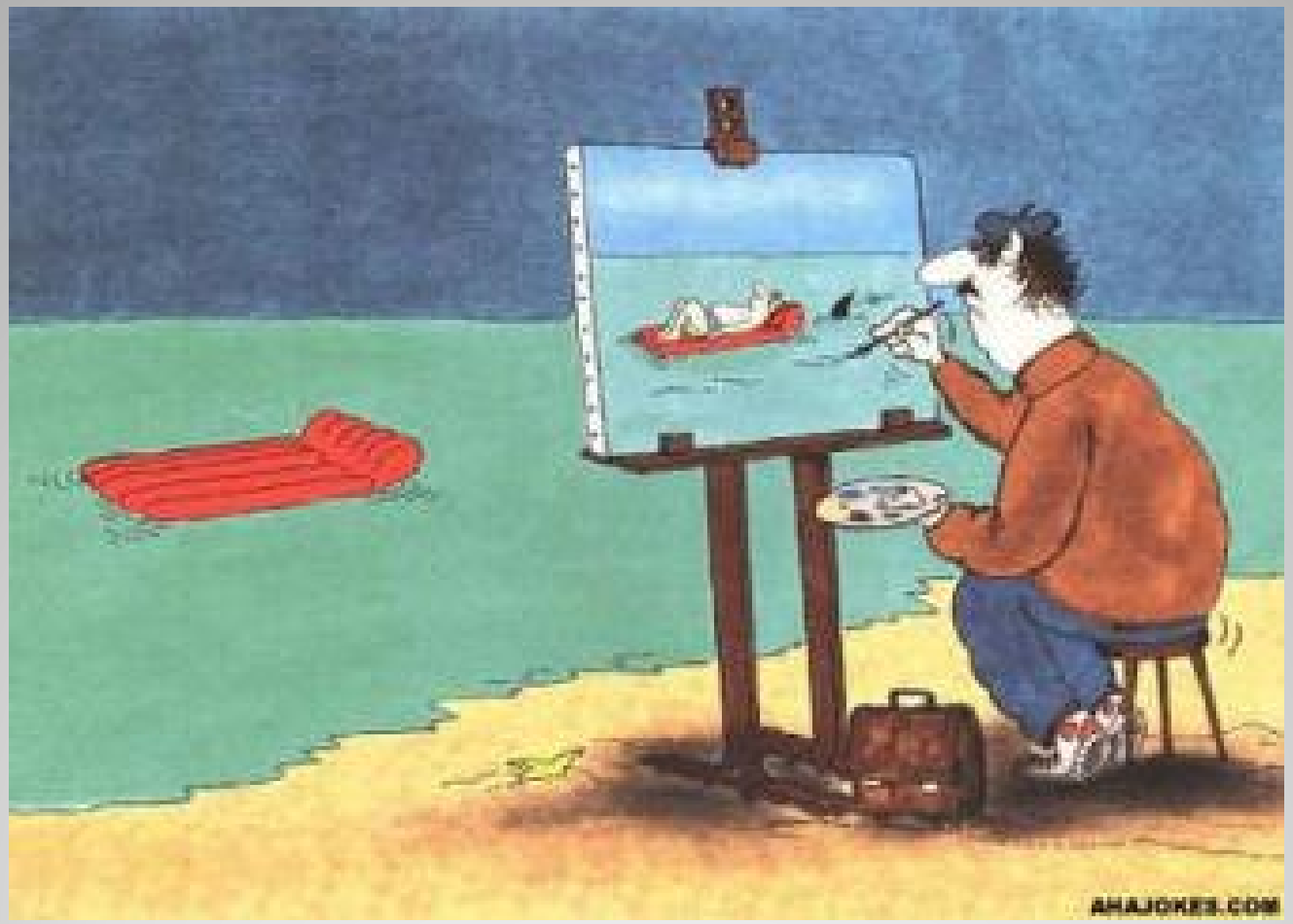
Duplex Ultrasound Assessment of the Venous System

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


AHAJOKES.COM

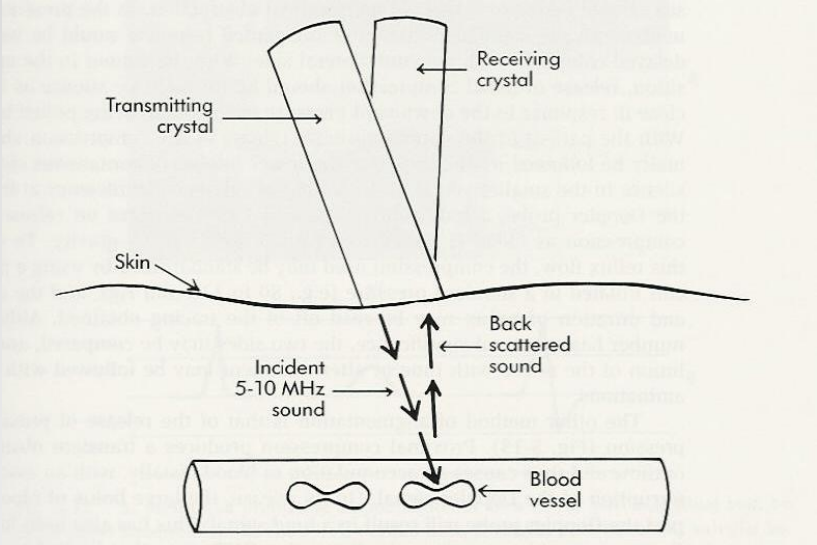
Overview:

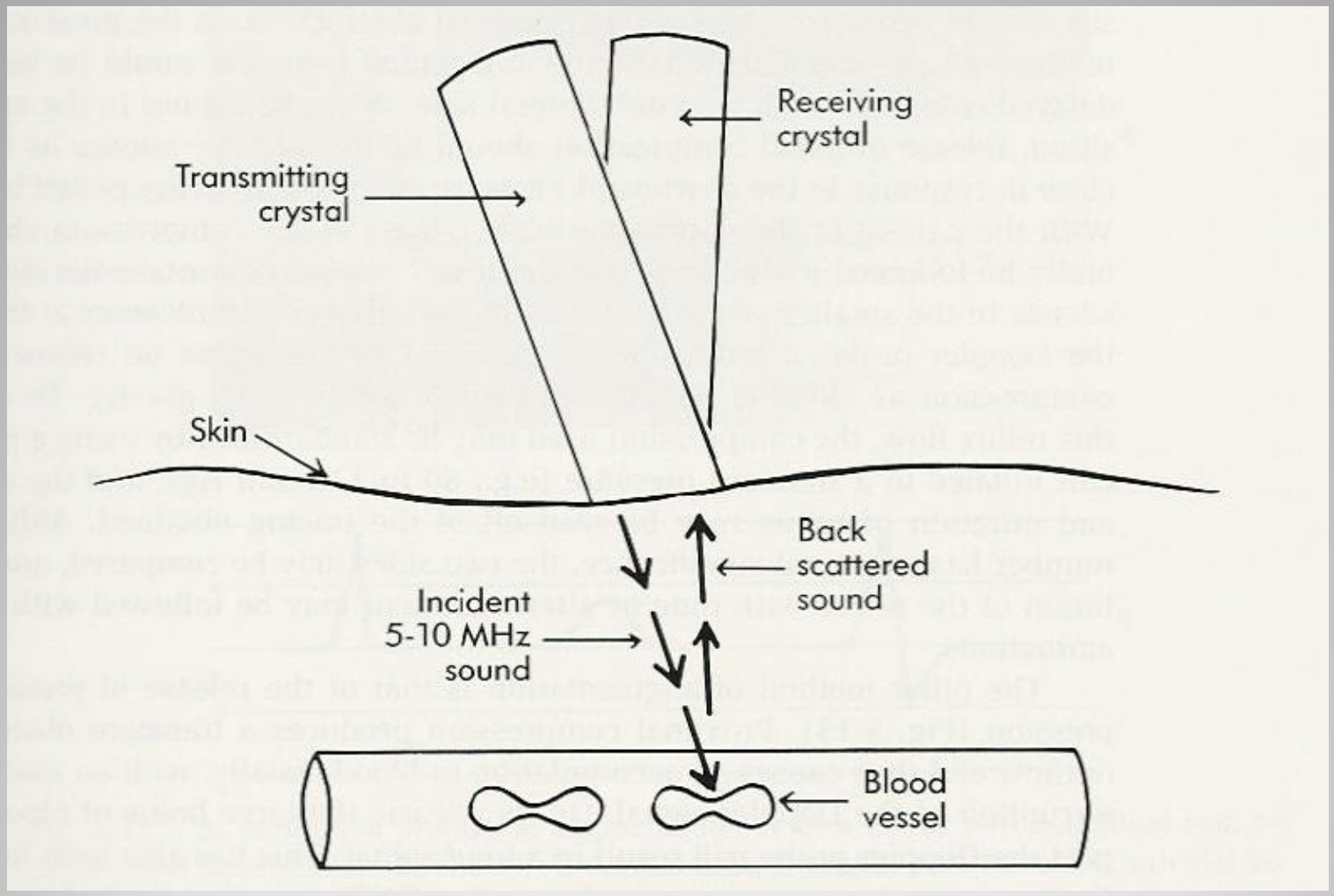
Replaced venography as the "gold standard"

- High specificity
- High sensitivity
- Non-invasive
- Accessible
- Cost effective

Hand held Doppler:

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




Receiving crystal
Transmitting crystal
Skin
Back scattered sound
Incident 5-10 MHz sound
Blood vessel

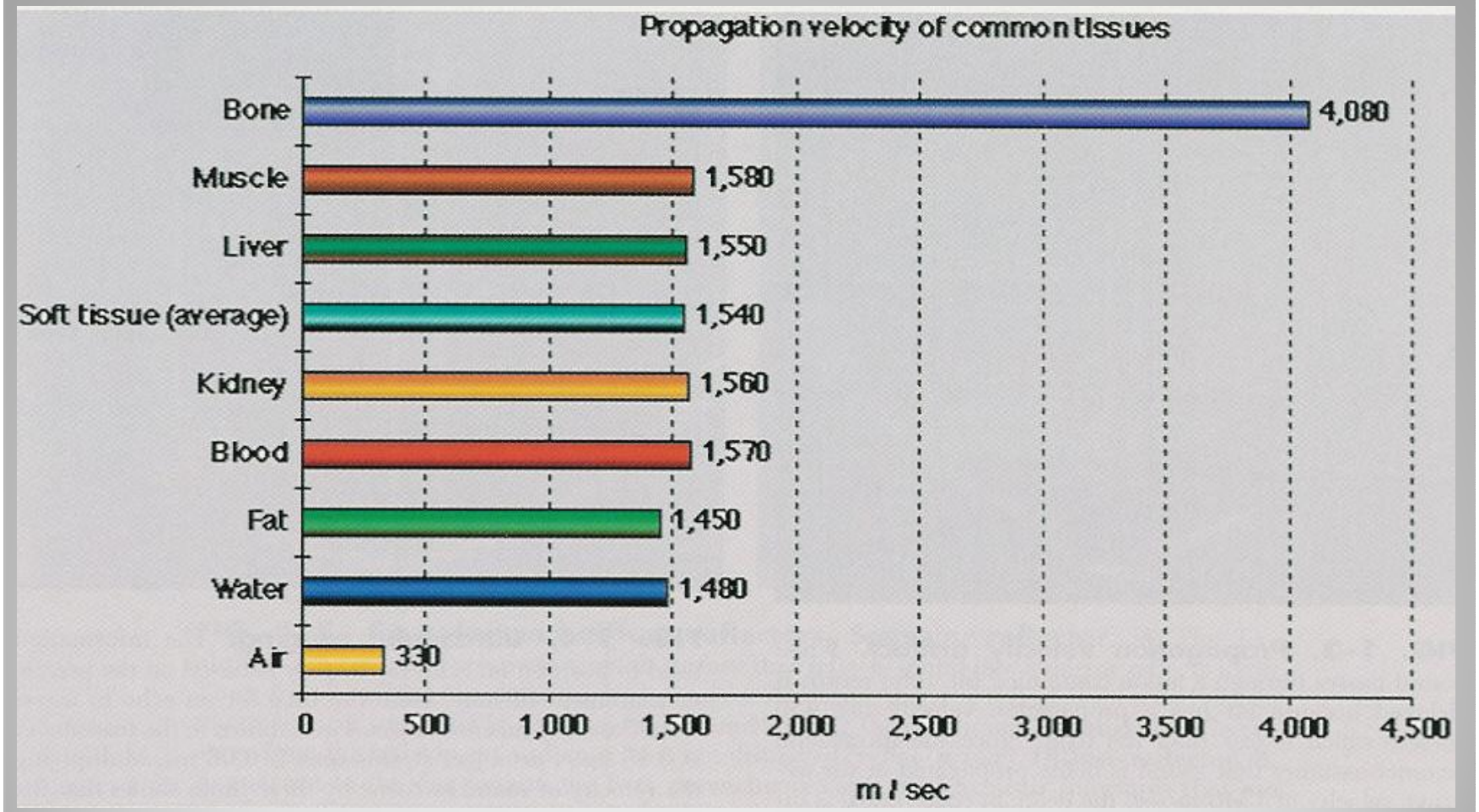
- Doppler Shift

$$f_d = \frac{f_t \, 2 \, u \cos\theta}{c}$$

- f_t is transmitted frequency
- θ = angle source motion and direction of receiver
- u = source velocity
- C = velocity of sound

Table 20–1. Velocity of Sound in Various Materials

MATERIAL	VELOCITY (m/sec)
Air	331
Fat	1450
Mercury	1450
Castor oil	1500
Water (50° C)	1540
"HUMAN SOFT TISSUE"	1540
Brain	1541
Liver	1549
Kidney	1561
Blood	1570
Muscle	1585
Lens of eye	1620
PZT-5A	3780
PZT-4	4000
Skull (bone)	4080
Brass	4490
Quartz	5740
Aluminum	6400


Propagation velocity of common tissues
Bone
Muscle
Liver
Soft tissue (average)
Kidney
Blood
Fat
Water
Air
4,080
1,580
1,550
1,540
1,560
1,570
1,450
1,480
330
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
m / sec

Transducer piezoelectric crystals

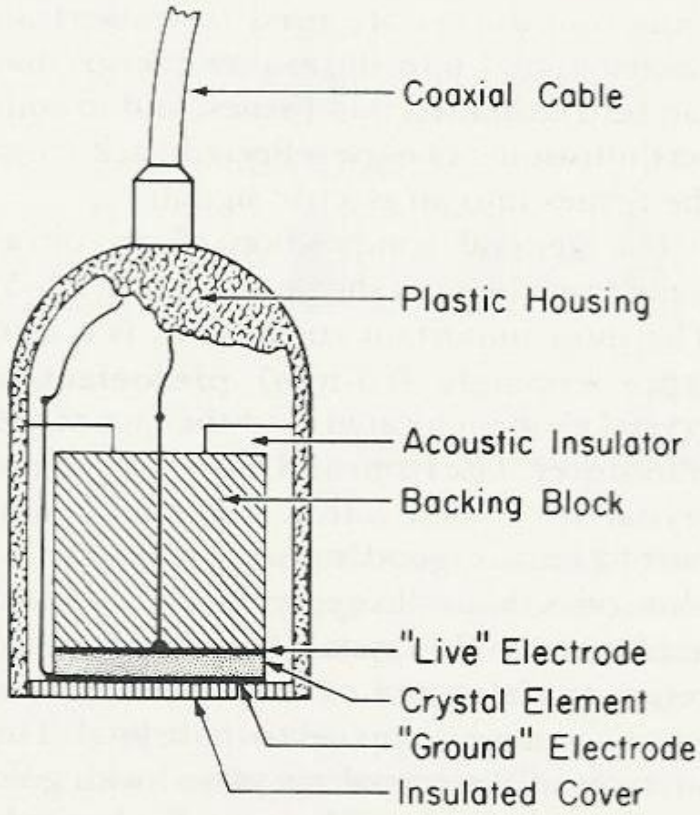


Figure 20–5 Ultrasound transducer

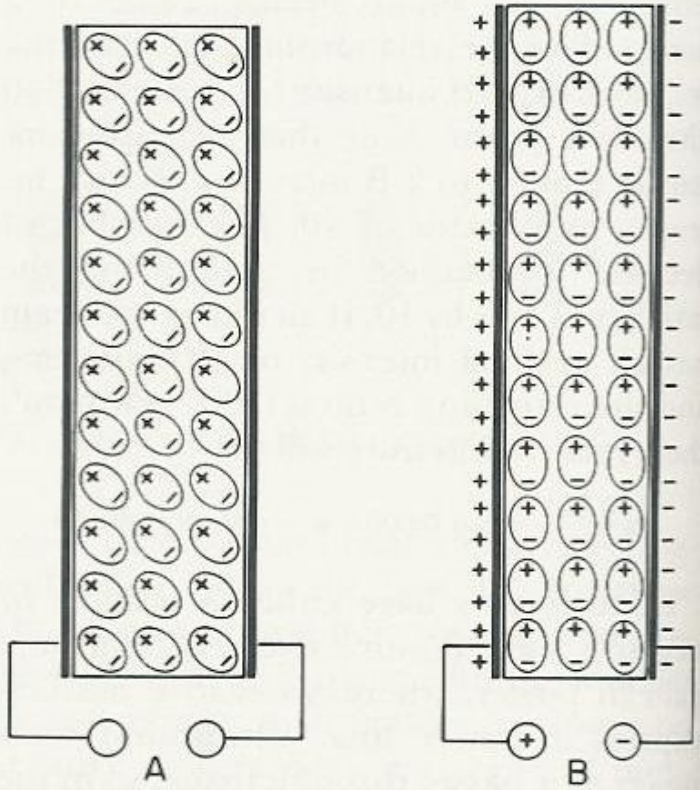


Figure 20–6 An electric field realigns the dipoles in a piezoelectric crystal

Wavefront

Reflection

Refraction

Absorption

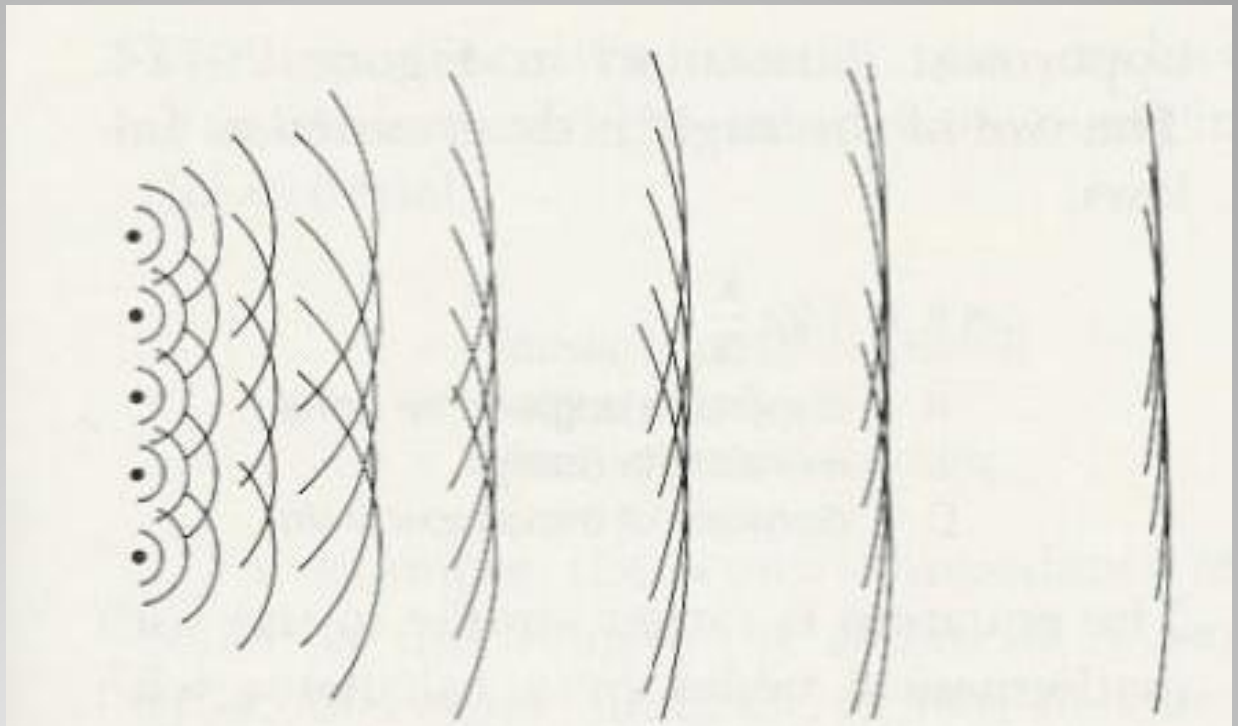
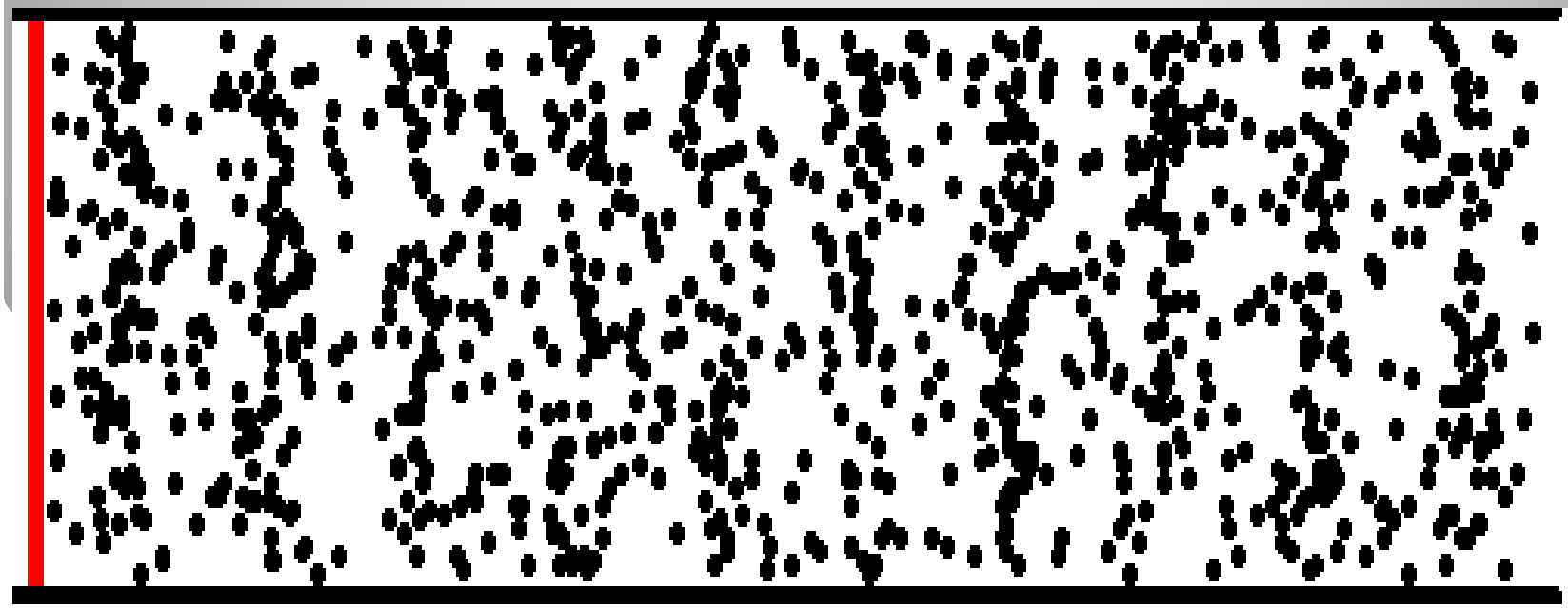
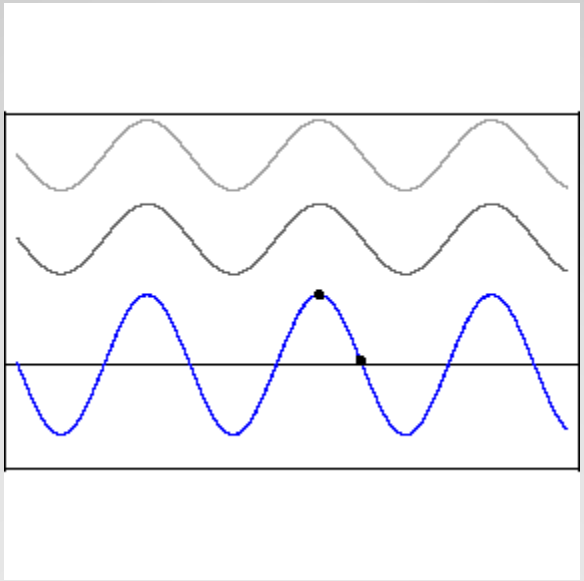


Figure 20–11 Superimposition of waves to form a wavefront



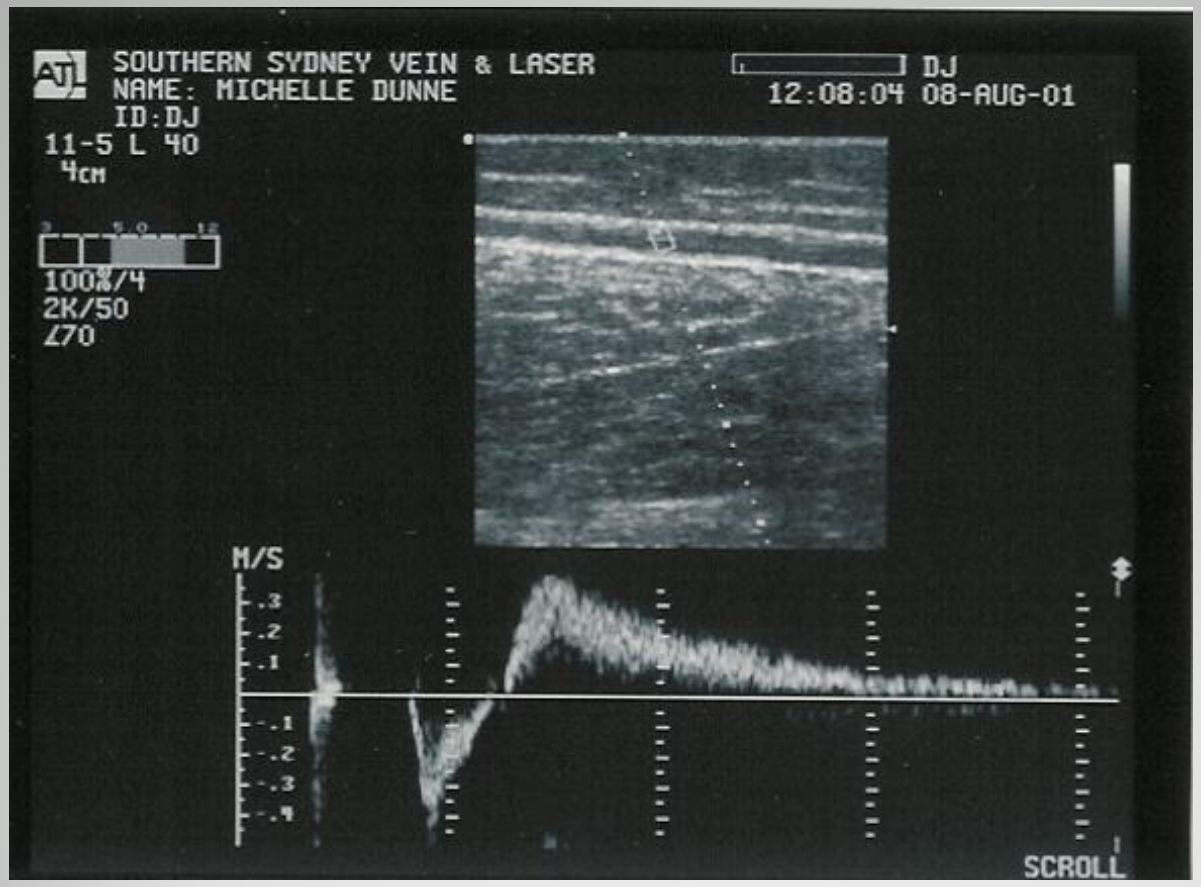


Ultrasonic display:

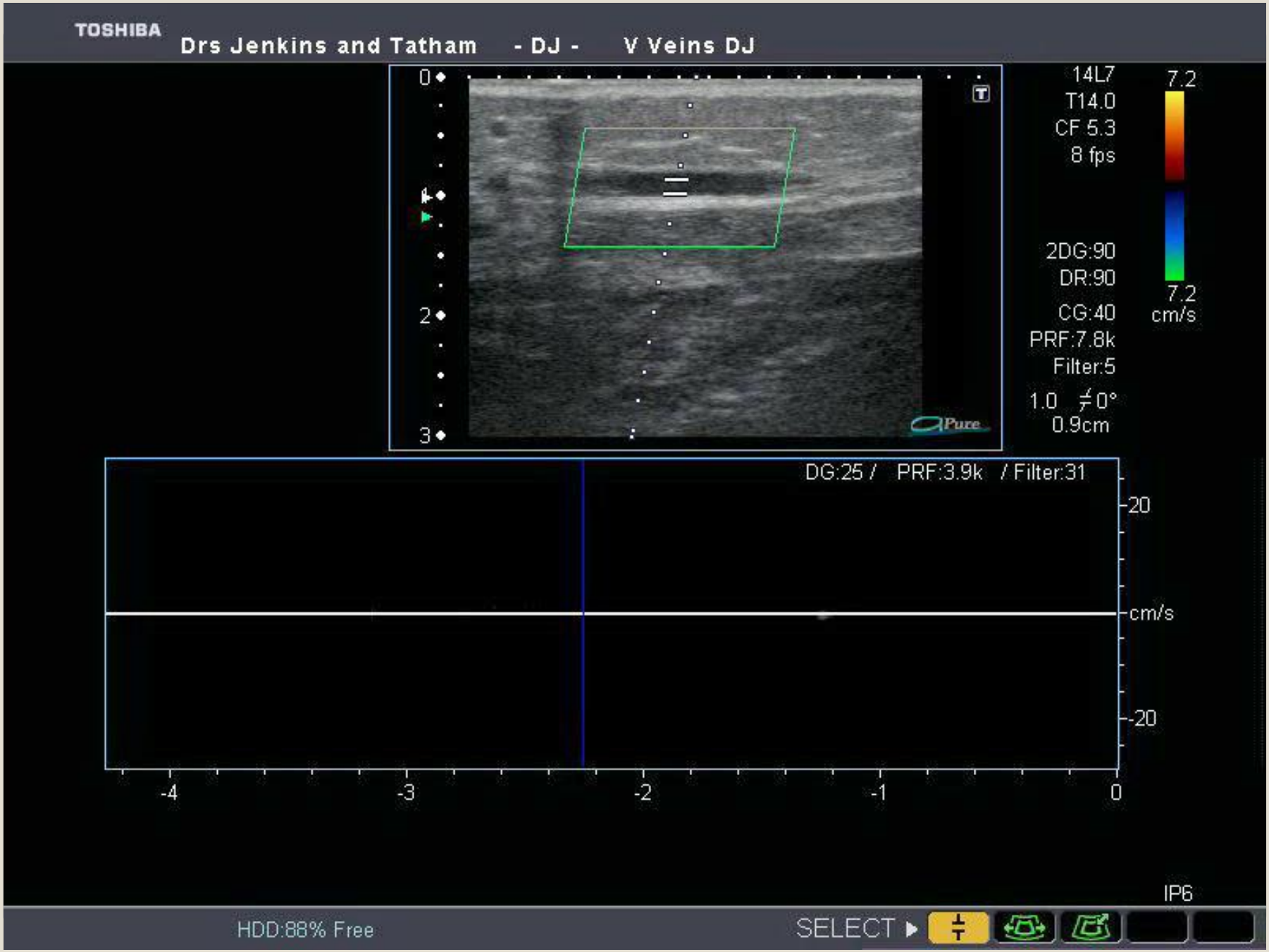
A mode (amplitude)
M mode (movement) - cardiac ultrasound
B mode (brightness) - grey-scale imaging
DUPLEX
TRIPLEX
Spectral Display
Colour Flow Doppler
Power Doppler


TOSHIBA
Drs Jenkins and Tatham - DJ - V Veins DJ
Pure
0
1
2
3
4
MI:1.1
2DG
90
DR
90
14L7
T14.0
37 fps
IP6
HDD:89% Free

Spectral trace




TOSHIBA
Drs Jenkins and Tatham - DJ - V Veins DJ
0
2
3
14L7
T14.0
CF 5.3
7 fps
2DG:90
DR:90
CG:37
PRF:7.8k
Filter:5
1.0 ≠0°
0.7cm
7.2
7.2
cm/s
DG:25 / PRF:3.9k / Filter:31
-20
cm/s
-20
-4
-3
-2
-1
0
IP6
HDD:87% Free
SELECT


TOSHIBA
Drs Jenkins and Tatham - DJ - V Veins DJ
0
2
3
14L7
T14.0
CF 5.3
8 fps
2DG:90
DR:90
CG:40
PRF:7.8k
Filter:5
1.0
0°
0.9cm
7.2
7.2
cm/s
Pure
DG:25 / PRF:3.9k / Filter:31
20
cm/s
-20
-4
-3
-2
-1
0
IP6
HDD:88% Free
SELECT

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

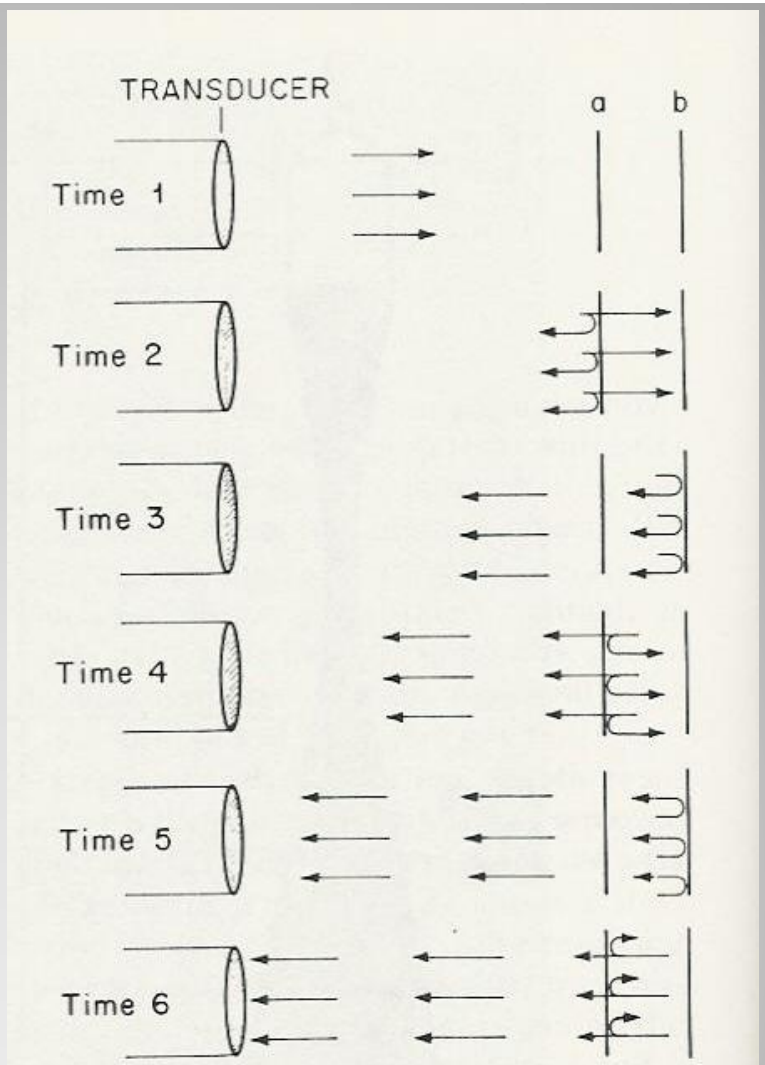
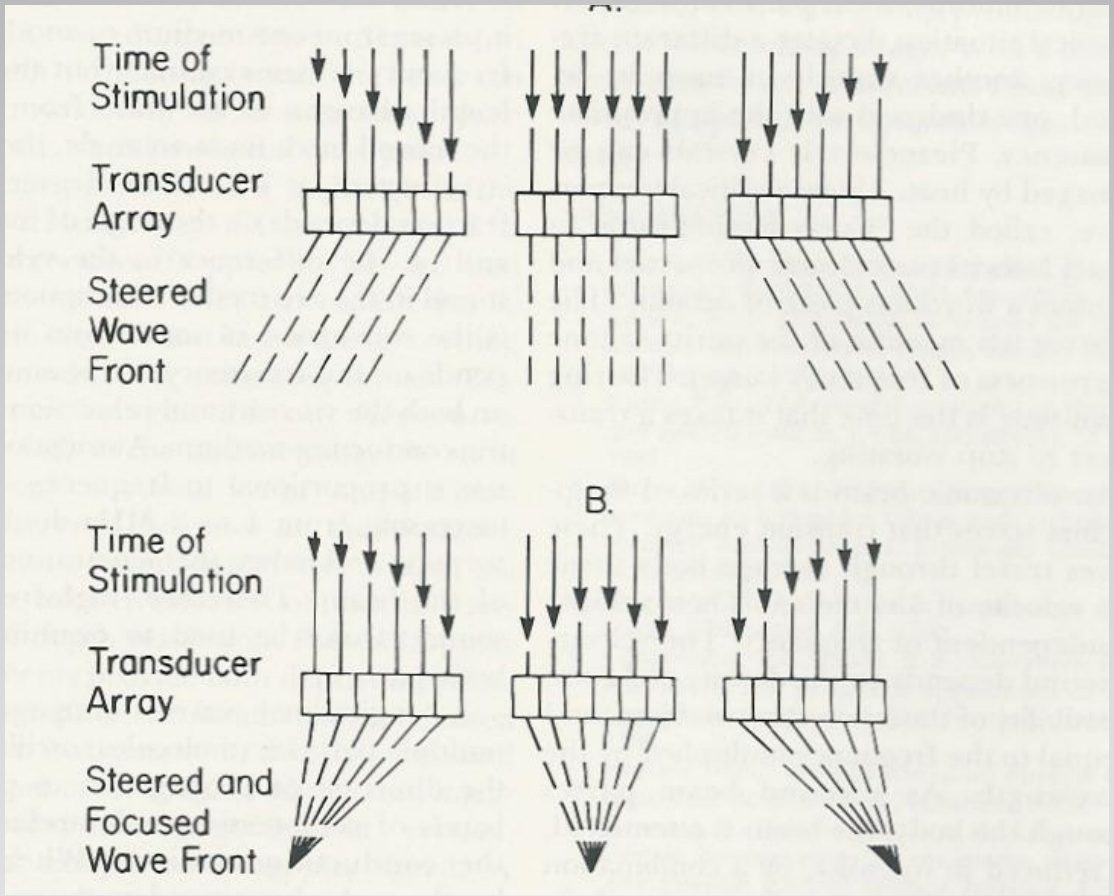


Figure 20–29 Reverberation images

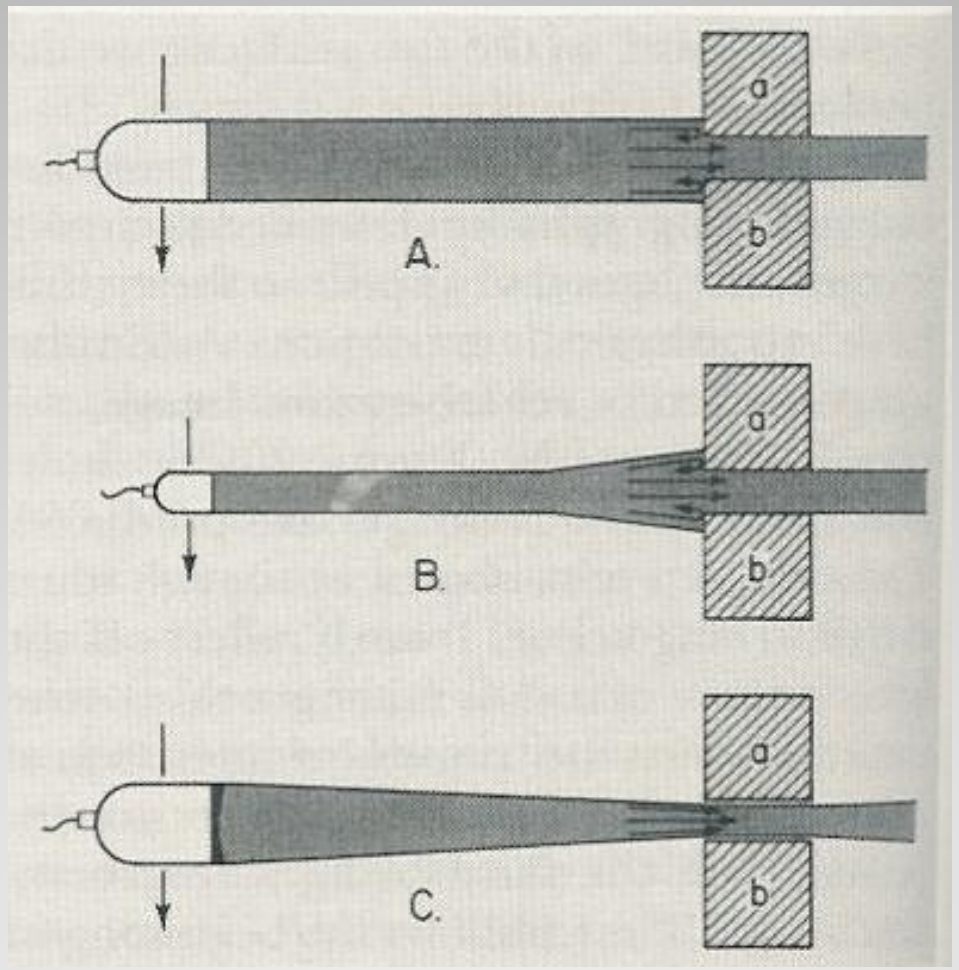
Steering & Focusing Pulsed Doppler



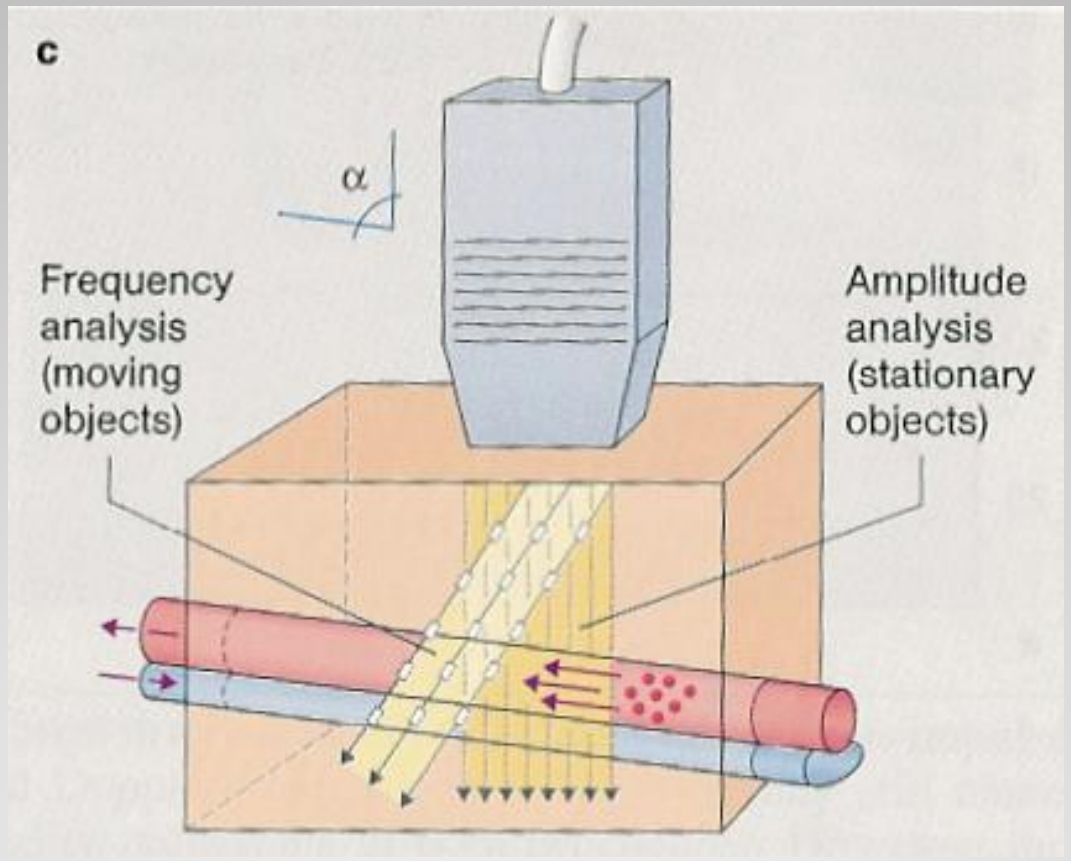

TOSHIBA
1111:- - O
Drs Jenkins and Tatham - DJ - V Veins DJ
24/04/2007
4:24:19 PM
0
1
2
3
2DG
82
DR
90
14L7
T14.0
37 fps


TOSHIBA
1111:- - O
Drs Jenkins and Tatham - DJ - V Veins DJ
24/04/2007
4:24:35 PM
0
1
2
3
2DG
82
DR
90
14L7
T14.0
37 fps

Lateral resolution



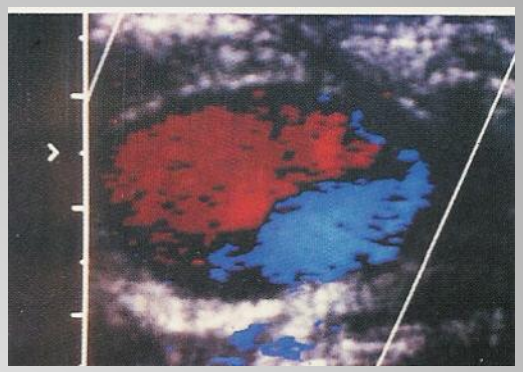
Duplex Sonography:

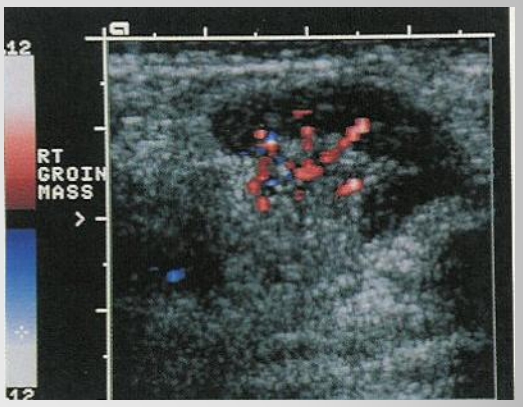


Duplex Sonography:

Diagnosis with duplex

- PVD
- DVT
- CVI
- Baker's cyst
- Haematoma, gastroc tear
- Aneurysm, pseudoaneurysm
- Lymph nodes





Duplex Sonography:

Normal venous flow:

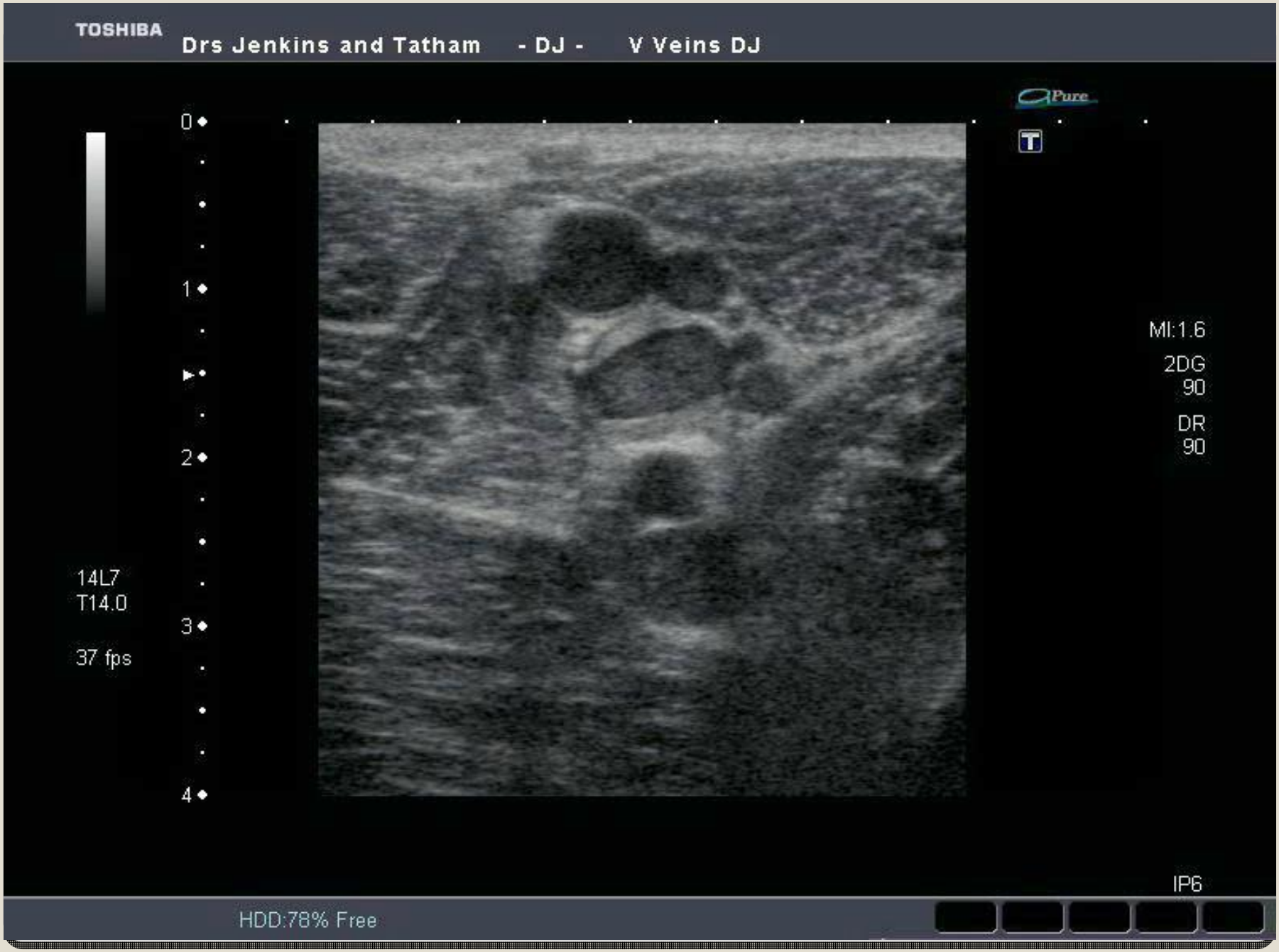
- Spontaneous
- Phasic
- Non-pulsatile
- Cephalad
- Augmentable

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


TOSHIBA
Drs Jenkins and Tatham - DJ - V Veins DJ
Pure
0
2
3
T
MI:1.6
2DG
90
DR
90
14L7
T14.0
37 fps
IP6
HDD:80% Free


TOSHIBA
Drs Jenkins and Tatham - DJ - V Veins DJ
Pure
T
0
1
2
3
4
MI:1.6
2DG
90
DR
90
14L7
T14.0
37 fps
IP6
HDD:78% Free

Duplex Sonography:

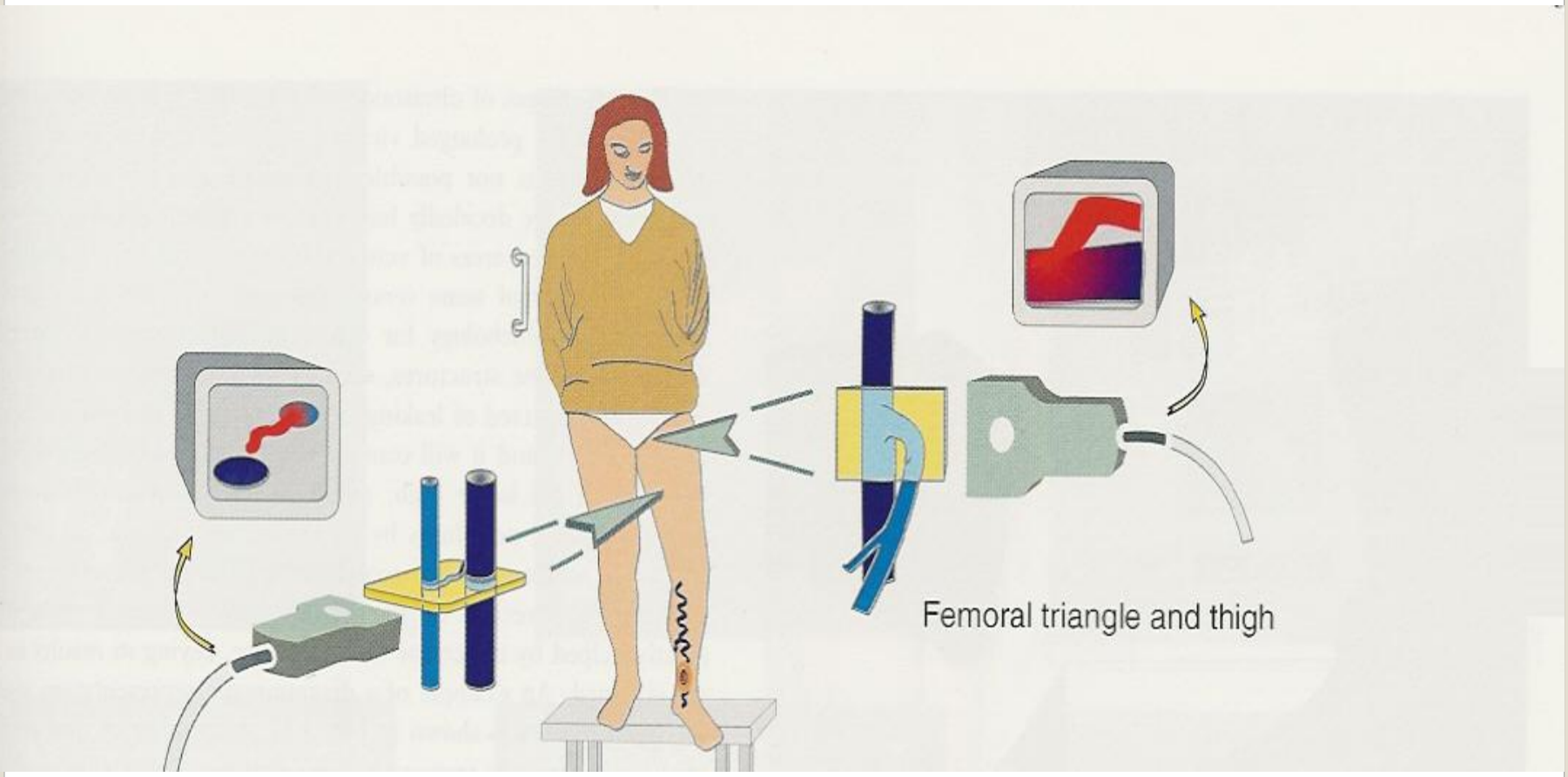
Reflux:

- 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

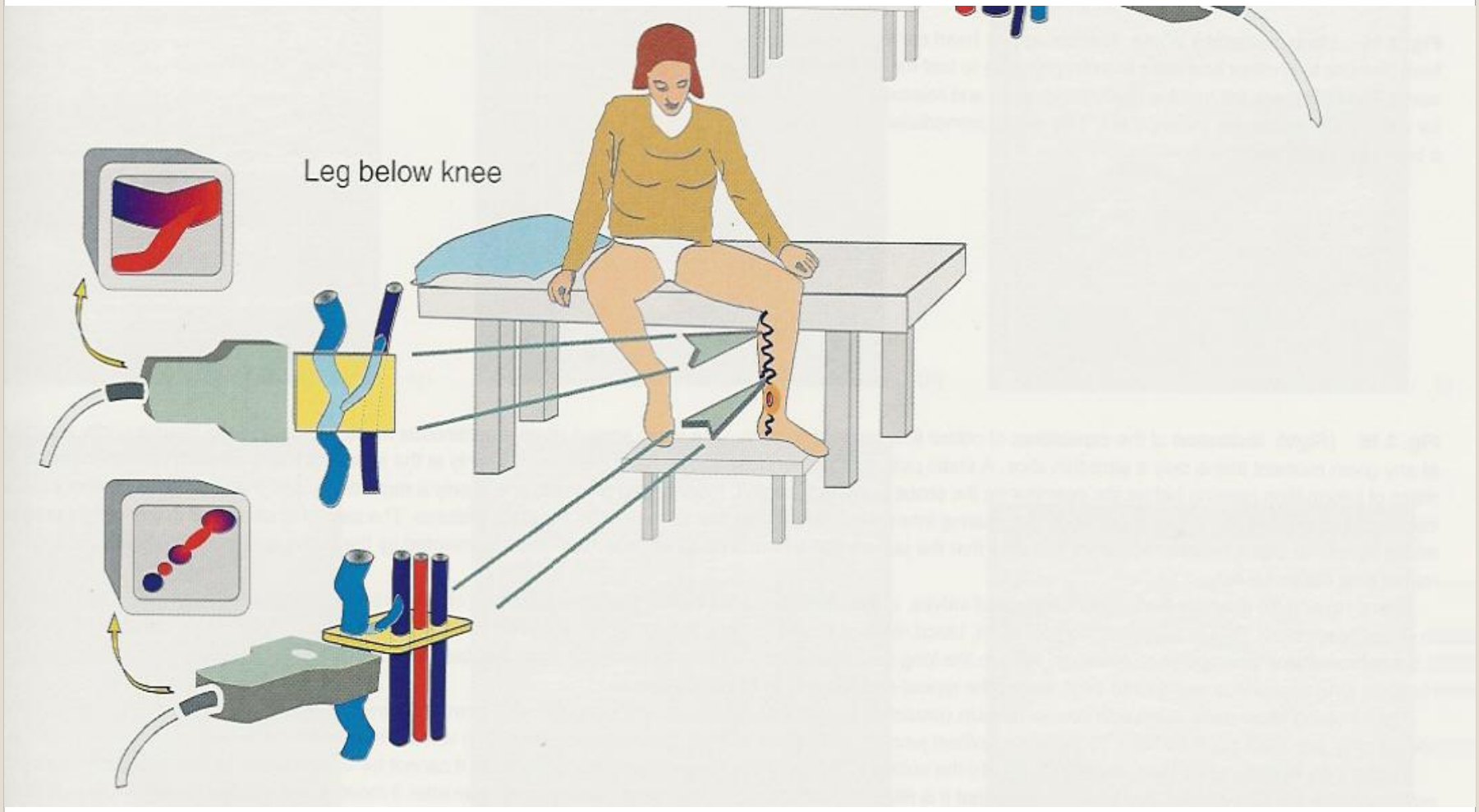
Duplex Sonography:

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


Femoral triangle and thigh

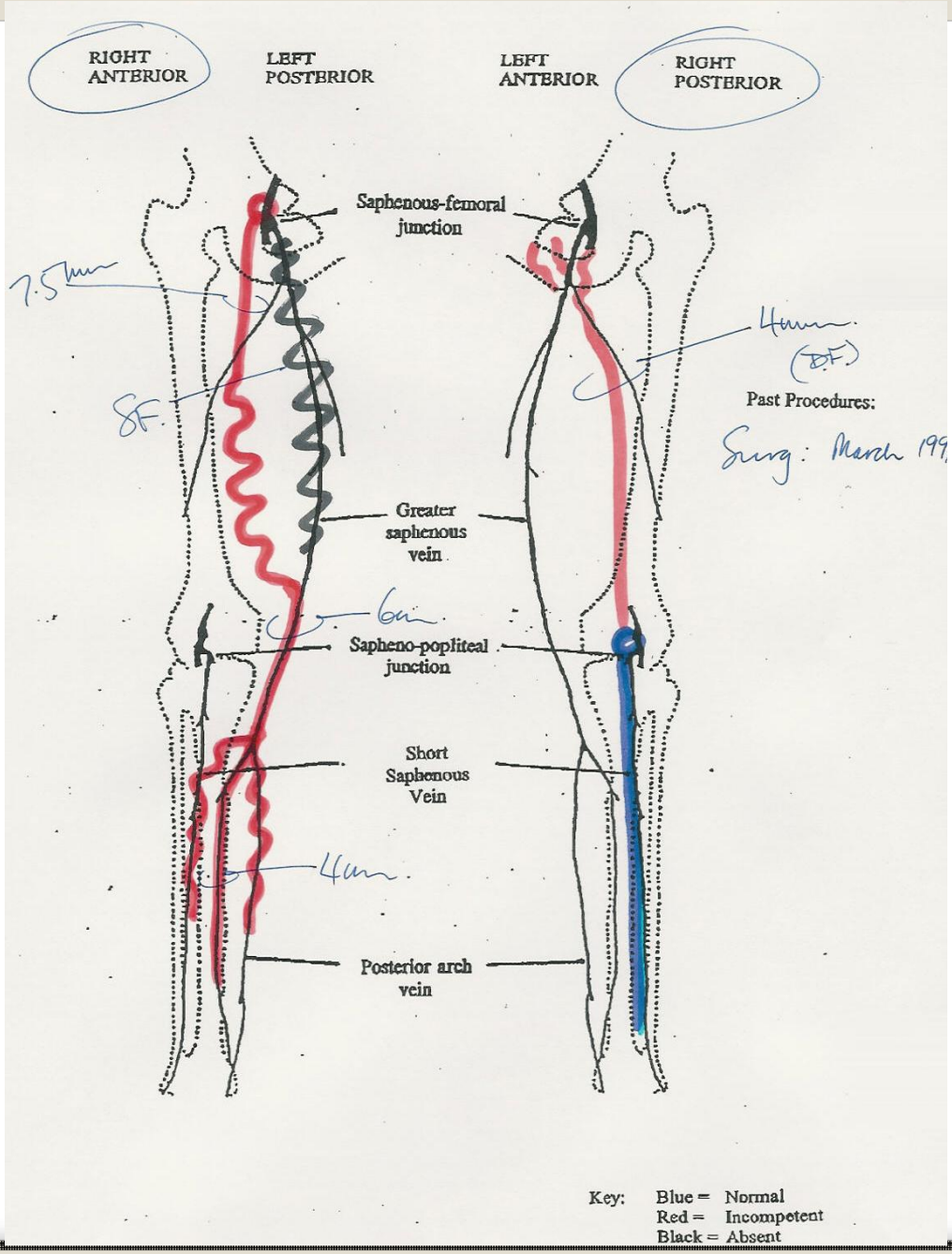

To test valves for competence use manual compression to calf. Downward colour flow on release signifies incompetent valves
Politeal fossa

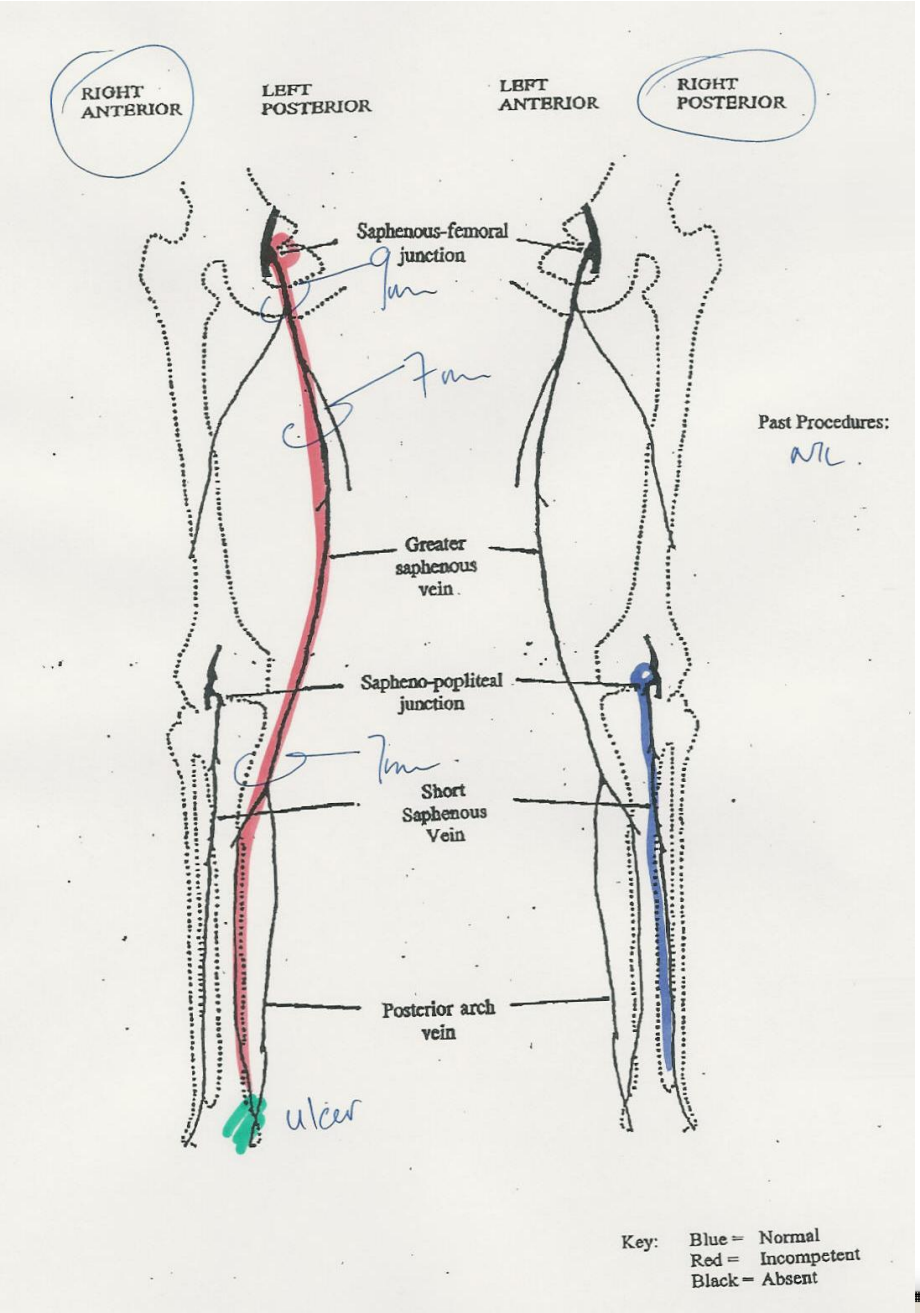

Leg below knee

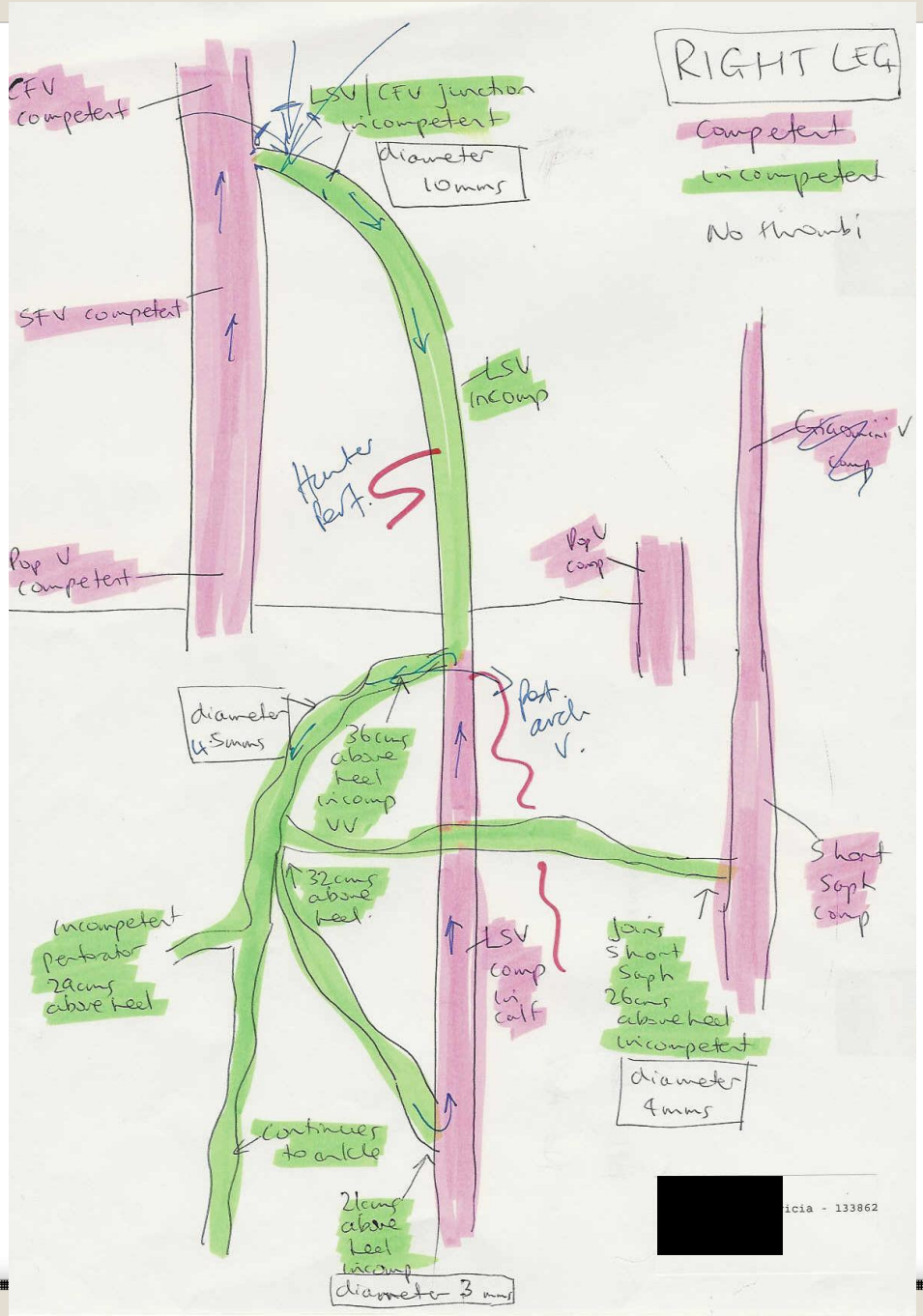
Mapping:

"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


RIGHT ANTERIOR
LEFT POSTERIOR
LEFT ANTERIOR
RIGHT POSTERIOR
Saphenous-femoral junction
7.5mm
SF.
4mm.
(D.F.)
Past Procedures:
Surg: March 199
Greater saphenous vein
6cm
Sapheno-popliteal junction
Short Saphenous Vein
4cm
Posterior arch vein
Key: Blue = Normal
Red = Incompetent
Black = Absent


RIGHT ANTERIOR
LEFT POSTERIOR
LEFT ANTERIOR
RIGHT POSTERIOR
Saphenous-femoral junction
9mm
7mm
Past Procedures:
NIL.
Greater saphenous vein
Sapheno-popliteal junction
7mm
Short Saphenous Vein
Posterior arch vein
ulcer
Key: Blue = Normal
Red = Incompetent
Black = Absent


RIGHT LEG
Competent
Incompetent
No thrombi
CFV competent
LSV/CFV junction incompetent
diameter 10mms
SFV competent
LSV incomp
Hunter pert.
Pop V competent
Pop V comp
Extra Saphenic V comp
diameter 4.5mms
36cms above heel incomp VV
Post. arch V.
32cms above heel
Short Saph comp
Incompetent perforator 29cms above heel
LSV comp in calf
Joins Short Saph 26cms above heel incompetent
diameter 4mms
Continues to ankle
21cms above heel incomp
diameter 3 mms
[redacted]icia - 133862

[redacted]

KEY	VARIABLE	DEEP	PERFORATORS
FLOW	AUGMENT	REFLUX	THROMBUS COMPRESS
0 Norm / Phasic	YES	[0]	0 Normal
1 No Flow	or	[1]	1 Partial
2 Continuous Hyperaemic	NO	[2] [3]	2 Incompress

RIGHT LEG

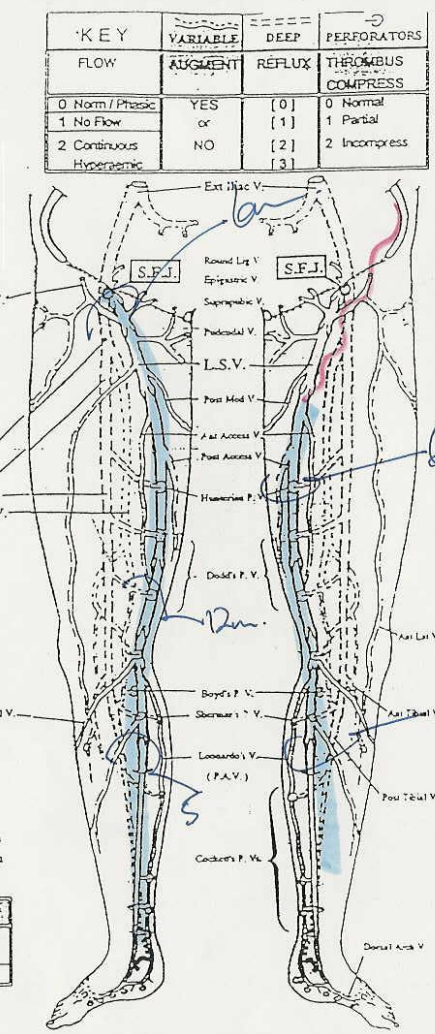
	FLOW	AUGM	REFL	THROM COMPR
Ext Iliac				
Com Fem				
Prox S Fem				
Dist S Fem				
Profunda V.				
Popliteal				
Gastroc				
Post Tib.				
Peroneal				
Ant Tib.				
Soleal				

SSV			
	cm Above / At Skin Crease / cm Below	0	LEVEL S.P.J.
		0	Upper Calf
		0	Lower Calf
LSV		3	S.F.J.
		2	Upper Thigh
		3	Lower Thigh
		3	Below Knee

OTHER PATHOLOGY

☐ Calf Muscle Haematoma ☐ Baker's Cyst

Other Path. (Specify)



LEFT LEG

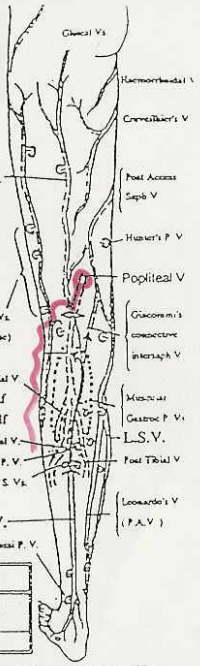
	FLOW	AUGM	REFL	THROM COMPR
Ext Iliac				
Com Fem				
Prox S Fem				
Dist S Fem				
Popliteal				
Gastroc				
Post Tib.				
Peroneal				
Ant Tib.				
Soleal				

SSV			
	cm Above / At Skin Crease / cm Below	0	LEVEL S.P.J.
		0	Upper Calf
		0	Lower Calf
LSV		0	S.F.J.
		3	Upp Thigh
		3	Low Thigh
		3	Bel Knee

OTHER PATHOLOGY

☐ Calf Muscle Haematoma ☐ Baker's Cyst

Other Path. (Specify)



CONCLUSION H/o RT. venous ulcer implantation + stripping.

RIGHT

- SPJ, LSV incompetent
- SPJ, SSV competent
- Incomp. perforators medial calf 27cms sup to floor
- " " lat " 22, 29 cms " "

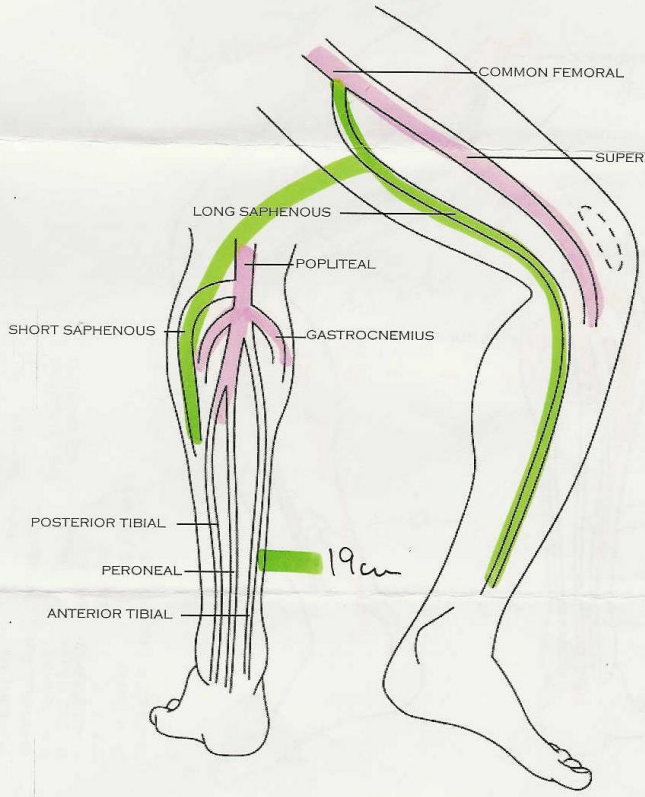
LEFT

- SFJ competent, LSV incompetent
- SSV Competent + Giacomini's
- Incomp. perforators medial calf 18cms superior to floor posteria " 16 cms " " "

[redacted]

LEFT LEG VENOUS IMAGING

JJ 24-6-02



PATENT

INCOMPETENT

COMPETENT

THROMBUS

Dr. David Jenkins M.B.,B.S. Provider No. 033105AB
Southern Sydney Vein & Laser Clinic
Suite 1-3, Yarrawarrah Shopping Centre
Cnr Old Bush Road & Laurina Avenue, Engadine 2233
Telephone: 9548.3777 Facsimile: 9548 3011

VENOUS DUPLEX ASSESSMENT

NAME: MR JOHN McVITTY AGE: 83 DATE: 20/6/01.

	COMMON FEMORAL		SUPERFICIAL FEMORAL		POPLITEAL		PERONEAL		POSTERIOR TIBIAL		ANTERIOR TIBIAL	
	L	R	L	R	L	R	L	R	L	R	L	R
COMPRESSIBLE		✓		—		✓		—		✓✓		—
COMPETENT		✓		—		✓		—		✓✓		—
PATENT		✓		—		✓		—		✓✓		—
PHASIC		✓		—		—						

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

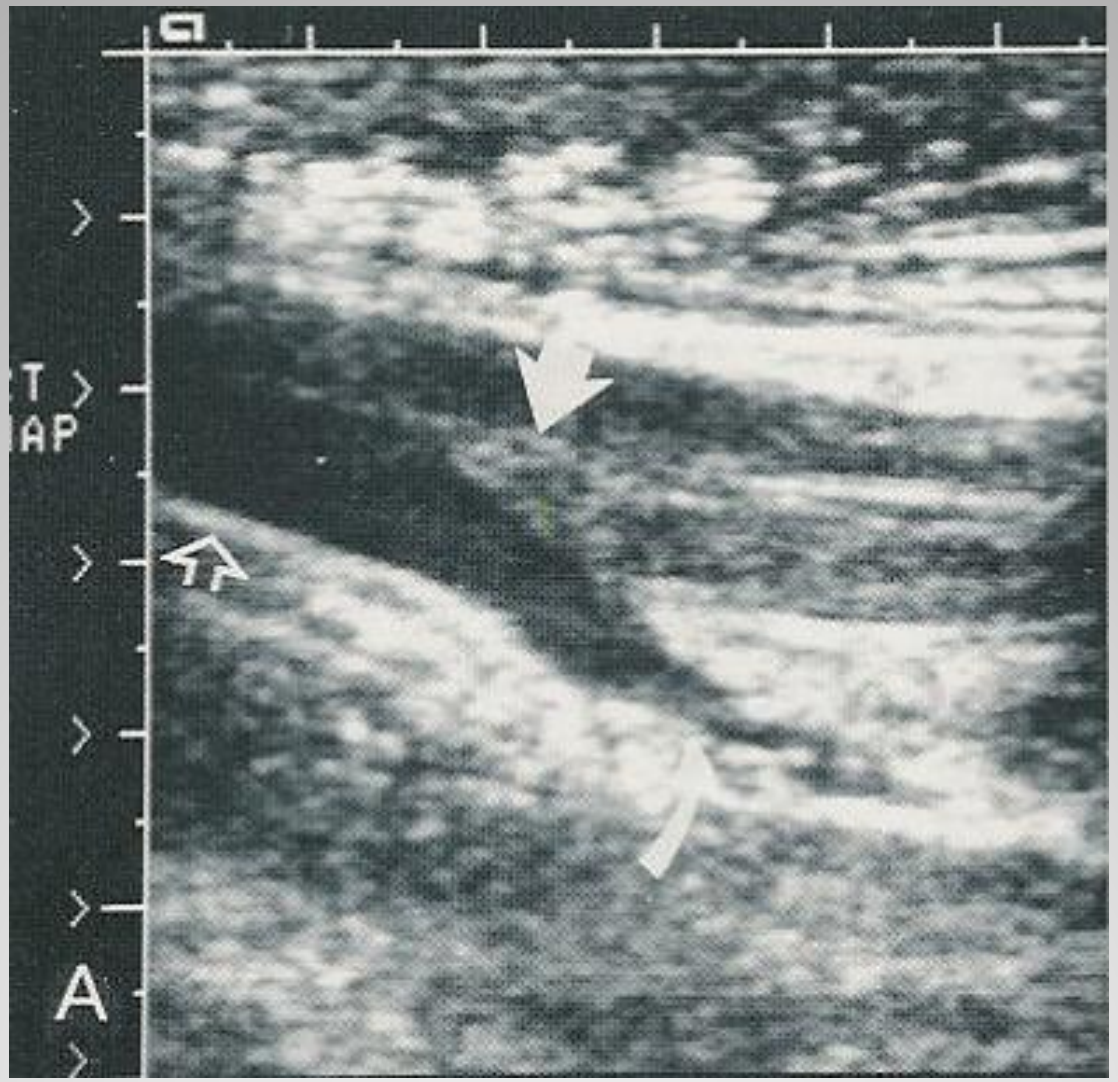
Pitfalls in diagnosis:

- 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

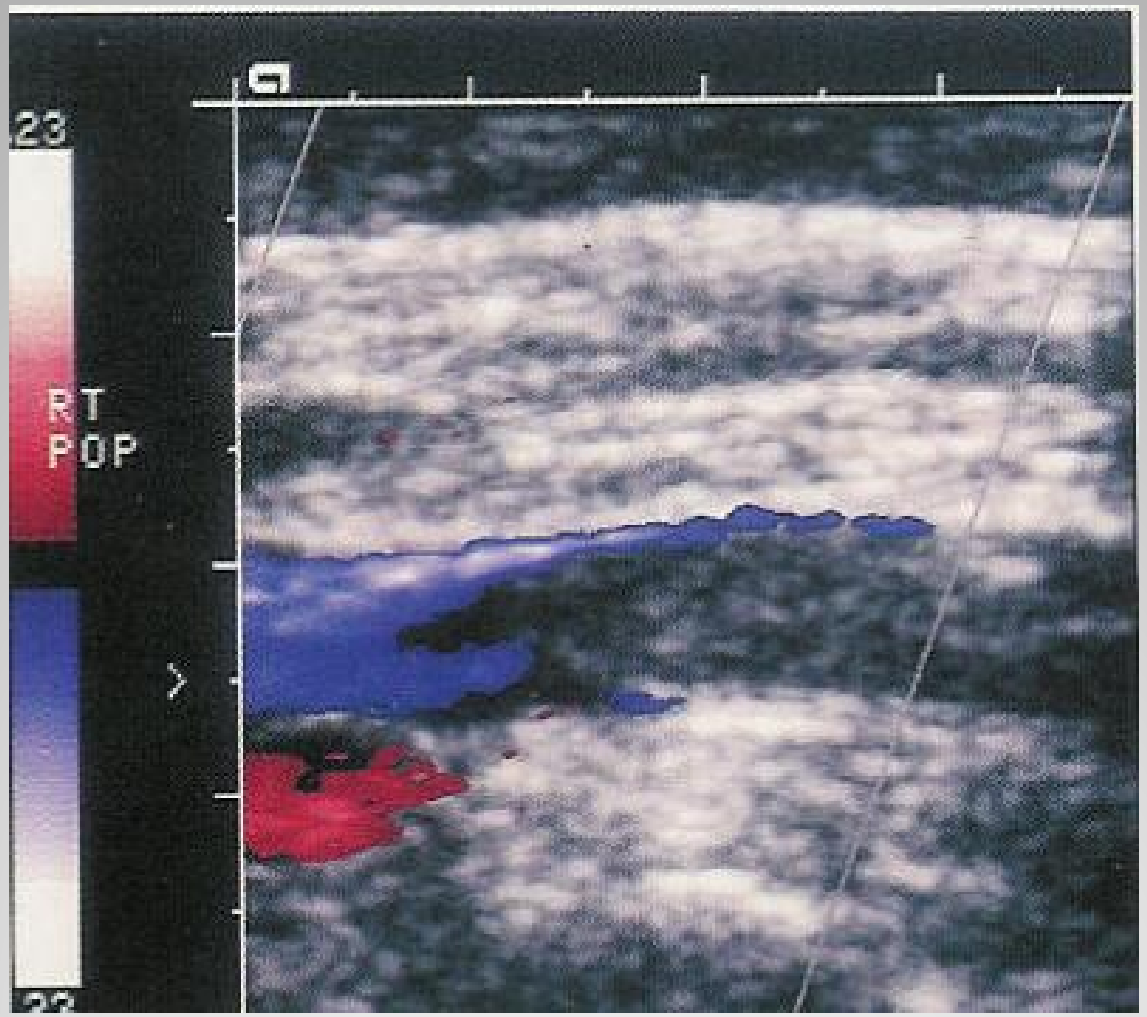
Deep Vein Thrombosis

Chronic DVT:

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


T
AP
A


17
RT SFV
PROF V
JUNCTION
SFV
17


23
RT
POP

THE END

Books:

Zwiebel,WJ Introduction to VascularSonography
ISBN 0-7216-6949-2

Hennerici,M. Vascular Diagnosis With Ultrasound *ISBN 3-13-103-8314*