Duplex Ultrasound Assessment of the Venous System

David Jenkins
Phlebologist
Sydney
• Seize the opportunity

• Ask ANY questions - you will be doing many others present a favour!

• Be involved – don’t go home disappointed that you could have learned more
What you should achieve in this session:

• Understand the basic principles involved in production of an ultrasound image

• Practical hands-on experience to become familiar with duplex technology
Overview:

Replaced venography as the “gold standard”

- High specificity
- High sensitivity
- Non-invasive
- Accessible
- Cost effective
Hand held Doppler:

- Used clinically for ~ 25 yrs
- Relatively poor sensitivity (30% to 50% of reflux missed)$^1,^2$
- Poor specificity (auditory signal only, not anatomically precise)
- Cheap
Transmitting crystal

Receiving crystal

Skin

Incident 5-10 MHz sound

Back scattered sound

Blood vessel
• Doppler Shift

\[ f_t \ 2 \ u \cos \theta \]

\[ f_d = \ \text{__________} \]

c

• \( f_t \) is transmitted frequency
• \( \theta \) = angle source motion and direction of receiver
• \( u \) = source velocity
• \( C \) = velocity of sound
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>VELOCITY (m/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>331</td>
</tr>
<tr>
<td>Fat</td>
<td>1450</td>
</tr>
<tr>
<td>Mercury</td>
<td>1450</td>
</tr>
<tr>
<td>Castor oil</td>
<td>1500</td>
</tr>
<tr>
<td>Water (50° C)</td>
<td>1540</td>
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<tr>
<td>“HUMAN SOFT TISSUE”</td>
<td>1540</td>
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<tr>
<td>Brain</td>
<td>1541</td>
</tr>
<tr>
<td>Liver</td>
<td>1549</td>
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<tr>
<td>Kidney</td>
<td>1561</td>
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<tr>
<td>Blood</td>
<td>1570</td>
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<tr>
<td>Muscle</td>
<td>1585</td>
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<tr>
<td>Lens of eye</td>
<td>1620</td>
</tr>
<tr>
<td>PZT-5A</td>
<td>3780</td>
</tr>
<tr>
<td>PZT-4</td>
<td>4000</td>
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<tr>
<td>Skull (bone)</td>
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<tr>
<td>Brass</td>
<td>4490</td>
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<tr>
<td>Quartz</td>
<td>5740</td>
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<tr>
<td>Aluminum</td>
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</table>
Propagation velocity of common tissues

- Bone: 4,080 m/sec
- Muscle: 1,580 m/sec
- Liver: 1,550 m/sec
- Soft tissue (average): 1,540 m/sec
- Kidney: 1,560 m/sec
- Blood: 1,570 m/sec
- Fat: 1,450 m/sec
- Water: 1,480 m/sec
- Air: 330 m/sec
Transducer      piezoelectric crystals

Figure 20-5  Ultrasound transducer

Figure 20-6  An electric field realigns the dipoles in a piezoelectric crystal
Wavefront
Reflection
Refraction
Absorption

Figure 20-11 Superimposition of waves to form a wavefront
Ultrasonic display:

A mode (amplitude)
M mode (movement) - cardiac ultrasound
B mode (brightness) - grey-scale imaging
DUPLEX
TRIPLEX
Spectral Display
Colour Flow Doppler
Power Doppler
Spectral trace
How to hold the transducer:

- Picture moves opposite direction to hand
- Arteries are red, veins are blue
- Right angle to skin (or area of interest)
- Toe and heel
Resolution

Axial reverberation echoes
Steering & Focusing Pulsed Doppler
Lateral resolution
Duplex Sonography
Duplex Sonography:

Diagnosis with duplex

- PVD
- DVT
- CVI
- Baker’s cyst
- Haematoma, gastroc tear
- Aneurysm, pseudoaneurysm
- Lymph nodes
Duplex Sonography:

Normal venous flow:

- Spontaneous
- Phasic
- Non-pulsatile
- Cephalad
- Augmentable
Duplex Sonography:

Normal venous flow:

- Lumen is hypoechoic, compressible, diameter changes with respiration
- Vein wall is thin, regular and smooth
- Valves appear as localised dilatations, the cusps are thin and project obliquely. Cusps move with respiration and can be seen to approximate
Duplex Sonography:

Reflux:

- Valves close due to retrograde flow – gravity, compression and Valsalva
- Flow rate ~ 30m/sec required for valve closure
- No consensus as to what degree of reflux is physiological
- Pathological reflux > ½ sec
- Volume and duration of reflux variable
**Duplex Sonography:**

**Reflux:**

- Assess vein in saggital plane (transverse for compressibility)
- SV for PW should be 25-50% of lumen
- Inspect entire length of vein – not simply SFJ & SPJ
- Allow time for refilling
- Poor augmentation may be due to obstruction
- Make a hard copy of spectral analysis
To test valves for competence use manual compression to calf. Downward colour flow on release signifies incompetent valves.
Mapping:

“One picture paints ten thousand words” F Barnard (1927)

- Accurate mapping is critical for good management and follow up
- Concise information that is easily interpreted
- Needs to contain all information necessary to write report
Past Procedures:

Surg: March 199

Key: Blue = Normal
Red = Incompetent
Black = Absent
Greater saphenous vein
Sapheno-popliteal junction
Short Saphenous Vein
Posterior arch vein
Saphenous-femoral junction
Past Procedures:

Key:
Blue = Normal
Red = Incompetent
Black = Absent
**Conclusion**

- Right - SFT, LW incompletely
- SFT, SSV complete
- Incomplete perforators mid calf 27 cm, sp to flow, Sp to flow 22.2 cm

**Left**

- SFT, SSV complete, LSV incomplete
- Incomplete perforators mid calf 8 cm, sp to flow 16 cm
**VENOUS DUPLEX ASSESSMENT**

**NAME:** Mr. John McVitty  
**AGE:** 83  
**DATE:** 20/6/01

<table>
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<th></th>
<th>COMMON FEMORAL</th>
<th>SUPERFICIAL FEMORAL</th>
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<th>POSTERIOR TIBIAL</th>
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<td>L</td>
<td>R</td>
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<td>COMPETENT</td>
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**COMMENTS:** Absent R & sup. fem v!!
Deep Vein Thrombosis

B mode:
- Incomplete compression
- Echogenic clot visible
- Vein distended by thrombus
- Loss of phasic flow

Colour:
- Filling defect
- Distention
- Absence of flow
Deep Vein Thrombosis

Pitfalls in diagnosis:

- Acute thrombus may be sonolucent
- Subacute thrombus may not distend wall
- Partial thrombus may not interfere with Valsalva/augmentation
- Valsalva’s only works above the knee
Deep Vein Thrombosis

Chronic DVT:

- Reduced venous diameter / occlusion
- Thickened irregular vein walls
- Echogenic weblike filling defects
- Absence of acute DVT
- Coexistent deep venous insufficiency
- Presence of collateral vessels
THE END

**Books:**

*Zwiebel, WJ Introduction to Vascular Sonography*


*Hennerici, M. Vascular Diagnosis With Ultrasound*

ISBN 3-13-103-8314