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Hellenic Journal of Vascular and Endovascular Surgery

Contents

EDITORIAL

CREST-2: Game Changer or Yet Another Argument for optimised risk stratification?

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Only a limited number of vascular surgical treatment areas are supported by a broad and high-quality evidence base. One of these is the surgical and interventional treatment of extracranial carotid stenosis. Based on randomized controlled trials and meta-analyses including more than 7,000 patients, national, European, and international guidelines recommend carotid endarterectomy (CEA) as the first-line invasive revascularization strategy.[1-5] However, clinical evidence was more robust for symptomatic, rather than asymptomatic, carotid stenosis. The indication for primary preventive revascularization in asymptomatic carotid stenosis remains challenging and requires careful interdisciplinary assessment. The individual long-term stroke risk must be weighed against the perioperative or periprocedural risk. Current guidelines recommend selecting the revascularization strategy based on individual anatomical and clinical factors. Arguments favoring carotid artery stenting (CAS) include high cervical stenosis extending to the skull base, tandem lesions, restenosis after previous open surgery, contralateral cranial nerve injury, and radiation-induced stenosis.

There is broad consensus that outcomes reported in clinical trials are only valid if evidence-based best medical treatment (BMT) is consistently implemented. This includes smoking cessation, optimal blood pressure control, lipid lowering, glycemic control, weight management, and dietary optimization. In routine clinical practice, however, adherence to these measures is often insufficient, resulting in worse outcomes than those reported in randomized trials.[6] This assumption is supported by a recently published longitudinal registry analysis of nearly 47,000 propensity score-matched patients in Germany. Among patients undergoing invasive treatment for carotid stenosis, the 5-year cancer incidence was approximately 17% with a mortality during the same period of 18% in men and 14% in women.[7] This excess non-stroke-related mortality has relevant implications for mortality-related endpoints such as stroke-free survival and may bias trial results if best medical treatment is suboptimal.

At the same time, it has been postulated that best medical treatment has improved substantially over recent decades due to changes in risk factor prevalence and advances in pharmacological therapy. The annual stroke risk in the Asymptomatic Carotid Artery Study was 2% per year and decreased to <1% over time.[8] The assumption that contemporary medical management for extracranial carotid artery stenosis has diminished the clinical utility and net benefit of surgical or endovascular revascularization was a key rationale for the Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial (CREST-2).[9]

CREST-2 consisted of two parallel randomized superiority trials comparing either CEA or CAS with strictly defined BMT in patients with asymptomatic high-grade (≥70%) carotid stenosis. Between December 2014 and July 2025, a total of 2,485 patients were randomized in 155 centers, predominantly in the United States, with a mean follow-up of approximately four years. Both trials were conducted using an intention-to-treat design.[10] In the CEA trial (n = 1,240), 18% of patients randomized to best medical treatment crossed over to invasive revascularization. A similar crossover rate (17%) was observed in the CAS trial (n = 1,245). The primary endpoint in both trials was a composite of any stroke or death within 44 days after randomization, or ipsilateral ischemic stroke during follow-up. In the CEA trial, the primary endpoint occurred in 5.3% of patients receiving best medical treatment and in 3.7% of patients undergoing surgery. The absolute risk difference was 1.6% (95% CI: −1.1% to +4.3%; p = 0.240) and the relative risk only 1.43 (95% CI: 0.78 to 2.72). In the CAS trial, the primary endpoint occurred in 6.0% of patients receiving best medical treatment and in 2.8% of patients undergoing stenting, corresponding to an absolute risk difference of 3.2% (95% CI: +0.6% to +5.9%; p = 0.020) and the relative risk 2.13 (95% CI: 1.15 to 4.39).[10] Although CREST-2 was not designed for a direct comparison between CEA and CAS, the authors concluded that carotid stenting provided a statistically significant benefit over best medical treatment, whereas carotid endarterectomy did not.

This interpretation has been the subject of substantial debate regarding the external validity and the extent to which its findings can be extrapolated to broader clinical populations. A

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closer interrogation of the study data highlights several methodological nuances that warrant rigorous critical appraisal. First, the two trials were conducted independently and differed in patient selection and exclusion criteria. In particular, the CAS trial excluded patients with unfavorable anatomy, including complex aortic arch anatomy, circumferential calcification, severe kinking, lesion length greater than 3 cm, and vulnerable plaque morphology. In contrast, inclusion criteria for CEA were considerably broader. Moreover, primary endpoint rates in the conservative arms differed between the two trials (absolute risk difference of 0.7%), raising concerns regarding comparability of patient populations and follow-up. In this context, differences were also observed in baseline characteristics, including the prevalence of cardiovascular disease, prior coronary revascularization (55% vs 43%), and previous stroke or transient ischemic attack (4.9% vs 8.4%).

Generalizability of the results is further limited by healthcare system differences. In the predominantly North American study centers, CEA was also performed by neurosurgeons and sometimes without adjunctive cross-sectional imaging. Potential interventionalists had to submit 100 CAS operative notes with at least 25 cases performed in the past year; only 50% of applicants were accepted. Potential surgeons had to submit 50 CEA operative notes over any time period; 90% of applicants were accepted. This deviation from the initially required minimum case volume and the relatively low proportion of randomized patients suggest potential selection bias. Moreover, the study protocol allowed local investigators to allocate patients to either trial primarily based on stenosis severity, without applying additional guideline-based criteria. While this reflects real-world practice, it introduces confounding by indication and precludes valid conclusions regarding procedural superiority.

Given the restricted lesion characteristics in the CAS trial (median lesion length 18 mm) and the broader inclusion criteria for CEA, procedural and lesion-related risks were likely not comparable between the two trials. These factors, together with changes in medical therapy during the study period, as discussed also by the authors, may have influenced the results and their statistical robustness as well as the applicability to routine clinical decision-making.

From a clinical perspective, the absolute benefit observed remains modest. Among 100 patients treated with carotid stenting, approximately one ipsilateral stroke is prevented over four years, while this benefit is offset by one periprocedural stroke or death. During a four-year study period, 95 out of 100 patients underwent an unnecessary carotid artery angioplasty. Consequently, the majority of patients undergo invasive treatment without measurable benefit. This underscores the need for improved risk stratification in asymptomatic carotid stenosis, including the evaluation of plaque morphology and other imaging-based predictors.

Inspection of the Kaplan-Meier curves reveals that the benefit observed at the beginning of the follow-up period changes after approximately one year for both the surgical and interventional study arms. The curves then intersect and, after largely overlapping, only diverge in the final year of the follow-up period. The reasons for this pattern remain unclear and require further subgroup and adherence analyses. It is noteworthy that, at the interim analysis, the CEA arm showed more favorable outcomes than CAS. However, there were six late stroke events in the CEA arm 2 to 4 years postoperatively that were unrelated to the procedure or carotid restenosis or reintervention. Because these strokes occurred years after surgery and were not linked to restenosis or reinterventions, it is difficult to understand how they meaningfully reflect the comparative performance of the treatment options.

In summary, interpretation of CREST-2 requires caution. Given the methodological limitations and heterogeneity of the study population, improved risk stratification through interdisciplinary evaluation in neurovascular boards remains essential. Imaging findings, clinical risk profiles, and patient preferences should be integrated into individualized decision-making. Moreover, the role of newer techniques, such as transcarotid artery revascularization (TCAR), and novel stent designs, including dual-layer stents, cannot be assessed based on the CREST-2 data and remains a subject for future studies.

REFERENCES

1 Brott TG, Howard G, Roubin GS, Meschia JF, Mackey A, Brooks W, et al. Long-Term Results of Stenting versus Endarterectomy for Carotid-Artery Stenosis. N Engl J Med. 2016;374(11):1021-31.

2 Halliday A, Bulbulia R, Bonati LH, Chester J, Cradduck-Bamford A, Peto R, et al. Second asymptomatic carotid surgery trial (ACST-2): a randomised comparison of carotid artery stenting versus carotid endarterectomy. Lancet. 2021;398(10305):1065-73.

3 Naylor R, Rantner B, Ancetti S, de Borst GJ, De Carlo M, Halliday A, et al. Editor's Choice - European Society for Vascular Surgery (ESVS) 2023 Clinical Practice Guidelines on the Management of Atherosclerotic Carotid and Vertebral Artery Disease. European Journal of Vascular and Endovascular Surgery. 2023;65(1):7-111.

4 AbuRahma AF, Avgerinos ED, Chang RW, Darling RC, III, Duncan AA, Forbes TL, et al. Society for Vascular Surgery clinical practice guidelines for management of extracranial cerebrovascular disease. Journal of Vascular Surgery. 2022;75(1):4S-22S.

5 Kleindorfer DO, Towfighi A, Chaturvedi S, Cockroft KM, Gutierrez J, Lombardi-Hill D, et al. 2021 Guideline for the Prevention of Stroke in Patients With Stroke and Transient Ischemic Attack: A Guideline From the American Heart Association/American Stroke Association. Stroke. 2021;52(7):e364-e467.

6 Bulbulia R, Halliday A. Carotid Stenting: The Myth of Real World Evidence versus the Magic of Randomisation. Eur J Vasc Endovasc Surg. 2024;67(1):97-8.

7 Acar L, Martial Mboulla N, Marschall U, Peters F, Lubcke J, Behrendt CA. Differences in Long Term Cancer Incidence and Overall Mortality Rate between Cardiovascular Dis-

eases: A Nationwide Retrospective Health Insurance Claims Analysis. Eur J Vasc Endovasc Surg. 2025.

8 Poorthuis MHF, Solomon Y, Herings RAR, Visseren FLJ, Kappelle LJ, Bots ML, et al. Temporal Trends and Determinants of Stroke Risk in Patients With Medically Treated Asymptomatic Carotid Stenosis. Stroke. 2023;54(7):1735-49.

9 Howard VJ, Meschia JF, Lal BK, Turan TN, Roubin GS, Brown RD, Jr., et al. Carotid revascularization and medical management for asymptomatic carotid stenosis: Protocol of the CREST-2 clinical trials. Int J Stroke. 2017;12(7):770-8.

10 Brott TG, Howard G, Lal BK, Voeks JH, Turan TN, Roubin GS, et al. Medical Management and Revascularization for Asymptomatic Carotid Stenosis. N Engl J Med. 2025.

ORIGINAL ARTICLE

Thoracic Endovascular Aortic Repair for Acute and Chronic Type B Aortic Dissections: Short- and Long-Term Outcomes

Rafaelia Patsia[1], Camilo Martinez[2], Stefanos Giannopoulos[2], Yuli Breier[2], Spiros Koustas[2], Binit Katuwal[2], Alex Houser[2], Apostolos Tassiopoulos[2], Angela A Kokkosis[2]

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Abstract:

Introduction: The aim of this study is to identify outcomes of thoracic endovascular aortic repair (TEVAR) for acute and subacute or chronic type B aortic dissections (TBAD) at a tertiary referral center.

Methods: All patients who underwent TEVAR for TBAD from 2010 to 2022 at a tertiary referral center were included in this cohort study. The primary outcomes were all-cause mortality, any endoleak, and thoracic aortic reintervention.

Results: Thirty-three patients were included (mean age 63 years, male 60.6%), with mean follow-up of 40.7 months. Timing of TEVAR was classified by timing of intervention since onset of symptoms: hyperacute (0-2 weeks: 54.6%), acute (2-12 weeks: 24.2%), and subacute or chronic (> 12 weeks: 21.2%). The extent of the TBAD was in 21.2% contained to the thoracic aorta, and in 24.2% and 54.6% it was extending to the abdominal aorta and iliac segment, respectively. The thirty-day all-cause mortality was 0%, rupture 0%, retrograde type A dissection 3% (n=1), myocardial infarction 0%, stroke 12.1% (n=4), spinal cord ischemia 0%, endovascular reinterventions 3%, intervention for visceral malperfusion 3%, and intervention for limb ischemia 0%. The follow-up all-cause mortality was 21.9%, rupture 0%, retrograde type A dissection 6.5%, any endoleak (32%), and thoracic aortic endovascular reintervention 32.3%.

Conclusion: TEVAR has emerged as a valuable tool in the management of TBAD. Nonetheless, endoleaks and other aortic-related complications are not uncommon during follow-up. Careful patient selection and an individualized approach play a crucial role for durable outcomes.

Keywords: aortic dissection, thoracic endovascular aortic repair, aortic surgery, type B aortic dissection, TEVAR

INTRODUCTION

Stanford Type B aortic dissections (TBAD) involve an entry tear in the intima of the thoracic aorta, distal to the left subclavian artery, and allow for false lumen (FL) development and expansion over time.[1] Most often, the true lumen supplies the celiac axis, superior mesenteric artery, and right renal artery, while the false lumen supplies the left renal artery.[2] False lumen expansion and distal extent of the dissection can progress to arterial compromise in the visceral segment and lower extremities, leading to end-organ malperfusion and ischemic events.

Medical management is the mainstay for uncomplicated TBAD, but those with high-risk anatomic features, refractory pain, or uncontrolled hypertension may benefit from TEVAR.[3]

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The objective of a TEVAR is to occlude the entry tear and promote false lumen thrombosis, which would help depressurize the aorta and minimize the risk of aortic degeneration.[4] In this study, we aim to present short- and long-term outcomes of TEVAR for acute, subacute, and chronic TBAD at a tertiary referral center, emphasizing lesion characteristics, utilizing Vascular Quality Initiative (VQI) cases.

METHODS

Selection of Patients and Procedure Details

All patients (n = 173) who underwent TEVAR at Stony Brook University Hospital between 2010 and 2022 were identified using the local Vascular Quality Initiative registry. Patients who had acute, subacute, or chronic TBAD were included. Those with residual TBAD after type A repair was excluded. Patients undergoing hybrid thoracoabdominal procedures (combining endovascular techniques with open debranching or bypass) were excluded. After inclusion and exclusion criteria were applied, the number of patients studied in our cohort was thirty-three.

Patients were classified by the timing of TEVAR from the onset of symptoms: hyperacute (0-2 weeks), acute (2-12

weeks), subacute or chronic (> 12 weeks), and asymptomatic versus symptomatic status. Indications for treatment in subacute or chronic TBAD cohort included refractory chest, abdominal, or back pain or uncontrolled hypertension. TEVAR case planning was performed using three-dimensional reconstruction software, and the case was discussed preoperatively at case conferences among multiple vascular surgeons. Spinal drainage was performed at the surgeon's discretion based on anticipated aortic length coverage or concern for spinal cord ischemia postoperatively. Anti-thrombotic therapy with anti-platelets (e.g., aspirin, clopidogrel) or anti-coagulants was administered pre- and post-procedurally based on the operator's preference. Follow-up consisted of in-person visits with CT angiography at 48 hours postoperatively, 1 month, 6 months, 12 months, and annually thereafter, unless an endoleak was detected, in which case closer surveillance was undertaken at the discretion of the operator.

Data Collection

Patient characteristics and preoperative comorbidities were collected from the electronic medical record, including a history of hypertension (HTN), coronary artery disease (CAD), and prior aortic surgery **(Table 1)**. Operative details and adjunct procedures were registered. Important lesion characteristics, including thoracic and abdominal aorta diameters, number of re-entry tears, and determination of luminal flow to visceral arteries, were measured using Computed Tomography Angiography (CTA) and registered **(Table 2)**. The measurements were performed on CTA images with intravenous contrast in the arterial phase, with the absence of contrast in the false lumen suggestive of false lumen thrombosis.

Study Outcomes

The primary outcomes of our study included all-cause mortality, any endoleak, and any aortic reintervention related to the index TBAD repair. Secondary outcomes included the rate of major complications perioperatively (i.e., within 30 days) and during follow-up (i.e., rupture, retrograde type A dissection, immediate type IA endoleak, and ESRD). Maximum diameter in the thoracic and abdominal aorta was also measured during follow-up to assess for aortic remodeling.

Table 1 Important patient demographics

Variables	Event/Total	Percentage, %
Male	20/33	60.6
Caucasian	25/33	75.8
HTN	28/33	84.5
Dyslipidemia	9/33	27.3
DM	8/33	24.2
CVD	7/33	21.2
CAD	8/33	24.2
Pulmonary disease	5/33	15.2
Previous Smoker	9/33	27.3
Current smoker	8/33	24.2
CKD	5/33	15.2
ESRD	0/33	0.0
Prior aortic surgery	2/33	6.1
Pre-operative aspirin	20/33	60.6
Pre-operative P2Y12 antagonist	2/33	6.1
Pre-operative statin	6/33	18.2
Pre-operative beta blocker	19/33	57.6
Pre-operative ACE-Inhibitor/ARB	12/33	36.4
Pre-operative chronic anticoagulant	1/33	3.0
Aspirin on discharge	30/33	93.8
P2Y12 antagonist on discharge	6/33	18.8
Statin on discharge	13/32	40.6
Beta blocker on discharge	28/32	87.5
ACE-Inhibitor/ARB on discharge	12/32	37.5
Chronic anticoagulant on discharge	5/32	15.6
Variables	**Observations**	**Mean (SD)**
Mean age, yrs	33/33	63.0 (13.6)
BMI	31/33	29.3 (7.2)

HTN: hypertension, DM: diabetes, CVD: cerebrovascular disease, CAD: coronary artery disease, CKD: chronic kidney disease, ASA: American Society of Anesthesiologists physical status classification, SD: standard deviation, yrs: years, BMI: body mass index

Table 2 Important lesion characteristics

Variables	Event/Total	Percentage, %
Hyperacute intervention (0-2 weeks)	18/33	54.6
Acute intervention (2-12 weeks)	8/33	24.2
Subacute intervention (>12 weeks)	7/33	21.2
Symptomatic	26/33	78.8
Extent of dissection - thoracic	7/33	21.2
Extent of dissection - thoracoabdominal	8/33	24.2
Extent of dissection - to the iliacs	18/33	54.6
False lumen of thoracic aorta - patent	19/33	57.6
False lumen of thoracic aorta - partially thrombosed	13/33	39.4
False lumen of thoracic aorta - completely thrombosed	1/33	3.0
N of re-entry tears - 0	9/33	27.3
N of re-entry tears - 1	5/33	15.2
N of re-entry tears - ≥ 2	19/33	57.6
Blood supply of Celiac - true lumen	26/33	78.8
Blood supply of Celiac - false lumen	4/33	12.1
Blood supply of Celiac - both	3/33	9.1
Blood supply of SMA - true lumen	27/33	81.8
Blood supply of SMA - false lumen	2/33	6.1
Blood supply of SMA - both	4/33	12.1
Blood supply of Left renal artery - true lumen	28/33	84.9
Blood supply of Left renal artery - false lumen	5/33	15.2
Blood supply of Left renal artery - both	0/33	0.0
Blood supply of Right renal artery - true lumen	20/30	60.6
Blood supply of Right renal artery - false lumen	11/33	33.3
Blood supply of Right renal artery - both	2/33	6.1
Variables	**Observations**	**Mean (SD)**
Maximum diameter of thoracic aorta, mm	33/33	37.9 (12.3)
Maximum diameter of thoracic false lumen, mm	33/33	21.7 (6.8)
Maximum diameter of abdominal aorta, mm	33/33	29.9 (11.9)
Size of most proximal entry tear, mm	30/33	11.8 (7.2)
Aortic diameter at most proximal visible entry tear, mm	30/33	37.4 (8.9)

SMA: superior mesenteric artery, SD: standard deviation

Statistical Analysis

Categorical variables were presented as absolute and relative frequencies (i.e., percentages), while continuous variables were presented as means ± standard deviations. The cumulative incidence of primary and secondary outcomes was also presented with absolute and relative frequencies. Furthermore, the Kaplan-Meier (KM) method was used to estimate the 24-month freedom from primary and secondary endpoints. All analyses were performed using STATA software (version 14.1; STATA Corporation, College Station, TX, USA).

RESULTS

Patients and lesion characteristics

The average age of this patient cohort was 63.0 ± 13.6 years. Most of the patients were Caucasian males and had a history of hypertension. About one-fourth of the patients had diabetes and coronary artery disease (CAD) at presentation. Most of the cases were symptomatic (78.8%) and were treated in the hyperacute (54.6%) or acute setting (24.2%). Involvement of the thoracoabdominal aorta with dissection extending to the common iliac arteries was observed in 54.6% of the cases, with the false thoracic lumen being completely patent in most cases. The average maximum thoracic and abdominal aortic diameters were 37.9 ± 12.3 mm and 29.9 ± 11.9 mm, respectively. Details regarding patients' baseline demographics and lesion characteristics are summarized in **Tables 1 & 2**, respectively.

Procedural characteristics and short-term outcomes

As this was a retrospective study, all included patients were deemed suitable candidates for TEVAR, and no patients were denied treatment for anatomical reasons. Stent grafts were deployed in all cases, followed by bare metal stents in 12.1%. The average initial covered length of the aorta was 166 ± 36.9mm. Intravascular ultrasound (IVUS) was used in 81.8% of

Supplementary Table 1 Important procedural characteristics

Variables	Event/Total	Percentage, %
IVUS	27/33	81.8
TEE	3/33	9.1
Proximal landing at zone 2	16/33	48.5
Proximal landing at zone 3	17/33	51.5
More than one aortic stent placed	13/33	39.4
Bare metal stents	4/33	12.1
LCCA-LSCA bypass during same admission	3/33	9.1
LSCA snorkeling stenting	1/33	3.0
CSF drain placement	17/33	51.5
Variables	**Observations**	**Mean (SD)**
Fluoroscopy time	31/33	28.9 (27.6)
Procedure time	33/33	175 (117.5)
Contrast, ml	32/33	108.9 (52.2)
ICU stay, days	31/33	3.9 (2.9)
Time from admission to procedure, days	33/33	3.1 (4.1)

IVUS: intravascular ultrasound, TEE: transesophageal echocardiogram, LCCA: left common carotid, LSCA: left subclavian, CSF: cerebrospinal fluid, ICU: intensive care unit, SD: standard deviation

Supplementary Table 2 Periprocedural outcomes

Variables	Event/Total	Percentage, %
All-cause mortality	0/33	0.0
Rupture	0/33	0.0
Retrograde type A dissection	1/33	3.0
Immediate type Ia endoleak	0/33	0.0
Myocardial Infarction	0/33	0.0
Stroke	4/33	12.1
Spinal cord ischemia	0/33	0.0
Reintervention	1/33	3.0
Intervention for visceral malperfusion	1/33	3.0
Intervention for limb ischemia	0/33	0.0

the cases, and transesophageal echocardiography (TEE) was utilized in 9.1% of the cases to facilitate accurate deployment. The stent grafts were placed at zone 2 in 48.5% of the cases. Left carotid subclavian bypass was performed in 9.1% during the same admission, while 3% of the cases underwent left subclavian snorkeling stenting during the same procedure. A spinal drain was placed in 51.5% of the cases. Details are presented in **Supplementary Table 1**.

The average procedure time was 175 ± 117.5 min, with an average fluoroscopy time of 28.9 ± 27.6 min and an average contrast volume of 108.9 ± 52.2 mL. During the procedure, one patient experienced retrograde type A aortic dissection that required further intervention. Additionally, one patient required intervention for visceral malperfusion in the same setting. No peri-operative mortality was observed, although 4 patients experienced peri-operative neurologic deficits. The average length of intensive care unit (ICU) stay is 3.9 ± 2.9 days. No peri-operative all-cause mortality was observed. No patients experienced myocardial infarction or spinal cord ischemia. The incidence of short-term outcomes is summarized in **Supplementary Table 2.**

Long-term outcomes

The average follow-up was 40.7 ± 30.77 months, with up to 8.7 years maximum follow-up. The follow-up was performed with CT scan at 48h post-op, 1 month, 6 months and at 12 months and yearly after unless endoleak occurs. Aortic remodeling with complete thrombosis of the false lumen or resolution of the aortic dissection was observed in 23.3% and 40% of the cases. However, an increase in the average maximum thoracic diameter was observed compared to preoperative values. The average maximum thoracic and abdominal aortic diameters during follow-up were 40.2 ± 30.7 mm and 40.2 ± 15.7 mm, respectively. Over time an endoleak was observed in 10 out of 31 cases with long-term CT data (i.e., type Ia: 12.9%, type Ib: 6.5%, type II: 6.55%, type III: 6.55%) and

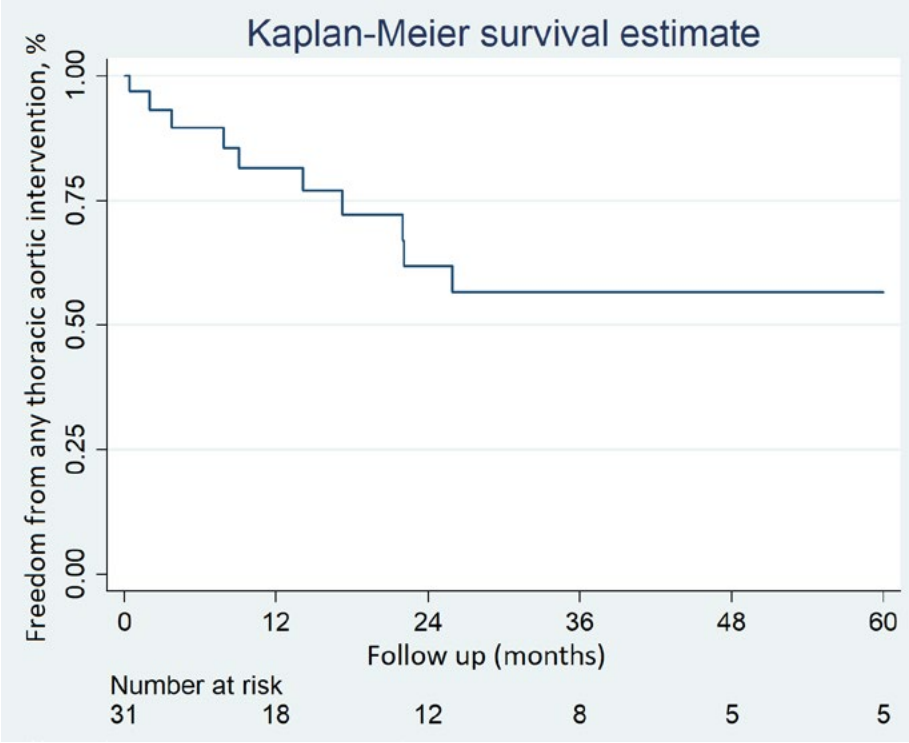

Figure 1 Freedom from any thoracic aortic intervention during follow-up

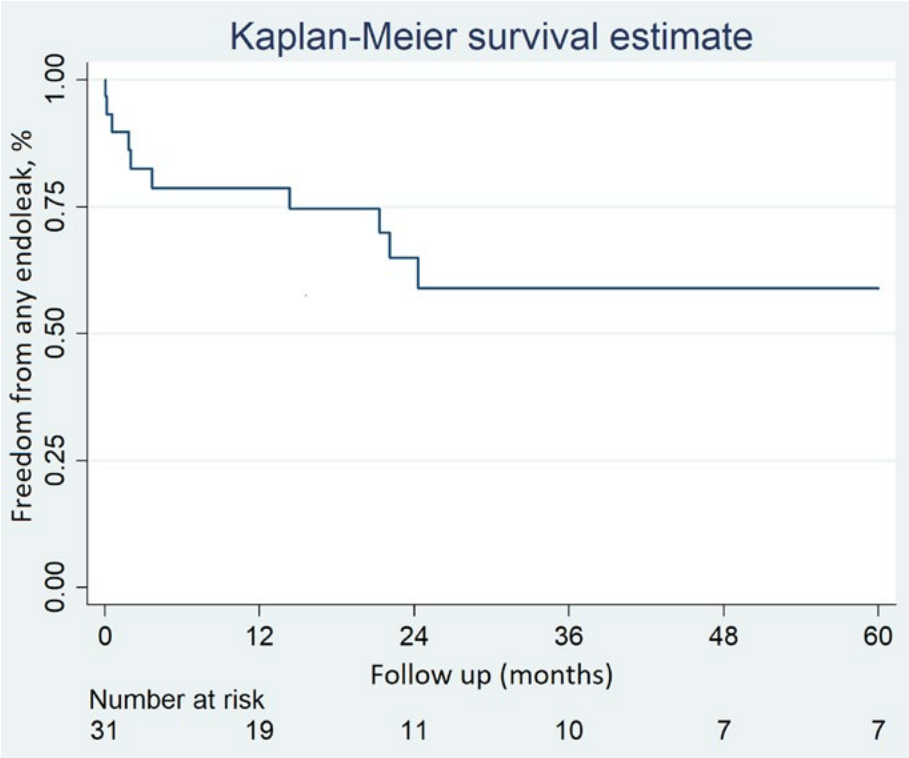

Figure 2 Freedom from any endoleak during follow-up

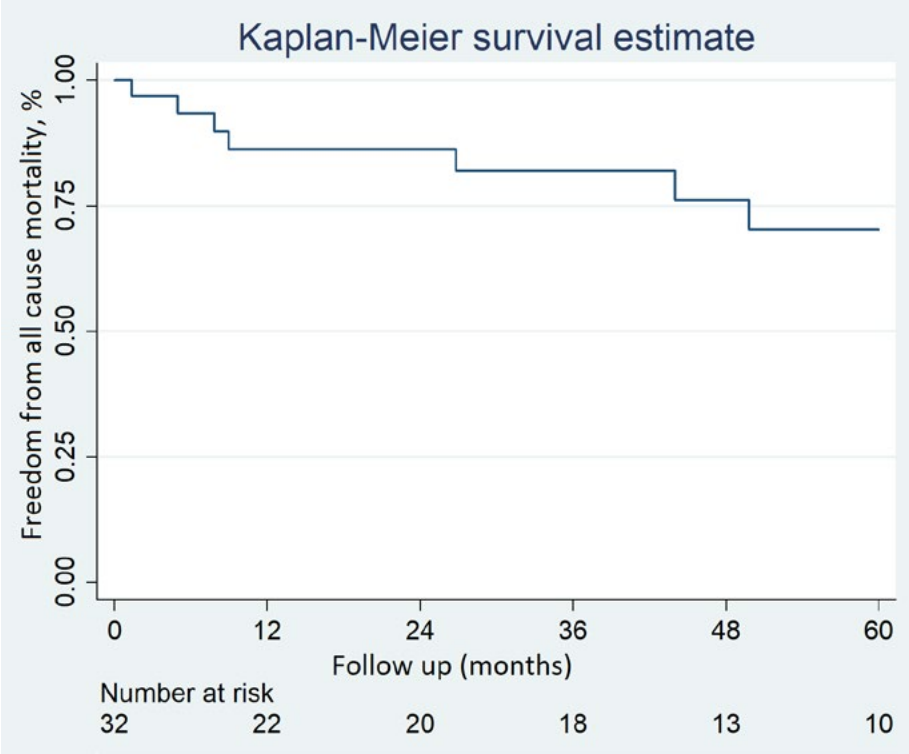

Figure 3 Freedom from all-cause mortality during follow-up

Table 3 Outcomes during follow-up

Variables	Event/Total	Percentage, %
All-cause mortality	7/32	21.9
Rupture	0/33	0.0
Retrograde type A dissection	2/31	6.5
Endoleak, type Ia	4/31	12.9
Endoleak, type Ib	2/31	6.5
Endoleak, type II	2/31	6.5
Endoleak, type III	2/31	6.5
Thoracic aortic reintervention	10/31	32.3
ESRD	4/31	12.9
False lumen of thoracic aorta - patent	1/30	3.3
False lumen of thoracic aorta - partially thrombosed	10/30	33.3
False lumen of thoracic aorta - completely thrombosed	7/30	23.3
False lumen of thoracic aorta - normal	12/30	40
False lumen of abdominal aorta - patent	15/30	50
False lumen of abdominal aorta - partially thrombosed	5/30	16.7
False lumen of abdominal aorta - completely thrombosed	1/30	3.3
False lumen of abdominal aorta - normal	9/30	30.0
Variables	**Observations**	**Mean (SD; range)**
Mean follow-up, months	32/33	40.7 (30.77; 0.1-103.7)
Time from procedure to last CT scan, months	30/33	40.1 (30.7; 1.4-112.5)
Maximum diameter of thoracic aorta, mm	30/30	40.2 (15.7; 3.3-77.4)
Maximum diameter of abdominal aorta, mm	30/30	32.5 (12.8; 4.8-67.9)

CT: computed tomography, SD: standard deviation

Supplementary Table 3 5-year Kaplan - Meier estimates for long term outcomes

Variables	KM estimate % (95% CI)
All-cause mortality	70.2% (45.1%-85.1%)
Rupture	100% (N/A)
Retrograde type A dissection	87.1% (51.6%-97.2%)
Endoleak	58.9% (36.1%-76.1%)
Thoracic aortic reintervention	56.7% (33.7%-74.4%)
ESRD	85.0% (60.2%-94.9%)

KM: Kaplan-Meier, CI: confidence interval, N/A: not available, ESRD: end stage renal disease

required thoracic aortic reintervention **(Figure 1)**. The 5-year KM estimate for freedom from any endoleak was 58.9%, and the corresponding survival curve is presented in **Figure 2.** The overall all-cause mortality rate was 21.9% without any events associated with aortic rupture. Outcomes during follow-up are summarized in **Table 3.** The 5-year KM curve for freedom from all-cause mortality is illustrated in **Figure 3.** The 5-year Kaplan - Meier estimates for primary outcomes are summarized in **Supplementary Table 3.**

Discussion

Aortic dissection is estimated to affect about 4 to 5 persons per 100,000 annually, constituting one of the most common aortic emergency pathologies associated with high morbidity and mortality rates[5]. Its incidence is increasing as a result of the aging of the population and superior imaging techniques that facilitate early diagnosis. Stanford TBAD originate just distal to the ostium of the left subclavian artery and can extend to the iliac arteries. Type B aortic dissections can be complicated (i.e., rupture, malperfusion) or uncomplicated (e.g., asymptomatic, hypertension, etc.) based on the symptoms at presentation.

Early intervention with an open repair or, more recently, with TEVAR, the first-line therapeutic option, is recommended for complicated aortic dissections[5,6], while best medical management is usually preferred for uncomplicated cases[7,8]. Nonetheless, a significant proportion of uncomplicated cases of TBAD will eventually experience adverse aortic remodeling requiring TEVAR[8]. Furthermore, experts suggest that "prophylactic" TEVAR in certain occasions of high-risk features may be beneficial[9,10]. However, long-term data have been limited for studies investigating the outcomes of TEVAR for complicated but uncomplicated aortic dissections, with a reported mean follow-up of fewer than 20 months in most cases[11-14]. The current study aimed to summarize institutional VQI TEVAR data with long-term follow-up[15].

In our study, no peri-operative mortality (within 30 days) was observed, although neurologic deficits were observed in 4 out of 33 patients, with 1 out of 4 cases causing significant disability. Interestingly no incidents of spinal cord ischemia were observed. Although the incidence of neurologic complications is closely correlated with the population characteristics (e.g., trauma vs. no trauma cases, zone 2 vs. zone 3 coverage, etc.), it has been shown that stroke and transient ischemic attack rates can approximate 8% and 3% respectively[14-16], with in-hospital mortality reaching up to 4% 6, with patients presenting with visceral ischemia having worse short- and long-term outcomes[17,18]. This was shown in our study as well. One patient who developed visceral ischemia perioperatively expired 11 weeks after the procedure, accounting for our study's only short-term all-cause death event.

Aortic-related complications during the chronic stage are common and depending on the severity of the disease at presentation, it can affect up to one-third of the cases[9]. Similarly, in our study, during an average follow-up of about 41 months, a thoracic reintervention was required in 32.3% of the cases, with endoleaks constituting the most common aortic-related complication (32.4%). A late *endoleak* is defined as one occurring 30 days post-TEVAR, and the most commonly occurring types of late endoleaks are I and II.[19] The reported rates of type I and type II endoleaks after TEVAR range from approximately 0% to 15% and 10-40% in various studies and systematic reviews, depending not only on aortic characteristics (e.g., diameter, aneurysmal degeneration, oversizing) but also on the duration of follow-up. In our study, type Ia, Ib, and II endoleaks were seen in 12.9%, 6.5%, and 6.5% of the cases, respectively. Although there are currently no standardized ways to predict the probability of late aortic expansion and associated aortic-related complications in general, advancements in stent graft technology, operator expertise, and ongoing research are continually improving the outcomes of TEVAR.

While there is current enthusiasm about TEVAR procedures given promising short- and mid-term outcomes, the long-term (e.g., > 2 years) durability of aortic remodeling after TEVAR is an ongoing area of research. In our study, the average maximum thoracic and abdominal aortic diameters were 37.9 mm and 29.9 mm at presentation and 40.2 mm and 40.2 mm during follow-up, respectively. In our cohort, gradually over time, all patients experienced a degree of aortic "degeneration" reflected by larger mean diameters, although only one-third of the patients required a reintervention. Further research is needed to help identify at-risk patients who would benefit from more intense follow-up or a different initial approach. Clinical decision-making is challenged even further by developing newer devices (e.g., branched devices, conformable covered stent grafts, etc.) and techniques (e.g., Petticoat technique); additional research is warranted.

Limitations

The present study has several limitations. It is based on data from a single center, and the study population is small. Using a retrospective cohort design introduces the possibility of unaccounted confounding factors. It has led to a heterogeneous study population, including cases of acute, subacute, and chronic presentations of TBAD, which grossly translated to hyperacute, acute, and subacute interventions. Imaging interpretation was performed by the same reviewers, which reduces variability but may introduce observer bias, as no independent core lab was used.

CONCLUSION

TEVAR is an effective treatment for TBAD, with favorable perioperative outcomes but substantial rates of late endoleaks and reinterventions. Careful patient selection and an individualized approach to optimizing outcomes are crucial for durable outcomes. Future research in stent designs and techniques (e.g., patient-specific, branched/fenestrated, hybrid approaches, etc.), imaging and navigation modalities, and surveillance protocols is warranted to improve patients' outcomes.

REFERENCES

1 Criado FJ. Aortic dissection: a 250-year perspective. *Tex Heart Inst J.* 2011;38(6):694-700.

2 Nienaber CA, Clough RE. Aortic Dissection. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2025 May 19]

3 Howard C, Sheridan J, Picca L, et al. TEVAR for complicated and uncomplicated type B aortic dissection-Systematic review and meta-analysis. *J Card Surg.* 2021;36(10):3820-3830.

4 Lin PH, Huynh TT, Kougias P, Huh J, LeMaire SA, Coselli JS. Descending thoracic aortic dissection: evaluation and management in the era of endovascular technology. *Vasc Endovascular Surg.* 2009;43(1):5-24.

5 Zeeshan A, Woo EY, Bavaria JE, et al. Thoracic endovascular aortic repair for acute complicated type B aortic dissection: superiority relative to conventional open surgical and medical therapy. *J Thorac Cardiovasc Surg.* 2010;140(6 Suppl):S109-115; discussion S142-S146.

6 Cambria RP, Crawford RS, Cho JS, et al. A multicenter clinical trial of endovascular stent graft repair of acute catastrophes of the descending thoracic aorta. *J Vasc Surg.* 2009;50(6):1255-1264.e1251-1254.

7 Alfson DB, Ham SW. Type B Aortic Dissections: Current Guidelines for Treatment. *Cardiol Clin.* 2017;35(3):387-410.

8 Akin I, Kische S, Ince H, Nienaber CA. Indication, timing and results of endovascular treatment of type B dissection. *Eur J Vasc Endovasc Surg.* 2009;37(3):289-296.

9 Riambau V, Böckler D, Brunkwall J, et al. Editor's Choice - Management of Descending Thoracic Aorta Diseases: Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg.* 2017;53(1):4-52.

10 Tadros RO, Tang GHL, Barnes HJ, et al. Optimal Treatment of Uncomplicated Type B Aortic Dissection: JACC Review Topic of the Week. *J Am Coll Cardiol.* 2019;74(11):1494-1504.

11 Eggebrecht H, Nienaber CA, Neuhäuser M, et al. Endovascular stent-graft placement in aortic dissection: a meta-analysis. *Eur Heart J.* 2006;27(4):489-498.

12 Parker JD, Golledge J. Outcome of endovascular treatment of acute type B aortic dissection. *Ann Thorac Surg.* 2008;86(5):1707-1712.

13 Xiong J, Jiang B, Guo W, Wang SM, Tong XY. Endovascular stent graft placement in patients with type B aortic dissection: a meta-analysis in China. *J Thorac Cardiovasc Surg.* 2009;138(4):865-872.

14 Lombardi JV, Cambria RP, Nienaber CA, et al. Prospective multicenter clinical trial (STABLE) on the endovascular treatment of complicated type B aortic dissection using a composite device design. *J Vasc Surg.* 2012;55(3):629-640.e622.

15 The VIRTUE Registry of type B thoracic dissections--study design and early results. *Eur J Vasc Endovasc Surg.* 2011;41(2):159-166.

16 Buth J, Harris PL, Hobo R, et al. Neurologic complications associated with endovascular repair of thoracic aortic pathology: Incidence and risk factors. a study from the European Collaborators on Stent/Graft Techniques for Aortic Aneurysm Repair (EUROSTAR) registry. *J Vasc Surg.* 2007;46(6):1103-1110; discussion 1110-1101.

17 Trimarchi S, Jonker FH, Froehlich JB, et al. Acute type B aortic dissection in the absence of aortic dilatation. *J Vasc Surg.* 2012;56(2):311-316.

18 Umaña JP, Miller DC, Mitchell RS. What is the best treatment for patients with acute type B aortic dissections-medical, surgical, or endovascular stent-grafting? *Ann Thorac Surg.* 2002;74(5): S1840-1843; discussion S1857-1863.

19 Ameli-Renani S, Pavlidis V, Morgan RA. Secondary Endoleak Management Following TEVAR and EVAR. *Cardiovasc Intervent Radiol.* 2020;43(12):1839-1854.

ORIGINAL ARTICLE

European Junior Doctors' Work Experiences, Job Satisfaction, and Proposals for Reform - with Contextual Emphasis on Greece

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Abstract:

Introduction: Despite workforce growth, European healthcare systems face ongoing shortages, uneven distribution, and retention challenges, all worsened by COVID-19. Nearly half of residents experience burnout, driven by workload, poor environments, and rigidity. In Greece, the pandemic deepened exhaustion, burnout, and distrust in the health system, as shown by the JDN-Hellas/PhMA "Barometer" findings. Vascular trainees were also affected, reporting steep declines in operative exposure and confidence - reflecting the broader European crisis in postgraduate training and the need for targeted retention strategies.

Methods: The present study's purpose is to review the results of a pan-European qualitative study conducted by the European Junior Doctors Association (EJD) to explore the work-related experiences of junior doctors (JD) and their impact on professional and personal wellbeing. Between January and June 2023, 25 representatives were interviewed (10 men, 15 women) from 24 EJD member countries. Seventeen interviews were held in English via online platforms. Transcripts were analysed using ATLAS.ti v9. Sampling was purposive, ensuring gender representation. Ethical approval and informed consent were obtained in accordance with the EU General Data Protection Regulation (GDPR).

Results: Despite contextual diversity, the participants demonstrated a notable agreement on the principal challenges. Across Europe, dissatisfaction, exhaustion, frustration, and insecurity stem from challenging working conditions, excessive workload, long and unpredictable hours, and inflexibility. Workload demands and a lack of resources negatively impact both learning and quality of care, consequently fueling stress and burnout. Deficiencies in supervision, time allocation, and feedback compromise training quality. Inequalities related to gender and migration, including obstacles like career breaks, negative perception of part-time work, blocked career advancement, and limited possibilities, exacerbate susceptibility. Changes in values across generations, emphasizing work-life balance and self-care, are causing both job departures and shifts in career choices. Nordic countries demonstrate superior practices through adaptable scheduling and robust equity policies.

Conclusion: Junior doctors' dissatisfaction threatens workforce sustainability. Improving retention necessitates integrated European and national strategies that prioritise flexibility, safe staffing levels, fair remuneration, protected training opportunities, and equity. Within Greece, where burnout and distrust persist, the implementation of such reforms and the fostering of institutional transparency are essential to restoring morale and protecting healthcare resilience.

Keywords: junior doctors, workforce retention, burnout, work–life balance, job satisfaction

INTRODUCTION

1. Background

Since the 1960s, the European Union has seen sustained growth in its health workforce, including physicians, driven by demographic ageing and demand-side trends in convenience-oriented care delivery. Despite this growth, all countries in the WHO European Region face intensifying medical workforce (MWF) planning challenges **(Figure 1)** - long-term shortages, maldistribution (e.g., rural/remote "medical deserts"), recruitment deficits in key sectors (primary care, mental health), and underinvestment in workforce development - exacerbated by the COVID-19 pandemic's system shocks.[1-3] Retention has thus moved to the forefront of MWF planning: job dissatisfaction is strongly associated with intentions to quit (Mobley's model), while negative self-evaluation and poor work experiences are linked to psychological distress and burnout.[4-7] Junior doctors (JD) are particularly vulnera-

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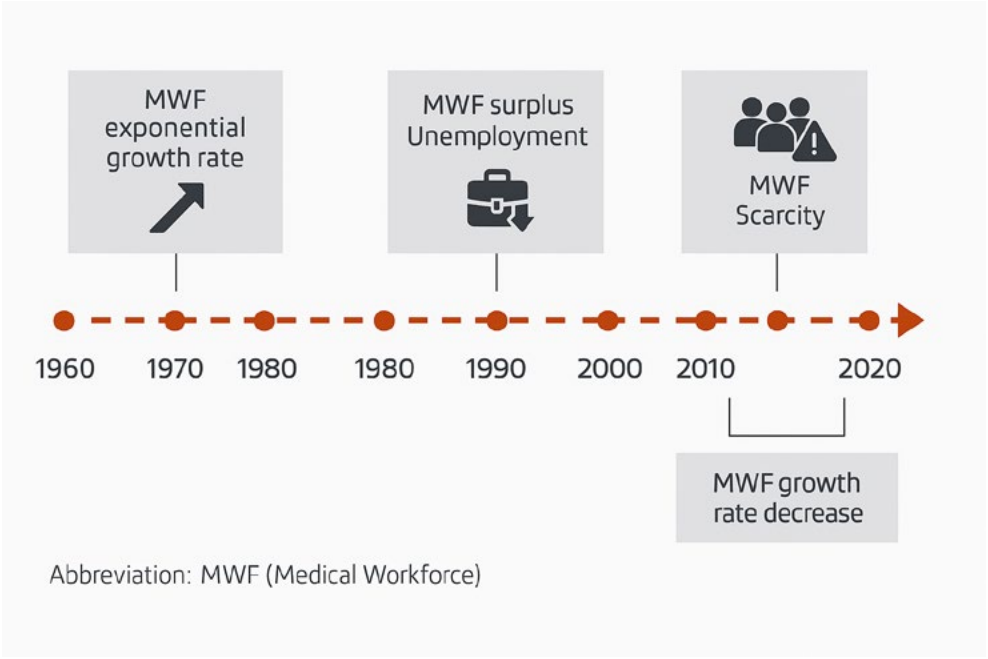

Figure 1. Changing Dynamics of Medical Workforce Supply, 1960–2020

ble; meta-analytic estimates suggest nearly half of residents experience burnout, with work-related drivers (workload, patient-care stressors, poor environments, work-life imbalance) outweighing nonmodifiable factors.[8-10] EJD's 2022 survey already highlighted work overload and career "bottlenecks" across transitions.[11]

Simultaneously, the profession's demographics are changing: the workforce is aging (approximately 30% over 60 years old in Europe, near-term retirements) and becoming increasingly feminized (women from 43% in 2010 to 48% in 2020), while gender inequities persist (approximately 20% health-sector pay gap, under-representation in leadership), with female gender identified as a risk factor for burnout in young doctors.[2,10,12,13]

2. Situation in Greece

The situation in Greece encapsulates many of the pressures described across Europe but with amplified intensity. Years of underinvestment, low remuneration and rigid administrative structures have created a system that relies heavenly on personal dedication rather than institutional support. Junior doctors often rotate through understaffed regional hospitals with long on-call stretches -that go beyond the official maximum working hours directive, with average weekly hours 65± and limited supervision, while mandatory service obligations delay career planning and family life. These conditions, combined with low perceived transparency and minimal feedback loops, have eroded professional trust and contributed to a long-standing outward migration of doctors putting additional strain on the remaining staff. During the pandemic, Greek physicians reported marked exhaustion and rising burnout, with public discourse highlighting systemic strain and entrenched distrust toward health institutions.[14-16]

The initial findings from the JDN-Hellas / Panhellenic Medical Association (PhMA) "Barometer" of Greek junior doctors mirror the European trends of exhaustion and dissatisfaction but reveal a deeper cultural dimension: a sense of powerlessness and detachment from decision-making. This, along with the perception of a significant workload, inadequate support, dissatisfaction with the national healthcare system, and regular exhaustion, indicated that technical reforms alone (e.g., salary adjustments) will not suffice without parallel measures. It highlights the pressing need for Greek-tailored policy adjustments that will rebuild confidence in institutions and governance.[17] Greece represents a microcosm of the wider European crisis, illustrating what happens when workforce fragility meets structural rigidity.

3. Vascular trainees after COVID-19

Among all medical disciplines, procedural and emergency specialties -particularly surgical specialties- demonstrate the most acute interaction between workload, supervision and training quality. In such environments, extended hours and unpredictable emergencies directly affect patient safety and skill acquisition. Vascular surgery exemplifies this tension: the field combines technical precision with high emergency burden, making consistent operative exposure and mentoring essential for competence. When service pressure rises and elective caseloads fall, as during COVID-19, trainees lose both confidence and progression milestones. These challenges are not unique to surgery but act as a magnifying lens for how systemic inefficiencies translate into training deficits and burnout across the profession. A European survey by Pereira-Neves et al. (2022) showed that nearly 77% of vascular trainees experienced reduced operative exposure during the COVID-19 pandemic, and 60% reported a decline greater than half. Over 70% felt their training and career progression were negatively affected, and almost half of senior trainees faced fewer job prospects.

Despite online teaching efforts, most called for compensatory measures to offset lost experience. These findings highlight how pandemic disruptions worsened workload, limited training, and deepened uncertainty - mirroring challenges faced by junior doctors across Europe, including Greece.[18]

To address these gaps, the EVaST (European Vascular Surgical Training) Survey, led by the ESVS and EVST, will collect Europe-wide data on training, simulation, and mentorship. Through anonymised feedback from trainees and trainers, EVaST aims to identify effective educational models and expose disparities. The initiative seeks to build a unified, data-driven foundation for improving vascular training quality, fostering mentorship, and ensuring the next generation of vascular surgeons is both technically skilled and professionally supported.[19]

4. Study rationale

Understanding JD work experiences and their impacts is essential to inform retention-oriented reforms. This paper presents the qualitative findings of EJD's pan-European study [20] and synthesizes proposals from JD representatives, with specific attention to Greece.

5. Objectives

General objective: To explore European junior doctors' work-related experiences and the impact of those experiences on their professional and personal lives. **Specific objectives:** a) To identify commonalities in JD work-related experiences across the EJD's member countries, b) to collect proposals from JD to increase job satisfaction and contribute to retention in this group.

METHODS

1. Methodology

The present study is based on the results of a pan-European qualitative study[20] which employed semi-structured interviews and thematic analysis (ATLAS.ti v9). This study was conducted by EJD between January and June 2023 with representatives from EJD national member associations. Purposive sampling of EJD-nominated country representatives (close to the research problem, representing national JD). Gender balancing achieved (parity or female over-representation). N=25 participants (10 men, 15 women), ages 25-47; 16 in postgraduate training (PGT) and 9 early career specialists (ECS). Seventeen interviews were held (8 dyads, 9 individuals). To deepen the analysis of gender inequities, an additional group comprising women from contexts with advanced gender-equity measures was convened (Finland, with double representation). Sociodemographic data of participants are shown in detail in **Table 1**.

2. Data collection and analysis

Interviews (English, online; ≈90 minutes for dyads, ≈60 minutes individual) followed a consensual guide but allowed flexibility to elicit diverse perspectives. Interviews were audio-recorded with consent. Dimensions probed included job satisfaction, wellbeing, resignations, work experiences, training quality, personal life affects, gender inequalities, proposals, and context-specific issues **(Table 2)**. Thematic analysis of interview transcripts was conducted to identify recurrent patterns and categories reflecting European junior doctors' shared experiences. The analysis was performed using ATLAS.ti v9 (Scientific Software Development GmbH, Berlin, Germany). This software facilitates a transparent and systematic approach to qualitative analysis. Informed consent obtained. Personal data processed under EU GDPR (Regulation 2016/679). To protect confidentiality, quotes are not linked to identifiable country data (Turkey excepted due to unique context). A list of organizations providing representatives is available by the study's authors upon request.

Table 1. Sociodemographic variables assessed in the study

Gender		
Male	10	40%
Female	15	60%
Age		
25-30	10	40%
31-35	9	36%
36-40	5	20%
41-50	1	4%
Part of JD's journey		
PGT[a]	16	64%
ECS[b]	9	36%
Specialisations		
1	22	88%
>1	3	12%
Total participants	25	100%

[a] PGT=post-graduate training, [b] ECT=early career specialist

Table 2. Overview of key dimensions explored

Dimension	Description
Job satisfaction	Opinions of JD on the collective's job satisfaction
Wellbeing	Impact of work on JD's wellbeing, emotions and psychosocial sphere
Job resignations	Opinions on job resignations of JD
Working experiences	JD's work-related experiences and their impact (e.g., working conditions, working hours, workload)
Quality of training	Impact of work on JD's skills acquisition, supervision by mentors, PGT programs' quality
Personal lives	Impact of work on JD's personal lives
Gender inequalities	Gender inequalities experienced by JD regarding work, wellbeing, quality of training
Proposals	EJD's proposals or recommendations to improve JD professional satisfaction and wellbeing
Specific issues	Experiences or impacts related to certain contexts (country, postgraduate training programme, early career specialist or specialty)

RESULTS

Heterogeneity across European systems (financing, organization, training, remuneration, culture) coexists with high cross-national consensus among JD on core concerns. We summarize (i) an overview of JD situations (feelings, vulnerabilities, generational shift, resignations), (ii) factors shaping job satisfaction (work, training, overload, inequities), and (iii) proposals.

1. Overview of European junior doctors' situation

JDs are motivated and enthusiastic, yet report pervasive negative emotions: tiredness/exhaustion, frustration, insecurity, stress, and pressure. Psychological distress is frequently mentioned, including anxiety, depression, burnout, and even suicidal ideation **(Figure 2)**. Two structural vulnerabilities recur:

a) Dependence on mentors (dual roles as supervisors and evaluators), which constrains voice and raises fear of repercussions regarding workload, schedules, and leave.

b) Limited experience in high-pressure, high-responsibility environments (especially post-COVID), with abrupt entry and insufficient monitoring of mental-health impact; the transition to specialist roles can be sudden, with responsibility outpacing support.

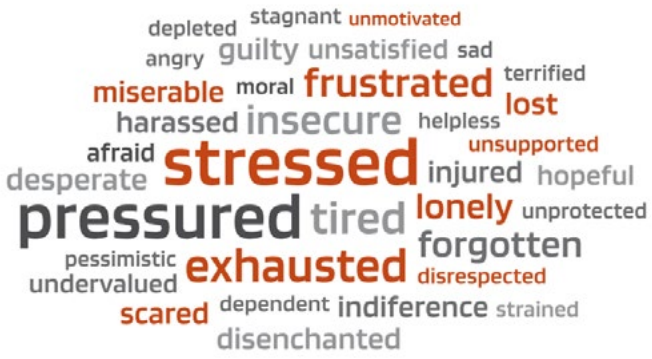

Figure 2. Word cloud: Emotions and feelings of junior doctors

1.1. The generational change regarding work

Participants consistently describe a value shift: today's JD prize work-life balance, protected time, and fair compensation over "total vocational sacrifice." They increasingly set boundaries (e.g., on unsafe overtime) and seek flexibility (e.g., scheduling, academic time). Workforce shortages also confer more agency in job and specialty selection. Feminization has catalyzed cultural change - initially voiced by women, now embraced broadly.

Consequences include specialty choice drift toward domains with predictable hours or fewer on-calls, and declining attractiveness of medicine for some students where conditions are comparatively worse than in other sectors.

1.2. Job resignations

With few Nordic exceptions, resignations are reportedly rising - before or after residency - and post-training migration to better conditions is common. Some graduates depart clinical medicine altogether (e.g., pharma, consulting). Drivers include stressful/rigid conditions, inadequate staffing, lack of career continuity (no guaranteed posts), and EU mobility opportunities.

2. Factors that influence European junior doctors' job satisfaction

Lack of flexibility, overload, long hours, and poor environments degrade satisfaction, learning, and health - most acutely for residents, while early-career specialists face temporariness and location mandates.

2.1. Work-related experiences

Four drivers dominate:

a) *Lack of flexibility.* Hinders academic development, conference participation, and caregiving responsibilities; flexibility is pivotal for modern professional identities.

b) *Compensation concerns*. Pay is often perceived as misaligned with workload/ responsibility; may push JD to extend hours, though salary alone won't fix dissatisfaction.

c) *Mobility & temporariness*. Frequent relocations during and after PGT, weak career projection, temporary contracts, unclear employment rights (e.g., university vs. labor contracts), and in some contexts mandatory rural service post-residency - fostering instability and isolation.

d) *Working environment*. Persistent tension, pressure, stress; impaired interprofessional relations; low recogni-

tion. Some Nordic/Central contexts report positive shifts (support for relocation, training opportunities, greater flexibility).

2.2. Training-related experiences

While many PGT programs are valued, work stress degrades training quality:

a) Insufficient time for study and academic activities; training time displaced by bureaucratic/nonmedical tasks.

b) Supervision gaps and limited feedback, especially on nights/on-call; limited incentives and time for mentors.

c) Competency attainment is harder under overload; variable standards across sites; structural issues (e.g., too many residents for caseloads, too few accredited centers/mentors).

d) Resultant insecurity about clinical progress and care quality.

2.3. Work overload

Universally cited and worsening:

a) Demand increases without commensurate resource growth generate high pace, hasty decisions, and "firefighting," with limited time to consult or reflect - fueling moral distress and frustration.

b) Overload propagates vicious cycles of fatigue and under-recovery, undermining work-life balance and retention.

c) JD shoulder many nonmedical tasks amid staff shortages; their dependent status narrows options to reduce hours or change posts.

d) Some systems (notably Nordic) report movement away from perceiving JD as "cheap labour", with fairer task distribution.

2.4. Working times/EWTD

EWTD has improved conditions in several countries, but compliance varies. Even where observed, postponed rest, excessive hours, and night work remain common, harming wellbeing and learning (especially in procedural and emergency specialties).

2.5. Working environment revisited

Overload plus resource scarcity breeds poor climates (competition, incivility), disproportionately affecting JD; recognition deficits amplify demoralization. Change is uneven; "revanchist" cultures ("we suffered, so must you") slow progress.

2.6. Inequities

Gendered and migration-related inequities compound JD vulnerability; progress varies, with Nordic/Central contexts reporting stronger public care supports and equity policies.

Gender

Despite feminization, women face:

a) Career interruptions for caregiving; more part-time and stigma thereof; reduced opportunities and recognition.

b) Glass ceiling and leadership under-representation; specialty segregation (women underrepresented in surgical fields), with greater exposure to harassment in some settings.

c) Pay gaps emerge indirectly via interruptions, fewer on-calls, and specialty mix.

Migration

Migrant JD encounter racism/xenophobia, limited training & employment opportunities, language barriers, and social isolation - despite their growing system contribution.

3. Proposals

JD proposals cluster into governance & planning, working conditions & balance, occupational wellbeing, training, and inequalities.

3.1. Governance & planning

a) Elevate medical workforce to a top political priority.

b) Implement robust planning/forecasting

c) Strategically address maldistribution (e.g., incentives for medical deserts)

d) Increase health-workforce investment.

e) Align policies with evolving work values.

3.2. Working conditions & balance

a) Flexibility & autonomy: options for part-time, flexible scheduling, academic/protected time, and facilitated transfers.

b) Environment: HR best-practice adoption (civility, teamwork, soft-skills training); reduce bureaucracy through digitalization.

c) Workload: monitor and reduce; add staff where needed; attend to high-risk contexts (nights, emergency, procedural specialties).

d) Hours & rest: enforce EWTD, monitor time, pay overtime, ensure rest facilities and fatigue-risk management.

e) Stability: longer contracts and career planning.

f) Pay: fair and adequate remuneration (as part of a bundle, not a stand-alone fix).

3.3. Occupational wellbeing

a) Prioritize primary prevention (fix conditions). Expand research/monitoring (prevalence, dashboards).

b) Build peer networks and structured debriefing (e.g., Balint groups), on paid time.

c) Implement violence prevention protocols and safe leave policies; reasonable accommodations for vulnerable JD.

d) Train leaders in mental-health supportive management; embed mental-health literacy in PGT core curricula.

3.4. Training

a) Protect structured, competency-based programs via su-

pervisor preparation (including incentives) and protected training time.

b) Reduce variability by aligning to European standards; increase accountability through evaluation of residents, mentors, and institutions (at multiple time points).

c) Fund and time-protect academic development (courses, conferences, research).

3.5. Inequalities

a) Treat parental leave as active time; promote paternity-leave uptake; maintain full-time feasibility via public care services.

b) Affirmative actions for leadership parity; pay-gap monitoring and remediation funds; targeted recruitment of women in under-represented specialties.

c) System-wide training on gender and diversity; targeted supports for migrant JDs.

3.6. Translation into Policy

Bridging the gap between policy and practice requires translating shared concern into enforceable measures. The findings point toward a coherent policy package: adherence to working time regulations, transparent career progression, structured mentorship and supervision incentives, and the systematic integration of wellbeing and equity into workforce governance. There are not optional welfare measures but prerequisites for patient safety and health system resilience. Pilot initiatives -such as national burnout observatories or flexible rotation frameworks- could serve as scalable models across Europe, particularly in contexts like Greece where trust and retention remain fragile. The synthesis of these proposals sets the stage for the concluding discussion on practical implementation and the broader implications for workforce resilience.

CONCLUSION

Across Europe, there's a notable consistency in job satisfaction reports: high workloads, rigid and volatile working conditions, declining training standards, and inequities, all reflecting a generational preference for work-life balance and respectful, safe employment. The combination of these factors negatively affects satisfaction, learning, and retention **(Figure 3)**.

1. Challenges & outlooks for vascular trainees

Procedural specialties, and vascular surgery in particular, have emerged as sentinel indicators of post-pandemic training deficits. Beyond reduced operative numbers, many trainees reported fragmented mentorship, suspended fellowships and redeployment to non-surgical services. The resulting loss of continuity has affected both confidence and retention, with some considering early career change. The Pereira-Neves et al. survey found that over 70% of vascular trainees reported educational regression due to reduced procedures and redeployment. Many expressed concerns about long-term competency and employability. To rebuild competence and morale, training systems should adopt structured compensatory measures, such as simulation-based training, supervised extended fellowships, formalised mentorship networks.

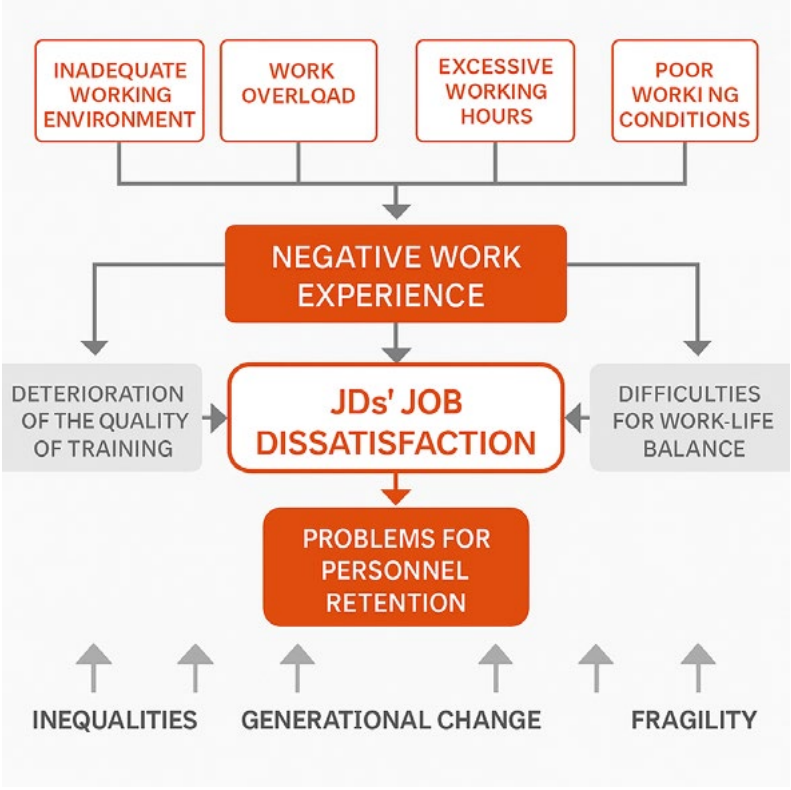

Figure 3. Interconnected drivers of junior doctors' dissatisfaction and attrition

Cross-border collaboration—supported by European scientific societies- could equalise opportunities between peripheral and central regions. These measures align with the EJD proposals on flexibility and protected training time but add a specialty-specific dimension: ensuring that technical skill progression keeps pace with service recovery, especially in settings like Greece, where systemic fatigue and limited trust already challenge specialist retention.[18, 19]

2. Implications for Greece

Greek physicians entered COVID-19 with pre-existing system fragilities; the pandemic accelerated exhaustion, burnout, and distrust toward institutions.[14-16] Preliminary "Barometer" findings among Greek JD—high workload, insufficient support, low satisfaction, frequent exhaustion—mirror Europe-wide patterns but appear amplified in Greece.[17] Greece should therefore prioritize:

(i) trust-building measures (transparent governance, participatory decision-making),

(ii) condition-first prevention (staffing, EWTD enforcement, rest, reduced bureaucracy),

(iii) protected training time and supervision,

(iv) stable career pathways and flexibility, and

(v) equity investments (public childcare, leadership parity initiatives).

Delivering this bundle - not piecemeal fixes - offers the best chance to retain JD, restore morale, and strengthen care quality.

Ensuring the future resilience of European healthcare requires listening to and acting upon the voices of its junior doctors. Their experiences reveal a system under strain but also a clear roadmap for improvement—fair conditions, protected training, meaningful flexibility, and genuine equity. Addressing these needs is not only a matter of workforce sustainability but a commitment to safe, high-quality patient care. By prioritizing wellbeing and modernizing medical workforce policies, Europe can rebuild trust, retain its young clinicians, and secure a stronger, more compassionate health system for the generations to come.

BIBLIOGRAPHY

1 Eurostat. Healthcare personnel statistics - physicians. Statistics Explained [Internet]. 2022. [cited 2023 Jul 04]. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Healthcare_personnel_statistics_-_physicians&oldid=460643#Healthcare_personnel

2 OECD, European Observatory. State of Health in the EU: Companion Report 2021 [Internet]. Luxembourg: Publications Office of the European Union, 2022. Available from: https://ec.europa.eu/health/sites/default/files/state/docs/2019_companion_en.pdf

3 WHO Europe Health Workforce and Service Delivery. Health and care workforce in Europe: time to act [Internet]. Copenhagen: WHO Regional Office for Europe; 2022 [cited 2025 Oct 14]. 1-205 p. Available from: https://www.who.int/europe/publications/i/item/9789289058339

4 Fragkiadakis GF. The impact of COVID-19 on European and Greek healthcare systems: an overview of public finances and healthcare challenges. ICBE-HOU [Internet]. 2024 Aug. 1 [cited 2025 Oct. 14];3(1). Available from: https://eproceedings.epublishing.ekt.gr/index.php/ICBE-HOU/article/view/7123

5 Mobley WH. Intermediate linkages in the relationship between job satisfaction and employee turnover. J Appl Psychol. 1977;62:237-40.

6 Hom PW, Griffeth RW, Sellaro CL. The validity of Mobley's (1977) model of employee turnover. Organ Behav Hum Perform. 1984 Oct;34(2):141-74.

7 Maslach C, Schaufeli WB, Leiter MP. Job burnout. Annu Rev Psychol. 2001;52:397-422.

8 Klesmite-Bluma A, Cerame A, Berhanu D, Pihelgas P, Eerens D, Trumpickaitė M. On behalf of the European Junior Doctors Association. From mandate to motivation: transforming junior doctors' retention strategies in Europe [Internet]. Brussels: European Junior Doctors Association; 2024 [cited 2025 Oct 14]. Available at: https://www.juniordoctors.eu/sites/default/files/2024-07/FMM_FINAL.pdf

9 Naji L, Singh B, Shah A, Naji F, Dennis B, Kavanagh O, Banfield L, Alyass A, Razak F, Samaan Z, Profetto J, Thabane L, Sohani ZN. Global prevalence of burnout among postgraduate medical trainees: a systematic review and meta-regression. CMAJ Open. 2021 Mar 8;9(1):E189-E200.

10 Hariharan TS, Griffin B. A review of the factors related to burnout at the early-career stage of medicine. Med Teach [Internet]. 2019 [cited 2025 Oct 14]; 41(12): 1380-91. Available from: https://www.tandfonline.com/doi/abs/10.1080/0142159X.2019.1641189?journalCode=imte20

11 Zhou AY, Panagioti M, Esmail A, Agius R, Van Tongeren M, Bower P. Factors Associated With Burnout and Stress in Trainee Physicians. JAMA Netw Open [Internet]. 2020 [cited 2025 Oct 14]; 18;3(8):e2013761. Available from: https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2769385

12 Cerame, A. On behalf of the European Junior Doctors Association. Medical Workforce Planning in Europe: Overview and 2022 preliminary survey's results. European Junior Doctors Association; 2022. Internal report.

13 WHO and the International Labour Organization. The gender pay gap in the health and care sector a global analysis in the time of COVID-19. Geneva: World Health Organization. [Internet]. [cited 2025 Oct 14]. Available from: https://www.who.int/publications/i/item/9789240052895

14 Georganta M-N. The pandemic has exhausted doctors in Europe [Internet]. Athens: Eleftheros Typos Newspaper; 15 Nov 2022 [cited 2025 Oct 14]. Available at: https://eleftherostypos.gr/ygeia-epistimi/i-pandimia-exantlise-

tous-giatrous-stin-evropi

15 Ignatiadis V. How much were doctors' burnout rates increased in the pandemic [Internet]? Athens: Iatronet online health newspaper; 9 Dec 2023 [cited 2025 Oct 14]. Available at: https://www.iatronet.gr/article/121226/poso-ayxhthhke-to-burnout-ton-giatron-sthn-pandhmia

16 Papadatos-Anagnostopoulos D. Who and why don't trust the healthcare system and why this is a serious problem [Internet]. Athens: Ygeianet online health portal; 16 Sep 2025 [cited 2025 Oct 14]. Available at: https://ygeianet.gr/poioi-kai-giati-den-empisteyontai-to-systima-ygeias-kai-giati-ayto-einai-sovaro-provlima/

17 Theodorou A, Papaioannou Ch, Roditis K, Tsiapakidou S, Panou Ch, Giorgalla V, Koutsostathis E, Galanakis N, and Vavouranakis Ch. on behalf of JDN-Hellas & Panhellenic Medical Association. Evaluation of the professional development and training of junior doctors in Greece: First results of the "Barometer for junior doctors" [Internet]. Athens: Athens Medical Society. Abstracts Book of the 51st Panhellenic Medical Congress; 24 May 2025 [cited 2025 Oct 14]. Abstract available at: https://www.mednet.gr/sites/default/files/51-EPIS-Abstracts-Book_final.pdf

18 Pereira-Neves A, Domingos LF, Ancetti S. The Impact of the First COVID-19 Wave on European Vascular Education. EJVES Vasc Forum. 2022;54:54-57.

19 Wippel D. Closing the Gaps in Vascular Training: The EVaST Survey Launches [Internet]. European Society for Vascular Surgery; 24 Jun 2025 [cited 2025 Oct 14]. Available at: https://esvs.org/blog/2025/06/24/closing-the-gaps-in-vascular-training-the-evast-survey-launches/

20 Cerame A, Körner M, Launio S, McCourt E, Montvila A, Ribeiro Mourão F, Roditis K, and Sharma S. On behalf of the European Junior Doctors Association. From Tradition to Transition: European Junior Doctors' Experiences with Work and Their Impact Brussels: European Junior Doctors Association; 2023; Qualitative report; ISBN 978-2-9603376-1-7. Available at: https://www.juniordoctors.eu/sites/default/files/2023-10/Report%20EJD_2023_1.pdf

REVIEW ARTICLE

Physician modified endografts for complex abdominal aortic aneurysms. Are we ready for the next step? A systematic review of the literature

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Abstract:

Introduction: Physician-modified endografts (PMEGs) have emerged as an alternative endovascular solution for the treatment of complex abdominal aortic aneurysms, particularly when custom-made devices are unavailable or unsuitable due to anatomical constraints or urgent clinical presentation. However, evidence regarding their safety, feasibility, and durability remains heterogeneous.

Methods: A systematic review of the literature was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA guidelines). Studies reporting outcomes of PMEGs for complex abdominal aortic aneurysms were identified through a comprehensive search of major medical databases. Early outcomes, including 30-day mortality, aorta-related mortality, technical success, major adverse events (MAEs), and reintervention rates, as well as late outcomes such as overall and aorta-related mortality and reinterventions, were analyzed.

Results: The available literature consisted predominantly of retrospective cohort studies. Technical success rates were high across studies. Early mortality and aorta-related mortality were generally acceptable, although outcomes varied depending on clinical presentation, with a relevant proportion of procedures performed in urgent or emergent settings. MAEs included spinal cord ischemia, myocardial infarction, respiratory failure, stroke, bowel ischemia, and renal failure, not all of which were directly attributable to aortic-related events. Early and late reintervention rates were mainly associated with endoleaks and target vessel complications.

Conclusion: Physician-modified endografts represent a feasible and effective endovascular option for selected patients with complex abdominal aortic aneurysms, particularly in experienced centers and time-sensitive clinical scenarios. While early and mid-term outcomes are encouraging, the current evidence base remains limited by heterogeneity and lack of long-term follow-up. Further prospective studies, standardized reporting, and multicenter registries are required to better define durability, optimize patient selection, and update current guideline recommendations.

Keywords: physician modified endograft, PMEG, complex, abdominal aortic aneurysm, systematic review

INTRODUCTION

The rapid evolution of innovative technologies led to the appropriate development of endovascular techniques for treating complex aortic cases.[1,2] Custom-made devices are considered the gold standard of the technological progress, with the companies working hard to make grafts tailored to the patient's anatomy, allowing for optimal alignment between graft and target vessels, succeeding parallel favourable outcomes regarding aneurysm exclusion and survival.[1,3] However, the manufacturing time, cost, and limited availability of custom-made devices restrict their widespread use, particularly in urgent or emergent settings.[4] Several solutions to overcome this issue have been proposed, including the off-the-shelf branched stent grafts,[5,6] parallel endografts,[7,8] and the physician-modified endografts (PMEGs).[9-11]

Physician-modified endografts have gained increasing popularity since 2010, following the first description by Starnes of modifications or adaptations of commercially available aortic stent grafts replicating fenestrated and branched devices already used in Europe and Asia or available as investigational devices in the United States.[12] The rationale behind using these devices is to nullify the patients' waiting time, creating fenestrations and/or branches for aortic arch, visceral and renal vessels, thereby constituting the most reliable alternative of CMDs.[9-11]

The aim of the present study was to review the literature and summarize all available data on physician-modified endografts for the treatment of complex aortic diseases involving the aortic arch and the abdominal aorta.

METHODS

Design and registration

The present systematic review was designed and reported in accordance with the Preferred Reporting Items for Systematic

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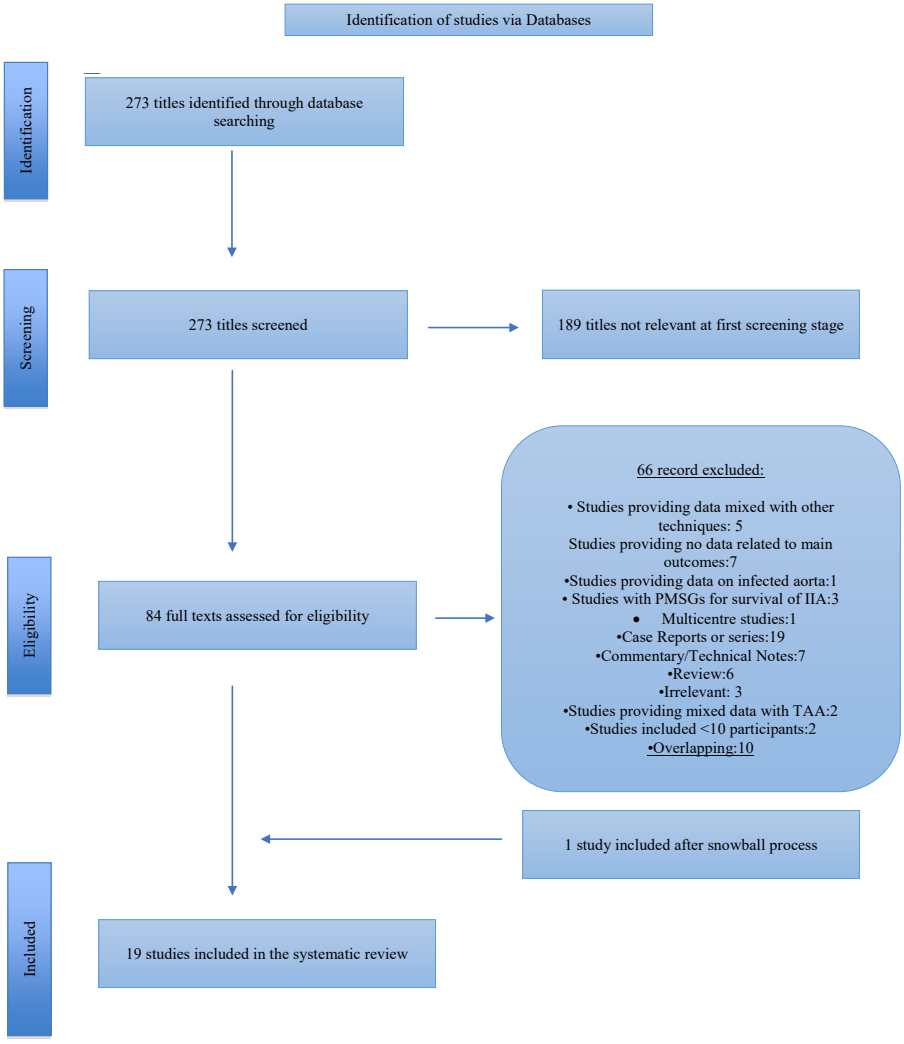

Figure 1: Study flow chart ("Preferred Reporting Items for Systematic reviews and Meta-Analysis" diagram)

Reviews (PRISMA) statement **(Figure 1)**.

Eligibility criteria

Studies published in English that reported on physician-modified endografts for thoracoabdominal and pararenal aortic aneurysms were included in the present systematic review. At least one target vessel (including renal arteries, coeliac trunk, or mesenteric arteries) had to be included with either a branched (including side branch, inner branch, antegrade, and retrograde) or fenestrated (including reinforced and non-reinforced, and mini cuff reinforced fenestrations) technique for the study to be eligible. Graft modifications that did not include adding a fenestration or branch to the main aortic graft for target vessel revascularisation were excluded. Case reports and case series of 10 patients or less were excluded. The following were also excluded: studies that provided mixed outcomes with other endovascular techniques or had not provided data regarding the main outcomes, review articles, commentary and technical notes, editorials and letters. Multicenter studies that included vascular centers reporting their experiences separately were also excluded to avoid overlap and overestimation of the data.

Search strategy

A thorough literature search was conducted in MEDLINE (via PubMed; 1966 to November 2025), EMBASE (via Ovid; 1980 to November 2025), the Cochrane Central Register of Controlled Trials (CENTRAL) (through November 2025), and Google Scholar (through November 2025). A snowball process of the reference lists from the eligible studies was following the retrieval of relevant reports from the databases searches. The following search items, including expanded Medical Subject Headings (MeSH) terms were used in various combinations: ((physician-modified) OR (surgeon-modified) OR (home-made) OR (back-table)) AND (fenestrated) AND (branched) AND (aorta) AND aneurysm). **Figure 1** depicts the eligible studies available in the literature, including 19 retrospective studies.[12-30]

Definitions

Technical success was defined as satisfactory deployment of the PMEG, successful catheterisation of all fenestration(s)/

branches and deployment of the intended bridging stents/stent grafts into the target vessel(s), with patency of the endograft and all target vessels as evidenced by intra-operative completion angiography.[2]

Fenestration was defined as a constructed hole in the main aortic endograft for catheterization of the visceral vessels and the deployment of the intended bridging stent graft. Branch was defined as a side or inner branch attached to the main endograft prior to its deployment.[2]

Major adverse events at 30-days were defined as all-cause mortality, myocardial infarction, respiratory failure requiring prolonged (>24 hours from anticipated) mechanical ventilation or reintubation, renal function decline resulting in >50% reduction in baseline eGFR or new-onset dialysis, bowel ischemia requiring surgical resection or not resolving with medical therapy, major stroke, and paraplegia.[2]

Preoperative planning and Technique

Preoperative planning for physician-modified endografts is routinely based on high-resolution computed tomography angiography with thin-slice acquisition (<1mm) and advanced multiplanar and three-dimensional reconstruction. This imaging approach allows accurate assessment of vascular anatomy, including the identification of target vessel origin, diameter, and the inter-vessel distances required for appropriate fenestration planning.[31]

The technique for mapping fenestration location differs among operators.[24,32] The use of three-dimensional printed templates to assist with fenestration alignment has been explored, particularly among less experienced operators.[24] Available evidence indicates that these adjunctive tools may enhance the precision of fenestration transfer when resources allow; however, clinical outcomes remain closely linked to institutional expertise in complex aortic repair.[24,32] Recently, a new software has been proposed for more precise design and construction of fenestrations.[15] The punch card technique was developed to eliminate the 3D printing workflow while preserving the benefits of having a 3D model.[32]

The physician-modification technique has been previously described in detail.[33] After partial deployment of the first stent graft rings on a back table, proximal markers are used to orientate on the endograft, and a curved clamp is utilized to unfold the fabric for placement of the fenestrations. **(Figure 2)** The position of the fenestrations was marked with a sterile pen through the holes of the punch card, and the preparation was continued in a standard fashion. Considerable technical heterogeneity was observed with respect to the instruments used for fenestration creation. While some operators favor the use of a scalpel, others prefer ophthalmic cautery.[33-35] This divergence is largely driven by concerns that the use of ophthalmic cautery may weaken the graft fabric compared with mechanical cutting using a scalpel; however, this hypothesis has not yet been definitively proven. The created fenestrations were reinforced using a double-layer Goose Snare wire (ev3 Endovascular, Plymouth, MN, USA) or alternative materials, such as loops cut from snares or the tip of a radiopaque wire, and secured with a running 4-0 polyfilament suture.[33, 35] Re-sheathing of the PMEG was performed using vessel loops or Mersilene bands.[33, 35]

In published reports, incorporation of target vessels in physician-modified endografts has most commonly been accomplished using fenestrations, although the use of scallops and directional branches has also been described.[25,28,36,37] **(Table 1)** Several studies have highlighted anatomical factors that may guide the selection of the incorporation strategy. Fenestrations are generally favored for target vessels with upward or transverse orientations and in cases involving relatively narrow aortic diameters, whereas directional branches are more frequently applied to caudally oriented vessels or those originating from widened aortic segments.[16, 38] Despite these proposed considerations, no consensus has emerged regarding the optimal choice among fenestrations, scallops, and branches, and marked variability in technique persists across reported series.[25, 28, 36, 37]

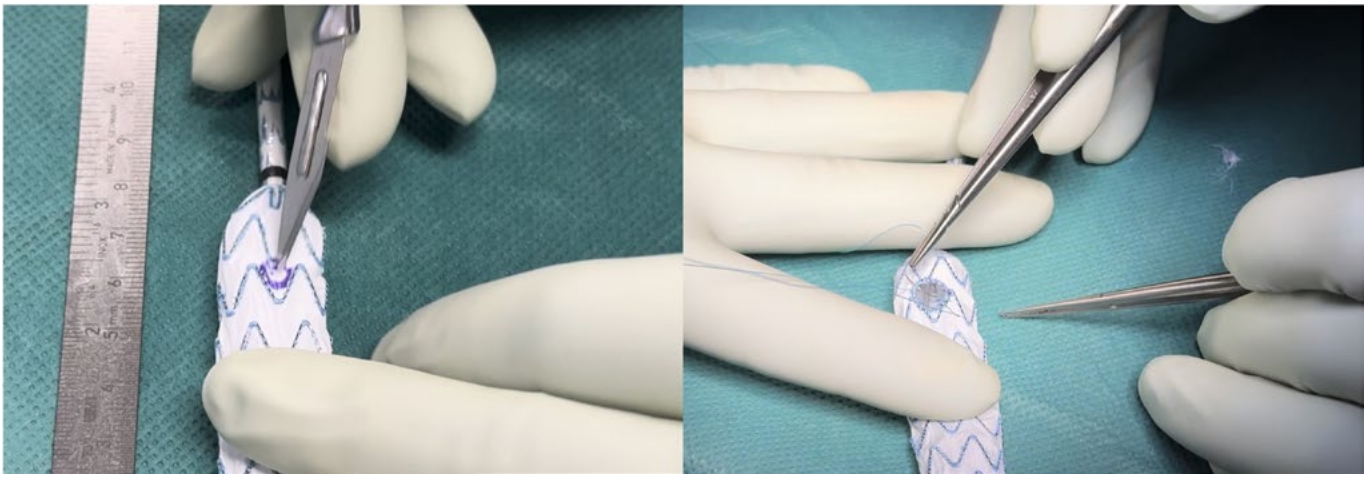

Figure 2: Construction of a physician-modified endograft (PMEG). (A) Creation of a fenestration on the endograft fabric after target vessel marking and sizing. (B) Circumferential reinforcement of the fenestration with a running polypropylene suture to improve radiographic visualization and maintain fenestration integrity during device manipulation and deployment.

Table 1: Baseline characteristics of PMEGs studies for reno-visceral segment

Investigator	Year	Participants No	Type of Presentation			Aortic Diameter (mm)	Morphology of PMEGs (n)			Mean follow-up period (months)
			Elective	Urgent	Emergent		Fenestrations	Branches	Scallop	
Yang et al[32]	2025	186	104	82	nr	56	530	86	2	40
Alvarez et al[26]	2025	18	12	nr	6	70	37	nr	nr	10
Sanders et al[20]	2024	184	165	18	1	62	691	nr	nr	nr
Han et al[39]	2025	161	111	2	48	68	nr	nr	nr	23
Starnes et. al[19]	2024	203	NR	NR	NR	67	237	nr	nr	12
Nguyen et al[27]	2024	100	94	4	2	66	383	nr	nr	10
Asirwatham et al[33]	2023	103	91	8	4	66	383	7	nr	7
Chan et. Al[28]	2023	37	34	2	1	64	37	nr	nr	18
Chait et. Al[23]	2022	156	128	16	12	70	407	16	29	47
Rynio et al[14]	2022	43	34	nr	9	62	162	nr	nr	14
Branzan et al[29]	2021	19	nr	6	13	72	71	nr	nr	14
Sénémaud Jn et al[30]	2020	28	15	nr	13	74	98	nr	nr	1
Juszczak et al[34]	2020	54	4	10	40	76	171	nr	3	20
Oderich et al[35]	2019	145	145	nr	nr	69	393	21	39	38
Dossabhoy et al[31]	2018	41	32	9	nr	65	106	nr	nr	21
Tsilimparis et al[21]	2017	21	nr	13	8	74	58	2	9	13
Scali et al[37]	2015	37	nr	10	27	73	82	23	4	8
Starnes et. Al[19]	2012	47	9	nr	38	61	82	nr	nr	20
Ricotta JJ et al[38]	2012	12	nr	5	7	81	33	2	nr	9
Overall	2012-2025	1595	978	185	229	56-81	3961	157	86	18 (1-47)

Type of modified endografts

Endografts manufactured from Dacron or polytetrafluoroethylene (PTFE) were the most frequently reported devices across the available literature. Commonly used platforms included the Zenith TX2 and Zenith Alpha systems (Cook Medical, Bloomington, IN), the TREO stent graft (Terumo Aortic, Tokyo, Japan), as well as the Valiant Captivia and Endurant devices (Medtronic, Minneapolis, MN).[16,28,33,36] At present, there is no clear evidence regarding the optimal endograft material for the construction of physician-modified endografts. A recent small retrospective cohort study evaluated the use of polytetrafluoroethylene endografts for physician-modified endografts.[39] Over a short follow-up period of seven months, the authors reported one case of type Ic endoleak and six cases of type II endoleaks, with a reintervention rate of 12%.[39] While most published studies have focused on Dacron-based grafts for physician-modified endografts, this report explored the use of polytetrafluoroethylene-based devices, citing improved ease of manipulation and implantation. Nevertheless, further evidence is required to validate these findings.

RESULTS

Physician modified endografts for reno-visceral segments

A total of 19 retrospective studies published between 2012 and 2025 were included in this systematic review. Of the 1595

Table 2: Early outcomes of PMEGs studies

Investigator	Technical success per patient (%)	30-day Aorta related mortality(n)	30-day Mortality (n)	Early MAE (n)	Early Reintervention (n)	Patency Rate of visceral grafts (n)
Yang et al[32]	98%	2	6	34	10	614/618
Alvarez et al[26]	100%	nr	0	nr	0	36/37
Sanders et al[20]	100%	0	9	53	58	691
Han et al[39]	92%	5	8	36	8	574/576
Starnes et. Al[19]	94%	0	6	29	nr	540/575
Nguyen et al[27]	99%	1	2	25	2	382/383
Asirwatham et al[33]	99%	nr	3	22	nr	nr
Chan et. Al[28]	87%	0	0	5	2	41/47
Chait et. Al[23]	99%	2	9	40	0	NR
Rynio et al[14]	86%	0	5	5	2	162/162
Branzan et al[29]	100%	0	0	4	2	70/71
Sénémaud Jn et al[30]	100%	1	4	4	9	98/98
Juszczak et al[34]	100%	nr	9	1	3	182/189
Oderich et al[35]	98%	NR	8	70	18	438/447
Dossabhoy et al[31]	nr	nr	2	18	nr	106
Tsilimparis et al[21]	100%	2	3	6	2	69/69
Scali et al[37]	92%	nr	7	15	5	96/105
Starnes et. Al[19]	98%	0	1	3	3	80/82
Ricotta JJ et al[38]	100%	0	1	6	2	35/36

n: number of cases; **nr:** no reported; **MAE:** major adverse events

Table 2 (continue)
Table 2: Late outcomes of PMEGs studies

Investigator	Late Aorta related mortality (n)	Late Mortality (n)	Late MAE (n)	Late Reintervention (n)	Late Patency Rate of visceral grafts (n)
Yang et al[32]	1	2	nr	13	209/211
Alvarez et al[26]	0	3	0	0	36/37
Sanders et al[20]	nr	nr	8	nr	nr
Han et al[39]	nr	44	nr	7	nr
Starnes et. Al[19]	3	3	nr	nr	nr
Nguyen et al[27]	0	2	nr	7	380/383
Asirwatham et al[33]	nr	nr	nr	10	nr
Chan et. Al[28]	0	4	nr	8	45/47
Chait et. Al[23]	3	3	nr	88	nr
Rynio et al[14]	7	17	nr	6	150/162
Branzan et al[29]	0	1	nr	2	69/71
Sénémaud Jn et al[30]	nr	nr	8	5	98/98
Juszczak et al[34]	nr	nr	nr	12	nr
Oderich et al[35]	0	nr	nr	42	nr
Dossabhoy et al[31]	nr	nr	nr	19	nr
Tsilimparis et al[21]	1	4	nr	1	69/69
Scali et al[37]	nr	5	nr	6	102/105
Starnes et. Al[19]	0	2	1	2	81/82
Ricotta JJ et al[38]	1	2	nr	0	35/36

n: number of cases; **nr:** no reported; **MAE:** major adverse events

(mean age 73 (67-79) years) patients included, 1252 (78%) were male. Of them, 93% (1478 of 1595) had hypertension, 48% (759 of 1595) had coronary artery disease, 49% (788 of 1595) dyslipidaemia, 27% (427 of 1595) chronic kidney disease, 9% (136/1595) history of cerebrovascular diseases, 40% (606/1595) chronic obstructive pulmonary disease and 19% diabetes (311 of 1595), 32% (507/1595) had prior aortic procedure whereas 45% (717/1595) were active smokers.

Operative Details

Of the procedures, 62% had been elective, 24% had been emergent and 15% urgent. Physician-modified endografts were almost equally used for PRAA (56%) and TAAA (44%). Overall, 4204 target vessels were addressed through fenestrations, branches, or scallop configuration. Ten out of the nineteen studies reported on fenestration (n=3961)[12, 13, 15, 17, 18, 21, 24, 25, 27, 28] while the rest reported on combined branched and fenestrated (n=243) repair.[14, 16, 20, 22-24, 26, 29, 30]

The mean operative time ranged from 138 to 453 minutes (reported in 17 studies),[12-30] the mean fluoroscopy time from 39 to 136 minutes (reported in 15 studies),[12, 14-23, 25-30] the contrast medium from 70 to 235 mL (reported in 16 studies)[12, 14-30] and the estimated blood loss from 120 to 936 ml (reported in eight studies).[12, 16, 17, 19, 23, 26, 28, 30] The mean length of stay was reported in 15 studies, [12, 19, 20, 23, 27-39] ranging from 4 to 17 days and the intensive care unit stay ranged from 2 to 4 days (reported in six studies). The mean follow-up was reported in all included studies, varied between 1 to 47 months.[12-30] **(Table 1)**

Early outcomes

The technical success of PMEGs ranged from 87% to 100% among the studies.[12-30] **(Table 2)** Chan et al.[17] reported the lower technical success rate of 87%. Recently, our group reported that the pooled technical success in elective cases was 98.6% (95% CI 97.2-99.3%, p<0.001, I^2=83%;), while in the emergent/urgent group, it was 95.1% (95% CI 90.5-97.5%, p<0.15, I^2=39%;).[10]

The 30-day mortality among the studies ranged from 0% to 18.9%.[12-30] Scali et al.[26] reported the highest crude 30-day mortality rate of 18.9% (7/37 patients) **(Table 2)**. It is worth mentioning that this study reported outcomes in emergent and/or urgent settings. The aorta related mortality ranged from 0.3% to 9.5%.[12-30] Tsilimparis et al[29] reported the highest aorta related mortality rate of 9.5%.

The early major adverse events rate among the studies ranged from 1.8% to 50%.[12-30] Ricotta et al.[23] reported the highest MAE rate of 50% (6/12 patients) **(Table 2).** A more detailed analysis of major adverse events showed rates of spinal cord ischemia ranging from 2% to 7.6%,[14, 16-19, 21, 22, 24-27, 29, 30] myocardial infarction from 3.5% to 4%,[14, 16-19, 21, 22, 24-27, 29, 30] respiratory failure from 5% to 7.5%,[14, 16-19, 21, 22, 24-27, 29, 30] stroke from 2% to 3.5%, [14, 16-19, 21, 22, 24-27, 29, 30] bowel ischemia from 1.1% to 5.8%,[14, 16-19, 21, 22, 24-27, 29, 30] and new-onset hemodialysis from 2.2% to 3.4%.[14, 16-19, 21, 22, 24-27, 29, 30]

The early reintervention rate ranged from 0% to 31% [12, 13, 15-17, 19-27, 29, 30] The most common aetiology was type II endoleak followed by Ia, Ic and IIIc.[2, 12, 13, 15, 17, 19, 21, 26, 27, 29] Our group reported that the pooled rate of target vessel instability was 1.9% (95% CI 1.1-3.2%, p=0.00, I^2=80%;).[10]

Late outcomes

At a mean of 18 (1-47) months of follow-up **(Table 1)**, late mortality among the studies ranged from 0% to 39%.[12, 13, 15-17, 19, 21, 23, 24, 26, 28-30] Rynio et al[24] reported the highest crude 30-day mortality rate of 39%, however, this percentage is not strictly related with aorta-specific events. **(Table 2)**

The late aorta related mortality ranged from 1.0% to 9.5%.[12, 13, 15-17, 19, 21, 23, 24, 26, 28-30] Tsilimparis et al[29] reported the highest crude 30-day aorta related mortality rate of 9.5%. It should be noted that this study reported outcomes exclusively in emergent or urgent settings. **(Table 2)**

The late major adverse events rate among the studies ranged from 2.1% to 28%.[12,13,25,27] Sénémaud et al[27] reported the highest rate of 28% (8/28 patients) **(Table 2)**. In this study spinal cord injury was observed in 7% (2/28) patients, while transient renal failure was detected in 14% (4/28) patients.

The late reintervention rate ranged from 0% to 37% among the studies.[12-24, 26, 29, 30] Chait et al.[16] reported the highest reintervention rate of 37% (57/156 patients). Of them, 33 were due to endoleak of bridging stents grafts, 20 for bridging stents stenosis and the rest (n=16) due to access related complications.

Discussion

This systematic review summarizes the available evidence on physician-modified endografts for the treatment of complex aortic diseases, with particular emphasis on early and late clinical outcomes. Overall, the findings suggest that physician-modified endografts represent a feasible and effective treatment option in selected patients, achieving acceptable rates of technical success, early mortality, and mid-term outcomes, particularly in settings where custom-made devices are unavailable or unsuitable.

Early outcomes demonstrated high technical success rates across the included studies, reflecting the growing expertise of specialized centers in planning, device modification, and implantation techniques.[34, 36] Thirty-day mortality and aorta-related mortality were generally low and comparable to those reported for alternative endovascular strategies in complex aortic repair.[6] However, it is important to note that a substantial proportion of the reported experience involved urgent or emergent cases, which may partly explain the observed variability in early mortality and major adverse event rates.[6, 26, 29, 30]

Major adverse events remained a relevant concern, with reported complications including spinal cord ischemia, myocardial infarction, respiratory failure, stroke, bowel ischemia, and new-onset renal failure requiring hemodialysis.[14, 16-19, 21, 22, 24-27, 29, 30] Importantly, not all major adverse events were directly attributable to aortic-related causes, highlighting the complexity of the treated population and the significant burden of comorbidities. These findings underscore the need for careful patient selection, meticulous perioperative management, and

the implementation of established protective strategies, particularly in extensive thoracoabdominal repairs.[10, 36]

Reintervention rates in the early postoperative period were acceptable and most commonly related to endoleaks or target vessel issues. Type II endoleaks were frequently reported but were often managed conservatively, whereas type I and type III endoleaks more frequently required secondary interventions.[2,12,13,15,17,19, 21, 26, 27, 29] These observations reinforce the importance of accurate fenestration or branch alignment and durable target vessel incorporation. Limited data are available in the literature regarding the type of bridging stent grafts used, therefore, it remains difficult to draw firm conclusions, about which BSG is optimal.[10] Comparing these rates with other endovascular techniques seem identical.[40] Two multicenter studies[34,36] based on PMEGs showed a freedom of reintervention of 73.8%, 61.8%, and 51.4% at 1, 3, and 5 years respectively, which is consistent with the results reported on CMDs.[40-42]

With regard to late outcomes, overall survival and aorta-related survival appeared favorable in the available mid-term follow-up, although long-term data remain limited.[12, 13, 15-17, 19, 21, 23, 24, 26, 28-30] Late reinterventions were reported in a subset of patients and were primarily related to endoleaks, bringing stents instability, or disease progression. Our group, reported a pooled late bridging stent instability rate of 13.9%.[10] In the elective group, the late reintervention rate was 14.6% (95% CI 7.5%-26.5%, p=0.00, I2=43%) while for the emergent/urgent group, it was 15.6%. Another factor that appears to have influenced the survival related outcomes seems to be the high American Society of Anesthesiologists (ASA) score and the low estimated glomerular filtration rate observed in these patients.[36] As a result, outcomes were worse than expected, suggesting that these variables may be useful in improving patient selection. The need for secondary procedures highlights the importance of structured imaging surveillance following physician-modified endograft implantation, particularly given the customized nature of these devices.

Considerable heterogeneity was observed across studies in terms of device platforms, modification techniques, fenestration design, and materials used for reinforcement.[12, 13, 15, 17, 18, 21, 24, 25, 27, 28,32-38] While most reports favored Dacron-based endografts, emerging data on polytetrafluoroethylene-based devices suggest potential advantages in handling and implantation; however, current evidence is insufficient to define an optimal endograft material.[39] Similarly, no consensus has been reached regarding the optimal strategy for target vessel incorporation, with fenestrations, scallops, and directional branches each being applied according to anatomical considerations and operator preference.

In the 2024 ESVS abdominal aorto-iliac aneurysm guidelines, PMEGs (and in situ laser fenestration) are specifically recommended to be reserved for urgent patients when the manufacturing delay for a custom-made device is too long or when no suitable off-the-shelf option exists, and urgent/ruptured complex AAA repair may be considered using these strategies based on patient status, anatomy, and preferences (Class IIa, Level C).[1]

This systematic review has several limitations. First, all included studies were retrospective observational cohorts, which may introduce selection bias and limit the generalizability of the findings. Second, considerable heterogeneity existed among studies regarding patient selection, device platforms, modification techniques, and outcome reporting. Third, due to variability in outcome definitions and reporting across studies, a formal quantitative meta-analysis could not be reliably performed. Finally, long-term follow-up data remain limited, highlighting the need for prospective studies and multicenter registries to better define the durability and safety of physician-modified endografts.

CONCLUSION

Physician-modified endografts appear to be a valuable endovascular option for the management of complex aortic diseases, demonstrating acceptable early and late outcomes when performed in experienced centers. While current evidence supports their use in selected clinical scenarios, particularly in urgent or emergent settings, further prospective studies and standardized reporting are needed to better define long-term durability, optimal device selection, and patient-specific indications.

REFERENCES

1 Wanhainen A, Van Herzeele I, Bastos Goncalves F, Bellmunt Montoya S, Berard X, Boyle JR, et al. Editor's Choice -- European Society for Vascular Surgery (ESVS) 2024 Clinical Practice Guidelines on the Management of Abdominal Aorto-Iliac Artery Aneurysms. Eur J Vasc Endovasc Surg. 2024;67(2):192-331.

2 Oderich GS, Forbes TL, Chaer R, Davies MG, Lindsay TF, Mastracci T, et al. Reporting standards for endovascular aortic repair of aneurysms involving the renal-mesenteric arteries. J Vasc Surg. 2021;73(1S):4S-52S.

3 Wanhainen A, Gombert A, Antoniou GA, Fidalgo Domingos LA, Gouveia EMR, Grabenwoger M, et al. European Society for Vascular Surgery (ESVS) 2026 Clinical Practice Guidelines on the Management of Descending Thoracic and Thoraco-Abdominal Aortic Diseases. Eur J Vasc Endovasc Surg. 2025.

4 Gallitto E, Faggioli G, Spath P, Pini R, Mascoli C, Ancetti S, et al. The risk of aneurysm rupture and target visceral vessel occlusion during the lead period of custom-made fenestrated/branched endograft. J Vasc Surg. 2020;72(1):16-24.

5 Farber MA, Oderich GS, Timaran C, Sanchez LA, Dawson Z, Zenith p-Branch Feasibility Study I. Results from a prospective multicenter feasibility study of Zenith p-Branch stent graft. J Vasc Surg. 2019;70(5):1409-18 e3.

6 Karaolanis GI, Makaloski V, Jungi S, Weiss S, Kotopoulos K, Chaikhouni B, et al. Endovascular repair of pararenal and thoracoabdominal aortic aneurysms with inner and outer off-the-shelf multibranched endografts: A systematic re-

view and meta-analysis. J Vasc Surg. 2025;81(1):251-60. e3.

7 Donas KP, Torsello GB, Piccoli G, Pitoulias GA, Torsello GF, Bisdas T, et al. The PROTAGORAS study to evaluate the performance of the Endurant stent graft for patients with pararenal pathologic processes treated by the chimney/snorkel endovascular technique. J Vasc Surg. 2016;63(1):1-7.

8 Karaolanis GI, Pipitone MD, Torsello G, Austermann M, Donas KP. Endovascular treatment of proximal para-anastomotic aneurysms after previous surgical repair of infrarenal aortic aneurysms by the chimney technique. Vascular. 2019;27(1):3-7.

9 Karaolanis GI, Papazoglou DD, Donas KP, Helfenstein F, Kotelis D, Makaloski V. Physician-modified versus chimney endografting for pararenal aortic aneurysms: a systematic review and meta-analysis. J Cardiovasc Surg (Torino). 2024;65(2):124-31.

10 Karaolanis GI, Kotopoulos K, Dabravolskaite V, Peroulis MG, Bosiers MJ, Kotelis D, et al. High Technical Success and Low Reintervention Rate of Physician-Modified Endografts for Reno-Visceral Aortic Pathologies: Systematic Review and Meta-Analysis. J Endovasc Ther. 2025:15266028251388732.

11 Karaolanis GI, Makaloski V, Jungi S, Celik M, Bosiers MJ, Kotelis D. Endovascular Repair of Aortic Arch Zones 0 to 2 Using Physician-Modified Endografts: A Systematic Review and Meta-Analysis. J Endovasc Ther. 2024:15266028241292485.

12 Starnes BW. Physician-modified endovascular grafts for the treatment of elective, symptomatic, or ruptured juxtarenal aortic aneurysms. J Vasc Surg. 2012;56(3):601-7.

13 Alvarez Marcos F, Reyes Valdivia A, De Blas Bravo M, Alonso Perez M. Physician-Modified Endografts for Non-deferrable Complex Abdominal Aortic Aneurysm Repair Using the Endurant Platform: Templates and Initial Results. J Endovasc Ther. 2025:15266028251318952.

14 Asirwatham M, Konanki V, Lucas SJ, Grundy S, Zwiebel B, Shames M, et al. Comparative outcomes of physician-modified fenestrated/branched endovascular aortic aneurysm repair in the setting of prior failed endovascular aneurysm repair. J Vasc Surg. 2023;78(5):1153-61.

15 Branzan D, Geisler A, Grunert R, Steiner S, Bausback Y, Gockel I, et al. The Influence of 3D Printed Aortic Models on the Evolution of Physician Modified Stent Grafts for the Urgent Treatment of Thoraco-abdominal and Pararenal Aortic Pathologies. Eur J Vasc Endovasc Surg. 2021;61(3):407-12.

16 Chait J, Tenorio ER, Hofer JM, DeMartino RR, Oderich GS, Mendes BC. Five-year outcomes of physician-modified endografts for repair of complex abdominal and thoracoabdominal aortic aneurysms. J Vasc Surg. 2023;77(2):374-85 e4.

17 Chan HL, Papazoglou DD, Jungi S, Weiss S, Becker D, Kotelis D, et al. Fenestrated Physician-Modified Endografts for Preservation of Main and Accessory Renal Arteries in Juxtarenal Aortic Aneurysms. J Clin Med. 2023;12(14).

18 Dossabhoy SS, Simons JP, Flahive JM, Aiello FA, Sheth P, Arous EJ, et al. Fenestrated endovascular aortic aneurysm repair using physician-modified endovascular grafts versus company-manufactured devices. J Vasc Surg. 2018;67(6):1673-83.

19 Han JY, DiBartolomeo AD, Pyun AJ, Hong YH, Paige JF, Magee GA, et al. Impact of Combining Iliac Branch Endoprosthesis and Physician-Modified Fenestrated-Branched Endovascular Repair for Complex Abdominal and Thoracoabdominal Aortic Aneurysms with Concomitant Iliac Artery Aneurysms. Ann Vasc Surg. 2025;111:13-24.

20 Juszczak MT, Vezzosi M, Khan M, Mascaro J, Claridge M, Adam D. Endovascular repair of acute juxtarenal and thoracoabdominal aortic aneurysms with surgeon-modified fenestrated endografts. J Vasc Surg. 2020;72(2):435-44.

21 Nguyen T, Gittinger M, Gryzbowski C, Patel S, Asirwatham M, Grundy S, et al. One-hundred Consecutive Physician-Modified Fenestrated Endovascular Aneurysm Repair of Pararenal and Thoracoabdominal Aortic Aneurysms Using the Terumo TREO Stent Graft. Ann Vasc Surg. 2024;106:369-76.

22 Oderich GS, Ribeiro MS, Sandri GA, Tenorio ER, Hofer JM, Mendes BC, et al. Evolution from physician-modified to company-manufactured fenestrated-branched endografts to treat pararenal and thoracoabdominal aortic aneurysms. J Vasc Surg. 2019;70(1):31-42 e7.

23 Ricotta JJ, 2nd, Tsilimparis N. Surgeon-modified fenestrated-branched stent grafts to treat emergently ruptured and symptomatic complex aortic aneurysms in high-risk patients. J Vasc Surg. 2012;56(6):1535-42.

24 Rynio P, Jedrzejczak T, Rybicka A, Milner R, Gutowski P, Kazimierczak A. Initial Experience with Fenestrated Physician-Modified Stent Grafts Using 3D Aortic Templates. J Clin Med. 2022;11(8).

25 Sanders AP, Gomez-Mayorga J, Manchella MK, Swerdlow NJ, Schermerhorn ML. Ten years of physician-modified endografts. J Vasc Surg. 2025;81(1):1-12 e1.

26 Scali ST, Neal D, Sollanek V, Martin T, Sablik J, Huber TS, et al. Outcomes of surgeon-modified fenestrated-branched endograft repair for acute aortic pathology. J Vasc Surg. 2015;62(5):1148-59 e2.

27 Senemaud JN, Ben Abdallah I, de Boissieu P, Touma J, Kobeiter H, Desgranges P, et al. Intraoperative adverse events and early outcomes of custom-made fenestrated stent grafts and physician-modified stent grafts for complex aortic aneurysms. J Vasc Surg. 2020;71(6):1834-42 e1.

28 Starnes BW, Zettervall S, Larimore A, Singh N. Long-Term Results of Physician-Modified Endografts for the Treatment of Elective, Symptomatic, and Ruptured Juxtarenal Abdominal Aortic Aneurysms. Ann Surg. 2024;280(4):633-9.

29 Tsilimparis N, Heidemann F, Rohlffs F, Diener H, Wipper S, Debus ES, et al. Outcome of Surgeon-Modified Fenestrated/Branched Stent-Grafts for Symptomatic Complex Aortic Pathologies or Contained Rupture. J Endovasc Ther. 2017;24(6):825-32.

30 Yang G, Zhang Y, Ni H, Zhang L, Wang P, Li X, et al. Result of a Multicenter Study on the Physician-Modified Fenestrated and Branched Endovascular Grafts for Thoracoabdominal Aneurysms. Ann Thorac Surg. 2025;119(6):1241-8.

31 Canonge J, Jayet J, Heim F, Chakfe N, Coggia M, Coscas R, et al. Comprehensive Review of Physician Modified Aortic Stent Grafts: Technical and Clinical Outcomes. Eur J Vasc Endovasc Surg. 2021;61(4):560-9.

32 Juhos B, Szentivanyi A, Berczi A, Huttl A, Borzsak S, Szablics F, et al. A Novel Surgical Software Tool to Improve the Physician-Modified Endograft Workflow. J Endovasc Ther. 2026:15266028251406185.

33 Papazoglou DD, Karaolanis GI, Kotelis D, Makaloski V. Physician-Modified Endografts with the TREO Stent Graft System. J Endovasc Ther. 2024:15266028241282643.

34 Csobay-Novak C, Dionisi CP, Szentivanyi A, Berczi A, Osztrogonacz P, Di Sabato A, et al. Physician-Modified Endografts in Elective Care: A Report From the REgistry of MOdified Treo Endografts in Europe (REMOTE). J Endovasc Ther. 2026:15266028251405754.

35 Stana J, Bertrand L, Assaf B, Khangholi DB, Konstantionou N, Tsilimparis N. Optimizing PMEG Technique: Enhancing Endovascular Repair With Pre-Manufactured Fenestrated Endografts. J Endovasc Ther. 2025:15266028251397850.

36 Tsilimparis N, Gouveia EMR, Tenorio ER, Scali S, Mendes B, Han S, et al. Multicenter Study on Physician-Modified Endografts for Thoracoabdominal and Complex Abdominal Aortic Aneurysm Repair. Circulation. 2024;150(17):1327-42.

37 Smith JA, Sarode AL, Stern JR, Cho JS, Harth K, Wong V, et al. Physician-modified endografts are associated with a survival benefit over parallel grafting in thoracoabdominal aneurysms. J Vasc Surg. 2022;76(2):318-25 e4.

38 Torrealba J, Panuccio G, Kolbel T, Gandet T, Heidemann F, Rohlffs F. Physician-Modified Endograft With Inner Branches for the Treatment of Complex Aortic Urgencies. J Endovasc Ther. 2022;29(5):697-704.

39 Zambetti BR, Shiva A, Hardy JT, Babick OM, DeMartino AG, Shah NN, et al. Physician Modification of Polytetrafluoroethylene Based Endografts for Aortic Aneurysm Repair. J Endovasc Ther. 2025:15266028251353359.

40 Patel SR, Ormesher DC, Griffin R, Jackson RJ, Lip GYH, Vallabhaneni SR, et al. Editor's Choice - Comparison of Open, Standard, and Complex Endovascular Aortic Repair Treatments for Juxtarenal/Short Neck Aneurysms: A Systematic Review and Network Meta-Analysis. Eur J Vasc Endovasc Surg. 2022;63(5):696-706.

41 Roy IN, Millen AM, Jones SM, Vallabhaneni SR, Scurr JRH, McWilliams RG, et al. Long-term follow-up of fenestrated endovascular repair for juxtarenal aortic aneurysm. Br J Surg. 2017;104(8):1020-7.

42 Tenorio ER, Mirza AK, Lima GBB, Marcondes GB, Wong J, Mendes BC, et al. Characterization of Secondary Interventions After Fenestrated-branched Endovascular Repair of Complex Aortic Aneurysms and Its Effect on Quality of Life and Patient Survival. Ann Surg. 2023;278(1):140-7.

REVIEW ARTICLE

Cancer Incidence and Mortality Following EVAR and Open Aneurysm Repair: A Systematic Review

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Abstract:

Introduction: There is limited evidence in the literature regarding the incidence and mortality of cancer following either open surgical repair (OR) or endovascular aneurysm repair (EVAR) of abdominal aortic aneurysms (AAA). This study aims to compare cancer-related incidence and mortality between EVAR and OR in patients with no pre-existing malignancy.

Methods: Relevant studies were identified through electronic database searches and manual reference screening. The MEDLINE database (via PubMed) was searched using unrestricted strategies combining Medical Subject Headings (MeSH) and keywords. Studies published between 2010 and 2025 were included.

Results: From 710 initial articles, six met the inclusion criteria. These comprised a total of 67,866 patients (85% male), with a mean age of 72.9 ± 1.5 years. There was no significant age difference between EVAR and OR groups (p = 0.42). Among the included population, 48.4% (n=32,880) underwent EVAR, while 51.6% (n=34,986) underwent OR. The average follow-up period across studies was 10.6 years (range 1.8–15.8 years).

Conclusion: Although some studies have reported possible differences in cancer incidence between EVAR and open repair, the findings remain inconsistent and may be affected by variations in patient risk profiles, follow-up protocols, or study design. Future large, methodologically robust studies with standardized data collection and long-term surveillance are needed to clarify whether a true causal relationship exists between EVAR, radiation exposure, and cancer development.

Keywords: abdominal aortic aneurysm, endovascular repair, open repair, malignancy, neoplasm, cancer incidence, cancer mortality

INTRODUCTION

There is limited evidence in the surgical literature regarding the incidence and mortality of cancer following either open surgical repair (OR) or endovascular aortic aneurysm repair (EVAR). Many published studies have primarily focused on patients presenting with both malignancy and abdominal aortic aneurysm (AAA), rather than on the de novo risk of cancer following these procedures.[1,2]

Over the past two decades, endovascular repair has progressively gained predominance over open surgery in the management of abdominal aortic aneurysms.[3] EVAR offers significant perioperative advantages, including reduced morbidity and mortality, shorter hospital stays, and faster recovery.[4-6] These benefits have led to its widespread adoption, particularly among elderly or comorbid patients, while open repair is now mainly reserved for anatomically unsuitable cases or younger, low-risk individuals.[3]

Nevertheless, there is emerging evidence suggesting that the endovascular approach may be associated with a higher long-term risk of developing metachronous malignancies.[7-10] This has been attributed to cumulative radiation exposure, both during fluoroscopy-guided procedures and during postoperative CT surveillance, which remains the gold standard for detecting endograft-related complications.[11,12] Despite proposed low-dose CT protocols for follow-up, such strategies are not yet routinely implemented in clinical practice.[12,13] Notably, in the EVAR-1 trial, an increased rate of aneurysm-related deaths was accompanied by a higher incidence of cancer-related mortality in the EVAR group.[4] Similar findings were observed in the EVAR-1, OVER, and DREAM trials, which together reported 2,484 patients with long-term follow-up, confirming that deaths due to aneurysm rupture or cancer were present in both treatment groups. [4,5,6] Interestingly, in the OVER trial, cancer-related mortality was higher in the open repair group than in the endovascular group.[5]

The aim of this study was to compare cancer-related incidence and mortality between EVAR and OR in patients with no pre-existing malignancy.

METHODS

Search Strategy

Relevant studies were identified through a comprehensive

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search of electronic databases and a manual review of reference lists. The National Library of Medicine's MEDLINE database was accessed via the PubMed interface and searched from 1976 to the present.

An unrestricted search strategy was applied using exploded Medical Subject Headings (MeSH) terms and keywords combined with the Boolean operators AND, OR, and NOT to identify relevant articles. A secondary manual search of reference lists from selected studies was performed to capture additional eligible publications.

Eligibility assessment was conducted independently and in an unblinded manner by two authors (PG and CFP). The literature search process is summarized in a flow diagram **(Table 1).** Ultimately, six studies reporting a combined total of 67,866 patients with postoperative cancer mortality data were identified and analyzed **(Table 2).** These studies were published between 2010 and 2025, covering study periods from 1999 to 2023.

A PRISMA flow diagram summarizes the study selection process **(Figure 1)**. The risk-of-bias assessment figures were generated as weighted bar plots **(Figures 2 and 3)** and "traffic light" **(Figures 4 and 5)** using the ROBVIS (Risk of Bias VISualization) online application in conjunction[14] with the Cochrane Risk of Bias 2 (RoB 2) tool for Randomized Controlled Trials[15] and the ROBINS-I V2 (Risk Of Bias In Non-randomised Studies - of Interventions, Version 2) tool for observational cohort studies.[16]

Eligibility, Exclusion and Inclusion Criteria

Studies were included if they reported on patients considered suitable candidates for either EVAR or OR, whether in elective or emergency (ruptured) settings. Data from all cancer-free patients were reviewed and analyzed.

Inclusion Criteria

- Studies reporting the incidence or occurrence of cancer following EVAR and/or OR
- Explicit description of cancer outcomes (preferably specifying the cancer type)
- Defined follow-up period, including time to cancer occurrence

Exclusion Criteria

- Articles not published in English
- Case reports or small series with insufficient statistical data
- Patients with concomitant malignancy or metastatic solid

Table 1: Search Strategy

	Search Strategy	Results
1	("cancer*"[All Fields] AND "risk*"[All Fields]) OR "cancer risk*"[All Fields] OR ("EVAR"[All Fields] AND "Open Repair *"[All Fields] AND "Cancer*"[All Fields]) OR "Cancer incidence*"[All Fields] OR "Cancer Mortality"[MeSH Terms]	560,724
2	("cancer" or "neoplasm"or "malignancy"[All Fields]) OR ("postoperative"[All Fields] AND "period"[All Fields]) OR "postoperative period"[All Fields] OR ("post"[All Fields] AND (EVAR OR endovascular OR open repair[All Fields]) OR (AAA OR "abdominal aort* aneurysm" OR "abdominal aort*"[All Fields])	75,779
3	("cancer "[All Fields]) OR "postoperative period"[All Fields] OR ("post"[All Fields] AND (EVAR OR ¨"endovascular" AND "open repair"[All Fields]) OR ("AAA" OR "abdominal aortic aneurysm"[All Fields])	38,324
4	(cancer OR malignancy) AND (aortic aneurysm OR AAA OR TAAA OR TAA) AND (EVAR OR "open repair" OR aneurysm repair) NOT ("concomitant cancer"[Title/Abstract] OR "concomitant malignancy"[Title/Abstract])	710

Table 2: Included studies according to study period, mean age, number of patients, total number of patients, male (%) and Type of Cancer

Trial / Senior author	Journal / Year of Publication	Study Period	Mean Age (y)	Total / Male (%)	EVAR (%)
Evar-1 Trial, Patel[4]	LANCET, 2016	1999-2004	74.1	1252/91	50.0
Over Trial, Lederle[5]	NEJM, 2019	2002-2008	NS	881/92	50.3
Dream Trial, Bruin[6]	NEJM, 2010	2000-2003	70.0	351/91	50.7
Markar[8]	JVS, 2019	2005-2013	73.0	39390/NS	36.7
Ettengruber[7]	LANGENBECK'S ARCHIVES OF SURGERY, 2022	2010-2016	72.1	18802/86	75.6
Meuli[19]	JAMA NETWORK, 2025	2004-2023	NS	6891/83	43

EVAR, Endovascular Aortic Repair; y, years

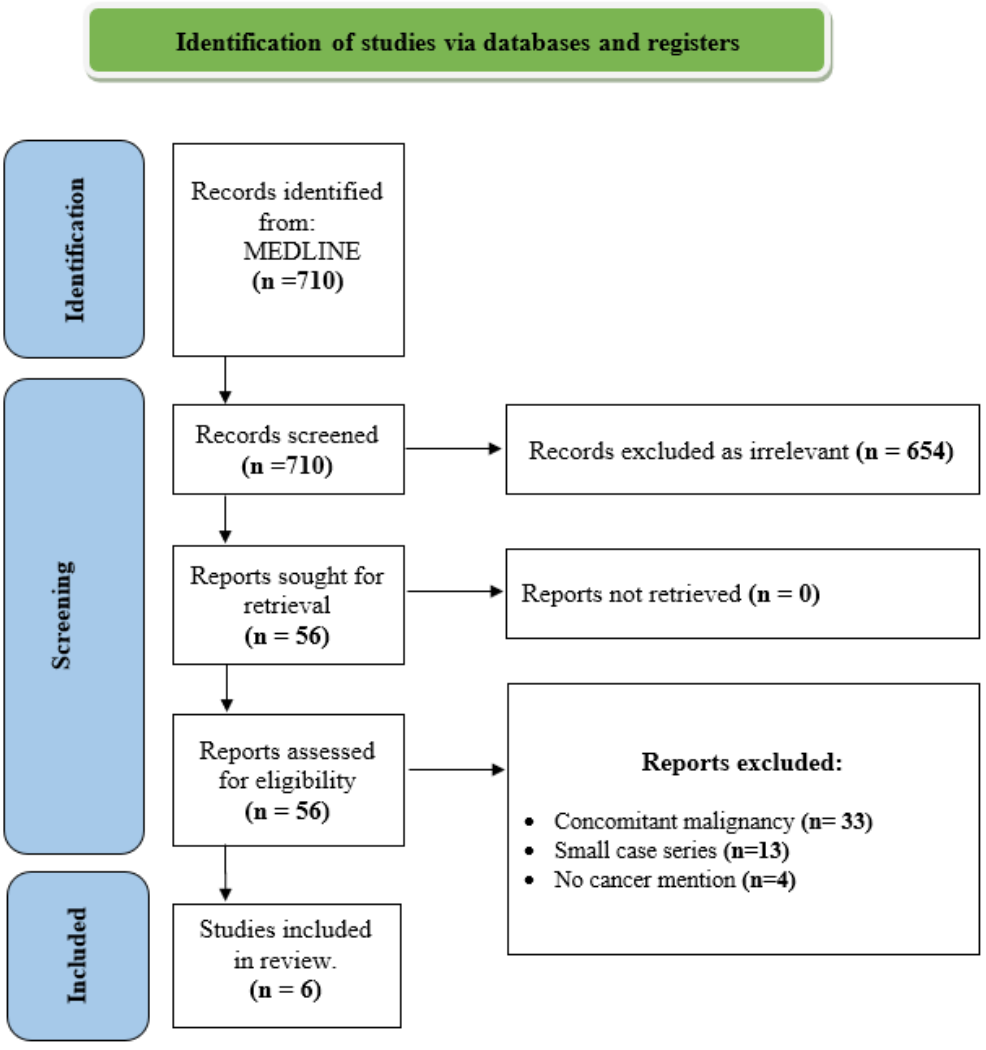

Figure 1: PRISMA flow diagram

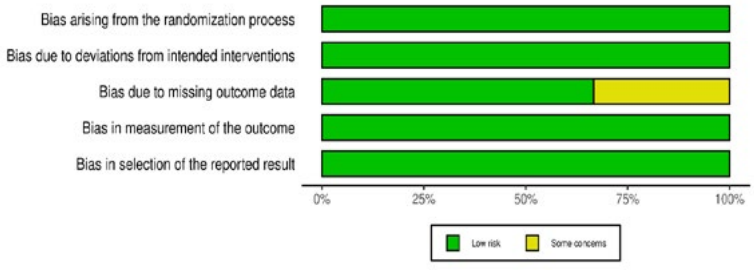

Figure 2: Bias assessment risk

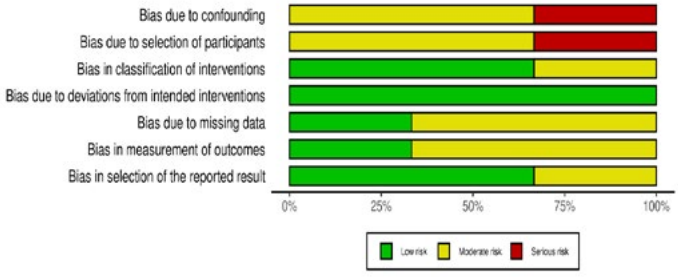

Figure 3: Bias assessment risk

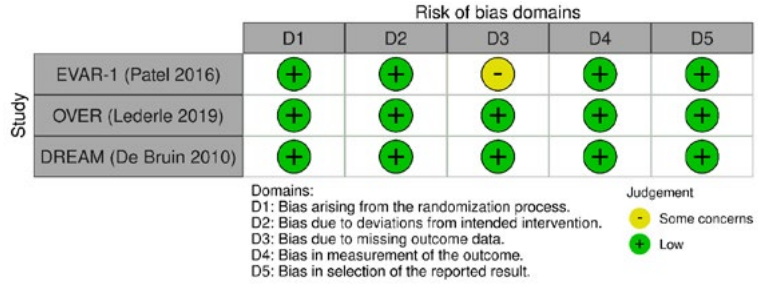

Figure 4: Risk of Bias VISualization

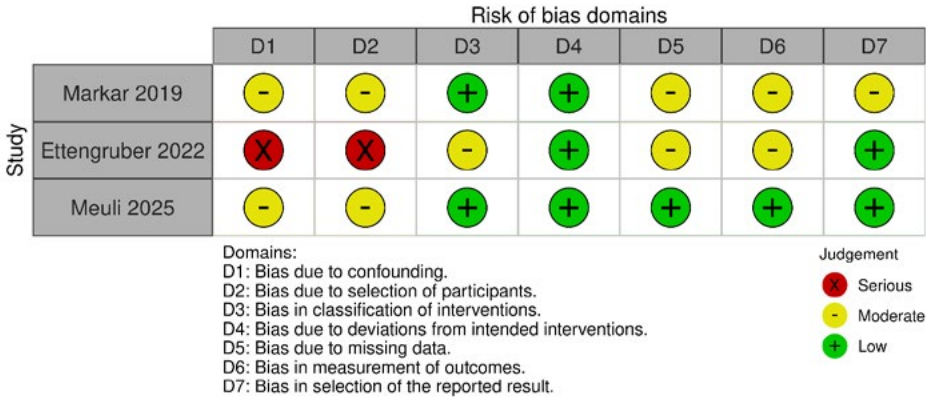

Figure 5: Risk of Bias VISualization

tumors before surgery

- Patients with a previous history of cancer

Collection of data

For each study, data were extracted regarding publication year, study duration, demographic characteristics, and relevant clinical variables, including:

- Smoking history
- Cardiac disease
- Arterial hypertension
- Chronic obstructive pulmonary disease (COPD)
- Cerebrovascular disease (CVD)

Additional parameters such as radiation exposure, number of reinterventions, and non-cancer causes of death (e.g., cardiovascular mortality) were also collected when available. Statistical comparisons focused on cancer incidence, cancer-related mortality, and overall mortality between EVAR and OR groups. Where available, hazard ratios (HR) and confidence intervals (CI) were recorded.

Weighted outcome analysis

Outcome measures were analyzed using study-size weighted pooling, where event counts were derived from each study's sample size and reported event rate. Weighted pooled proportions were compared between EVAR and OR using two-proportion z-tests with 95 % confidence intervals (CIs). Demographics and baseline comorbidities were summarized descriptively and not weighted. Statistical significance was defined as $p < 0.05$.

RESULTS

A total of 710 articles were initially identified through the literature search. After screening titles, abstracts, and full texts, six studies fulfilled the inclusion criteria and were selected for final analysis.

Baseline Demographics and Comorbidities

These comprised a total of 67,866 patients (85% male), with a mean age of 72.9 ± 1.5 years. There was no significant age difference between EVAR and OR groups ($p = 0.42$). Among the included population, 48.4% (n=32,880) underwent EVAR, while 51.6% (n=34,986) underwent OR. The average follow-up period across studies was 10.6 years (range 1.8-15.8 years).

Baseline characteristics were largely comparable between the EVAR and OR groups, although some differences were noted. Pulmonary disease was reported in 20.1% of EVAR patients compared to 18.2% of OR patients. The DREAM trial was the only study providing detailed smoking data, reporting a prevalence of 64.2% among EVAR patients and 55.1% among

those undergoing OR.

Other comorbid conditions were common across both groups. Hyperlipidemia occurred in 33.1% of EVAR patients versus 26.6% of OR patients, while diabetes mellitus was observed in 16.7% and 9.9%, respectively. Similarly, cardiovascular disease was recorded in 13.1% of EVAR and 9.1% of OR patients. Cerebrovascular disease affected 9.1% of EVAR patients but only 1.4% of those who underwent open repair. Arterial hypertension was prevalent in over half of EVAR patients (53.1%), compared with 42% of those treated with OR **(Table 3).**

Follow-Up and Reinterventions

The duration of follow-up varied across studies, with the EVAR-1 trial providing the longest observation period (up to 15.8 years). The overall mean follow-up across studies was approximately 10.6 years, sufficient to capture late events, including secondary malignancies and late mortality.

Follow-up duration varied among studies, with the longest follow-up reported in the EVAR-1 trial (15.8 years). Reintervention rates were significantly higher after EVAR than open repair (26.4% vs 15.2%, $p < 0.001$), largely due to graft-related complications such as endoleak, device migration, or limb occlusion. **(Table 4).** This finding was consistent across the EVAR-1, DREAM, and OVER trials and remains a well-recognized trade-off between the lower perioperative risk of EVAR and its higher long-term maintenance burden.

Mortality Outcomes

Overall mortality was significantly higher in the EVAR group, with a weighted rate of 40.6% (95% CI 39.7-41.5) compared with 35.1% (95% CI 34.1-36.2) in the OR group. The absolute difference of 5.5% (95% CI 4.3-6.7) was statistically significant ($p < 0.001$). This finding, while partly influenced by the large Ettengruber cohort,[7] remained robust across all included studies. **(Table 5).**

Two of the largest randomized controlled trials - EVAR-1 and OVER - provided detailed long-term follow-up beyond eight years. Both demonstrated a trend toward increased late-onset cancer mortality in the EVAR group, although neither achieved statistical significance. In EVAR-1, cancer accounted for 28% of deaths in the EVAR group compared to 20% in the OR group (p = 0.09), while in OVER, the respective rates were 24.8% and 22.4% (p = 0.27).

Cancer Incidence and Type

For any cancer, pooling the two studies that report overall incidence[7,8] yielded a higher weighted incidence after EVAR (25.97%, 95% CI 25.46-26.48) compared with open repair (22.95%; 95% CI, 22.5-23.4), corresponding to an absolute difference of 3.01% (95% CI, 2.3-3.7; p < 0.001).

Subgroup analyses from the Markar et al. study[8] provided further insight into the relationship between imaging surveillance and cancer risk. When comparing EVAR patients who underwent routine CT follow-up with those who did not, the

Table 3: Percentage of Co-morbidities in each study, NS=not specified

Trial / Senior Author	Cardiac Disease History (EVAR/OR%)	Cerebrovascular disease (EVAR/OR%)	Hypertension (EVAR/OR%)	Diabetes Mellitus (EVAR/OR%)	Pulmonary Disease (EVAR/OR%)	Hyperlipidemia (EVAR/OR%)	Tobacco Smoking (EVAR/OR%)
Evar-1 Trial, Patel[4]	NS	NS	NS	NS	NS	NS	NS
Over Trial, Lederle[5]	NS	NS	NS	NS	NS	NS	NS
Dream Trial, Bruin[6]	41.0/46.6	14.5/15.2	58.4/54.5	10.4/9.6	27.7/18.5	47.0/52.6	64.2/55.1
Markar[8]	12.6/10.5	10.5/8.1	NS	16.2/11.5	26.3/20.3	NS	NS
Ettengruber[7]	13.3/8.9	7.6/1.9	53.1/41.6	17.2/11.1	13.9/10.1	32.9/25.6	NS
Meuli[19]	NS	NS	NS	NS	NS	NS	NS

EVAR, Endovascular Aortic Repair; OR, Open Repair

Table 4: Follow-up period, number of reinterventions and type of cancer examined in each study.

Trial / Senior Author	Maximum Follow-Up Period (Years)	Mean Follow-Up Period (Years)	Median Follow-Up Period (Years)	Range Follow-Up Period (Years)	No of re-interventions (EVAR/OR%)	Type of Cancers Examined
Evar-1 Trial, Patel[4]	15.8	12.7	12.4	1.8-15.8	26.2/11.8	Lung
Over Trial, Lederle[5]	14.2	8.4	9.4	5.7-11.2	26.7/19.8	All
Dream Trial, Bruin[6]	7	NS	6.4	5.2-8.2	27.8/16.9	All
Markar[8]	7	NS	2.45	0.56-4.76	NS	Lung, Abdominal
Ettengruber7	9	6.4	NS	NS	NS	Abdominal
Meuli[19]	12.5	NS	8.3	8.1-8.5	NS	Solid tumor, Lymphoma

EVAR, Endovascular Aortic Repair; OR, Open Repair; NS, Not Specified

incidence of abdominal cancer was virtually identical (10.3% vs. 10.8%, p = 0.21), suggesting that CT surveillance itself was not an independent risk factor in this cohort. However, overall freedom from cancer was slightly lower among patients undergoing CT follow-up (77.5%) compared to those without (74.1%), a difference that did not reach significance (p = 0.14) **(Table 6)**.

Lung and abdominal cancer were the predominant cancer types reported after AAA repair. When the EVAR-1[4] and Markar[8] cohorts were combined in a weighted analysis, lung-cancer mortality was slightly higher after EVAR (6.7%; 95% CI, 6.3-7.1) than after open repair (5.7%; 95% CI, 5.4-6.0), an absolute difference of 0.98% (95% CI, 0.5-1.5) that reached statistical significance (p < 0.001). Although significant when pooled, this difference remained modest and was not significant within the individual studies **(Table 7)**. Abdominal cancers - particularly hepatic, gastric, and colorectal - showed a more consistent association with EVAR. The multivariable analysis within the Markar cohort[8] demonstrated that EVAR was associated with a 14% increased risk of abdominal cancer (HR 1.14; 95% CI, 1.03-1.27; p = 0.02) and a 9% higher overall cancer incidence (HR 1.09; 95% CI, 1.02-1.17; p = 0.01) compared with open repair.

However, more contemporary large-scale studies, including that of Meuli et al. (2025), have not confirmed a significant difference in cancer incidence between patients undergoing endovascular versus open aneurysm repair. Specifically, the study evaluated a secondary endpoint and found no difference in 10-year incidence of solid malignant tumors between OSR and EVAR (OSR: 18.6% vs EVAR: 20.5%; P=0.35) in their weighted analysis.

DISCUSSION

This pooled analysis of more than 67,000 patients provides contemporary evidence on long-term outcomes after endovascular (EVAR) versus open abdominal aortic aneurysm repair (OR). Although baseline characteristics were broadly comparable, EVAR patients exhibited slightly higher rates of cardiopulmonary comorbidities, reflecting selection of higher-risk individuals for the endovascular approach. Advancing age inherently increases the likelihood of genetic mutations, and shared risk factors -particularly smoking and chronic obstructive pulmonary disease (COPD) - may predispose these patients to both diseases.[10,17]

The most novel aspect of this analysis concerns the potential association between EVAR and increased cancer incidence. When data from Markar[8] and Ettengruber[7] were pooled, EVAR was associated with a 3% absolute increase in overall cancer incidence (25.9% vs 22.9%, *p*<0.001).[7,8] These observations raise important questions regarding possible eti-

Table 5: Overall mortality in FU, overall cancer mortality and late cancer mortality after 8 years

Trial / Senior Author	Overall Mortality EVAR/OR (%)	Overall mortality p-value (HR) EVAR/OR	Overall Cancer Mortality EVAR/OR (%)	Overall cancer mortality p-value (HR) EVAR/OR	Cancer mortality after 8 years EVAR/OR(%)
Evar-1 Trial, Patel[4]	466(74)/444(71)	0.14(1.1)	126(20.1)/ 123(19.6)	0.53(1.09)	50(28)/31(20)
Over Trial, Lederle[5]	302(68)/306(70)	0.61(0.96)	80(18)/85(19.5)	NS	41(24.8)/37(22.4)
Dream Trial, Bruin[6]	60(33.8)/58(33.6)	NS	18(10.1)/18(10.4)	NS	NS
Markar[8]	NS	NS	2595(18)/3670(14.7)	NS	NS
Ettengruber[7]	6625(46.6)/2383(52.0)	NS	2800(19.7)/958(20.9)	NS	NS
Mueli[19]	38(1.3)/233(6.6)	NS	NS	NS	NS

EVAR, Endovascular Aortic Repair; OR, Open Repair; NS, Not Specified; FU, follow-up

Table 6: Freedom from cancer of cancer patients over the years of follow-up in Markar Study. There is comparison in overall freedom between the two groups as well as freedom from CT and non-CT surveillance

Time (years)	Overall freedom from Abdominal Cancer (EVAR/OR%)	Overall freedom from all types of cancer (EVAR/OR%)	Freedom from Abdominal Cancer with EVAR (CT/NON-CT%)	Freedom from overall Cancer with EVAR (CT/NON-CT%)
0	100/100	100/100	100/100	100/100
1	98.3/98.7	96.5/97	98.0/98.0	96.0/95.9
2	96.9/97.4	93.2/93.9	96.3/96.6	92.3/92.4
3	95.6/96.0	90.1/90.7	94.7/95.7	88.7/90.1
4	94.3/94.8	86.2/87.3	93.0/94.3	84.6/87.4
5	92.8/93.3	84.0/82.7	90.8/92.3	80.5/82.5
6	91.2/91.9	81.1/80.9	89.7/89.2	78.3/80.3
7	90.5/90.6	78.1/77.9	87.8/89.2	77.5/74.1

EVAR, Endovascular Aortic Repair; OR, Open Repair; CT, Computed Tomography

Table 7: Lung cancer mortality, overall cancer incidence according to age and gender in EVAR vs. OR

Trial/Senior Author	Lung Cancer Mortality EVAR/ OR(%)	Cancer incidence EVAR/OR (%)	Cancer incidence <70yrs EVAR/OR (%)	Cancer incidence>70yrs EVAR/OR (%)	Cancer incidence M(EVAR/OR)	Cancer incidence F(EVAR/OR)
Evar-1 Trial, Patel[4]	45(7.2)/46(7.3)	NS	NS	NS	NS	NS
Markar[8]	966(6.7)/1416(5.8)	NS	NS	NS	NS	NS
Ettengruber[7]	NS	30.1/27.6	24.9/25.5	33.3/29.1	31.6/28.6	20.1/22.1

EVAR, Endovascular Aortic Repair; OR, Open Repair; M, Males; F, Females; NS, Not Specified

ologic mechanisms, including chronic inflammation from the implanted endograft, local hemodynamic or ischemic effects, and repeated radiation exposure from postoperative imaging.

Radiation exposure from intraoperative fluoroscopy and postoperative CT surveillance remains a key concern in EVAR patients[11,12,13] Arterial hypertension, present in 53.1% of EVAR cases, often requires higher contrast doses, indirectly increasing radiation exposure - a recognized stochastic carcinogenic risk.[18] Although standard EVAR involves modest radiation, repeated CT follow-up markedly increases cumulative exposure.[19] Monte Carlo models estimate that about one-third of lifetime cancer risk after EVAR arises from combined pre-, intra-, and postoperative imaging. [20] More intensive CT regimens (biannual vs. annual) nearly double attributable cancer risk. While Markar et al.[8] found no significant difference in cancer incidence among patients undergoing CT surveillance, recent dosimetric studies confirm that cumulative exposure remains clinically relevant.[21] Organ-specific analyses show that the liver, stomach, and colon receive the highest doses, though related cancer mortality remains below 0.1%. Bone marrow exposure—mainly from fluoroscopy—may contribute most to long-term stochastic effects.[12,22]

The present analysis benefits from inclusion of large randomized trials with extended follow-up, ensuring adequate power to detect late events. However, heterogeneity in study design, imaging protocols, and cancer ascertainment methods introduces potential bias. The lack of granular data on smoking history, radiation dose, and cancer subtype limits mechanistic interpretation. Additionally, despite adjustment in individual studies, residual confounding cannot be excluded.

This review has several limitations. It was not a formal meta-analysis; results were derived from sample-size weighting without adjustment for study heterogeneity. Reported p-values are descriptive and should be interpreted cautiously. Included studies varied in design, population risk, and follow-up protocols, with incomplete data on confounders such as smoking, radiation dose, and cancer type. Direct quantification of radiation exposure was not possible, and publication bias cannot be excluded.

CONCLUSION

In conclusion, long-term data indicate that while EVAR remains less invasive and initially safer than open repair, it carries a greater burden of reinterventions and possibly higher late mortality. The observed association between EVAR and increased cancer incidence is modest, inconsistent across studies, and likely multifactorial. Ongoing surveillance of contemporary EVAR cohorts, particularly with modern low-dose imaging protocols, is essential to clarify whether these associations persist in current practice.

REFERENCES

1 Ahn S, Min JY, Kim HG, Mo H, Min SK, Min S, et al. Outcomes after aortic aneurysm repair in patients with a history of cancer: a nationwide database analysis. BMC Surg. 2020;20(1):85.

2 Kumar R, Dattani N, Asaad O, Bown MJ, Sayers RD, Saratzis A. Meta-analysis of outcomes following aneurysm repair in patients with synchronous intra-abdominal malignancy. Eur J Vasc Endovasc Surg. 2016;52(6):747-756.

3 Jetty P, Husereau D. Trends in the utilization of endovascular therapy for elective and ruptured abdominal aortic aneurysm procedures in Canada. J Vasc Surg. 2012;56(6):1518-1526.

4 Patel R, Sweeting MJ, Powell JT, Greenhalgh RM; EVAR Trial Investigators. Endovascular versus open repair of abdominal aortic aneurysm in 15 years' follow-up of the UK endovascular aneurysm repair trial 1 (EVAR trial 1): a randomized controlled trial. Lancet. 2016;388:2366-2374.

5 Lederle FA, Freischlag JA, Kyriakides TC, Padberg FT, Matsumura JS, Kohler TR, et al. Long-term comparison of endovascular and open repair of abdominal aortic aneurysm. N Engl J Med. 2012;367(21):1988-1997.

6 De Bruin JL, Baas AF, Buth J, Prinssen M, Verhoeven EL, Cuypers PW, et al; DREAM Study Group. Long-term outcome of open or endovascular repair of abdominal aortic aneurysm. N Engl J Med. 2010;362(20):1881-1889.

7 Ettengruber A, Epple J, Schmitz-Rixen T, Böckler D, Grundmann RT. Long-term outcome and cancer incidence after abdominal aortic aneurysm repair. Langenbecks Arch Surg. 2022;407(8):3691-3699.

8 Markar SR, Mackenzie H, Karthikesalingam A, Holt PJ, Thompson MM, Loftus IM, et al. A population-based cohort study examining the risk of abdominal cancer after endovascular abdominal aortic aneurysm repair. J Vasc Surg. 2019;69(6):1776-1785.e2.

9 Spencer C, Jamrozik K, Kelly S, Bremner P, Norman P. Is there an association between chronic lung disease and abdominal aortic aneurysm expansion? ANZ J Surg. 2003;73(10):787-789.

10 Blochle R, Lall P, Cherr GS, Harris LM, Dryjski ML, Hsu HK, et al. Management of patients with concomitant lung

cancer and abdominal aortic aneurysm. Cardiol Res Pract. 2011;2011:516146.

11 Motaganahalli R, Martin A, Feliciano B, Murphy MP, Slaven J, Dalsing MC. Estimating the risk of solid organ malignancy in patients undergoing routine computed tomography scans after endovascular aneurysm repair. J Vasc Surg. 2012;56(4):929-937.

12 Kramer R, Khoury HJ, Vieira JW. CALDose_X: a software tool for the assessment of organ and tissue absorbed doses, effective dose, and cancer risks in diagnostic radiology. Phys Med Biol. 2008;53:6437-6459.

13 Saltybaeva N, Martini K, Frauenfelder T, Alkadhi H. Organ dose and attributable cancer risk in lung cancer screening with low-dose computed tomography. PLoS One. 2016;11(5):e0155722.

14 McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. Res Synth Methods. 2021;12(1):55-61.

15 Sterne JAC, Savović J, Page MJ, Elbers RG, Blencowe NS, Boutron I, et al. RoB 2: A revised tool for assessing risk of bias in randomised trials. BMJ. 2019;366:l4898.

16 Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ. 2016;355:i4919

17 Goodney PP, Tavris D, Lucas FL, Gross T, Fisher ES, Finlayson SRG. Causes of late mortality after endovascular and open surgical repair of infrarenal abdominal aortic aneurysms. J Vasc Surg. 2010;51(6):1340-1347.e1.

18 Brambilla M, Cerini P, Lizio D, Vigna L, Carriero A, Fossace R. Cumulative radiation dose and radiation risk from medical imaging in patients subjected to endovascular aortic aneurysm repair. Radiol Med. 2015;120(6):563-570.

19 Singh B, Andersson M, Edsfeldt A, Sonesson B, Gunnarsson M, Dias NV. Estimation of the added cancer risk derived from EVAR and CTA follow-up. J Endovasc Ther. 2023;30(6):1021-1030.

20 Blaszak MA, Juszkat R. Monte Carlo simulations for assessment of organ radiation doses and cancer risk in patients undergoing abdominal stent-graft implantation. Eur J Vasc Endovasc Surg. 2014;48(1):23-28

21 Blakely EA. Biological effects of cosmic radiation: deterministic and stochastic. Health Phys. 2000;79(5):495-506.

22 Meuli L, Zimmermann A, Petersen JK, Fosbøl EL, Dabravolskaitė V, Makaloski V, et al. Risk stratification and treatment selection in patients with asymptomatic abdominal aortic aneurysms. Eur J Vasc Endovasc Surg. 2021;61(2):275-283

CASE REPORT

Simultaneous Acute Thrombosis of Bilateral Popliteal Artery Aneurysms Causing Acute Ischemia of both lower limbs

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Abstract:

Purpose: Popliteal artery aneurysms (PAAs) are rare, typically asymptomatic lesions that are managed electively. Acute thrombosis, however, poses an immediate threat to limb viability, necessitating prompt diagnosis and intervention. We report a rare case of simultaneous bilateral PAA thrombosis presenting with acute limb ischemia.

Case report: A 60-year-old male presented to the emergency department with acute bilateral lower limb pain and numbness due to simultaneous thrombosis of bilateral PAAs, resulting in acute limb ischemia. Aneurysmal disease involving both the left common iliac and common femoral arteries, with significant intramural thrombus resulting in >60% stenosis, posed substantial challenges to management. A hybrid endovascular and open surgical approach was selected to address all aneurysms concurrently. To our knowledge, this is the first reported case of simultaneous bilateral PAA thrombosis causing acute limb ischemia.

Conclusion: This complex presentation underscores the need for meticulous diagnostic and therapeutic strategies to achieve optimal outcomes.

Keywords: popliteal artery aneurysm, bilateral thrombosis, acute limb ischemia, case report

INTRODUCTION

Popliteal artery aneurysms (PAAs) are the most common peripheral artery aneurysms, comprising approximately 85% of cases.[1,2] About 80% of PAAs are asymptomatic at diagnosis but acute thrombosis can cause limb-threatening ischemia, requiring urgent intervention.[2] This report presents a unique case of simultaneous acute thrombosis of bilateral PAAs causing bilateral lower limb ischemia, a presentation not previously documented in the literature. This case is reported per CARE guidelines.

CASE REPORT

Patient Information: A 60-year-old male heavy smoker presented to the emergency department with acute-onset bilateral lower limb pain and numbness. No history of thrombophilia, genetic disorders, autoimmune conditions or relevant family history was identified.

Clinical Findings: Both lower limbs appeared pale with cold feet and delayed capillary refill (>3 seconds). The patient reported numbness with no sensory or motor deficits. Femoral pulses were palpable bilaterally while more distal pulses were absent. Doppler ultrasound showed weak monophasic signals at the malleolar level, with an ankle-brachial index of 0.2 bilaterally. Thrill and bruit were present over the left femoral artery. These findings indicated Rutherford Grade I (viable) acute ischemia bilaterally.

Diagnostic Assessment: Laboratory tests were unremarkable. Computed tomography angiography (CTA) of the thoracoabdominal aorta and lower limbs revealed occluded bilateral PAAs (maximum diameter: 18 mm bilaterally) with good three-vessel tibial runoff **(Figure 1A, B).** Additionally, left common iliac (19 mm) and common femoral (16 mm) artery aneurysms were identified, each with thrombus causing >60% stenosis **(Figure 1C, D).**

Therapeutic Intervention: Given the concurrent aneurysms, a hybrid approach was selected, under spinal anesthesia, in the angiography suite. Open aneurysmatectomy and interposition grafting of the left common femoral artery aneurysm was performed (8-mm Dacron graft), Retrograde access through the graft facilitated insertion of a 16x12x70-mm iliac limb extension stent-graft (W. L. GORE & Associates, Flagstaff, Ariz), delivered through a 12x33mm sheath to exclude the left

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common iliac artery aneurysm **(Figure 2A).** Antegrade access through the left SFA (direct vision, 8x11mm sheath) and right common femoral artery (percutaneous access, ProGlide closure device) enabled bilateral PAA exclusion with Viabahn® (W. L. GORE & Associates, Flagstaff, Ariz) stent-grafts (7x150mm and 8x75mm bilaterally) **(Figure 2 B, C).** Catheterization of the occluded PAAs was straightforward bilaterally, confirming the fact that thrombosis was acute. The stent grafts were deployed first distally (2cm below knee crease) and then proximally (above-the-knee) ensuring adequate sealing.

Follow-up and Outcomes: Immediately postoperatively, palpable distal pulses were restored and ABI normalized bilaterally. The postoperative course was uneventful. The patient was discharged on day 8, with antiplatelet and anticoagulant therapy and genetic screening recommendations. One-month CTA (knee extended/flexed) confirmed optimal stent-graft po-

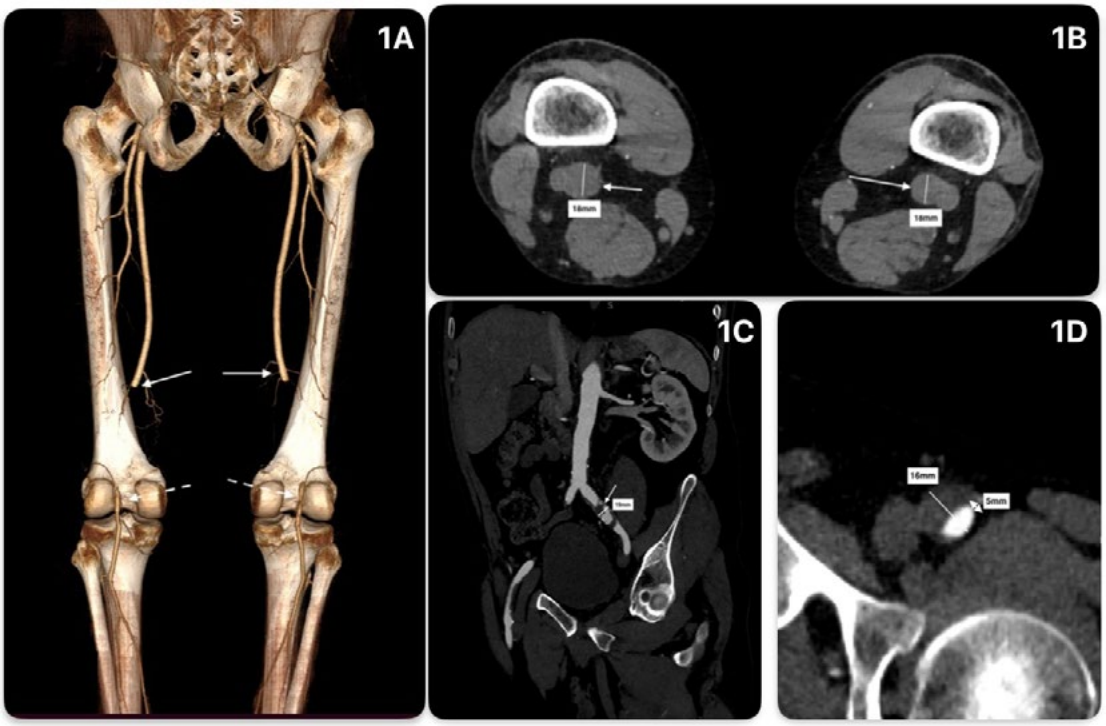

Figure 1: A. 3-dimensional reconstruction of the pre-operative CT scan, in which a posterior view is demonstrated, showing the occluded popliteal arteries (solid white arrows show the proximal and dashed arrows the distal extent of the occlusions) B. Axial CT views at the level of the knee crease showing bilateral 18mm occluded popliteal artery aneurysms C. Coronal view showing the left common iliac artery aneurysm (solid white arrow) with a significant amount of intraluminal thrombus. D. Axial view showing the left common femoral artery aneurysm with a significant amount of intraluminal thrombus, leaving around 30% of residual patent lumen (white arrow).

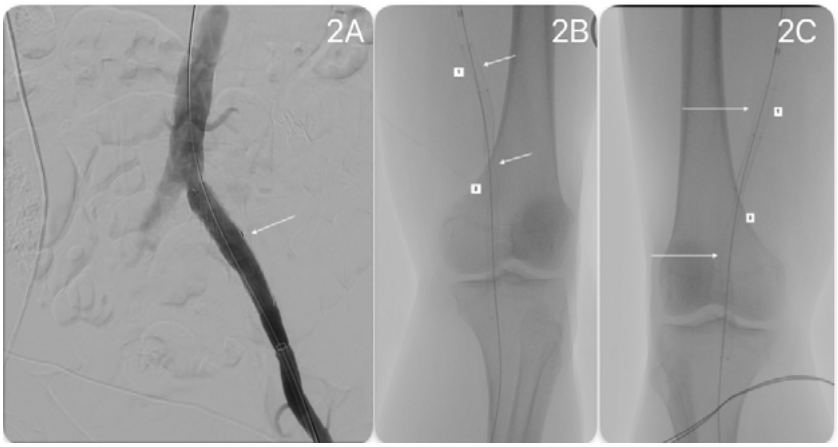

Figure 2: A. Intraoperative angiography showing successful exclusion of the left common iliac artery aneurysm with the deployment of an iliac limb extension (white arrow) B. Intraoperative x-ray indicating successful deployment of the 2 Viabahn® stent-grafts on the left side (1 for the proximal/8x75mm and 2 for the distal/7x150mm stents), which were deployed from distal to proximal. C. Same for the right side.

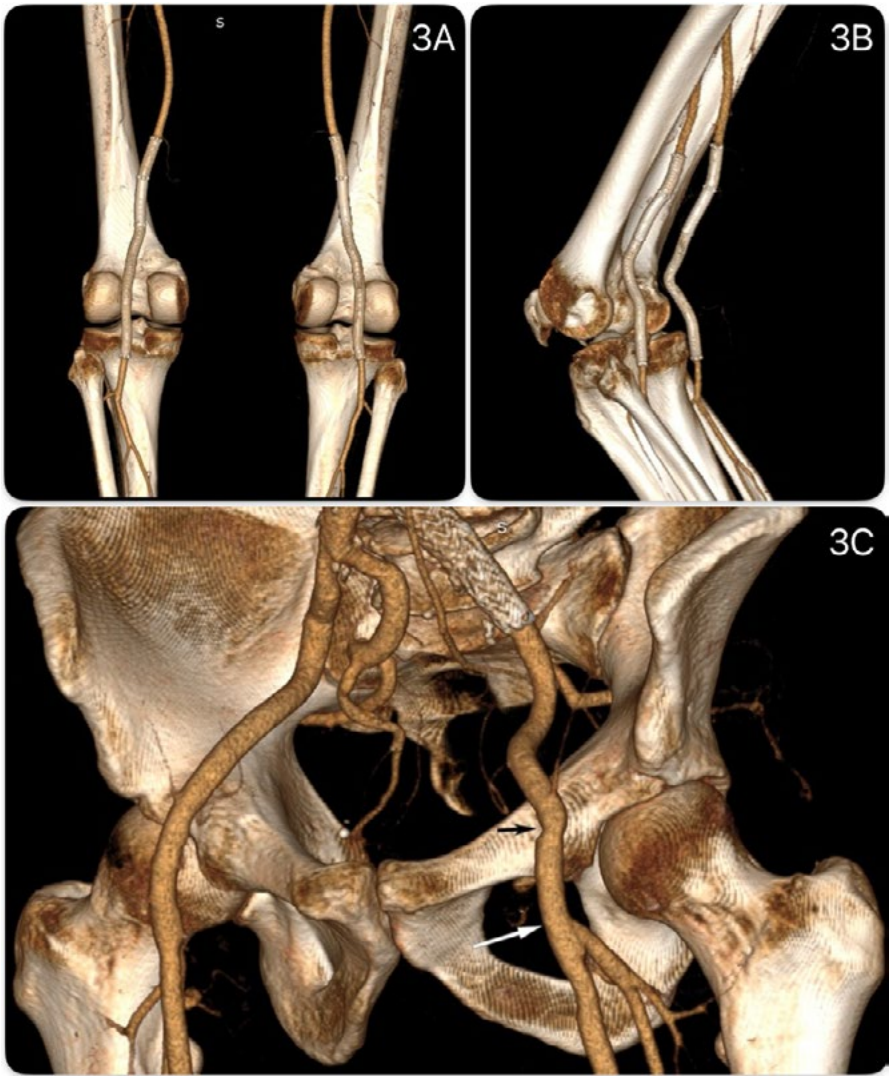

Figure 3: A. 3-dimensional reconstruction of postoperative CT angiography with limbs in extension B. Same with limbs in flexion. C. The surgical graft is shown with the black arrow indicating the level of the proximal and the white arrow the level of the distal anastomosis.

sitioning **(Figure 3A, B).** Left interposition graft and both SFA and PFA remained patent **(Figure 3C)**. At 3-months, clinical examination showed palpable distal pulses and ABI 1.0 bilaterally. Mid- and long-term follow-up outcomes are not currently available and they are anticipated.

DISCUSSION

Acute PAA thrombosis is a limb-threatening emergency, with amputation rates in symptomatic cases up to 25%.[3]

No universal consensus exists on the optimal PAA management.[3,4] The 2022 SVS guidelines recommend open repair for asymptomatic patients with >5 years life expectancy and suitable vein conduits, while acute ischemia management depends on ischemia grade.[5] Adequate inflow and outflow are critical for durable patency in both techniques.[3, 4] Recent literature suggests progressively increased rates of endovascular interventions compared to open surgery.[6]

Here, the CFA aneurysm mandated open reconstruction, whereas the common iliac artery [CIA] and bilateral PAAs were amenable to either open or endovascular approach. Good tibial runoff was considered favorable in order for the patient to undergo endovascular treatment **(Figure 1A)**.

The chosen hybrid approach, open femoral repair combined with endovascular repair of the left CIA and bilateral PAAs, optimized both inflow and outflow, enhancing long-term patency, while reducing operative time and perioperative morbidity compared to fully open repair.

In the literature, endovascular repair yields outcomes comparable to open reconstruction, in acute settings.[2] Antonello et al found no significant difference in 4-year patency or limb salvage rates between open (OPAR) and endovascular (EPAR) reconstruction, with EPAR offering shorter hospital stay and faster recovery.[7] Recent reviews highlight EPAR benefits, including reduced operative time, minimal blood loss, fewer wound infections and avoidance of general anesthesia.[4] A large study of 1159 PAA showed no difference in reinterven-

tion rates or major amputation, at 1-, 3- and 5- years, between OPAR and EPAR, even with vein conduits.[8]

EPAR risks include stent-graft occlusion, fracture, migration or endoleak, largely due to repetitive knee motion.[4]

The Viabahn® stent-graft offers flexibility and durability, via its thin, heparin-coated PTFE lining and self-expanding nitinol framework, with patency and limb salvage rates comparable to OPAR.[9] Post-operative CTA (knee flexed/extended) confirmed no excessive angulation, fracture or migration **(Figure 3)**.

Approximately one third of PAA patients are ineligible for EPAR, and another 23% have significant contraindications. Therefore, strict adherence to Instructions for Use (IFU) is critical for success.[10]

Dual antiplatelet therapy (DAPT) is commonly recommended post-EPAR, with potential transition to single therapy.[11] When anticoagulation is indicated, triple therapy may be considered (DAPT plus warfarin, INR 2.0-3.0), balancing bleeding risk.[12] Guidelines for infrainguinal endovascular reconstruction suggest low-dose rivaroxaban twice daily plus aspirin] or DAPT for at least six months, while not addressing specifically post-EPAR.[13] Lacking specific EPAR guidance and given acute ischemia with multiple stents placed, we opted for lifelong aspirin 100mg daily and rivaroxaban 20mg daily.

This represents the first reported case of simultaneous bilateral acute PAA thrombosis causing bilateral limb ischemia, illustrating the complexity of managing multiple aneurysms and the value of individualized hybrid strategies.

CONCLUSION

Popliteal artery aneurysms are rare, often bilateral and asymptomatic, typically managed electively. Acute thrombosis is a major complication, causing limb-threatening ischemia, requiring prompt treatment. Simultaneous, acute thrombosis of bilateral PAAs, resulting in bilateral ischemia, is exceptionally uncommon. This case report underscores the complexity of such presentations, emphasizing critical role of meticulous pre-procedural planning to optimize outcomes.

REFERENCES

1 Demas N, Saha SP. Popliteal artery aneurysm repair-A single center experience. Asian Cardiovasc Thorac Ann.2024;32:157-163.

2 Aragão JA, de Miranda FGG, Aragão ICS, Aragão FMS, Reis FP. Treatment of bilateral popliteal artery aneurysms. J Vasc Bras. 2019 Nov 29;19:e20180142.

3 Ripepi M, Gibello L, Ferrero E, Scevola M, Manzo P, Varetto G et al. Open Versus Endovascular Repair of Patent Popliteal Artery Aneurysms in an Elective Setting: A Multicenter Retrospective Study with Long-Term Follow-Up. Ann Vasc Surg. 2025;117:64-71.

4 Tian Y, Yuan B, Huang Z, Zhang N. A Comparison of Endovascular Versus Open Repair of Popliteal Artery Aneurysms: An Updated Meta-Analysis. Vasc Endovascular Surg. 2020;54:355-361.

5 Farber A, Angle N, Avgerinos E, Dubois L, Eslami M, Geraghty P, et al. The Society for Vascular Surgery clinical practice guidelines on popliteal artery aneurysms. J Vasc Surg. 2022;75(1S):109S-120S.

6 Wrede A, Wiberg F, Acosta S. Increasing the Elective Endovascular to Open Repair Ratio of Popliteal Artery Aneurysm. Vasc Endovascular Surg. 2018;52:115-123.

7 Antonello M, Frigatti P, Battocchio P, Lepidi S, Cognolato D, Dall'Antonia A, et al. Open repair versus endovascular treatment for asymptomatic popliteal artery aneurysm: results of a prospective randomized study. J Vasc Surg. 2005;42:185-93.

8 Satam K, Brahmandam A, Zheng X, Mao J, Goodney P, Ochoa Chaar CI. Long-term outcomes of elective endovascular vs open repair of popliteal artery aneurysms in the VISION database. J Vasc Surg. 2025;81:672-681.

9 Patel SR, Hughes CO, Jones KG, Holt PJ, Thompson MM, Hinchliffe RJ, et al. A Systematic Review and Meta-analysis of Endovascular Popliteal Aneurysm Repair Using the Hemobahn/Viabahn Stent-Graft. J Endovasc Ther. 2015;22:330-7.

10 Hellwig K, Hoffmann L, Rother U, Meyer A, Lang W, Schmid A. Eligibility of Endovascular Repair for Popliteal Artery Aneurysms According the Instructions for Use. Ann Vasc Surg. 2020;67:370-375.

11 van Leeuwen GL, Baggel S, Tielliu IFJ, Schuurmann RCL, van Walraven LA, de Vries JPM. Editor's Choice - Long Term Follow-Up after Endovascular Popliteal Artery Aneurysm Repair: A Two Centre, Retrospective Cohort Study (1998 - 2023). Eur J Vasc Endovasc Surg. 2025 Oct;70(4):483-489. doi: 10.1016/j.ejvs.2025.04.041. Epub 2025 Apr 26. PMID: 40294783.

12 Ullery BW, Tran K, Itoga N, Casey K, Dalman RL, Lee JT. Safety and efficacy of antiplatelet/anticoagulation regimens after Viabahn stent graft treatment for femoropopliteal occlusive disease. J Vasc Surg. 2015 Jun;61(6):1479-88. doi: 10.1016/j.jvs.2014.12.062. Epub 2015 Feb 19. PMID: 25704407.

13 Twine CP, Kakkos SK, Aboyans V, Baumgartner I, Behrendt CA, Bellmunt-Montoya S, Jilma B, Nordanstig J, Saratzis A, Reekers JA, Zlatanovic P; ESVS Guidelines Committee; Antoniou GA, de Borst GJ, Bastos Gonçalves F, Chakfé N, Coscas R, Dias NV, Hinchliffe RJ, Kolh P, Lindholt JS, Mees BME, Resch TA, Trimarchi S, Tulamo R, Vermassen FEG, Wanhainen A; Document Reviewers; Koncar I, Fitridge R, Matsagkas M, Valgimigli M. Editor's Choice - European Society for Vascular Surgery (ESVS) 2023 Clinical Practice Guidelines on Antithrombotic Therapy for Vascular Diseases. Eur J Vasc Endovasc Surg. 2023 May;65(5):627-689. doi: 10.1016/j.ejvs.2023.03.042. Epub 2023 Apr 3. PMID: 37019274.

VASCULAR IMAGE

Left Superior Gluteal Pelvic Escape Point Associated with Nonthrombotic Iliac Vein Compression Syndrome

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***Keywords*:** superior gluteal vein pelvic escape point, nonthrombotic iliac vein compression syndrome, atypical pelvic-origin varices, foam sclerotherapy

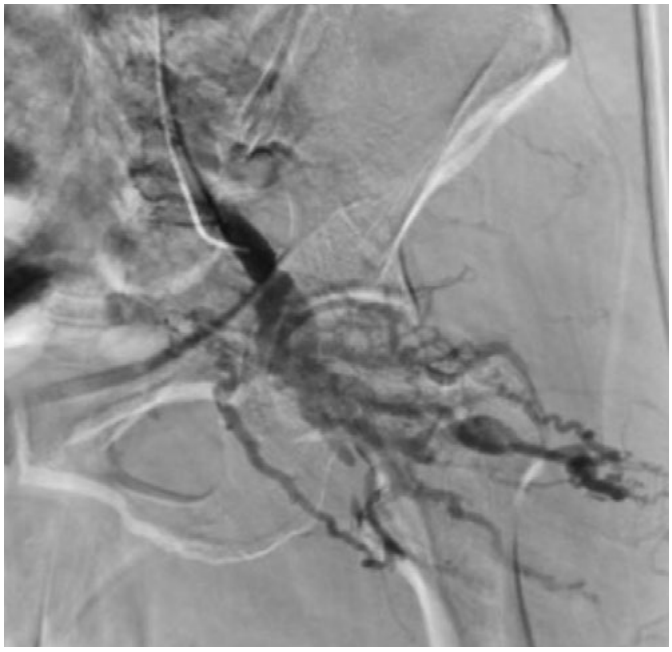

Figure 1: Descending venography of the left internal iliac vein demonstrating voluminous reflux arising from the left superior gluteal vein (SGV), feeding numerous varicosities of the ipsilateral buttock

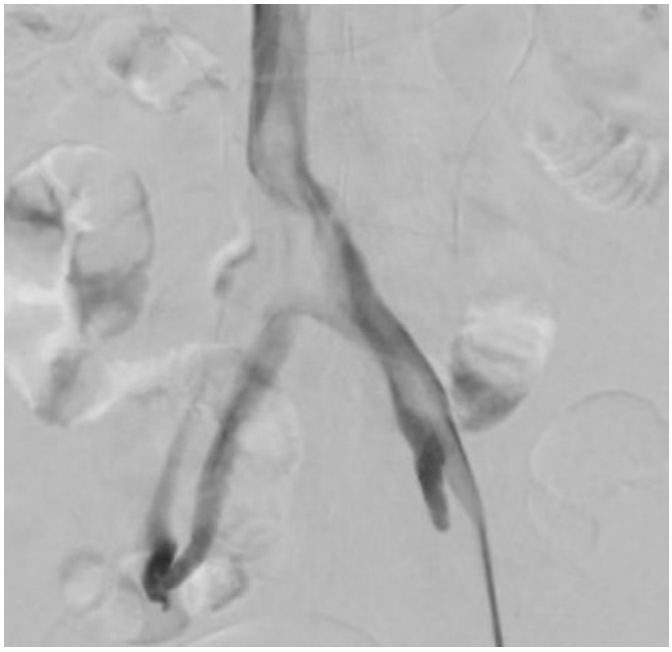

Figure 2: Nonthrombotic left iliac vein compression syndrome (NTIVC)

A 52-year-old female presented with pelvic vein disorders (PeVD**)** and symptomatic extensive atypical varicosities on the left buttock, posterior thigh, and lower leg. Duplex ultrasound (DUS) revealed reflux originating from a pelvic vein superior to the piriformis muscle. Descending venography of the left internal iliac vein demonstrated voluminous reflux arising from the left superior gluteal vein (SGV), feeding numerous varicosities of the ipsilateral buttock **(Figure 1)**. This was associated with a nonthrombotic left iliac vein compression syndrome (NTIVC) **(Figure 2)**. The patient was therefore classified as $\mathbf{S}_{2,3b}\mathbf{V}_{2,3b}\mathbf{P}_{LCIV,O,NT;\ LPELV,R,NT}$; $[_L]\mathbf{C}_{2s}\mathbf{E}_{sie}\mathbf{A}_{s,d}\mathbf{P}_{o(CIV),r(PELV,NSV)}$ according to the Symptoms-Varices-Pathophysiology and Clinical-Etiology-Anatomy-Pathophysiology classifications.

Venographic description of the superior gluteal pelvic escape point (SGP) has been rarely reported. The SGV typically enters the pelvis at an acute, superior angle, and is deeply encased by surrounding gluteal muscle. Consequently, blood outflow from high-pressure pelvic veins into the SGV is restricted compared to other internal iliac vein branches. The occurrence of the SGP was potentially triggered by anatomical variants and NTIVC.

A combination of foam sclerotherapy and coil embolization, along with recanalization of the left common iliac vein, has been performed. Follow-up visits extending up to eight years post-intervention have consistently demonstrated significant clinical improvements, a patent iliac stent, and the absence of pre-existing reflux from SGP on DUS. The Patient consented to the publication.

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VASCULAR IMAGE

Bridging the gap: Short prosthetic graft adjunctive conduit for primary brachiocephalic fistula construction

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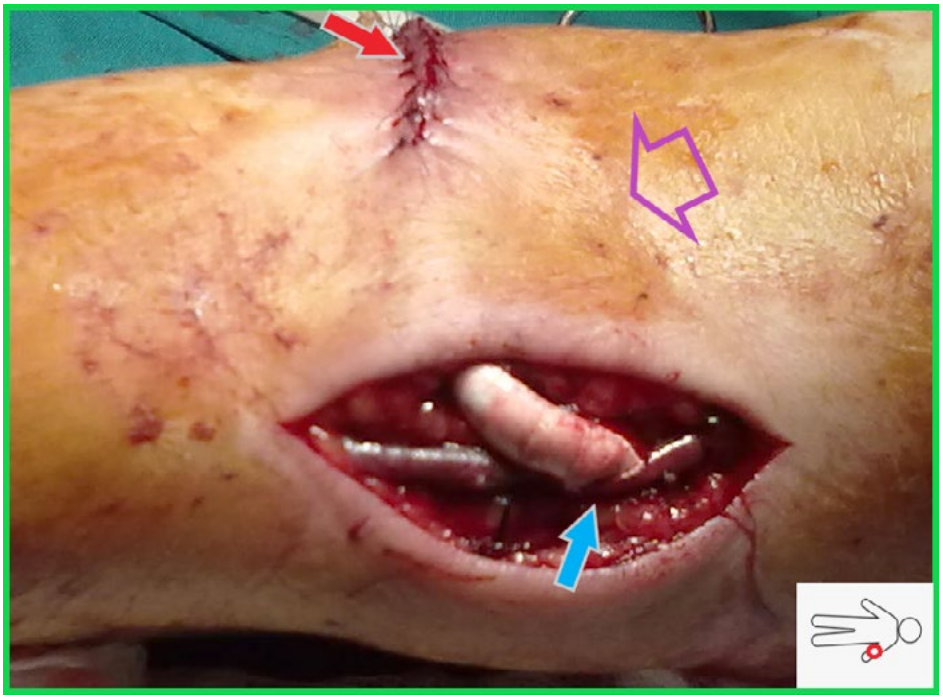

Figure 1. A short conical synthetic graft bridged the gap between the left brachial artery and the cephalic vein (Purple arrow: the antecubital fossa, red arrow: the site of arterial anastomosis-not seen as skin incision is closed, light blue arrow: the venous anastomosis)

A 75-year-old-male diabetic patient with end-stage renal disease was scheduled for left upper arm arteriovenous fistula (AVF) creation. He initiated dialysis via a right-sided tunneled central catheter. Preoperative ultrasound mapping revealed suitable vessels at the elbow level. Unfortunately, the median cubital vein was absent and the distance between the brachial artery and cephalic vein was about 4cm. We proceeded with a bridging graft between these vessels with end-to-side anastomoses. We preferred to use the conic part of a 4-7 tapered polytetrafluoroethylene (PTFE) graft (Gore Intering; W.L. Gore & Associates, Flagstaff, AZ, USA) **(Figure 1)**. The upper arm cephalic matured adequately and the cannulation was normal for the next 9 years, when the patient died.

An entirely autologous construction would require wide mobilization of the upper arm cephalic vein with longer skin incisions, as the forearm cephalic vein was diminutive. In this case, the autologous anastomosis would rather be performed above the elbow resulting in a reduced functional cannulation length. This pushed the decision towards the use of a short graft, having in mind the disadvantages of a non-autologous access. Reviewing the English literature, we were not able to find a similar approach in primary AVF procedures. However, use of short PTFE grafts has been widely used in redo operations to correct AVF stenoses, bleeding, pseudoaneurysms, high-flow AVFs and steal syndrome[1,2,3] with satisfactory results.

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REFERENCES

1 Georgiadis GS, Lazarides MK, Lambidis CD, Panagoutsos SA, Kostakis AG, Bastounis EA, Vargemezis VA. Use of short PTFE segments (<6 cm) compares favorably with pure autologous repair in failing or thrombosed native arteriovenous fistulas. *J Vasc Surg*. 2005 Jan;41(1):76-81.

2 Papadoulas S, Mulita F, Theodoropoulou T, Dousdampanis P. Short interposition grafting for dialysis-access steal syndrome treatment. *BMJ Case Rep*. 2022 Feb 28;15(2):e248446.

3 Papadoulas SI, Kouri N, Tsimpoukis A, Kitrou P, Papasotiriou M, Nikolakopoulos KM, Moulakakis KG. Treatment options for dialysis access steal syndrome. *Pol J Thorac Cardiovasc Surg*. 2022 Sep;19(3):141-145.

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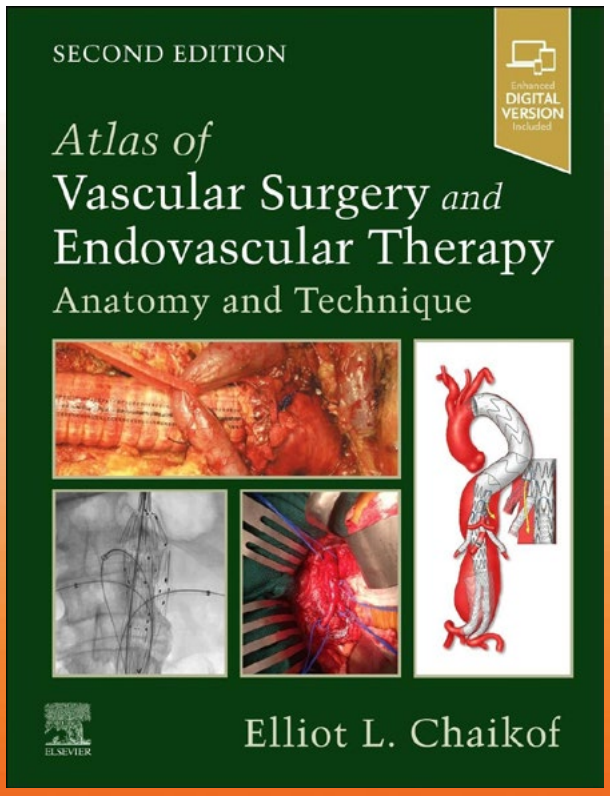

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