Current Status of Duplex Vein Graft Surveillance

- What to look for and how to report it -

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DISCLOSURE

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No Relevant Financial Relationship Reported
Session Objectives: Arterial Bypass Grafts

- Rationale & history of graft surveillance
- Testing protocol & documentation
- Expected findings and lesion identification
- Interpretation criteria
- Expected outcomes of graft surveillance
“when distal anastomosis narrowed, the ankle pressure began to decrease and the exercise test was abnormal. After the anastomosis was revised, the ankle pressure increased to 130 mm Hg and claudication disappeared”
Evolution of Graft Surveillance – Duplex U/S

1980s
Define the hemodynamics of lower limb bypass grafts – pulsed Doppler patterns at anastomotic sites

Duplex surveillance of lower limb bypass graft – identification of graft stenosis & the “low flow” bypass

Hemodynamics of in situ saphenous vein bypass & vein graft stenosis

Intraoperative duplex assessment of infrainguinal vein bypass

1990s
The origin of vein graft stenosis; role of early graft scanning

Natural history of vein graft stenosis relative to grafting technique

2000s
Duplex monitoring of interventions for graft stenosis

Surveillance of arm vein bypass - popliteal aneurysm repair

Surveillance of endovascular interventions
Surveillance of Infrainguinal Vein Bypass

- **Rationale**
  - 20-30% incidence of graft stenosis within 1 yr
  - High failure rate of grafts with stenosis (PSV > 300 cm/s)
  - Repair stenosis in a patent graft better than salvage for thrombosed graft (In situ bypass: 93% vs 47%)

Life-Table Plot of Graft Patency
Duplex Surveillance Factors Predictive of Lower Extremity Vein Graft Thrombosis


- Prospective duplex surveillance of 165 infrainguinal vein bypasses
- Testing at 1,3,6,9,12,18, 24 mo, then annually
- Incidence of graft thrombosis without stenosis – 2.9%/year
- Factors predictive of graft thrombosis:
  - Mean graft velocity (MGV): < 50 cm/s  \( p < 0.001 \) (15x incidence)
  - Vr at Stenosis: > 3.5  \( p < 0.001 \) (9 x incidence)
  - PSV at Stenosis: > 400 cm/s  \( p < 0.001 \)
  - Decrease in MGV > 30 cm/s  \( p < 0.002 \)
Arterial Bypass Vein Graft Duplex US Evaluation

Clinical History
Measure Limb Pressures
(ABI, toe pressures)

Scan Proximal Anastomotic Region
- assess inflow artery (pulsatility, acceleration time)
- image anastomosis
- record graft velocity spectra
-- measure PSV

Scan Body of Graft
- assess for stenosis or AV fistula (in situ)
- record flow velocity along graft length

Scan Distal Anastomotic Region
- assess outflow art.
- image anastomosis
- measure PSV, record spectral waveform in distal graft & runoff arteries

Normal Scan
Low Flow Graft Identified
Graft Stenosis Identified
Duplex Velocity Criteria for Stenosis Repair

\[ \text{PSV}_{\text{max}} > 300 \text{ cm/sec} \]

\[ V_r = \frac{\text{PSV}_{\text{max}}}{\text{PSV}_{\text{prox}}} > 3.5 \]

Vein Diameter (mm)  

PSV\(_{\text{prox}}\)  

\(\rightarrow\)  

PSV\(_{\text{max}}\)  

Stenosis Length (cm)
Efficacy of duplex ultrasound surveillance after infrainguinal vein bypass may be enhanced by identification of characteristics predictive of graft stenosis development

Chelsey N. Tinder, MD, Joe P. Chavanpun, MD, Dennis F. Bandyk, MD, Paul A. Armstrong, DO, Martin R. Back, MD, Brad L. Johnson, MD, and Murray L. Shames, MD, Tampa, Fla

353 clinically successful infrainguinal vein bypasses
- CLI: 80%
- Arm vein: 19%

Duplex surveillance program

Predictors of graft revision
- Abnormal 1st duplex scan (P<0.001)
- Redo bypass (P<0.001)
- Non single segment saph. vein (P<0.01)
- Warfarin therapy (p<0.01)
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Patency Curves Suggest Surveillance Benefit

![Patency Curves Graph]

- Primary Patency
- Assisted Primary Patency
- Secondary Patency

$P < 0.0001$, log rank

SE $\geq 10\%$
Lower Extremity Bypass Graft Surveillance
(In-Hospital – Outpatient Diagnostics)

Intraoperative Assessment
Color Duplex Ultrasound

Abnormal
Correct Graft Abnormality

Normal
Pre-Discharge Color Duplex Scan & ABI/toe pressure measurement

Abnormal

Outpatient Graft Surveillance at 4 wks, at 4-mo, q 6 mo if normal
<table>
<thead>
<tr>
<th>Category</th>
<th>High Velocity Criteria (cm/s)</th>
<th>Low Velocity Criteria</th>
<th>( \Delta ) ABI</th>
</tr>
</thead>
<tbody>
<tr>
<td>I - Highest Risk</td>
<td>PSV &gt; 300; Vr &gt; 3.5 or EDV &gt; 100</td>
<td>GFV &lt; 45 cm/s</td>
<td>&gt; 0.15</td>
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<tr>
<td>II - High Risk</td>
<td>PSV &gt; 300, Vr &gt; 3.5</td>
<td>GFV &gt; 45 cm/s</td>
<td>&lt; 0.15</td>
</tr>
<tr>
<td>III - Intermediate Risk</td>
<td>200 &lt; PSV &lt; 300, Vr &gt; 2</td>
<td>GFV &gt; 45 cm/s</td>
<td>&lt; 0.15</td>
</tr>
<tr>
<td>IV – Low Risk</td>
<td>PSV &lt; 200, Vr &lt; 2</td>
<td>GFV &gt; 45 cm/s</td>
<td>&lt; 0.15</td>
</tr>
</tbody>
</table>
Category I – Abnormal Graft Waveforms

Low flow graft
- PSV 18 cm/s
- low resistance
- proximal stenosis

Staccato graft flow
- high resistance
- distal stenosis
<table>
<thead>
<tr>
<th>Lesion Type</th>
<th>Risk for Thrombosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-grade stenosis + low flow</td>
<td>High</td>
</tr>
<tr>
<td>Flow-limiting stenosis</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Non-flow limiting stenosis</td>
<td>Low</td>
</tr>
<tr>
<td>- Triphasic graft flow; nl ABI</td>
<td></td>
</tr>
<tr>
<td>Arteriovenous fistula – in situ vein</td>
<td>Low</td>
</tr>
<tr>
<td>Vein graft aneurysm</td>
<td>Intermediate</td>
</tr>
<tr>
<td>- mural thrombus</td>
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</table>
J Vas Surg - 2007

The relative importance of graft surveillance and warfarin therapy in infrainguinal prosthetic bypass failure

Robert Scott Brumberg, DO,* Martin R. Back, MD,* Paul A. Armstrong, DO,* David Cuthbertson, MS,^ Murray L. Shames, MD,^ Brad L. Johnson, MD,^ and Dennis F. Bandyk, MD,
 Tampa, Fla.

Mid-graft PSV < 45 cm/s

- Failed
- Patent

J Vas Surg - 2003

Postoperative duplex scan surveillance of axillofemoral bypass grafts


J Vas Surg - 2004

Optimizing infrainguinal arm vein bypass patency with duplex ultrasound surveillance and endovascular therapy

Paul A. Armstrong, DO, Dennis F. Bandyk, MD, Jeffrey S. Wilson, MD, Murray L. Shames, MD, Brad L. Johnson, MD, and Martin R. Back, MD, Tampa, Fla.

48% intervention rate
91% asst primary patency
Lower limb bypass grafts are susceptible to modes of failure that can be identified and corrected – prolonging patency.

The incidence of graft stenosis and inflow/outflow artery disease progression is sufficient to warrant routine duplex surveillance of all graft types – beginning immediately after the procedure.

Secondary procedures to correct identified abnormalities are associated with a high success rate if duplex testing confirms no residual stenosis.

At present, drugs to prevent myointimal hyperplasia formation have not been effective – the need for graft surveillance remains.