In Vitro Study of AVF Outflow Vein Wall Shear Stress and Pulse Pressure
Disclosures

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Background & Objective

- Outflow vein hemodynamics are implicated in AVF maturation failure
- Previous studies suggest:
  - Wall shear stress (WSS) levels of 2.5 – 7.5 Pa are optimal for peripheral vein dilation1-4
  - Non-physiologic cyclic stretching of AVF outflow vein wall by pulsatile pressure is likely associated with neointimal hyperplasia, vein stenosis, and maturation failure5-8
- Benchtop pulsatile mock loop simulating radiocephalic AVF was built and used to evaluate outflow vein WSS and pulsatility

Methods

- VAD and compliance chamber to simulate pulsatile arterial pressures and flows
- Tygon tubing of various diameters to simulate AVF
- Two outflow vein collaterals
- Pressures and flows measured, and WSS calculated at various points
Arterial Pulse Pressure is Transmitted Into AVF Outflow Veins

Pulse pressure causes cyclic stretching of AVF outflow vein wall, which is known to stimulate venous SMC proliferation.

- Radiocephalic AVF mock loop
- Mean AoP = 100 mmHg
- Aortic pulse pressure = 40 mmHg
- Radial and ulnar arteries ID = 3 mm
- Two cephalic vein collaterals, ID = 2 mm
Pulse Pressure Increases With Decreasing AVF Outflow Vein Diameter

- Radiocephalic AVF mock loop
- Mean AoP = 100 mmHg
- Aortic pulse pressure = 40 mmHg
- Radial and ulnar arteries ID = 3 mm
- Two cephalic vein collaterals, ID = 2 mm

Increase in pulse pressure could amplify cyclic stretching, stimulate neointimal hyperplasia, and increase risk of vein stenosis
WSS Too High in Small AVF Outflow Veins and Too Low in Large Veins

- Radiocephalic AVF mock loop
- Mean AoP = 100 mmHg
- Aortic pulse pressure = 40 mmHg
- Radial and ulnar arteries ID = 3 mm
- Two cephalic vein collaterals, ID = 2 mm

Outflow vein WSS level affected by vein diameter and cannot be controlled at AVF creation or during AVF maturation.
Arterial Blood Pressure Affects AVF Outflow Vein WSS Levels

### Hypertension

- Radiocephalic AVF mock loop
- Mean AoP = 100 or 140 mmHg
- Aortic pulse pressure = 40 mmHg
- Radial and ulnar arteries ID = 3 mm
- Two cephalic vein collaterals, ID = 2 mm

Hypertension may improve maturation with large AVF outflow veins but may exacerbate endothelial injury with small AVF outflow veins

<table>
<thead>
<tr>
<th>Mean AoP (mmHg)</th>
<th>WSS in AVF Outflow Vein</th>
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<tbody>
<tr>
<td>100</td>
<td>Too High</td>
</tr>
<tr>
<td>140</td>
<td>Too Low</td>
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</tbody>
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### Graph

- **Vein Inner Diameter (mm)**: 1, 2, 3, 4, 5, 6
- **WSS (Pa)**: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
- **Target Zone**: 8.5 WSS (Pa)

- **Too High** markers at 6.5 and 7.5 WSS (Pa)
- **Too Low** markers at 4.5 and 5.5 WSS (Pa)
How Provide Non-Pulsatile Flow and WSS Control During Vein Maturation?

The Arteriovenous Fistula Eligibility (AFE) System™ delivers nonpulsatile flow to peripheral veins. Adjustment of pump speed allows control of WSS, providing constant WSS dose during vein maturation.
Patient Ineligible for AVF Due to Small Vein Diameter

AFE System in Place for 2 – 3 Weeks

Vein Dilated; Patient Eligible for AVF

AVF Created

**AFE System™ Dilates Veins Prior to AVF Surgery Using Controlled, Non-Pulsatile Blood Flow**
AFE System Mock Loop Shows No Pulsatility in Outflow Vein

- Radiocephalic AVF mock loop vs AFE System mock loop
- AVF: Mean AoP = 100 mmHg
- AVF: Aortic pulse pressure = 40 mmHg
- Radial and ulnar arteries ID = 4 mm
- Cephalic vein ID = 2 mm
- Two cephalic vein collaterals, ID = 2 mm
- AFE System conduits, ID = 4 mm

No cyclic stretching of vein wall with AFE System
Outflow vein WSS levels can be set and maintained during vein maturation by adjusting AFE System pump speed.

- AFE System mock loop
- Two cephalic vein collaterals, ID = 2 mm
- AFE System conduits, ID = 4 mm
AVF maturation failure likely multifactorial
- High WSS levels and pulsatility in small veins likely contribute to AVF failure
- Low WSS levels with larger veins likely contribute to slow AVF maturation
- AFE System can provide non-pulsatile flow and optimal WSS doses to outflow veins during maturation, potentially enabling use of small veins for AVF creation, reducing neointimal hyperplasia, accelerating vein dilation, and improving maturation success
Contact Us

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