Hemodialysis Access Maturation and Ultrasound Surveillance

Michael Lilly, M.D.
University of Maryland School of Medicine
Baltimore, Maryland
Disclosures:

- Practicing Academic Vascular Surgeon
  - School of Medicine
  - University Medical Center and Inner city hospital
- Medical Director of a Vascular Ultrasound Lab
- Board of Directors of the Inteleos (ARDMS/APCA)
- Board of Directors of Intersocietal Accreditation Commission (IAC)
- No industry relationships
Outline

- Maturation of new autogenous access
- Surveillance of existing access to predict failure (thrombosis)
Fistula Maturation

- Increased flow
- Vein dilation
- Vein wall thickening

Flow mediated expansile remodeling

Functional definition

North American Vascular Access Consortium (NAVAC)

“A minimum criterion for successful use of a fistula for conventional HD would be 2-needle cannulation for 2/3 runs within a month at an average blood flow rate (total blood processed over duration of HD) of 300 ml/minute in a 3.5-hour HD session.”

North American Vascular Access Consortium (NAVAC)
Anatomic Criteria

- Effective hemodialysis requires:
  - At least 300 mL/min flow
  - Low venous resistance
  - Easy, safe cannulation & hemostasis

- 2006 KDOQI Guidelines
  - time @ 6 weeks post construction
  - blood flow > 600 mL/min
  - diameter > 6 mm
  - depth < 6 mm

“the Rule of 6s”

Maturation failure

At least 20-30% of native AV - (? 50% )

Risk factors: gender, location, type
- Flow limitation - stenosis
  • Inflow
    - Native arterial disease
    - Anastomotic stenosis
  • Conduit
    - Focal sclerosis
    - Diffuse sclerosis
    - Small vein
- Flow diversion from the main cannulation segment
  • Accessory / tributary / perforator veins
Early AVF lesions

Table 4. Frequency and distribution of vascular stenoses

<table>
<thead>
<tr>
<th>Lesion</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peripheral artery stenosis</td>
<td>6 (5.1%)</td>
</tr>
<tr>
<td>Arterial anastomosis stenosis</td>
<td>56 (47.1%)</td>
</tr>
<tr>
<td>Juxta-arterial anastomosis stenosis</td>
<td>76 (63.9%)</td>
</tr>
<tr>
<td>Peripheral vein stenosis</td>
<td>70 (58.8%)</td>
</tr>
<tr>
<td>Peripheral vein occlusion</td>
<td>25 (21%)</td>
</tr>
<tr>
<td>Central vein stenosis</td>
<td>10 (8.4%)</td>
</tr>
<tr>
<td>Arterial with juxta-arterial stenosis</td>
<td>45 (37.8%)</td>
</tr>
<tr>
<td>Juxta-arterial with peripheral vein stenosis</td>
<td>46 (38.7%)</td>
</tr>
</tbody>
</table>

119 patients

AVF early lesions & salvage

• 100 patients with maturation failure
  - 38% arterial anastomotic stenosis
  - 78% venous stenosis
    • 43% in juxta-anastomotic region
    • 36% in proximal vein
  - 46% accessory vein

• Success of treatment:
  - Angioplasty of arterial stenosis 100%
  - Angioplasty of venous stenosis 98%
  - Occlusion of accessory veins 100%

• Fistula function:
  - 84% at 3 months, 72% at 6 months, 68% at 12 months.

Clinical program to reduce maturation failure

- Early first post-op visit ~ 2 weeks
- Thoughtful physical exam
- Ultrasound of any AVF not maturing well
- Identify the major issues
- Treat

*Coordinated approach is key: surgeon, dialysis center, patient*
Hemodialysis duplex evaluation

- **Complete examination of the access**
  - In-flow artery:
    - beginning one segment above the AV anastomosis
  - AV anastomosis:
    - AVF - the only anastomosis
    - AVG - the proximal (or arterial) anastomosis
  - Entire length of the conduit
  - Distal (or venous) anastomosis:
    - AVG only
  - Outflow veins as centrally as possible
Stenosis Criteria

• Focal stenosis

    *No clear/rigid velocity criteria for stenosis*
    - Flow is always turbulent
    - Flow is often bidirectional
    - Flow velocities are always high
    - Color mosaic always seen
Radial artery stenosis
Peak velocity criteria?

2008-2015
Single center
780 stenotic accesses
  372 radiocephalic
  361 brachiocephalic
  47 brachiobasilic

Volumetric flow

\[ Q = \nu \left( \pi d^2 \right)/4 \]

• Technical features:
  - At least 2 cm from anastomosis
  - Straight, uniform diameter, no branches
  - No turbulence
  - Grey-scale diameter measurements at 90 degrees (zoom in)
  - Doppler spectra at 60 degrees
  - Spatial averaging (open sample volume: +/- walls)
  - Temporal averaging (at least 3-5 cardiac cycles)
  - Average measurements at multiple sites (3-5)

Volumetric flow calculation

Dist = 0.885 cm
TAMV = 282 cm/s
Vol Flow = 10407 cc/min
Area = 0.615 cm²
Volume flow
Brachial artery vs. access

\[ y = 0.8611x + 257.84 \]
\[ R^2 = 0.8051 \]

### Combined criteria
*stenosis + flow*

<table>
<thead>
<tr>
<th></th>
<th>Low Flow Rate (≤800 mL/min)</th>
<th>High Flow Rate (&gt;800 mL/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stenosis</strong></td>
<td>Fistulogram + remedial treatment</td>
<td>Surveillance or remedial treatment (dysfunctional accesses)</td>
</tr>
<tr>
<td><strong>No stenosis</strong></td>
<td>Surveillance</td>
<td>Cannulation for dialysis</td>
</tr>
</tbody>
</table>

Currently recommended criteria for HD access stenosis

- **Graft**
  - PSV ratio > 2 venous anastomosis vs mid graft
  - Volume flow < 500 ml/min
- **Fistula**
  - Gray scale lumen diameter < 2-3 mm
  - Anastomosis: PSV ratio > 3
  - Vein: PSV ratio > 2-3 vs. adjacent or mid-conduit
  - Focal PSV > 400 cm/s (≥ 500 cm/s)
  - Volume flow < 800 ml/min
HD access monitoring and surveillance

Clinical Monitoring

Evaluations based on physical examination or routine laboratory data
- Physical examination (inspection & auscultation) of the access and arm (absent thrill, abnormal auscultation, or edema distal to the graft);
- Problems during the dialysis treatment (difficult cannulation or post-decannulation bleeding)
- An unexplained decrease in Kt/V over time on a constant dialysis prescription

- Inconsistent
- Low cost - staff dependent

Access Surveillance

Noninvasive methods using specialized equipment and trained staff
- Access venous pressures (static/dynamic)
- Access flow monitoring ($Q_A$, Fick)
- Recirculation
- Duplex ultrasound

- More consistent
- Higher cost
- Trained personnel
- Equipment


### Physical examination of HD access

<table>
<thead>
<tr>
<th>Table 1. Clinical features of basic lesions</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td><strong>Clinical abnormality</strong></td>
</tr>
<tr>
<td>None</td>
</tr>
<tr>
<td>Difficult cannulation</td>
</tr>
<tr>
<td>Poor flow</td>
</tr>
<tr>
<td>Negative arterial pressure</td>
</tr>
<tr>
<td>Prolonged bleeding</td>
</tr>
<tr>
<td>Poor flow</td>
</tr>
<tr>
<td>High venous pressure</td>
</tr>
<tr>
<td>Difficult cannulation +</td>
</tr>
<tr>
<td>Poor flow +</td>
</tr>
<tr>
<td>Increased venous pressure +</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Physical examination</strong></td>
</tr>
<tr>
<td>Inspection</td>
</tr>
<tr>
<td>Normal appearance</td>
</tr>
<tr>
<td>Poorly defined +</td>
</tr>
<tr>
<td>Distended</td>
</tr>
<tr>
<td>Aneurysmal +</td>
</tr>
<tr>
<td>Does not collapse with arm elevation</td>
</tr>
<tr>
<td>Swollen arm, etc</td>
</tr>
<tr>
<td>Collateral veins</td>
</tr>
<tr>
<td>Does not collapse with arm elevation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Palpation</strong></td>
</tr>
<tr>
<td>Pulse</td>
</tr>
<tr>
<td>Soft, easily compressible</td>
</tr>
<tr>
<td>Poor pulse augmentation</td>
</tr>
<tr>
<td>Hyperpulsatile</td>
</tr>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>May be present beneath clavicle</td>
</tr>
<tr>
<td>Thrill</td>
</tr>
<tr>
<td>Continuous</td>
</tr>
<tr>
<td>Discontinuous</td>
</tr>
<tr>
<td>Discontinuous</td>
</tr>
<tr>
<td>Disconnected</td>
</tr>
<tr>
<td>Accentuated at site of lesion</td>
</tr>
<tr>
<td>Variable</td>
</tr>
<tr>
<td>May be present beneath clavicle</td>
</tr>
<tr>
<td>Auscultation</td>
</tr>
<tr>
<td>Continuous</td>
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<tr>
<td>Discontinuous</td>
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</table>
Sequential occlusion test

Step 1. WARNING SIGNS OF STENOsis

Step 2. DIAGNOSIS OF STENOsis

Step 3. DIAGNOSIS OF STENOsis AT HIGH RISK OF THROMBOSIS

Step 4. ELECTIVE INTERVENTION FOR STENOsis

STEPS FOR MANAGEMENT OF ARTERIOVENOUS ACCESS STENOsis

Ultrasound

Physical exam, monitoring
Ultrasound surveillance for AVG

U Alabama
3 years
65 US
63 control
AVG
95% loops

Figure 3 | Comparison of thrombosis-free graft survival between randomized patients with clinical monitoring vs clinical monitoring plus regular ultrasound surveillance of grafts. P = 0.33 by the log-rank test.

Ultrasound surveillance AVF

- Prevalent native AV fistulas
- Randomized, controlled, multicenter, open-label trial, 2012-15.
- $Q_A$ surveillance + pre-emptive intervention vs. clinical monitoring
- 3-year follow-up

CMS view of monitoring

“An ESRD facility must furnish all necessary services, equipment, and supplies associated with a dialysis treatment, either directly or under arrangements. The ESRD facility is financially responsible for the service. If an ESRD facility or a renal physician decides to monitor the patient’s access site with a non-invasive vascular study and does not have the equipment to perform the procedure, the ESRD facility or physician may arrange for the service to be furnished by another source. The alternative source, such as an independent diagnostic testing facility must look to the ESRD facility for payment.”

Medicare Benefit Policy Manual (Rev. 257, 03-01-19), Chapter 11 - End Stage Renal Disease (ESRD), p 32.
Doppler flow studies may be considered appropriate in the presence of signs or symptoms of possible failure of the ESRD patient’s vascular access site, and when the results are used in determining the clinical course of the treatment for the patient. Routine monitoring by noninvasive Doppler flow studies is included under the ESRD PPS.

Examples supporting the medical necessity for Doppler flow studies include:

- Elevated dynamic venous pressure >200mm Hg when measured during dialysis with the blood pump set on a 200cc/min.,

- Access recirculation of 12 percent or greater,

- An otherwise unexplained urea reduction ratio <60 percent, and

- An access with a palpable “water hammer” pulse on examination, (which implies venous outflow obstruction).

Unless the documentation is provided supporting the necessity of more than one study, Medicare will limit payment to either a Doppler flow study or an arteriogram (fistulogram, venogram), but not both. An example of when both studies may be clinically necessary is when a Doppler flow study demonstrates:

- Reduced flow (blood flow rate less than 800cc/min or
- A decreased flow of 25 percent or greater from previous study) and
- The physician requires an arteriogram to define the problem.

This policy is applicable to claims from ESRD facilities and all other sources, such as independent diagnostic testing facilities and hospital outpatient departments.
Indications for HD Access Ultrasound

• Abnormal HD Access function
  - Difficult cannulation
  - Thrombus aspiration
  - High dynamic venous pressure (>200 mmHg at 200 ml/min) CMS
  - Prolonged recirculation time (15%) CMS
  - Unexplained urea reduction ratio (<60%) CMS

• Clinical signs / symptoms of HD access problem
  - Access collapse (inadequate arterial inflow)
  - Pulsatility (post-decannulation bleeding) CMS
  - Loss of thrill / bruit
  - Graft-associated mass (infiltration, aneurysm, pseudoaneurysm)
  - Distal arm ischemia (sensory / motor)
  - Signs of infection
Summary

• **Fistula maturation - surveillance & guidance**
  - Yes! As part of a comprehensive program to deliver functional long-term HD access
  - Must be performed for a defined indication

• **Existing Access - surveillance**
  - May be of value - unproven to date
  - Not accepted for payment

• **Existing Access - for indication**
  - Select lesions needing intervention
  - Guide the intervention
Thank you!

mlilly@som.umaryland.edu