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Hellenic Journal of Vascular and Endovascular Surgery

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EDITORIAL

Selective Graft Preservation in Peripheral Vascular Graft Infections: Sound Practice or Risky Compromise?

Constantine N. Antonopoulos

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One of the most demanding complications in vascular surgery is the peripheral vascular graft infection (PVGI). Even as perioperative care, antimicrobial regimens, and prosthetic technologies have advanced, infection of a lower-limb graft remains a potentially catastrophic event. It threatens not only limb viability but also patient survival, often entailing prolonged hospitalization, repeated operations, and major psychological and economic consequences. Over time, the field has evolved from the dogma of graft excision toward a nuanced, evidence-based, patient-specific strategy combining infection control, graft preservation, and biological or engineered reconstruction. The modern surgeon faces not a binary choice of removal versus salvage but a sophisticated spectrum of possibilities—each dependent on infection extent, microbial virulence, host resilience, and available materials.

Despite its apparent rarity, PVGI remains one of the most devastating vascular complications. Reported incidence ranges between 0.5 % and 6 % depending on anatomic location and patient risk profile. According to the ESVS 2020 guidelines, infrainguinal reconstructions carry the highest risk, particularly when prosthetic material is placed in the groin or subcutaneous plane.

A recent multicenter retrospective series—one of the most recent real-world datasets—reported an 8 % infection rate among 196 prosthetic bypasses, with mortality of 17-30 % and major amputation rate of approximately 27 %. Such figures reaffirm that PVGI, although infrequent, has disproportionate impact. In the era of endovascular dominance, open bypass is reserved for the most complex cases: patients with diffuse multilevel disease, failed endovascular interventions, or chronic limb-threatening ischemia. These individuals are typically elderly, diabetic, and immunocompromised—the very conditions that predispose to wound infection. The burden therefore concentrates in a smaller yet frailer cohort, making prevention and individualized management even more critical.

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The groin remains vulnerable to infection owing to its complex anatomy and proximity to contaminated areas. Its dense lymphatic network, proximity to perineal flora, and frequent use for prosthetic anastomoses create an ideal environment for contamination. Once bacteria reach the graft surface, they exploit the biofilm—a polymeric shield that renders them resistant to both antibiotics and host immunity.

PVGI results from three interrelated mechanisms: intra-operative contamination, contiguous spread from nearby infection, or hematogenous seeding from distant sites. Each pathway underscores the delicate host-device interface. Dacron and ePTFE grafts, though durable and hemodynamically efficient, remain intrinsically foreign; their microstructure facilitates bacterial adherence. Host factors such as diabetes, renal failure, malnutrition, chronic steroid use, or immunosuppression further compromise the local defence barrier.

Traditionally, *Staphylococcus aureus* and *Staphylococcus epidermidis* have dominated the microbiologic spectrum, responsible for up to 60 % of infections. The recent shift, however, toward Gram-negative pathogens—notably *Pseudomonas aeruginosa* and *Escherichia coli*, together comprising almost one-third of isolates in a recent series—poses new therapeutic challenges. These organisms often exhibit multidrug resistance, form aggressive biofilms, and precipitate anastomotic rupture or sepsis.

The ESVS guidelines advocate a comprehensive diagnostic approach combining clinical assessment, microbiology, and imaging. High-resolution CT angiography delineates fluid collections or pseudoaneurysms, while 18F-FDG PET/CT and labeled-leukocyte scintigraphy distinguish sterile inflammation from active infection. Direct tissue sampling of perigraft fluid or graft material remains the diagnostic gold standard—superficial swabs are inadequate.

Temporal classification retains practical value. Early (< 4 months) infections are typically high-grade, caused by *S. aureus* or Gram-negative rods, and present with local erythema, purulence, or systemic sepsis. Late (> 4 months) infections are indolent, often involving *S. epidermidis* or low-virulence flora, and may manifest through pseudoaneurysm, bleeding, or graft occlusion.

The Samson-Szilagyi classification, although decades old, remains a useful guide—distinguishing superficial wound in-

fections (Groups I-II), limited graft involvement (Group III), and anastomotic or systemic infections (Groups IV-V). The ESVS framework extends this by incorporating imaging and microbiologic data, encouraging individualized decision-making rather than adherence to a single algorithm.

Historically, "infected graft = excision" was an unassailable rule. Yet the current era recognizes degrees of infection and patient heterogeneity. The ESVS 2020 recommendations explicitly endorse selective graft preservation when feasible—particularly in early, localized infections without systemic sepsis or anastomotic breakdown.

De Caridi et al. demonstrated that conservative management—meticulous debridement, vacuum-assisted closure (VAC) therapy, and muscle-flap coverage—achieved successful infection control and limb salvage in one-third of patients. These outcomes rival, and occasionally surpass, those of excisional strategies, provided strict patient selection and close surveillance are maintained. Nevertheless, when sepsis, bleeding, or anastomotic rupture occur, complete graft removal remains lifesaving. The art lies in balancing infection eradication against preservation of perfusion and functional outcome.

Antibiotic therapy is both preventive and therapeutic. The ESVS guidelines outline a staged regimen: 1) empirical coverage directed at Gram-positive cocci (including MRSA) and Gram-negative bacilli until cultures specify pathogens. 2) targeted intravenous therapy for 4-6 weeks, followed by oral continuation up to six months depending on infection control and reconstruction. 3) lifelong suppressive therapy may be warranted when complete excision is impossible. In a recently published cohort, cefazolin or vancomycin served as preoperative empiric therapy; targeted regimens were adjusted by antibiogram. Integration of systemic antibiotics with VAC therapy yielded an impressive 69 % limb salvage rate—proof that local control and systemic therapy must operate synergistically. Adjunctive measures include optimization of nutrition, glycemic control, and cessation of smoking. Early consultation with infectious-disease specialists is strongly recommended, ensuring proper antimicrobial stewardship and prevention of resistance.

When excision is inevitable, the choice of conduit dictates both immediate and long-term outcomes. Autologous vein grafts remain the gold standard due to their biocompatibility and resistance to infection. The great and small saphenous, arm veins, or even femoropopliteal segments may be employed, though harvesting can be technically demanding and occasionally limited by patient factors. When suitable autologous conduit is unavailable, cryopreserved arterial allografts (CAAs) provide a valuable alternative. Supported by both the ESVS guidelines and several clinical series, CAAs exhibit mid-term patency rates of 80-90 % and reinfection rates near 15 %. They are particularly suited for controlled infection environments or as bridges until definitive autogenous reconstruction. Limitations include restricted availability, structural degeneration, and uncertain long-term durability. Biologic and biosynthetic conduits have gained traction. The Omniflow II biosynthetic graft, composed of bovine collagen matrix reinforced with polyester, demonstrated promising results, achieving limb salvage without reinfection in selected patients. Similarly, bovine-pericardial xenografts and silver- or rifampicin-bonded prostheses expand the reconstructive armamentarium, though robust randomized evidence is pending.

Among recent advances, the combination of muscle-flap coverage (MFC) and negative-pressure wound therapy (NPWT) stands out as transformative. The goal is to provide well-vascularized tissue that fills dead space, delivers oxygen and antibiotics, and isolates the prosthesis from contamination. The ESVS guidelines recommend MFC—typically using sartorius, gracilis, or rectus femoris muscles—for groin infections, reserving combined or free flaps for complex or recurrent cases. Clinical reports, including De Caridi et al., document infection-control rates > 80 % and robust limb preservation. Beyond technical success, these methods represent a cultural shift: from isolated vascular intervention to multidisciplinary collaboration with plastic and reconstructive surgeons. This partnership has redefined the limits of limb salvage.

No therapy is as beneficial as prevention. The ESVS 2020 guidelines articulate a comprehensive protocol including: 1) preoperative optimization: correct malnutrition, anemia, and glycemic imbalance; decolonize nasal *S. aureus* carriers; use chlorhexidine showers. 2) intraoperative measures: administer antibiotics within 60 minutes before incision; maintain normothermia; ensure meticulous hemostasis; minimize operative time; avoid unnecessary drains; prefer oblique over vertical groin incisions. 3) postoperative vigilance: early detection of lymphoceles or wound dehiscence; limit prophylaxis to 24 hours to prevent resistance. Evidence also supports the adjunctive use of local vancomycin powder or rifampicin-bonded grafts, though high-quality trials remain sparse. Consistent implementation of these fundamentals can reduce infection risk dramatically.

Despite preventive rigor, the presence of any prosthesis maintains inherent infection risk. The next frontier lies in smart biomaterials capable of biological integration and active antimicrobial defense. Nanotechnology offers several promising platforms. Electrospun nanofibrous scaffolds can replicate extracellular matrix microarchitecture, enhancing endothelialization and cell adhesion. Nanoparticles of silver, copper, or zinc provide sustained antibacterial activity through reactive oxygen species and ion release, while polymeric nanocarriers enable localized, controlled antibiotic delivery. Experimental studies reveal excellent biocompatibility and infection prevention in animal models. Yet key questions persist: long-term patency, host immune response, degradation kinetics, and scalability. Bridging the laboratory-clinic divide will demand rigorous translational research, standardized testing, and regulatory harmonization. Ultimately, the vision is a biointegrative vascular conduit—one that supports endothelialization, resists colonization, and interacts harmoniously with host tissue. Such technology would transform PVGI from a surgical complication to a preventable relic.

The ESVS 2020 document represents a global consensus on best practice, but implementation in daily clinical settings often encounters practical constraints: limited access to allografts, variable microbiologic support, or lack of specialized reconstructive teams. Recent studies highlight this gap—demonstrating that real-world decisions frequently rely on surgeon judgment and resource availability as much as on formal algorithms. To bridge this divide, vascular centers should establish multidisciplinary vascular infection teams, comprising vascular, plastic, and infectious-disease specialists, radiologists, and microbiologists. Regular case reviews, shared databases, and adherence audits can align practice with evidence. National or international registries will further enable benchmarking and foster collaborative research on this relatively rare yet critical complication.

Behind statistics lie patients enduring repeated operations, extended antibiotic therapy, and functional loss. The psychological toll of amputation, coupled with prolonged dependency, cannot be overstated. For health-care systems, PVGI represents a heavy financial burden—estimated at hundreds of millions annually in hospitalization and rehabilitation costs. For surgeons, these infections are a sobering reminder that technical perfection alone is insufficient. The true measure of excellence lies in preventing infection through preparation, discipline, and collaboration.

To advance the field, several priorities emerge: 1) standardized classification and reporting integrating imaging, microbiology, and biomaterial data. 2) prospective multicenter registries capturing incidence, management strategies, and outcomes. 3) randomized evaluation of preservation techniques, particularly VAC and MFC, to establish clear indications, 4) development of antimicrobial and bio-functional grafts through surgeon-engineer partnerships. 5) educational initiatives emphasizing infection prevention, early recognition, and multidisciplinary care within vascular training curricula. Such collective efforts will ensure that the next generation of vascular specialists approaches PVGI with both scientific rigor and clinical pragmatism.

In conclusion, peripheral vascular graft infection remains one of the most formidable challenges in vascular surgery. Despite modern prophylaxis, its incidence persists, driven by increasingly complex patient profiles and evolving microbial resistance. Yet progress is tangible: the shift from obligatory graft removal to selective preservation, the synergy of NPWT and muscle-flap coverage, and the emergence of bioengineered conduits collectively redefine outcomes once considered unattainable. The convergence of surgical expertise, infectious-disease management, and materials science promises to convert this “old problem” into a controllable, perhaps preventable, condition. Ultimately, the success of PVGI management will rest not only on operative skill but on our ability to foresee, coordinate, and innovate—safeguarding both the graft and the patient whose life depends upon it.

REFERENCES

1 De Caridi G, Massara M, Barilla C, Benedetto F. Peripheral Prosthetic Vascular Graft Infection: A 5-Year Retrospective Study. Med Sci (Basel). 2025 1;13(2):71.

2 Chakfé N, Diener H, Lejay A, Assadian O, Berard X, Caillon J, et. al.. Editor’s Choice - European Society for Vascular Surgery (ESVS) 2020 Clinical Practice Guidelines on the Management of Vascular Graft and Endograft Infections. Eur J Vasc Endovasc Surg. 2020;59(3):339-384.

The Use of Bovine Pericardium self-made graft for the Treatment of Aortic Infection - a Single Center Experience

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Abstract:

Purpose: To evaluate the feasibility, early and mid-term outcomes of in-situ aortic reconstruction using self-made bovine pericardium grafts for the treatment of prosthetic and endograft infections or mycotic aortic infections at a single tertiary center.

Methods: This retrospective single-center study included all patients undergoing in-situ reconstruction with self-made bovine pericardial grafts between January 2019 and December 2024. All patients fulfilled diagnostic criteria according to the MAGIC definition. Radical debridement was followed by intraoperative fabrication of straight or bifurcated bovine pericardial grafts. Perioperative management included broad-spectrum antibiotics and omental wrapping when feasible. Primary endpoints were 30-day, in-hospital, and overall mortality. Secondary endpoints included perioperative complications, graft patency, re-intervention, and reinfection.

Results: Sixteen patients (87.5% male; mean age 66.6 years) were treated: indications included mycotic aneurysm (25%), infected endografts (25%), and infected prosthetic grafts (50%). Aortoenteric fistulae were present in 31.3%. Microbiological cultures were positive in 81.3% of cases. Thirty-day mortality was 31.3%, and in-hospital mortality 37.5%, mainly due to graft disruption and sepsis. Median follow-up was 8.3 months (range, 0-43). No reinfections were observed. Two reinterventions were required: one proximal pseudoaneurysm (treated endovascularly) and one graft limb thrombosis (treated with femoro-femoral crossover bypass).

Conclusions: Self-made bovine pericardium grafts are a feasible and effective option for in-situ aortic reconstruction in infected fields, demonstrating excellent resistance to reinfection and satisfactory mid-term durability. Despite high perioperative mortality reflecting patient frailty, graft-related outcomes are favorable. These findings support bovine pericardium as a valuable biological conduit when allografts or autologous vein are unavailable.

Keywords: Aortic graft infection; In-situ reconstruction; Bovine pericardium graft; Mycotic aneurysm; Aortoenteric fistula; Endograft infection; Xenopericardial conduit

INTRODUCTION

Abdominal aortic prosthetic graft and endograft infections are an uncommon yet severe condition that can result in substantial morbidity and mortality if not properly addressed. These infections include native mycotic aneurysms, infected synthetic grafts, and endograft infections and represent one of the most challenging entities in vascular surgery. They originate from diverse sources, including hematogenous dissemination, adjacent infections, or iatrogenic factors.[1] Despite being relatively uncommon, with an estimated incidence of 0.5-5% after open or endovascular aortic repair, these conditions are associated with significant morbidity and mortality due to sepsis, rupture, and fistula formation.[2] Management is further complicated by diagnostic difficulties, the need for surgical debridement, and the limited availability of options for in-situ reconstruction.

Historically, treatment has relied on extra-anatomic bypass, cryopreserved arterial allografts, or autologous vein reconstruction. Extra-anatomic reconstructions, however, are associated with poor long-term patency and high reinfection rates. Autologous vein grafts (NAIS procedure) can provide durable results but are technically demanding, associated with significant donor site morbidity, and are often unsuitable in emergencies.[2] Cryopreserved allografts are considered an excellent biological option, but their availability is limited, and they may undergo structural degeneration over time.[3] Bovine pericardium has emerged as a promising biological material for in-situ reconstruction in infected sites. Its advantages include wide availability, biocompatibility, resistance to infection, and the ability to be tailored into self-made tube or bifurcated grafts. Since the first descriptions of custom-made xenopericardial tubes,[4] a growing amount of research has shown positive results in various regions of the aorta. Initial

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studies conducted at single centers showed that the approach was feasible and resulted in low rates of reinfection.[5, 6, 7] Subsequent larger studies across multiple centers have validated the mid-term durability of these findings. The European multicenter study by Weiss et al., including 168 patients, reported a 30-day mortality of 15% and a reinfection rate of only 6% at a median 26-month follow-up, with no cases of graft degeneration.[8] Similarly, systematic reviews and meta-analyses have highlighted the consistently low reinfection rates (≈1-6%) and high patency (≈95-99%) associated with bovine pericardium reconstructions.[9, 10, 11]

Both self-made and prefabricated bovine pericardium grafts have been studied. Self-made xenopericardial tubes can be fabricated on-table into straight or bifurcated grafts, allowing customization to patient's anatomy.[7, 11] Prefabricated bovine pericardial grafts, such as the BioIntegral conduit, have also shown favorable outcomes in multicenter cohorts, with reinfection rates around 5-9% and patency exceeding 85% at mid-term follow-up.[12, 13, 14] In various studies, the primary late complications are either an anastomotic pseudoaneurysm or stenosis occurring at the central or peripheral anastomosis.[8, 4]

The role of bovine pericardium grafts has now been recognized in international guidelines, with the 2020 ESVS Clinical Practice Guidelines on graft infections recommending xenopericardial grafts as a valid alternative when allografts or autologous vein are not available.[2] Nevertheless, most published data are collected from heterogeneous, multicenter, or mixed pathology cohorts, and long-term (>5 - 10 year) durability remains insufficiently characterized.

Given these considerations, reporting additional single-center experiences is essential to refine the evidence base. In this study, we present our institutional results using self-made bovine pericardial grafts for the treatment of aortic infections, focusing on technical feasibility, early and mid-term outcomes, and comparison with published literature.

METHODS

This retrospective single-center cohort study included all patients who underwent in-situ aortic reconstruction with self-made bovine pericardium grafts for the treatment of synthetic or endografts infections and mycotic aortic infections in our Department between January 2019 and December 2024. The study was conducted in accordance with institutional ethical standards, and informed consent was obtained from all patients or their legal representatives.

All patients had clinical or radiologic evidence of infection as defined by the Management of Aortic Graft Infection Collaboration (MAGIC) criteria.[15] Computed tomography imaging demonstrated inflammatory changes in all cases, and five patients (31.3%) presented with aortoenteric fistulae.

Preoperative microbiological assessment included blood cultures, wound swabs, and analysis of the explanted grafts when this was feasible. Empirical broad-spectrum intravenous antibiotics were started at the time of the diagnosis and subsequently tailored to culture results in collaboration with Infectious Disease Department.

All surgical procedures were performed through midline laparotomy or retroperitoneal exposure, depending on the site of infection. Radical debridement of all infected and necrotic tissue was performed in every case, followed by in-situ reconstruction with a self-made bovine pericardium graft. The grafts were fabricated intraoperatively from commercially available bovine pericardial patches. In cases involving the aortic bifurcation, bifurcated grafts were constructed in a similar fashion (Fig. 1). Omental wrapping of the reconstruction site was performed whenever technically feasible. The simultaneous surgical management for aortoenteric fistulae was conducted in collaboration with gastrointestinal surgeons.

Postoperatively, all patients were transferred to the Intensive Care Unit (ICU) for hemodynamic monitoring and continued intravenous antibiotic therapy. Antibiotics were administered for a minimum of six weeks and prolonged antibiotic

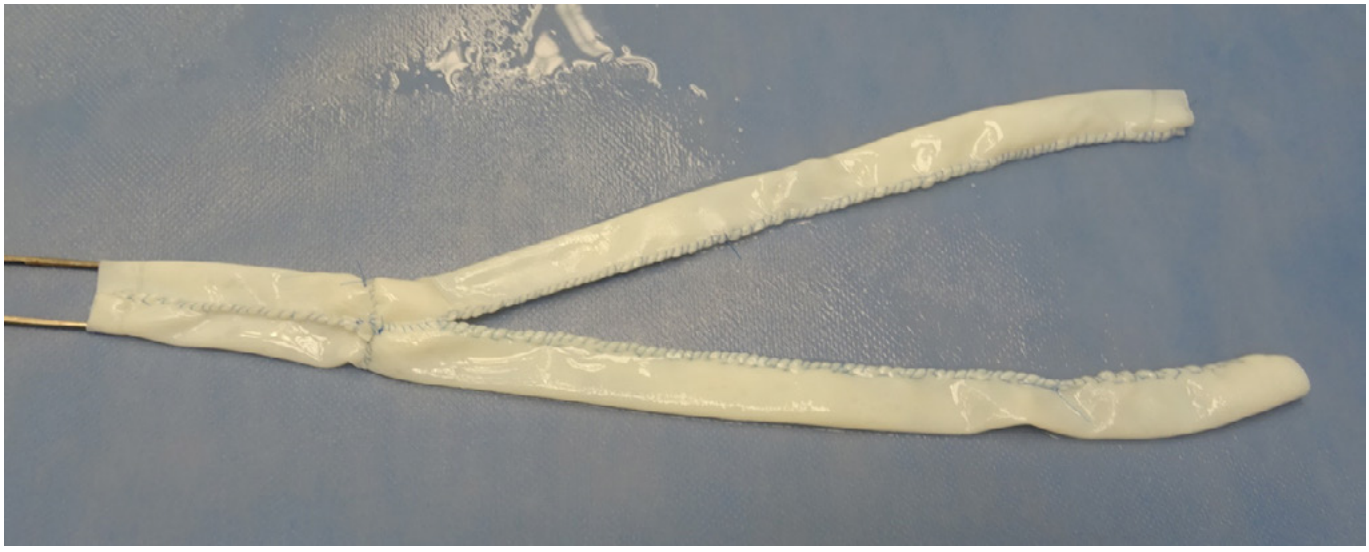

Figure 1: The construction of a self-made bifurcated graft made of bovine pericardium. At first we create the tubes and then we sew them together to form a bifurcated graft. When an extra length is needed we add a main body, as in this case.

therapy was prescribed in selected high-risk patients. Patients were followed at one, three, six, and twelve months after discharge, and annually thereafter. Follow-up included clinical examination, laboratory evaluation of inflammatory markers, and, if needed, computed tomography angiography to assess graft integrity, patency, and possible recurrence of infection.

Clinical data were retrieved retrospectively from hospital records, including demographic variables, microbiological results, operation details, and postoperative outcomes. Statistical analysis was performed using Jamovi 2.6 version. The primary endpoints of the study were in-hospital mortality, 30-day mortality and overall mortality. Secondary endpoints included perioperative complications, re-intervention rates, graft patency, and recurrence of infection.

RESULTS

Between 2019 and 2024, a total of 16 patients underwent in-situ aortic reconstruction using self-made bovine pericardium grafts at our center (Fig 2, 3). The cohort was predominantly male (87.5%), with a mean age of 66.6 years (range, 25-87 years). Indications for surgery included mycotic aneurysm in four patients (25%), infection of a prior endovascular aortic repair (EVAR/TEVAR) in four patients (25%), and infection of a conventional prosthetic graft in eight patients (50%).

All patients presented with clinical symptoms at diagnosis, including fever in 9 patients (56%), abdominal pain in 3 (19%), purulent discharge from a femoral-inguinal fistula in 2 (12.5%), pseudoaneurysm of the femoral anastomosis in 2 (12.5%) and gastrointestinal bleeding in 2 patients (12.5%).

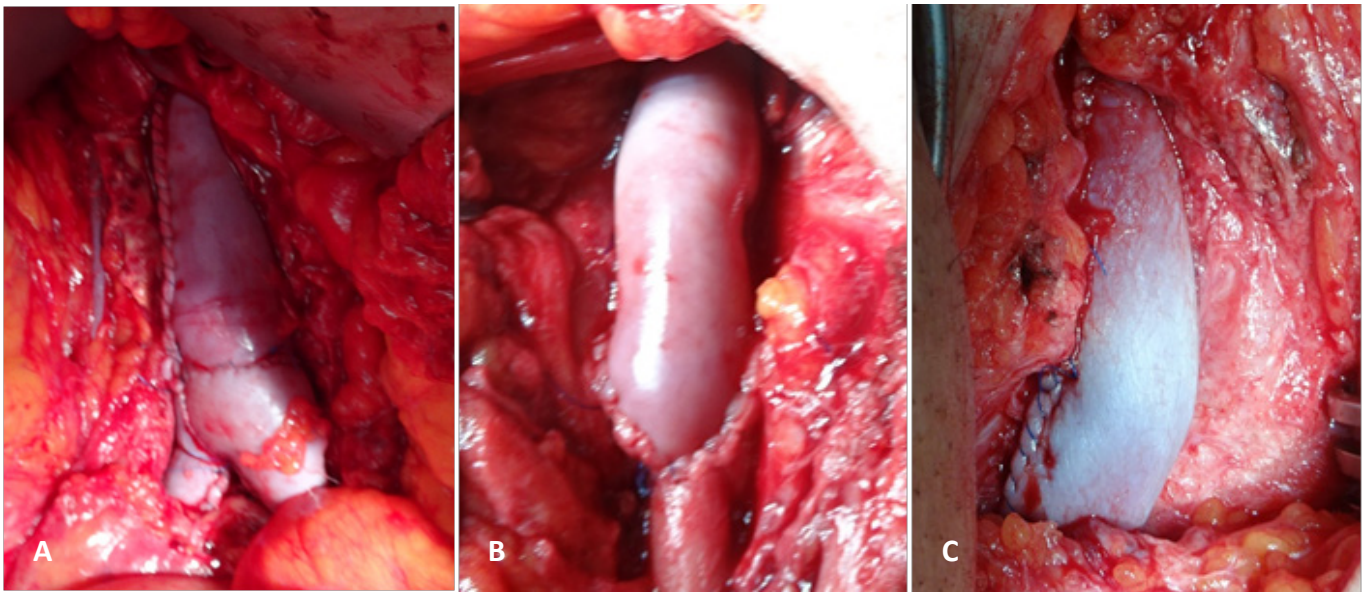

Figure 2. Intraoperative picture of a bifurcated bovine graft, depicting the aortic (A), the right femoral (B) and the left femoral (C) anastomosis.

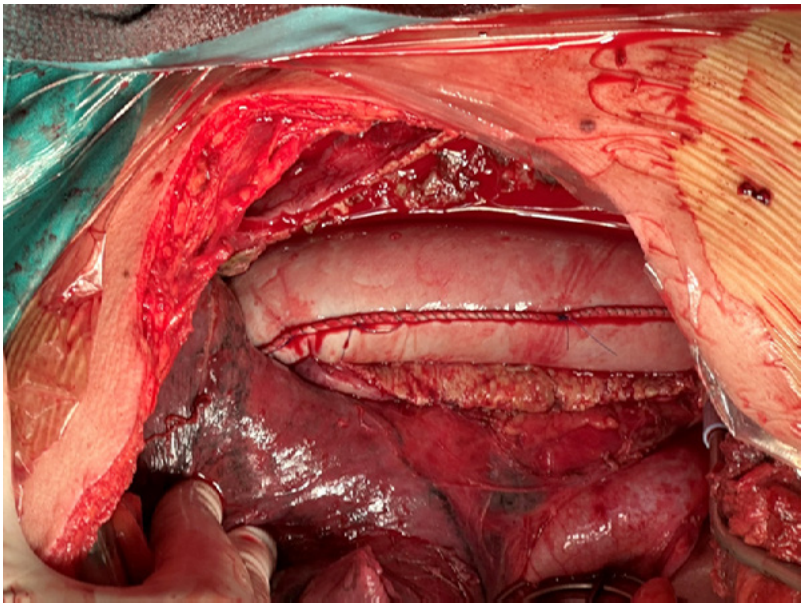

Figure 3. Intraoperative picture of a TEVAR infection treated with a bovine pericardium tube graft.

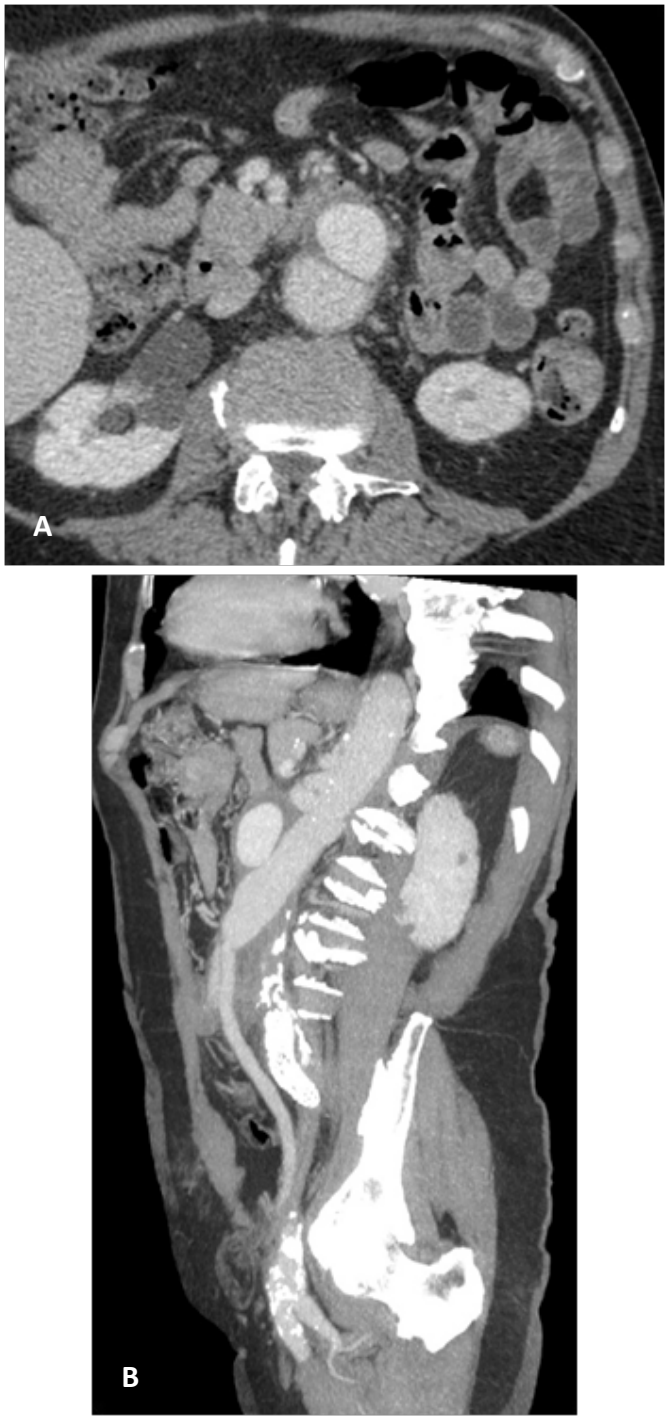

Figure 4. Computed tomography angiography in axial (A) and sagittal (B) view revealing a pseudoaneurysm of the proximal anastomosis of a self-made aortobifemoral bovine graft.

Computed tomography imaging demonstrated inflammatory lesions in every case, namely perigraft gas or fluid. Five patients (31.3%) had an associated aortoenteric fistula. Microbiological cultures were positive in 13 patients (81.3%), most frequently from explanted grafts (62.5%), followed by wound cultures (12.5%) and blood cultures (6.3%). Three patients (18.8%) had negative cultures. The mean duration of the preoperative antibiotic therapy was 7.1 ± 6.6 days.

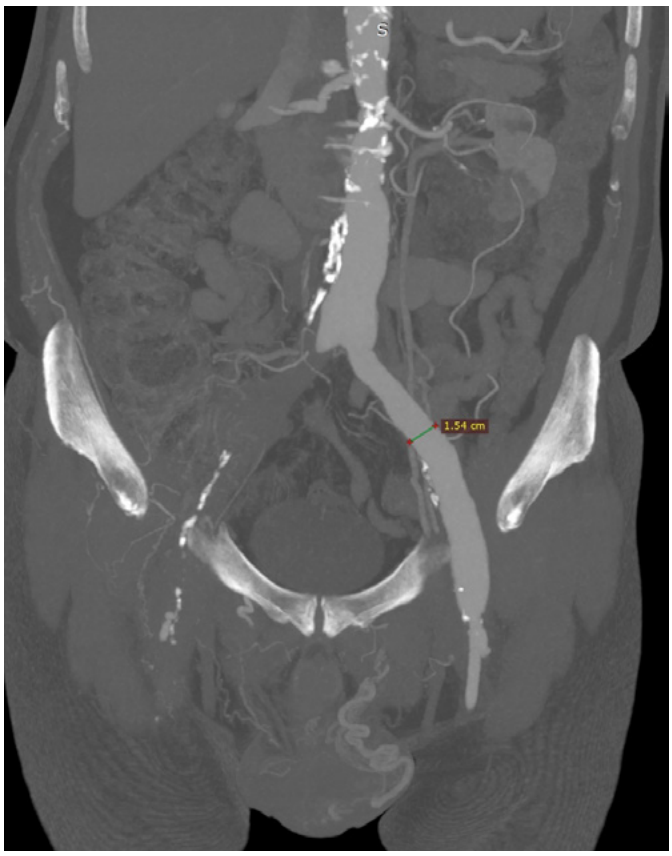

Figure 5. Computed tomography angiography showing occlusion of the right limb of the aortobifemoral bovine graft.

The mean ICU stay was 2.6 days (range, 0-19 days), and the mean postoperative hospital stay was 11.9 days (range, 0-45 days). The 30-day death rate was 31.3% (5 patients), while in-hospital mortality was 37.5% (6 patients). The most common cause of death was graft disruption in 4 patients, followed by multiorgan failure due to sepsis in 2.

No patient died after hospital discharge, during a median follow-up of 8.3 months (range, 0-43 months), and no cases of infection recurrence were documented. One patient developed a pseudoaneurysm of the proximal anastomosis (Fig 4) 6 months after the bovine graft implantation, which was treated by endovascular repair with an aortic cuff. Another patient suffered from thrombosis of the right limb of an aortobifemoral bovine graft (Fig 5) 2 years after its implantation, which was treated with a femoro-femoral crossover graft.

DISCUSSION

In this retrospective single-center study, we evaluated the outcomes of 16 patients treated with self-made bovine pericardium graft for aortic infections. Our series demonstrates a 30-day mortality of 31.3% and an overall mortality of 37.5%. Despite the high perioperative risk associated with the severity of the disease in this cohort, we observed no cases of reinfection at a median follow-up of 8.3 months. Additionally, graft durability was favorable, with only one case of limb thrombosis and one case of proximal anastomotic pseudoan-

eurysm. These results align with, and further support, the growing evidence that bovine pericardium grafts are a viable option for in-situ reconstruction in infected aortic cases.

Comparison with existing evidence

Multiple single-center studies have reported favorable outcomes with self-made xenopericardial tubes. In the early feasibility series by Lutz et al., infection control was achieved in 75%, with 100% graft patency at 9 months, although two late ruptures occurred due to reinfection.[6] Alonso et al. documented a 30-day mortality of 4.7% and 95% primary patency, with no recurrency of infection during a median follow-up of 14 months.[7] Similarly, Czerny and colleagues reported in-hospital mortality of 16%, excellent mid-term patency, and freedom from reinfection in 98% of cases, though fungal infections were associated with poor outcomes.[16] Zientara et al. highlighted the technical feasibility of self-made bovine pericardium grafts, showing 100% patency and no reinfections in their pericardium subgroup, with lower complication rates than allograft reconstructions.[5]

Our results compare favorably with these smaller series, particularly in terms of infection resistance, where we observed zero reinfections despite one-third of our patients (31.3%) presenting with aortoenteric fistulae. However, our early mortality was higher, which likely reflects the prolonged age and comorbidities in our population, including octogenarians and patients with septic clinical presentation. These results align with the study by Weiss et al., which is the most extensive multicenter cohort involving 168 patients. They observed a 30-day mortality rate of 15%, with higher rates in cases of graft infection compared to native infection and reported an 86% rate of freedom from reinfection over a period of 5 years.[8] Significantly, throughout that series, no inherent deterioration of bovine pericardium grafts was observed, supporting the mid-term durability observed in our study.

Other mid-sized cohorts support these observations. Kreibich et al. reported acceptable outcomes using xenopericardial grafts for infectious aortic disease across various segments, emphasizing the technical versatility of the material.[16] In a systematic review by Hostalrich et al., involving 71 patients, the mortality rate within 30 days was 25%. Additionally, 5.7% of the patients experienced reinfection, and 9% required further intervention, with no instances of graft thrombosis reported.[9] Likewise, Grills et al. combined data from nine studies involving 133 patients and found that reinfection rates were extremely low (less than 1%) and patency was very high (over 95%). However, the overall mortality rate remained elevated at approximately 40% due to the underlying disease.[10] A broader meta-analysis in the HJVES by Theodosopoulos et al., including 290 patients, confirmed these findings, with reinfection-free survival of 98.6% and primary patency of 99%.[11] The collective data highlight the infection resistance and durability of bovine pericardium grafts, emphasizing that patient frailty and the severity of sepsis are the primary factors influencing overall outcomes.

Prefabricated bovine pericardial grafts

Alongside physician-made conduits, prefabricated bovine pericardium grafts have emerged as an attractive "off-the-shelf" option. The VASC-REGAIN study demonstrated a 1-year reinfection rate of 9%, occlusion in 6% of the cases, and procedure-related mortality of 16%.[12] A preliminary experience with prefabricated grafts for aorto-iliac and infrainguinal reconstructions reported 30-day mortality of 17% for aorto-iliac and 8% for infrainguinal reconstructions, with reinfection-free survival of 94% and acceptable patency.[17] Further mid-term analysis showed primary patency of 85% at 1 year and assisted primary patency rate of 96.3%.[13] In a retrospective analysis conducted by Donato et al., which involved 20 patients, the in-hospital mortality rate was as low as 5%. Additionally, the primary patency was reported at 95%, and the re-infection rate was 5%.[14] Our findings with self-fabricated grafts demonstrated comparable robustness in infection resistance, indicating that both approaches are effective. However, prefabricated grafts offer logistical advantages when rapid intervention is required, particularly in scenarios necessitating rapid intervention.

Comparison with alternative strategies

Autologous femoral vein reconstruction (NAIS) is considered highly resistant to infection but is technically demanding, time-consuming, and associated with donor-site morbidity, making it less feasible in urgent settings. Cryopreserved allografts remain an excellent biologic alternative, but supply is limited, and structural degeneration can occur. A French bicentric comparative study, involving 169 patients from 2010 to 2023, identified no significant differences in mid-term survival or reinfection-free survival between cryopreserved allografts and xenopericardial substitutes. This finding highlights the clinical efficacy equivalence of bovine pericardium grafts while emphasizing their advantage in terms of availability.[3] Synthetic grafts treated with rifampicin or silver coatings have been used, but reinfection rates remain higher, particularly in cases with gross contamination or fistulation, as noted in the 2020 ESVS Guidelines.[2]

Limitations and clinical implications

Our study is limited by its retrospective design, small cohort size, and relatively short follow-up, which may underestimate late complications such as para-anastomotic pseudoaneurysm or primary or assisted primary patency —complications reported in other series.[8, 4] Nevertheless, the absence of reinfections in our cohort, even in complex cases with aortoenteric fistulae, contributes additional evidence to the expanding collection of research that endorses the safety and efficacy of bovine pericardium grafts.

Taken together, the available evidence indicates that bovine pericardium, whether self-made or prefabricated, offers a robust, infection-resistant, and versatile solution for in-situ aortic reconstruction. While perioperative mortality remains significant, reflecting the critical illness of this patient population, graft-related outcomes are consistently favorable. Larger multicenter studies with long-term follow-up are required to confirm the durability of this approach and to better define its

role relative to allografts and autologous vein grafts.

CONCLUSION

Our single-center experience demonstrates that self-made bovine pericardium grafts provide an effective and versatile option for in-situ reconstruction in patients with aortic infections. Despite an early mortality rate of 31.3%, indicative of the advanced age and comorbidity burden within our cohort, we observed no reinfections and excellent graft durability during follow-up. These results are in line with the largest European multicenter study, which reported a reinfection rate of only 6% at 5 years with no graft degeneration,[8] and with other single-center series showing patency rates exceeding 90-95% and low recurrence of infection.[7, 16, 6] Systematic reviews and meta-analyses further support these findings, consistently demonstrating very low reinfection rates (<6%) and high primary patency (~95-99%) across heterogeneous patient populations.[9, 10, 11]

Prefabricated bovine pericardial conduits have shown similar safety and efficacy, with reinfection rates of 5-9% and good mid-term patency.[12, 13, 14] Compared with alternatives such as cryopreserved allografts, autologous femoral vein, or antibiotic-coated synthetic grafts, bovine pericardium offers the advantages of wide availability, on-table adaptability, and biocompatibility in contaminated fields, while achieving equivalent mid-term outcomes.[2, 3]

Taken together, the accumulated evidence establishes bovine pericardium - both self-made and prefabricated - as a durable biological conduit for aortic infection surgery. While perioperative mortality remains high, determined largely by patient frailty and clinical presentation, graft-related outcomes are consistently favorable. Larger multicenter studies with long-term follow-up are warranted, but current data, including our own, strongly support bovine pericardial grafts as a safe and effective alternative for the treatment of this complex and life-threatening condition.

REFERENCES

1 Antonello RM, D'Oria M, Cavallaro M, Dore F, Cova MA, Ricciardi MC, et al. Management of abdominal aortic prosthetic graft and endograft infections. A multidisciplinary update. J Infect Chemother Off J Jpn Soc Chemother. 2019 Sept;25(9):669-80.

2 Chakfé N, Diener H, Lejay A, Assadian O, Berard X, Caillon J, et al. Editor's Choice - European Society for Vascular Surgery (ESVS) 2020 Clinical Practice Guidelines on the Management of Vascular Graft and Endograft Infections. Eur J Vasc Endovasc Surg Off J Eur Soc Vasc Surg. 2020 Mar;59(3):339-84.

3 Battistella L, Kireche R, Ricco JB, Boisroux T, Shourick J, Chaufour X, et al. Outcomes of native or graft abdominal aortic infection managed with orthotopic xeno pericardial grafts or cryopreserved allograft. J Vasc Surg. 2025 July 1;82(1):90-101.e3.

4 Kreibich M, Siepe M, Morlock J, Beyersdorf F, Kondov S, Scheumann J, et al. Surgical Treatment of Native and Prosthetic Aortic Infection With Xenopericardial Tube Grafts. Ann Thorac Surg. 2018 Aug;106(2):498-504.

5 Zientara A, Schwegler I, Dzemali O, Bruijnen H, Peters AS, Attigah N. Xenopericardial self-made tube grafts in infectious vascular reconstructions: Preliminary results of an easy and ready to use surgical approach. Vascular. 2016 Dec 1;24(6):621-7.

6 Lutz B, Reeps C, Biro G, Knappich C, Zimmermann A, Eckstein HH. Bovine Pericardium as New Technical Option for In Situ Reconstruction of Aortic Graft Infection. Ann Vasc Surg. 2017 May 1;41:118-26.

7 Alonso W, Ozdemir B, Chassin-Trubert L, Ziza V, Alric P, Canaud L. Early outcomes of native and graft-related abdominal aortic infection managed with orthotopic xenopericardial grafts. J Vasc Surg. 2021 Jan;73(1):222-31.

8 Weiss S, Hugas Mallorqui M, Czerny M, Walter T, Biro G, Puttini I, et al. Physician Made Bovine Pericardial Tube Grafts in Aortic Infection: A European Multicentre Study. Eur J Vasc Endovasc Surg Off J Eur Soc Vasc Surg. 2024 June;67(6):997-1005.

9 Hostalrich A, Ozdemir BA, Sfeir J, Solovei L, Alric P, Canaud L. Systematic review of native and graft-related aortic infection outcome managed with orthotopic xenopericardial grafts. J Vasc Surg. 2019 Feb 1;69(2):614-8.

10 Grills S, El-Diaz N, Walker-Jacobs A, Borucki J, Stather P. Outcomes Following Use of Bovine Pericardium (Xenoprosthetic) Grafts for Reconstruction of Mycotic Aortic Aneurysms and Infected Aortic Grafts: A Systematic Review and Meta-Analysis. Ann Vasc Surg. 2024 May 1;102:181-91.

11 Theodosopoulos IT, Rorris FP, Antonopoulos CN, Krinos NT, Sfyroeras GS, Lazaris AM, et al. The use of bovine pericardium for the treatment of aortic infection [Internet]. Heljves | Hellenic Journal of Vascular and Endovascular Surgery. 2022 [cited 2025 Oct 10]. Available from: https://www.heljves.com/2022-issue-3-86-92/

12 Reinders Folmer EI, Verhofstad N, Zeebregts CJ, van Sambeek MRHM, Saleem BR, Willigendael EM, et al. Performance of the BioIntegral Bovine Pericardial Graft in Vascular Infections: VASCular No-REact Graft Against INfection Study. Ann Vasc Surg. 2023 Sept 1;95:116-24.

13 Torre JAC de la, Jakober N, Jung G, Reeg A, Attigah N, Hakimi M. Perioperative and Mid-term Outcome of Prefabricated Bovine Pericardial Grafts in the Context of Infected Aortic/Iliac Pathologies. Ann Vasc Surg. 2025 Dec 1;121:218-28.

14 Donato F, Donati T, Minelli F, Borghetti A, Minucci M, Luparelli A, et al. Treatment of Aorto-iliac and Infrainguinal Vascular Infections with a Prefabricated Bovine Pericardial Graft. Ann Vasc Surg. 2024 Aug 1;105:177-88.

15 Anagnostopoulos A, Mayer F, Ledergerber B, Bergadà-Pijuan J, Husmann L, Mestres CA, et al. Editor's Choice - Validation of the Management of Aortic Graft Infection Collaboration (MAGIC) Criteria for the Diagnosis of Vascular Graft/Endograft Infection: Results from the Prospective

Vascular Graft Cohort Study. Eur J Vasc Endovasc Surg Off J Eur Soc Vasc Surg. 2021 Aug;62(2):251-7.

16 Kreibich M, Siepe M, Berger T, Pingpoh C, Puiu P, Morlock J, et al. Treatment of infectious aortic disease with bovine pericardial tube grafts. Eur J Cardiothorac Surg. 2021 July 1;60(1):155-61.

17 Gregio A, Pini R, Faggioli G, Freyrie A, Tshomba Y, Pagliariccio G, et al. A Preliminary Experience on Prefabricated Bovine Pericardium Grafts for Aorto-iliac and Infrainguinal Reconstructions. J Vasc Surg. 2023 June 1;77(6):e220.

Proximal landing zone of TEVAR. Are there any limits? A narrative review

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Abstract:

Thoracic endovascular aortic repair (TEVAR) is increasingly utilized for managing thoracic aortic pathologies, necessitating adequate proximal stent graft apposition to healthy aortic wall to optimize outcomes..This review highlights the evolution of TEVAR techniques and devices, emphasizing the importance of anatomical suitability, technical success rates, and the need for a standardized approach to LSA reperfusion.Ultimately, careful patient selection, device choice, and interdisciplinary collaboration are critical to enhancing procedural outcomes and reducing complications in TEVAR.

Thoracic endovascular aortic repair (TEVAR) has gained widespread use in the treatment of acute and chronic pathologies of the thoracic aorta. Optimal outcomes in TEVAR are dependent upon obtaining adequate proximal apposition of stent graft against a healthy aortic wall.[1, 2] According to the instructions for use of the available endografts, this should be at least 15-20 millimeters long. **(Table 1**) In the proximal thoracic aorta, this may require coverage of one or more of the branches of the aortic arch, most commonly the left subclavian artery (LSA) (26-40%).[3-5] However, coverage of the LSA during endovascular repair of the thoracic aorta has been identified in the literature as a significant modifiable risk factor for: cerebrovascular ischemia, stroke (anterior circulation), vertebral ischemia, ischemia of the upper extremities.[3, 4, 6-8] There are also some special cases that make reperfusion of the LSA imperative, such as:

-Presence of a patent coronary bypass between the left internal mammary artery and coronary arteries.

-Termination of the left vertebral artery on the posterior inferior cerebellar artery.

-Absent, hypoplastic or occluded right vertebral artery.

-Presence of a patent arteriovenous dialysis shunt in the left upper limb.

-Planned extensive coverage (20 cm) of the descending thoracic aorta.

-Previous infrarenal aortic surgery with concomitant ligation of lumbar and middle sacral arteries.

-Occlusion of the internal iliac artery.[5, 9, 10]

Based on the above, all current guidelines of the European Society of Vascular Surgery, the Society of Vascular Surgery and the American Heart Association recommend prior or simultaneous reperfusion of the LSA, when coverage is necessary for adequate proximal landing zone achievement, in order to prevent neurological ischemic complications.[9, 11, 12] Traditionally, reperfusion of the LSA was performed with a carotid-subclavian bypass. **(Figure 1)** Alternatively, LSA is transposed to the left common carotid artery (LCCA).[13] **(Figure 2)** Although this technique eliminates the need for a synthetic graft and does not require secondary central embolization, it is contraindicated in cases of early take-off of the left vertebral artery and in the presence of a patent coronary bypass from the left internal mammary artery. Adopting all these open LSA reperfusion techniques, an excellent patency rate of >97% has been described at five years follow-up.[14, 15]

Therefore, arises the question whether there is a need for alternative methods of reperfusion of the LSA. Indeed, in obese patients, open reperfusion of the LSA becomes technically demanding and is associated with an increased risk of local complications, the incidence of which is not negligible; i.e bleeding, (10-20%), peripheral nerve injury (9-25%) and lymph leakage, although relatively rare (3-5%), may require more sophisticated treatment techniques.[15-17] **(Figure 3)**

This was realized by the team of Lawrence-Brown in Liverpool, who first described in 2004 the in-situ creation of a fenestration in a thoracic dacron endograft using the hard tip of a guide wire and the sequential use of cutting balloons so that a covered stent could be placed and blood flow to the LSA could be maintained.[18] While in 2009, the team of Frank Arco from Texas described for the first time the use of an ultraviolet laser catheter to create a fenestration in a Talent thoracic endograft and, after balloon dilation, placed an iCast covered stent in a patient with traumatic thoracic aortic injury.[19] A recent meta-analysis on the use of laser to create fenestrations during the endovascular treatment of aortic arch pathologies identified 6 studies with a total of 247 patients, almost 81% of whom underwent surgery on an emergency or urgent setting. The pooled technical success rate was estimated at 98%, the pooled 30-day mortality rate was estimated at 3.2% and the pooled estimate for stroke was estimated at 4.5%. Regarding the mid-term results, a target-vessel patency rate of 100% and

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Table 1: Anatomic requirements for the proximal landing zone of the available thoracic stent-grafts

MANUFACTURER	NAME	PROXIMAL LANDING ZONE	
		Diameter (mm)	Length (mm)
W. L. Gore & Associates	Conformable Thoracic Aortic Graft (c-TAG)™	16-42	≥20
Medtronic	Valiant Captivia™	18-42	≥20
Cook Medical	Zenith Alpha™	22-42	≥20
Terumo Aortic	Relay™	19-42	15-25
Lifetech Scientific	Ankura™	18-44	≥15

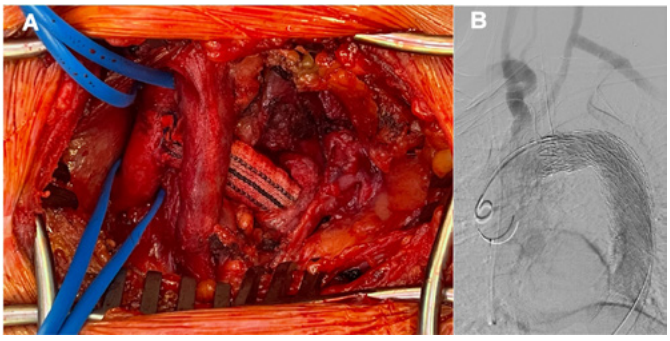

Figure 1: Left common carotid - left subclavian artery bypass. A: intraoperative view. B: angiographic view

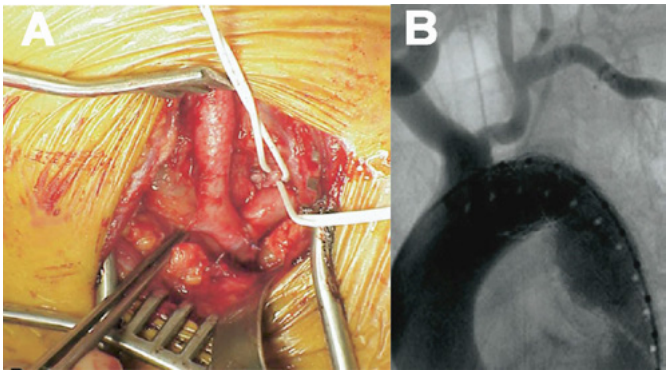

Figure 2: Transposition of the left subclavian artery. A: intraoperative view. B: angiographic view

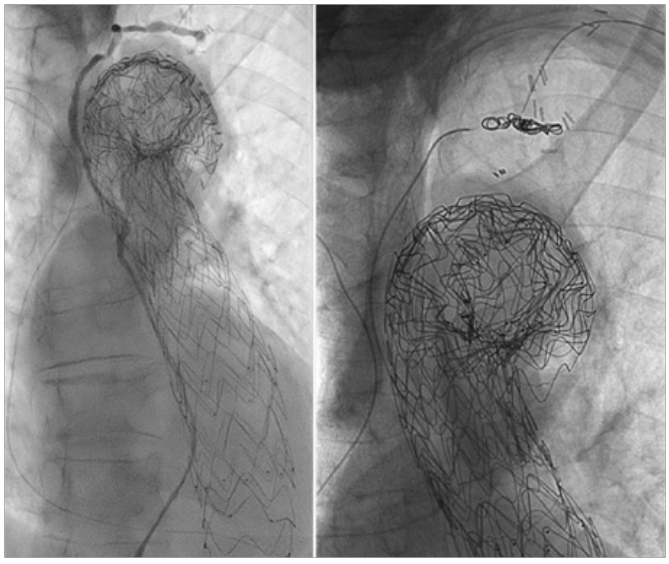

Figure 3: Embolisation of the the thoracic duct due to persistent chylous leak after a LCCA-LSA bypass

a reintervention rate of 6% during a median follow-up period of 12 months was recorded.[20] The recently published early results of the multicenter LIFE (Laser In Situ Fesnestrated Endograft) confirmed the feasibility of the technique with a perioperative mortality and neurologic risk profile that is comparable to standard techniques, but with a modest (9.8% within 15 months) reintervention rate.[21]

In 2021, the Fu-through™ in situ needle fenestration system in combination with the Fustar™ steerable guided sheath and the Ankura™ thoracic endograft (Lifetech Scientific, Shenzhen, China) were introduced in Europe and received CE mark. This system allows stabilizing and centralizing the 20G puncture needle, which is designed with 3 puncture depths and is convenient for 0.018" guidewire to go through and PTA balloon can be used for rapid dilation. In a single-center retrospective study on 52 TEVAR patients, an anatomic feasibility rate of 61.5% (32/52) was found based on the aortic arch morphology. The LSA angulation was identified to be the most important and limiting anatomical constraint.[22] The experience so far, mainly from China, has shown excellent results in terms of technical success, 30-day mortality and the occurrence of cerebrovascular events.[23-27] **(Table 2)**

Various other techniques for in-situ fenestration of thoracic endografts such as the use of recanalization catheters, or wire connected to electrodiathermy have been suggested. However, all of them are characterized by a lack of standardization, a combination of many materials and technologies and of course the absence of long-term results. Thus, the need for a standardized endovascular method for reperfusion of the LSA arises.

The solution to this need aspires to be the single-branch stent-grafts. Currently available in Europe is the GORE TBE™ (W. L. Gore & Associates, Newark, DE, USA) (MDR CE mark 2024), which is based on the well-known TAG platform and has a retrograde internal branch for the subclavian artery of 8 mm at a distance of 20 to 25 mm from the central end, a 12

mm branch at a distance of 40 mm from the central end. It includes a bridging endograft with diameters of 8 or 12 mm and a length of 6 cm and an aortic extension of 36 to 46 mm. **(Figure 5)** So far, this endograft has been used mainly in the United States of America, where it has been available in clinical studies since 2014 with excellent results.[28-35] **(Table 3)** However, it should be noted that, as with all endografts, there is a limitation of anatomical suitability. In a retrospective single center study of 210 patients who underwent TEVAR in zone 2, only 38.1% of patients met the anatomical criteria for a central landing zone. The left carotid artery - LSA distance being the most frequent factor of anatomic suitability violation.[36]

The second branched thoracic endograft currently available in Europe -in a custom-made platform- is the Castor™ (Lombard Medical Limited, in partnership with MicroPort Endovastec, Newark UK). It is a PTFE-coated nitinol scaffold en-

Table 2: Published results with the Fu-through™ in situ needle fenestration system

	N	Technical success	30-d Mortality	Cerebrovascular events (%)	Follow up (median, months)	Survival
Fan B, et al. 2024[23]	43	99.1%	0.9%	0	50	97.7%
Li G, et al. 2024[24]	115	100%	3.5%	0	31	92.2%
Yu Z, et al. 2024[27]	68	94.1%	2%	3.1%	29.2	98.5%
Usai M, et al. 2023[25]	18	94.4%	0	0	1	100%
Shu X, et al. 2022[26]	51	98.0%	2.0%	4.0%	31	96.0%

Table 3: Published results with the GORE TBE™ stent-graft

	Aneurysm	Dissection	Traumatic transection	Other isolated lesion	Total
N of enrolled subjects	84	132	9	13	238
Procedure time (min)	154.5	129.0	109.0	142.0	132.5
Contrast use (mL)	139.0	126.8	74.4	96.1	127.7
Technical success	77/84 (91.7%)	129/132 (97.7%)	9/9 (100%)	13/13 (100%)	228/238 (95.8%)
Permanent Paraplegia	1/84 (1.2%)	0/132 (0.0%)	0/9 (0%)	0/13 (0%)	1/238 (0.4%)
Disabling Stroke	4/84 (4.8%)	3/132 (2.3%)	0/9 (0%)	1/13 (7.7%)	8/238 (3.4%)
Type I/III EL	8/82 (9.8%)	5/121 (4.5%)	0/9 (0%)	0/13 (0%)	13/225 (5.8%)
30-d Mortality	0/84 (0%)	2/132 (1.5%)	0/9 (0%)	1/13 (7.7%)	3/238 (1.3%)
12-month lesion related mortality	0/80 (0%)	3/132 (2.3%)	0/9 (0%)	1/13 (7.7%)	4/234 (1.7%)
12-month LSA patency	67/67 (100%)	96/96 (100%)	8/9 (88.9%)	12/12 (100%)	183/184 (99.4%)
12-month freedom from type I/III EL	61/66 (92.4%)	92/94 (97.9%)	9/9 (100%)	12/12 (100%)	174/181 (96.2%)
12-month-freedom from reintervention	79/80 (98.7%)	126/132 (95.4%)	9/9 (100%)	13/13 (100%)	227/234 (97.0%)
24-month lesion related mortality	0/74 (0%)	3/132 (2.3%)	0/9 (0%)	1/13 (7.7%)	4/228 (1.75%)
24-month LSA patency	51/51 (100%)	61/61 (100%)	8/9 (88.9%)	12/12 (100%)	132/133 (99.2%)
24-month freedom from type I/III EL	46/51 (90.2%)	117/122 (95.9%)	9/9 (100%)	12/12 (100%)	184/194 (94.8%)
24-month-freedom from reintervention	73/74 (98.6%)	126/132 (95.4%)	9/9 (100%)	12/12 (100%)	220/227 (96.9%)
36-month lesion related mortality	0/40 (0%)	3/132 (2.3%)	0/9 (0%)	1/13 (7.7%)	4/194 (2.0%)
36-month LSA patency	27/27 (100%)	25/25 (100%)	8/9 (88.9%)	12/12 (100%)	72/73 (98.6%)
36-month freedom from type I/III EL	74/82 (90.2%)	117/122 (95.9%)	9/9 (100%)	12/12 (100%)	212/225 (94.2%)
36-month-freedom from reintervention	39/40 (97.5%)	126/132 (95.4%)	9/9 (100%)	12/12 (100%)	186/193 (96.4%)

Table 4: Published results with custom-made fenestrated stent-grafts

	Cook Arch Fen™	Terumo Fen±Scal Relay™	Najuta™ Device
Study design	International, 6 centres, 2014-2020	10 Italian centres 2014 - 2022	21 Italian centres 2018 - 2022
n	108	49	76
Technical success	107/108 (99%)	48/49 (98%)	74/76 (97.4%)
In-hospital mortality	4/108 (3.7%)	0	1/76 (1.3%)
Stroke	8/108 (7.5%)	3/49 (6.1%)	3/76 (3.9%)
rTAAD	3/108 (2.7%)	0	0
Follow up (months)	12	36.3	7
EL type I/II	3.5%	4.2%	2/76 (2.6%)

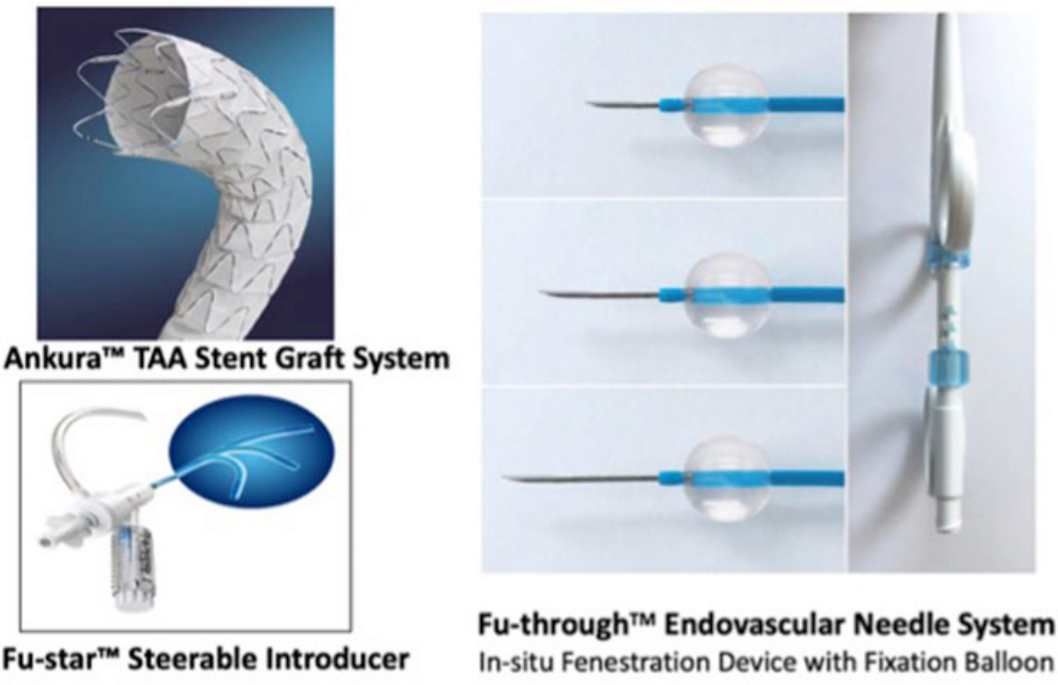

Figure 4: Fu-through™ in situ needle fenestration system in combination with the Fustar™ steerable guided sheath and the Ankura™ thoracic endograft. (Courtesy Lifetech Scientific)

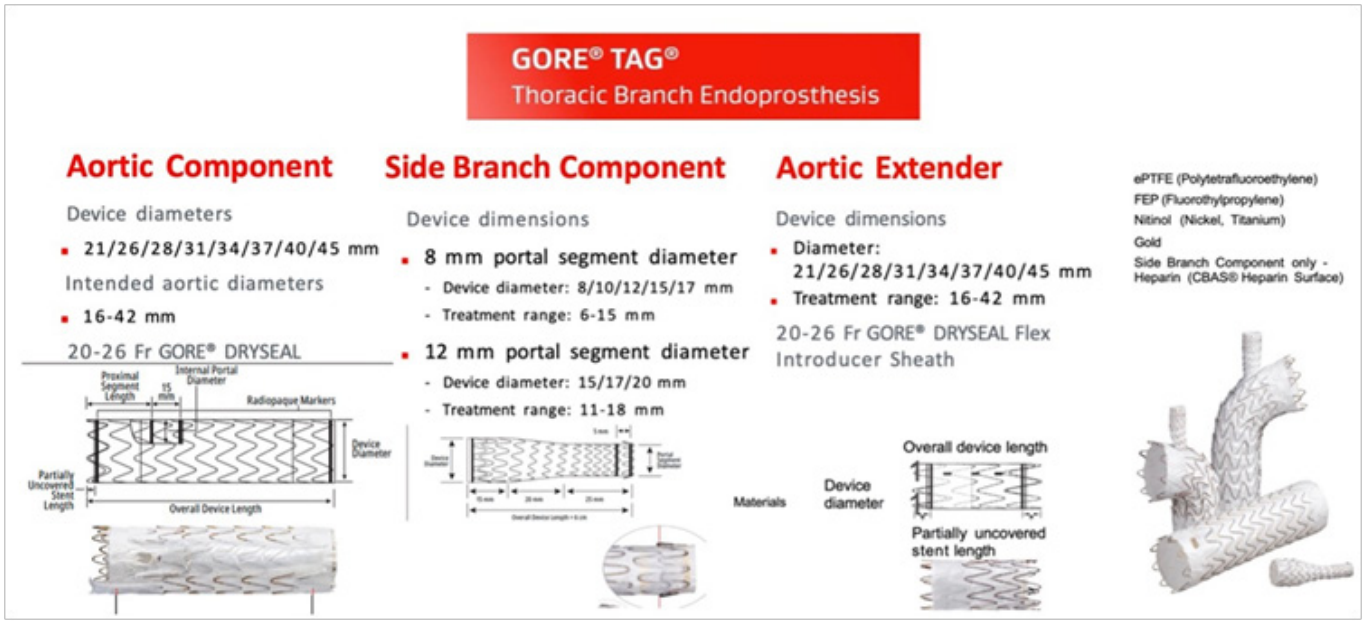

Figure 5: GORE TBE™single-branch stent-graft (Courtesy W. L. Gore & Associates)

dograft with a single branch 6-14 mm in diameter and 25 or 30 mm in length at a distance of 5 to 30 mm from the central tip. **(Figure 6)** The endograft was initially available in China with the indication of type B aortic dissection. A recent meta-analysis identified 11 studies with a total of 415 patients.[37] Technical success was recorded at 97.5%, no postoperative strokes were observed, while the 30-day mortality was almost 1%, while the patency of the LSA branch at 12 months was found to be 95%. Recently the first experience from Europe was published with encouraging results.[38] The second generation of Castor™, Cratos™, which has a redesigned delivery mechanism with a 2 Fr smaller sheath, was recently put into clinical trials in Europe and Japan (ongoing CREATION clinical trial).

Alternatives are also currently available as custom-made stent-grafts: the fenestrated endograft Cook Arch Fen™ (by COOK, Bloomington, IN, USA), the Najuta™ (by B-Kawasumi Laboratories, Inc., Kanagawa, Japan) and the Relay™ (by Terumo Aortic, Inchinnan, UK). All 3 endografts have shown high

technical success rates with a stroke risk of 3.9% to 7.5%.[39-41] However, they set as an anatomical prerequisite the presence of a 2 cm sealing zone (with diameter <40mm) in the mid-aortic arch, which is not always possible, especially in cases of type III aortic arch. In such cases, it is necessary to shift the proximal sealing zone centrally, towards the ascending aorta. Thus, branched aortic arch endografts, the Relay™ (by Terumo Aortic, Inchinnan, UK), Cook Arch Branch™ (by COOK, Bloomington, IN, USA) and the NEXUS™ (by Endospan, Herzlia, Israel) with central sealing zone in the ascending aorta, were developed. **(Figure 7)**

The multicenter postmarket study for Nexus, which in-

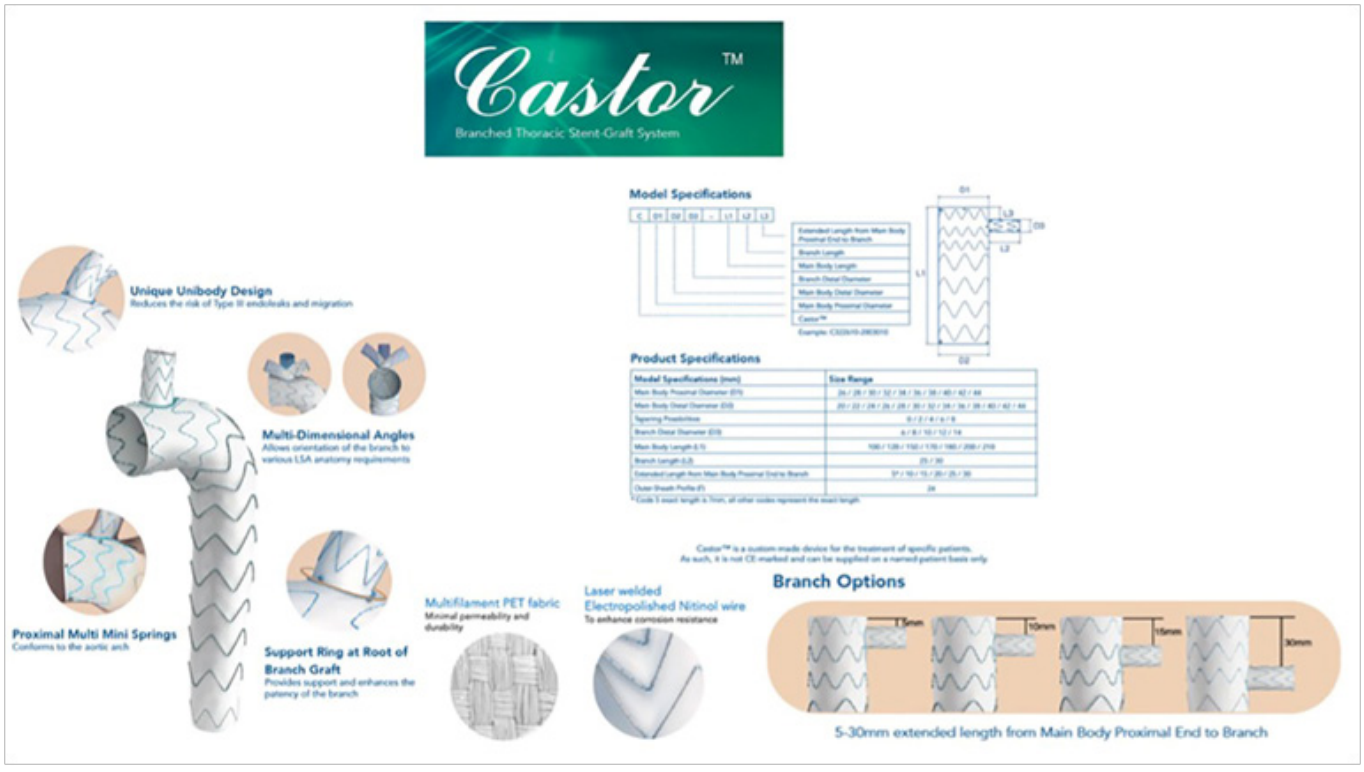

Figure 6: Castor™ branched thoracic endograft (Courtesy Lombard Medical

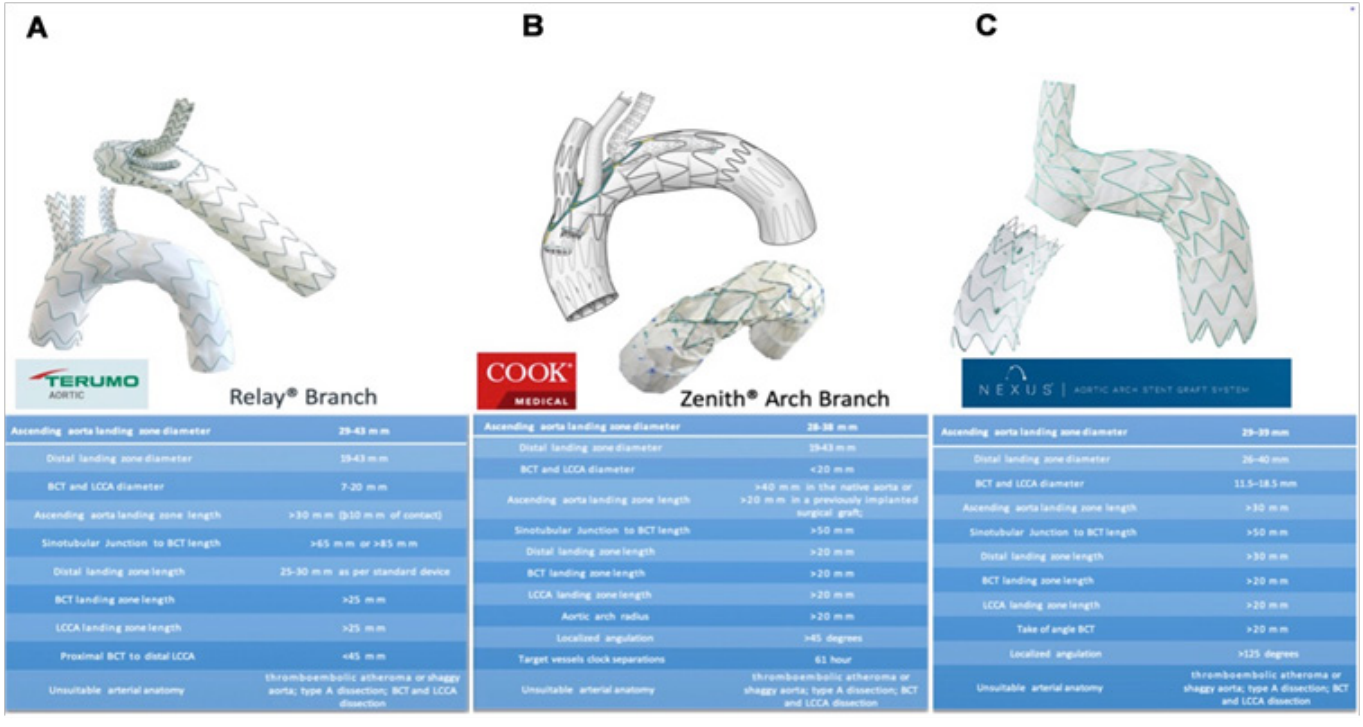

Figure 7: Available in Europe branched aortic arch endografts and their IFUs. A: Relay™(by Terumo Aortic, Inchinnan, UK), B: Cook Arch Branch™ (by COOK, Bloomington, IN, USA) C: NEXUS™ (by Endospan, Herzlia, Israel)s

Table 5: anatomical suitability of branched aortic arch endografts

		Cook Zenith Arch Branch™		Terumo Relay Branch™	Nexus™
	N	Double- Branch	Triple-Branch	2-Branch	
Leone N, et al. J Vasc Surg. 2024[54]	120	52.1%		46.6%	
Exelmans W, et al. CVIR Endovascular. 2023[53]	37				40.9%
Benfor B, et al. Eur J Cardio-Thoracic Surg. 2022[52]	90	36%	32%	34%	
Burke CR, et al. J Endovasc Surg. 2020[50]	27	45%			
Smorenburg S, et l. JAHA. 2020[51]	110	11.8%		17.3%	13.6%

cluded 28 patients, showed excellent technical success rates (100%), and extremely low stroke rates (3.6%), but in 29% of patients a reintervention was necessary at 36 months.[42, 43] Similarly, a multicenter study on the Terumo Relay branched endograft, which included 43 patients showed a 30-day mortality of 9%, and 7% disabling stroke rate.[44]

Regarding the COOK endograft, the version with the 2 branches, the initial experience was rather disappointing with a technical success of only 84% and a 30-day mortality at 13% and cerebrovascular accidents at approximately 16%.[45] These results were attributed to the required learning curve and, indeed, in the following series excellent technical success rates were observed, as well as acceptable 30-day mortality rates. However, the risk of stroke remained significant.[45-47] Recently, the international experience with the version with the 3 branches was also published. An improvement was found in terms of the risk of stroke, but the need for secondary interventions was estimated at 31% during a median follow-up period of 3.2 months.[48] Interstingly, a recent study from Hamburg found that the proximal landing zone in the native ascending aorta is associated with high stroke rates (13.5%, 7.9% major) and high need for reinterventions (24-month freedom from rentervention 46.4%).[49]

It should, however, be mentionted that the anatomical suitability of these endografts ranges from 10% to 50%, depending on the population under examination. **(Table 5)** All of studies identified the short length (<5cm) and the large diameter (>40mm) of the ascending aorta as the main factors for limiting the anatomical suitablity.[50-54] Indeed, the presence of a mechanical aortic valve, the short length of the ascending aorta and its severe angulation constitute significant challenges for the use of branched aortic arch endografts. Tsilimbaris et al. proposed the use of a small tip, 35 mm, and its passage lateral to the metallic leaflet, in order to preserve the function of the other one in cases of patients with a metallic aortic valve.[55] A recently published multicentre experience on these patients showed excellent technical success rates. However, it should be mentioned that, the included patients were highly selected and the participating centers were experienced high volume aortic centres.[56] Moreover, in patients with short ascending aorta length, endografts with 3 inverted branches can be used.[57] It should be noted, however, that these endografts are not readily available to everyone, so in selected cases the chimney technique, the in-situ fenestration technique or surgeon-modified endografts can be applied.

Recently, have been published efforts to expand the proximal landing zone in the aortic root. These are based in the combination of fenestrated or branched endografts along with percutaneous aortic valves with encouraging early outcomes for highly selected patients. Long-term follow-up data are, however, needed to assess the persistence of the seal and ongoing durability of this novel technique. [58-62]

In summary, the proximal sealing zone represents the most important factor related to early and long-term results after TEVAR and ensuring its adequate length is the main challenge. Several different technologies have expanded the boundaries of what can be achieved through endovascular techniques worldwide. While the long-term results of the use of branched endografts are pending, most technical limitations are being eliminated and a satisfactory level of technical success has been noted with F/BTEVAR. However, this comes at the cost of increased stroke and reoperation rates. Therefore, patient selection, respecting the anatomical requirements, judicious choice of the most appropriate device considering the pros and cons of each system, in a high-volume centre and by an interdisciplinary team are the keys to minimize complications and achieve an adequate proximal landing zone.

REFERENCES

1 Boufi M, Aouini F, Guivier-Curien C, Dona B, Loundou AD, Deplano V, et al. Examination of factors in type I endoleak development after thoracic endovascular repair. J Vasc Surg. 2015;61(2):317-23.

2 Yoon WJ, Mell MW. Outcome comparison of thoracic endovascular aortic repair performed outside versus inside proximal landing zone length recommendation. J Vasc Surg. 2020;72(6):1883-90.

3 Luehr M, Etz CD, Berezowski M, Nozdrzykowski M, Jerkku T, Peterss S, et al. Outcomes After Thoracic Endovascular Aortic Repair With Overstenting of the Left Subclavian Artery. Ann Thorac Surg. 2019;107(5):1372-9.

4 Waterford SD, Chou D, Bombien R, Uzun I, Shah A, Khoynezhad A. Left Subclavian Arterial Coverage and Stroke During Thoracic Aortic Endografting: A Systematic Review. Ann Thorac Surg. 2016;101(1):381-9.

5 Matsumura JS, Rizvi AZ, Society for Vascular S. Left subclavian artery revascularization: Society for Vascular Surgery Practice Guidelines. J Vasc Surg. 2010;52(4 Suppl):65S-70S.

6 Chen X, Wang J, Premaratne S, Zhao J, Zhang WW. Meta-analysis of the outcomes of revascularization after in-

tentional coverage of the left subclavian artery for thoracic endovascular aortic repair. J Vasc Surg. 2019;70(4):1330-40.

7 Batubara EAD, Nugraha RA, Amshar M, Siddiq T, Indriani S, Adiarto S. Ischemic Complications Following Thoracic Endovascular Aortic Repair with and Without Revascularization of Left Subclavian Artery: A Systematic Review and Meta-Analysis. Annals of Vascular Surgery. 2022;86:417-27.

8 Rizvi AZ, Murad MH, Fairman RM, Erwin PJ, Montori VM. The effect of left subclavian artery coverage on morbidity and mortality in patients undergoing endovascular thoracic aortic interventions: a systematic review and meta-analysis. J Vasc Surg. 2009;50(5):1159-69.

9 Isselbacher EM, Preventza O, Hamilton Black J, 3rd, Augoustides JG, Beck AW, Bolen MA, et al. 2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease: A Report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines. Circulation. 2022;146(24):e334-e482.

10 Alanezi T, Altoijry A, AlSheikh S, Al-Mubarak H, Alhamzah M, Alomran F, et al. Predicting the need for subclavian artery revascularization in thoracic endovascular aortic repair: A systematic review and meta-analysis. J Vasc Surg. 2024;80(3):922-36 e5.

11 Czerny M, Schmidli J, Adler S, van den Berg JC, Bertoglio L, Carrel T, et al. Editor's Choice - Current Options and Recommendations for the Treatment of Thoracic Aortic Pathologies Involving the Aortic Arch: An Expert Consensus Document of the European Association for Cardio-Thoracic Surgery (EACTS) & the European Society for Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg. 2019;57(2):165-98.

12 Upchurch GR, Jr., Escobar GA, Azizzadeh A, Beck AW, Conrad MF, Matsumura JS, et al. Society for Vascular Surgery clinical practice guidelines of thoracic endovascular aortic repair for descending thoracic aortic aneurysms. J Vasc Surg. 2021;73(1S):55S-83S.

13 Bianco V, Sultan I, Kilic A, Aranda-Michel E, Cuddy RJ, Srivastava A, et al. Concomitant left subclavian artery revascularization with carotid-subclavian transposition during zone 2 thoracic endovascular aortic repair. The Journal of Thoracic and Cardiovascular Surgery. 2020;159(4):1222-7.

14 Protack CD, Smith A, Moennich LA, Hardy D, Lyden SP, Farivar BS. Midterm outcomes of subclavian artery revascularization in the setting of thoracic endovascular aortic repair. J Vasc Surg. 2020;72(4):1222-8.

15 Voigt SL, Bishawi M, Ranney D, Yerokun B, McCann RL, Hughes GC. Outcomes of carotid-subclavian bypass performed in the setting of thoracic endovascular aortic repair. J Vasc Surg. 2019;69(3):701-9.

16 Konstantinou N, Debus ES, Vermeulen CFW, Wipper S, Diener H, Larena-Avellaneda A, et al. Cervical Debranching in the Endovascular Era: A Single Centre Experience. Eur J Vasc Endovasc Surg. 2019;58(1):34-40.

17 D'Oria M, Kärkkäinen JM, Tenorio ER, Oderich GS, Mendes BC, Shuja F, et al. Perioperative Outcomes of Carotid-Subclavian Bypass or Transposition versus Endovascular Techniques for Left Subclavian Artery Revascularization during Nontraumatic Zone 2 Thoracic Endovascular Aortic Repair in the Vascular Quality Initiative. Ann Vasc Surg. 2020;69:17-26.

18 McWilliams RG, Murphy M, Hartley D, Lawrence-Brown MM, Harris PL. In situ stent-graft fenestration to preserve the left subclavian artery. J Endovasc Ther. 2004;11(2):170-4.

19 Murphy EH, Dimaio JM, Dean W, Jessen ME, Arko FR. Endovascular repair of acute traumatic thoracic aortic transection with laser-assisted in-situ fenestration of a stent-graft covering the left subclavian artery. J Endovasc Ther. 2009;16(4):457-63.

20 Houerou TL, Nana P, Pernot M, Guihaire J, Gaudin A, Lerisson E, et al. Systematic Review on In Situ Laser Fenestrated Repair for the Endovascular Management of Aortic Arch Pathologies. J Clin Med. 2023;12(7).

21 Ullery BW, Alie-Cusson F, Magee GA, Han SM, Stern JR, Barleben A, et al. Laser In Situ Fenestrated Endograft (LIFE) Repair of Complex Aortic Arch Pathology: Early Outcomes from the Multicenter LIFE Registry. Journal of Vascular Surgery.

22 Piffaretti G, Franchin M, Gnesutta A, Gatta T, Piacentino F, Rivolta N, et al. Anatomic Feasibility of In-Situ Fenestration for Isolate Left Subclavian Artery Preservation during Thoracic Endovascular Aortic Repair Using an Adjustable Needle Puncturing System. J Clin Med. 2023;13(1).

23 Fan B, Fang K, Tian C, Fang J, Chen D, Zhao J, et al. In Situ Fenestration and Carotid-Subclavian Bypass for Left Subclavian Artery Revascularization During Thoracic Endovascular Aortic Repair. Cardiovasc Intervent Radiol. 2024;47(6):717-27.

24 Li G, Li M, Dong Z, Gu J, Liu H, Xu X, et al. In situ needle fenestration for aortic arch conditions during thoracic endovascular aortic repair. BMC Cardiovasc Disord. 2024;24(1):625.

25 Usai MV, Austermann M. Experience with the Ankura Thoracic Stent Graft and In-situ Fenestration for the Left Subclavian Artery with the Fu-Through Needle - a Technical Overview and Comparison to Similar Endovascular Techniques. Zentralbl Chir. 2023;148(5):425-8.

26 Shu X, Xu H, Wang E, Wang L, Guo D, Chen B, et al. Midterm Outcomes of an Adjustable Puncture Device for In Situ Fenestration During Thoracic Endovascular Aortic Repair. Eur J Vasc Endovasc Surg. 2022;63(1):43-51.

27 Yu Z, Hu S, Wang D, Yang T, Lang D. Early and midterm outcomes of in situ fenestration via adjustable puncture needle for Ankura aortic stent graft: A single-center experience. Vascular. 2024;32(5):964-72.

28 Dake MD, Brinkman WT, Han SM, Matsumura JS, Sweet

MP, Patel HJ, et al. Outcomes of endovascular repair of aortic aneurysms with the GORE thoracic branch endoprosthesis for left subclavian artery preservation. J Vasc Surg. 2022;76(5):1141-9 e3.

29 Dake MD, Fischbein MP, Bavaria JE, Desai ND, Oderich G, Singh MJ, et al. Evaluation of the Gore TAG thoracic branch endoprosthesis in the treatment of proximal descending thoracic aortic aneurysms. J Vasc Surg. 2021;74(5):1483-90 e2.

30 Patel HJ, Dake MD, Bavaria JE, Singh MJ, Filinger M, Fischbein MP, et al. Branched Endovascular Therapy of the Distal Aortic Arch: Preliminary Results of the Feasibility Multicenter Trial of the Gore Thoracic Branch Endoprosthesis. Ann Thorac Surg. 2016;102(4):1190-8.

31 Squiers JJ, DiMaio JM, Schaffer JM, Baxter RD, Gable CE, Shinn KV, et al. Surgical debranching versus branched endografting in zone 2 thoracic endovascular aortic repair. J Vasc Surg. 2022;75(6):1829-36 e3.

32 Desai ND, Wang GJ, Brinkman W, Coselli J, Taylor B, Patel H, et al. Outcomes of a Novel Single-Branched Aortic Stent Graft for Treatment of Type B Aortic Dissection. Ann Thorac Surg. 2025;119(4):826-34.

33 DiLosa K, Harding J, Donde N, Silverman D, Heafner T. Symptomatic carotid stenosis in Eagle syndrome managed with traditional endarterectomy and styloidectomy. J Vasc Surg Cases Innov Tech. 2024;10(1):101372.

34 DiLosa KL, Manesh M, Kanamori LR, Chan M, Magee GA, Fleischman F, et al. Multi-center experience with an off-the-shelf single retrograde thoracic branch endoprosthesis for acute aortic pathology. J Vasc Surg. 2025;81(4):839-46.

35 Liang NL, Dake MD, Fischbein MP, Bavaria JE, Desai ND, Oderich GS, et al. Midterm Outcomes of Endovascular Repair of Aortic Arch Aneurysms with the Gore Thoracic Branch Endoprosthesis. Eur J Vasc Endovasc Surg. 2022;64(6):639-45.

36 Blitti C, Die-Loucou J, Jazayeri A, Bouchot O, Bamde CC, Steinmetz E. Anatomic Suitability of Left Subclavian Artery Off-The-Shelf Branch Graft in a Real-World Setting. Ann Vasc Surg. 2025;122:792-800.

37 Yao S, Chen X, Liao Y, Ding G, Li D, Qin G, et al. Systematic review and meta-analysis of type B aortic dissection involving the left subclavian artery with a Castor stent graft. Front Cardiovasc Med. 2022;9:1052094.

38 Zolnierczuk M, Rynio P, Rybicka A, Glowinski J, Milnerowicz A, Pormanczuk K, et al. Initial Multicenter Experience With the New Castor Arch Branched Device in Europe: A Middle-term Results Study. J Endovasc Ther. 2024:15266028241304307.

39 Tsilimparis N, Prendes CF, Rouhani G, Adam D, Dias N, Stana J, et al. Pre-Loaded Fenestrated Thoracic Endografts for Distal Aortic Arch Pathologies: Multicentre Retrospective Analysis of Short and Mid Term Outcomes. Eur J Vasc Endovasc Surg. 2021;62(6):887-95.

40 Sica S, Pratesi G, Rossi G, Ferraresi M, Lovato L, Volpe P, et al. Proximal sealing in the aortic arch for inner curve disease using the custom Relay scalloped and fenestrated stent graft. J Vasc Surg. 2024;80(5):1317-25 e2.

41 Isernia G, Simonte G, Orrico M, Silingardi R, Gaggiano A, Covic T, et al. Preliminary results from an Italian National Registry on the outcomes of the Najuta fenestrated aortic arch endograft. J Vasc Surg. 2023;77(5):1330-8 e2.

42 Planer D, Elbaz-Greener G, Mangialardi N, Lindsay T, D'Onofrio A, Schelzig H, et al. NEXUS Arch: A Multicenter Study Evaluating the Initial Experience With a Novel Aortic Arch Stent Graft System. Ann Surg. 2023;277(2):e460-e6.

43 D'Onofrio A, Lachat M, Mangialardi N, Antonello M, Schelzig H, Chaykovska L, et al. Three-year follow-up of aortic arch endovascular stent grafting with the Nexus device: results from a prospective multicentre study. Eur J Cardiothorac Surg. 2022;63(1).

44 Czerny M, Berger T, Kondov S, Siepe M, Saint Lebes B, Mokrane F, et al. Results of endovascular aortic arch repair using the Relay Branch system. Eur J Cardiothorac Surg. 2021;60(3):662-8.

45 Haulon S, Greenberg RK, Spear R, Eagleton M, Abraham C, Lioupis C, et al. Global experience with an inner branched arch endograft. J Thorac Cardiovasc Surg. 2014;148(4):1709-16.

46 Spear R, Haulon S, Ohki T, Tsilimparis N, Kanaoka Y, Milne CP, et al. Editor's Choice - Subsequent Results for Arch Aneurysm Repair with Inner Branched Endografts. Eur J Vasc Endovasc Surg. 2016;51(3):380-5.

47 Tsilimparis N, Detter C, Law Y, Rohlffs F, Heidemann F, Brickwedel J, et al. Single-center experience with an inner branched arch endograft. J Vasc Surg. 2019;69(4):977-85 e1.

48 Tenorio ER, Oderich GS, Kolbel T, Dias NV, Sonesson B, Karelis A, et al. Multicenter global early feasibility study to evaluate total endovascular arch repair using three-vessel inner branch stent-grafts for aneurysms and dissections. J Vasc Surg. 2021;74(4):1055-65 e4.

49 Nana P, Spanos K, Panuccio G, Rohlffs F, Detter C, von Kodolitsch Y, et al. Branched and fenestrated endovascular aortic arch repair in patients with native proximal aortic landing zone. J Vasc Surg. 2024;80(3):621-9 e3.

50 Burke CR, Kratzberg JA, Yoder AD, Steele NZ, Aldea GS, Sweet MP. Applicability of the Zenith Inner Branched Arch Endograft. J Endovasc Ther. 2020;27(2):252-7.

51 Smorenburg SPM, Montesano M, Hoogteijling TJ, Truijers M, Symersky P, Jansen EK, et al. Anatomic Suitability for Branched Thoracic Endovascular Repair in Patients with Aortic Arch Pathological Features. J Am Heart Assoc. 2020;9(20):e016695.

52 Benfor B, Prendes CF, Peterss S, Stavroulakis K, Stana J, Pichlmaier M, et al. Anatomical analysis of the aortic arch and feasibility study of double and triple branched thoracic endografts in the treatment of isolated arch pathol-

ogies. Eur J Cardiothorac Surg. 2022;62(3).

53 Exelmans W, Mufty H, Maleux G, Verbrugghe P, Fourneau I. Anatomical feasibility of an endovascular aortic arch repair with the NEXUS endograft in patients treated with a frozen elephant trunk procedure for aortic arch pathology. CVIR Endovasc. 2023;6(1):10.

54 Leone N, Bartolotti LAM, Baresi GF, Silingardi R, Resch TA, Gennai S. Anatomical suitability for branched endovascular aortic arch repair and balloon-expandable bridging stent grafts in a cohort of patients previously treated with a hybrid approach. J Vasc Surg. 2024;79(2):198-206 e15.

55 Konstantinou N, Peterss S, Stana J, Rantner B, Banafsche R, Pichlmaier M, et al. Passing a Mechanical Aortic Valve With a Short Tip Dilator to Facilitate Aortic Arch Endovascular Branched Repair. Journal of Endovascular Therapy. 2021;28(3):388-92.

56 Konstantinou N, Jakimowicz T, Haulon S, Pichlmaier M, Abisi S, Pedro LM, et al. Outcomes after Endovascular Arch Repair in Patients with a Mechanical Aortic Valve: Results from a Multicentre Study. Eur J Vasc Endovasc Surg. 2025;69(2):263-70.

57 Nana P, Houérou TL, Guihaire J, Gaudin A, Fabre D, Haulon S. Early Outcomes on Triple-Branch Arch Device With Retrograde Left Common Carotid Branch: A Case Series. J Endovasc Ther. 2025;32(3):802-12.

58 Ghoreishi M, Chahal D, Shah A, Kang J, Hirsch J, Tran D, et al. First-in-Human Endovascular Aortic Root Repair (Endo-Bentall) for Acute Type A Dissection. Circ Cardiovasc Interv. 2023;16(10):e013348.

59 Felipe Gaia D, Bernal O, Castilho E, Baeta Neves Duarte Ferreira C, Dvir D, Simonato M, et al. First-in-Human Endo-Bentall Procedure for Simultaneous Treatment of the Ascending Aorta and Aortic Valve. JACC Case Rep. 2020;2(3):480-5.

60 Leshnower BG, Duwayri YM, Nicholson WJ, Ueyama H, Gleason PT, Shekiladze N, et al. Endo-Bentall Procedure Using Off-the-Shelf Catheter Devices to Repair an Aorto-Atrial Fistula. Circ Cardiovasc Interv. 2023;16(4):e012848.

61 Ghoreishi M, Shah A, Chahal D, Kang J, Gupta A, Taylor BS, et al. Endo-Bentall repair: Early results and feasibility of a physician-constructed Endo-Bentall device. J Thorac Cardiovasc Surg. 2025;170(3):639-49.

62 Shehab M, Prendes CF, Wanhainen A, Lindblom R, James S, Mani K. The Endo-Bentall Procedure in the Treatment of Ascending Aorta Pathologies: A Scoping Review. Eur J Vasc Endovasc Surg. 2025.

A whisper from the past: does plethysmography still have a role in the contemporary evaluation of peripheral arterial intervention?

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Abstract:

Introduction: Air plethysmography (APG), or pulse volume recording (PVR), is a quantitative, non-invasive method for assessing arterial hemodynamics by measuring limb volume changes from pulsatile blood flow. Although its venous applications are well established, its arterial role, especially in revascularization assessment, has not been clearly defined. This narrative review examined the physiological basis, technical implementation, and clinical utility of APG in evaluating open and endovascular arterial interventions.

Methods: A narrative literature review of PubMed, Scopus and Web of Science electronic databases (1960-2025) identified studies describing APG use in intra-operative assessment, post-operative surveillance, or functional evaluation of peripheral revascularization. Only verified peer-reviewed studies were included.

Results: In open bypass surgery, intra-operative APG provides immediate feedback on graft function and anastomotic integrity, with improved waveform amplitude predicting durable patency. Serial post-operative measurements detect early hemodynamic decline, before clinical or Duplex evidence of failure. After endovascular therapy, APG offers a functional measure of perfusion improvement, particularly valuable when imaging is limited by calcification. APG also quantifies post-operative reactive hyperaemia and transient limb oedema, reflecting physiologic reperfusion responses.

Conclusion: APG remains a useful, yet underutilized method for assessing arterial revascularization. By providing reproducible, calcification-independent, and physiologically meaningful data, it complements Duplex ultrasonography and may re-emerge as a key modality in post-operative hemodynamic surveillance of peripheral arterial intervention.

Key-words: air plethysmography, pulse volume recording, hemodynamics, peripheral arterial intervention, surveillance

INTRODUCTION

Peripheral arterial disease (PAD) is a common manifestation of systemic atherosclerosis, characterized by progressive narrowing and occlusion of peripheral arteries, leading to chronic tissue ischemia, claudication, and in advanced stages, critical limb-threatening ischemia.[1] The management of PAD has evolved substantially over the past decades, moving from exclusively open surgical bypass to a multidisciplinary approach, encompassing endovascular, open, and hybrid revascularization techniques.[1] These interventions aim to restore perfusion, relieve symptoms, and prevent limb loss, and their success is determined by durable patency and sustained hemodynamic improvement.[1,2]

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Non-invasive hemodynamic assessment constitutes the cornerstone in the diagnosis and post-operative surveillance of PAD.[1,3] Accurate evaluation of arterial flow dynamics is essential for quantifying ischemic severity, determining the adequacy of revascularization, and detecting early graft or stent failure.[1,2] Conventional techniques such as the ankle-brachial index (ABI) and continuous-wave Doppler waveform analysis remain fundamental tools, but their sensitivity is limited in cases of arterial wall calcification, multilevel disease, or post-interventional settings.[3,4] These limitations have prompted the adoption of complementary modalities, capable of providing a more direct, physiologic representation of regional perfusion.[3]

Air plethysmography (APG), also referred to as pulse volume recording (PVR), offers a quantitative, non-invasive method for assessing arterial hemodynamics, through the measurement of limb volume changes induced by pulsatile blood flow.[5] The technique records pressure variations within an air-filled cuff that encircles the limb segment, generating characteristic waveforms that reflect arterial compliance, peripheral resistance, and inflow dynamics.[5,6] Since its introduction in the 1970s, APG has been employed both intra-operatively, where it can verify restoration of distal pulsatility after revascularization, and post-operatively, as a reproducible tool for non-invasive monitoring of perfusion recovery.[7,8] Although its clinical use is dominated by its venous applications, the growing emphasis on objective functional assessment have reawakened

interest in its role for evaluating outcomes following open and endovascular arterial interventions.[9]

The aim of this narrative review was to provide a comprehensive and critical appraisal of the role of APG in the evaluation of peripheral arterial interventions. Specifically, it sought to elucidate the physiological principles of APG, its technical applications in both open and endovascular arterial reconstruction, and its value in assessing procedural success and long-term hemodynamic outcomes. By summarizing evidence from historical and contemporary studies, this review aimed to define the diagnostic accuracy, and prognostic implications of APG-derived parameters, such as waveform amplitude, in relation to graft and stent patency, re-intervention rates, and post-operative limb edema, therefore, highlighting its contemporary role within the context of modern vascular imaging and hemodynamic arterial assessment.

METHODS

A comprehensive narrative review of the literature was conducted on the use APG in the evaluation of peripheral arterial interventions. An extensive, electronic search strategy was applied to PubMed, Scopus, and Web of Science databases, focusing on studies published between 1960 and 2025. The search strategy used various combinations of the following keywords: “air plethysmography”, “pulse volume recording”, “peripheral arterial disease”, “bypass surgery”, “angioplasty”, “endovascular”, “hemodynamic monitoring”, and “limb perfusion”. The last search was run on 14 October 2025. Only articles published in English and indexed in peer-reviewed journals were included. Eligible studies were those reporting original clinical data, intra-operative or post-operative plethysmographic assessments, or methodological advancements relevant to arterial hemodynamics. Publications restricted solely to venous plethysmography were excluded. Additional references were identified through manual screening of bibliographies from relevant articles, with cross-referencing to original reports whenever possible. Data were synthesized narratively to highlight physiologic principles, intra- and post-operative applications, and comparative outcomes across open and endovascular interventions. No formal quantitative meta-analysis was performed, given the heterogeneity of methodologies, outcome measures, and study designs.

Principles and technical aspects of APG

APG quantifies changes in limb segmental volume by detecting pressure variations within air-filled cuffs positioned circumferentially around the extremity.[5] These cuffs are connected to sensitive transducers, that record minute fluctuations in air pressure, corresponding to volumetric changes, typically in the range of 75-400cm^3, induced by arterial pulsations during the cardiac cycle.[5] The resulting waveform, commonly referred to as PVR, reflects the dynamic relationship between arterial inflow, vascular compliance, and peripheral resistance.[6]

Characteristic waveform morphology provides qualitative and quantitative information on the severity of arterial obstruction.[6,9,10] A triphasic contour represents normal arterial compliance and unobstructed flow, while a biphasic configuration indicates reduced elasticity or moderate proximal stenosis.[6,9,10] A monophasic or flattened waveform denotes severe inflow limitation or distal perfusion deficit, often associated with critical limb ischemia.[6,9,10] In clinical practice, segmental measurements are typically performed at standardized levels - thigh, calf, ankle, and foot - to delineate the anatomical level of disease, and to monitor post-operative hemodynamic improvement.[7,10]

Because APG assesses pulsatile volume change rather than static pressure, it remains unaffected by arterial wall calcification and non-compressibility, that can compromise the accuracy of ABI measurements.[7,11] This renders the method particularly valuable in patients with diabetes mellitus, chronic kidney disease, or medial arterial calcinosis, where conventional ABI is often unreliable.[12] Beyond its diagnostic capacity, the reproducibility and quantitative nature of APG make it a useful adjunct in both intra-operative and post-operative monitoring of lower limb revascularization.[6,10]

Historical role in open arterial surgery

The earliest clinical applications of APG were closely associated with open arterial surgery, where the method served as a real-time hemodynamic monitoring tool.[8] Intra-operative plethysmographic recordings provided immediate, objective assessment of graft patency and distal perfusion following arterial reconstruction, long before the widespread availability of Duplex ultrasonography.[13,14]

Griffin et al[13] conducted one of the seminal studies on intra-operative segmental plethysmography, analyzing 156 vascular operations, that included femoropopliteal and femorodistal bypasses, as well as endarterectomies. Restoration of a normal pulsatile waveform immediately after graft or endarterectomy closure predicted durable post-operative patency in 94% of limbs, while the absence of pulsatility correlated strongly with technical failure requiring immediate revision. These early data underscored the value of waveform morphology as a sensitive indicator of flow restoration and anastomotic adequacy.[13]

Baird et al[14] subsequently expanded on these findings in a series of 83 limbs undergoing femoropopliteal or femorodistal bypass procedures. Mean pulse amplitude increased from 4.5mm prior to revascularization to 18mm post-reconstruction, quantitatively confirming improved perfusion. Importantly, intra-operative waveform deterioration identified with an accuracy of 86% graft or distal anastomotic defects in 11% of cases, all of which were corrected before wound closure, thus preventing early graft failure. When APG is used in addition to traditional angiography, the diagnostic accuracy improved to 95%.[9] These results established intra-operative APG as an effective adjunct to Doppler ultrasonography, particularly in distal reconstructions, where even subtle technical errors could jeopardize long-term graft success.[14]

In the post-operative setting, segmental plethysmography was adopted as a non-invasive tool for early detection of graft dysfunction.[15] Studies from the 1970s and 1980s demon-

strated that an increase in waveform amplitude greater than 25% at the calf or thigh level following bypass correlated with successful revascularization and improved ankle systolic pressures.[16,17] Conversely, progressive amplitude reduction or delayed systolic upstroke during follow-up was found to precede graft stenosis, often weeks before clinical symptoms emerged, or before it got angiographically confirmed.[18,19] These observations highlighted the prognostic value of plethysmographic waveforms as early indicators of hemodynamic compromise, and provided the foundation for integrating APG into long-term graft surveillance protocols.[7,10]

Modern application in endovascular interventions

The rapid expansion of endovascular therapy, including percutaneous transluminal angioplasty, stent implantation, and atherectomy, has created a growing need for accurate, reproducible, and non-invasive methods to evaluate procedural efficacy and long-term hemodynamic improvement.[20,21] Although Duplex ultrasonography remains the reference standard for post-intervention assessment, APG offers distinct physiological insights.[21] Unlike Doppler imaging, which provides localized velocity measurements at discrete arterial sites, APG reflects the cumulative hemodynamic effect of revascularization on distal perfusion and overall limb compliance.[21] This global perfusion assessment could complement imaging-based modalities by quantifying the functional improvement in limb blood flow.[10] However, the literature around the use of APG/PVR for assessment and surveillance of endovascular intervention is scarce.

In a prospective evaluation of 120 limbs treated with infra-inguinal angioplasty, McPharlin et al[23] demonstrated that pulse volume waveforms improved following technically successful interventions, whereas limbs with suboptimal angiographic results showed minimal or no change in amplitude. However, these findings were not significant, and the authors noted that absolute waveform amplitude alone was less predictive of long-term patency than Doppler-derived peak systolic velocity ratios. Moreover, in the context of stent surveillance, preservation or further enhancement of waveform amplitude and contour stability has been correlated with sustained luminal patency, whereas waveform flattening or amplitude attenuation frequently precede Duplex-detected instent restenosis.[24,25] However, the broader integration of APG into routine endovascular surveillance has been limited by the absence of standardized criteria for waveform interpretation, and the lack of comprehensive normative datasets. This emphasizies the complementary, rather than substitutive, role of APG in the endovascular era.[23]

Comparative patency outcomes: open vs endovascular

When comparing the use of APG across open and endovascular revascularization strategies, several hemodynamic and clinical outcome domains warrant consideration, including patency, re-intervention rates, and post-operative limb volume dynamics.[10] In open arterial reconstructions, intra-operative APG has consistently demonstrated a strong predictive relationship with early graft patency.[13,14] Restoration of a normal or near-normal waveform at the time of graft completion correlates with durable hemodynamic success, while persistent waveform attenuation frequently indicates technical error or residual inflow obstruction.[13,14] In contrast, although endovascular interventions show a similar directional correlation, the strength of this association is often attenuated due to confounding factors, such as distal microvascular resistance, recoil, or uncorrected outflow disease.[23] Some studies have suggested that an increase in PVR amplitude exceeding 30%, immediately after the procedure, predicts superior primary patency at 12 months.[26,27] However, these findings remain preliminary and require validation in larger prospective cohorts.

Post-operative limb hyperemia and oedema

Post-operative limb edema represents another important but often underappreciated domain in which APG provides unique insights.[28] Following arterial revascularization, the limb undergoes dynamic hemodynamic and microvascular adjustments.[29] Restoration of arterial inflow induces reactive hyperaemia, characterized by transiently increased perfusion driven by ischemic vasodilation, accumulation of vasodilatory metabolites, and increased capillary permeability.[30] APG, through real-time quantification of limb volume changes, provides a sensitive, non-invasive measure of this hyperaemic response.[10] Early post-operative recordings typically show marked increases in pulse amplitude and baseline limb volume, reflecting both restored inflow and microvascular reactivity.[31,32] Serial APG measurements after open bypass demonstrate limb volume increases of 5-8% during the first postoperative week, with gradual normalization as venous drainage adapts.[31,32] This transient swelling generally corresponds to successful revascularization, whereas persistent or progressive edema, particularly if accompanied by reduced waveform amplitude, may indicate venous outflow obstruction or reperfusion injury.[13-15]

Endovascular interventions are typically associated with smaller and shorter-duration postoperative volume increase, likely due to reduced tissue dissection, preservation of lymphatic pathways, and lower inflammatory response.[33] By concurrently monitoring arterial pulse amplitude, waveform contour, and total limb volume, APG could provide comprehensive insight into both macrovascular inflow restoration and microvascular reperfusion dynamics.[10] Unfortunately, there are no studies focusing on hemodynamic assessment of post-operative leg edema with APG, following endovascular peripheral intervention.

Beyond serving as a sensitive marker of arterial patency, APG offers valuable information on postoperative tissue physiology, enabling differentiation between expected hyperaemic responses, benign edema, and pathologic perfusion abnormalities.[34] By integrating both perfusion and volume metrics, plethysmography provides a more comprehensive evaluation of procedural efficacy and limb recovery.[34] Following successful revascularization, reactive hyperaemia produces a transient rise in pulse amplitude and a brisk systolic upstroke, reflecting restored inflow and vasodilatory response.[11,14,25] In contrast, benign postoperative edema manifests as a sus-

tained increase in baseline limb volume with preserved waveform contour, representing transient capillary leakage and lymphatic adaptation rather than arterial compromise.[11,14,25] Conversely, pathologic perfusion abnormalities, such as graft stenosis or in-stent restenosis, are characterized by persistent amplitude reduction, delayed upstroke, and waveform flattening, often preceding clinical or Duplex-detected deterioration.[11,14,25] Future studies integrating APG-derived volume metrics with biochemical or imaging markers of microcirculatory function may further elucidate the complex interactions between revascularization and tissue recovery.

Integration of APG in modern clinical practice

In contemporary vascular practice, APG serves as a valuable adjunctive rather than primary diagnostic modality for the evaluation of peripheral arterial interventions.[7,10,23] During open bypass surgery, intra-operative APG provides immediate, objective confirmation of technical success by documenting the restoration of pulsatile flow and quantifiable hemodynamic improvement across reconstructed segments.[13-19] This real-time feedback allows intra-operative correction of residual defects, complementing duplex and intraoperative flow assessments.[13,14] In endovascular procedures, APG functions as a global physiological assessment tool, offering whole-limb perfusion insight when duplex ultrasonography is inconclusive or technically limited by heavy arterial calcification, deep vessel location, or acoustic shadowing.[20-25]

Incorporating standardized APG protocols into structured post-intervention surveillance pathways could enhance early recognition of hemodynamic deterioration preceding overt graft or stent failure.[6,10,11,21] Several studies have already been mentioned demonstrating that waveform amplitude decline and loss of triphasic flow often precede symptomatic restenosis or ABI reduction, emphasizing the role of APG as an early warning signal for re-intervention.[13-16] Such proactive monitoring has the potential to improve long-term patency and limb salvage outcomes.[13-16] As the demand grows for objective, reproducible, and cost-effective follow-up modalities, particularly in elderly, diabetic, and multimorbid PAD populations, APG may regain a central position within multimodal hemodynamic assessment frameworks, complementing Duplex ultrasonography, ABI, and imaging-based surveillance after both open and endovascular arterial reconstruction.

Future perspectives

Recent technological advances have transformed traditional APG into sophisticated, digital hemodynamic monitoring systems, capable of multi-segmental data acquisition and automated waveform analysis.[35] Modern devices employ high-resolution pressure transducers and digital signal processing to improve sensitivity, reduce operator dependency, and enable precise temporal and amplitude quantification of arterial waveforms.[35] Segmental and multi-level recordings now allow a more detailed hemodynamic assessment of arterial inflow and outflow dynamics, complementing Duplex ultrasonography.[35] Emerging research explores the fusion of APG with near-infrared spectroscopy and photoplethysmography to provide simultaneous macro- and microcirculatory assessment.[36] In parallel, machine-learning algorithms trained on plethysmographic waveform datasets have demonstrated the potential to identify restenosis and hemodynamic deterioration with high diagnostic accuracy.[37] Although these systems remain in the developmental phase, their philosophy suggests a transition from descriptive waveform interpretation to data-driven, precision hemodynamic monitoring, amplified by machine-learning-enhanced analysis, thus positioning APG as a valuable adjunct in the future of vascular diagnostics.[37]

Limitations

The primary limitation of this review lies in the heterogeneity of available data. Published studies on APG in arterial reconstruction span more than five decades, encompassing diverse devices, calibration methods, and waveform analysis techniques, which limit direct comparison and pooled interpretation. Many early studies predate modern imaging and lack standardized outcome reporting or objective validation against reference modalities, such as Duplex ultrasonography or angiography. In addition, small sample sizes and retrospective designs predominate in the existing literature, with few prospective investigations assessing APG as a predictive surveillance tool. The absence of standardized diagnostic thresholds and normative datasets further constrains the generalizability of findings. Finally, current evidence remains preliminary and requires validation in contemporary patient cohorts with standardized post-intervention follow-up protocols.

CONCLUSION

APG remains a robust, non-invasive physiological tool capable of providing quantitative insights into arterial inflow, waveform morphology, and limb perfusion dynamics after revascularization. It offers valuable complementary data to conventional imaging modalities, facilitating intra-operative verification of technical success, early detection of hemodynamic deterioration, and functional assessment of tissue reperfusion. Its ability to simultaneously capture macrovascular and microvascular adjustments, such as reactive hyperemia and transient post-operative edema, underscores its physiological relevance beyond simple patency assessment. Despite historical underutilization, renewed technological advances, position APG/PVR for a potential resurgence in modern vascular practice. Standardization of acquisition protocols and validation of predictive metrics will be key to defining its future role within multimodal surveillance strategies after peripheral arterial intervention.

REFERENCES

1 Yuksel A, Velioglu Y, Cayir MC, Kumtepe G, Gurbuz O. Current Status of Arterial Revascularization for the Treatment of Critical Limb Ischemia in Infrainguinal Atherosclerotic Disease. *Int J Angiol*. 2018 Sep;27:132-137.

2 Wiseman JT, Fernandes-Taylor S, Saha S, et al. Endovascular Versus Open Revascularization for Peripheral Arterial Disease. *Ann Surg*. 2017 Feb;265:424-430.

3 Shabani Varaki E, Gargiulo GD, Penkala S, Breen PP. Peripheral vascular disease assessment in the lower limb: a review of current and emerging non-invasive diagnostic methods. *Biomed Eng Online*. 2018 May 11;17:61.

4 Mohler ER 3rd. Peripheral arterial disease: identification and implications. *Arch Intern Med*. 2003 Oct 27;163:2306-14.

5 Christopoulos DG, Nicolaides AN, Szendro G, Irvine AT, Bull ML, Eastcott HH. Air-plethysmography and the effect of elastic compression on venous hemodynamics of the leg. *J Vasc Surg*. 1987 Jan;5:148-59.

6 Raines JK. The pulse volume recorder in peripheral arterial disease. In: Bernstein EF, ed. Noninvasive Diagnostic Techniques in Vascular Disease. St. Louis, MO: CV Mosby; 1985:513-544.

7 Raines JK, Darling RC, Buth J, et al. Vascular laboratory criteria for the management of peripheral vascular disease of the lower extremities. *Surgery*. 1976;79:21-29.

8 Baird RN and Davies P. Evaluation of a pulse volume recorder as a method of assessing peripheral vascular disease. *Br. J. Surg*. 1977;64, 825.

9 Rutherford RB, Lowenstein DH, Klein MF. Combining segmental systolic pressures and plethysmography to diagnose arterial occlusive disease of the legs. *Am J Surg*. 1979;138:211-218.

10 Raines JK and Almeida JI. Pulse Volume Recording in the Diagnosis of Peripheral Vascular Disease. In: AbuRhama AF and Bergan JJ, eds. Noninvasive Vascular Diagnosis A Practical Guide to Therapy. Springer-Verlag London Limited 2007:245-252.

11 Raines J, Larsen PB. Practical guidelines for establishing a clinical vascular laboratory. *Cardiovasc Dis Bull Texas Heart Inst* 1979;6:93-123.

12 Babaei MR, Malek M, Rostami FT, Emami Z, Madani NH, Khamseh ME. Non-invasive vascular assessment in people with type 2 diabetes: Diagnostic performance of Plethysmographic-and-Doppler derived ankle brachial index, toe brachial index, and pulse volume wave analysis for detection of peripheral arterial disease. *Prim Care Diabetes*. 2020 Jun;14:282-289.

13 Griffin LH, Wray CH, Moretz WH. Immediate assessment of vascular operations using segmental plethysmography. *Am Surg*. 1975 Feb;41:67-76.

14 Baird RN, Davies PW, Bird DR. Segmental air plethysmography during arterial reconstruction. *Br J Surg*. 1979 Oct;66:718-22.

15 Darling RC, Raines JK, Brener BJ, Austen WG. Quantitative segmental pulse volume recorder: a clinical tool. *Surgery*. 1972 Dec;72:873-7.

16 Samson RH, Gupta SK, Veith FJ, Scher LA, Ascer E. Evaluation of graft patency utilizing the ankle-brachial pressure index and ankle pulse volume recording amplitude. *Am J Surg*. 1984 Jun;147:786-7.

17 Clifford PC, Morgan AP, Thomas WE, Baird RN. Monitoring arterial surgery: a comparison of pulse volume recording and electromagnetic flowmetering in aortofemoral reconstruction. *J Cardiovasc Surg (Torino)*. 1986 May-Jun;27:262-7.

18 Terry HJ, Allan JS, Taylor GW. The relationship between blood-flow and failure of femoropopliteal reconstructive arterial surgery. *Br J Surg*. 1972 Jul;59:549-51.

19 O'Donnell TF Jr, Cossman D, Callow AD. Noninvasive intraoperative monitoring: a prospective study comparing Doppler systolic occlusion pressure and segmental plethysmography. *Am J Surg*. 1978 Apr;135:539-46.

20 Thukkani AK, Kinlay S. Endovascular intervention for peripheral artery disease. *Circ Res*. 2015 Apr 24;116:1599-613.

21 Wong KHF, Zucker BE, Wardle BG, et al. Systematic review and narrative synthesis of surveillance practices after endovascular intervention for lower limb peripheral arterial disease. *J Vasc Surg*. 2022 Jan;75:372-380.e15.

22 Kleinert JM, Gupta A. Pulse volume recording. *Hand Clin*. 1993 Feb;9:13-46.

23 McPharlin M. Lower-Extremity Arterial Air Plethysmography Evaluation. *Journal for Vascular Ultrasound*. 2012;36:135-142.

24 Yang D, Sacco P. Reproducibility of air plethysmography for the evaluation of arterial and venous function of the lower leg. *Clin Physiol Funct Imaging*. 2002 Nov;22:379-82.

25 Hashimoto T, Ichihashi S, Iwakoshi S, Kichikawa K. Combination of pulse volume recording (PVR) parameters and ankle-brachial index (ABI) improves diagnostic accuracy for peripheral arterial disease compared with ABI alone. *Hypertens Res*. 2016 Jun;39:430-4.

26 Ascher E, Hingorani AP, Marks NA, Popliteal artery volume flow measurement: A new and reliable predictor of early patency after infrainguinal balloon angioplasty and subintimal dissection, *J Vasc Surg*,. 2007;45:17-24.

27 Symes JF, Graham AM, Mousseau M. Doppler waveform analysis versus segmental pressure and pulse-volume recording: assessment of occlusive disease in the lower extremity. *Can J Surg*. 1984 Jul;27:345-7.

28 Soong CV, Barros B'Sa AA. Lower limb oedema following distal arterial bypass grafting. *Eur J Vasc Endovasc Surg*. 1998 Dec;16:465-71.

29 Normahani P, Khosravi S, Sounderajah V, Aslam M, Standfield NJ, Jaffer U. The Effect of Lower Limb Revascularization on Flow, Perfusion, and Systemic Endothelial Function: A Systematic Review. *Angiology*. 2021 Mar;72:210-220.

30 Grace PA. Ischaemia-reperfusion injury. *Br J Surg*. 1994 May;81:637-47.

31 AbuRahma AF, Woodruff BA, Lucente FC. Edema after femoropopliteal bypass surgery: lymphatic and venous theories of causation. *J Vasc Surg*. 1990 Mar;11:461-7.

32 Persson NH, Takolander R, Bergovist D. Edema after low-

er limb arterial reconstruction. Influence of background factors, surgical technique and potentially prophylactic methods. *Vasa*. 1991;20:57-62.

33 Zenunaj G, Acciarri P, Baldazzi G, Cosacco AM, Gasbarro V, Traina L. Endovascular Revascularisation versus Open Surgery with Prosthetic Bypass for Femoro-Popliteal Lesions in Patients with Peripheral Arterial Disease. *J Clin Med*. 2023 Sep 15;12:5978.

34 Shabani Varaki E, Gargiulo GD, Penkala S, Breen PP. Peripheral vascular disease assessment in the lower limb: a review of current and emerging non-invasive diagnostic methods. *Biomed Eng Online*. 2018 May 11;17:61.

35 Danieluk A, Kamieńska A, Chlabicz S. Assessing Automatic Plethysmographic Ankle-Brachial Index Devices in Peripheral Artery Disease Detection: A Comparative Study with Doppler Ankle-Brachial Index Measurements. *Med Sci Monit*. 2023 Aug 5;29:e940829.

36 Joyner MJ, Dietz NM, Shepherd JT. From Belfast to Mayo and beyond: the use and future of plethysmography to study blood flow in human limbs. *J Appl Physiol (1985)*. 2001 Dec;91:2431-41.

37 Masoumi Shahrbabak S, Kim S, et al. Peripheral artery disease diagnosis based on deep learning-enabled analysis of non-invasive arterial pulse waveforms. *Comput Biol Med*. 2024 Jan;168:107813.

Revising a failing antebrachial loop graft for hemodialysis: the "snail" procedure

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Abstract:

Maintaining the lifespan of a vascular access (VA) is of paramount importance especially for end-stage renal disease patients. Any revision operation is an integral part of VA expertise, and in this regard any description of dedicated surgical or endovascular solution is of value. This case refers to the conversion of a purely prosthetic VA (loop antebrachial shunt) to a composite one, un-recruiting the outflow deep vein system of the lower arm and creating a different venous drainage pathway using a newly created superficial vein vessel. This technique incorporates the use of a new PTFE segment "looking" downwards to the antebrachial level, resembling a "snail" configuration of the whole circuit.

Key words: AV fistula, prosthetic grafts, dialysis access, techniques in vascular access, revision procedure

INTRODUCTION

The arteriovenous communication generates a large pressure gradient between the high-pressure, inflow artery and the low-resistance outflow vein, deviating an increased flow volume through the fistula, because of the bypassed resistance of the peripheral capillary bed.[1] We noticed in selected prosthetic lower or upper arm vascular access (VA) cases that despite superficial outflow vein thrombosis the circuit continues its functionality through the deep vein system especially when the initial vein anastomosis incorporates large perforating branches. In this occasion, the deep vein network decreases its resistance when the vein valves become gradually incompetent. However, this diversion of blood flow enables primary or secondary superficial veins, initially of suboptimal diameter to dilate, contributing to the total vein blood proximal outflow. From a practical point of view, these newly created veins could be used in future dedicated revision operations extending the VA lifespan. We describe the "*snail*" technique revising a failing antebrachial loop graft with thrombosis of the outflow basilic vein but draining to multiple deep vein branches, in which the vein anastomosis was relocated distally to a newly created large superficial antebrachial vein. This facilitation of its drainage, from the deep to superficial vein network was performed using a new PTFE portion in a retrograde direction, achieving a "*snail*" circuit configuration.

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CASE AND TECHNIQUE DESCRIPTION

M.Y. is a 76 year old female patient with past medical history of diabetes mellitus, hyperlipidemia and moderate aortic valve stenosis. She was on hemodialysis program through an antebrachial short loop shunt on the left side for the last 34 months. Renal physicians requested a venography because of evidence of high venous pressures during dialysis, although a satisfactory thrill was detected at clinical examination. The patient complained for intermittent rest pain due to the presence of a moderate lower arm edema. Primary patency of the loop shunt was 25 months and initial vein outflow was through the elbow basilic vein.

Surprisingly, the fistulogram at the level of the elbow revealed basilic vein occlusion however, blood outflow was now diverted to the deep antebrachial vein system through a large perforating brach. Furthermore, no central vein lesion was detected (Fig. 1A). An unexpected finding was the presence of a large antebrachial superficial branch, possibly receiving the blood flow from the high flow graft fistula, through the deep veins.

The latter branch showed continuity with the cephalic vein above elbow (Fig. 1B). This new superficial vein network was not present at the primary operation. To rescue this long-standing VA before thrombosis occurs, we performed a novel but simple technique, we called *"snail"* procedure. Instead of extending the vein limb of the PTFE to the brachial cephalic vein in an antegrade fashion we choose to extend retrograde to the antebrachial superficial branch, at its most distal dilated point, in order to considerably increase the puncture area. The latter would include a long vein component (Fig. 2). This facilitation of its drainage from the deep to

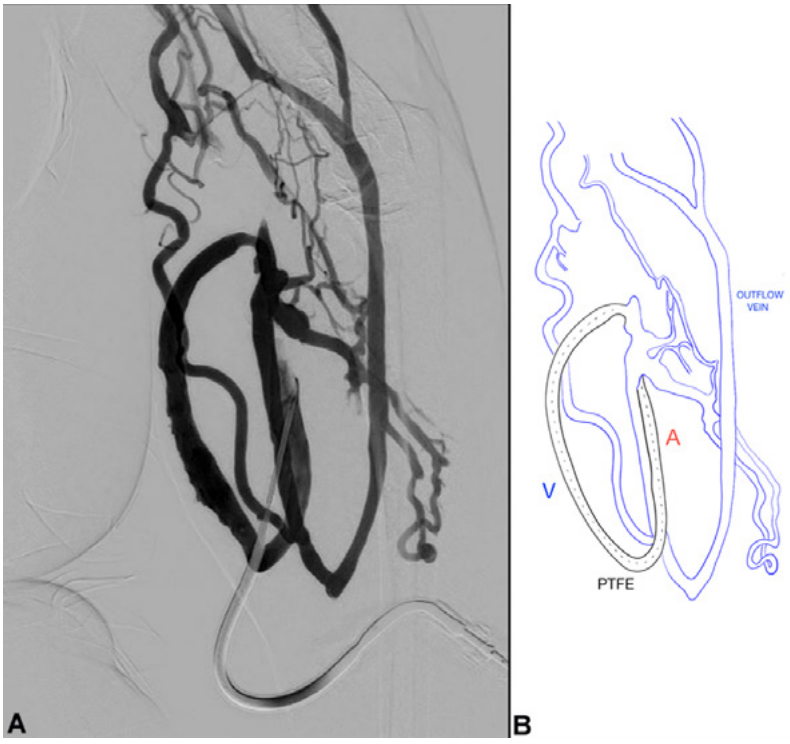

FIGURE 1: A. Venography of the left arm at the level of the elbow. Note the diversion of blood flow to the deep and subsequently to the superficial vein network. The initial arteriovenous graft loop is rather short B. Schematic representation of the venogram (A: graft arterial limb, V: graft vein limb, PTFE: polytetrafluoroethylene).

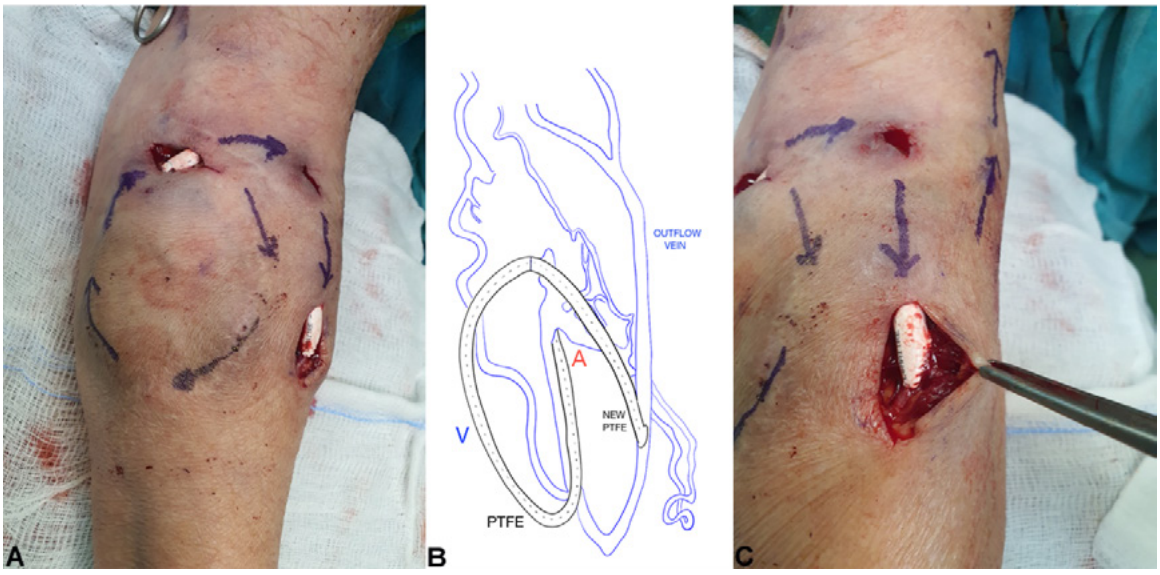

FIGURE 2: A. The “*snail*” operation: The new inserted PTFE portion “looks” antegrade, ending to the large superficial antebrachial vein vessel B. Schematic representation of the procedure. Note that the previous vein anastomosis is interrupted, un-recruiting the outflow deep vein system of the lower arm and creating a different venous drainage pathway C. The new vein anastomosis was performed at the antebrachial superficial mature branch, at its most distal dilated point, in order to considerably increase the puncture area.

superficial vein network using a new PTFE portion in a “*snail*” circuit configuration enabled us to increase the lifespan of the arm regarding the available sites for VA construction. Furthermore, most of the old PTFE portion of this “*snail*” configuration can be punctured immediately for hemodialysis without the need of a central venous catheter (CVC). The “*snail*” configuration resembles to the loop antebrachial “*semi-shunt*” or “*semi-graft*” we described earlier, utilizing a PTFE segment as the arterial limb and a long cephalic vein segment as the vein limb (semi-loop forearm composite graft). Their difference is a

longer PTFE portion (three halves) and a vein anastomosis oriented towards the distal vein network (antegrade direction). Furthermore, un-recruit of the outflow deep vein system of the lower arm and creation of a different venous drainage pathway takes place.

It is obvious that the previous vein anastomosis is interrupted, and the new PTFE portion anastomosed in an end-to-end fashion with the old PTFE segment. Definitely, several other revision options arose for this interesting and complex case. Firstly, a mid-antebrachial autogenous fistula or secondly, an elbow brachial-cephalic fistula could be performed, without interrupting the PTFE graft circuit and without requirement for a CVC. However, these autogenous options render the PTFE graft in danger of thrombosis while awaiting the vein to further mature adequately. Another option is to extend the vein limb of the previous PTFE to the cephalic vein at elbow level using a short PTFE in horizontal position (POLO operation), however, this solution would sacrifice the whole antebrachial cephalic vein and few cm of brachial cephalic vein, even if again a CVC would not be necessary. Preserving the antebrachial vein outflow in the POLO operation and obtain more cm of puncture area would require a supplementary procedure (destroying the vein valves using a valvulotome to obtain retrograde blood flow) but the high possibility of antebrachial edema should not be overlooked.

Preservation of veins is an integral part of the VA plan reported in the latest DOQI guidelines.[2] We managed to do this preserving proximal VA options while transferring the previous VA version to a distal one. This technique can be applied in prosthetic failing VA's, when vein flow is diverted to the deep circulation and simultaneously a superficial and of good caliber distal vein is present. Preferably, the latter should have a long, not deep and continuing path above the elbow.

VA operations like the "*snail*" procedure need experience and preferentially should be performed by VA surgeons.[3,4] Any revision procedure extending the VA lifespan and more importantly lower and upper arm lifespan, is of value. This practice although simplistic, was sound, and enabled the conversion of a purely prosthetic VA to a composite one, with obvious benefits. In contrary to the "distal to proximal, step by step approach", we applied the reversed rule, with the next step to the antebrachial area instead of the brachial area. So far, we perform the "*snail*" procedure in 3 patients. We had one thrombosis 14 months after revision, which was treated extending the PTFE after thrombectomy, few cm proximally to the same outflow vein.

REFERENCES

1 Georgakarakos EI, Xenakis A, Kapoulas KC, Tsangaris S, Georgiadis GS, Lazarides MK. A computational study of the factors influencing pressure in arteriovenous fistulae venous aneurysms. *J Vasc Access* 2013; 14(4): 325-329.

2 Lok CE, Huber TS, Lee T, Shenoy S, Yevzlin AS, Abreo K, et al; KDOQI Vascular Access Guideline Work Group. KDOQI clinical practice guideline for vascular access: 2019 update. *Am J Kidney Dis* 2020;75(4)(suppl 2): S1-S164.

3 Georgiadis GS, Polychronidis A. Access surgery and the role of nephrologists. *Am J Kidney Dis* 2003; 41(5): 1126; author reply 1127.

4 Georgiadis GS, Kantartzi K, Argyriou C. Complex revision operations should be performed only by vascular surgeons and a few expert nephrologists. *J Vasc Access* 2017; 18(1): e6-e7.

Staged Approach of Acute Limb Ischaemia on the Background of Popliteal Artery Aneurysm

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Abstract:

Patients with Popliteal Artery Aneyrysm (PAA) may present, quite often, with Acute Limb Ischaemia (ALI) and despite treatment the risk of amputation remains high due to compromised run-off vessels. Sufficient evidence regarding the techniques to improve the run-off vessels in acute settings remains scarce with literature being inconclusive so far. Herein, we report a case of ALI on the background of PAA which was treated in a stepwise approach. The PAA was initially excluded by open repair through a posterior approach followed by run-off vessel restoration through a combination of endovascular techniques. Procedure was successful and highlights the importance of research of the new available techniques through a multidisciplinary team.

Keywords: Acute Limb Ischaemia, Popliteal Artery Aneurysm

INTRODUCTION

A significant proportion of patients with Popliteal Artery Aneurysm (PAA) may present acutely with limb ischaemia. Given the acute settings, the compromised run-off vessels and the absence of robust data from well-controlled studies to support the decision making, the current pathology remains demanding. Herein, we report a case of Acute Limb Ischaemia on the background of PAA (ALI-PAA) which was treated in a staged manner by combining open surgery and endovascular techniques. Informed consent was obtained from the patient before publishing images and history; therefore, approval by the institutional review board was waived.

CASE PRESENTATION

A 75-year-old female patient with 24-hours complaints of pain and numbness in her Right Lower Limb (RLL), presented initially in a district hospital. Duplex Ultrasound Scan (DUS) revealed a right-hand side PAA with parietal thrombus and absence of doppler signal in her tibial vessels distally; therefore, the patient was immediately transferred as a case of ALI-PAA. Upon presentation, a pale, slightly oedematic RLL with pulsatile mass in the popliteal fossa was noticed. Patient referred impaired sensory at least up to her malleoli and mild muscle weakness affecting her toes. Monophasic arterial doppler signal was limited respectively to peroneal. Patient denied any symptoms of intermittent claudication or swelling, in the past. She had a palpable Dorsalis Pedal artery (DP) in her contralateral leg and her past medical history was significant for Atrial Fibrillation (AF) under oral anticoagulation, dyslipidemia and epileptic seizures. Smoking was successfully ceased five years ago. An urgent Computed Tomography Angiography (CTA) revealed a right-hand side PPA of 4.6cm maximum diameter with mural thrombus. Ipsilateral tibial arteries were patent at the origin. Although there was a beaded appearance distally with sites of occlusion, DP reconstituted through a collateral network (Figure 1). A contralateral PPA was also present with a diameter of less than 2cm. Following an initial 80IU/Kg intravenous (IV) bolus dose of Unfractionated Heparin (UFH), a maintenance dose of UFH at 18IU/Kg/Hr was provided through an IV infusion targeting activated partial thromboplastin time (aPTT) of 46-70sec. Target was achieved through dose adjustments and despite of absence of any significant improvement 24 hours later, UFH pump was ceased and the patient was submitted under general anaesthesia to open repair of her right PPA. Through posterior approach, PPA was exposed, consequently cross-clamped and interposition of 8mm expanded polytetrafluoroethylene graft (PROPATEN®, W. L. Gore & Associates, Flagstaff, AZ, USA) was applied successfully. Upon completion, monophasic peroneal arterial Doppler signal was still present with no significant change in sensory and motor examination. On the first post-operative day parenteral anticoagulation treatment was restored with the plan for adjunctive endovascular procedure. On the second postoperative day, under local anaesthesia, the right common femoral artery was punctured. Diagnostic digital subtractive angiography revealed the patent graft and progressively occluded and thready tibial vessels reflecting the preoperative CTA with distal reconstitution of the pedal arch (Figure 2). The anterior tibial artery was engaged and crossed, reaching distally to DP. Vessel preparation was performed by Stealth 360® Orbital Atherectomy (Cardi-

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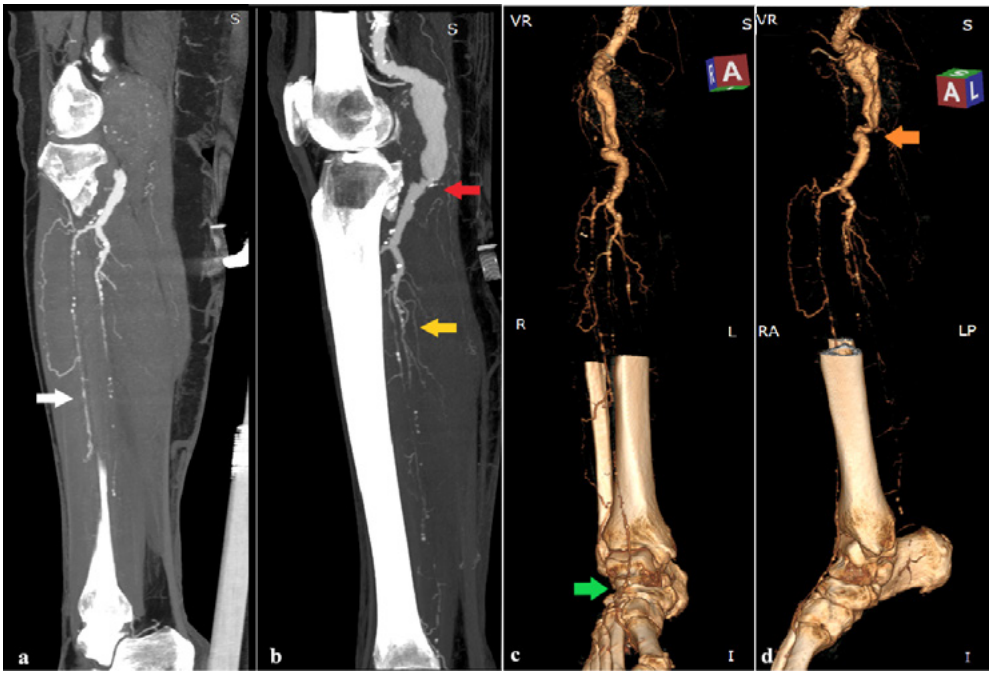

Figure 1. Preoperative Computed Tomography Angiography (CTA) of the Right Lower Limb (RLL). a) On a sagittal plane, white arrow shows the progressively occluded Anterior Tibial Artery (ATA) with beaded appearance and multifocal calcified plaques b) On a sagittal plane, red arrow shows the irregular popliteal lumen due to extensive mural thrombus of the aneurysm. Yellow arrow shows the posterior tibial and peroneal artery with appearance similar to ipsilateral ATA. c) Three-dimensional reconstruction where the green arrow shows the distal thready reconstitution of ATA through the collateral network d) Three-dimensional reconstruction where the orange arrow shows the severe angulation of the distal popliteal artery due to aneurysm formation.

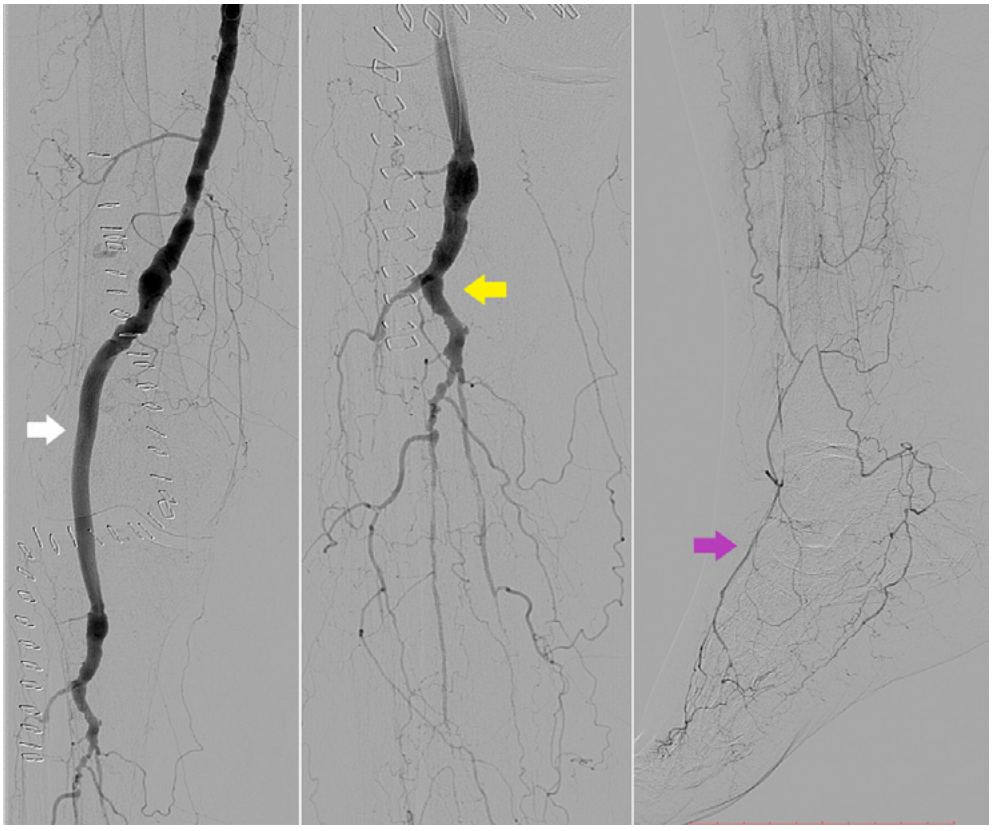

Figure 2. Diagnostic Digital Subtractive Angiography (DSA) of the RLL, on the second postoperative day, following open repair of the popliteal aneurysm through posterior approach. a) White arrow shows the patent interposition synthetic graft. C) Yellow arrow shows the patent trifurcation's orifices. c) Purple arrow shows the reconstitution of dorsalis pedis (DP) and incomplete pedal arch through collateral.

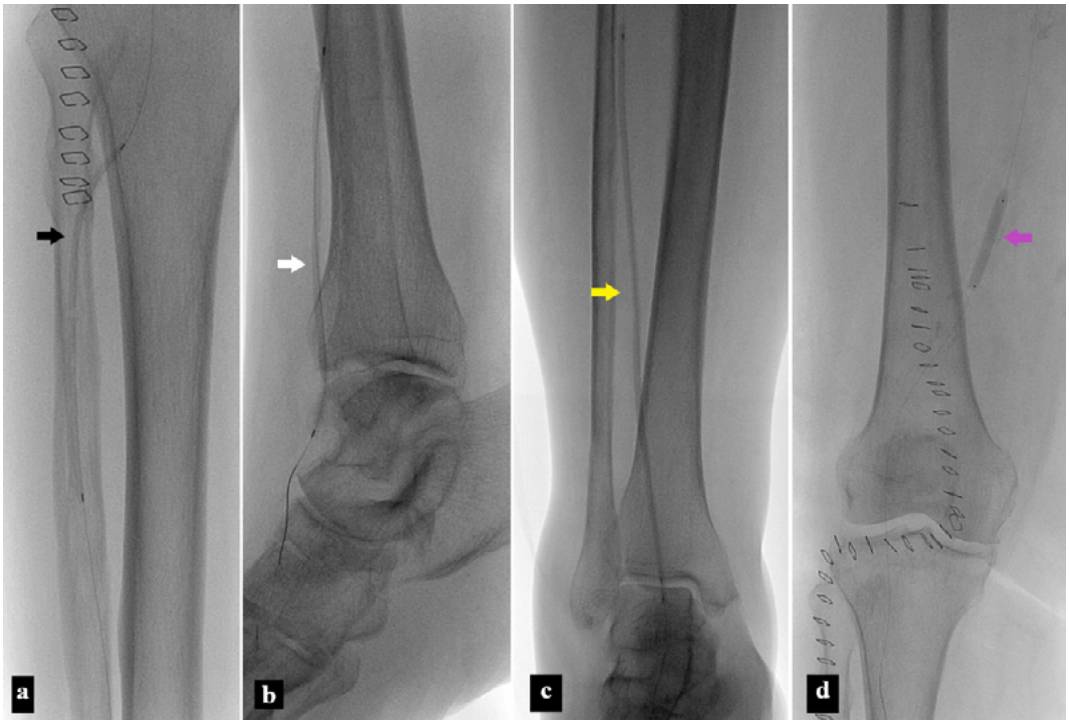

Figure 3. Percutaneous Transluminal Angioplasty (PTA) following the diagnostic DSA of the RLL. a) Black arrow shows balloon angioplasty of proximal ATA b) White arrow shows balloon angioplasty of distal ATA c) Yellow arrow shows balloon angioplasty of the mid-distal ATA d) Pink arrow shows the balloon angioplasty of superficial femoral artery at the level of Hunter's canal.

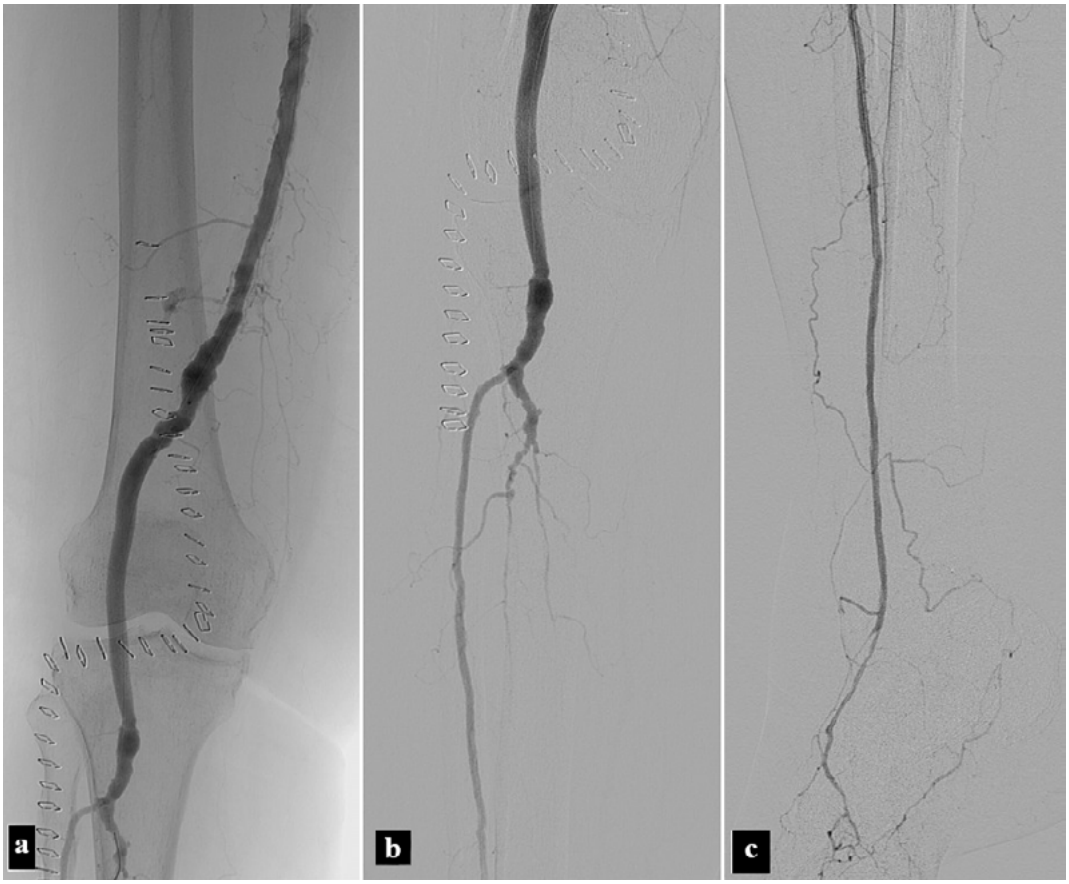

Figure 4. Completion angiography of the RLL following PTA. a) Improved inflow and brisk flow through the interposition graft. b) Restored perfusion of the ATA c) Sufficient opacification of DP and pedal arch.

ovascular Systems Inc., St. Paul, MN,) through the 1.25mm Micro Crown. Subsequently treatment was applied through balloon angioplasty by 3x22mm Ultraverse 014 (BD Interventional, 3rd Street Tempe, AZ, USA) as well as 2.5x100mm Coyote™, (Boston Scientific, Marlborough, MA, USA) (Figure 3a,3b,3c). Eventually, as the improvement of the inflow was succeeded by balloon angioplasty (6x40mm Passeo-18, Biotronik AG, Bülach, Switzerland) aiming at a significant local stenosis at the level of Hunter's canal (Figure 3d), the completion angiography revealed brisk flow to the DP (Figure 4). Clinical examination was significant for a palpable right DP. Although numbness and motor deficit of toes persisted there was no evidence supporting compartment syndrome. Given the history of AF, oral anticoagulation was reinstituted with a 3-month addition of Clopidogrel 75mg. The patient gradually convalesced uneventfully and regained complete function. At 3 months follow-up, patient denied any limb-relating symptoms, the graft was patent on Duplex Scan with palpable DP. Surveillance at 6months interval will continue, monitoring her contralateral PPA.

DISCUSSION

PAA has been reported as a rare disease, albeit the most common peripheral aneurysm. In almost 30 percent of the cases the presentation may be acute with symptoms of thrombosis and despite treatment the risk of amputation is reported as high as 14%[1]. The reason of the acute limb ischaemia may be the PAA thrombosis or distal embolisation or combination of them. Given the extensive mural PAA thrombus, the diminished collateral and the occupied tibial arteries through chronic distal embolization, the caused ALI may be severe and very challenging to treat specially in acute and out-of-hours settings[2]. In our case a narrow lumen inside the PAA of the affected limb was preserved upon presentation. However, the distal tibial arteries had been progressively packed with emboli in combination with multifocal calcified stenoses which in fact "helped" to preserve the pedal arch. A recent Vascunet report, showed that there is significant variability in the approach of PAA[3] calling the physicians to reconsider the endovascular repair (ER). Beuschel et al. conducted a systematic review and metanalysis of treatment and natural history of PAAs showing that open repair (OR) is more durable than ER[4]. Based on that study the Society of Vascular Surgery (SVS) published guidelines[5] dedicated to PAAs were although they do not recommend against ER, as the European Society of Vascular Surgery did with the guidelines on ALI[6], they recommend that the management of ALI-PAA should be based on the severity of ALI on presentation. More specifically, SVS recommend thrombolysis or pharmacomechanical intervention (PMI) to improve the runoff vessels for patients with mild or moderate ALI (Rutherford I and IIa) and prompt OR or ER with adjunctive thromboembolectomy (TEE) or PMI for severe ALI (Rutherford IIb). There is a controversy in literature regarding the preoperative thrombolysis (PT) with Kropman et al reporting no significant benefit on amputation rate by analysing data of 895 ALI-PAA cases[1] and on the other hand Ravn et al. reported significantly better results for PT on 235 ALI-PAA patients; however both of these studies lack of data regarding the severity of ischaemia. More recent studies focusing on the intraoperative thrombolysis (IT) during OR in ALI-PAA showed improved outcomes[7,8]. The complexity of the ALI-PAA management is reflected in the compromised run-off. In our case, a potential tibial TEE through medial approach would cause more damage than outflow restoration given the beaded, calcified appearance as well as the size of the vessels. On the other hand, given the thrombotic burden of the PAA, any endovascular intervention prior to aneurysm exclusion would pose the risk of further embolic events[7]. Therefore, we chose the posterior approach to exclude the aneurysm with the least insult and on a second stage improve the outflow through endovascular approach. Any potential delay between the stages would have risked the bypass, hence a good collaboration in a multidisciplinary team is crucial. As far as we are concerned, this is the first report in English literature of a staged approach to treat ALI-PAA, where initial OR excluded the PAA and subsequently endovascular techniques safely restored the run-off.

CONCLUSION

Treatment of ALI-PAA may be challenging. Versatility and great collaboration in a multidisciplinary team provide the best outcome.

REFERENCES

1 Kropman RHJ, Schrijver AM, Kelder JC, Moll FL, de Vries JPPM. Clinical Outcome of Acute Leg Ischaemia Due to Thrombosed Popliteal Artery Aneurysm: Systematic Review of 895 Cases. *Eur J Vasc Endovasc Surg*. 2010;39(4):452-457. doi:10.1016/j.ejvs.2009.11.010

2 Ravn H, Björck M. Popliteal Artery Aneurysm with Acute Ischemia in 229 Patients. Outcome after Thrombolytic and Surgical Therapy. *Eur J Vasc Endovasc Surg*. 2007;33(6):690-695. doi:10.1016/j.ejvs.2006.11.040

3 Grip O, Mani K, Altreuther M, Bastos Gonçalves F, Beiles B, Cassar K, et al. Contemporary Treatment of Popliteal Artery Aneurysms in 14 Countries: A Vascunet Report. *Eur J Vasc Endovasc Surg*. 2020;60(5):721-729. doi:10.1016/j.ejvs.2020.07.005

4 Beuschel B, Nayfeh T, Kunbaz A, Haddad A, Alzuabi M, Vindhyal S, et al. A systematic review and meta-analysis of treatment and natural history of popliteal artery aneurysms. *J Vasc Surg*. 2022;75(1):121S-125S.e14. doi:10.1016/j.jvs.2021.05.023

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(1):109S-120S. doi:10.1016/j.jvs.2021.04.040

6 Björck M, Earnshaw JJ, Acosta S, Gonçalves FB, Cochennec F, Debus SE, et al. Editor's Choice - European Society for Vascular Surgery (ESVS) 2020 Clinical Practice Guidelines on the Management of Acute Limb Ischaemia. *Eur J Vasc Endovasc Surg*. 2020;59(2):173-218. doi:10.1016/j.ejvs.2019.09.006

7 Gabrielli R, Rosati MS, Carra A, Vitale S, Siani A. Outcome after preoperative or intraoperative use of intra-arterial urokinase thrombolysis for acute popliteal artery thrombosis and leg ischemia. *Thorac Cardiovasc Surg*. 2015;63(2):164-167. doi:10.1055/s-0034-1378189

8 Jungi S, Kuemmerli C, Kissling P, Weiss S, Becker D, Schmidli J, et al. Limb Salvage by Open Surgical Revascularisation in Acute Ischaemia due to Thrombosed Popliteal Artery Aneurysm. *Eur J Vasc Endovasc Surg*. 2019;57(3):393-398. doi:10.1016/j.ejvs.2018.09.030

CONCURRENT CAROTID ENDARTERECTOMY AND CORONARY ARTERY BYPASS GRAFTING VS. ISOLATED CORONARY ARTERY BYPASS GRAFTING: A SYSTEMATIC REVIEW AND META-ANALYSIS OF RCTS AND PROPENSITY-MATCHED STUDIES

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Background-Aims: Patients with concomitant carotid and coronary artery disease face a surgical dilemma, with ongoing debate over whether CABG alone or concurrent carotid endarterectomy (CCC) offers better outcomes. Conflicting evidence has led to weak ACCF/AHA guidelines (Class IIa/b, Level C), reflecting the lack of high-quality data. While some studies suggest CCC reduces stroke risk, others report increased perioperative morbidity without a survival benefit. Our meta-analysis aims to clarify these uncertainties and guide surgical decision-making.

Methods: A thorough search of the literature was conducted in PubMed, Scopus, and Cochrane Library to identify randomised controlled trials and propensity matched studies involving patients with concurrent coronary and carotid artery disease who underwent either isolated CABG or CCC. Pooled statistical analyses, including odds ratios (OR) and mean differences (MD) with 95% confidence intervals, were performed using RevMan 8.13.0.

Results: A total of five studies, encompassing 23,916 patients, were included, with 29% undergoing CCC. CCC was associated with a significantly higher incidence of stroke compared to CABG alone [OR 1.47; 95% CI 1.07-2.00; p = 0.03; I^2 = 17%], indicating an increased perioperative neurological risk. However, 30-day mortality did not differ significantly between the two groups [OR 1.23; 95% CI 0.33-4.56; p = 0.68; I^2 = 85%]. Similarly, there were no significant differences in major adverse cardiovascular events (MACE) [OR 1.10; 95% CI 0.49-2.51; p = 0.75; I^2 = 91%], myocardial infarction (MI) [OR 0.93; 95% CI 0.17-5.06; p = 0.87; I^2 = 23%, or hospital length of stay [MD 1.85 days; 95% CI -11.91 to 15.61; p = 0.34; I^2 = 93%].

Conclusion: Our findings suggest that while combined revascularisation may not confer a mortality benefit or reduce cardiovascular complications, the elevated stroke risk warrants careful patient selection. Given the lack of clear survival benefit, further high-quality randomised controlled trials are needed to refine surgical guidelines and optimise patient outcomes.

Thursday May 15,2025
Conference Room 2
15.00-16.40

THE POST-IMPLANTATION SYNDROME AND ITS OUTCOME AFTER ELECTIVE ENDOVASCULAR REPAIR OF ABDOMINAL AORTIC ANEURYSM WITH THE NEWEST 4TH GENERATION DEVICES

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Background-Aim: Postimplantation syndrome (PIS) is a systemic inflammatory response occurring in the early phase after endovascular repair for abdominal aortic aneurysm (AAA). The aim of the study is to evaluate the inflammatory response and its outcome after elective standard endovascular repair of abdominal aortic aneurysms (EVAR) with newer-generation devices.

Methods: Consecutive patients undergoing standard EVAR were included in the study from August 2024 to March 1, 2025. Patients with perioperative infection, cancer, autoimmune disease, and those receiving long-term anti-inflammatory medications were excluded. Epidemiological characteristics, comorbidities, temperature, white blood cell count, C-reactive protein (CRP), platelet count, serum interleukin IL-6 concentration, creatinine, urea, and coagulation parameters (INR, PT, APTT, fibrinogen) were measured preoperatively, 24, and 48 hours postoperatively. To analyze changes in biomarker levels and assess the potential impact of endograft type, pairwise differences between time points and post-hoc pairwise comparisons were performed using Bonferroni correction to control for multiple comparisons, ensuring a more conservative estimate of significance.

Results: The study included 63 consecutive patients. The type of endograft implanted was Ankura-Lifetech: 13, Treovance-Bolton: 10, Excluder-Gore: 9, AFX-Endologix: 5, Zenith-Cook: 4, Endurant-Medtronic: 4, Alto-Endologix: 4, Incraft-Perquios: 3, Altura-Lombard: 2, Anaconda-Terumo: 1. Changes in biomarker levels and differences between time points are described in Table 1. After endovascular repair, there was a significant decrease in Hb and PLT levels, while WBC, CRP, and IL-6 showed a significant increase (Table). Renal function markers showed small variations without clinical significance. The type of endograft (manufactured polyester vs. polytetrafluoroethylene) did not significantly affect the trends of biomarkers postoperatively. Platelet count decsrease reflects platelet consumption or aneurysm sac clotting after surgery. The postoperative increase in fibrinogen levels reflects an acute phase response that potentially contributes to transient hypercoagulability. Subgroup analysis was not able to show significance between individualized different types of endografts.

Conclusions: The postimplantation syndrome was apparent during the first 24 and 48 hours postoperatively and was not associated with perioperative adverse clinical events showing a benign course.

ULTRASOUND DIAMETER-BASED GRADING IN CAROTID ARTERY STENOSIS

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Background-Aim: Flow velocity measurement and spectral analysis by duplex ultrasonography (DUS) are widely recognized as standard methods for assessing carotid stenosis. While angiographic methods rely on diameter-based grading, its application in DUS remains limited. This study evaluated the use of diameter-based grading using ultrasonography.

Methods: Patients who underwent a bilateral carotid ultrasound in our institution were included in the study. Patients >50% diameter stenosis, previous carotid interventions and non-atherosclerotic conditions were excluded. The internal carotid artery diameter (ICAd) was assessed on both sides. Using tri-axial DUS measurements (anterior, lateral, and posterior windows), the minimal residual lumen (MRL) was assessed. The maximum peak systolic velocity (PSV), end-diastolic velocity (EDV) and degree of spectral broadening within each ICA was also recorded.

Results: There were 400 arteries in 200 patients (100 male, 100 female) with a mean age of 67 years (range 50-87). The mean distal ICA diameter was 4.8 mm (95% CI: 4.7-4.9), with males having a larger mean ICAd (5.1 mm) compared to females (4.5 mm). Among all patients, only 3 females had an ICAd <4.0mm (1.5% among females and 0.75% among all patients). For detecting >50% ICA diameter stenosis, an MRL of ≤2 mm demonstrated a detection rate of 99% overall (100% in males, >98% in females). For detecting >75% ICA diameter stenosis, an MRL of ≤1 mm had a detection rate of 99% overall (100% in males, >98% in females).

Conclusion: Given that ICAd is ≥4.0mm almost in all patients, an MRL of 2mm is a safe cut-off for detecting a >50% diameter stenosis. Furthermore, a cut-off at 1mm would detect equally well a >75% diameter stenosis. As the ICAd is often larger than the 4mm used here, the above cut-off values would only underestimate stenosis.

INFLUENCE OF LATENCY AND APPLIED FORCE ON ACCURACY IN AN ENDOVASCULAR SIMULATION TASK: INSIGHTS FOR ROBOTIC TELESURGERY

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Background-Aim: Accurate force application and control are critical in endovascular procedures, which may be compromised by latency in robotic or telesurgical systems. The aim of this study was to examine the impact of latency and applied force on accuracy in an endovascular procedure simulation task and to assess the potential of haptic feedback in enhancing task accuracy.

Methods*:* A prospective, cross-sectional experimental study was conducted using a custom-build endovascular procedure simulator. In this study, 116 healthy volunteers performed a task where they were asked to maintain a target force (0.6N, 1.2N, or 1.8N) under different latency conditions (0, 100, 200, and 400 ms). The time duration for which participants successfully maintained the target force within the 10-second interval was recorded. The impact of latency and force was evaluated across three distinct age groups: Group 1 (18-25 years), Group 2 (35-45 years), and Group 3 (55-65 years).

Results*:* The youngest group consistently achieved the best results, while the oldest group showed the lowest results across all tasks. The Kruskal-Wallis test found statistically significant performance differences between age groups ($p<0.05$). Post hoc analysis revealed a statistically significant gap between the youngest and oldest groups in all tasks. The Friedman test indicated significant differences across force and latency conditions ($p<0.05$). Post hoc analysis further confirmed significant variations between all force and latency conditions, except for the 400 ms latency, where no significant difference was observed between 1.2N and 1.8N ($p>0.05$). Spearman's correlation analysis showed a strong negative correlation between latency and duration ($\rho=-0.642$) and a weak negative correlation between force and duration ($\rho=-0.257$), emphasizing the substantial effect of increased latency on task performance. *Conclusions*: This study demonstrated that increasing latency and higher applied force both impair performance, with latency having a more substantial impact. These results emphasize the importance of minimizing latency, particularly in older populations. Additionally, the findings suggest that haptic feedback technology may be more beneficial at lower force levels, warranting further investigation of its potential benefits.

THE IMPACT OF FRAILTY AND CLINICAL RISK FACTORS ON GROIN INFECTIONS AND POSTOPERATIVE OUTCOMES FOLLOWING CLEAN VASCULAR PROCEDURES

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BACKGROUND-AIM: Surgical site infections in the groin following clean vascular procedures are associated with significant morbidity, increased healthcare costs, and adverse postoperative outcomes. While established risk factors such as obesity, diabetes, and reintervention have been widely studied, the role of frailty remains underexplored. This study aims to evaluate the impact of frailty on the incidence of groin infections and its correlation with adverse clinical outcomes, including reintervention, amputation, and mortality. Clean vascular surgery is defined as planned, non-emergency and emergency procedures performed without pre-existing infection. Understanding the role of frailty in these patients could help refine preoperative risk stratification.

METHODS: A retrospective, single-center observational study was conducted on patients who underwent clean vascular groin surgery between August 2022 and December 2023. Frailty was assessed using the Clinical Frailty Score (CFS). The primary endpoint was the incidence of groin infections, classified according to the Centers for Disease Control and Prevention (CDC) criteria. Secondary endpoints included reintervention, limb amputation, and all-cause mortality, as these are strongly correlated with infection and can be impacted by frailty. Univariate and multivariate logistic regression analyses were employed to identify independent predictors of groin infections and postoperative complications. The study aimed to evaluate the potential mechanisms through which frailty contributes to poor outcomes.

RESULTS: A total of 357 groins of 308 patients were included, with a median follow-up period of 20 months. The overall incidence of groin infections was 16.8%. High frailty (CFS ≥5) was independently associated with an increased risk of groin infections (OR: 2.83, p=0.0003), reintervention (OR: 5.79, p<0.0001), amputation (OR: 6.95, p<0.0001), and mortality (OR: 2.42, p=0.0078). Diabetes (OR: 2.75, p=0.0004) and hypoalbuminemia (OR: 0.92 per 1g/L decrease, p=0.0003) were also identified as significant predictors of infection and adverse outcomes. Hypoalbuminemia is thought to contribute to impaired immune response, thus increasing the risk of infection.

CONCLUSIONS: Frailty is a critical determinant of surgical site infections and postoperative morbidity in patients undergoing vascular groin procedures. Incorporating frailty assessment into preoperative risk stratification may facilitate more precise patient selection and perioperative management. Targeted interventions addressing frailty-associated vulnerabilities could potentially mitigate the incidence of infections and improve long-term surgical outcomes.

EVALUATING THE CLINICAL PROFILE OF THORACIC ENDOVASCULAR AORTIC REPAIR IN BLUNT THORACIC AORTIC INJURY: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Background & Aims: Blunt thoracic aortic injury (BTAI) is a critical vascular emergency associated with high mortality rates. Thoracic endovascular aortic repair (TEVAR) is considered the gold-standard treatment for this condition. This meta-analysis seeks to provide a comprehensive evaluation of the clinical profile and outcomes associated with TEVAR in the management of BTAI.

Methods: A systematic review was undertaken using a rigorous methodology. This involved conducting searches across multiple electronic databases using defined search terms while adhering to stringent pre-established inclusion and exclusion criteria in accordance with the Cochrane Handbook and the PRISMA-2020 guidelines. Proportional meta-analysis was executed using Comprehensive Meta-Analysis software (version 4).

Results: A total of 117 studies comprising 29,972 patients were analyzed. The mean age was 42.3 years, with 74.9% being male. The mean Injury Severity Score (ISS) was 35.9, and the distribution of spinal cord injury grades was as follows: Grade 1 at 8%, Grade 2 at 18.1%, Grade 3 at 62.3%, and Grade 4 at 14.9%. The in-hospital and 30-day mortality rate was reported at an aggregated rate of 6.2%. A meta-regression analysis investigating the relationship between mortality and delayed intervention (defined as greater than 24 hours) demonstrated a significant inverse correlation (Regression Coefficient: -3.3, P-value=0.0007, I^2=87.9%). The incidence of postoperative stroke and endoleak was aggregated at 3.2% and 3%, respectively. Coverage of the left subclavian artery (LSA) was noted in 37.3% of the patients. A sub-analysis was performed to examine the association between BTAI grade and 30-day mortality, which indicated a weak and non-significant correlation (Regression Coefficient: 0.455, P-value=0.2588). Additionally, a meta-regression assessing the relationship between LSA coverage and left arm symptoms did not yield a significant re-

lationship (Regression Coefficient: 2.46, P-value=0.5524, I^2=85.8%). However, a significant inverse relationship was identified between LSA coverage and stroke incidence (Regression Coefficient: -7.4, P-value=0.0272, I^2=84.7%).

Conclusion: The management of BTAI poses significant challenges due to its associated high morbidity and mortality rates. However, TEVAR has emerged as a safe and effective intervention, yielding favourable outcomes for patients. Early diagnosis and timely referral to trauma centres equipped with TEVAR capabilities are essential to enhance survival rates and overall patient prognosis. Continued emphasis on these critical factors is necessary to improve the treatment of BTAI.

TEVAR VERSUS OPTIMAL MEDICAL THERAPY FOR UNCOMPLICATED TYPE B AORTIC DISSECTION - A SYSTEMATIC REVIEW & META-ANALYSIS

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Background-Aim: This meta-analysis reviewed outcomes of patients with uncomplicated Type B aortic dissection (unTBAD) treated with either thoracic endovascular aortic repair (TEVAR) plus optimised medical therapy (OMT) or OMT alone. The study evaluated both short-term and long-term outcomes to assess whether TEVAR improved overall mortality and reduced complications such as retrograde type A dissection, stroke, paraplegia, and aortic remodelling.

Methods: We conducted comprehensive searches on PubMed, Ovid, Scopus, and EMBASE to identify studies comparing long-term outcomes of TEVAR and OMT for Uncomplicated Type B Aortic Dissection. Using the PICO framework and adhering to PRISMA guidelines, we formulated the search query. The search was limited to titles and abstracts and included thorough citation reviews. Each study was evaluated against strict inclusion and exclusion criteria for eligibility. Statistical analysis was performed using Jamovi (Version 2.5) from the Jamovi project (2024).

Results: The total number of patients with uncomplicated Type B aortic dissection is 25650, with 21041 receiving optimal medical therapy (OMT) and 4,609 treated with TEVAR. The OMT group had an average age of 61.7 years, with 69.7% treated in the acute phase (<15 days). Their mean maximum aortic diameter was 38.5 mm, and the false lumen diameter averaged 25.4 mm. In the TEVAR group, the average age was 59.7 years, with 76.2% treated acutely. The average maximum aortic diameter was 40.2 mm, and the false lumen diameter was 26.4 mm. A pooled analysis showed no significant difference in 30-day and in-hospital mortality rates (log odds ratio 0.1058, p = 0.4971). However, a random-effects model indicated a log odds ratio of -1.3696, resulting in an odds ratio of 0.2542 (p < 0.0001). Survival rates were 95.4% for the OMT group and 98% for the TEVAR group. At 1 year, survival was 90.2% for the OMT group (95% CI: 85.7-90.7) and 94% for the TEVAR group (95% CI: 90.6-

97.5). At 2 years, OMT survival was 71.8% (95% CI: 63.4-80.1) compared to 83.7% for TEVAR (95% CI: 75.6-91.8). At 3 years, survival was 82.2% for OMT (95% CI: 77.4-87) and 89.9% for TEVAR (95% CI: 86.1-93.7).

Conclusions: The role of Thoracic Endovascular Aneurysm Repair (TEVAR) in managing uncomplicated Type B Aortic Dissection (unTBAD) remains debated. While studies show improved aortic remodelling post-TEVAR, there is no definitive evidence for increased survival rates. It is essential to conduct randomised trials and develop guidelines that include high-risk features for assessing this complex patient group.

NOVEL MECHANICAL THROMBECTOMY TECHNIQUES FOR UPPER EXTREMITY DEEP VEIN THROMBOSIS: A SINGLE CENTER CASE-SERIES

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Abstract: Background-Aim: Upper extremity deep vein thrombosis (UEDVT) has been widely managed with anticoagulation and selectively with catheter directed thrombolysis (CDT) targeting prompt venous recanalization. CDT, however, comes with a bleeding risk and complex perioperative logistics. Novel percutaneous mechanical thrombectomy (MT) devices can potentially simplify the procedure, its safety and efficacy though remain unknown.

Methods: In this single center study, we review the outcomes on 8 patients with symptomatic UEDVT treated with 3 different devices: the ClotTriever system (Inari Medical, Irvine, CA), the Aspirex Mechanical Aspiration Thrombectomy System and the Penumbra System (Penumbra Inc, Alameda, California, USA), with or without subsequent first rib resection and venoplasty.

Results: MT through basilic or brachial vein access was performed and successfully completed in all 8 patients. No major adverse events were noted and the patients were discharged within 24 hours. Five out of 8 patients underwent subsequent first rib resection and for 3 of them balloon venoplasty was additionally performed. At 2 years mean follow up, 6 out of 8 patients were free of symptoms without UEDVT recurrence. Two patients had partial symptom relief, one of them due to re-thrombosis.

Conclusion: For the management of symptomatic UEDVT, mechanical thrombectomy using novel technologies is feasible with high technical and clinical success.

PREEMPTIVE TEVAR AFTER TYPE I AORTIC DISSECTION REPAIR: THE ERADICARE TRIAL ON AORTIC REMODELING AND MID-TERM OUTCOMES

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Objectives: Persistent distal false lumen following surgery for DeBakey type I acute aortic dissection (AAD) is associated with an increased risk of adverse aortic events (AAEs). This pilot randomized controlled trial aimed to assess whether elective thoracic endovascular aortic repair (TEVAR), performed 1-3 months after type I AAD surgery in selected high-risk patients, promotes aortic remodeling and improves clinical outcomes.
Methods: Thirty-two patients who underwent surgical repair for type I AAD were randomized to either elective TEVAR (n = 15) or standard conservative management (n = 17). Eligibility criteria based on CT angiography included: (a) a re-entry tear in Ishimaru zones 3 or 4, and (b) a maximum descending thoracic aorta (DTA) diameter >40 mm and/or a false lumen diameter >20 mm. One-year follow-up included clinical assessment and CT angiography.
Results: The TEVAR group exhibited significantly more favorable aortic remodeling than the conservative group, as demonstrated by greater reductions in total aortic diameter (zones 2-9), greater increases in true lumen diameter (zones 3-8), and greater reductions in false lumen diameter (zones 2-8). Complete false lumen thrombosis was also more frequent in the TEVAR group (zones 2-6). Clinically, the TEVAR group had significantly lower rates of dissection extension (0% vs. 29.4%; $p = 0.050$), rehospitalization due to complications (0% vs. 58.8%; $p < 0.001$), and long-term AAEs (20.0% vs. 58.8%; $p = 0.026$).
Conclusions: In selected high-risk patients, performing TEVAR 1-3 months after surgical repair of type I AAD promotes aortic remodeling and improves mid-term clinical outcomes.

DEEPSEEK AND GRAPHRAG MAKE AN ALMOST FLAWLESS EVIDENCE-BASED TOOL FOR CARDIOVASCULAR CLINICAL DECISION-MAKING

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Background-Aim: Artificial intelligence (AI) can change medical practice only if accurate, reliable, and evidence-based output is available. Large Language Models (LLMs) provide valuable insights into medical literature by synthesizing vast amounts of medical literature, However, issues such as "hallucinated" facts, inconsistent responses, and inadequate documentation persist. To solve these challenges, DeepSeek R1 is combined with a Graph Retrieval Augmented Generation (GraphRAG) approach. This study evaluated the system's accuracy, consistency, and transparency when asked questions on the "2021 ESC Guidelines on cardiovascular disease prevention in clinical practice".

Methods: A pipeline has been developed that integrates knowledge graph creation, question parsing, document retrieval, and response generation. ESC Guidelines 2021 were incorporated into the knowledge graph, which facilitates structured, node-edge-based navigation of key concepts and recommendations. DeepSeek R1 answered queries by consulting graph-based evidence nodes, ensuring all outputs were firmly grounded in the retrieved information. We tested the pipeline against a series of 34 questions adapted from the "CardioNerds Decipher the Guidelines" initiative which is a trusted source of cardiovascular education. Each answer was assessed for correctness, citation of guidelines, and consistency when re-queried.

Results: The system correctly answered 33 of 34 questions, achieving an accuracy of 97%. For the remaining question, which fell outside the scope of the ESC Guidelines, DeepSeek R1 accurately identified that the requested information was unavailable within the knowledge base. It is noteworthy that no hallucinatory data or spurious citations were detected, underscoring the reliability of the GraphRAG approach. The results of repeated testing were consistent, with each answer referring directly to specific guideline sections. With this evidence-based, citation-driven framework, users could verify results quickly and remain confident in the system's outputs

Conclusions: Integrating DeepSeek R1 with Graph Retrieval Augmented Generation workflow, we demonstrate a high-performing, transparent, and reliable AI-driven clinical decision support tool, achieving 97% accuracy in a cardiovascular guideline-based evaluation. The knowledge graph's structured representation ensures that all responses remain grounded in verifiable evidence, which eliminates hallucinations and enhances user confidence. As AI continues to evolve, this approach provides a scalable blueprint for evidence-based practice across many fields of medicine.

FIRST-IN-EUROPE USE OF A TAPERED SELF-EXPANDING BRIDGING DEVICE IN ENDOVASCULAR THORACOABDOMINAL AORTIC ANEURYSM REPAIR

Efthymios Beropoulis, Konstantinos P. Donas

Introduction: Bridging devices in endovascular thoracoabdominal aortic aneurysm repair are key factors in term of sufficient and durable exclusion of the treated pathologies. In an era of balloon expandable covered stents, self-expanding endografts can address issues such as severe kinking and elongation of the target vessels.

Results: A 73-year-old female patient with a symptomatic thoracoabdominal aortic aneurysm (TAAA) and severe elongation of the left renal artery was treated endovascularly by the G-Branch device, at our institution. The left renal artery had a diameter of 5mm, upward orientation and stenosis of the orifice of the left renal artery. After deployment of the multibranched device and the cannulation of the left renal branch, different catheters and wires were used to achieve a stable position of the Rosen wire (Cook) and advance over the 7F sheath the Silverflow endoprosthesis (Lifetech) with a tapered design of 5mm distally and 7mm proximally. The trackability and placement accuracy of the device despite the challenging anatomy was very satisfactory. Completion angiography ensured free flow to the renal artery and also exclusion of the aneurysm. Post-operative computed tomography angiography confirmed the stenosis-free patency of the endoprosthesis and organ perfusion.

Conclusions: First-in-Europe use of a tapered self-expanding bridging device in endovascular thoracoabdominal aortic aneurysm repair was successful and promising. Further data and meticulous follow up is needed.

GENDER-BASED DIFFERENCES IN OPEN AND ENDOVASCULAR TREATMENT OF PERIPHERAL ARTERIAL DISEASE IN DIABETIC PATIENTS

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Background-Aim: Periferal arterial disease (PAD) manifests as claudication, ischemic rest pain or tissue loss. While PAD prevalence is similar or higher in women, the relationship between risk factors, PAD symptoms and treatment outcome varies by sex. The aim of this study is to analyze the outcomes of open and endovascular treatment of PAD in patients with diabetes based on gender.

Methods: This is retrospective analysis of patient data from 2018 to 2022. The primary outcome was to compare amputation free survival between male and female diabetic patients with PAD treated with open or endovascular treatment.

Results: Study included 420 diabetic PAD patients, 307 (73.1%) males and 113 (26.9%) females. In females most prevalent comorbidities were hypertension (98.2% vs 89.6%, p=0.04) and stable angina pectoris (17.7% vs 5.5%, p<0.001). Men had more positive family history of cardiovascular disease 183 (59.6% vs 38.1%, p<0.001). Claudication's were more common in women (59.3% vs 38.4%, p<0.001), while wounds were more common in men (35.8% vs 17.7%, p<0.001). Among endovascular procedures femoropopliteal segment as target lesion was more common among female patients (60.7% vs 41.5%, p<0.001) and among men infrapopliteal segment (31.2% vs 9.6%, p<0.001). For open surgery female patients had more aortobifemoral surgery (90.4% vs 68.8%, p<0.001) and men had more femoropopliteal below the knee reconstruction (22.6% vs 7.4%, p<0.001). The mean follow up was 10 months. Major amputation occurred in 43 cases - 3 in the female group and in 40 in male group (p=0.001). Mean major amputation free period for women was 15 months (range: 0-54) while for men was 9 months (range: 0-51). Higher percentage of men had an amputation of the ipsilateral extremity prior to current open or endovascular procedures compared to women (12.4% vs 4.4%, p=0.017). During follow up period there was 1 (0.2%) death among men and it was not related to the revascularisation procedure.

Conclusions: This study revealed that male diabetic patients had a significantly higher incidence of PAD with wound presentation, as well as a greater rate of major amputations during follow-up, due to more distal atherosclerotic lesions when compared to female. These findings highlight the crucial need for early intervention and vigilant monitoring, particularly in male PAD diabetic patients.

PERIPHERAL GRAFT INFECTION - A RARE BUT TRICKY CONDITION THAT BRINGS ALONG SOME SERIOUS COMPLICATIONS

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Stent infections are a rare yet serious and potentially life-threatening complication following endovascular procedures. It is essential to understand their incidence, risk factors, clinical signs, treatment options, and outcomes to enhance patient care and improve overall results.We report a case of a 63-year old man with a pseudoaneurysm of the external iliac artery due to a stent infection that was successfully treated by performing a bypass using a reversed saphenous vein graft-a semi-NAIS technique- and performed a systematic review of the literature to identify the incidence about the epidemiology, clinical presentation, management, and prognosis of these rare cases of graft infections.

We included all the studies that were published until January 2025, reporting 33 patients with stent infection and 23 with stent graft infections.The average age of patients was 63 years, with 71% of them being male. The average time from implantation to infection was 390 days for stents and 786 days for stent grafts.Patients typically present with fever, leukocytosis, and local symptoms such as pain, swelling, abscess formation, and distal embolization. Stent infections in the abdominal area tend to manifest with more severe symptoms, often including abscesses, retroperitoneal hematomas, and pseudoaneurysms.Surgical removal of the infected stent was carried out in 87% of cases. In seven instances, the stent was not removed, and four of these cases were treated exclusively with antibiotic therapy. Revascularization was successfully achieved in 71% of patients, primarily through in situ vein bypass, with the second approach being an extra-anatomic synthetic bypass graft.

Peripheral graft infections are rarely reported, with the iliac arteries being the most commonly affected. These infections tend to present earlier and are associated with higher rates of amputation and mortality compared to other peripheral sites.

MANAGEMENT OF INTERNAL ILIAC ARTERY DURING ENDOVASCULAR TREATMENT OF AORTOILIAC ANEURYSMS- 3 YEAR EXPERIENCE OF OUR DEPARTMENT

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Background-aim: Iliac artery aneurysms are rare when occurring in isolation; however, they are often found in conjunction with abdominal aortic aneurysms in up to 40% of cases. When faced with an inadequate distal landing zone or aneurysmal iliac arteries, a decision must be made: either to relocate the landing zone more distally and sacrifice the internal iliac artery or to preserve it. This study aims to describe our early 3-year experience in endovascular management of internal iliac arteries.

Methods: From February 2022 to February 2025, forty-one consecutive patients with aortoiliac aneurysms were treated with endovascular techniques in our department.

Results: Men were 97.6% of patients, and their mean age was 75 years. Thirty patients underwent EVAR procedure with occlusion of one internal iliac artery (with or without embolization), three patients underwent bilateral IIA occlusion in order to treat type IB endoleaks, six patients received iliac branch devices and two patients received a stent-graft in the common iliac artery. Technical success was achieved at a rate of 100%, regardless of the technique employed, and no major complications or 30-day mortality were observed.

Conclusions: Occlusion of the internal iliac artery used to be the standard procedure to overcome sealing issues. The introduction of techniques for preserving the internal iliac artery represents a significant advancement in the treatment of aorto-iliac aneurysms, as they demonstrate high technical success and low morbidity while reducing the risk of pelvic ischemia.

CAROTID ARTERY ANGIOPLASTY AND STENTING: A 15-YEAR EXPERIENCE

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Purpose: The aim of this study is to present our 15-year experience (2009-2024) with carotid artery angioplasty and stenting (CAS) and document the evolution of this technique over the specified period.

Materials and Methods: We retrospectively analyzed data from 394 patients (278 males; mean age 69 years) who underwent CAS. Of these, 254 (64.5%) were symptomatic, and 201 (51%) had left-sided lesions. All patients were treated with self-expanding stents and distal filter-type cerebral protection devices. Access was achieved via the femoral artery in all cases except one, which required access through the right brachial artery. Conversion to open carotid endarterectomy was performed in 3 patients due to technical difficulties (anatomical variations, challenging catheterization).

Results: In this patient cohort, perioperative stroke occurred in 5 patients (1.3%). Bradycardia was observed in 68 patients (16%), while hypotension occurred in 57 patients (14.5%). No deaths were reported within the first 30 days post-procedure. None of the prognostic risk factors tested proved to be statistically significant for peri-procedural stroke.

Conclusion: Our results demonstrate that CAS can be performed with low stroke/death rates. Comparing to our previously published experience, there is a shift nowadays to offer CAS in more symptomatic than asymptomatic patients (65% vs 35% in the period 2009-2024; and 35% vs 65% in the period 1997-2007). Increasing expertise in patient selection, appropriate device utilization, and execution of the endovascular technique is critical for minimizing adverse periprocedural events.

CLINICAL AND LONG-TERM OUTCOMES AFTER CAROTID ENDARTERECTOMY IN PRESENCE OF CONTRALATERAL CAROTID OCCLUSION

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Background: The optimal management for carotid stenosis in presence of contralateral carotid occlusion (CCO) remains controversial. The aim of the present study was to inverstigate the influence of CCO on the clinical and long-term outcomes after carotid artery endarterectomy.

Methods: In this retrospective, single-center study includes 340 consecutive patients submitted to carotid surgery between October 2011 and November 2017. The operative technique consisted of the carotid endarterectomy with bovine pericardium patch closure under general anesthesia with perioperative cerebral monitoring und selective use of intraoperative shunt placement. 41 patients CCO were mached with 82 patients without significant stenosis of contralateral carotid artery.

The primary clinical outcome measures included ipsilateral stroke, ipsilateral transient ischemic attack (TIA), myocardial infarction (MI), mortality within 30 days and the need for a shunt placement intraoperatively. The secondary clinical outcome measures included stroke, TIA, MI, mortality and restenosis in the long-term follow-up.

Results: Due to matching, there were no significant differences regarding patients' demographics or cardiovascular comorbidity. At 30 days there were 3 patients with ipsilateral stroke, all in the non-CCO group (p = 0.22). 4 Patients presented with bleeding with the need for redo surgery: 1 in the CCO group and 3 in the non-CCO group (p = 0.72). At the end of the follow-up period no new patients presented with an ipspilateral stroke. The incidence of restenosis was 4.8% in the CCO group *versus* 3.7% in the non-CCO group (p = 0.74).

Conclusions: Carotid endarterectomy in presence of CCO under selective use of intraoperative shunt placement appears to be a safe procedure without influence on the clinical and long-term outcomes. CCO should not considered always as a high-risk factor for operation.

INTERVENTION FOR NEAR TOTAL OCCLUSION OF THE INTERNAL CAROTID ARTERY. A SINGLE CENTER EXPERIENCE

Athanasios Haidoulis, Konstantinos Spanos, George Kouvelos, Konstantinos Tzimkas-Dakis, Christos Karathanos, Miltiadis Matsagkas, Athanasios Giannoukas

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Introduction: Recent guidelines recommend best medical treatment for the treatment of carotid near total occlusion (CNO), while the role of intervention with carotid endarterectomy (CEA) or stenting (CAS) remains controversial. The present study investigates our 16-year experience in the treatment of CNO with carotid intervention.

Methods: Single center retrospective study including patients treated with carotid intervention (patch or eversion CEA and CAS) from 2006-2025. Demographics, treatment details, and outcomes such as mortality, myocardial infarction (MI), stroke, intra-cerebral hemorrhage (ICH) were analyzed for the early period (30-day post-operation), while stroke, restenosis and death were also analyzed.

Results: From a total of 800 patients treated with carotid interventions, 36 were treated for CNO (CEA: 27 patch, 6 eversion and 3 with CAS). The mean patients' age was 72.2±9 (90% males). Almost half of the patients were symptomatic (47%; 17/36). The intra-operative stroke rate was 0% for asymptomatic patients and 5.88% (1/17) in symptomatic ones. The mean total hospital stay was 3.8±2. During 30-day period, intracerebral hemorrhage occurred in 5,26% in asymptomatic and in 5.88% in symptomatic patients and all within the first 7 days associated with development of hypertension. No MI or death occurred during early period. During mean follow up of 32±30 months, the survival rate was 95%, 87% and 58% at 12, 24, and 72 months, respectively. No patient experienced late stroke or significant (>50%) restenosis.

Conclusion: Perioperative risk of stroke and death in patients with CNO remains within the range of other symptomatic and asymptomatic patients with high grade stenosis. However, early postoperative intracerebral hemorrhage associated with hypertension remains high and therefore in such patients intense blood pressure control is of paramount importance.

SIMULTANEOUS INTERVENTIONS IN MULTIFOCAL ATHEROSCLEROSIS INVOLVING CORONARY ARTERIES AND LOWER LIMB ARTERIES

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Heart surgery and transplantation, Heart surgery and transplantation Department/Scientific Centre of surgery and Transplantation named after O.O.Shalimov/ National Academy of medical sciences of Ukraine/ Kyiv/ Ukraine

Background. The combination of coronary artery disease and peripheral artery disease is associated with almost doubling of all-cause mortality, to 4.6% per year, compared to mortality of each disease alone. When performing the first stage of intervention on lower limbs arteries, there is a high probability of getting a perioperative myocardial infarction in 4.9% of patients and performing an isolated coronary bypass can increase the lower extremities ischemia, up to the loss of limb in 7.9%. Remains unresolved: what should be the order and sequence of surgical interventions in multifocal atherosclerosis, are simultaneous interventions possible?

The aim. To study the possibilities and effectiveness of simultaneous interventions in patients with multifocal atherosclerosis, with coronary arteries damage and lower extremities' arteries.

Methods. The results of treatment of 84 patients with combined lesions of coronary arteries and lower extremities' arteries from 2016 to 2024 were analyzed. Coronary bypass operations were performed using the off-pump technique. During simultaneous interventions, coronary bypass surgery was always prioritized. Interventions on lower extremities were performed with coronary bypass surgery both simultaneously (n=38, 45%) and in stages (n=46, 55%). In staged interventions group, 2 sub-groups were indicated - performance of the first stage of coronary bypass followed by revascularization of lower extremities (n=28, 33%), or performance of the first stage of reconstruction of lower extremities' arteries with subsequent coronary bypass (n=18, 22%). The primary end points for evaluating simultaneous interventions were major adverse cardiac events and pain as an indicator of increased ischemia of lower extremities due to staggered staged interventions.

Results. Both group deaths were not detected. Simultaneously operated patients' major adverse cardiac events were not detected. In staged interventions group, where coronary bypass was primarily performed in 5 patients (18%), increased ischemia of lower extremities' presence was noted, which required emergency intervention on the arteries of lower extremities. In case of staged interventions, in which the first stage was revascularization of lower extremities, before coronary bypass surgery, an acute myocardial infarction in the early postoperative period developed for 4 patients (22%). Performing delayed interventions involves a considerable number of risks and complications, which significantly outweigh those that can occur with simultaneous interventions.

Conclusions. Performing simultaneous interventions in multifocal atherosclerosis with coronary arteries and lower extremities' arteries damages with appropriate indications is safe and effective method of treatment for this group of patients.

Thursday May 15,2025
Conference Room 2
18.00-19.10

POLYCYSTIN-1 AS A NOVEL BIOMARKER FOR PERIPHERAL ARTERY DISEASE: INSIGHTS FROM A PROSPECTIVE STUDY

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Background: Atherosclerosis remains a leading cause of morbidity and mortality worldwide. Recent studies highlight the potential role of mechanosensitive molecules, particularly Polycystin-1 (PC-1), in vascular pathology. However, its significance in carotid atherosclerosis remains largely unexplored. This study aims to evaluate PC-1 serum levels and its association with atherosclerotic plaque characteristics and the p53/p38/p21 signaling pathway.

Methods: A total of 70 patients undergoing carotid endarterectomy were included in this study. PC-1 levels in serum were measured using ELISA, while Western blot analysis was performed to assess p53/p38/p21 signaling pathway activation. Patients were stratified into symptomatic (n=17) and asymptomatic (n=53) groups. Correlations between PC-1 levels, clinical parameters, plaque characteristics, and protein expression were analyzed using Student's t-test and chi-square tests.

Results: PC-1 was detected in ten patients (7 asymptomatic, 3 symptomatic), with levels significantly correlating with age ($p<0.0001$), BMI ($p<0.0001$), lipid profile ($p<0.0001$), HbA1c ($p<0.0001$), and carotid stenosis severity ($p<0.0001$). No significant correlation was found between PC-1 levels and serum creatinine (TABLE 1). Western blot analysis revealed an increase in p21 and phospho-p38 expression in PC-1-positive samples, although this difference did not reach statistical significance. Heatmap analysis showed greater p53/p38/p21 activation in PC-1-positive samples, particularly in male patients.

Conclusion: These findings suggest that PC-1 may serve as a potential biomarker for carotid atherosclerosis, with implications for disease progression and mechano-transduction signaling. Further studies with larger cohorts are needed to validate these observations and explore the role of PC-1 as a therapeutic target in vascular disease.

IMPACT OF ISCHEMIC POSTCONDITIONING ON OUTCOMES OF EVERSION vs. CONVENTIONAL CAROTID ENDARTERECTOMY

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Introduction: Carotid endarterectomy (CEA) is the gold standard in preventing stroke in patients with carotid artery stenosis. Comparing eversion endarterectomy (eCEA) and conventional endarterectomy with patch angioplasty using biological material (pCEA) highlights differences in clamp time duration and the impact of ischemic postconditioning (IPCT) on ischemic events and reperfusion syndromes. The aim is evaluating the clamp time duration in eCEA and pCEA, assess the impact of clamp duration on surgical outcomes, and analyze the effectiveness of IPC in reducing ischemic and reperfusion complications.

Methods: The study included 45 patients who underwent eCEA (n=30) and pCEA (n=15). Clamp duration was recorded during the procedure, and IPCT was applied to 10 patients in each group. Outcomes were evaluated by the incidence of ischemic events and reperfusion syndromes in the postoperative period.

Results: The mean clamp time was significantly shorter in eCEA compared to pCEA (19±5min vs. 30±2min, $p<0.001$). Clamp duration did not have a statistically significant impact on total neurological or surgical outcomes ($p=0.411$). There was no observed difference between patients with IPCT compared to standard surgical procedure with regards to neurological or surgical outcomes ($p=0.871$). The mean clamp time was significantly shorter in eCEA+IPCT compared to pCEA+IPCT (20±3min vs. 31±4min, $p<0.001$).

Conclusion: CEA demonstrates an advantage in terms of shorter clamp duration compared to the conventional technique with patch angioplasty. Clamp duration does not directly affect clinical outcomes, while ischemic postconditioning significantly reduces the risk of ischemic events and reperfusion syndromes, making this technique valuable in optimizing carotid surgery outcomes.

CAROTID ARTERY DISEASE -SINGLE CENTER RETROSPECTIVE STUDY-

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Introduction: Carotid artery disease is one of the most common causes of ischemic stroke worldwide, and carotid endarterectomy remains an effective treatment method.

Method - Purpose: The aim of this study is to present our clinical experience with carotid artery disease over the past five years.

Results: Over the last five years, a total of 438 patients (309 men and 129 women) underwent treatment. The average patient age was 71 years. Of these, 101 patients (23%) were symptomatic.

Most symptomatic patients had a recent history of stroke (AE). The degree of stenosis in symptomatic patients ranged from 60% to 99%, while in asymptomatic patients, it ranged from 80% to 99%.

A total of 412 open carotid endarterectomies were performed, including 293 eversion endarterectomies, 115 with patch closure, 4 using grafts, and 2 primary closures. Additionally, 24 patients underwent endovascular intervention following a recurrent stenosis.

Regarding postoperative complications, three cases (0.7%) of endarterectomy site thrombosis were detected and treated surgically, as well as three cases (0.7%) of cervical hematomas that also required surgical intervention. Hyperperfusion syndrome occurred in five patients (1.1%), and there were two postoperative deaths (0.5%). Notably, 20 patients (4%) experienced postoperative voice hoarseness.

During follow-up, 25 cases (6%) of restenosis were observed. Of these, 15 were managed conservatively with monitoring, while 10 patients who had previously undergone open endarterectomy underwent repeat endarterectomy once the stenosis exceeded 90%.

Conclusion: Carotid endarterectomy remains a well-established and effective treatment for carotid artery disease. Modern endovascular techniques offer a minimally invasive alternative with high efficacy, particularly in cases of restenosis and in patients with significant comorbidities.

OUR EXPERIENCE SURGICAL TREATMENT IN PATIENTS WITH INTERNAL CAROTID ARTERY OCCLUSION AND CONTRALATERAL STENOSIS

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Background and Aim: Contralateral internal carotid artery occlusion increases the risk of ischemic complications during surgery. This study aims to compare two surgical strategies: (1) external carotid artery reconstruction before carotid endarterectomy and (2) carotid endarterectomy before external carotid artery reconstruction.

Methods: A total of 100 patients with hemodynamically significant internal carotid artery stenosis (≥70%) and contralateral internal carotid artery occlusion were randomized into two groups:

- Group 1 (n=50): External carotid artery reconstruction as the first stage, followed by carotid endarterectomy.
- Group 2 (n=50): Carotid endarterectomy first, followed by external carotid artery reconstruction.

Outcomes included intraoperative and postoperative complications, cerebral perfusion dynamics, 30-day stroke incidence, and long-term results at 12 months.

Results: 1. Intraoperative Complications:
- Transient ischemic episodes: 8% (Group 1) vs. 14% (Group 2).
- Temporary hypoperfusion: 6% (Group 1) vs. 12% (Group 2, $p<0.05$).
- Hypertensive responses: 18% (Group 1) vs. 22% (Group 2, $p>0.05$).

2. Postoperative (30-day) Outcomes:
- Stroke incidence: 8% (Group 1) vs. 12% (Group 2, $p=0.07$).
- Restenosis (>50%): 0% in both groups.
- Coronary complications: 4% (Group 1) vs. 6% (Group 2).
- Wound hematomas: 4% in both groups.

3. Cerebral Perfusion:
- 24-hour postoperative blood flow increase: +23% (Group 1) vs. +18% (Group 2).
- By day 7: +27% (Group 1) vs. +25% (Group 2).
- Early postoperative hypoperfusion: 6% (Group 1) vs. 12% (Group 2).

4. Long-Term (6-12 months) Results:
- Restenosis (>50%): 8% (Group 1) vs. 4% (Group 2, $p<0.05$).
- Recurrent ischemic events: 4% (Group 1) vs. 6% (Group 2).
- Cognitive improvement: 32% (Group 1) vs. 38% (Group 2).
- Mortality rate: 2% in both groups.

Conclusions: 1. Staged surgery with initial external carotid artery reconstruction improves early cerebral perfusion and reduces intraoperative ischemic episodes.

2. Primary carotid endarterectomy reduces the risk of long-term restenosis, which may be beneficial for patients with progressive atherosclerosis.
3. Both strategies demonstrate comparable complication rates, emphasizing the need for individualized surgical planning.

POTENTIAL OF ULTRA-HIGH HYDROSTATIC PRESSURE-TREATED AUTOLOGOUS SKIN AS A VASCULAR PATCH: A PILOT ANIMAL STUDY

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Background and Aim: An ideal vascular graft requires high biocompatibility, antithrombogenicity, and growth potential. We have been conducting research on an *in vivo* tissue engineering approach in which a foreign material (e.g., silicone) is implanted subcutaneously, allowing the host tissue response to form a connective tissue membrane that can be used as a vascular patch. This technique was first applied in pediatric cardiac surgery in 2014, and even after more than 10 years, its outcomes remain favorable.

However, tissue maturation requires approximately two months, making it unsuitable for emergency procedures. Furthermore, patients with low regenerative capacity (e.g., neonates, elderly, diabetic, and dialysis patients) may not form sufficient connective tissue.

Ultra-high hydrostatic pressure (UHP) treatment has been applied in plastic surgery for the treatment of congenital giant melanocytic nevi, where excised skin is treated with UHP and reimplanted to promote skin regeneration. UHP induces cell death while preserving the structure of the extracellular matrix (ECM), thereby maintaining biocompatibility.

This pilot animal study aimed to evaluate the feasibility of UHP-treated autologous skin as a vascular patch in an animal implantation model.

Methods:A 2-year-old female Beagle (10 kg) underwent full-thickness skin harvesting from the inguinal region. The excised skin was treated with UHP (980 MPa, 10 min) and then trimmed to 10 × 5 mm before being transplanted onto the anterior wall of the same dog's common carotid artery.

No antiplatelet or anticoagulant therapy was administered postoperatively. The graft was monitored using ultrasound imaging, and the patch was excised three months post-implantation for evaluation.

Results: The patch was successfully implanted using standard vascular anastomosis techniques. Ultrasound examinations showed that blood flow through the patch was well maintained, with no aneurysmal dilation, stenosis, or thrombus formation observed. Upon excision at three months, the luminal surface was extremely smooth, with no visible thrombus or macroscopic intimal thickening.

Conclusions: This pilot animal study suggests that ultra-high hydrostatic pressure-treated autologous skin is a promising material for vascular grafting. Further investigations, including histological evaluation and mechanical strength assessment, as well as larger-scale studies, are necessary.

ADVERSE INTRAPROCEDURAL EVENTS DURING TRANSFEMORAL CAROTID ARTERY STENTING THAT MAY REQUIRE CONVERSION TO OPEN SURGERY AS A BAILOUT

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Background-Aim: To summarize our experience with patients requiring intraprocedural conversion to open surgery during transfemoral carotid artery stenting (CAS).

Methods: Our standard CAS approach is transfemoral access, use of open-cell or closed-cell stents, and distal filters for cerebral protection. We retrospectively analyzed all transfemoral CAS patients that required immediate conversion to open surgery as a bailout due to adverse intraprocedural events. Causes, management and outcome are presented.

Results: Of >700 CAS procedures performed over the last two decades, 5 cases required conversion to open surgery as a bailout. The first case was complicated by a full filter basket (Spider Fx), necessitating open surgical removal. In the second patient, the Spider Fx filter was caught during the attempted retrieval in the distal struts of the carotid stent, requiring open surgical removal. In the third case, due to technical error, the distal green segment of a Spider Fx delivery catheter broke off and remained intravascularly, necessitating open removal. In the fourth patient, a closed cell X-act stent had been deployed in a position lower than the one required to cover the entire carotid lesion. As a result, the stent did not open fully at the top, rendering withdrawal of the delivery system impossible, and the procedure was converted to a conventional endarterectomy. In the fifth case, an RX Accunet filter detachment occurred during the attempted retrieval and open surgical removal was required. Despite the adverse events, all patients had an uneventful outcome.

Conclusions: Conversion to open surgery as a bailout during transfemoral CAS is a rare occurrence. Experience with the CAS technique, attention to detail and familiarity with the endovascular materials used are all necessary to avoid some of the above scenarios. Open surgical removal may be the only option in the rare case of a full filter basket.

TREATMENT OF SUPERFICIAL VEIN THROMBOSIS WITH INTERMEDIATE DOSE OF TINZAPARIN IN PATIENTS AT HIGH THROMBOEMBOLIC RISK

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Background/Aim: Superficial vein thrombosis (SVT) is considered as a superficial form of venous thromboembolism (VTE) and may be complicated with deep vein thrombosis (DVT) and/or pulmonary embolism (PE). Additionally, the thromboembolic risk may be higher in subgroups of patients. The aim of this study was to access the treatment outcomes of tinzaparin in intermediate dose in patients with acute SVT and additional thromboembolic risk factors.

Methods: A multicenter, prospective observational study of consecutive patients with symptomatic SVT from 17 sites (academic, community hospitals, and specialist practices) in Greece, was undertaken. Patients were treated with intermediate dose of tinzaparin (131IU/Kg) once daily for a period that was at the treating physician's discretion and were followed up for at least 6 months. Patients were eligible if they had symptomatic SVT ≥5cm in length and at least one additional risk factor (≥65 years, body mass index ≥30kg/m^2, previous VTE event, cancer, autoimmune disease, thrombosis of non-varicose veins, thrombus in a supragenual segment). Primary outcomes were any adverse events including symptomatic DVT and/or PE, thrombus extension and SVT recurrence. The principal safety outcome was major bleeding. Secondary objectives were the evaluation of treatment duration with respect to the presence of each component of primary and safety outcomes.

Results: A total of 524 patients (322 females, mean age 60.3±14.2 years) were included. Median treatment duration was 49 days (45-60). Thirty-two patients (6.11%) were treated for < 30 days and 492 for ≥30 days. Outcomes related adverse event, occurred in 17 patients (96.76%, 95% CI: 95.24% - 98.27%), including 5 cases with DVT (0.95% 95%CI: 0.12-1.78%), 1 case with PE (0.19% 95%CI: 0-0.56%), 5 cases with thrombus expansion (0.95% 95%CI: 0.12-1.78%) and 9 cases with SVT recurrence (1.72%, 95% CI: 0.61-2.83%). No major bleeding events were observed, while 7 patients experienced minor bleeding events (safety performance: 98.66%, 95% CI: 97.68-99.65%). Median time to any VTE event was 40 days (23-159) and for safety events 22 days (21-26). No significant differences were observed in median treatment duration and in number of risk factors between patients with recur-

rent VTE event and in patients without [48 days (43-55) vs 49 days (45-60) (p=0.5408) and 2.2±1.1 vs 1.7±1 (p=0.1090), respectively].

Conclusions: Tinzaparin at intermediate dose is an effective and safe treatment for patients with SVT of the lower limb and additional risk factors.

URGENT TREATMENT OF VENOUS THROMBOSIS AND COMPRESSION: A SINGLE CENTER REVIEW OF 25 CASES USING THE MEDTRONIC ABRE STENT PLATFORM

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Background/Aims: This study reviews the effectiveness and safety of the Medtronic Abre stent platform in treating urgent cases of venous thrombosis and compression. Outcomes measured include technical success, symptom relief, and short-term patency in a diverse cohort of patients.

Methods: Patients presenting with symptomatic acute or subacute venous thrombosis and/or extrinsic venous compression between November 2022 and February 2025 underwent urgent/emergent endovascular recanalization with or without thrombectomy/thrombolysis in a hybrid operating theatre setting. Lesions were dilated with the Bard Atlas Gold platform and treated using the Abre stent system under routine guidance of intravascular ultrasound. Primary endpoints included technical success (restoration of venous flow) and immediate symptom relief. Secondary endpoints were short-term patency, re-thrombosis rates, and post-procedural complications.

Results: Twenty-four patients (20 males, 4 females; mean age 70 years, range 40-83) underwent 25 interventions. Twenty cases involved thoracic venous outflow occlusion proximal to end-stage-renal-disease (ESRD) patients' arteriovenous vascular access. Three cases were neoplasm induced venous obstruction and 1 case presented as phlegmasia cerulea dolens in a relatively young female with colon neoplasia and concurrent May-Thurner. Technical success was 100% with the stents successfully deployed and restoring venous flow. On average, 1.25 stents were used per intervention.

Regarding symptom relief, all patients (100%) reported significant improvement in their symptoms, such as reduced limb pain and swelling within 48 hours of the procedure.

Mean follow-up was 12.9 months (1-28 months) and primary patency was maintained in 21 out of 24 patients (87.5%). Of the three ESRD patients who did not maintain primary patency, one (4.1%) experienced early occlusion in two weeks post-intervention and was converted to a HERO graft. The second patient suffered stent occlusion 11 months post implantation and was successfully managed with recanalization and repeat stenting with no further complications. The third patient developed stenosis at 6 and 18 months which was resolved by re-angioplasty.

Post-procedural complications were zero while no cases of stent migration or fracture were observed during the study period.

Conclusion: The Abre stent system demonstrated high technical success and effective symptom relief in urgent cases of venous thrombosis and compression. Short term primary patency rate was favorable although re-thrombosis remains a concern. These results suggest that this stent platform is a valuable tool for managing acute venous conditions.

Friday May 16,2025
Conference Room 2
14.45 - 16.00

MID-TERM RESULTS OF FEMORO-POPLITEAL BYPASS WITH THE USE OF A HEPARIN-BONDED ePTFE GRAFT: EXPERIENCE OF TWO VASCULAR CENTERS IN GREECE

Konstantinos Batzalexis[1], Konstantinos Dakis[1], Alexandros Barbatis[1], Dimitrios Chatzelas[2], Georgios Kouvelos[1], Konstantinos Spanos[1], Georgios Pitoulias[2], Athanasios Giannoukas[1]

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Background-Aim: There is still big controversy in the literature whether an endovascular or bypass intervention strategy is the best option for patients with chronic limb-threatening ischemia (CLTI) and infrainguinal disease. The aim of this study is to report mid-term results of infrainguinal bypasses in patients with CLTI using ePTFE grafts and their comparison with vein bypasses.

Methods: Between 2017-2025, 109 patients submitted to infrainguinal revascularization using a heparin-bonded ePTFE graft (HepBePTFE) or a vein conduit, in two Greek vascular centers. Patients pre-, intra- and postoperative, as well as follow-up (FU) data were prospectively collected in a registry. Early and mid-term results were analysed in terms of primary and secondary graft patency, amputation and survival rates with Kaplan-Meyer curves; Cox regression analysis for primary, secondary patency, amputation and survival was also performed.

Results: Patients were predominantly male (89.9%), with a mean age of 70 years. CLTI was present in 82 patients (75.2%), with Rutherford class 5 or 6 in 55% (60/109). 80 patients (73%) received an above-knee (AK). In all patients with AK bypass, a HepBePTFE graft was used. Among patients with BK bypass (29), a vein conduit was used in 17 cases, while an ePTFE graft in the rest.

30-day mortality rate was 2,75%. Mean follow-up period was 15.5 months (S.D. 16.4, range 1-69). Primary, secondary patency and limb salvage were 86.1% (standard error, SE, 0.09), 94.5% (SE, 0.09) and 88.1% (SE 0.06) at 32 months respectively. Overall survival rate was 78.9% (SE 0.16) at 72 months of FU. Comparing patients with AK and BK bypasses, primary patency rates were 88.6% at 32 months and 79.3% at 24 months (p=0.039, log rank 4.2), while secondary patency rates were 96.3% and 89.7% at 32 months, respectively (p=0.019, log rank 5.4). In patients with an ePTFE graft compared to those with a vein conduit, primary patency rates were 87.8% at 32 months and 77.8% at 18 months, respectively (p=0.042, log rank 4.1). Cox regression analysis showed rutherford 5 and 6 was the only factor associ-

ated to amputation during FU. (p=0.034, log rank 4.2).

Conclusion: The use of a HepBePTFE graft showed good early and mid-term results, with optimal primary patency and excellent secondary patency rates. Despite the small numbers of the study, it seems that HepBePTFE graft can be considered an acceptable alternative to autologous vein when it is unavailable or of poor quality, especially in the AK setting.

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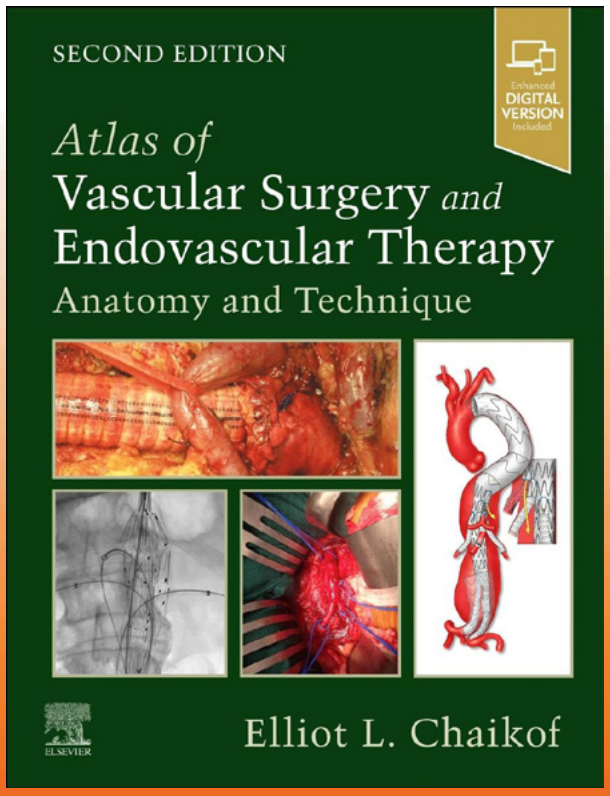

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