Duplex sonography for the detection of venous stent obstruction

A case control study

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Disclosure

Speaker name: Tim Sebastian

I have the following potential conflicts of interest to report:

☐ Consulting
☐ Employment in industry
☐ Stockholder of a healthcare company
☐ Owner of a healthcare company
☐ Other(s)

☐ I do not have any potential conflict of interest
Background

- Duplex ultrasound is the first-line examination tool for routine stent surveillance
- No validated criteria exists to detect stent obstruction (stenosis or occlusion)
- Stent patency loss remains a hazard over time

from the Swiss Venous Stent Registry
an analysis by Suvetha Gnanapiragasam
## Duplex characteristics

<table>
<thead>
<tr>
<th>B-mode (brightness)</th>
<th>C-mode (color)</th>
<th>PW-mode (pulsed wave)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct evaluation</td>
<td>Direct + indirect evaluation</td>
<td></td>
</tr>
<tr>
<td>Visualization of thrombi, in-stent deposits, planimetries (collapsed stents), collaterals</td>
<td>Presence or absence flow</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>Screening for slow / fast flow</td>
<td>Exact measurements of flow velocities (in cm/s)</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Flow pattern analysis: Flow modulated by respiration or cardiac cycle</td>
</tr>
</tbody>
</table>
Criteria for iliac obstruction (without stents) have been previously described in literature

**Direct criteria**
- Planimetric diameter stenosis
- Luminal changes
- Filling (color) defects
- Post-stenotic to pre-stenotic vein velocity ratio (> 2.5)

**Indirect criteria**
- Non-phasic flow in common femoral vein
- Asymmetric flow pattern in common femoral vein
- Presence of collateral veins
- Difficulty compressing the common femoral vein
- Reversed flow in internal iliac vein
The ideal examination

Patient information

Young women

Slim

Overnight fast (stomach empty)

Follow-up ultrasound after IVC and iliac vein reconstruction (PTS)

Residual leg symptoms including venous claudication and dyspnea when exercising
The ideal examination

B-mode

C-mode

B-mode

B-flow
The ideal examination

B-mode

Velocity ratio: 5

PW-mode (PFV 100 cm/s)

PW-mode (PFV 20 cm/s)
Limitation of duplex sonography

C-mode

PW-mode

Sometimes only the femoral veins are accessible
Criteria for iliac obstruction (without stents) proposed in literature

**Direct criteria**
- Planimetric diameter stenosis
- Luminal changes
- Filling (color) defects
- Post-stenotic to pre-stenotic vein velocity ratio (> 2.5)

**Indirect criteria**
- Non-phasic flow in common femoral vein
- Asymmetric flow pattern in common femoral vein
- Presence of collateral veins
- Difficulty compressing the common femoral vein
- Reversed flow in internal iliac vein
What if this is all you have?

Patient 1

Patient 2
What if this is all you have?

Patient 1

Patient 2
What if this is all you have?

Patient 1

Patient 2
Swiss Venous Stent Registry

- Includes baseline, procedural and follow-up data of >400 patients with venous stents and follow-ups up to 5 years including duplex ultrasound exams.

- Nested case-control study (120 patients)

- Cases (25 stent occlusion, 15 stent stenosis >50%)
  - Venous stent obstruction (>50%) diagnosed in venography (re-intervention)
  - Available duplex ultrasound exams prior to re-intervention.

- Controls (2:1):
  - Matched by age (+10 years), sex and index diagnosis
  - Criteria: ongoing symptom control, good imaging quality (review of stored images, reports), spontaneous color signal >50% of lumen in entire stent, availability of at least two ultrasound exams. No venographic images!
## Baseline

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Overall (120)</th>
<th>Venous stent obstruction (40)</th>
<th>Control (80)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>41.8 ± 17.2</td>
<td>42.5 ± 18.0</td>
<td>41.4 ± 16.8</td>
</tr>
<tr>
<td>Female</td>
<td>63 (53)</td>
<td>21 (53)</td>
<td>42 (53)</td>
</tr>
<tr>
<td>Index event</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postthrombotic syndrome</td>
<td>93 (78)</td>
<td>31 (78)</td>
<td>62 (78)</td>
</tr>
<tr>
<td>Acute deep vein thrombosis</td>
<td>21 (18)</td>
<td>7 (18)</td>
<td>14 (18)</td>
</tr>
<tr>
<td>Tumor provoked venous obstruction</td>
<td>6 (5)</td>
<td>2 (5)</td>
<td>4 (5)</td>
</tr>
<tr>
<td>Procedural</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean number of stents implanted</td>
<td>2.7 ± 1.8</td>
<td>2.9 ± 2.1</td>
<td>2.6 ± 1.7</td>
</tr>
<tr>
<td>IVC reconstruction</td>
<td>33 (28)</td>
<td>9 (23)</td>
<td>24 (30)</td>
</tr>
<tr>
<td>Stent below the inguinal ligament</td>
<td>63 (53)</td>
<td>24 (60)</td>
<td>39 (49)</td>
</tr>
</tbody>
</table>
## Continuous duplex parameters

<table>
<thead>
<tr>
<th></th>
<th>Cases (40)</th>
<th>Controls (80)</th>
<th>AUC (95% CI)</th>
<th>Cut-off, cm/s</th>
<th>Sensitivity (%) (95% CI)</th>
<th>Specificity (%) (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak flow velocities (in cm/s)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common femoral vein</td>
<td>9.6 ± 12.3</td>
<td>25.9 ± 13.0</td>
<td>0.88 (0.79-0.97)</td>
<td>14.0</td>
<td>81.1 (65.8-90.5)</td>
<td>91.3 (83.0-95.7)</td>
</tr>
<tr>
<td></td>
<td>7.0 (0.0;12.0)</td>
<td>20.0 (20.0; 30.0)</td>
<td></td>
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</tr>
<tr>
<td>Stent inlet</td>
<td>10.9 ± 9.5</td>
<td>25.9 ± 13.0</td>
<td>0.90 (0.83-0.97)</td>
<td>14.5</td>
<td>84.6 (70.3-92.8)</td>
<td>88.8 (80.0-94.0)</td>
</tr>
<tr>
<td></td>
<td>10.0 (5.0;12.0)</td>
<td>20.0 (20.0; 33.8)</td>
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<td></td>
</tr>
<tr>
<td><strong>Indices</strong></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Femoral index</td>
<td>0.43 ± 0.55</td>
<td>1.00 ± 0.41</td>
<td>0.83 (0.71-0.94)</td>
<td>0.57</td>
<td>73.1 (53.9-86.3)</td>
<td>92.0 (83.6-96.3)</td>
</tr>
<tr>
<td></td>
<td>0.29 (0.00; 0.76)</td>
<td>1.00 (0.72-1.11)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Stent inlet PFV baseline to follow-up ratio</td>
<td>0.40 ± 0.36</td>
<td>1.09 ± 0.57</td>
<td>0.88 (0.80-0.96)</td>
<td>0.48</td>
<td>74.2 (56.8-86.3)</td>
<td>89.9 (81.3-94.8)</td>
</tr>
<tr>
<td></td>
<td>0.33 (0.19; 0.50)</td>
<td>1.00 (0.60;1.47)</td>
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</tr>
</tbody>
</table>

Venous femoral velocity index, ratio of ipsilateral peak flow velocity divided by contralateral peak flow velocity

Stent inlet PFV baseline to follow-up ratio, ratio of ipsilateral peak flow velocity at follow-up divided by baseline measurement
<table>
<thead>
<tr>
<th>Categorical duplex parameters</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(95% CI)</td>
<td>(95% CI)</td>
</tr>
<tr>
<td>Any Doppler flow pattern other than spontaneously modulated by</td>
<td>84.6</td>
<td>94.9</td>
</tr>
<tr>
<td>respiration at stent inlet</td>
<td>(70.3-92.8)</td>
<td>(87.7-98.0)</td>
</tr>
<tr>
<td>Monophasic Doppler pattern or no flow at stent inlet</td>
<td>53.8</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>(38.9-68.4)</td>
<td>(95.4-100)</td>
</tr>
<tr>
<td>Pattern change at stent inlet from baseline to follow-up</td>
<td>81.0</td>
<td>95.0</td>
</tr>
<tr>
<td></td>
<td>(64.7-91.1)</td>
<td>(87.8-98.0)</td>
</tr>
<tr>
<td>Decrease in peak flow velocity at stent inlet ≥ 50% from baseline</td>
<td>74.2</td>
<td>82.0</td>
</tr>
<tr>
<td>to follow-up</td>
<td>(56.8-86.3)</td>
<td>(72.4-89.1)</td>
</tr>
<tr>
<td>Peak flow velocity at stent inlet ≤ 10 cm/s at follow-up</td>
<td>71.8</td>
<td>98.7</td>
</tr>
<tr>
<td></td>
<td>(56.2-83.5)</td>
<td>(93.3-99.8)</td>
</tr>
</tbody>
</table>
Main findings

Peak flow velocity >10 cm/s AND flow pattern spontaneously modulated by respiration ruled out >50% upstream venous stent obstruction with a specificity of 93.7% (95%CI 86.0-97.3%).

Peak flow velocity ≤10 cm/s OR any Doppler flow pattern other than spontaneously modulated by respiration was 92.1% (95%CI 79.2-97.3%) sensitive to detect upstream venous stent obstruction.
Indirect criteria for venous stent stenosis were less sensitive than for stent occlusion (but still specific)

Direct visualization should always be performed as gold standard for all patients!
Limitations

- Retrospective study design, rather small cohort
- Many duplex investigators and different machines
- Matched controls had no venography (but strict inclusion criteria applied)

Limitation of case-control studies
Predictive values depend on incidence, and incidence is determined by the ratio of cases to controls (here 1:2)
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