCTION

Endovascular repair of thoraco-abdominal aneurysms has gained popularity during the last decade, lowering the mortality and morbidity rates in comparison with open syrgery.[1] Fenestrated and branched endografts have substantially improved the operative outcomes in these patients.[2] However, these devices are not applicable in urgent cases or/and may not be suitable in tortuous aortic anatomy.[3] In this setting, "off-the-shelf" techniques, as chimney and sandwich, sustain as a valid alternative.[2,3] The sandwich technique for the treatment of thoraco-abdominal aneurysms (TAAAs) consists of four steps: A. A thoracic endograft is deployed to treat the thoracic part of the aneurysm. Its distal end is left above the celiac axis, B. Cannulation of the visceral arteries, usually from above and deployment of covered self-expandable stents in the visceral arteries, C. Treatment of the remaining segment of the aneurysm, using a thoracic or bifurcated endograft, depending on aneurysm type, demonstrating the final sandwich technique.[4] Herein, we report a case of a 73-year-old male, presenting a type II TAAA, treated with the sandwich technique. This report has been approved by the Ethics Committee of the Hospital.

CASE REPORT

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A 73-year old male, with a history of EVAR with a bifurcated endoprothesis (Talent, Medtronic, Minnesota, USA) 12 years ago, presented after a 7-year absence of follow-up. His medical history was significant for tobacco use, hypertension, dyslipidemia, coronary arterial disease and chronic obstructive pulmonary disease. Computed tomography angiography (CTA) revealed a graft migration associated with the development of a type II TAAA with a maximum diameter at 75mm and a 30mm left common iliac artery aneurysm (Figure 1A). A chronic coeliac trunk occlusion was also identified. Extreme angulations of the para-visceral aorta precluded any treatment with conventional complex endovascular techniques (Figure 1B). Considering this complex anatomy, a sandwich technique repair was decided. A two-stage approach with an interval of 12 weeks was initially decided, in order to decrease the possibility of spinal cord ischemia.

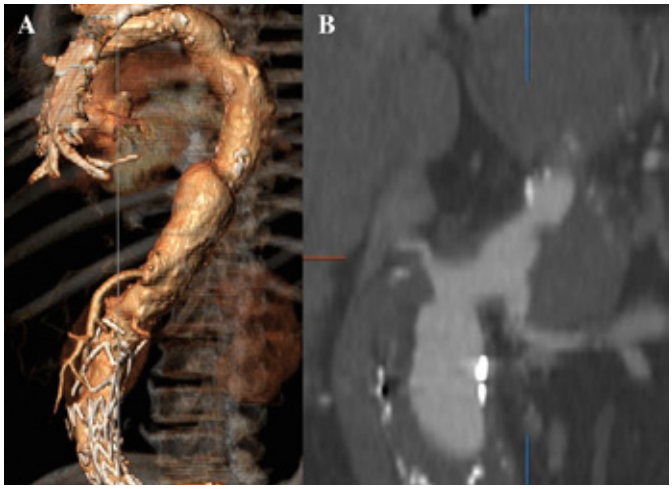

Figure 1. (A) A type II thoraco-abdominal aneurysm was developed after a failed previous EVAR. **(B)** Extreme angulations of the para-visceral aorta precluded any treatment with fenestrated or branched devices.

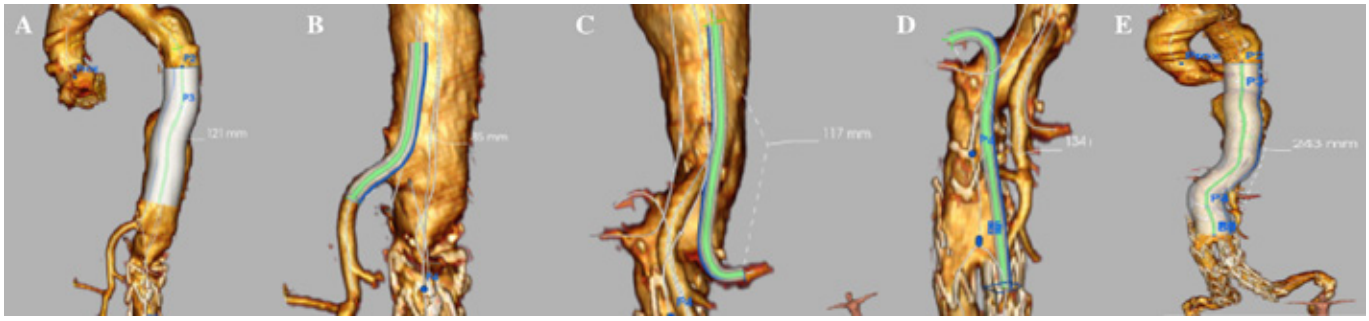

Figure 2. Pre-operative planning of the sandwich technique. A periscope was decided to be used to re-vascularize the right renal artery. Two custom-made endografts were deployed to achieve sealing.

Two custom-made thoracic endografts and 3 visceral stent grafts were used during the first procedure. A thoracic endograft (Relay 42x34x135mm, Bolton Medical, Sunrise, Florida, USA) (Figure 2) was implanted initially at the distal descending aorta. Parallel covered stents were deployed in the renal (RA) and superior mesenteric (SMA) arteries to achieve vascularization. The SMA and left RA were catheterized antegrade from the axillary arteries while the right RA was able to be catheterized via the left common femoral artery, creating a periscope. Covered self-expanding stents, with 100mm of length, were deployed in all arteries (Viabahn, W. L. Gore & Associates, Newark, Delaware, USA). Relining, using self-expanding bare metal stents, was applied in all vessels in order to achieve a better configuration and more stability (E-Luminex, Bard, Covington, USA). A second thoracic graft (Relay, 40x38x150mm, Bolton Medical, Sunrise, Florida) (Figure 2) was deployed down to the bifurcation of the previous endograft. An additional limb, extending to the external iliac artery, was used to seal the iliac aneurysm (Excluder, 16x14.5x120mm, W. L. Gore & Associates, Newark, Delaware, USA). The procedure was completed after kissing-balloon technique at the level of thoracic grafts' overlapping and visceral artery stents.

The completion angiography showed no endoleak and all visceral stents were patent (Figure 3). The operation duration was 300 min, contrast use was 250ml and dose area product was 735mGy/cm2 (113 min). Pre-discharge CTA confirmed no complication in terms of endoleaks and graft patency. The patient was discharged the 6th post-operative day with a mild renal impairment (GFR 44ml/min/1.73m^2). A close surveillance with clinical re-evaluations and laboratory exams confirm the good general status of the patient and the restoration of the renal function.

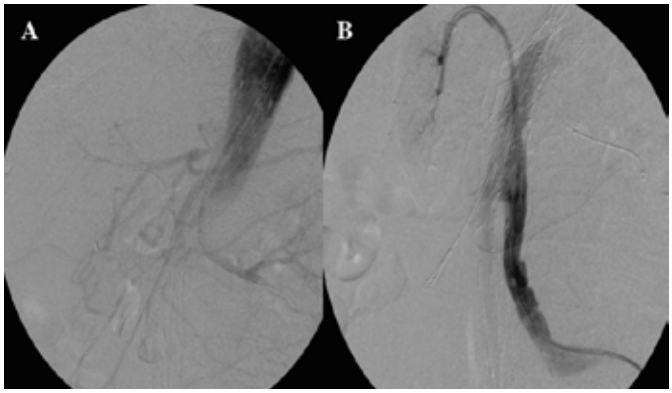

Figure 3. Completion angiography revealed no endoleak while all visceral stents were patent. Self-expanding stents, relined with bare metal stents, were used as parallel grafts.

A month later, the patient presented at the emergency department referring an atypical thoracic pain. An emergent CTA revealed a proximal descending aorta expansion from 69mm to 90mm (Figure 4). An additional thoracic endograft (Relay, 38x38x145mm, Bolton Medical, Sunrise, Florida) was successfully deployed below the left subclavian artery to the previous proximal thoracic graft, using a right femoral and left brachial access. The patient had an uncomplicated post-operative in-hospital stay. A pre-discharge CTA confirmed the complete exclusion of the aneurysm sac and no endoleak was revealed. The patient was discharged the 4th post-operative day in a good general condition.

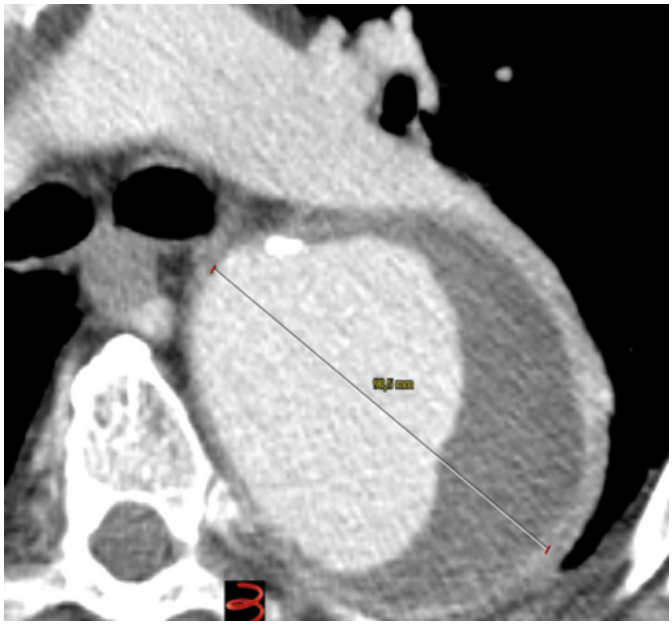

Figure 4. A thoracic aneurysm sac expansion was detected in an emergent CTA

Follow-up at 6 and 12 months revealed no complication, with a complete sac exclusion and patent visceral stents (Figure 5A, B and C), while the patient remains in good clinical condition.

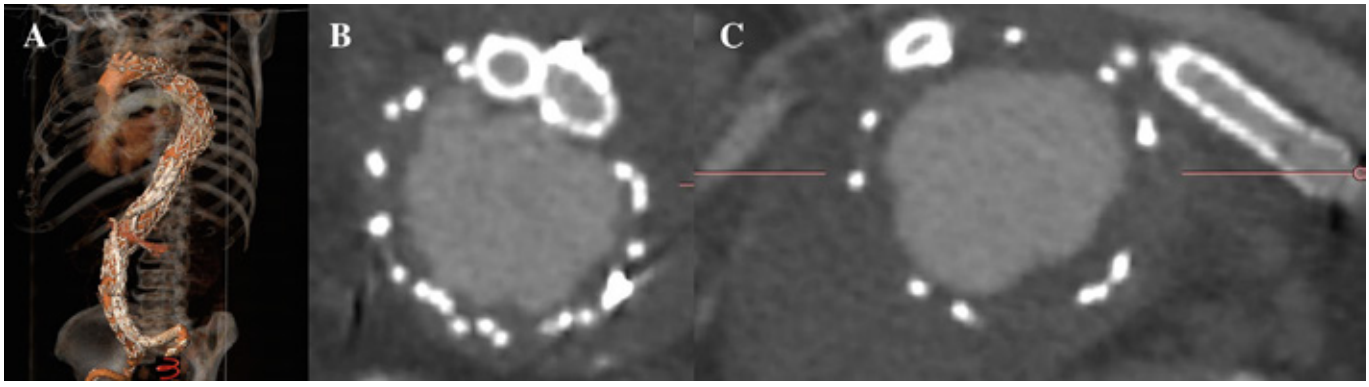

Figure 5. CTA at 6 **(A, B)** and 12 **(C)** months of follow-up revealed no endoleak. All stents remained patent.

DISCUSSION

TAAA repair is associated with 6.6% mortality rate in elective cases and up to 47% in the emergent setting.[4] Fenestrated and branched devices offer a safe and durable option when aneurysm anatomy is suitable for these techniques.[5] Hybrid procedures and other complex endovascular techniques have been used with conflicting outcomes.[4] The sandwich technique, which was initially presented by Lobato *et al*, may be a valid alternative in patients with unsuitable anatomy or in emergent/urgent cases, due to its intra-operative management flexibility, which characterizes the "off-the-shelf" techniques.[2,4,6,7,8] In these series, 15 patients, considered high-risk for open surgical repair, have been treated with the sandwich technique. Technical success rate was achieved in 92.3% of them and the total 30-day mortality rate was 20%.[4]

Visceral graft occlusions are a rare complication in patients treated with the sandwich technique.[9] They appear to occur generally during the early follow-up (mean 3.5 months) with an expected rate up to 4.5%.[9] In most cases, renal artery endograft occlusion may have mild or moderate consequences while SMA occlusion can be associated with life-threatening events.[9] Current literature records a high primary patency rate for the visceral grafts in the sandwich setting, while different management strategies may be applied in case of stenosis/occlusion, including open conversion, endovascular re-vascularization or conservative treatment.[9,10,11] In any case during the long-term follow-up, the cumulative primary patency rate may achieve 90%.[11] As reported in this case, the use of longer covered stents is usually necessary in the sandwich setting as a 5cm overlapping between the main endografts is usually demanded. This makes inadequate the use of balloon expandable stents in many cases, as most of the them come with lengths shorter than 60mm.[10] However, a novel one comes in 79mm of length and it maybe offer a valid option in some cases.[3] Thus, in many cases, self-expanding covered stents have to be used to facilitate the extended length needed. It should be mentioned that such long parallel grafts are more prone to kink, suppression, stenosis and eventually, thrombosis. Thus, in our opinion, relining with an extra self-expanding bare metal stent should be a standard approach, in order to avoid kinking and suppression.

Endoleak remains one of the most important disadvantages of the technique with a reported total intra-operative endoleak rate up to 35%.[3,9,10,12] Type I endoleaks may be treated with endovascular means while type III and IV may be treated conservatively as spontaneous sealing may be expected during the first month.[5,10] Gutter endoleak formation may be inevitable in parallel graft techniques. The low flow characteristics and their benign evolution separates them form high-flow type Ia endoleaks, formatted by an inadequate sealing between the endograft and the aortic wall.[13] Endoleaks may be detected during the mid-term follow-up (3-6months) due to graft migration. An endovascular re-approach may be a solution in these cases, even if a re-catheterization of the visceral grafts may be extremely challenging.[10] No late or recurrent endoleaks may be expected in the long-term follow-up according to the current literature. [10,11,12]

In this high-risk group of patients, sandwich technique seems to be associated with acceptable mortality and morbidity rates. In previous case series, all-cause mortality was up to 11% in 30-day follow-up while aneurysm-related death rate remained low.[12,14,15] During mid-term follow-up, aneurysm sac stability or shrinkage confirms the early durability of the technique.[14] Renal failure is usually seen in cases with stent thrombosis.[9] However, severe consequences are rarely reported.[9,14] In the current case, mild post-operative renal insufficiency was treated with aggressive hydration. No further measures were used. Spinal cord ischemia with associated paraplegia has already been recorded in such cases, as an important aortic length is needed to be covered during the endovascular repair of TAAAs.[15] In this case, a two-stage approach was decided during the pre-operative planning. Despite the emergent 2nd procedure, the patient revealed no neurological deficit.

Sandwich technique seems to be a safe and feasible "off-the-shelf" alternative for the treatment of TAAAs.[9] The flexibility of the technique permits its application in aneurysms with challenging anatomy, where fenestrated or branched devices are not applicable, or available.[8] In emergent cases, "off-the-self" parallel graft techniques may be the only existing solution.[7] In any case, this technique is rather complex and requires endovascular expertise as well as the availability of several materials and adequate imaging. Low aneurysm-relat-

ed mortality indicates that the sandwich technique may be a promising endovascular method for the treatment of TAAAs in certain conditions.[12,15]

CONCLUSION

Parallel-graft techniques may be a valid option for the treatment of complex cases of TAAAs. The sandwich technique seems to be a safe and durable intervention at least during the mid-term follow-up.

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Conflict of interest: None

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Axillo-femoral and femoro-femoral graft to bypass aorto-iliac occlusion. How is it possible for the latter to be patent if the former occludes?

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INTRODUCTION

A 70-year old male patient underwent left axillo-femoral bypass and retroperitoneal femoro-femoral bypass (via the femoral canals, posterior to the rectus muscles and anterior to the bladder) due to aorto-iliac occlusion presenting with critical left limb ischemia and right limb claudication. An aorto-bifemoral bypass was not selected for this patient due to severe comorbidities. Post-procedurally symptoms resolved bilaterally. During follow-up, bilateral recurrence of claudication was reported, notably without rest-pain. The CT angiography indicated that the axillo-femoral bypass had occluded, but the femoro-femoral bypass was preserved via an extensive collateral network from developed epigastric arteries, that produced reverse graft flow (right→left as noted with Duplex) and preserved hemodynamic improvement of the recipient limb. The collateral network was already present before the operation. Patent collaterals are not likely to have influenced patency of the axillo-femoral component, since they were mostly present on the contralateral (right) side. This case highlights the significance of collateral circulation to preserve arterial perfusion of the lower limbs and even maintaining patency of a synthetic graft in extreme cases.

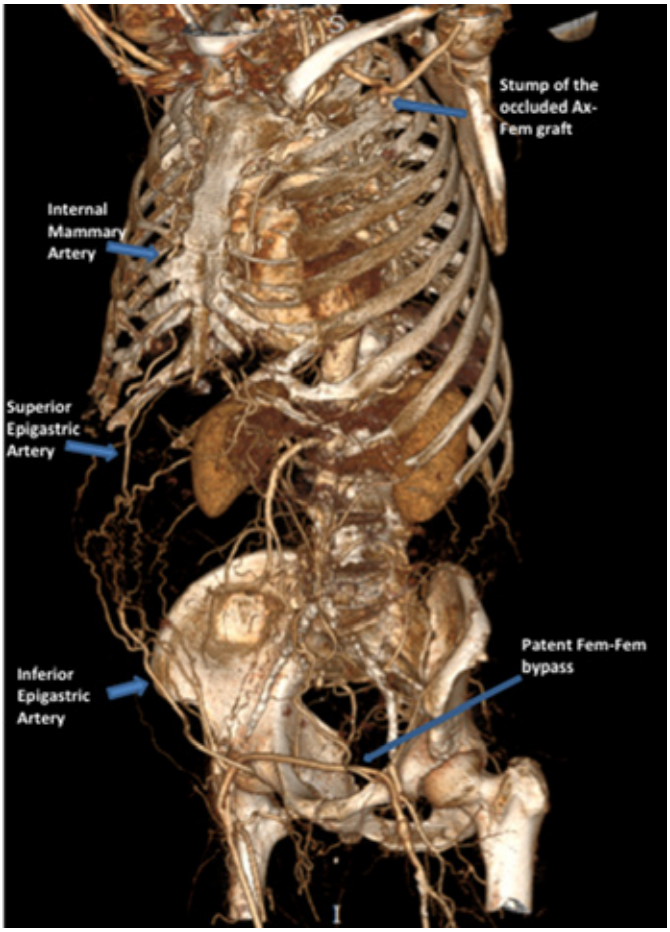

Figure 1.

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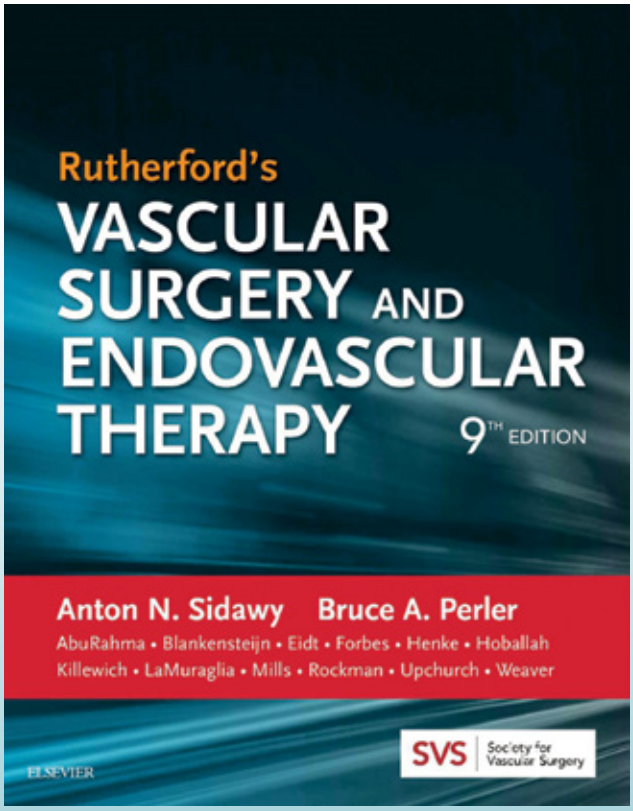

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