Ultralyd-fysikk for leger

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Vscan – 2010 – Handheld US
A gamechanger !

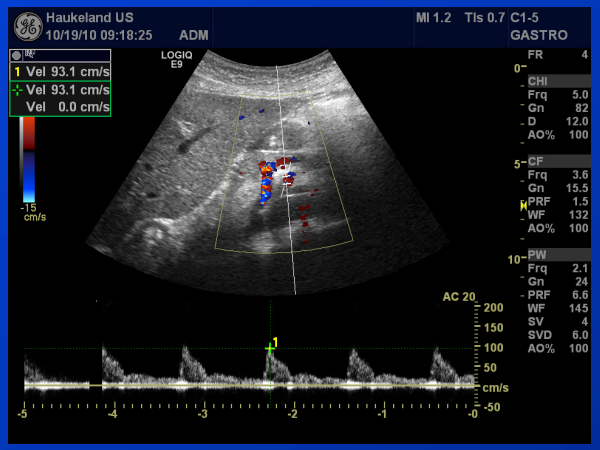
The Future:
From Stethoscope to Echoscope

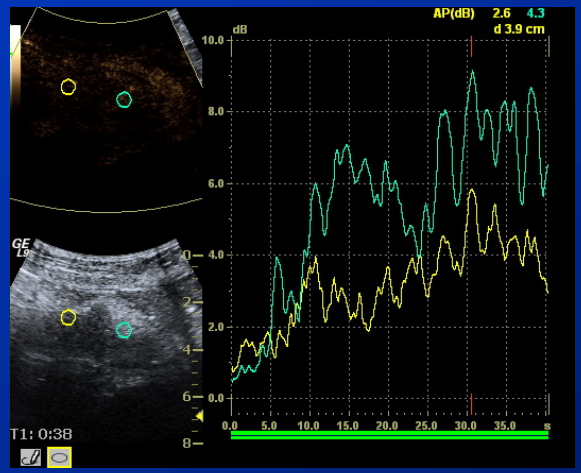
1816

2009

Ultrasound is more than an image

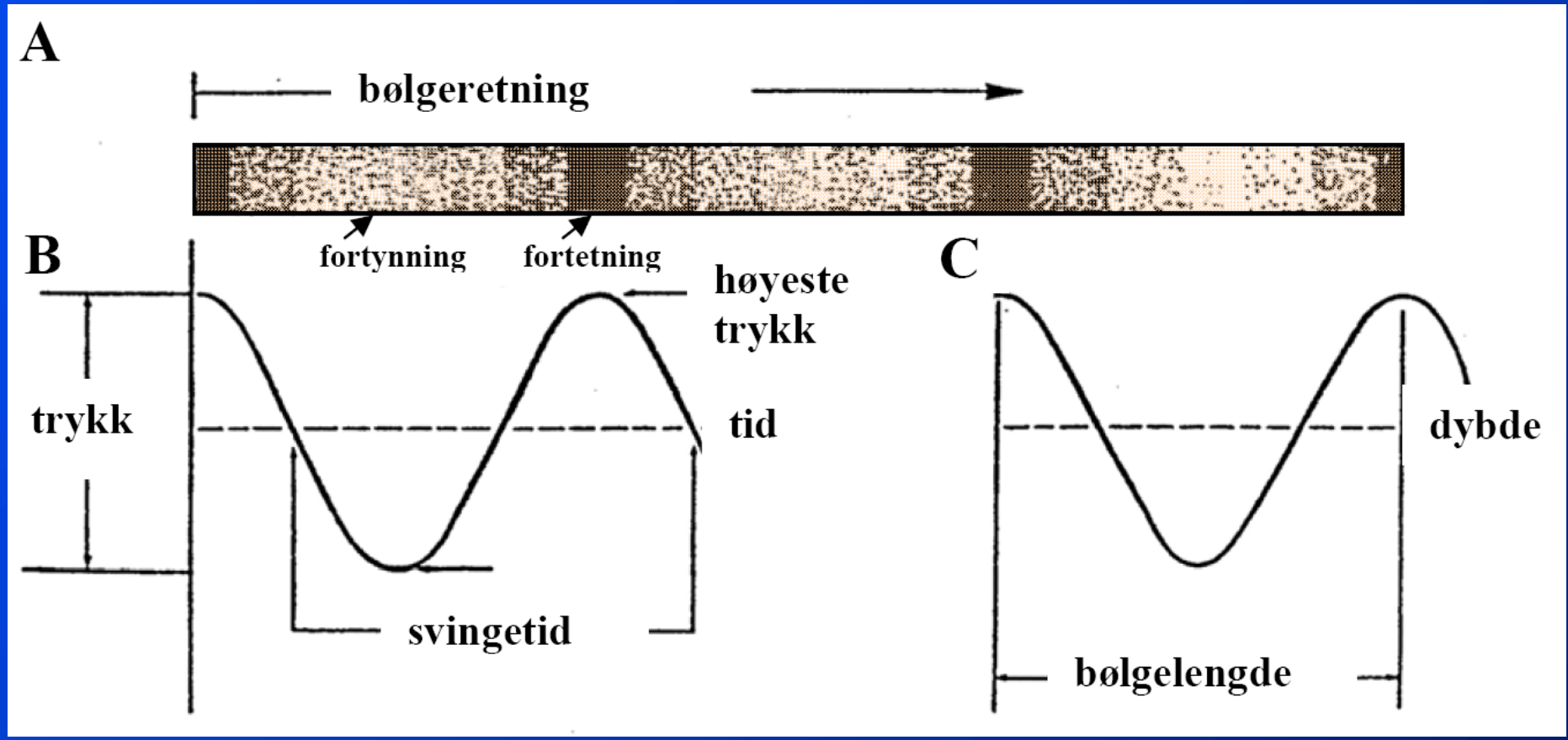
- A-mode
- B-mode
- M-Mode
- Doppler
  - Continous
  - Pulsed
  - Color
  - Power / Angio
  - Tissue Doppler
  - Strain Rate Imaging
  - Duplex – Triplex
- 3D and 4D ultrasound
- Elastography
- Harmonic imaging
- Contrast-enhanced ultrasound (CEUS)
- Guiding of interventions
- Ultrasound therapy - sonoporation





A versatile Ultrasound Toolbox !

Lydbølger



Longitudinale bølger: masseelementene beveger seg langs bølgeretningen. Trykkbølger - akustiske bølger

(Ødegaard S, Gilja OH, Matre K (red). Innføring i abdominal ultrasonografi, Fagbokforlaget 2009).

Egenskaper til ultralydbølger

Longitudinale bølger med frekvens over 20 000 Hz, 20 kHz

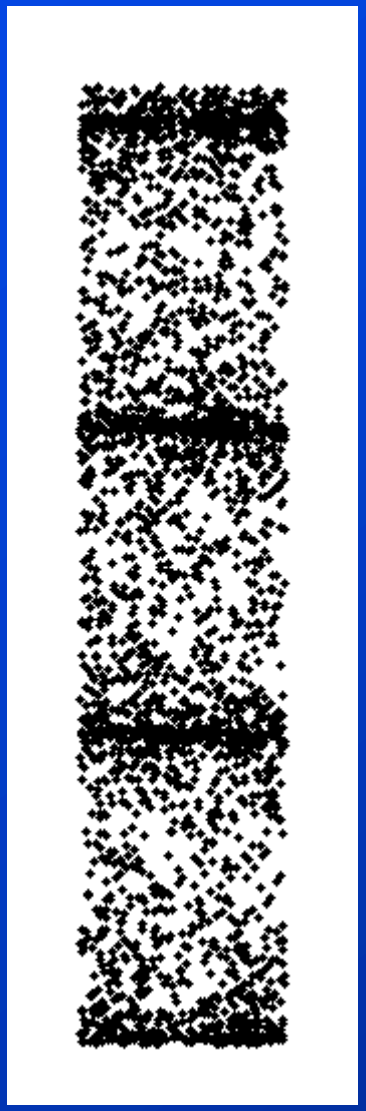
1. Kan ledes i stråler
2. Følger de samme lover som lys mht refleksjon og brytning
3. Reflekteres av relativt små objekter
4. Dårlig gjennomgang i gassfylte medier

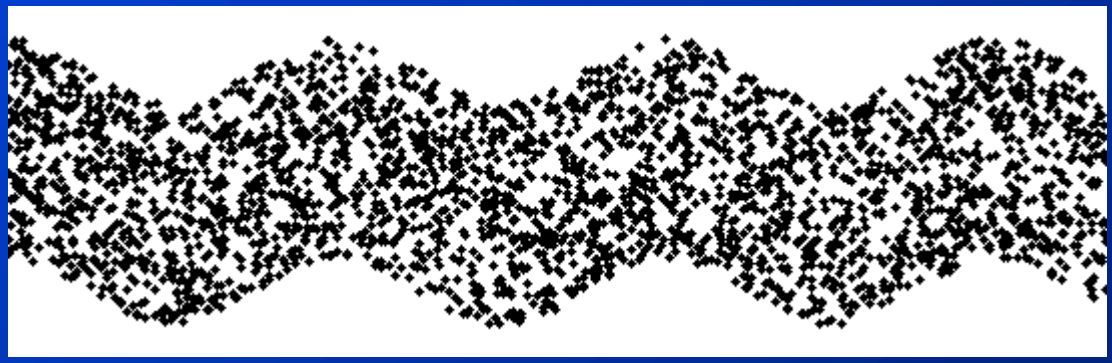
Longitudinal and Shear Waves

Ultrasound Wave

$$c_l = \sqrt{\frac{K}{\rho}}$$

$c_l \sim 1540$ m/s in tissue





Shear Wave

$$c_t = \sqrt{\frac{E}{3\rho}}$$

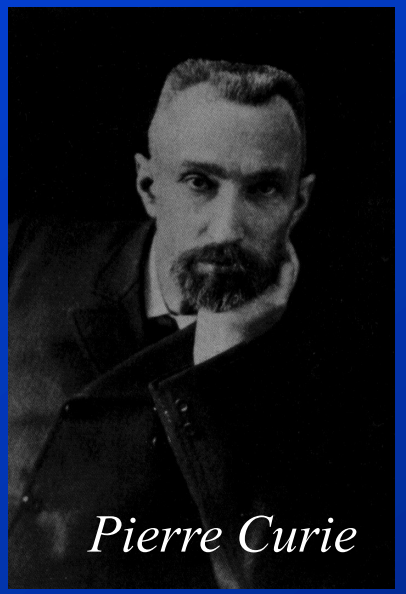
$c_t = 1\text{-}10$ m/s in tissue

UL-hastigheter i ulike vev

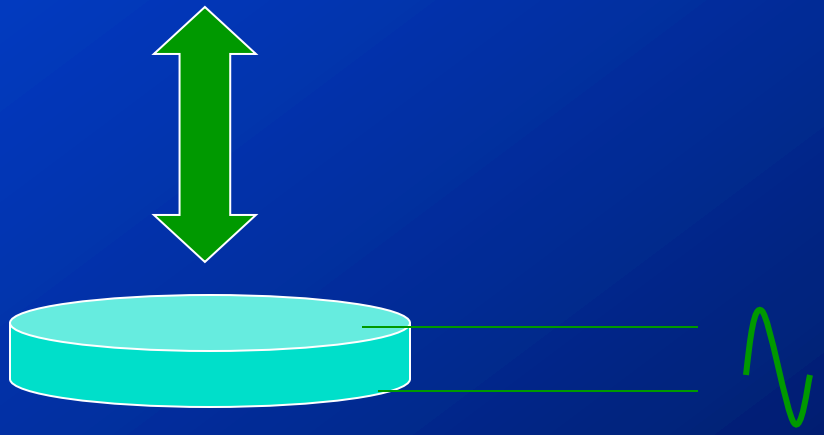
Ultralydhastighet i biologisk materiale i m/s:

Blod	1570
Lever	1547-1585
Nyre	1560
Myokard	1540
Fett	1440-1476
Bein	2700-4100
Luft	331

Piezoelectric Effect

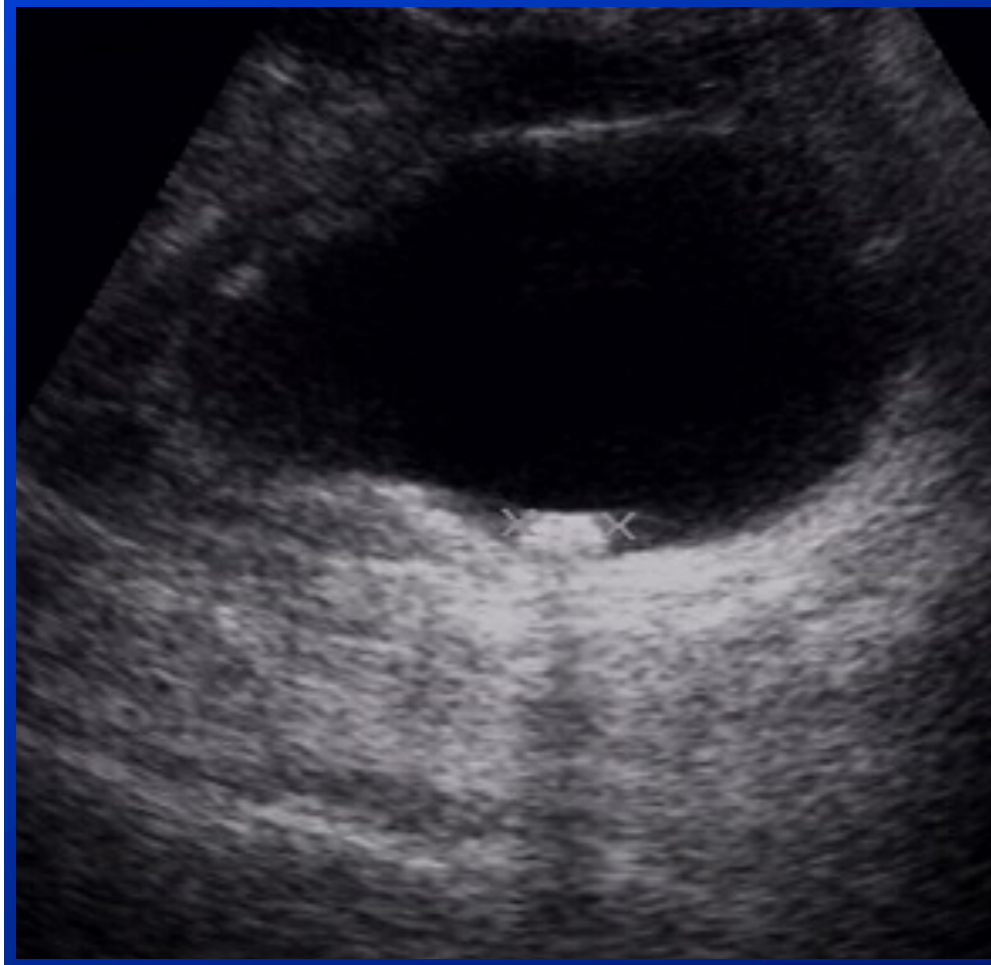


- Quartz, Barium, Titanate, Lead-ciconate
- Silicium oxide
- Electrical potential → Deformation of crystal
- Sound pressure → Electrical potential



Pixels in the US-image

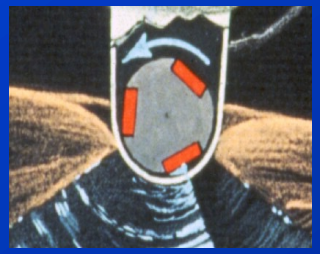
A	1	2	3	4	5	6	7	8	9	10	11
B											
C											
D											
E											
F											
G											
H											
I											
J											



Dynamic Range (dB)

Ultrasound Transducers

Mechanical Transducers



Electronic Array Transducers

- Convex
- Linear
- Phased

Parallel scanlines

Diverging scanlines

Hva betyr frekvensen for bildet?

Konsekvenser av økt ultralydfrekvens:

1) oppløsning går opp

2) penetrasjon går ned

Moderne skannere: frekvensen på en valgt probe
kan varieres noe, på bekostning av følsomhet (sensitivity)

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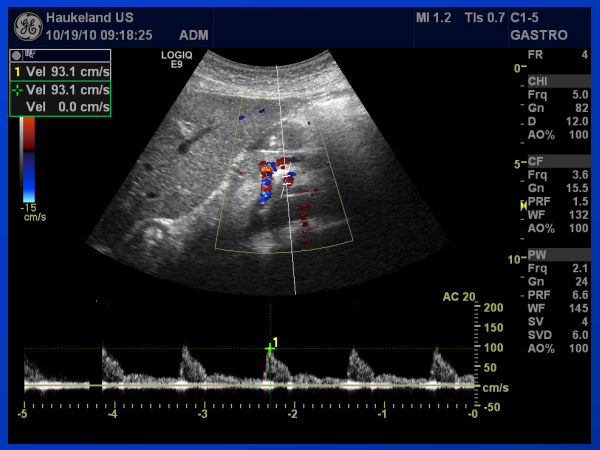
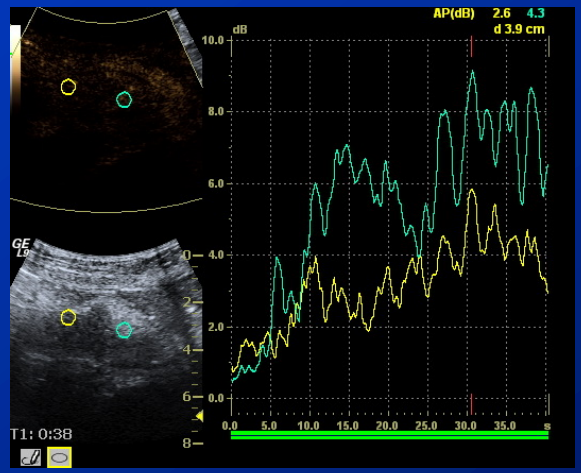
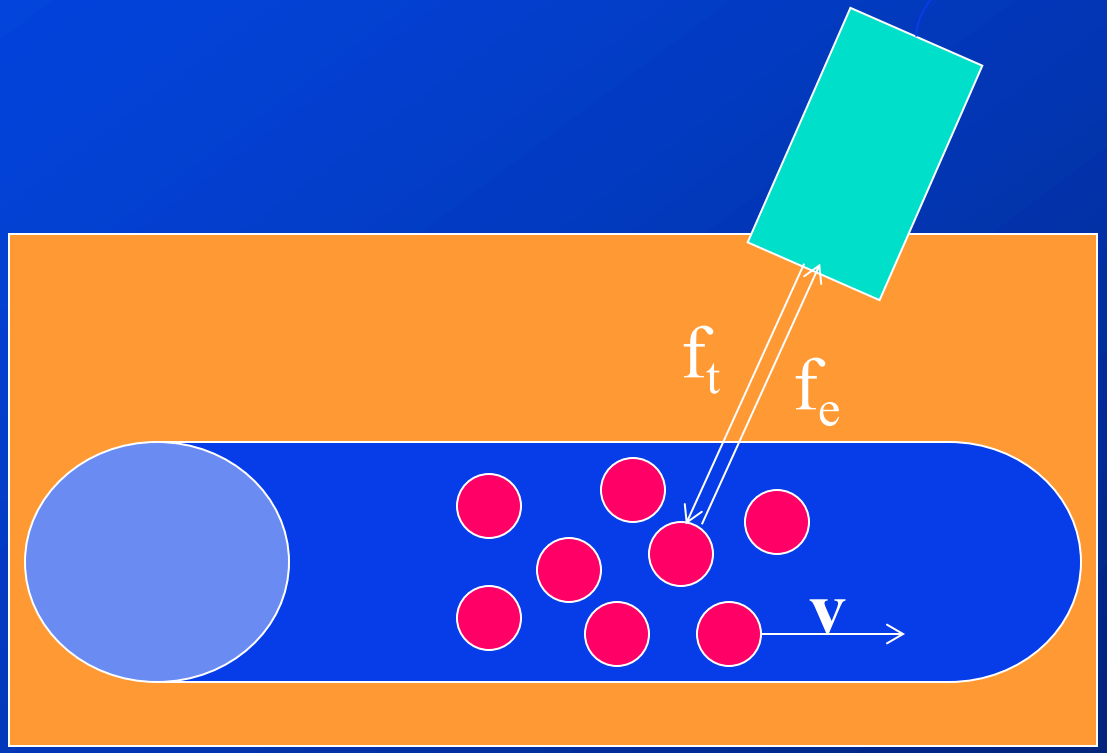
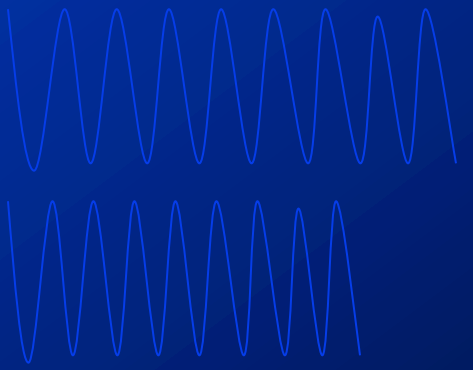




The Doppler effect in medical ultrasound

$f_d = f_e - f_t = 5\,002\,000\ \text{Hz} - 5\,000\,000\ \text{Hz} = 2\,000\ \text{Hz}$

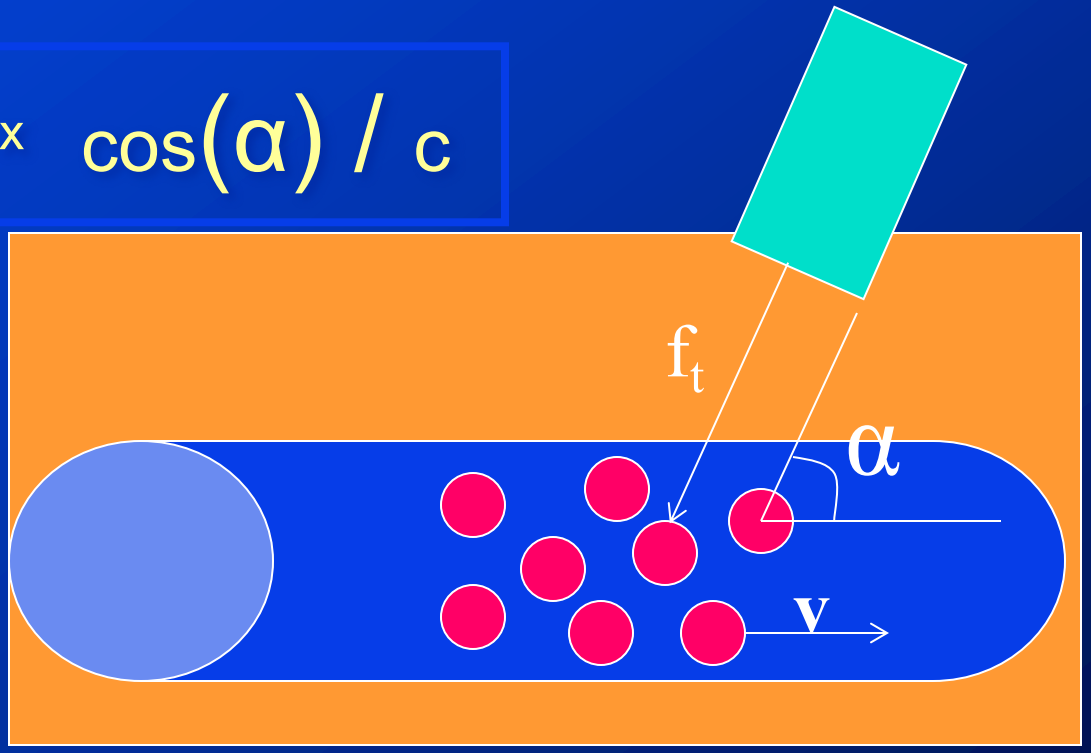




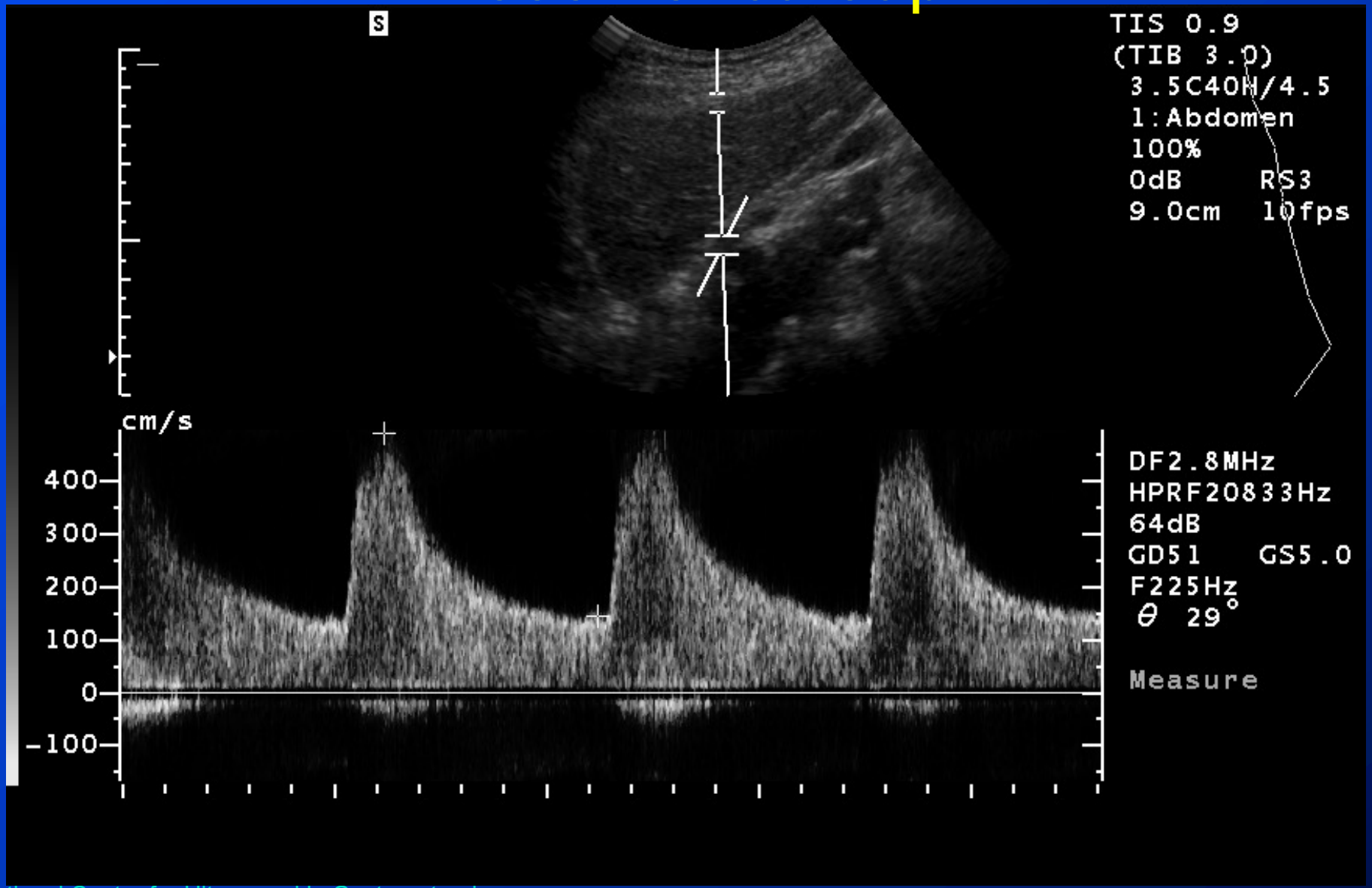
$f_e > f_t$

The Doppler equation

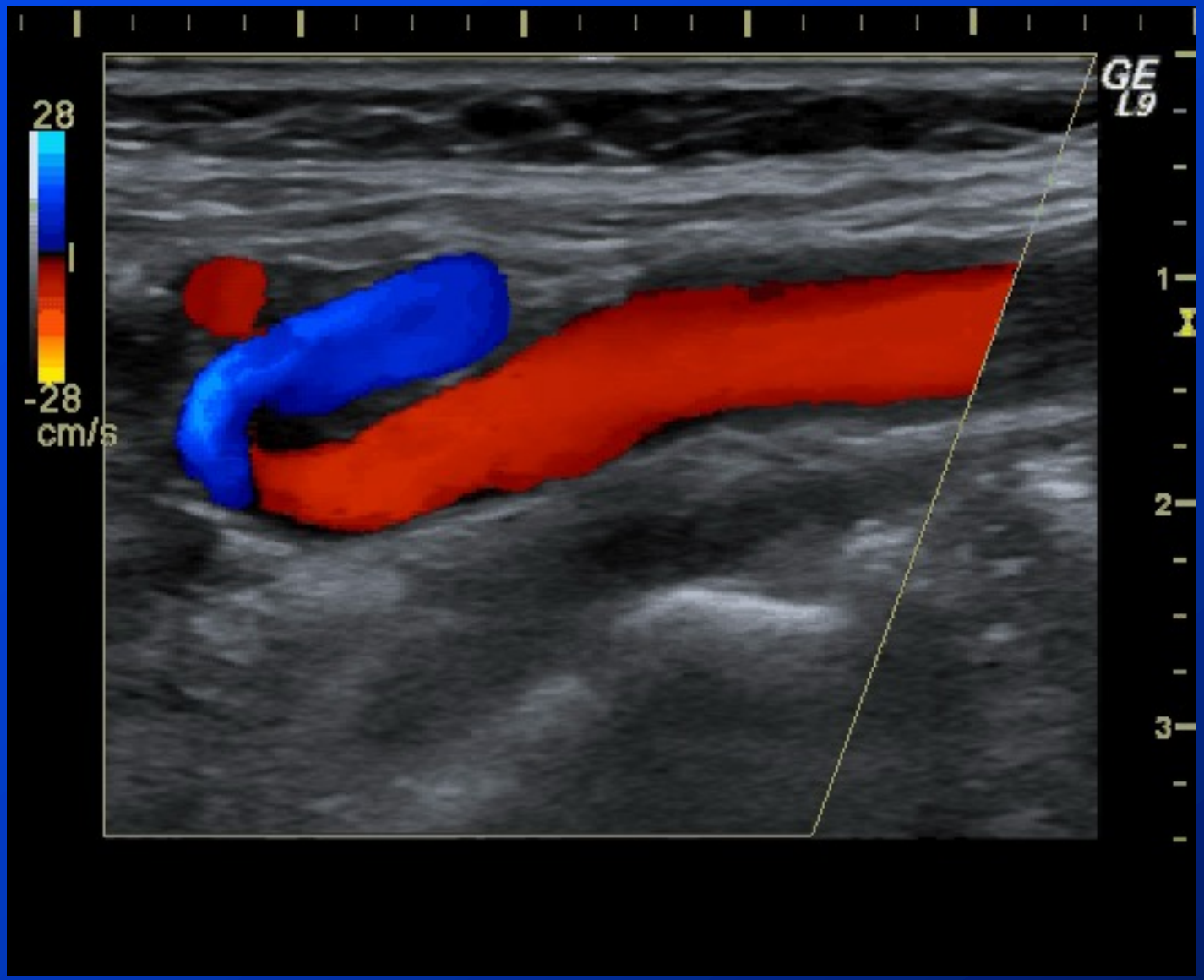
- Doppler frequency $f_d \approx v, \alpha, f_t$
- $f_d = 2 \times f_t \times v \times \cos(\alpha) / c$
- $c = 1\,500\ ^{m}/_{sec}$



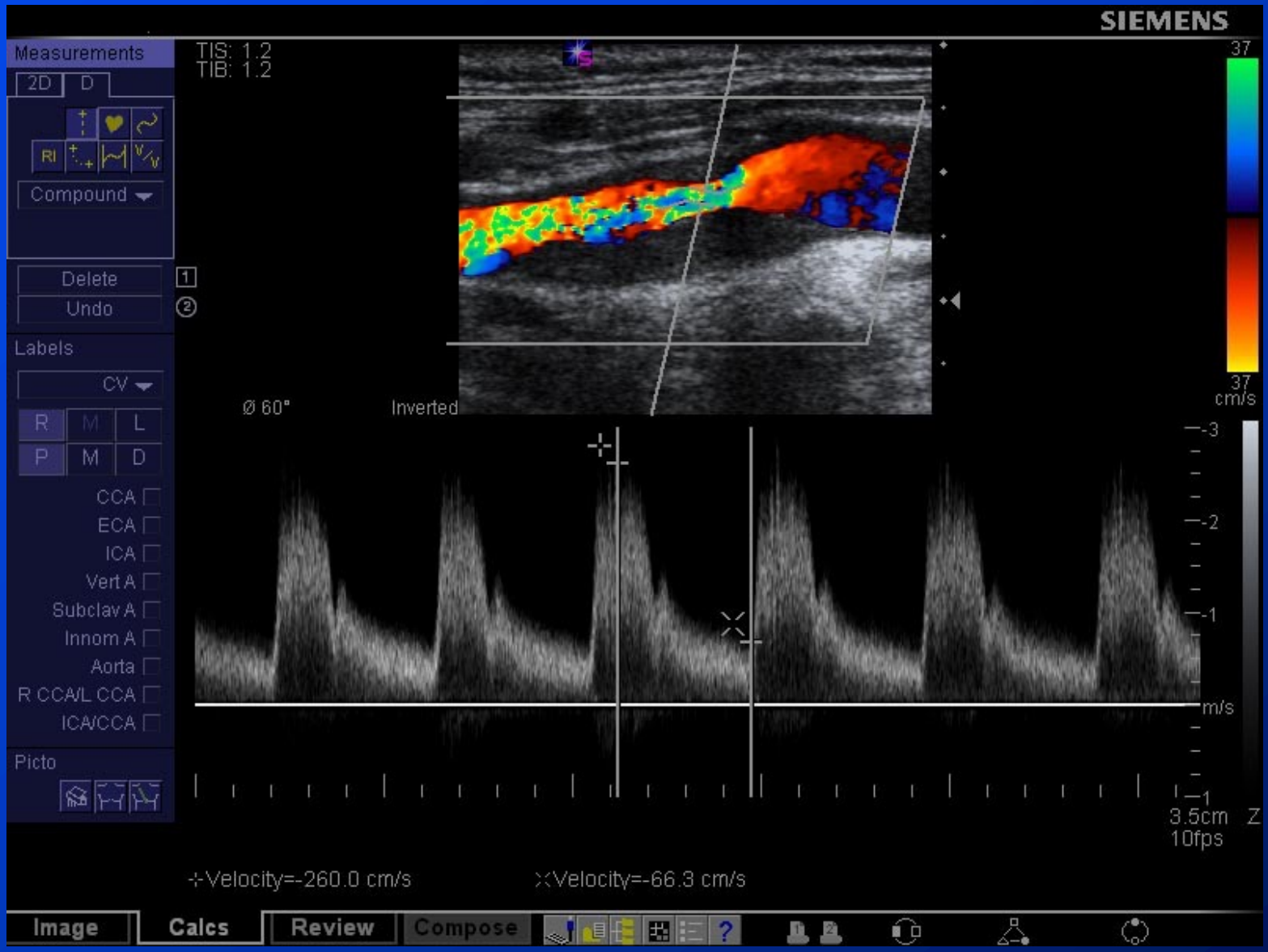
Pulsed Doppler of arteria mesenterica sup



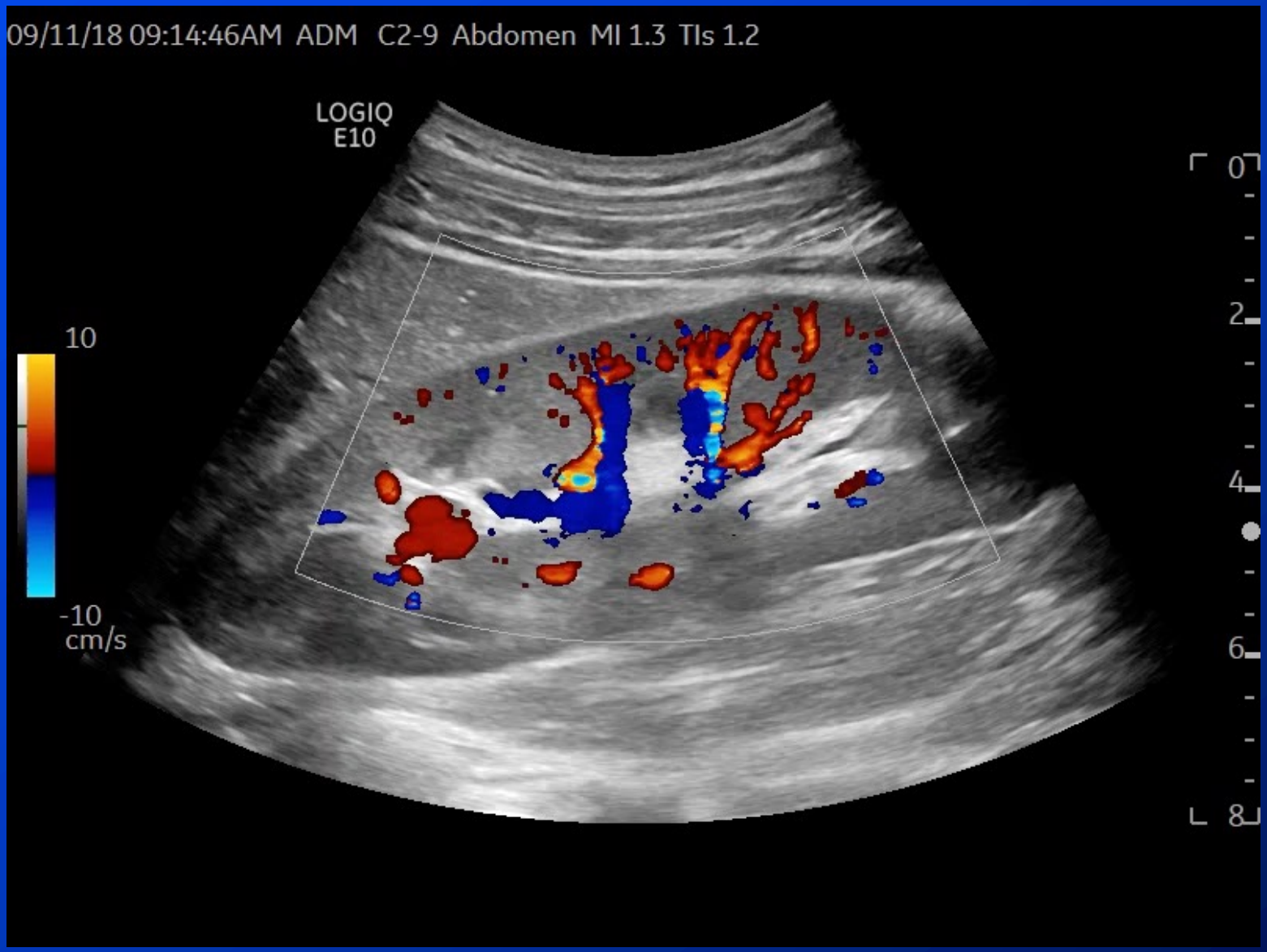
Color Doppler



Triplex – B-mode+Pulsed+Color



Real-time flow evaluation

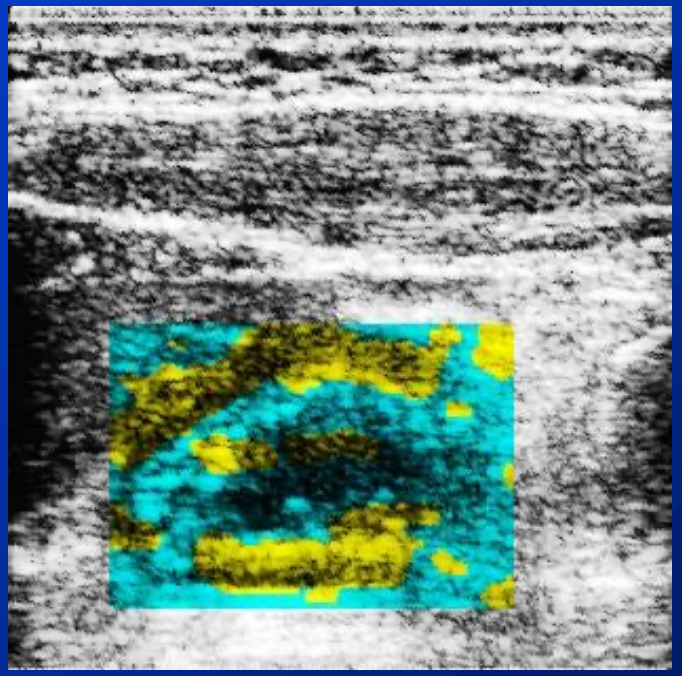


Power Doppler

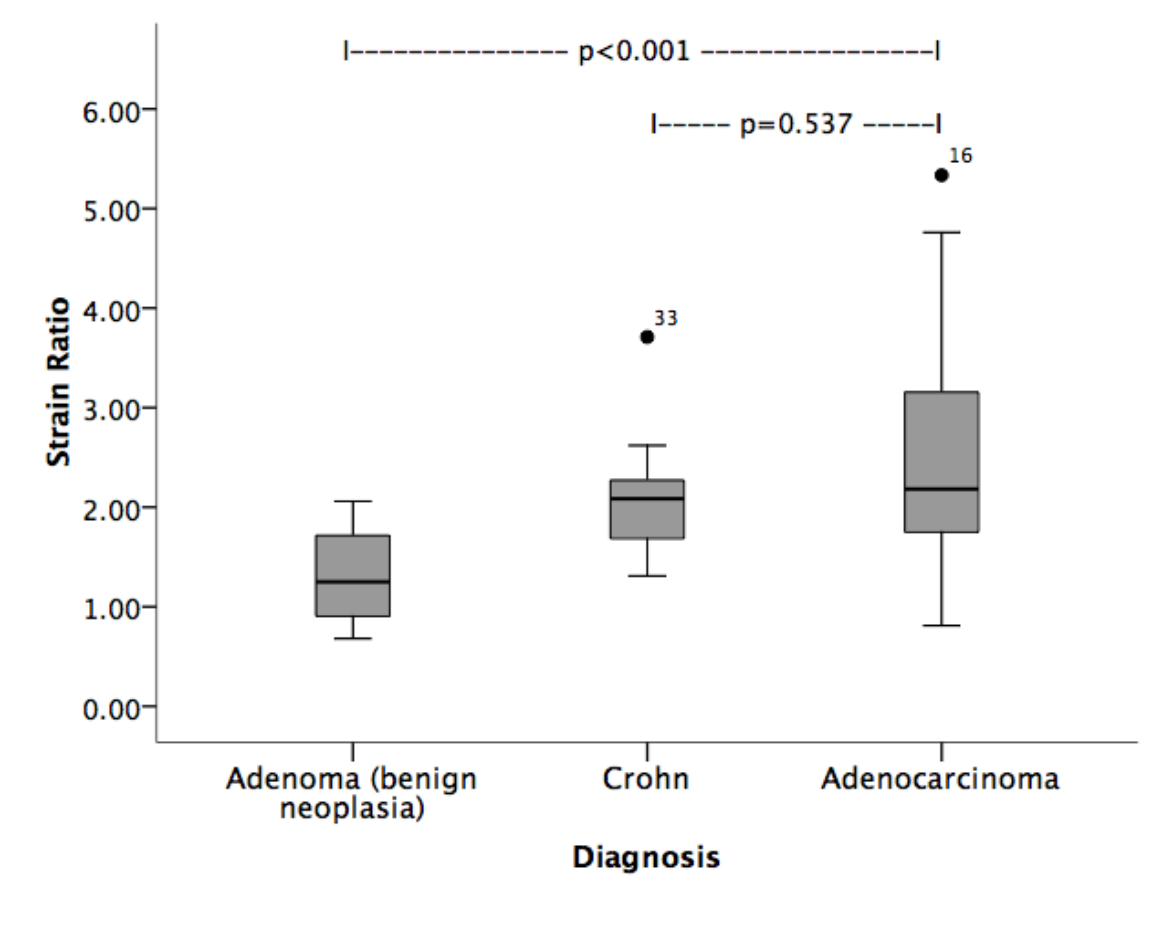
B Flow real-time dynamics

Tissue Doppler Imaging

- Tissue Doppler imaging (TDI) enables estimation of slow velocities
- TDI can map local tissue velocities (point velocities) in large organs
- The point velocity of tissue, however, does not differentiate between actively contracting and passively following tissue

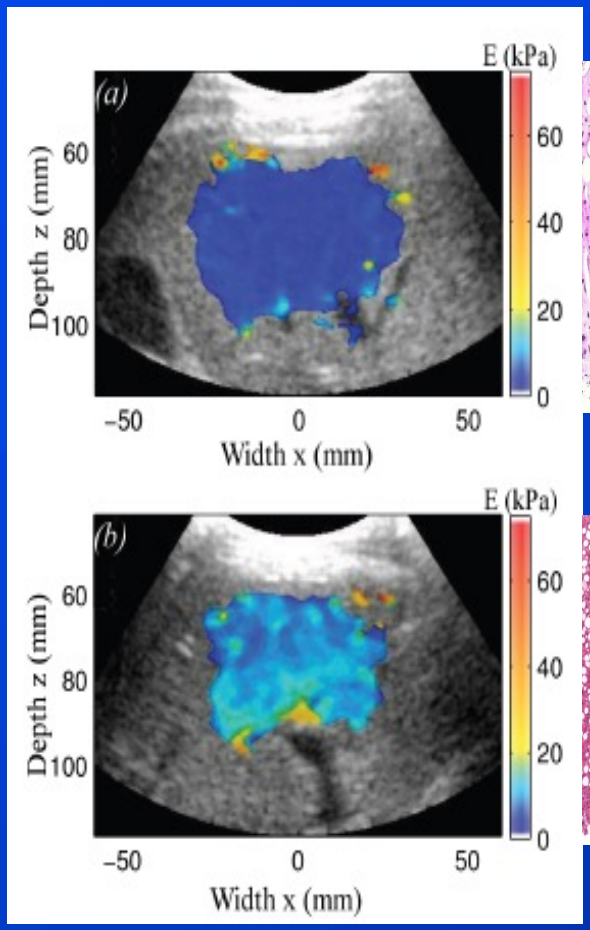


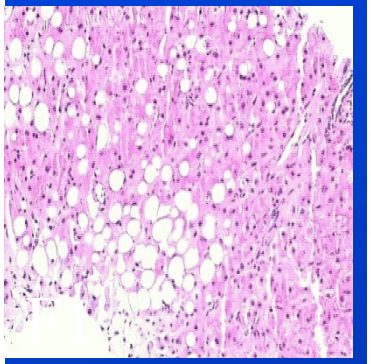
Elastographic Association between Strain Ratio and Pathology

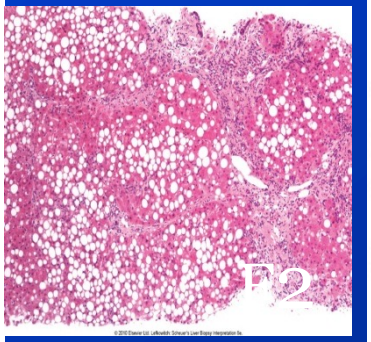


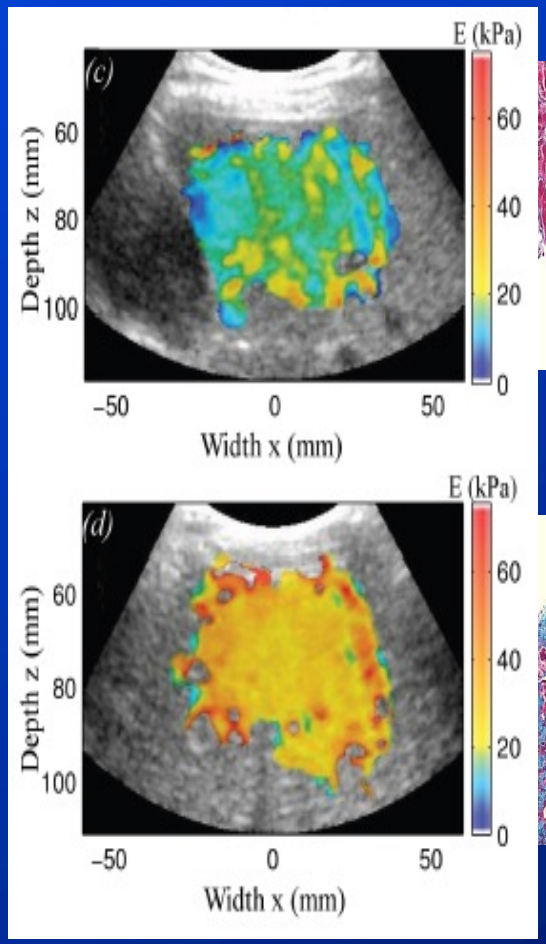
Havre R. et al., 2011

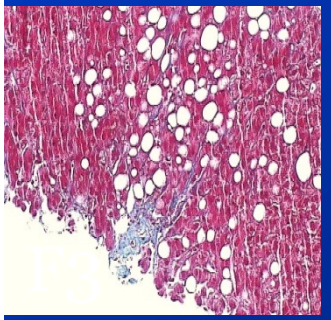
Shear Wave Elastography compared to histological findings and Liver Fibrosis

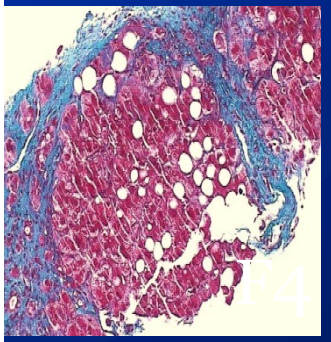












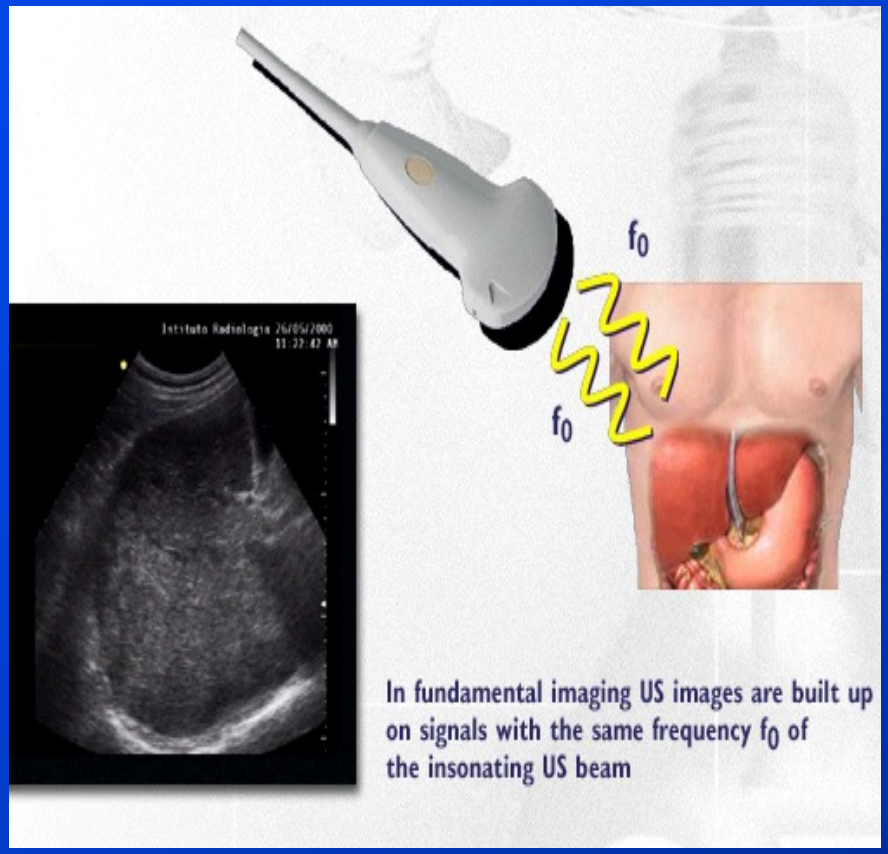
Ultrasound Med Biol. 2011 Sep;37(9):1361-73. Epub 2011 Jul 2011 Noninvasive in vivo liver fibrosis evaluation using supersonic shear imaging: a clinical study on 113 hepatitis C virus patients. Bavu E, Gennisson JL, Couade M, Bercoff J, Mallet V, Fink M, Badel A, Vallet-Pichard

Ultrasound elastography

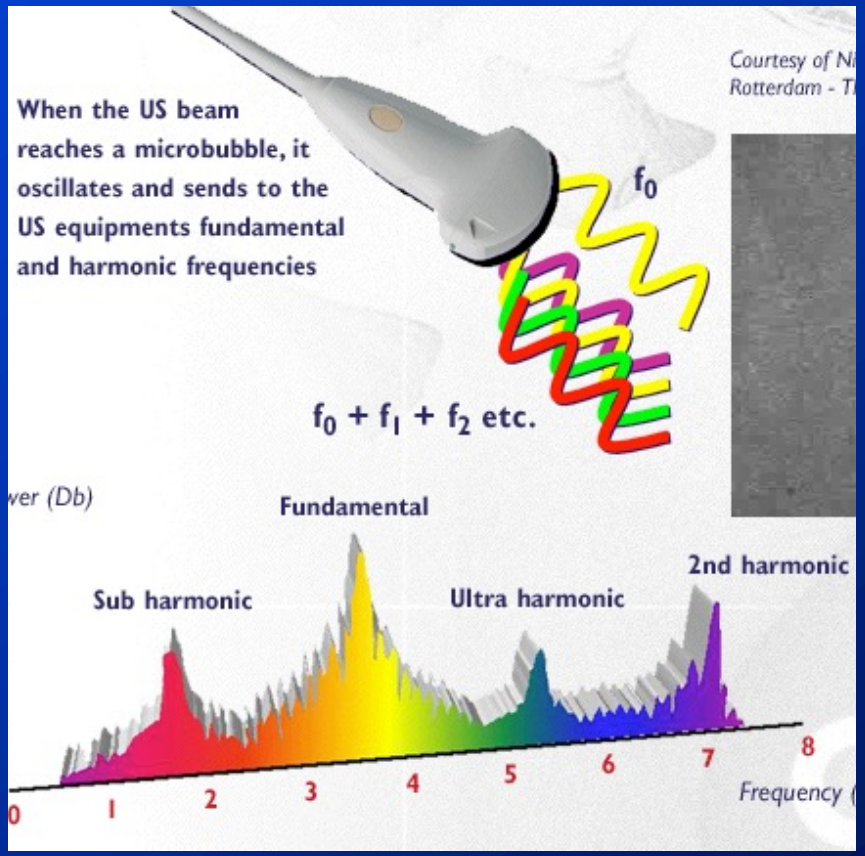
- Correlates well with histology regarding fibrosis
- Easy to perform
- Prolongs the US exam only with 2 min
- Provides valuable information to the clinician

- CT does not give data on liver stiffness
- MR elastography has low availability, is expensive and time consuming

Harmonic Imaging



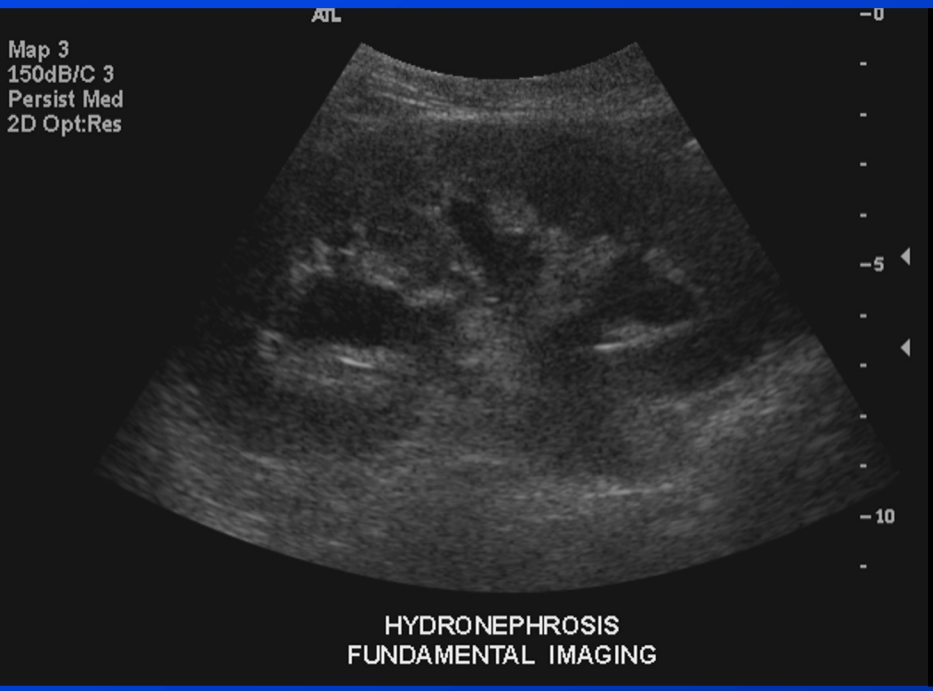
Fundamental Imaging



Harmonic Imaging

Harmonic Imaging

Harmonic Imaging Hydronefrose

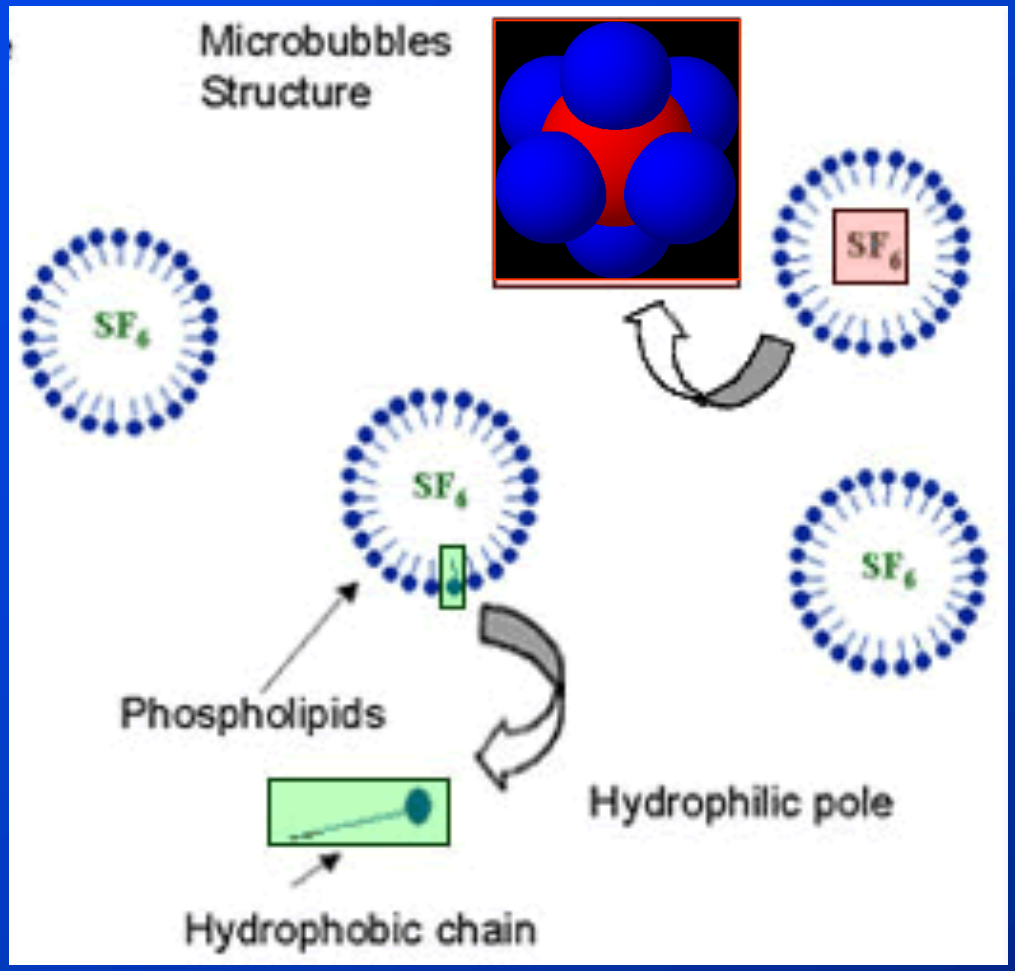


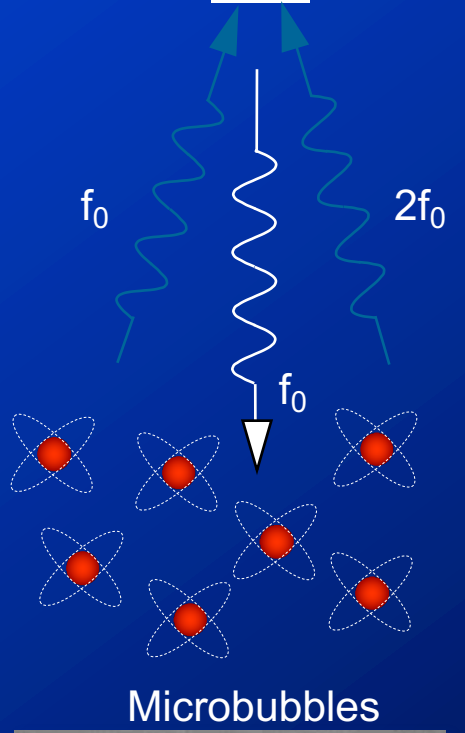
SONOVue®

Sulphur Hexafluoride

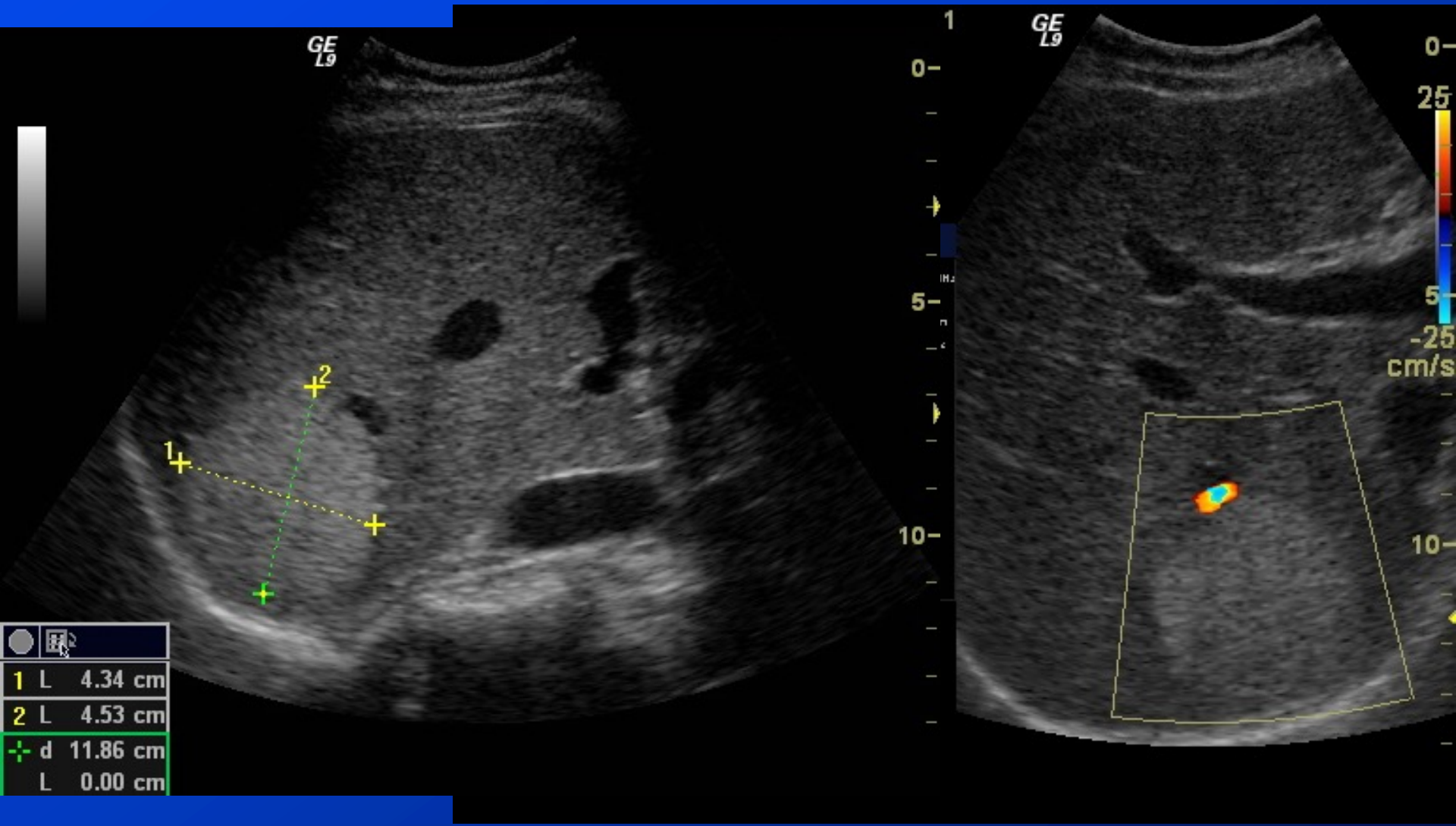
BRACCO

THE IMAGE OF INNOVATION

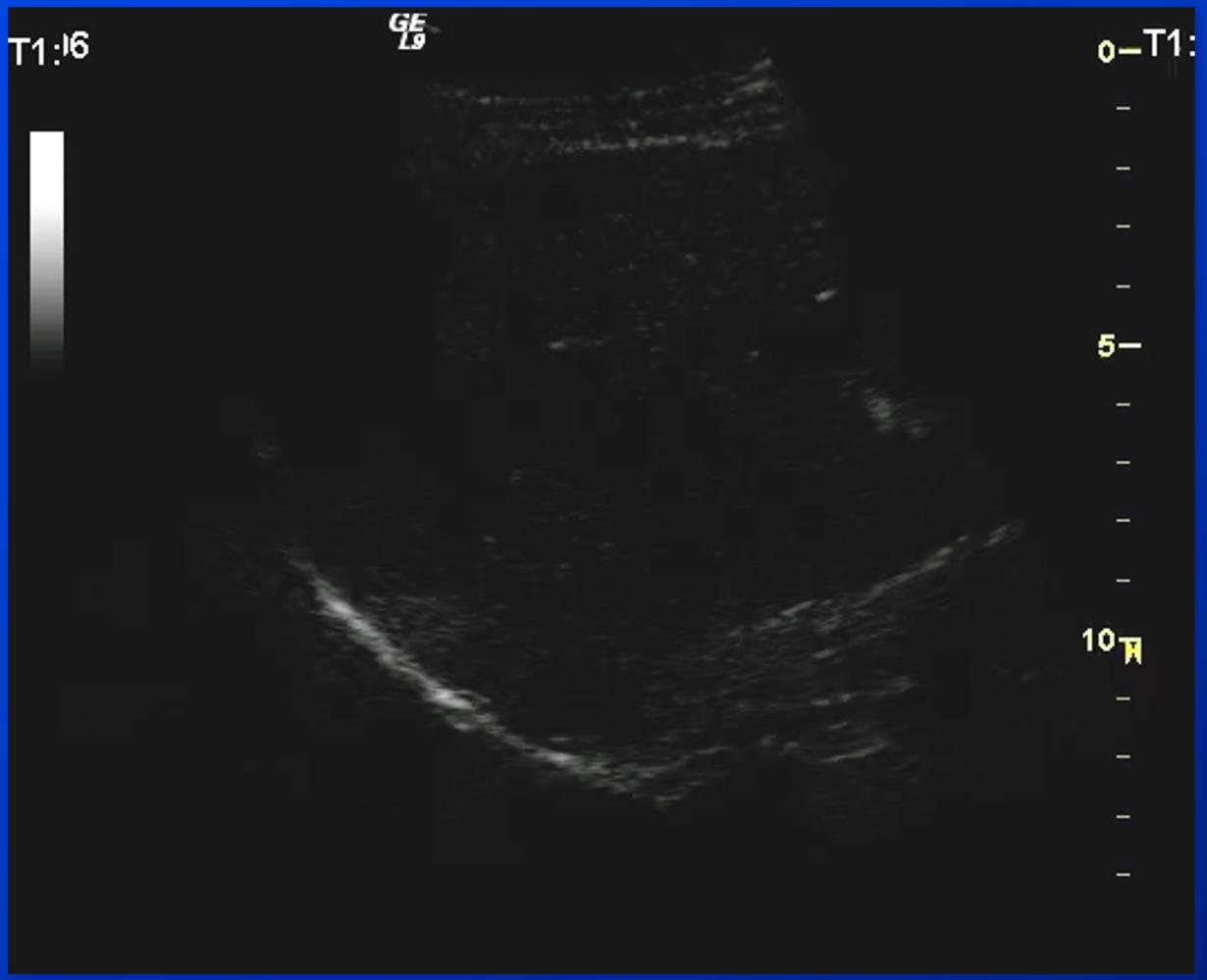




Referred from the CT-Lab
Haemangioma ?



Peripheral Globular Enhancement



…with slow sentripetal filling

EFSUMB Guidelines for CEUS

The EFSUMB Guidelines and Recommendations on the Clinical Practice of Contrast Enhanced Ultrasound (CEUS): Update 2011 on non-hepatic applications

Authors F. Piscaglia[1], C. Nolsøe[2], C. F. Dietrich[3], D. O. Cosgrove[4], O. H. Gilja[5], M. Bachmann Nielsen[6], T. Albrecht[7], L. Barozzi[8], M. Bertolotto[9], O. Catalano[10], M. Claudon[11], D. A. Clevert[12], J. M. Correas[13], M. D'Onofrio[14], F. M. Drudi[15], J. Eyding[16], M. Giovannini[17], M. Hocke[18], A. Ignee[19], E. M. Jung[20], A. S. Klauser[21], N. Lassau[22], E. Leen[23], G. Mathis[24], A. Saftoiu[25], G. Seidel[26], P. S. Sidhu[27], G. ter. Haar[28], D. Timmerman[29], H. P. Weskott[30]

Affiliations Affiliation addresses are listed at the end of the article.

Bibliography
DOI http://dx.doi.org/10.1055/s-0031-1281676

Published online 2011
Ultraschall in Med © Georg Thieme Verlag KG Stuttgart · New York · ISSN 0172-4614

Correspondence

Thematic sections

	Thematic Section	Chairperson
1	Introduction	F. Piscaglia – C. Nolsøe
2	Generalities	D. Cosgrove
3	Equipment	H. P. Weskott
4	Investigator's training	O. H. Gilja

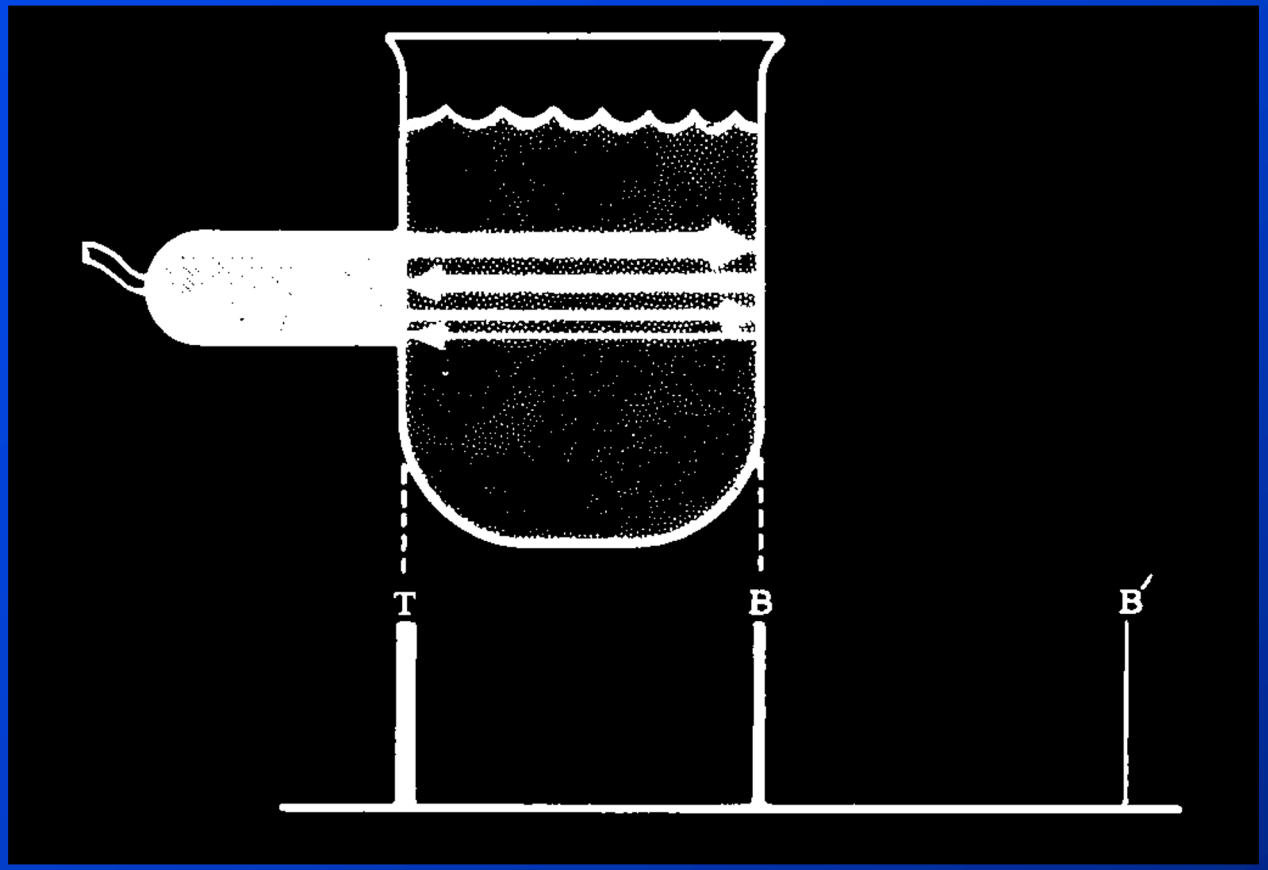
List of Abbreviations

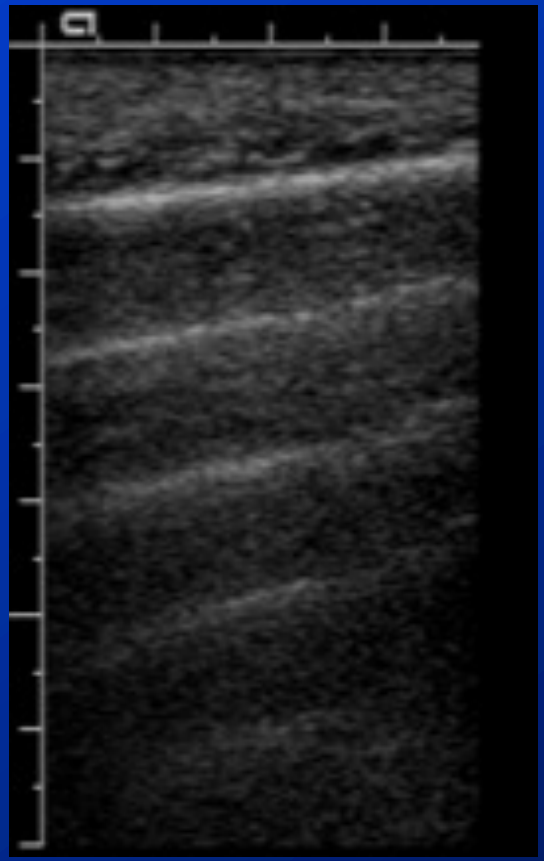
AAA = Abdominal Aortic Aneurysm
AUC = Area Under the Curve
CE = Contrast Enhanced
CECT = Contrast Enhanced Computed Tomography
CEMRI = Contrast Enhanced Magnetic Resonance Imaging

Over 1390 citations

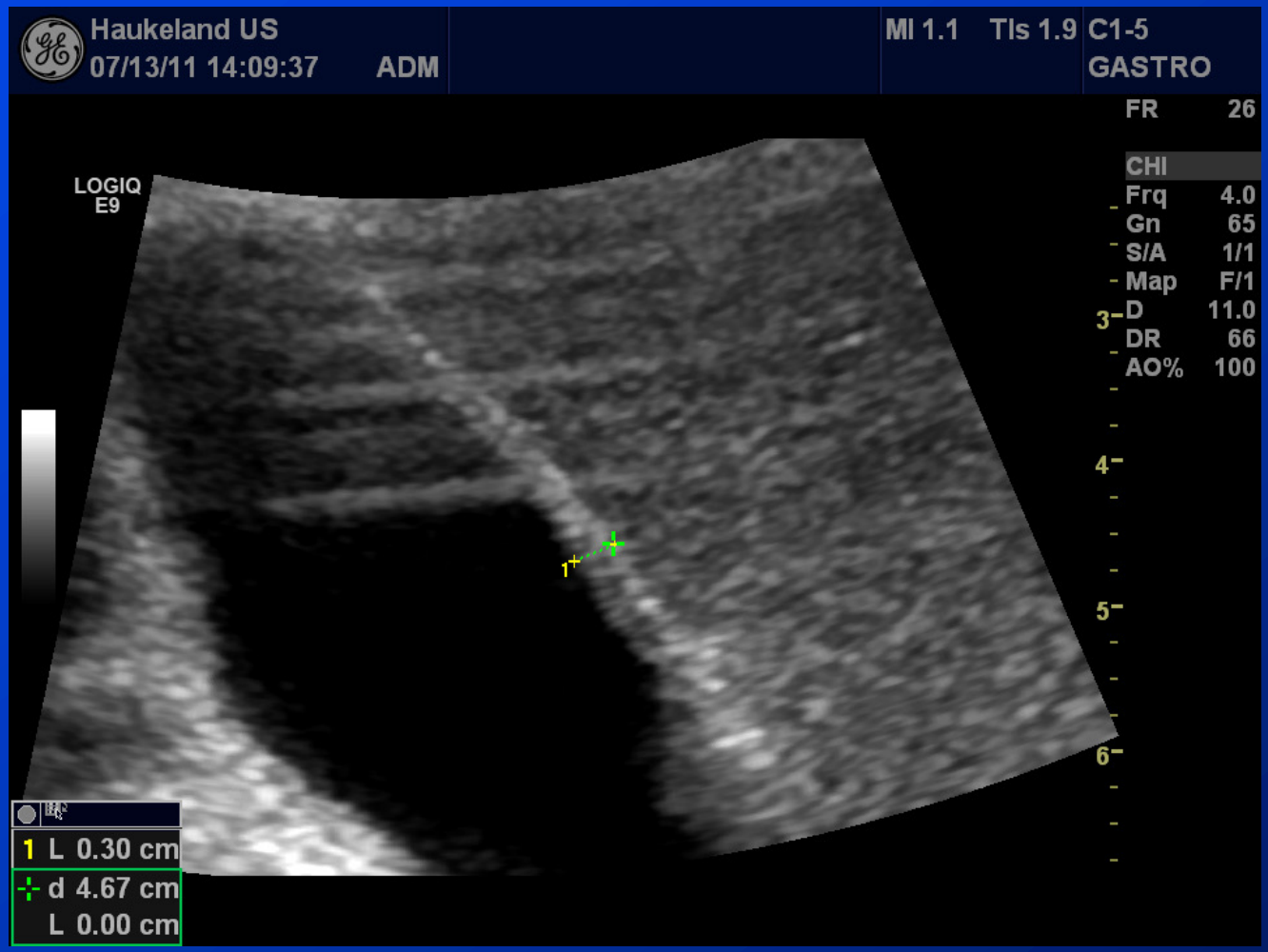
Ultraschall Med / EJU Aug. 2011

Artifacts - Reverberations

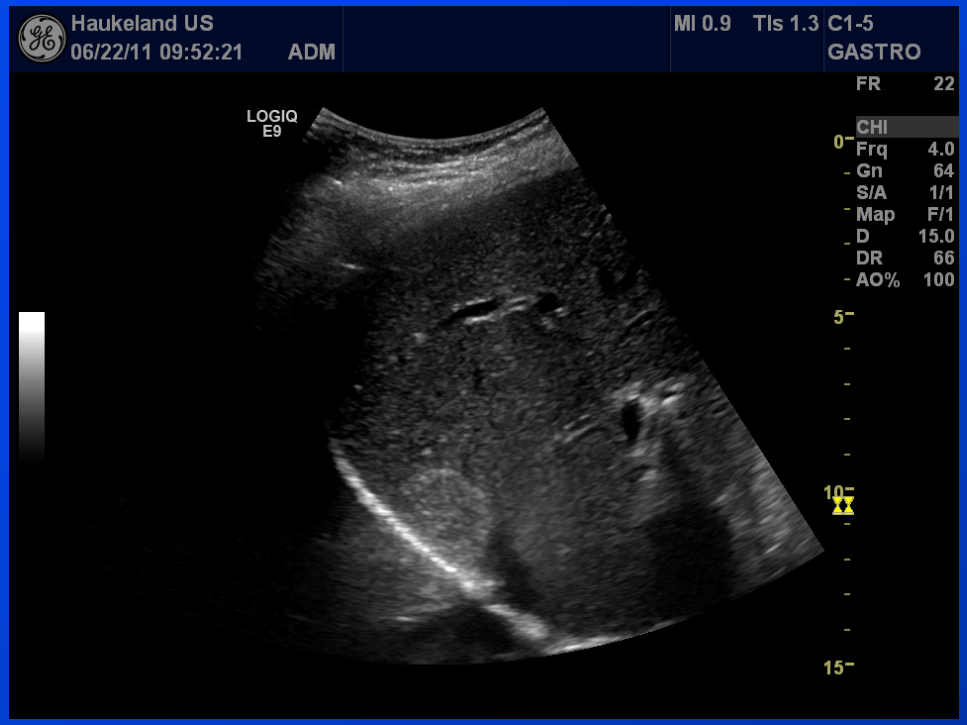


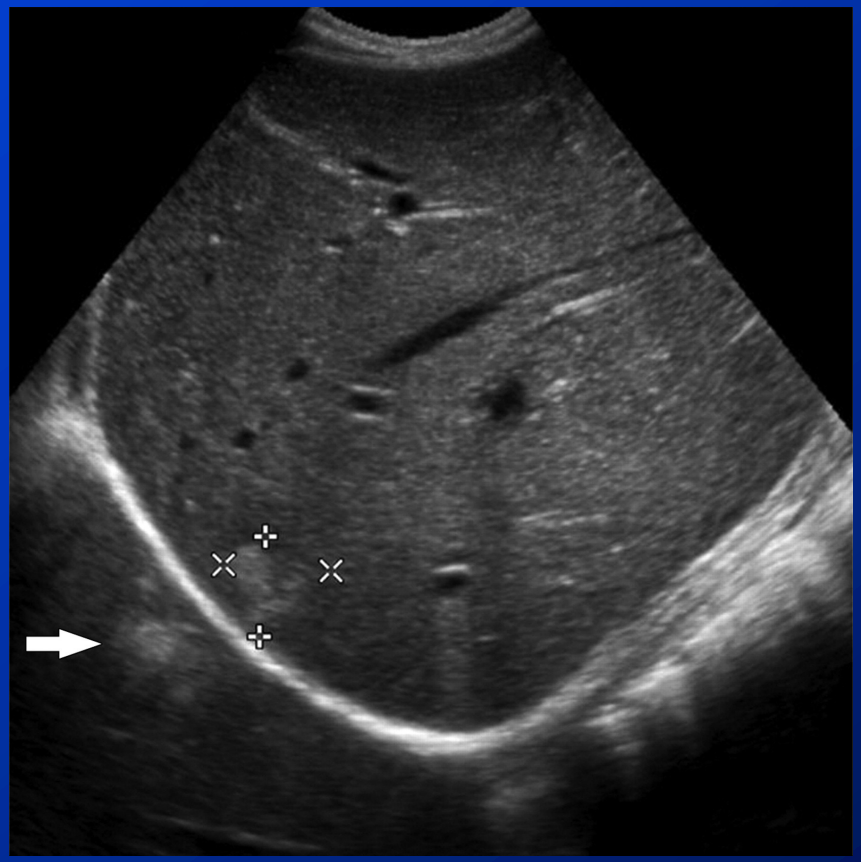


Reverberations in Gallbladder

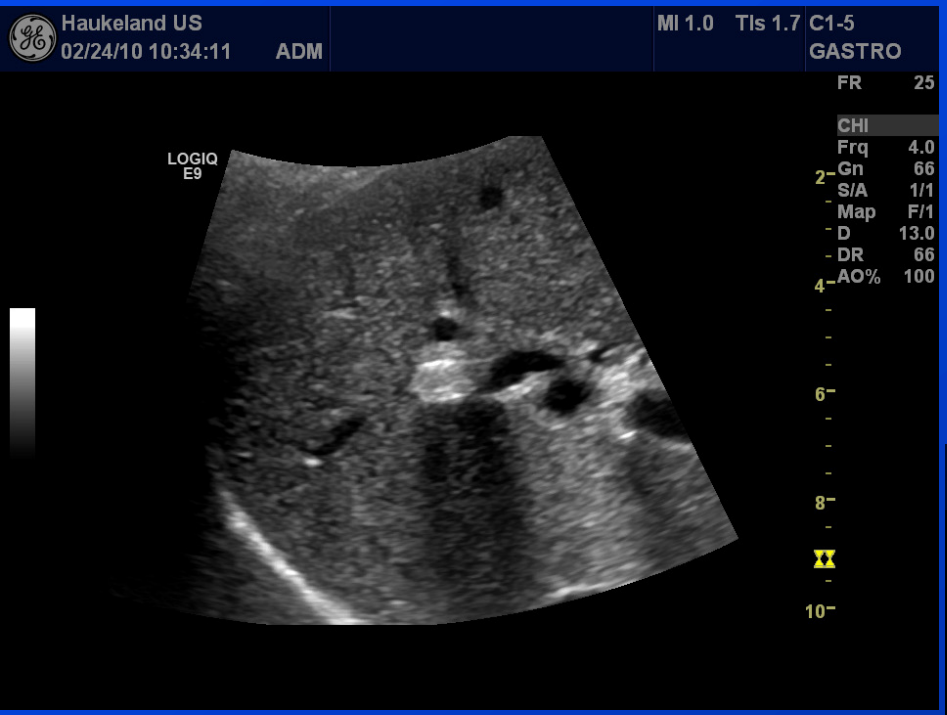


The Mirror Artifact

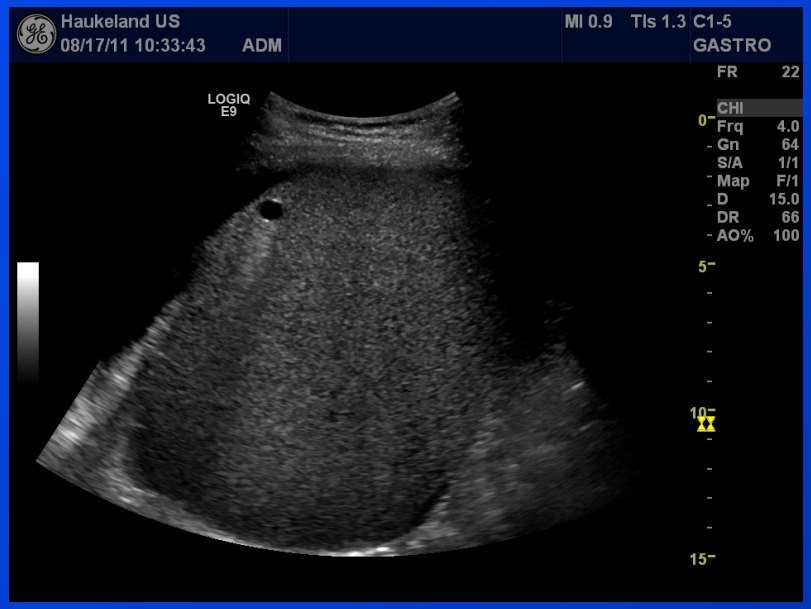


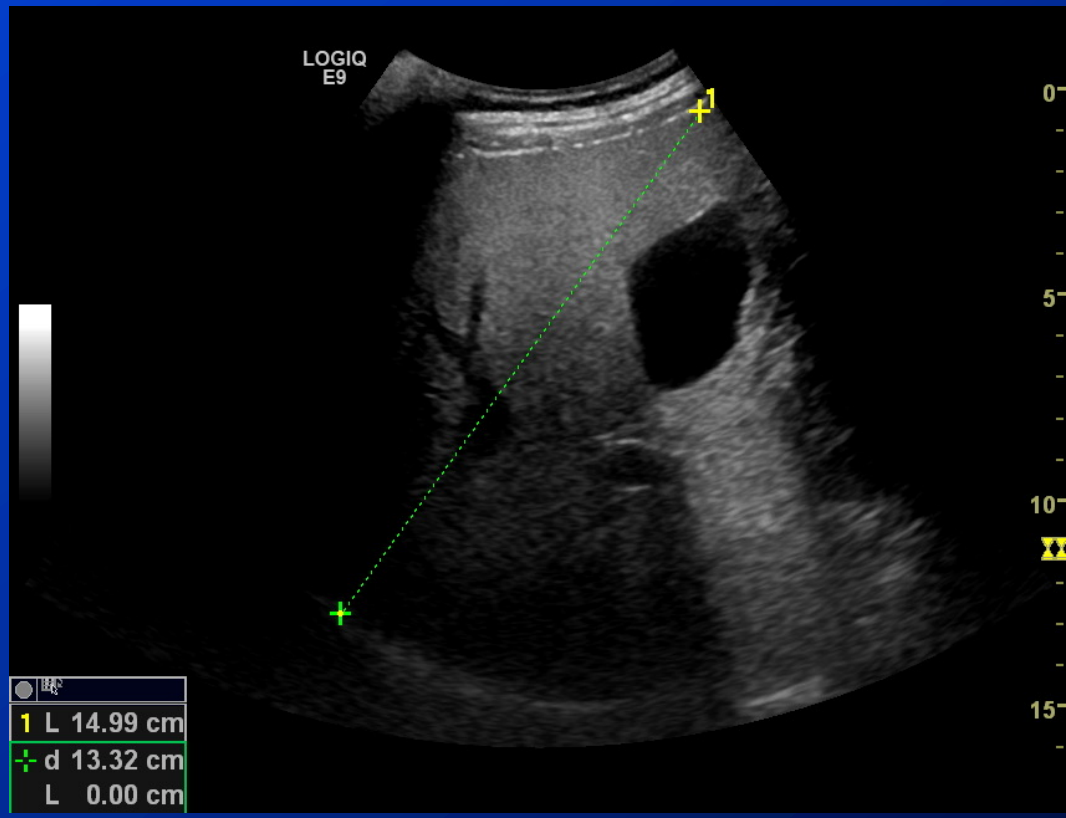


Artifacts is often clinically helpful

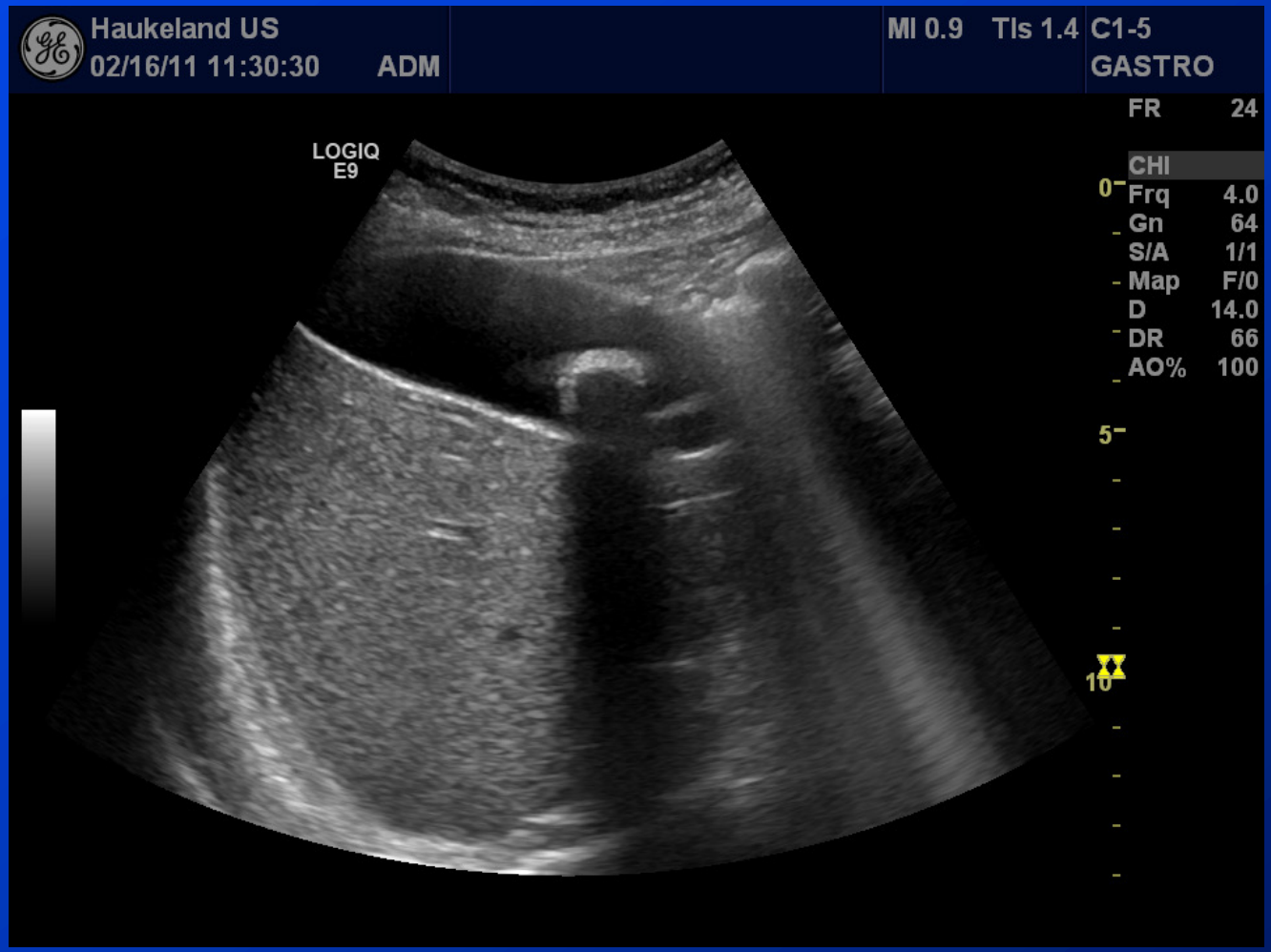


Acoustic Enhancment





Shadowing and Comet tail



Cholecystitis – twinkling artifact