What Can We Learn From Air Plethysmography?

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Chronic Venous Ulceration
- The most advanced form of venous insufficiency
- Affect 4% of people older than 65 years.
- Costs to the U.S. government for CVI treatment and venous ulcer care has been estimated to exceed $1 billion a year.
- In addition, 4.6 million work-days per year are lost to chronic venous disease.

Post-Thrombotic Syndrome

- Asymptomatic limbs
  - Normal U/S more common
- PTS limbs
  - Reflux + obstruction most common
- Combination of reflux and obstruction
  - Gives the highest levels of venous hypertension
  - The most severe symptoms compared with either alone

Duplex ultrasonography

Ambulatory Venous Hypertension
Ambulatory Venous Hypertension

Strain gauge plethysmography

photoplethysmography

Air plethysmography

Air plethysmography and the effect of elastic compression on venous hemodynamics of the leg.

Venous Ulceration Correlates with Elevated Residual Volume Fraction

<table>
<thead>
<tr>
<th>No. of Limbs</th>
<th>RVF, %</th>
<th>Incidence of Ulceration, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>24</td>
<td>31-40</td>
<td>8</td>
</tr>
<tr>
<td>48</td>
<td>41-50</td>
<td>18</td>
</tr>
<tr>
<td>43</td>
<td>51-60</td>
<td>42</td>
</tr>
<tr>
<td>32</td>
<td>61-80</td>
<td>72</td>
</tr>
<tr>
<td>8</td>
<td>&gt;80</td>
<td>88</td>
</tr>
</tbody>
</table>

From Christopoulos et al.

Twelve extremities with evidence of venous insufficiency examined with APG before and after venous surgery.

Surgery was directed at specific sites of venous incompetence defined by physical examination.

Color flow duplex

Patients underwent ligation and stripping of the greater saphenous vein.

APG showed an improvement in venous reflux as demonstrated by a decrease in the:

- Venous filling index: from 6.6 ml/sec to 1.8 ml/sec (p = 0.0001)
- Venous volume: from 177 ml to 139 ml (p = 0.0008)

Ejection fraction: 45.8% to 50.8% (p = 0.07)

Residual Volume Fraction: 45% to 42.0% (p = 0.4)

Endovenous Saphenous Ablation Corrects the Hemodynamic Abnormality in Patients with CEAP Clinical Class 3-6 CVI Due to Superficial Reflux

ENDO Survey of US Endovascular Physicians: RFA and EVLT. Significant differences are listed for each group comparing the preoperative to postoperative VFI.
Preoperative and postoperative venous filling index (VFI) for limbs with complete saphenous ablation (Group 1) compared to limbs with incomplete saphenous ablation (Group 2). *p=0.03 for postablation VFI comparing group 1 to group 2.

Hemodynamic and clinical improvement after superficial vein ablation in primary combined venous insufficiency with ulceration

Hemodynamic changes before and after surgical intervention are plotted over 2-year follow-up.

- hemodynamic suppression of reflux by focused Rx of reflux without GSV stripping
- Design: prospective study; single group of patients.
- Materials: forty patients affected by primary chronic venous insufficiency of all clinical classes, with demonstrated incompetence of the sapheno–femoral junction (SFJ) and the GSV trunk with the re-entry perforator located on a GSV tributary. The re-entry point was defined as the perforator, whose finger compression of the superficial vein above its opening eliminates reflux in the GSV.
- Methods: air–plethysmographic parameters as well as duplex scanning were performed both preoperatively, and 1 and 6 months later, respectively. Operation consisted in flush ligation and division from the GSV of the tributary containing the re-entry perforating vein.

Venous Filling Index from 4.9 ± 0.5 ml/s to 2.3 ± 0.2 ml/s (p<0.0001)
Residual Volume Fraction from 42 ± 3ml to 30 ± 2ml (p<0.0001).

Hemodynamic and clinical improvement after superficial vein ablation in primary combined venous insufficiency with ulceration


<table>
<thead>
<tr>
<th>CEAP summary clinical symptom scores</th>
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<tbody>
<tr>
<td>Before surgery</td>
</tr>
<tr>
<td>Pain</td>
</tr>
<tr>
<td>After surgery</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Before surgery</td>
</tr>
<tr>
<td>After surgery</td>
</tr>
</tbody>
</table>

CEAP summary clinical symptom scores

Outcomes in Venous Disease

- Clinically relevant outcomes
  - Symptoms
  - Function / Quality of Life
  - Survival
- Surrogate outcomes
  - Physical signs
  - Laboratory tests
  - Radiographic tests

VCSS scores
- decreased significantly
- Preablation 11.5 ± 4.3
- Postablation 4.4 ± 2.3

Endovenous Saphenous Ablation Corrects the Hemodynamic Abnormality in Patients with CEAP Clinical Class 3-6 CVI Due to Superficial Reflux

[Graph showing VCSS scores]
VCSS scores decreased significantly
- Preablation: 11.5 ± 4.5
- Postablation: 4.4 ± 2.3

RF compared to EVLT
- Pre/Post ablation VCSS
- No significant difference

Conclusion
- APG is a useful non-invasive tool to measure changes in venous filling index and residual volume fraction
- Useful as a research tool
- In general these are surrogate markers of outcomes and not as useful as ulcer healing or VCSS improvement

Thank you