OPEN ACCESS Freely available online

ISSN: 2329-6925
Journal of Vascular Medicine & Surgery

Commentary

Innovation in Vascular Access: Advances, Challenges, and Future Directions

Guillaume Mahe*

Department of Vascular Medicine Unit, Rennes University Hospital, Rennes, France

DESCRIPTION

Vascular access remains the lifeline for patients requiring hemodialysis, with significant implications for morbidity, mortality, and quality of life. Despite decades of experience and technological advancement, creating and maintaining durable vascular access continues to pose substantial challenges. This commentary examines recent innovations in the field, persistent obstacles, and emerging strategies that may reshape vascular access practice in the coming years.

The Arteriovenous Fistula (AVF) has long been considered the gold standard for chronic hemodialysis access, based on superior patency rates, fewer infections, and lower mortality compared to Arteriovenous Grafts (AVGs) and Central Venous Catheters (CVCs). This preference was codified in initiatives such as the Fistula First Breakthrough Initiative, which successfully increased AVF utilization in the United States from approximately 32% in 2003 to over 60% currently. However, this preferential approach has been tempered by recognition of significant limitations, including prolonged maturation times, high primary failure rates (20-60% in various studies), and unsuitable vascular anatomy in an increasingly complex dialysis population.

Recent evidence has prompted more nuanced consideration of access modality selection. The "right access, right patient, right time" philosophy acknowledges that for certain patients-particularly elderly individuals with limited life expectancy or poor vascular anatomy-AVGs or even tunneled catheters may represent more appropriate initial choices. This individualized approach requires comprehensive pre-operative assessment, including detailed ultrasound mapping of upper extremity vessels, consideration of comorbidities, and realistic appraisal of life expectancy.

Technological innovations have expanded our capabilities in fistula creation. Endovascular AVF creation represents perhaps the most significant recent advancement, with systems such as the Ellipsys (Avenu Medical) and WavelinQ (BD) enabling percutaneous arteriovenous anastomosis formation without open surgery. The multicenter VasQ External Support trial demonstrated promising 12-month primary patency rates of 79% for endovascular fistulas, with reduced maturation times compared to surgical AVFs. These approaches may be particularly valuable for patients with limited surgical options or those requiring preservation of proximal sites for future access.

Similarly, bioengineered grafts incorporating anti-thrombotic or anti-proliferative properties have shown promise in preliminary studies. Grafts coated with heparin, paclitaxel, or other bioactive agents aim to reduce the neointimal hyperplasia that commonly leads to access failure. The Gore PROPATEN Vascular Graft demonstrated improved 12-month primary patency rates compared to standard ePTFE grafts in a randomized trial, though more substantial benefits may require combination approaches targeting multiple pathways in the hyperplastic response.

Maturation remains the Achilles' heel of arteriovenous access, particularly for fistulas. Despite technical success in creation, 20-60% of fistulas fail to develop adequately for dialysis use. Our understanding of maturation biology has advanced considerably, with recognition of the complex interplay between hemodynamic factors, vascular remodeling, and patient-specific characteristics. Predictive models for maturation outcomes, such as the Lok score and REDUCE-FTM risk equation, may help identify patients at high risk for maturation failure, though their clinical implementation remains limited.

Strategies to enhance maturation have evolved from purely mechanical approaches to biologically targeted interventions. Far-infrared therapy has shown promise in randomized trials, with potential mechanisms including enhanced nitric oxide production and improved endothelial function. Regional anesthesia techniques during fistula creation may provide sympathectomy-like effects that promote vasodilation and favorable remodeling. Pharmacological approaches including antiplatelet agents, statins, and agents targeting specific molecular pathways in neointimal hyperplasia remain areas of active investigation.

Correspondence to: Guillaume Mahe, Department of Vascular Medicine Unit, Rennes University Hospital, Rennes, France, E-mail: maheguillaume55@yahoo.fr

Received: 28-Jan-2025, Manuscript No. JVMS-25-28756; **Editor assigned:** 31-Jan-2025, Pre QC No. JVMS-25-28756 (PQ); **Reviewed:** 14-Feb-2025, QC No. JVMS-25-28756; **Revised:** 21-Feb-2025, Manuscript No. JVMS-25-28756 (R); **Published:** 28-Feb-2025, DOI: 10.35248/2329-6925.25.13.583.

Citation: Mahe G (2025). Innovation in Vascular Access: Advances, Challenges, and Future Directions. J Vasc Surg. 13:583.

Copyright: © 2025 Mahe G. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

For established accesses, maintenance strategies have become increasingly proactive rather than reactive. Surveillance protocols combining clinical monitoring with ultrasound and dialysis adequacy metrics aim to identify stenosis before thrombosis occurs, though the optimal surveillance regimen remains controversial. The Dialysis Access Consortium trial found no benefit from routine angioplasty based on flow criteria alone, highlighting the need for more sophisticated approaches to distinguishing hemodynamically significant lesions from those unlikely to progress.

Endovascular interventions for failing or thrombosed access have expanded beyond simple balloon angioplasty to include specialized devices addressing specific pathologies. Drug-coated balloons have shown promising results in several trials, with the IN.PACT AV Access study demonstrating significantly improved target lesion primary patency at six months compared to standard angioplasty (82.2% vs. 59.5%). Specialized crossing tools for central venous occlusions, cutting balloons for resistant stenoses, and covered stents for rupture or aneurysmal disease have further expanded our endovascular armamentarium.

Patient engagement represents another frontier in access improvement. Education programs focused on self-cannulation, access monitoring, and recognition of complications can empower patients to participate actively in access care. The promotion of home dialysis modalities-both peritoneal dialysis and home hemodialysis-may reduce the need for high-flow access in appropriate candidates, potentially preserving vascular capital for future needs.

Bioengineered vessels created through tissue engineering approaches may eventually provide off-the-shelf conduits with reduced immunogenicity and enhanced durability compared to synthetic materials. Novel biomaterials incorporating nanotechnology could provide surfaces resistant to both infection and thrombosis. Devices for percutaneous vascular anastomosis may further simplify access creation and reduce surgical morbidity. Vascular access remains both an art and a science, requiring integration of technical skill, biological understanding, and systems-based approaches. By embracing innovation while maintaining focus on fundamental principles-timely planning, meticulous technique, vigilant monitoring, and prompt intervention-we can continue to improve outcomes for this vulnerable patient population. The ideal access remains elusive, but through multidisciplinary collaboration and continued research, we move closer to that goal.