WELCOME *To the*

2026 SYMPOSIUM

AVF Maturation: Criteria and Predictors

Jason K. Wagner, MD FACS, FSVS
Chairman, Department of Surgery, Sarasota Memorial Health System
Partner, Sarasota Vascular Specialists

Sarasota Vascular Specialists

Sarasota Memorial Health Care System

VASA Vascular Access Society of the Americas — Access Excellence.

Disclosures:

Merit Medical – Investigator, Educator

Boston Scientific – Investigator

Gore Medical – Investigator

Laminate Medical – Investigator

Xeltis – Investigator

Disclosures:

I am not a biomechanical engineer….

I tell people I am just a ”Fancy Plumber”….

Disclosures:

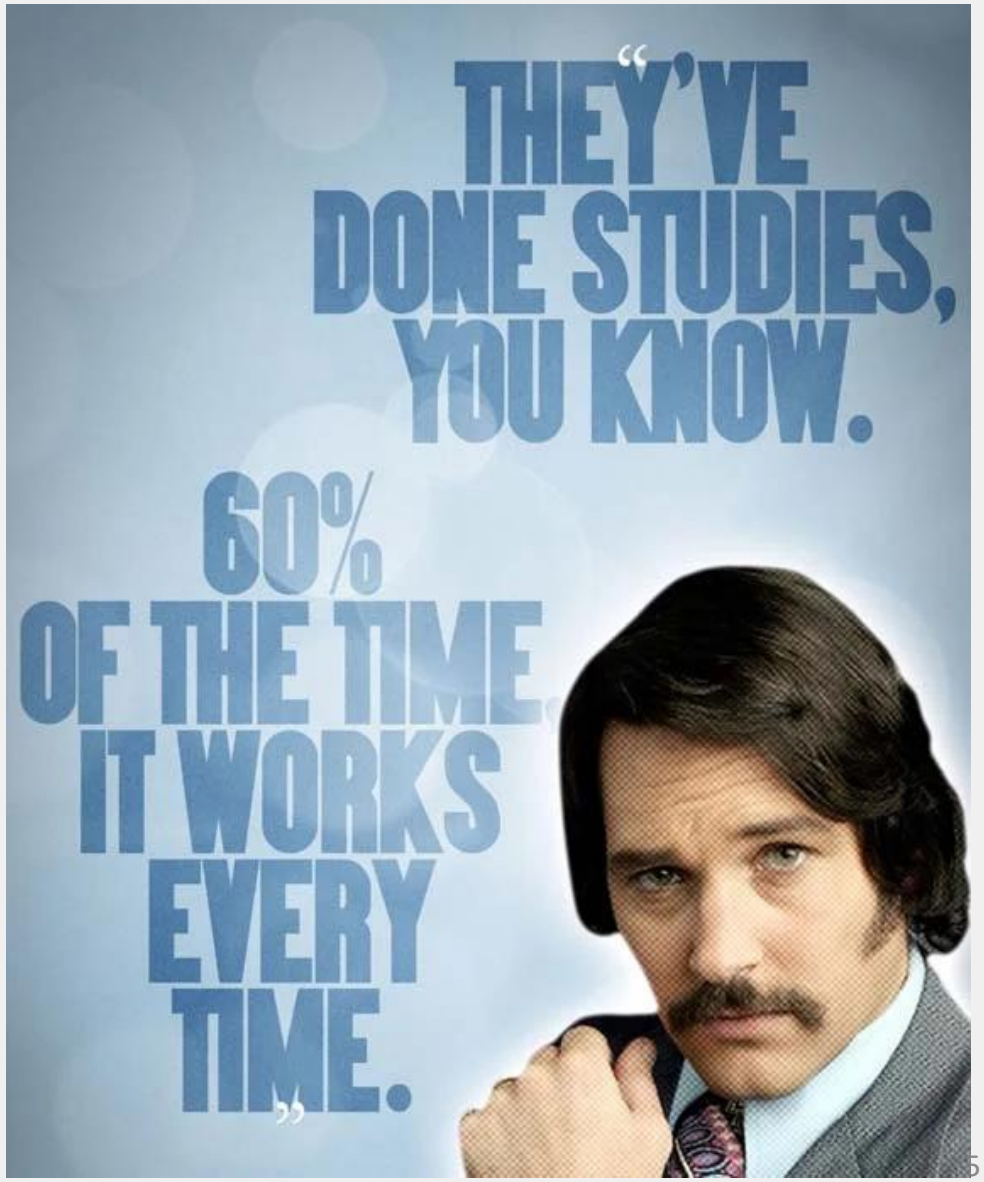
I am not a biomechanical engineer….

I tell people I am just a ”Fancy Plumber”….



Clinical Importance of AVF Maturation

- 20–40% of AVFs fail to mature adequately for dialysis use
- Failure to mature increases catheter dependence and morbidity
- Strongest predictors of successful maturation:
  - Hemodynamic factors
  - Anatomic factors



Dember et al., HFM Study, CJASN 2013

Definition of Successful Maturation

Hemodialysis Fistula Maturation (HFM) Study:

- Successful use of AVF for hemodialysis
- Cannulation adequate for dialysis for ≥4 consecutive weeks
- Without need for intervention (angioplasty/surgical revision)

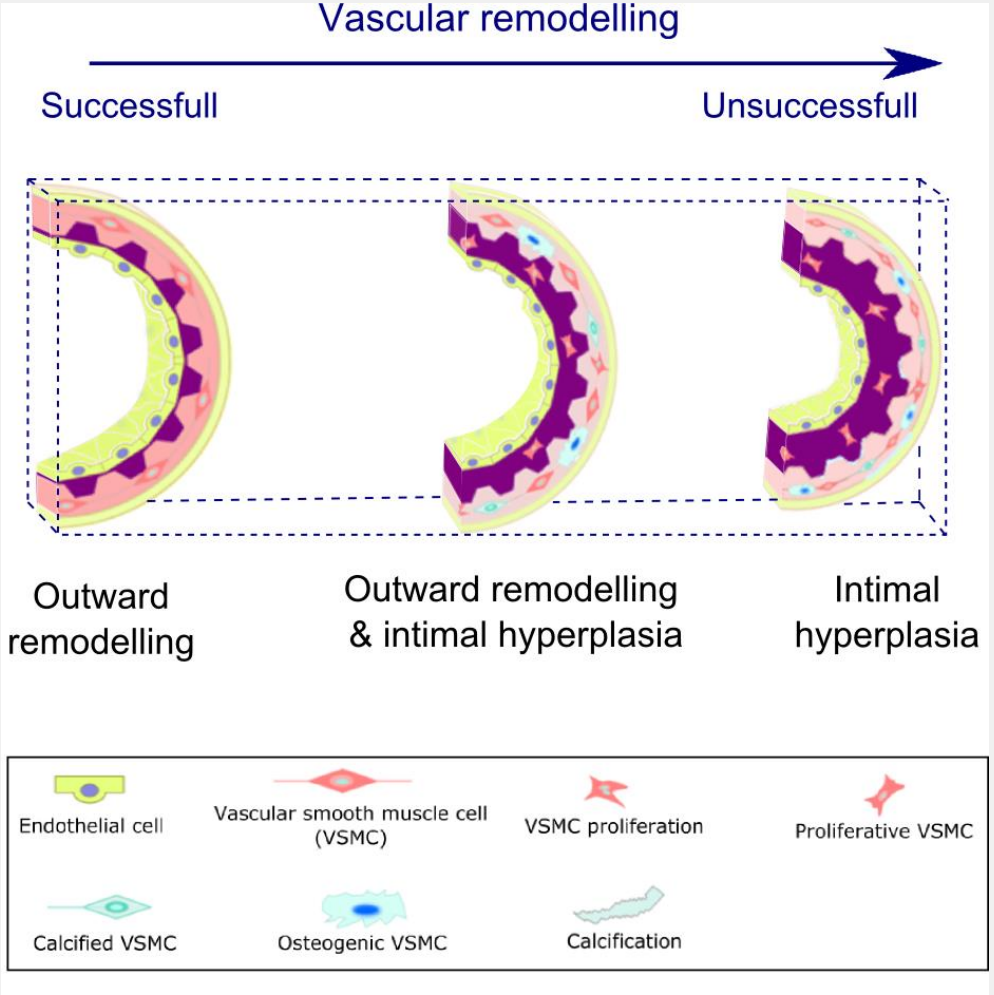


https://www.ren-med.com.tr/en/wp-content/uploads/2024/01/fistul-1.jpg

Dember et al., HFM Study, CJASN 2013

Overview of AVF Maturation

- AVF maturation is driven by vascular remodeling in response to altered hemodynamics
- Veins are exposed to arterial pressure, pulsatility, and increased flow
- Successful maturation requires adaptive endothelial and smooth muscle responses
- Failure results from maladaptive remodeling and stenosis



Browne LD, Bashar K, Griffin P, Kavanagh EG, Walsh SR, et al. (2015) The Role of Shear Stress in Arteriovenous Fistula Maturation and Failure: A Systematic Review. PLOS ONE 10(12): e0145795. https://doi.org/10.1371/journal.pone.0145795

Dember et al., HFM Study, CJASN 2013

Hemodynamic Changes After AVF Creation

- Normal venous flow: ~20–40 mL/min
- Mature AVF flow commonly exceeds 600–1500 mL/min
- Creation of a low-resistance circuit increases arterial inflow
- Increased flow generates elevated wall shear stress (WSS)
- Adequate dialysis generally requires flow volume >500–600 mL/min

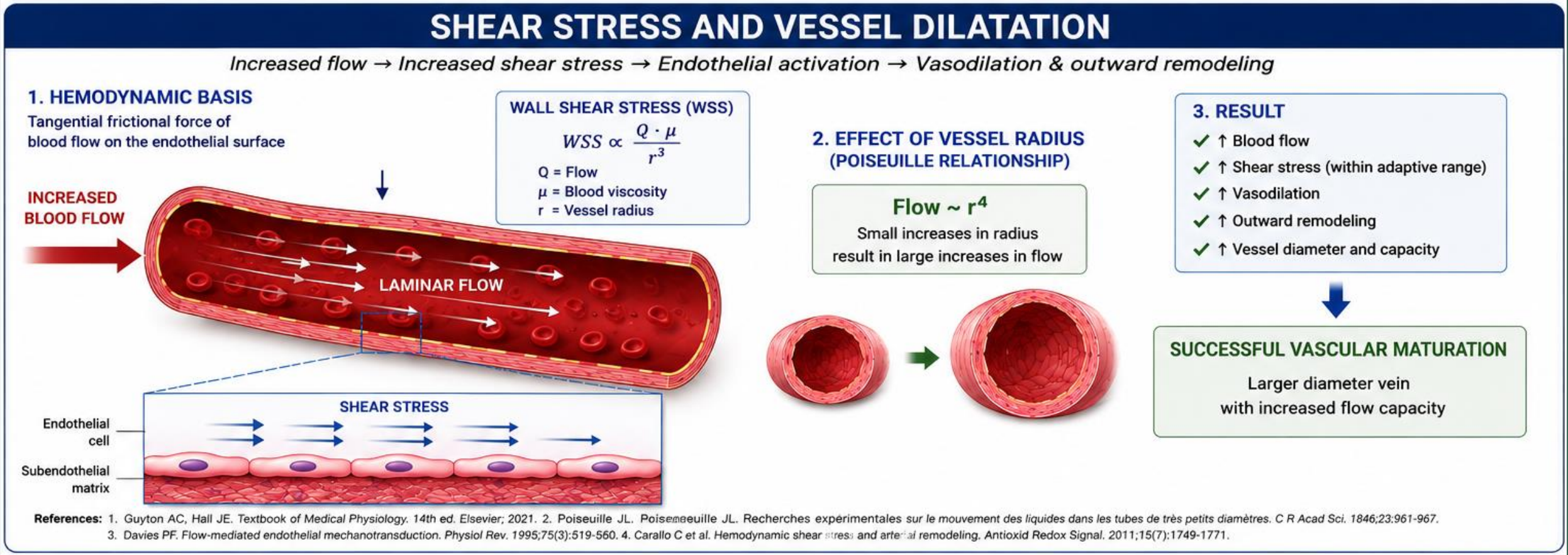


https://www.dpcedcenter.org/wp-content/uploads/2018/10/artificial-kidney-dialysis-device-1085080 65_2122x1415.jpeg

Reference: Lok CE et al. Am J Kidney Dis. 2020;75:S1-S164.

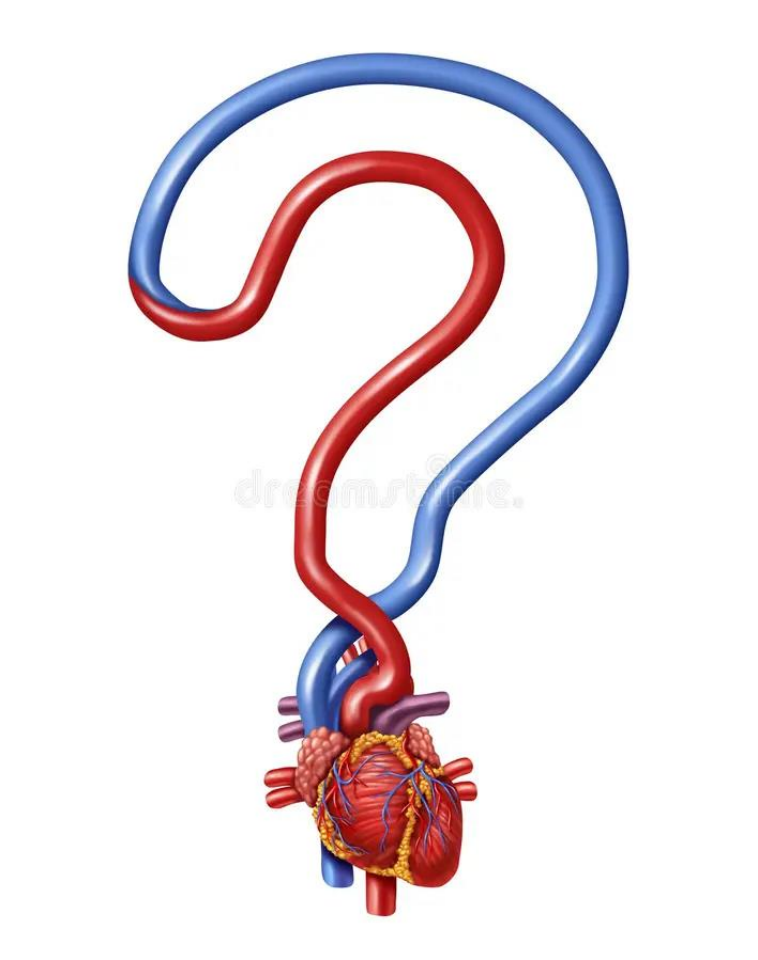
Hemodynamics and Wall Shear Stress

- AVF maturation is fundamentally a remodeling process
- Increased flow generates wall shear stress and venous dilation



Hemodynamics and Wall Shear Stress

- AVF maturation is fundamentally a remodeling process
- Increased flow generates wall shear stress and venous dilation



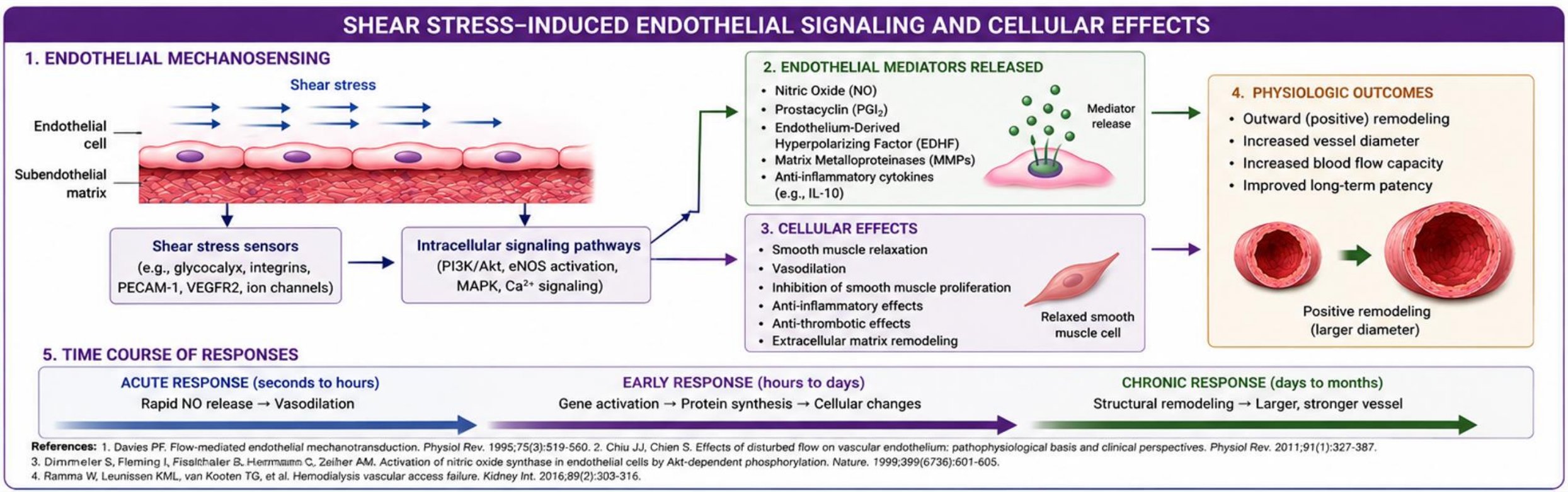
Hemodynamics and Wall Shear Stress

- AVF maturation is fundamentally a remodeling process
- Increased flow generates wall shear stress and venous dilation



Hemodynamics and Wall Shear Stress

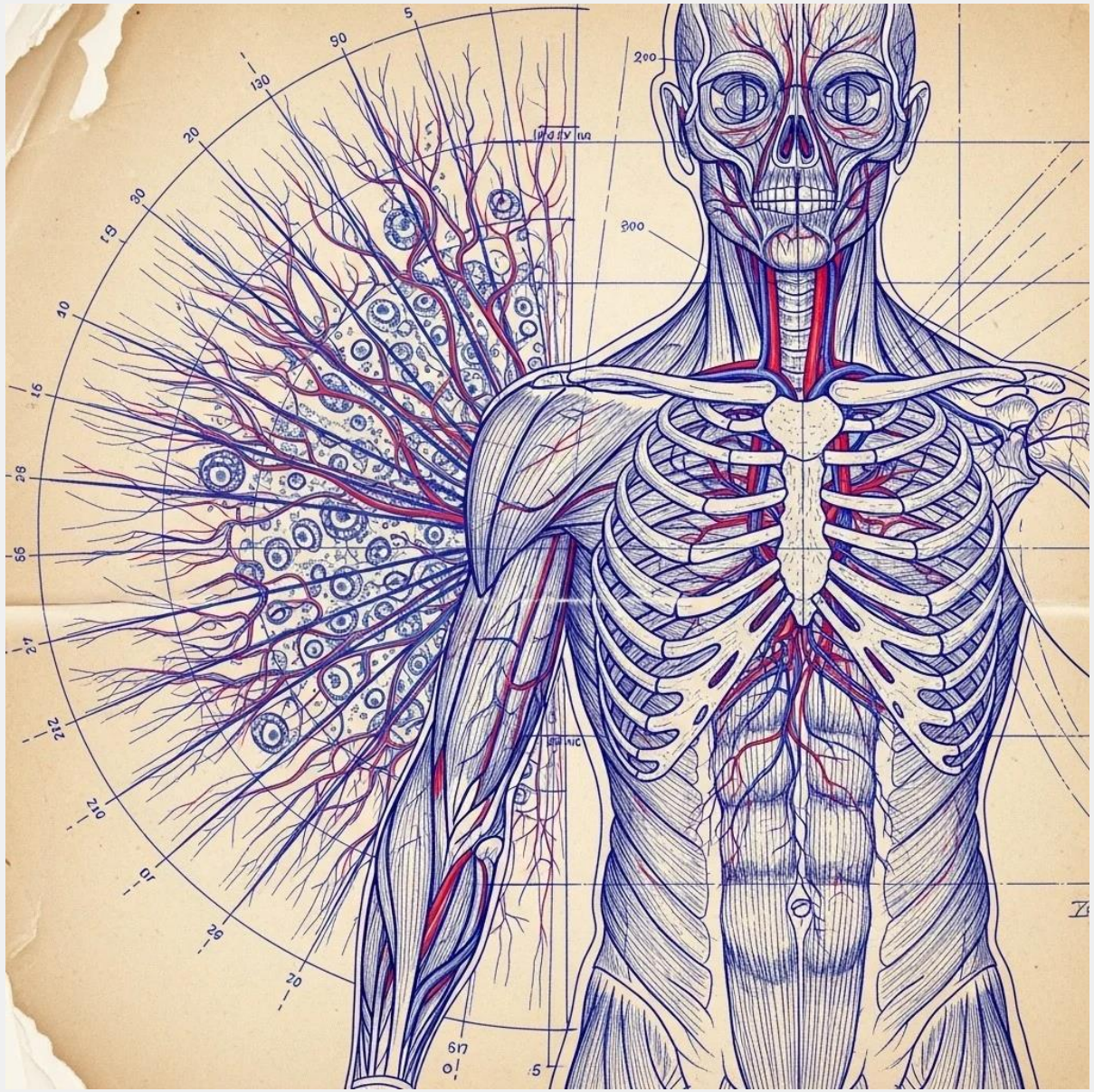
- AVF maturation is fundamentally a remodeling process
- Increased flow generates wall shear stress and venous dilation



References: 1. Davies PF. Flow-mediated endothelial mechanotransduction. *Physiol Rev.* 1995;75(3):519-560. 2. Chiu JJ, Chien S. Effects of disturbed flow on vascular endothelium: pathophysiological basis and clinical perspectives. *Physiol Rev.* 2011;91(1):327-387.
3. Dimmeler S, Fleming I, Fisslthaler B, Hermann C, Zeiher AM. Activation of nitric oxide synthase in endothelial cells by Akt-dependent phosphorylation. *Nature.* 1999;399(6736):601-605.
4. Ramma W, Leunissen KML, van Kooten TG, et al. Hemodialysis vascular access failure. *Kidney Int.* 2016;89(2):303-316.

Anatomic Factors

- Inflow and outflow vessel size
- Angulation
- Depth
- Tortuosity
- Side Branches



Preoperative Vessel Mapping

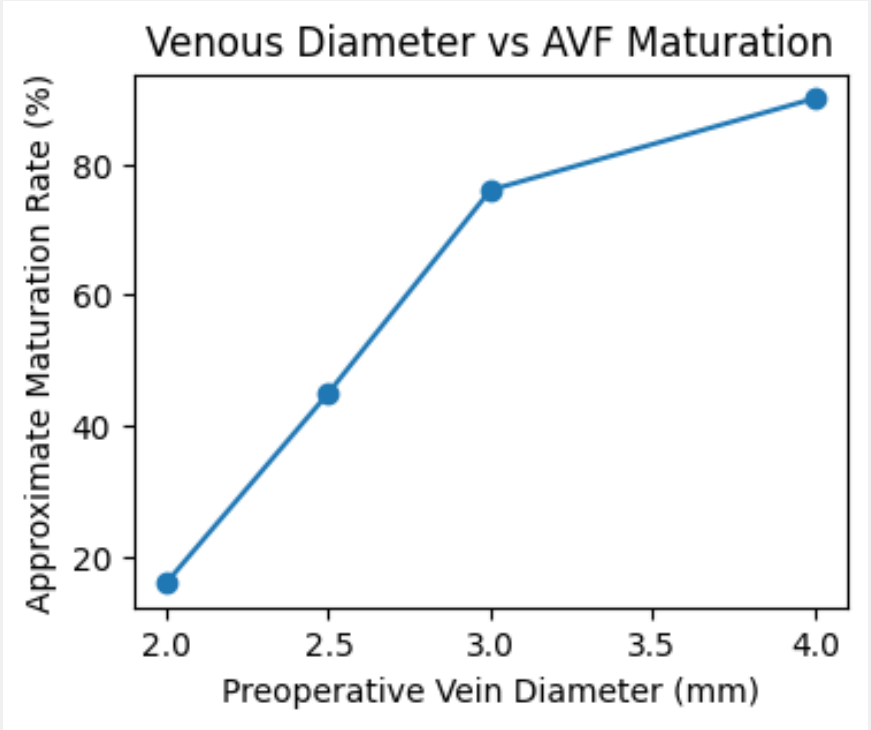
- Duplex ultrasound mapping is now standard before AVF creation
- Arterial diameter, venous diameter, depth, and continuity are critical
- Calcification, stenosis, and inadequate inflow predict failure
- Evidence supports improved outcomes with preoperative imaging



Robbin ML et al. JASN. 2018;29:2735-2744.

Vein Diameter and Maturation

- Baseline vein diameter strongly predicts maturation
  - Veins >2 mm demonstrate significantly higher maturation rates
  - Veins >3–4 mm have the best outcomes in multiple cohort studies
- Smaller veins demonstrate increased failure-to-mature rates
- Vein distensibility and wall quality are important
- Prior venipuncture and fibrosis impair remodeling
- Accessory veins may divert flow and reduce maturation



Bashar K et al. Role of venous diameter in AVF maturation. Eur J Vasc Endovasc Surg. 2015;49(4):432-438.

Vein Diameter and Maturation

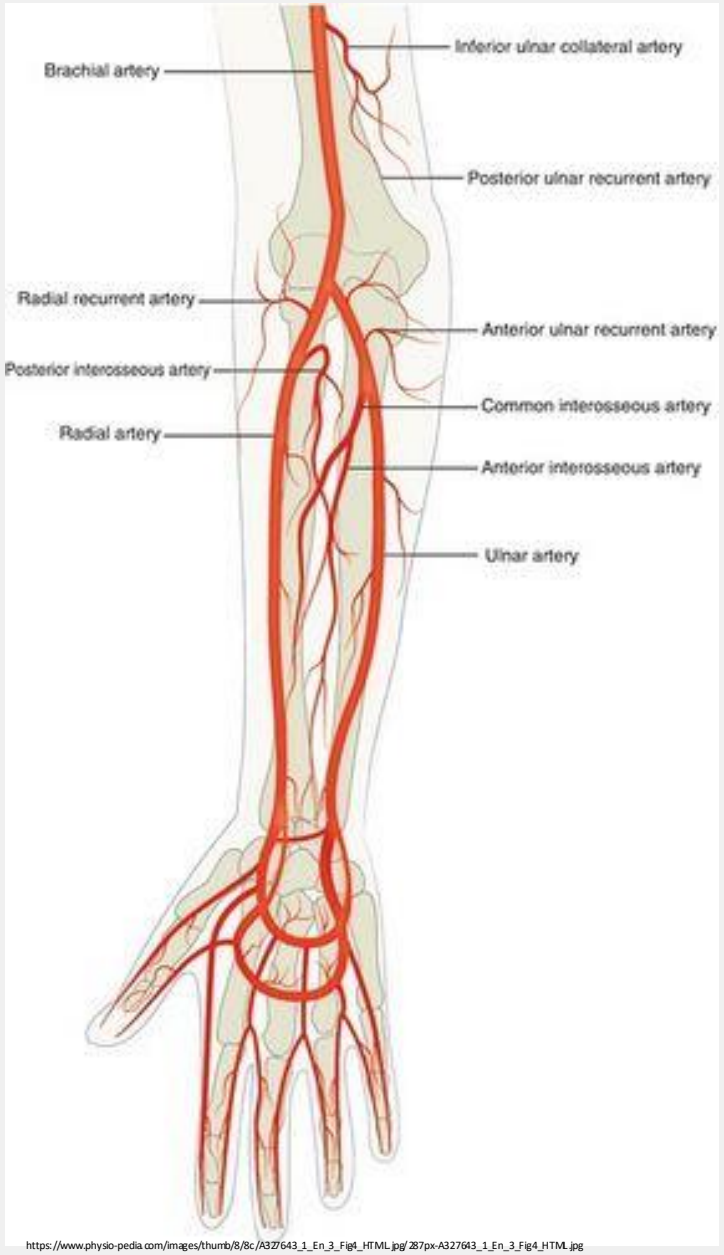
- Baseline vein diameter strongly predicts maturation
  - Veins >2 mm demonstrate significantly higher maturation rates
  - Veins >3–4 mm have the best outcomes in multiple cohort studies
- Smaller veins demonstrate increased failure-to-mature rates
- Vein distensibility and wall quality are important
- Prior venipuncture and fibrosis impair remodeling
- Accessory veins may divert flow and reduce maturation



Bashar K et al. Role of venous diameter in AVF maturation. Eur J Vasc Endovasc Surg. 2015;49(4):432-438.

Arterial Diameter and Inflow

- Adequate arterial inflow is essential for adaptive remodeling
- Arterial diameter <2 mm associated with high primary failure
- Higher preoperative arterial flow → increased maturation
- Brachial artery inflow generally produces more reliable maturation than radial inflow
- Diabetes and peripheral arterial disease impair adaptation
  - Calcification decreases compliance
  - Poor vasodilatory reserve limits shear stimulus

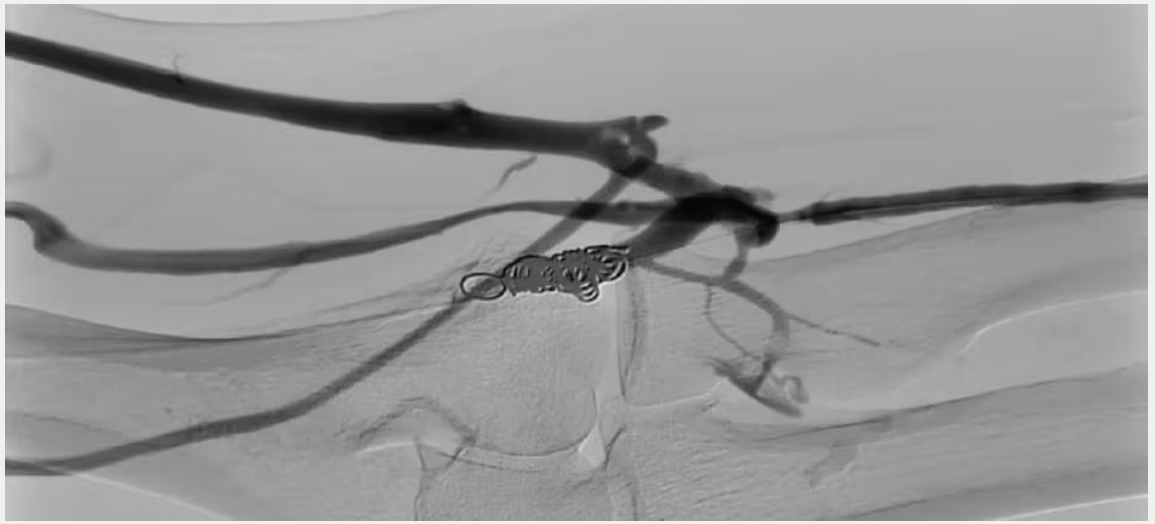


https://www.physio-pedia.com/images/thumb/8/8c/A327643_1_En_3_Fig4_HTML.jpg/287px-A327643_1_En_3_Fig4_HTML.jpg

Ramanan SV et al. Ann Vasc Surg. 2021.

Venous Stenosis and Remodeling

- Postoperative venous stenosis is strongly associated with nonmaturation
- The HFM Study demonstrated stenosis predicts failure better than baseline histology
- Accessory veins may divert flow away from the main outflow channel
- Early intervention can salvage nonmaturing fistulas



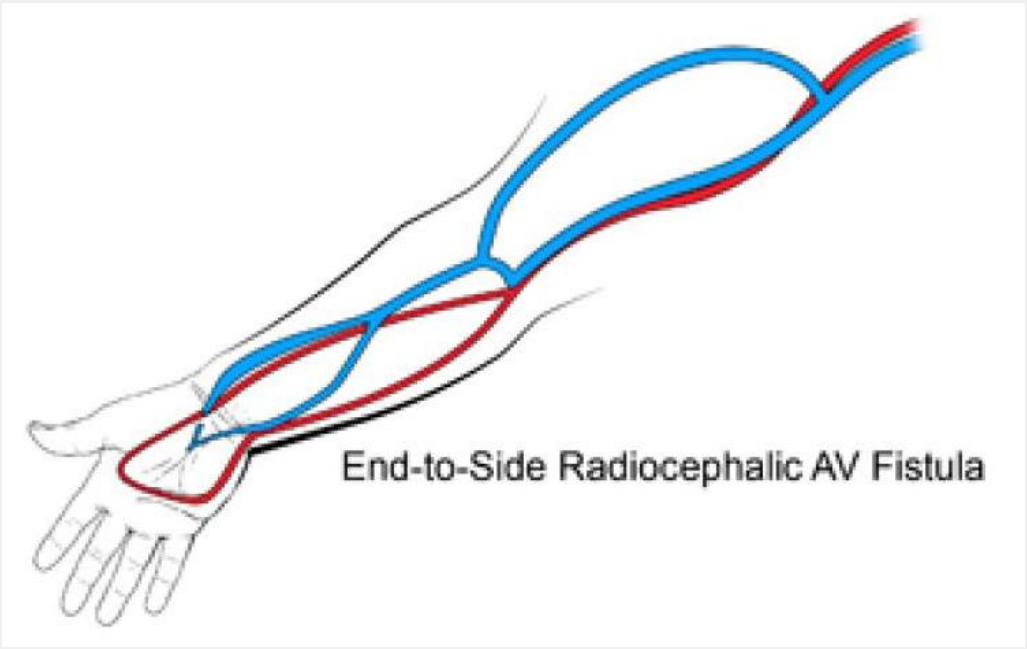


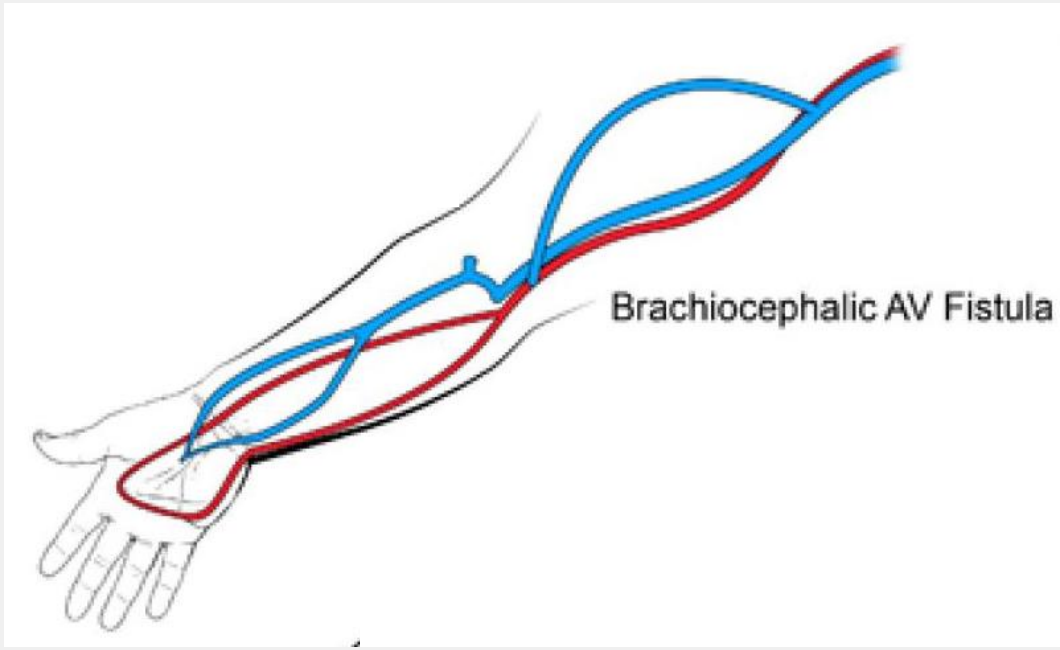
"Siri, Google, 'How much should I fill an angioplasty balloon?'"

Dember LM et al. CJASN. 2013;8:232-239.

Distal vs Proximal AVFs

- Radiocephalic fistulas preserve future access sites but mature less reliably
- Brachiocephalic AVFs generally demonstrate higher flow and maturation rates
- Basilic vein transposition provides excellent diameter but requires bigger surgery
- Anatomic vessel size largely explains these differences





Huber TS et al. JAMA Surg. 2021;156(10):950-959.

Depth and Cannulation Anatomy

- Vein depth is a major determinant of successful cannulation
- Deep fistulas may mature physiologically but remain clinically unusable
- Obesity increases average fistula depth
- Superficialization procedures can rescue deep accesses



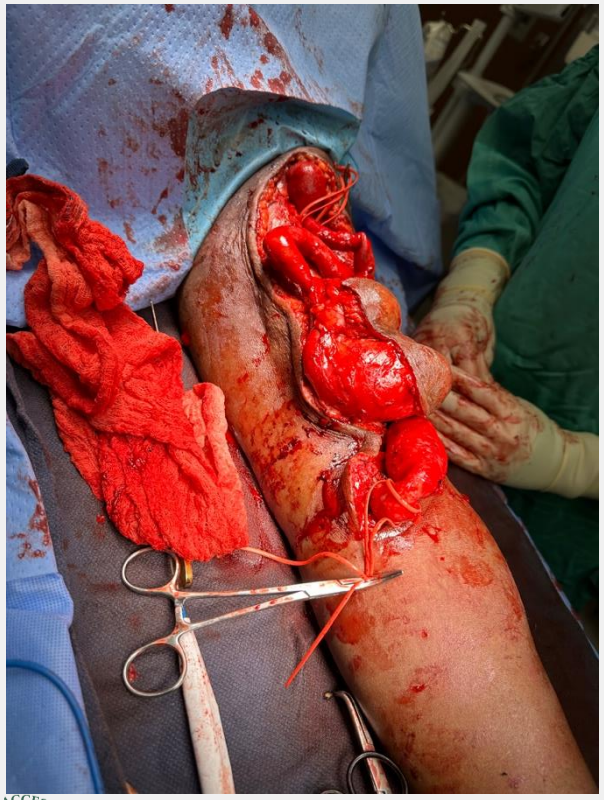
Depth and Cannulation Anatomy

- Vein depth is a major determinant of successful cannulation
- Deep fistulas may mature physiologically but remain clinically unusable
- Obesity increases average fistula depth
- Superficialization procedures can rescue deep accesses



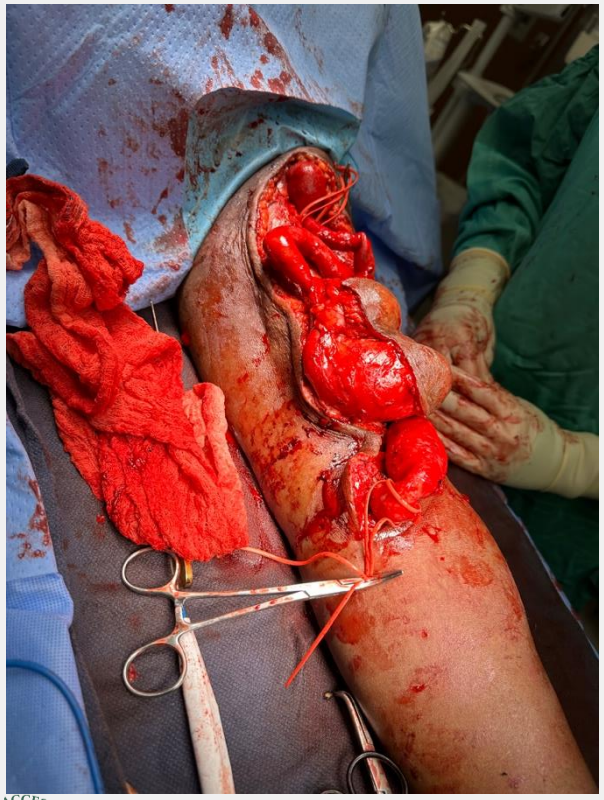
Tortuosity and Cannulation

- Tortuosity can complicate cannulation attempts
- Redundancy and tortuosity →kinking and pressurization → aneurysmal degeneration
- Surgical revision can improve access usability and maintain patency



Tortuosity and Cannulation

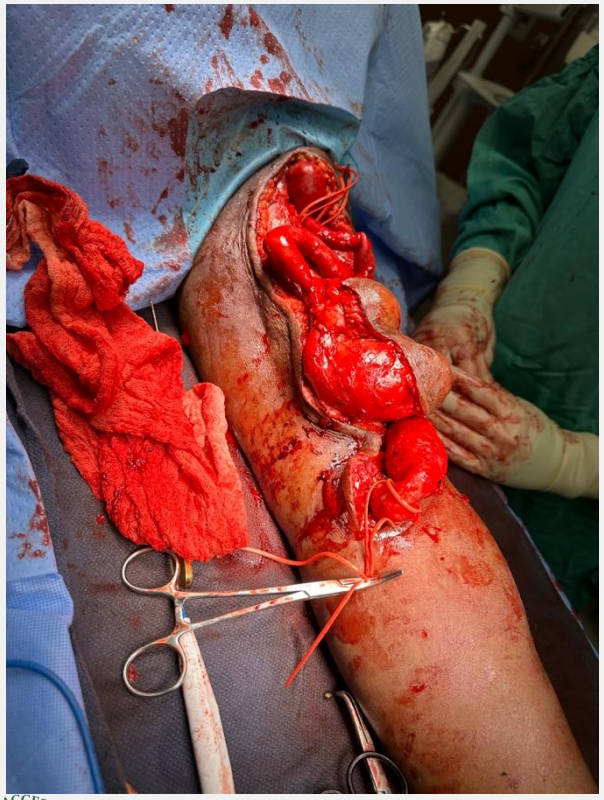
- Tortuosity can complicate cannulation attempts
- Redundancy and tortuosity →kinking and pressurization → aneurysmal degeneration
- Surgical revision can improve access usability and maintain patency





Tortuosity and Cannulation

- Tortuosity can complicate cannulation attempts
- Redundancy and tortuosity →kinking and pressurization → aneurysmal degeneration
- Surgical revision can improve access usability and maintain patency

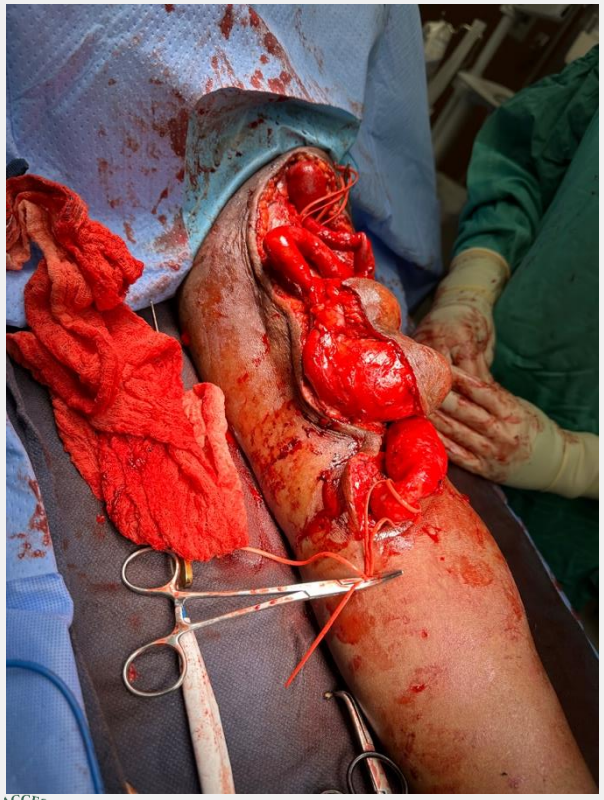






Tortuosity and Cannulation

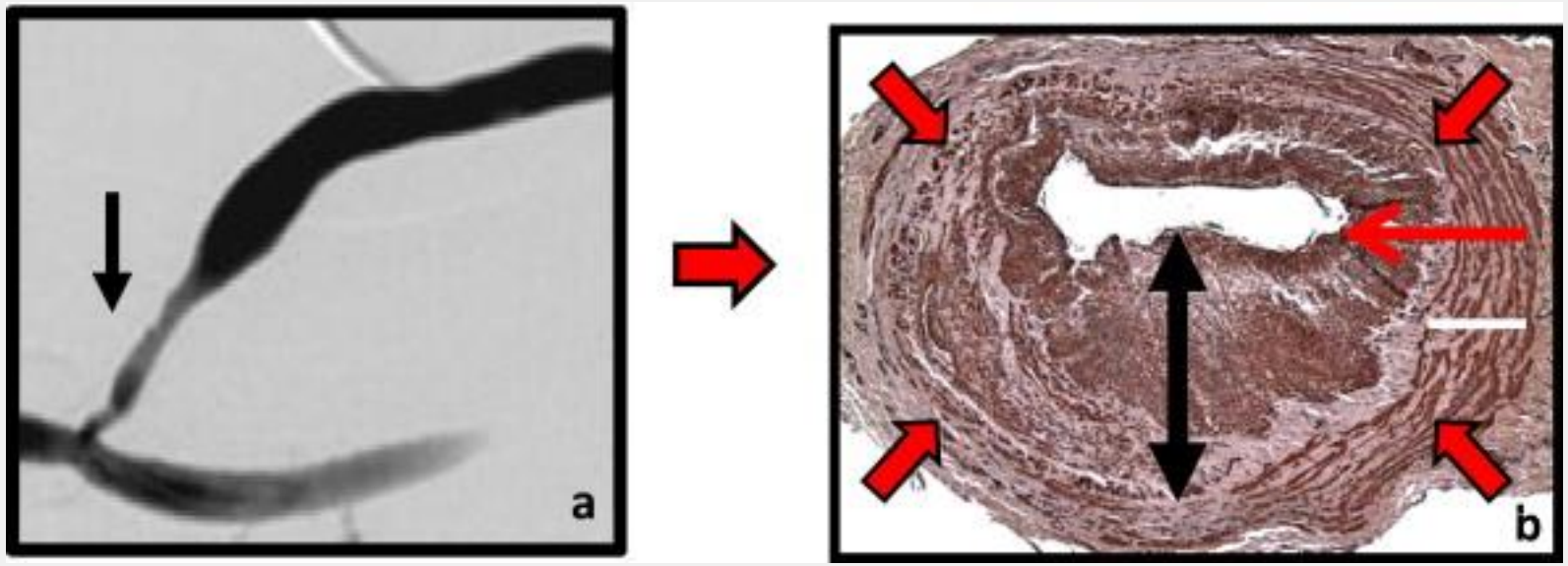
- Tortuosity can complicate cannulation attempts
- Redundancy and tortuosity →kinking and pressurization → aneurysmal degeneration
- Surgical revision can improve access usability and maintain patency






Current Understanding of AVF Failure

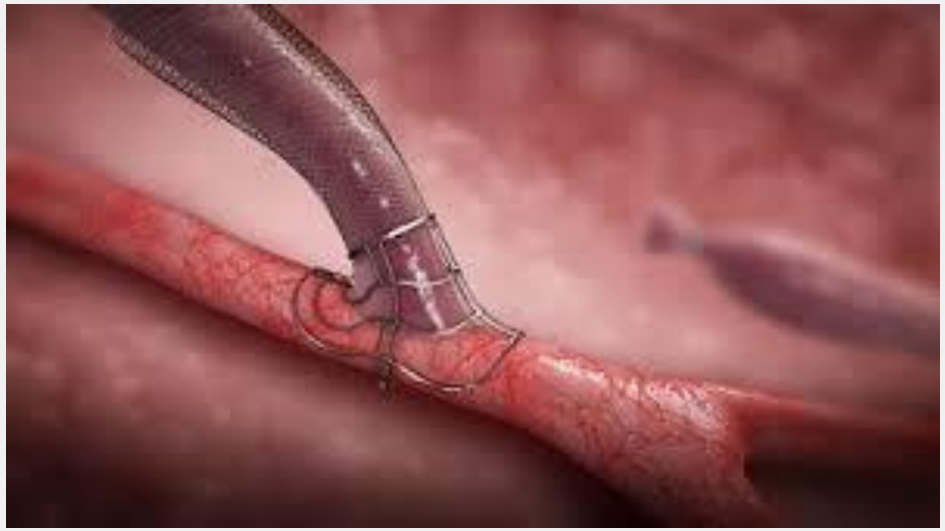
- AVF failure is increasingly viewed as maladaptive vascular remodeling
- Successful maturation depends on interaction between anatomy and biology
- Strongest predictors remain:
  - Vessel diameter, arterial inflow, venous outflow, and flow-mediated remodeling

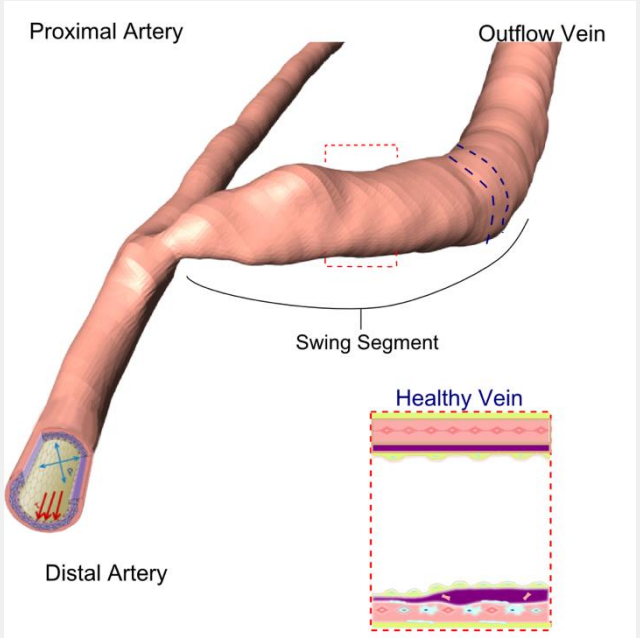




Contemporary Research Directions

- Computational fluid dynamics (CFD) modeling
- Patient-specific AVF geometry optimization
- Mechanotransduction and endothelial biology
- Novel strategies to reduce neointimal hyperplasia
- Flow modulation and bioengineered vascular conduits







Browne LD, Bashar K, Griffin P, Kavanagh EG, Walsh SR, et al. (2015) The Role of Shear Stress in Arteriovenous Fistula Maturation and Failure: A Systematic Review. PLOS ONE 10(12): e0145795. https://doi.org/10.1371/journal.pone.0145795

Thank you!



(QR Code for Contact Card)

Jason K. Wagner, MD, FACS, FSVS, RPVI
JWagner@SarasotaVascular.com
Direct Care Line: 941-899-4598