Nasjonalt Senter for
Gastroenterologisk Ultrasonografi
National Centre for Ultrasound in Gastroenterology
Haukeland University Hospital, Bergen, Norway

Ultrasound of diffuse and focal liver diseases

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Professor
Department of Medicine
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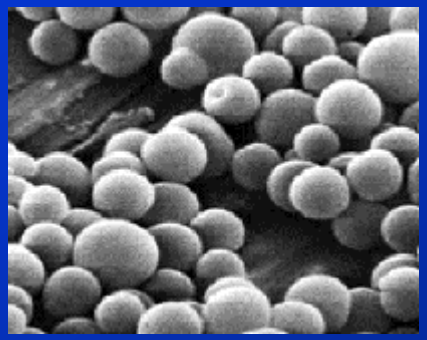
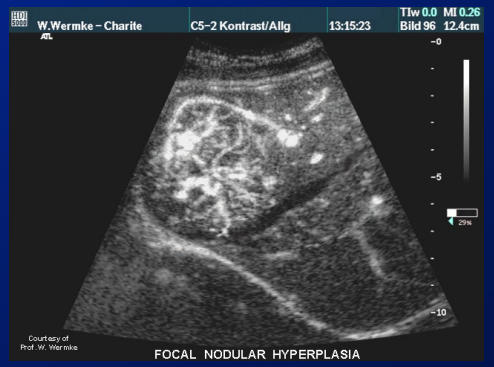
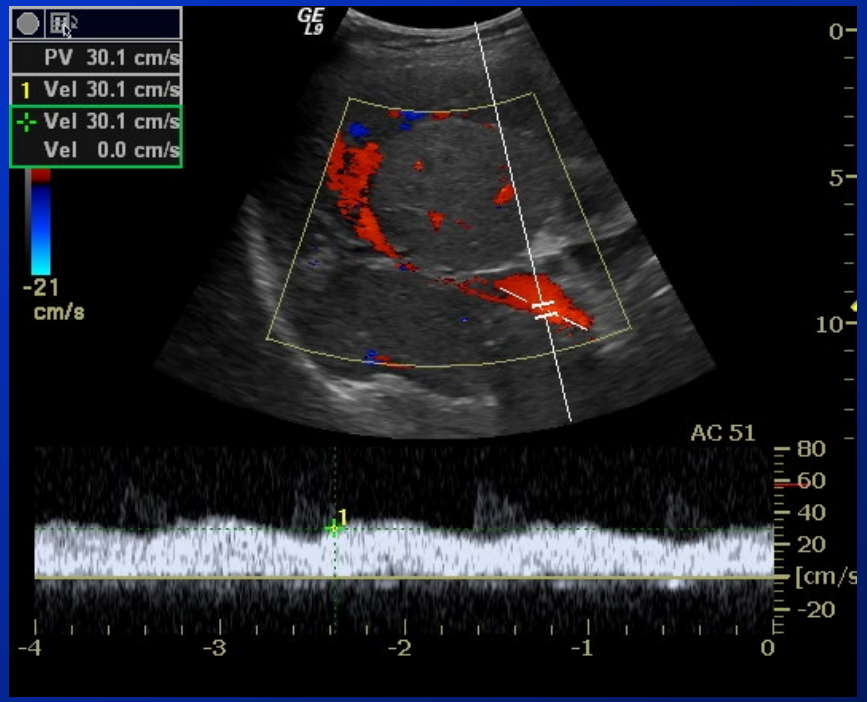




The Ultrasound Tool-box

- Ultrasound of liver
  - B mode
  - B-Flow
  - Doppler
    - Color Doppler
    - Pulsed Doppler
  - Elastography
    - Strain imaging
    - Shear wave
  - Contrast-US (CEUS)

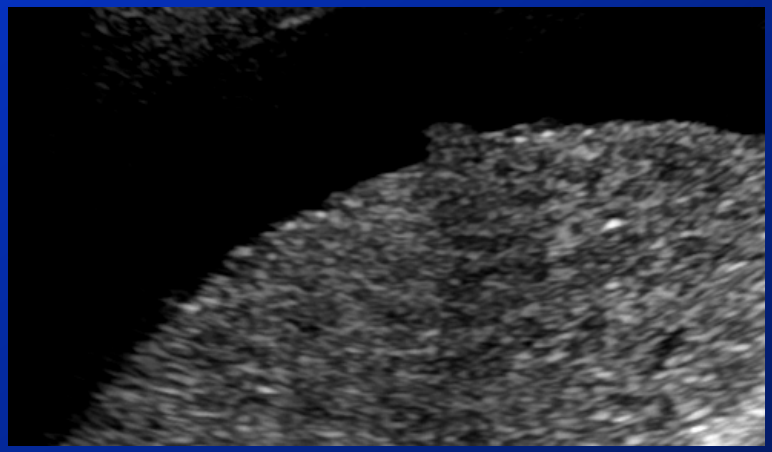


- US-guided liver biopsy (Menghini and Pistol)
- US-guided ablation techniques
- Sonoporation therapy

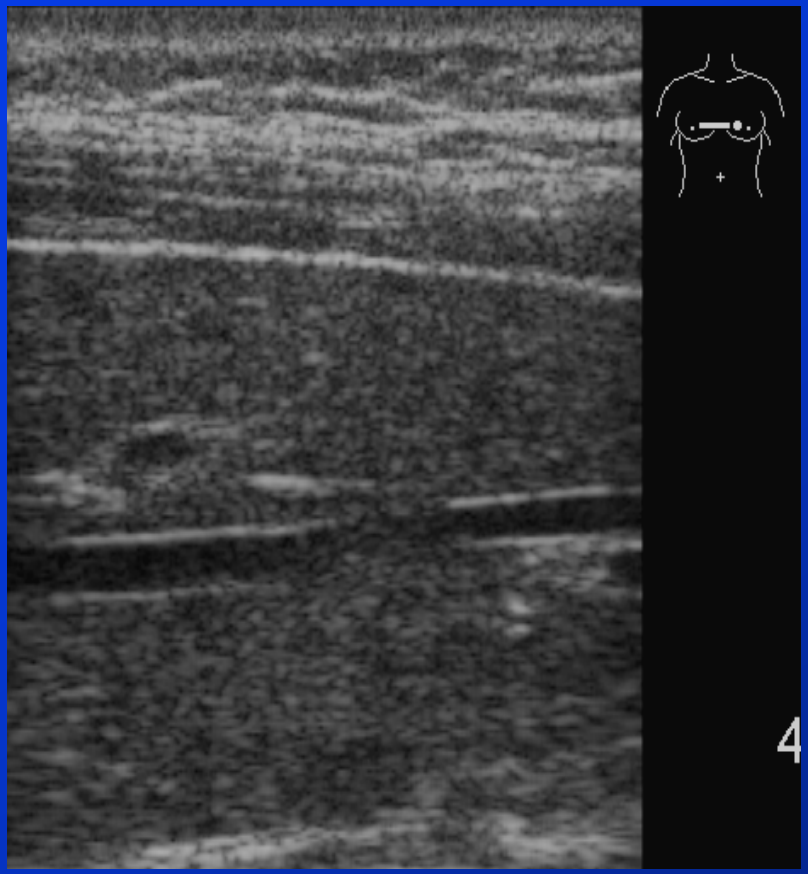
Ultrasound of the Liver

-What do we look for ?

- Echogenicity
- Size, capsule and form
- Any lesions?
- Liver veins
- Portal vein
- Arteria hepatica
- Intrahepatic bile ducts



The Liver capsule



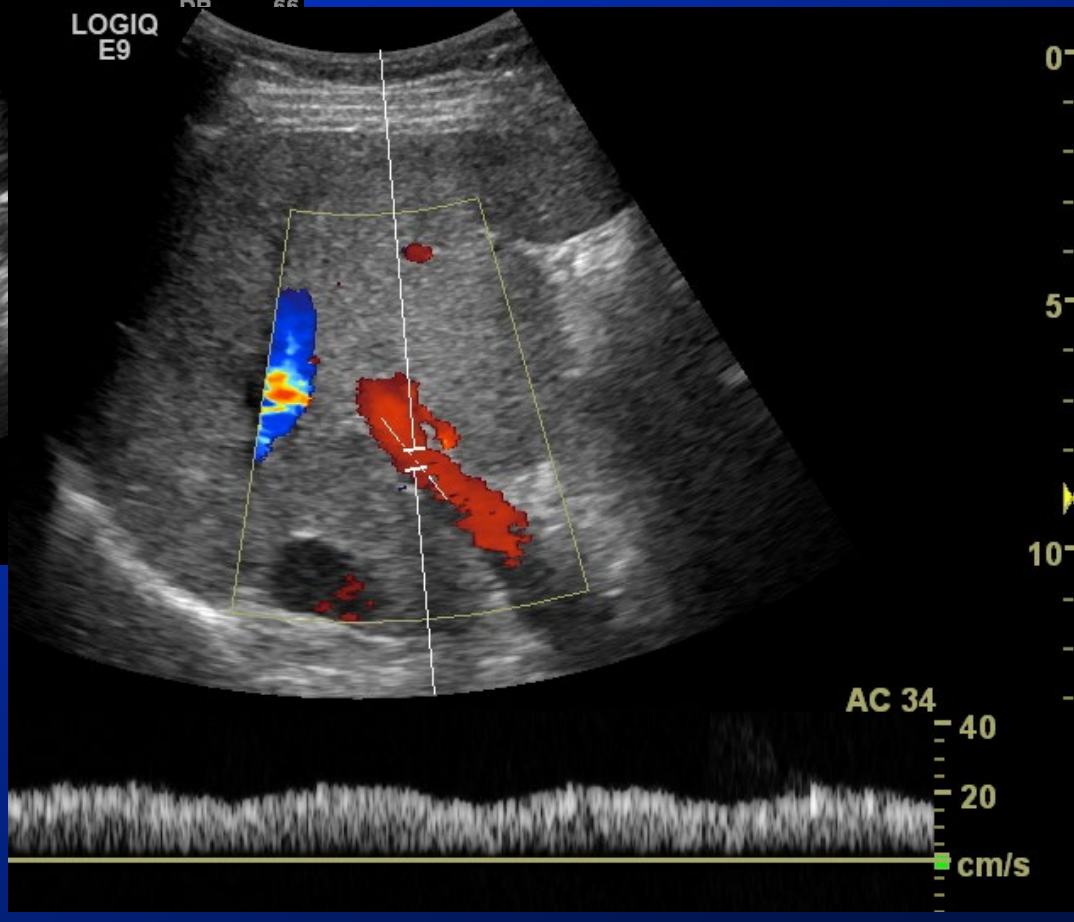
Normal

Cirrhosis

Use high frequency (9-12 MHz)

Vena Porta

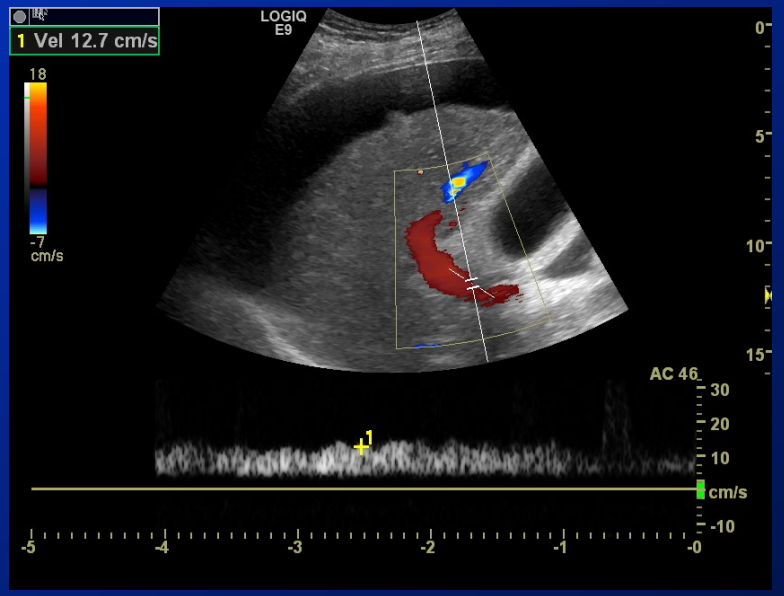

Haukeland US
09/29/10 09:20:35
ADM
MI 1.2
TIs 1.7
C1-5
GASTRO
FR 24
CHI
Frq 5.0
Gn 64
S/A 1/1
Map F/1
D 12.0
LOGIQ
E9


LOGIQ
E9
0
5
10
AC 34
40
20
cm/s

Color Doppler flow in real-time

US better than CT

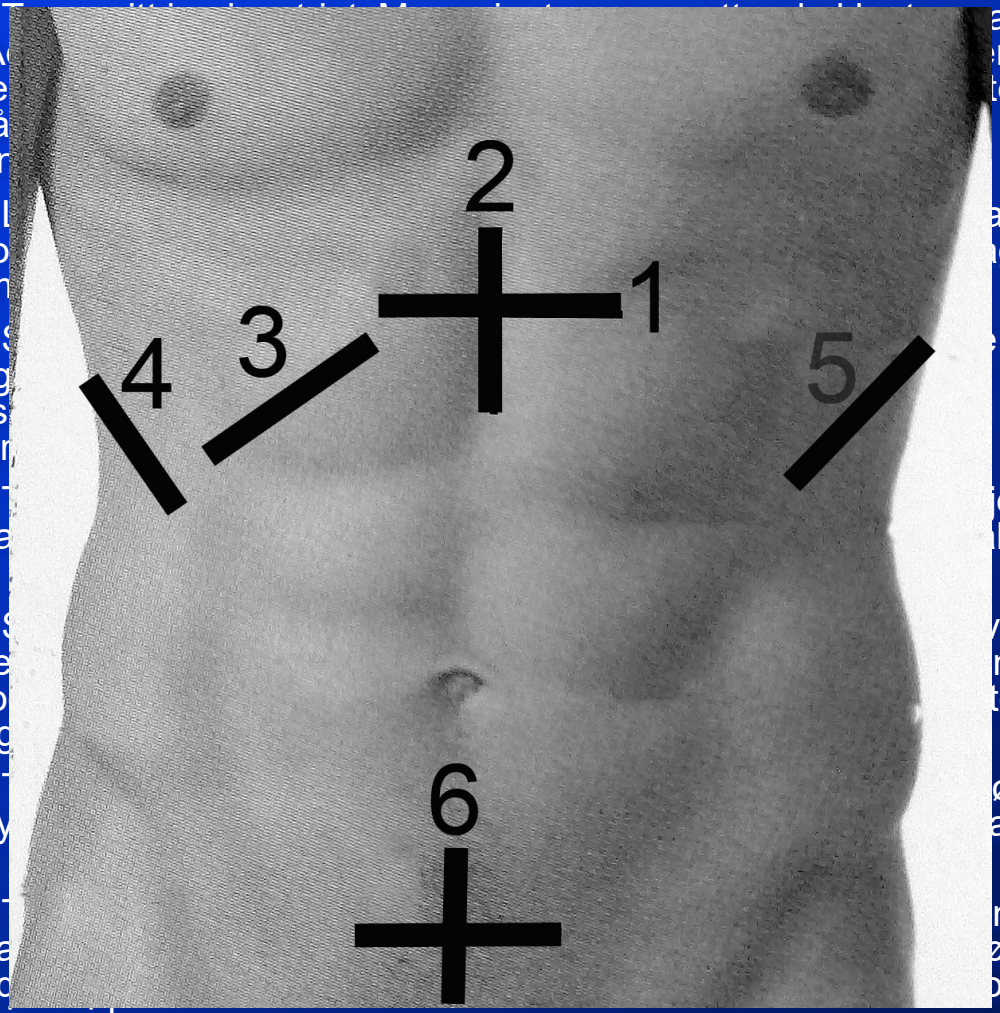
- Small and complex cysts
- Flow evaluation
  - Portal vein trombosis
  - Budd-Chiari
- Cirrhosis evaluation
  - Global liver assessment
  - Portal HT
  - TIPS



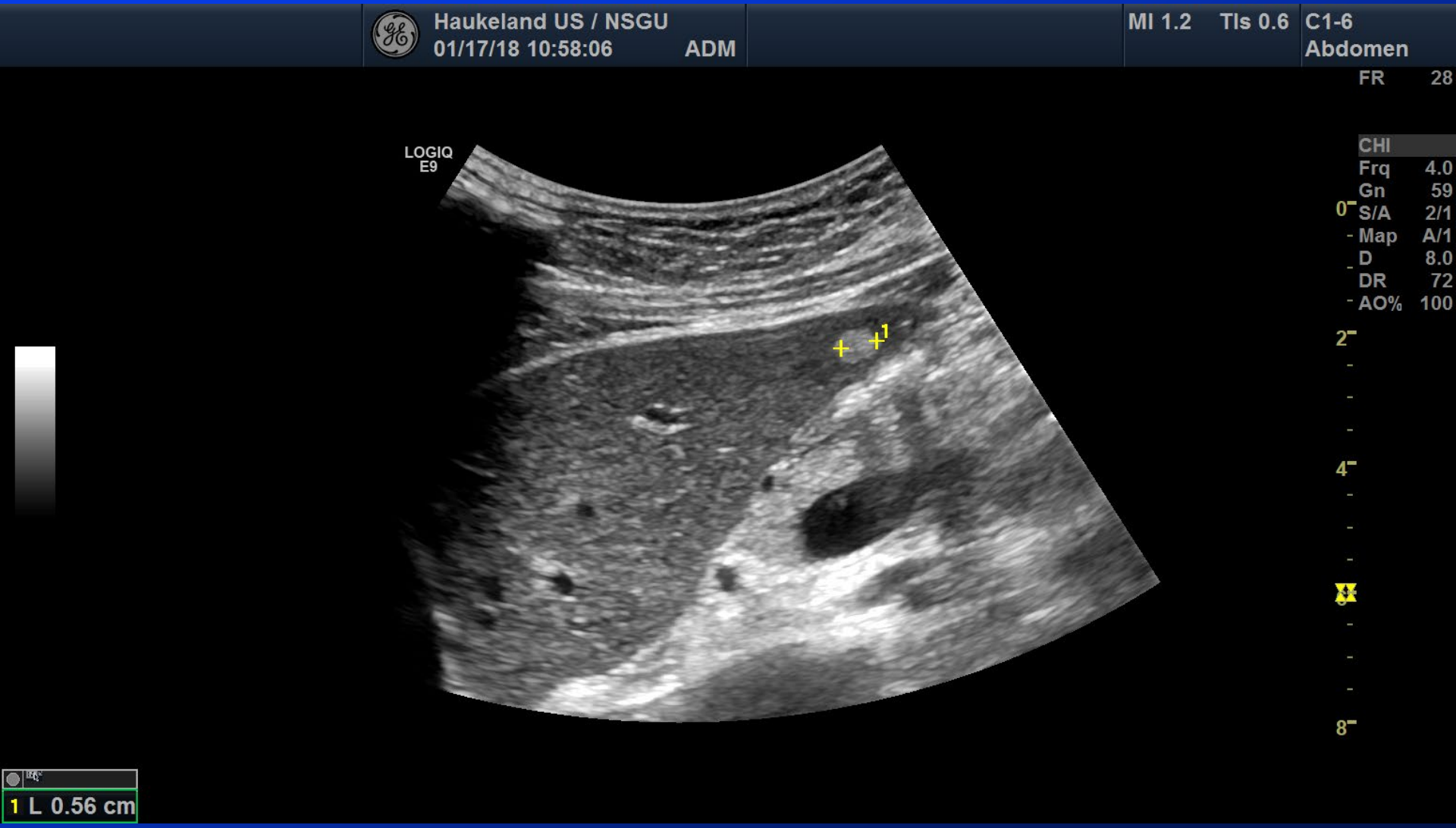
6+

A systematic examination of abdominal organs

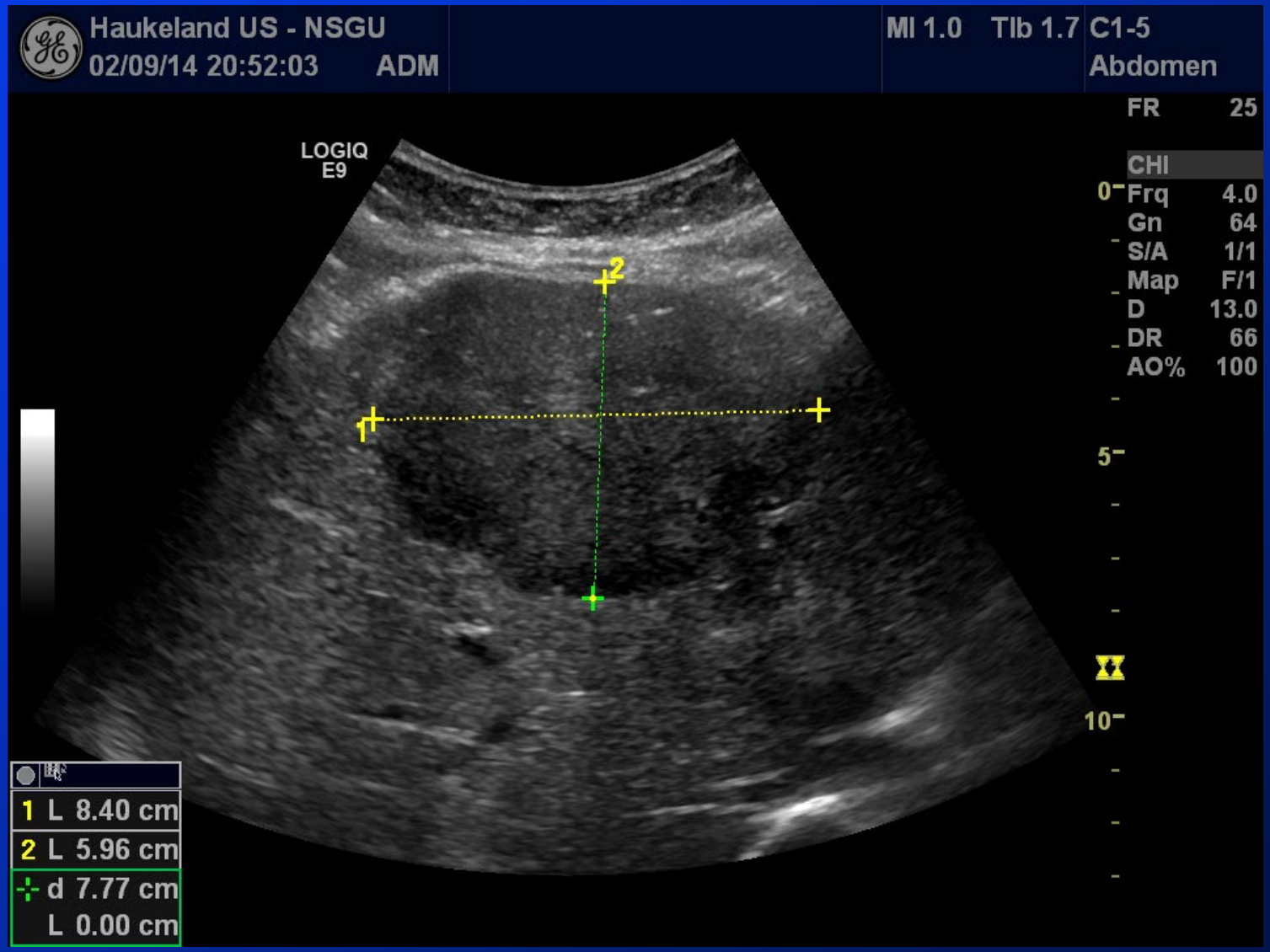
- **Stasjon 1** T… atomiske landemerker: A… r. Man skanner systematisk gje… ten til å puste dypt inn for å få… 2 glass vann å drikke kan noer…
- **Stasjon 2** L… avgående kar i lengderetning o… agesekken (antrum) i samn…
- **Stasjon 3** S… e som gjør at man noen gang… tilfelle undersøkes fas… subcostal vinkling og inter…
- **Stasjon 4** T… ion og grep om lydhodet og ska… lflaten samt intercostalt.
- **Stasjon 5** S… venstre flanke og lokaliserer milte… n fremstilling av nyre fra pol til p… te kunne sees fra venstre flanke g…
- **Stasjon 6** T… økes best når urinblæren er fy… a som regel sees.
- **Stasjon +** T… ning av tarmer for å se etter "ta… øyre fossa iliaca og identifisere c… ecum og i distal retning ned til sigmoideum.



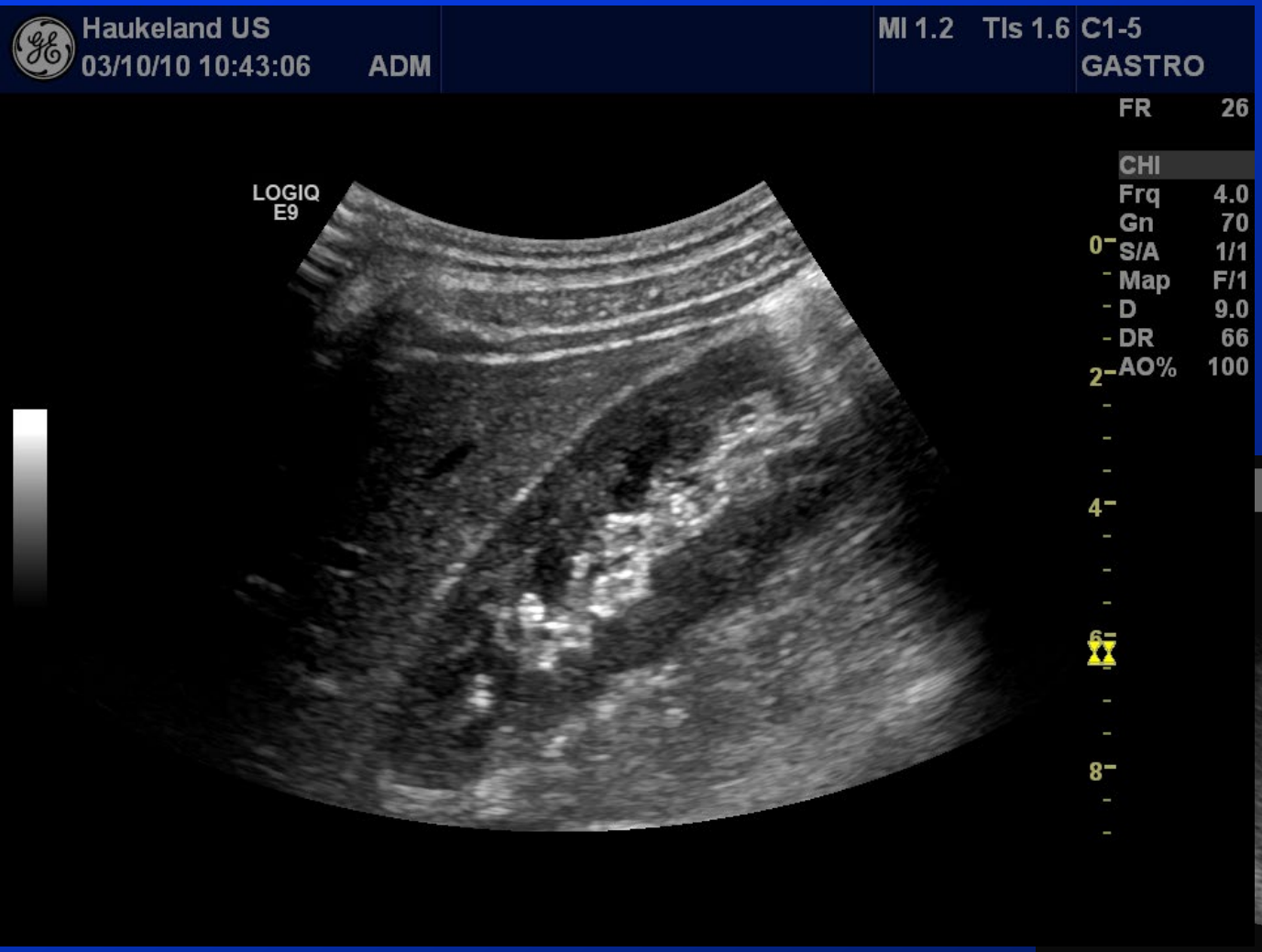
Stasjon 2 – Ve. lobe

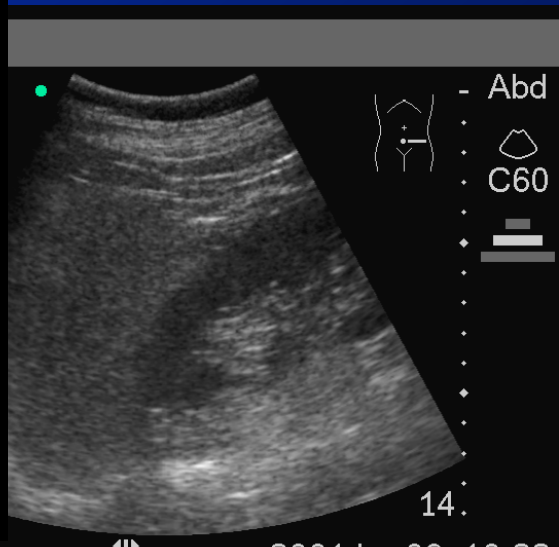


Stasjon 3 – Scanne for FLLs



Stasjon 4 - Sammenligne ekkogenisitet lever-nyre



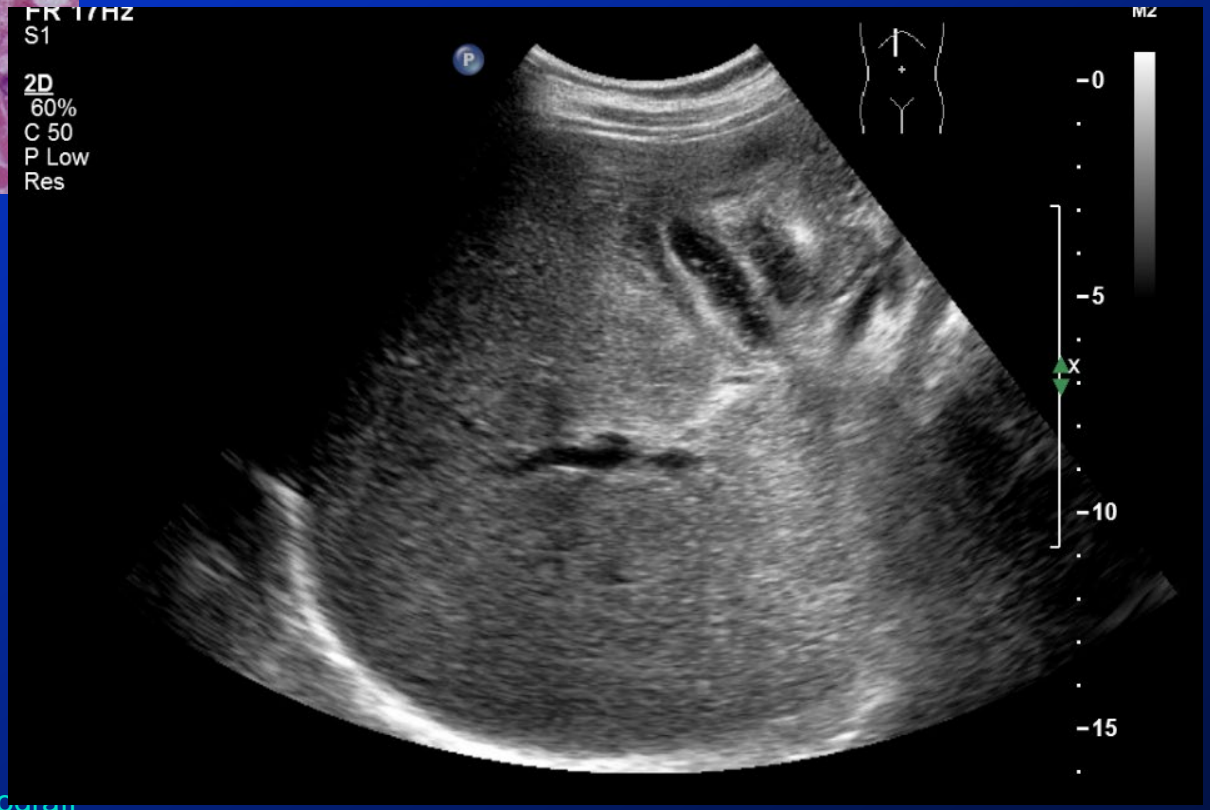


Alkoholiske leversykdommer

- Generell parenchymaffeksjon
  - Steatose
  - Hepatitter
  - Fibrose – Cirrhose
- Fokale lesjoner
  - Regenerasjonsknuter - DN
  - HCC

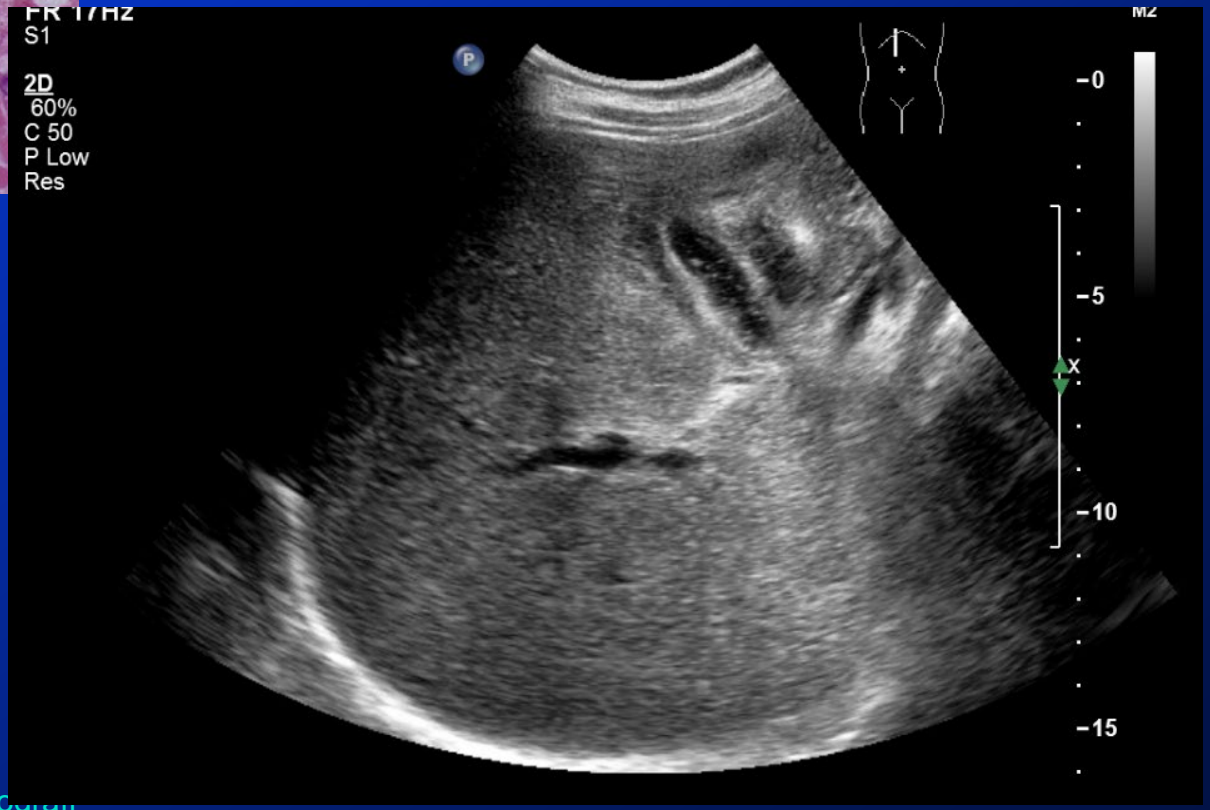
Alkoholisk Hepatitt

Hvordan spørre om Alkoholvaner?

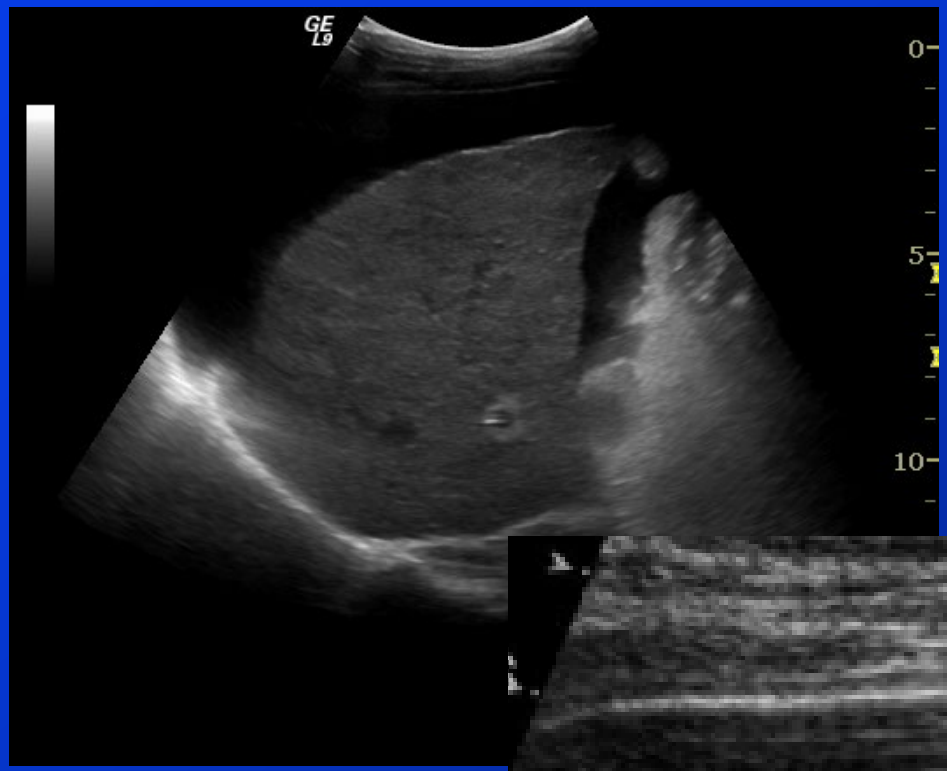


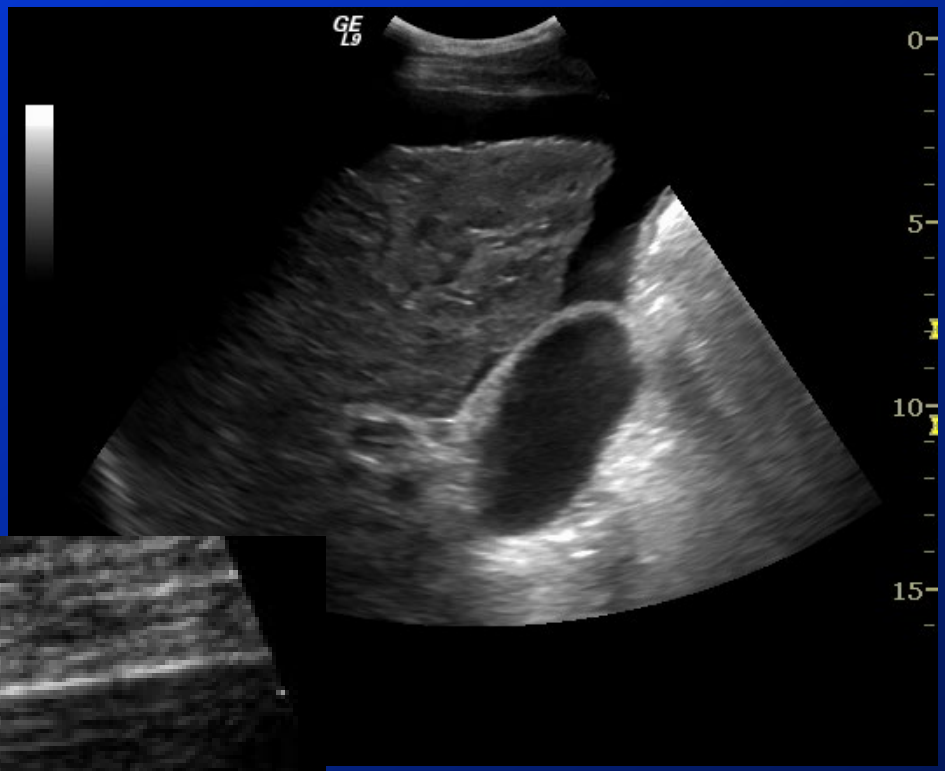
”Jeg drikker bare et glass om dagen, doktor !”

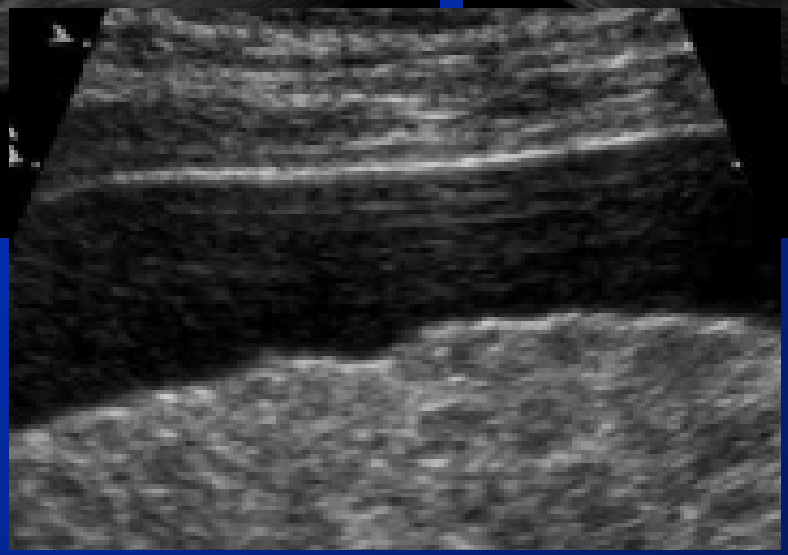
Alcoholic Hepatitis



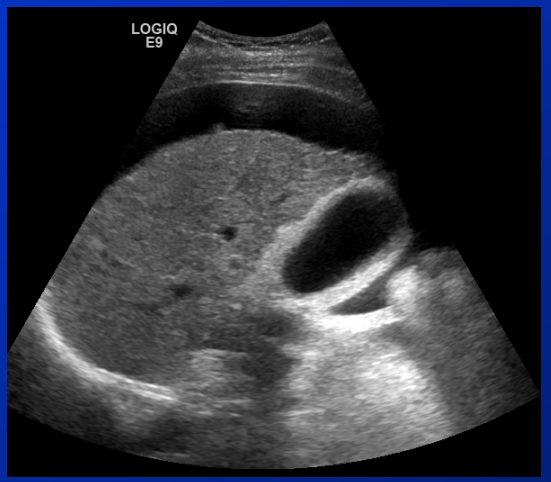
Liver cirrhosis





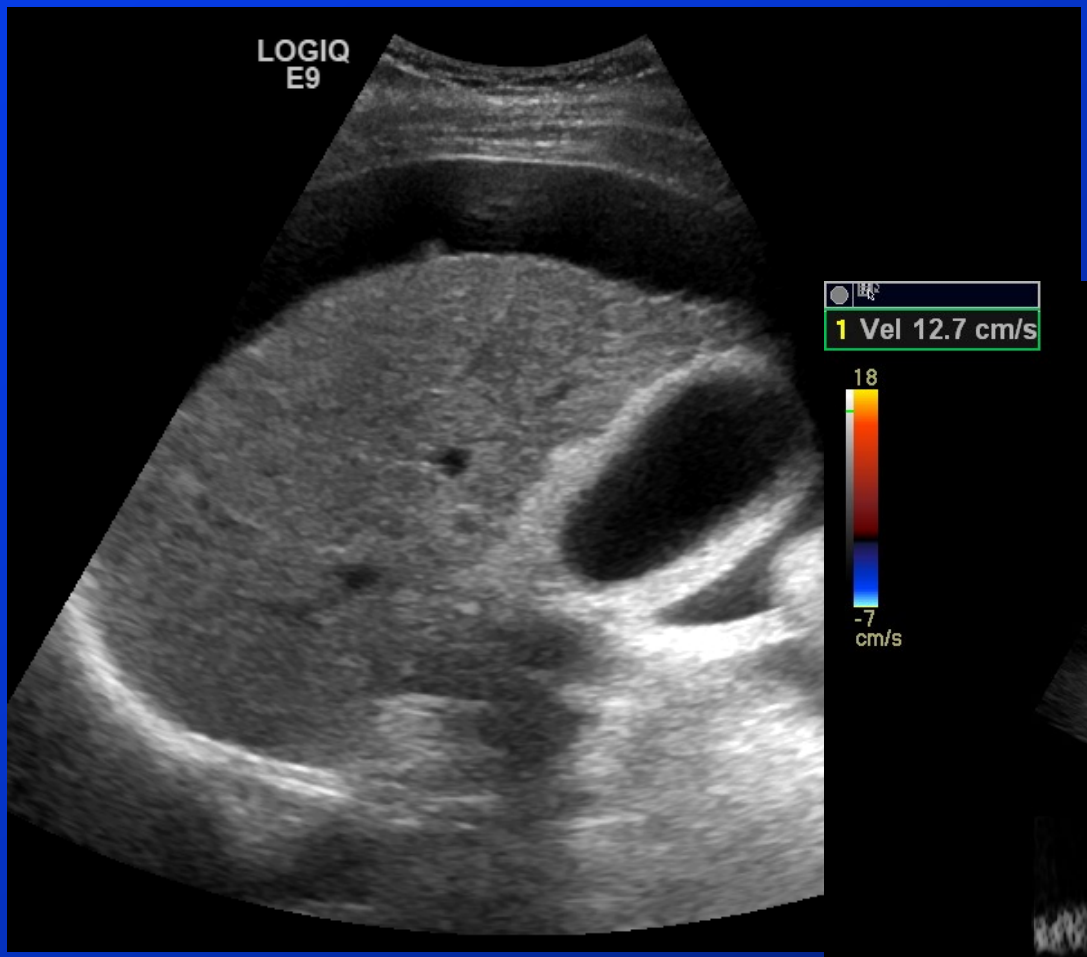


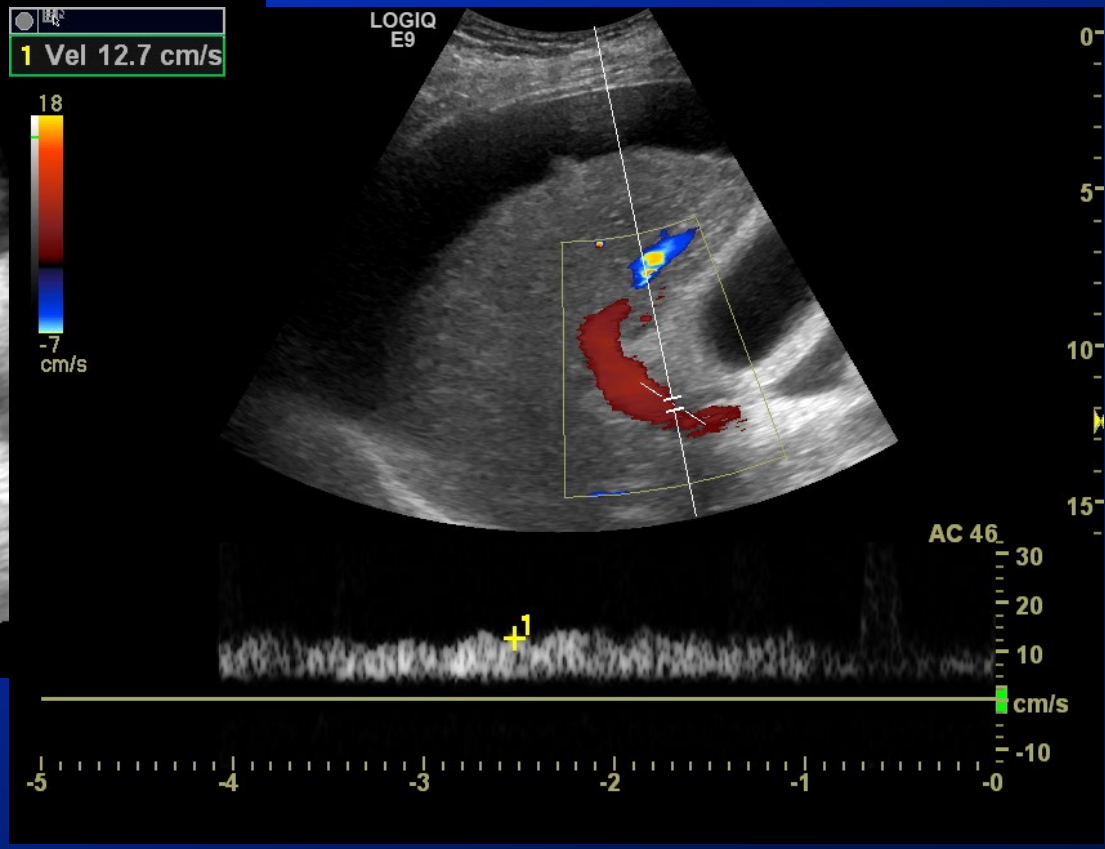
Ultrasound in the evaluation of cirrhotic livers



- Size of liver
- Size of left lobe and caudate lobe
- Capsule smoothness
- Ascites
- Echogenicity, homogenicity, nodularity, focal lesions
- Bile ducts and gallbladder
- Diameter of portal vein (+ splenic vein and spleen)
- Doppler measurements:
  - Color and pulsed Doppler of portal and hepatic veins
  - Doppler of hepatic artery (TX)
- Elastography, mainly right lobe
- CEUS
- US-guided biopsy and ablation procedures

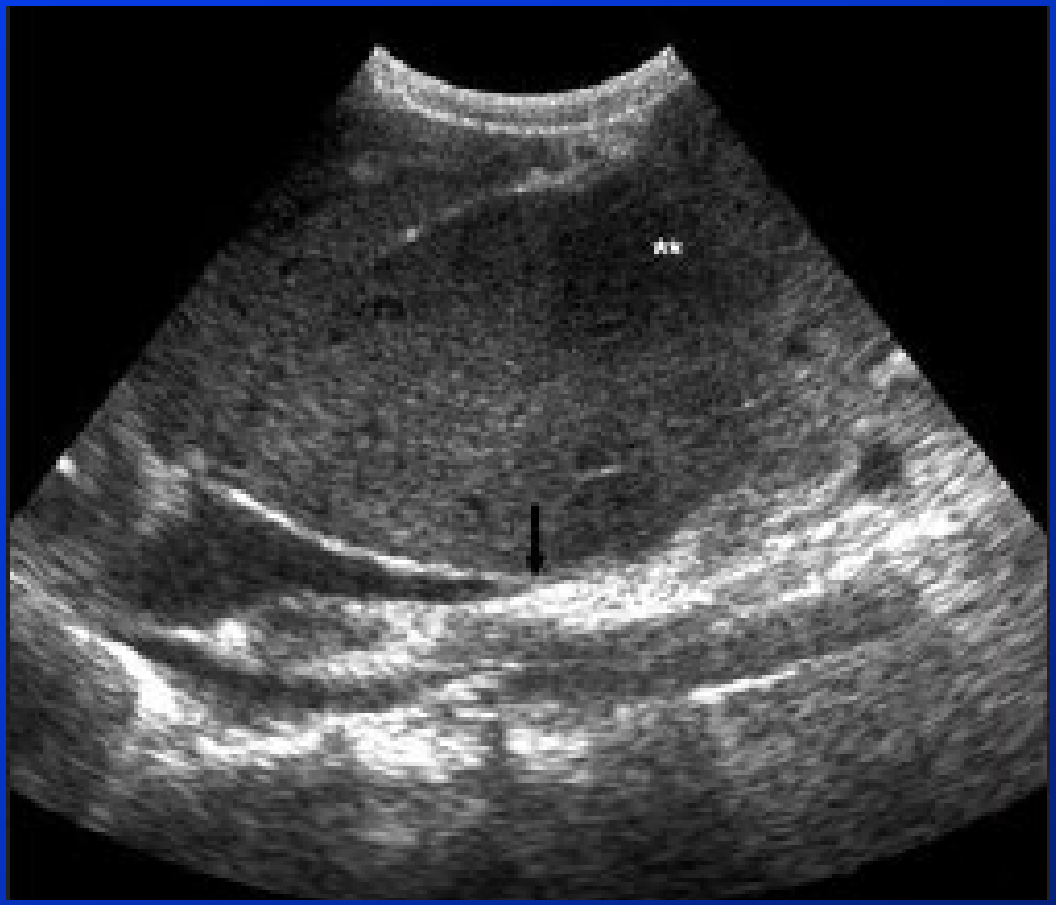
Lever Cirrhose

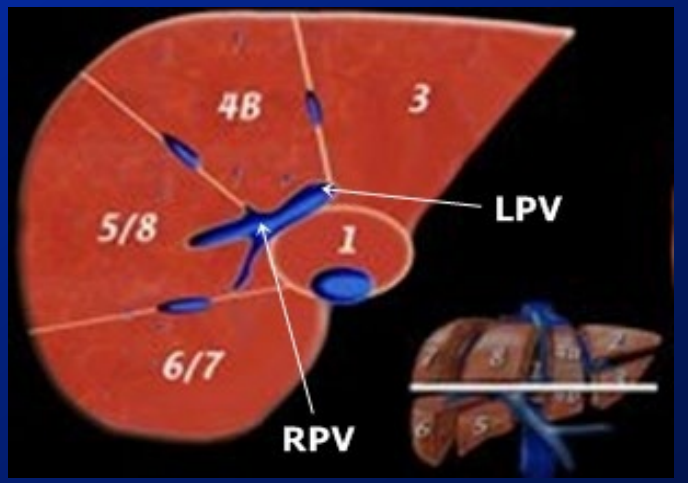




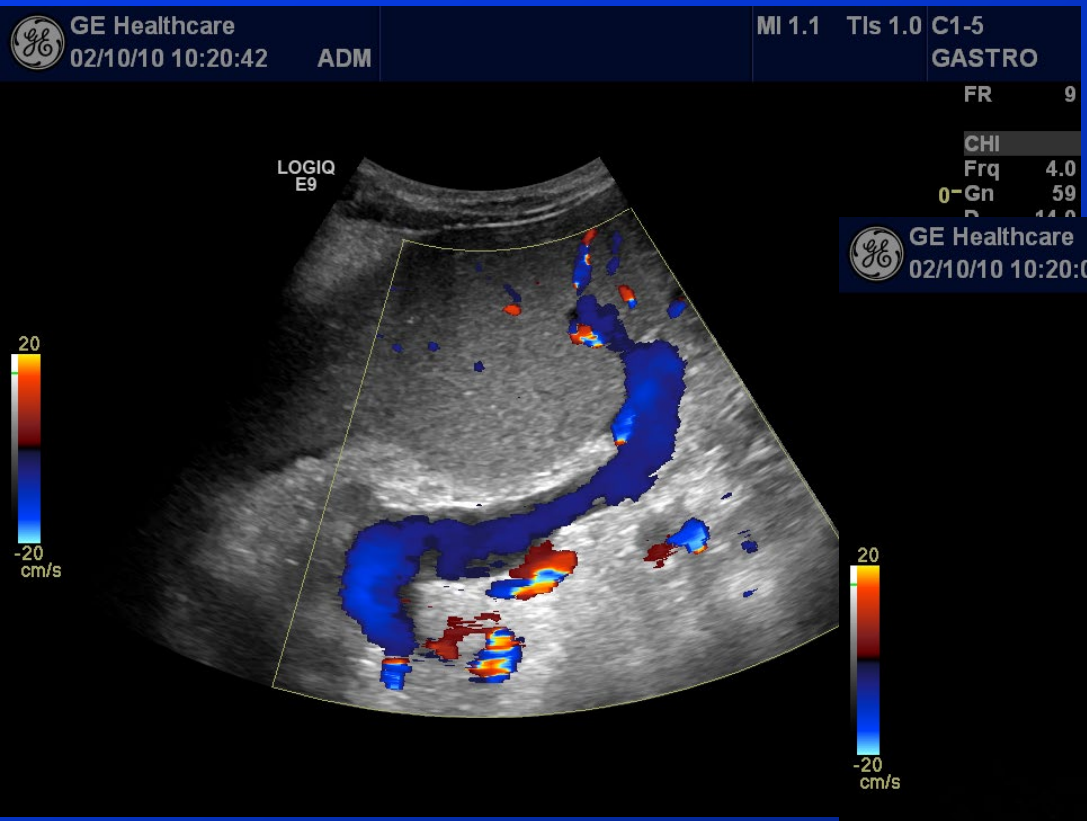
Color Doppler flow in real-time

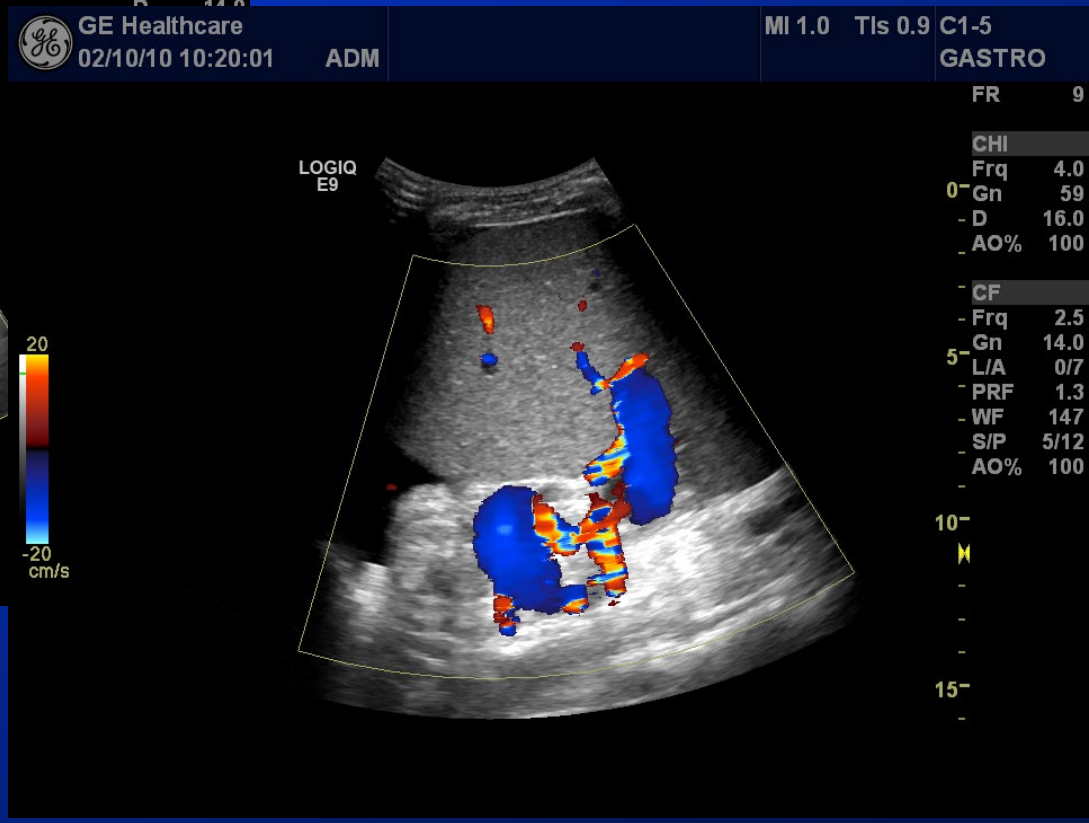
Enlarged caudate lobe



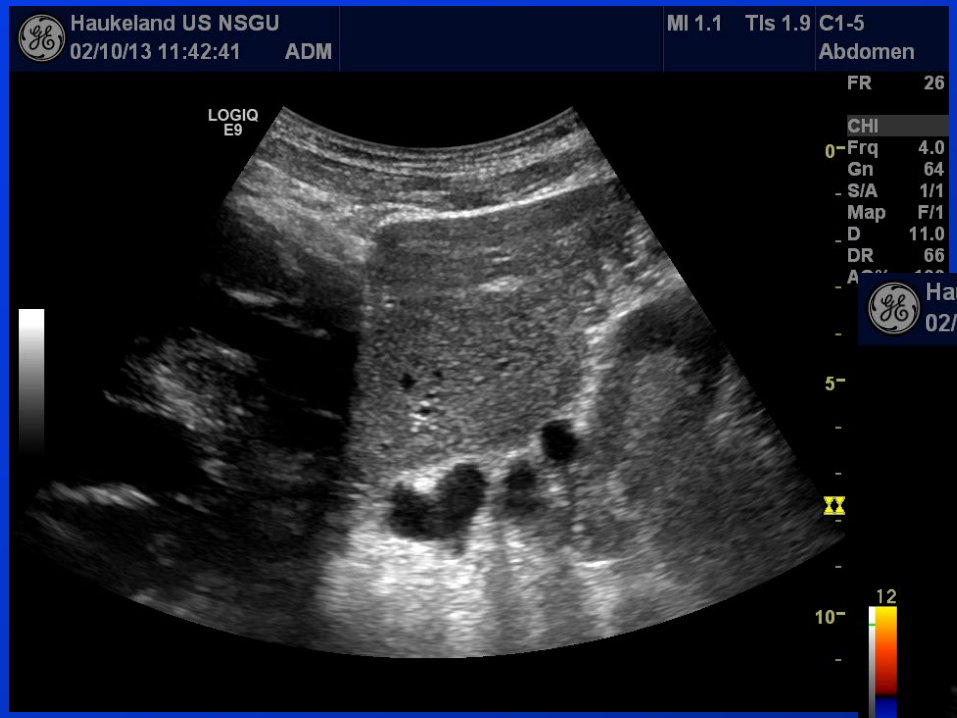


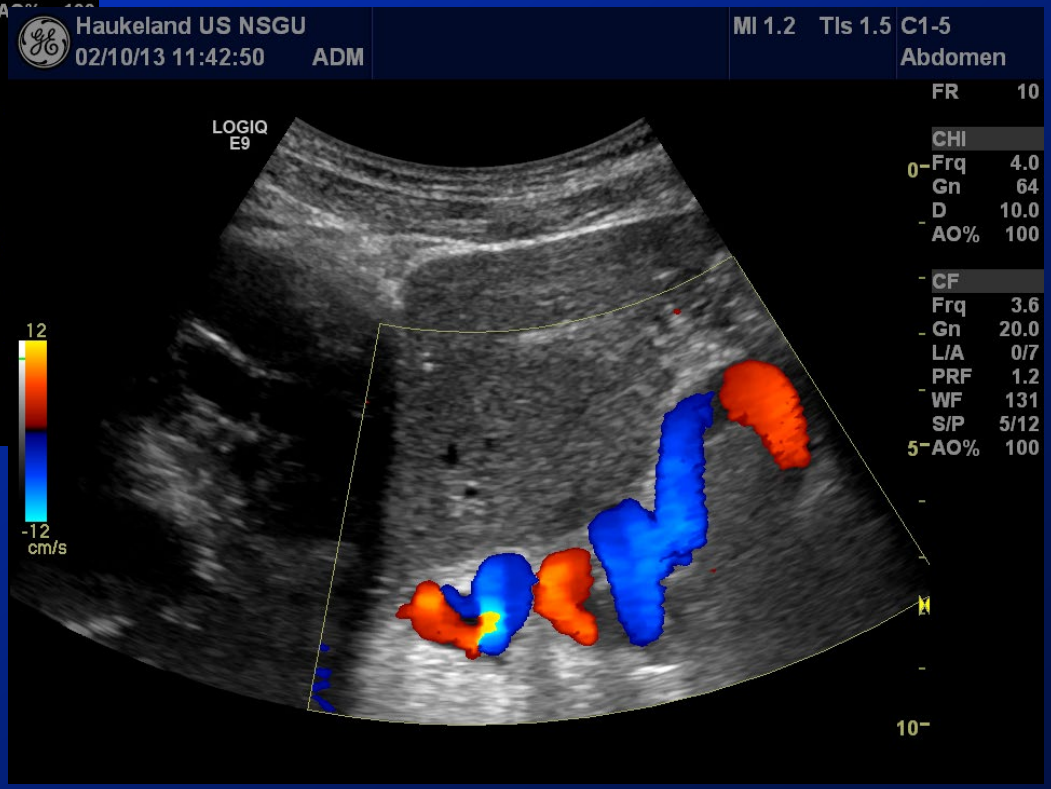
Dilated splenic vein in Portal HT





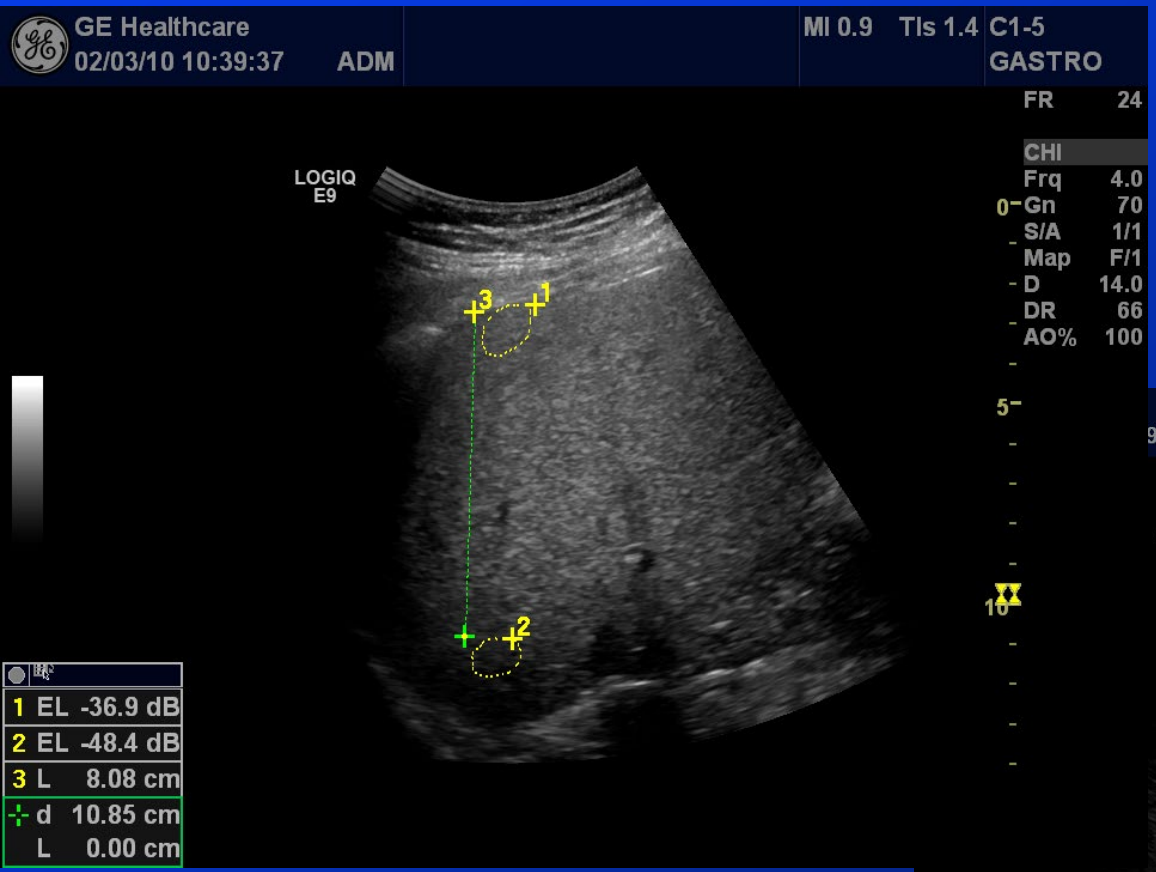
Esophageal Varices

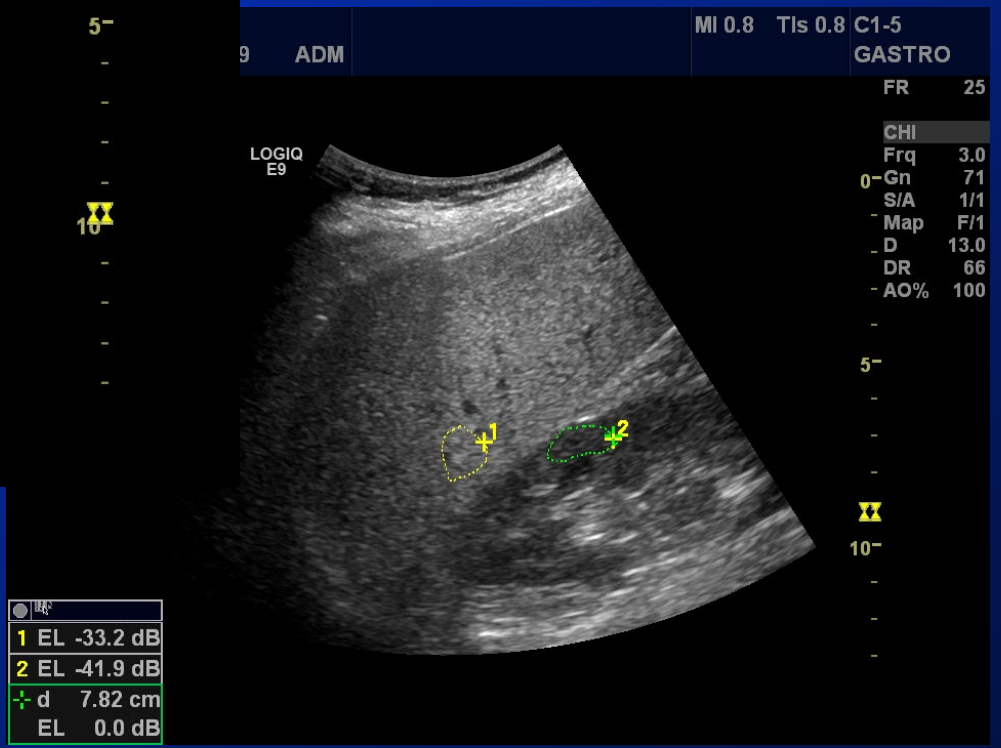




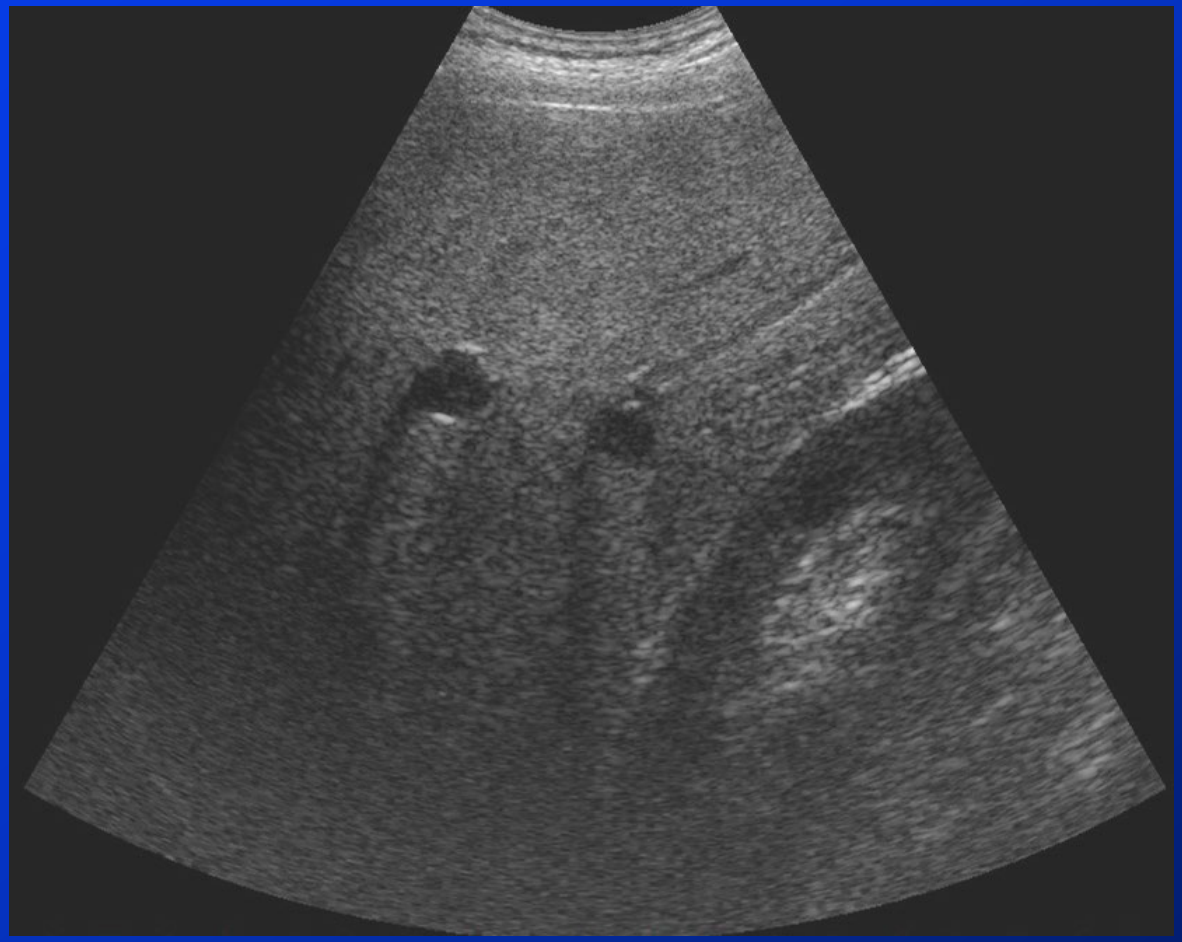
Fatty liver – Dangerous !

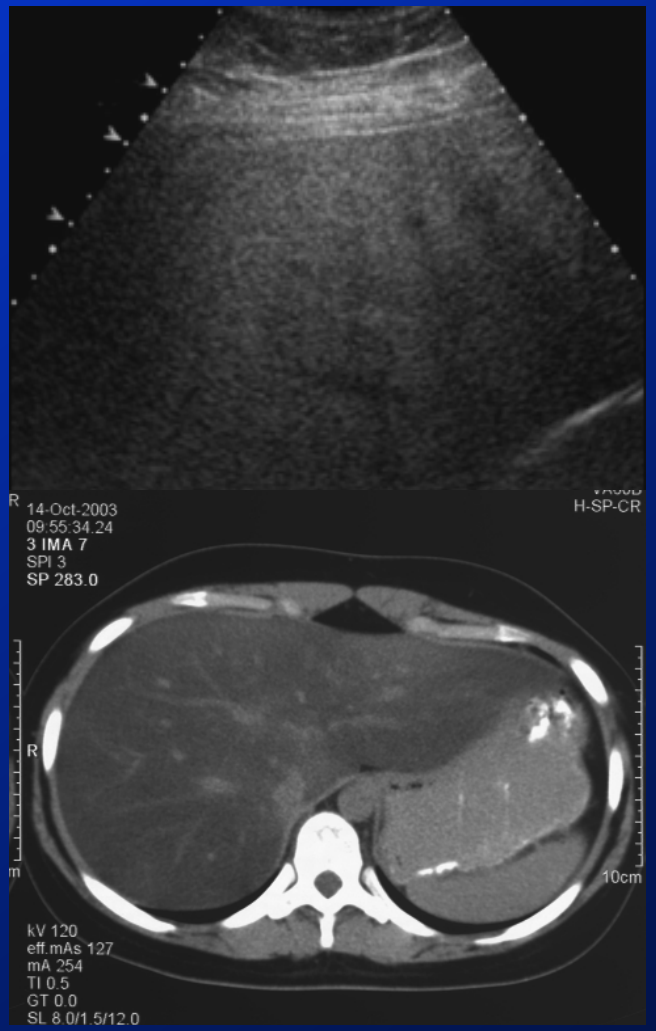
Steatose


GE Healthcare
02/03/10 10:39:37 ADM
MI 0.9 TIs 1.4 C1-5
GASTRO
FR 24
CHI
Frq 4.0
Gn 70
S/A 1/1
Map F/1
D 14.0
DR 66
AO% 100
LOGIQ E9
1 EL -36.9 dB
2 EL -48.4 dB
3 L 8.08 cm
d 10.85 cm
L 0.00 cm

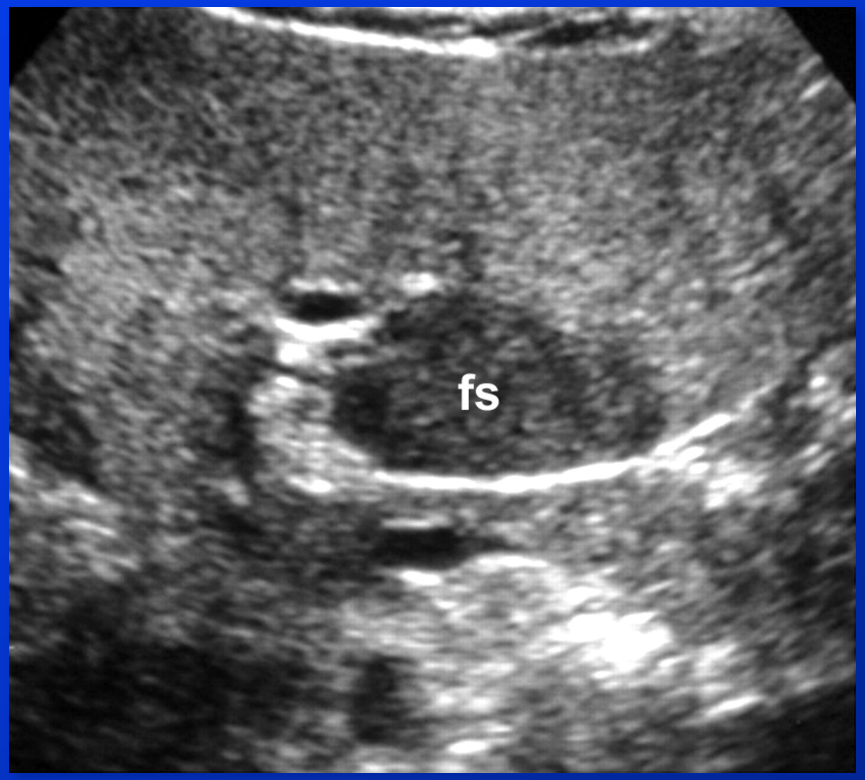

MI 0.8 TIs 0.8 C1-5
ADM
GASTRO
FR 25
CHI
Frq 3.0
Gn 71
S/A 1/1
Map F/1
D 13.0
DR 66
AO% 100
LOGIQ E9
1 EL -33.2 dB
2 EL -41.9 dB
d 7.82 cm
EL 0.0 dB

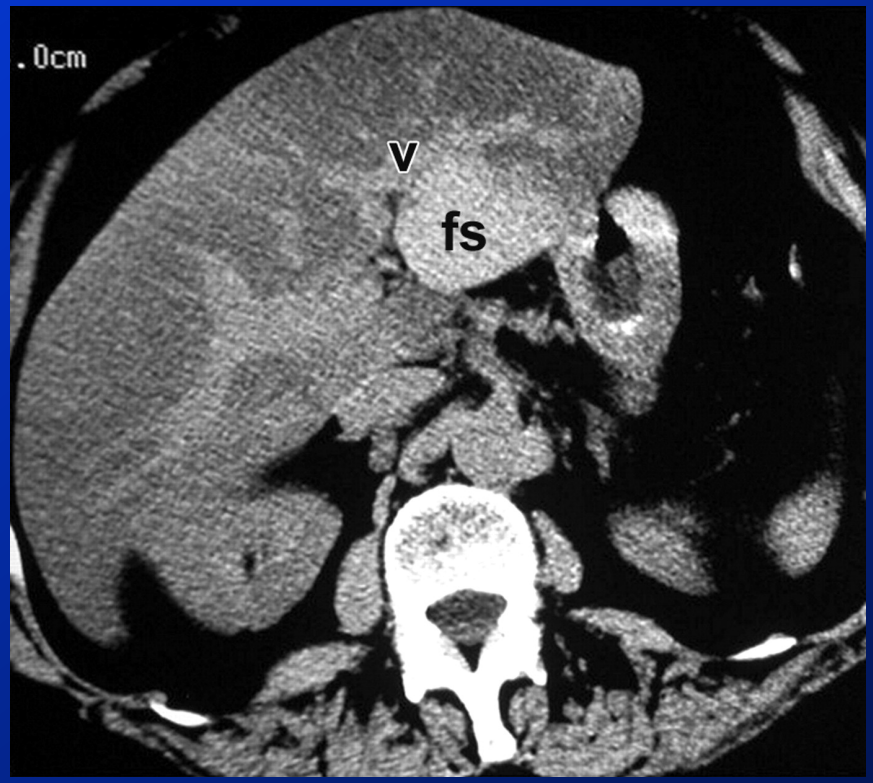
Steatosis



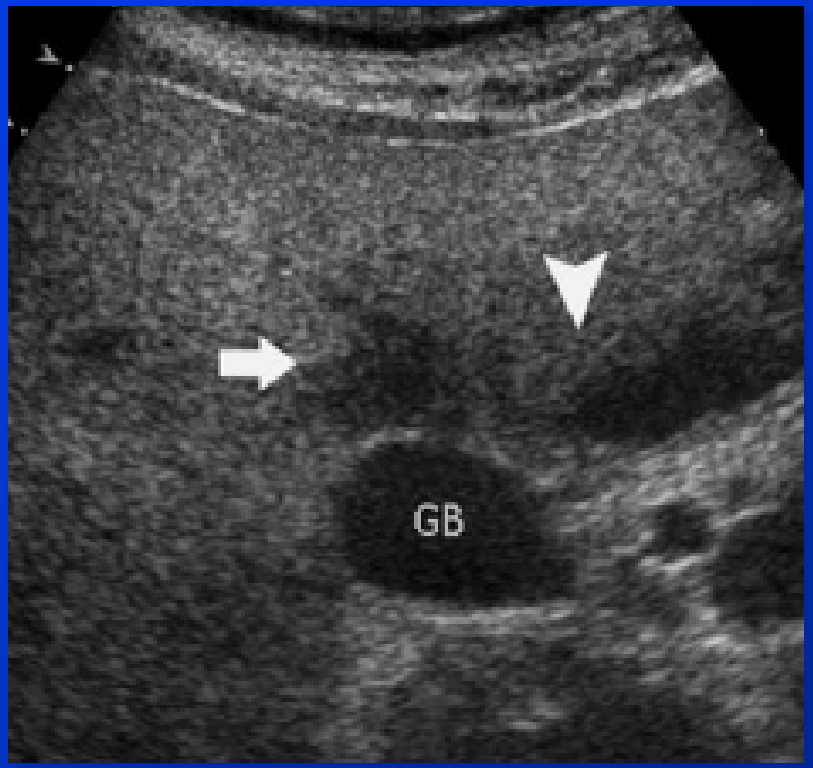

14-Oct-2003
09:55:34.24
3 IMA 7
SPI 3
SP 283.0
H-SP-CR
R
10cm
kV 120
eff.mAs 127
mA 254
TI 0.5
GT 0.0
SL 8.0/1.5/12.0

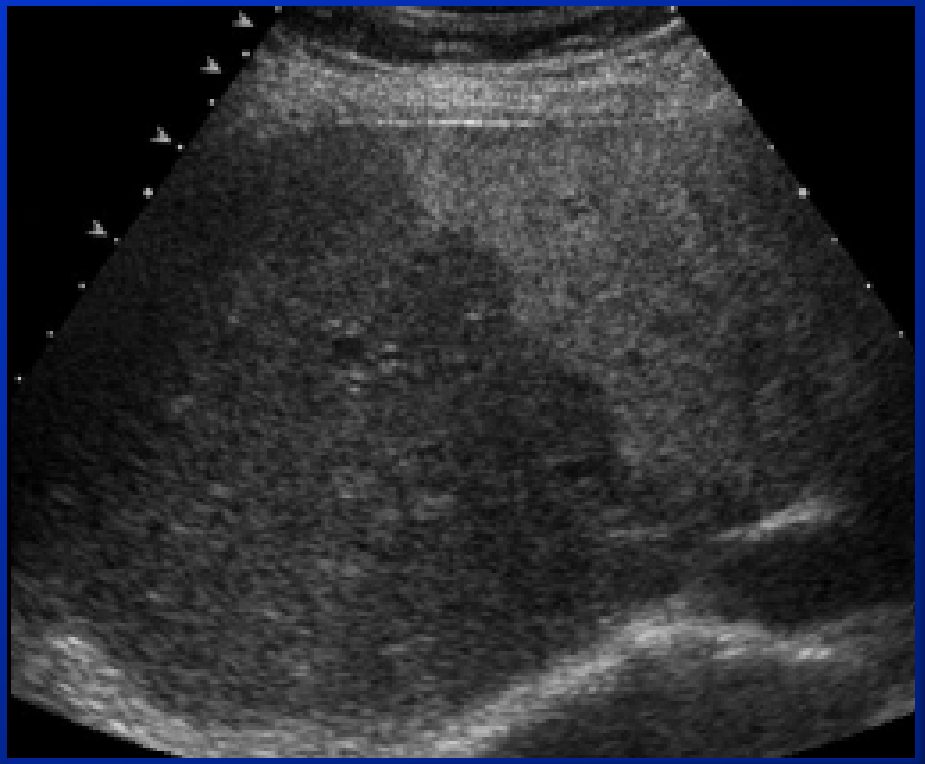
Fatty liver with ”focal areas of sparing”



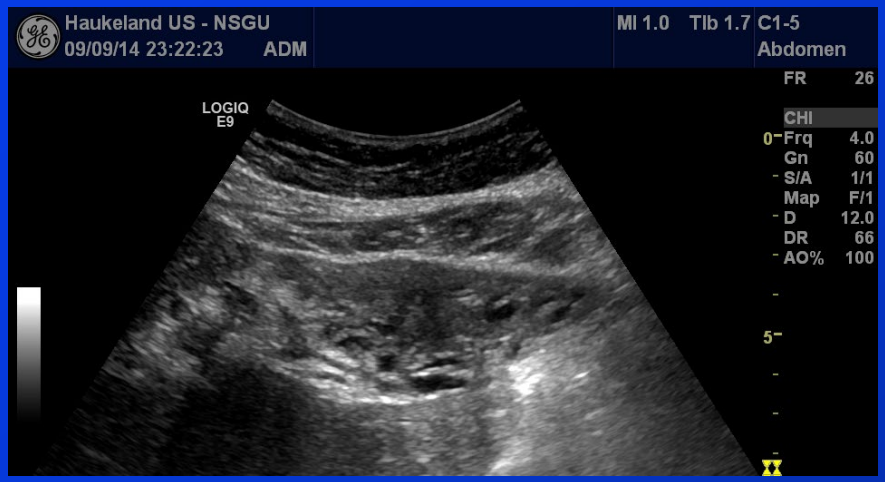


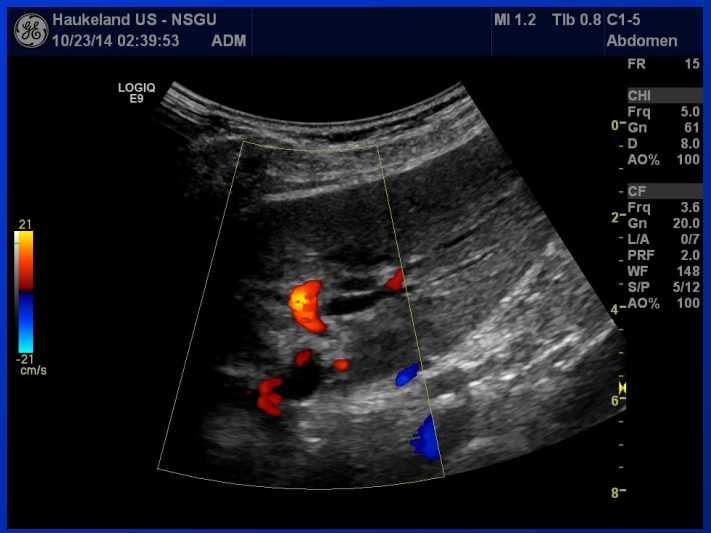
Fatty liver with ”focal areas of sparing”

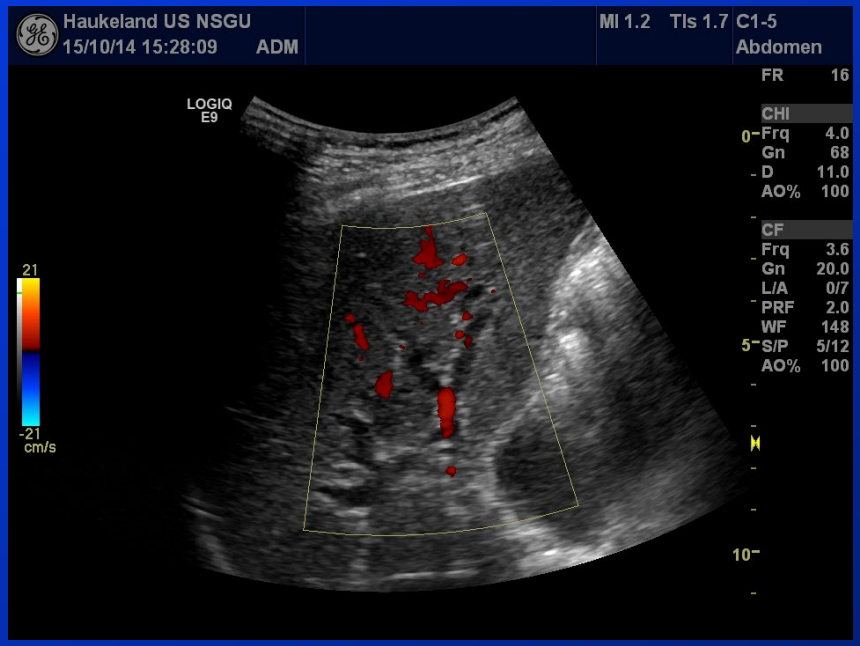


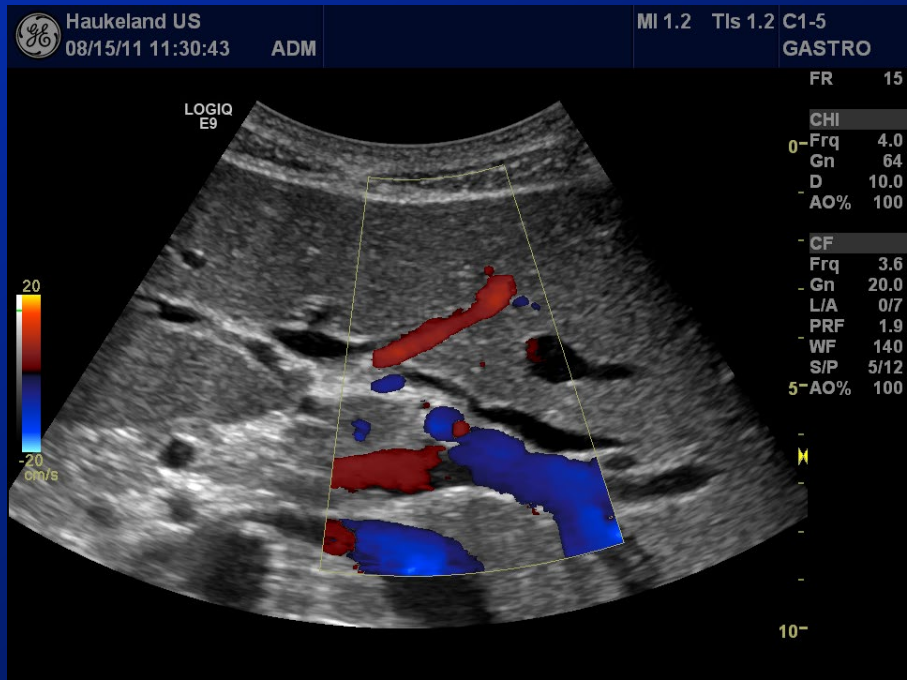


PSC: Primary Sclerosing Cholangitis

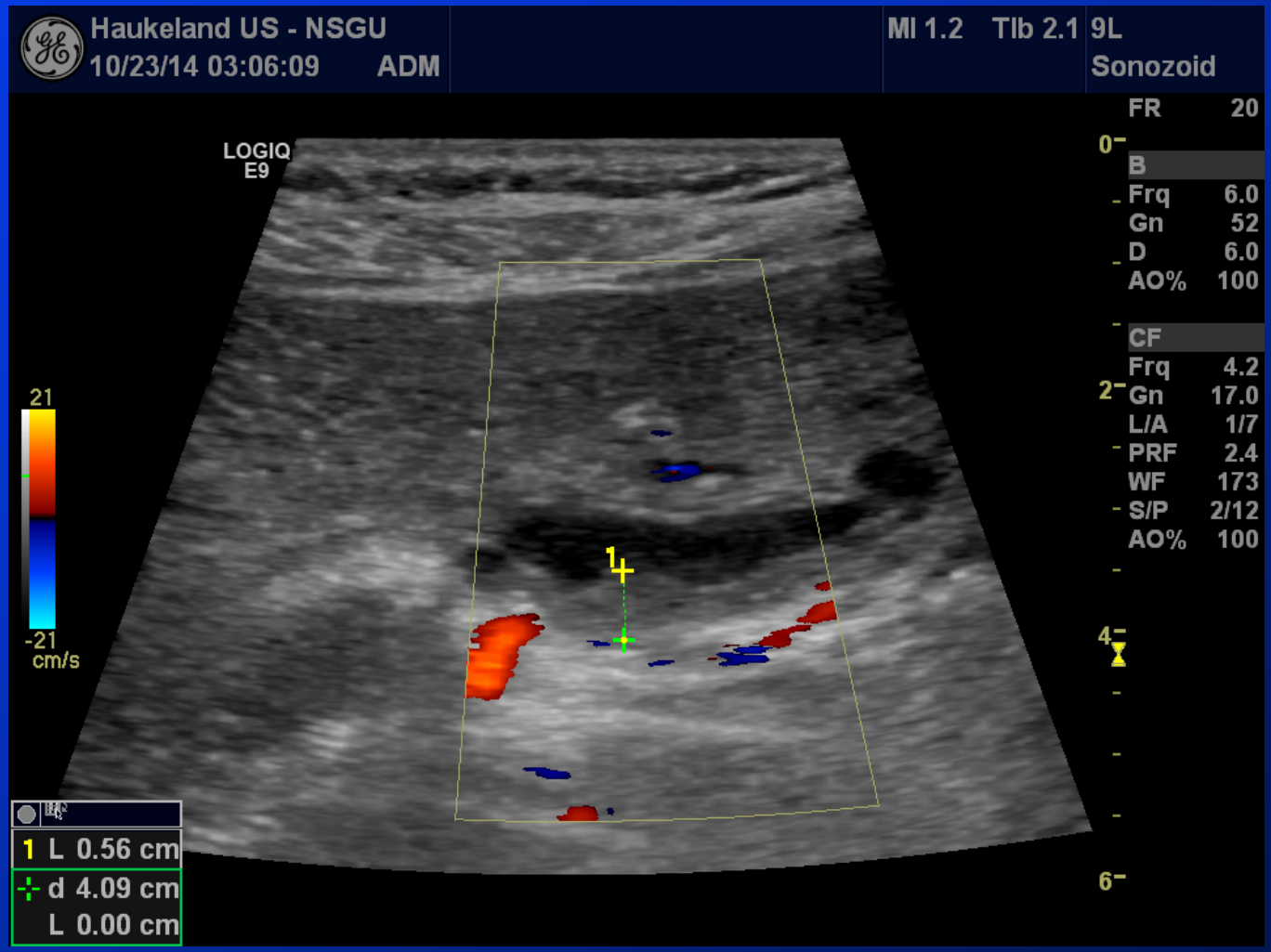








Intraductal growth: Inflammation or neoplasia ?

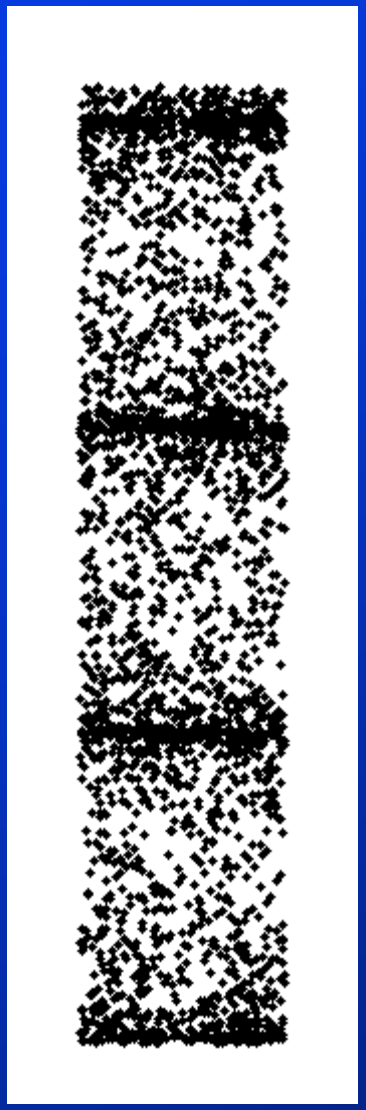


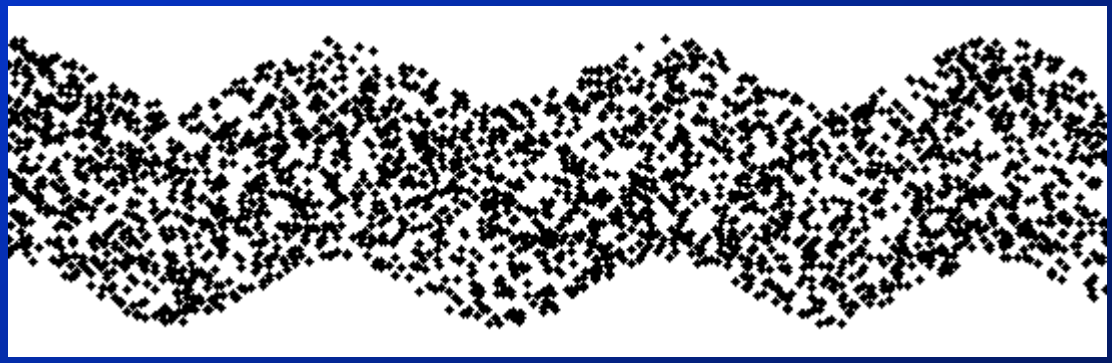
Longitudinal and Shear Waves

Ultrasound Wave

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

$c_l \sim 1540$ m/s in tissue



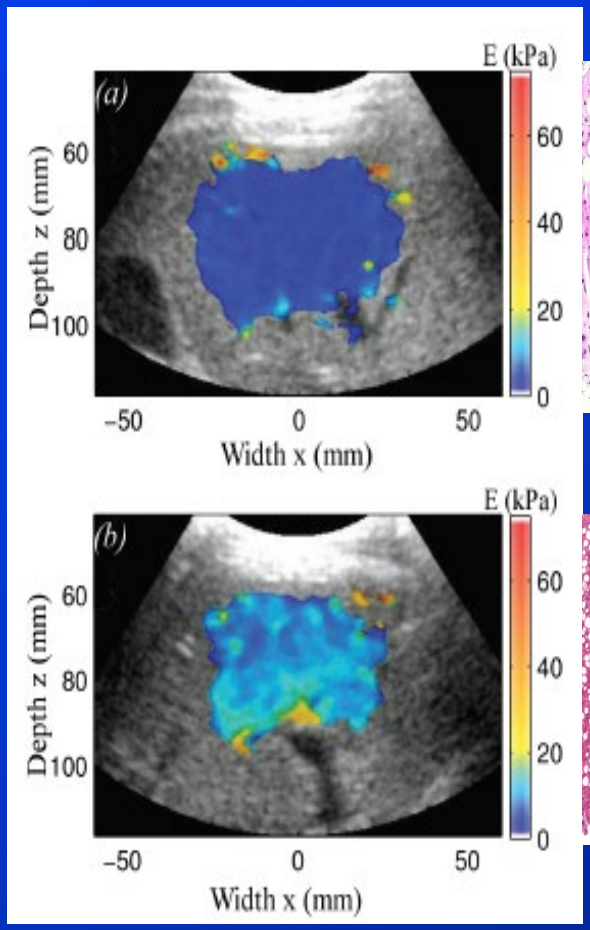


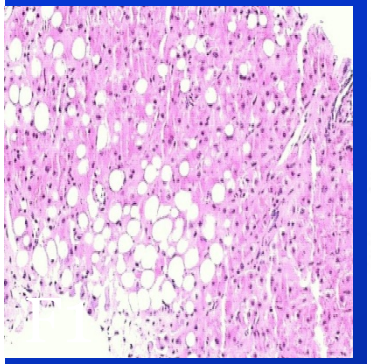
Shear Wave

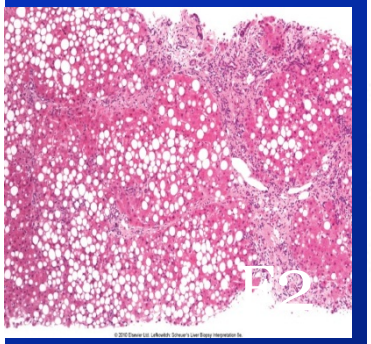
$$c_t = \sqrt{\frac{E}{3\rho}}$$

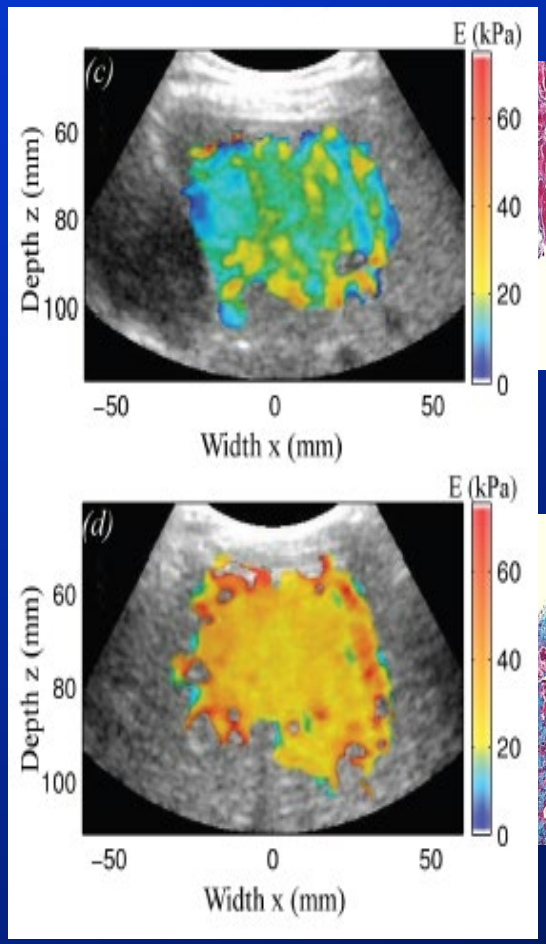
$c_t = 1\text{-}10$ m/s in tissue

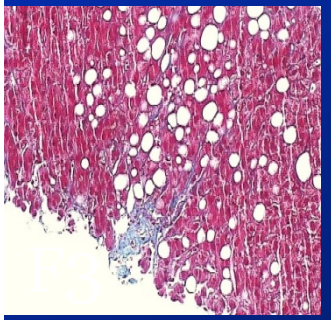
Shear Wave Elastography compared to histological findings and Liver Fibrosis

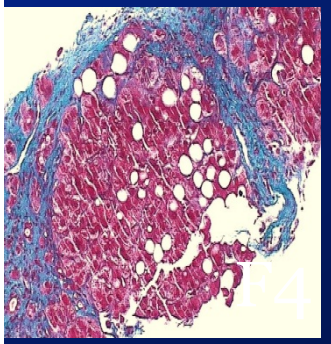












Ultrasound Med Biol. 2011 Sep;37(9):1361-73. Epub 2011 Jul 2011 Noninvasive in vivo liver fibrosis evaluation using supersonic shear imaging: a clinical study on 113 hepatitis C virus patients. Bavu E, Gennisson JL, Couade M, Bercoff J, Mallet V, Fink M, Badel A, Vallet-Pichard

New Guidelines 2017

Guidelines & Recommendations

29 recommendations

Thieme

EFSUMB Guidelines and Recommendations on the Clinical Use of Liver Ultrasound Elastography, Update 2017 (Long Version)

EFSUMB-Leitlinien und Empfehlungen zur klinischen Anwendung der Leberelastographie, Update 2017 (Langversion)

Authors

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Eur J Ultrasound, 2017

SWE in Hepatitis C and B

RECOMMENDATION 18

2D-SWE as demonstrated with SSI can be used as a first-line assessment for the severity of liver fibrosis in patients with chronic viral hepatitis C. It performs best with regard to the ruling out of cirrhosis (LoE 1b, GoR A) [139, 158, 159]. Broad consensus (17/0/1, 94 %)

RECOMMENDATION 24

2D-SWE as demonstrated with SSI is useful in patients with CHB to identify those with cirrhosis (LoE 3a, GoR C) [196, 197]. Broad consensus (17/0/1, 94 %)

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

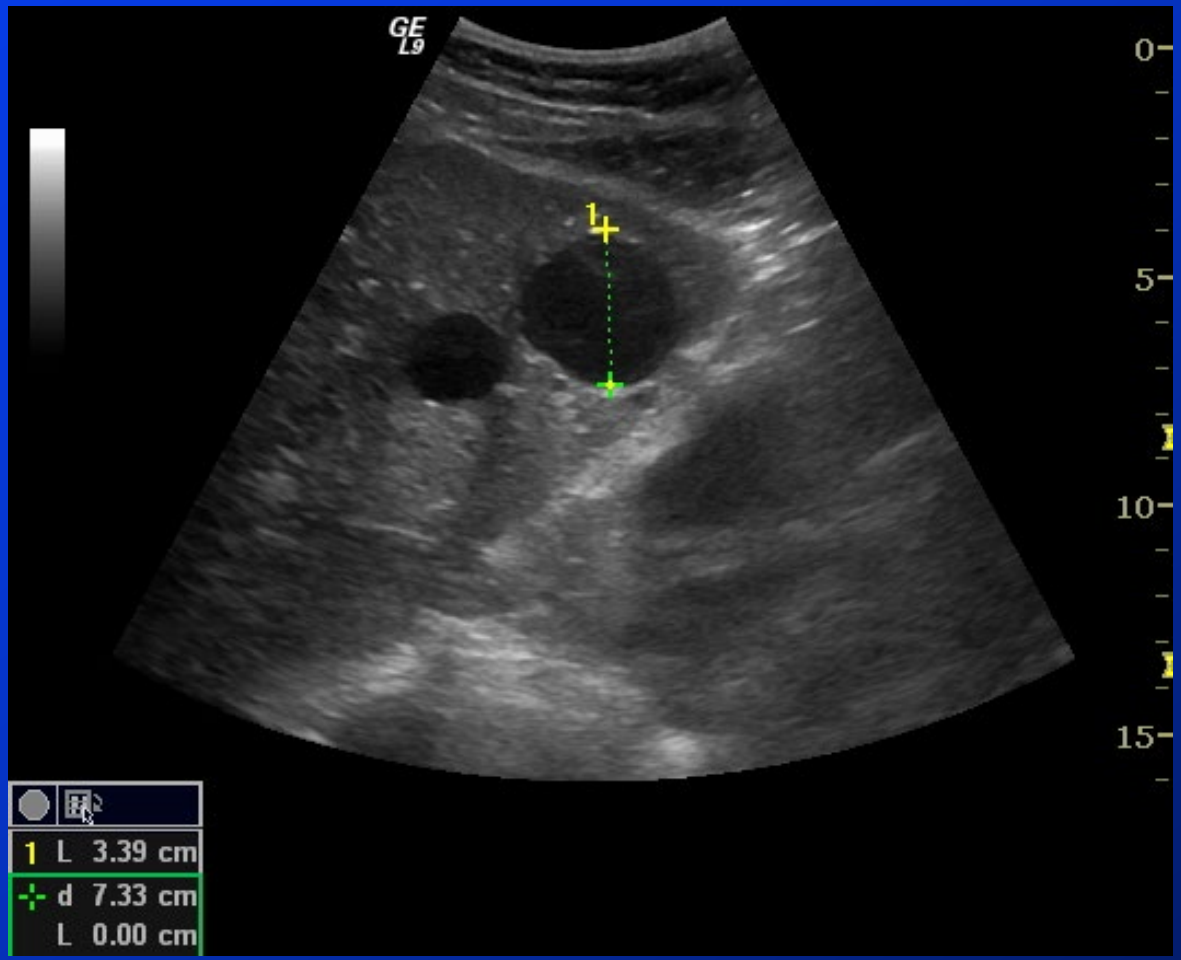
Detection of Focal Liver Lesions

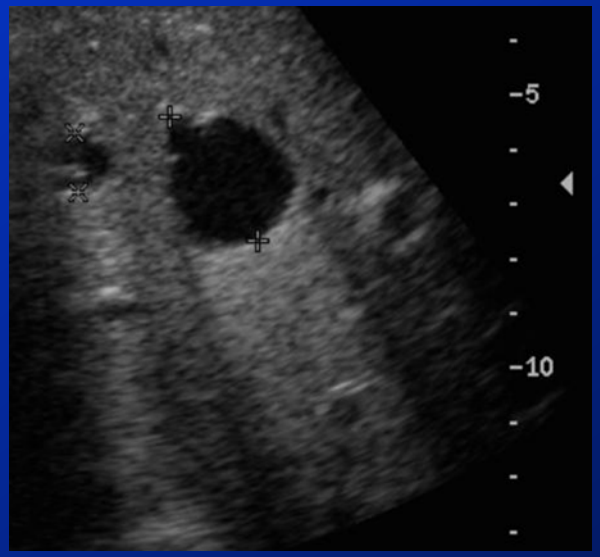
Hausken, Gilja et al., 1999

FLL Classification

Benign	Malignant
Hepatocellular	Hepatocellular
Adenoma	Hepatocellular Carcinoma
Focal Nodular Hyperplasia	(Hcc) and its variants
Diffuse Nodular Hyperplasia	Fibrolamellar Carcinoma
Macroregenerative Nodules	Hepatocholangiocarcinoma
Dysplastic Nodules	Hepatoblastoma
	Carcinosarcoma
Biliary Epithelium	Biliary Epithelium
Bile Duct Cyst	Cystadenocarcinoma
Biliary Duct -Adenoma	Cholangiocarcinoma
Mucinous Cystic Neoplasm	
Peribiliary Gland Hamartoma	
von Meyenburg Complex	
Biliary Cystadenoma	
Biliary Papillomatosis	
Vascular	Vascular
Cavernous Hemangioma	Angiosarcoma
Infantile Hemangioendothelioma	Epithelioid
	Hemangioendothelioma
Others	Others
Angiomyolipoma	Primary Lymphomas
Mesenchymal Hamartoma	Sarcomas
Solitary Fibrous Tumor	
Inflammatory Pseudotumor	

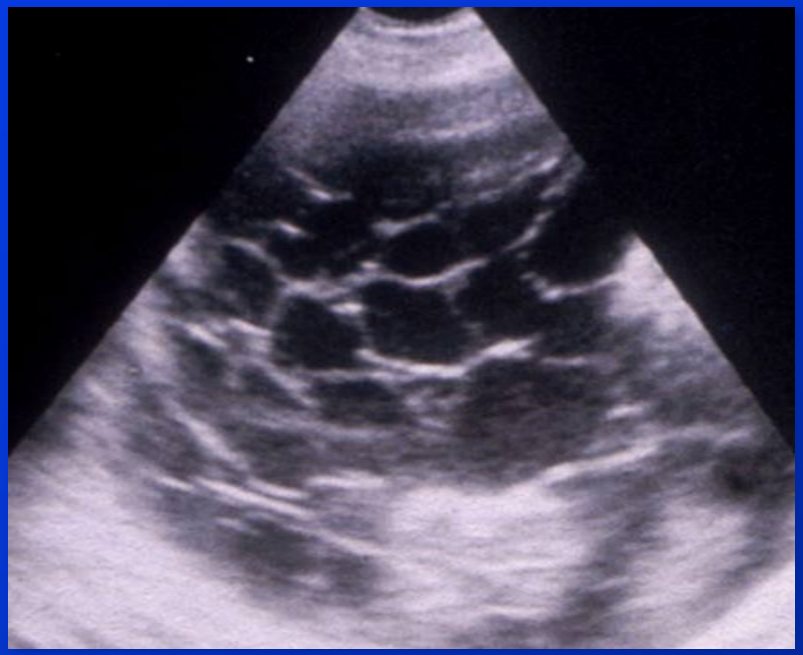
Liver cysts

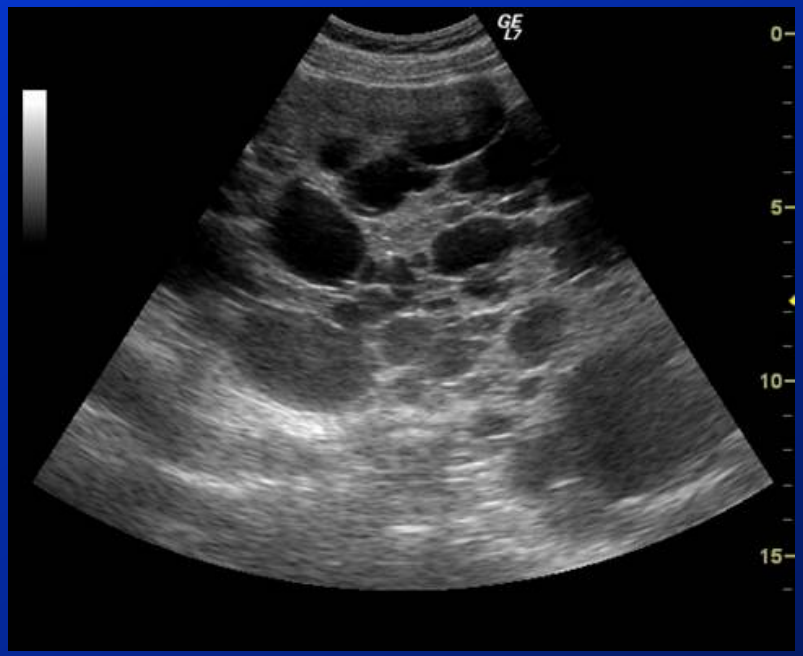




Ultrasound better than CT in small and complex cysts

Polycystic liver disease



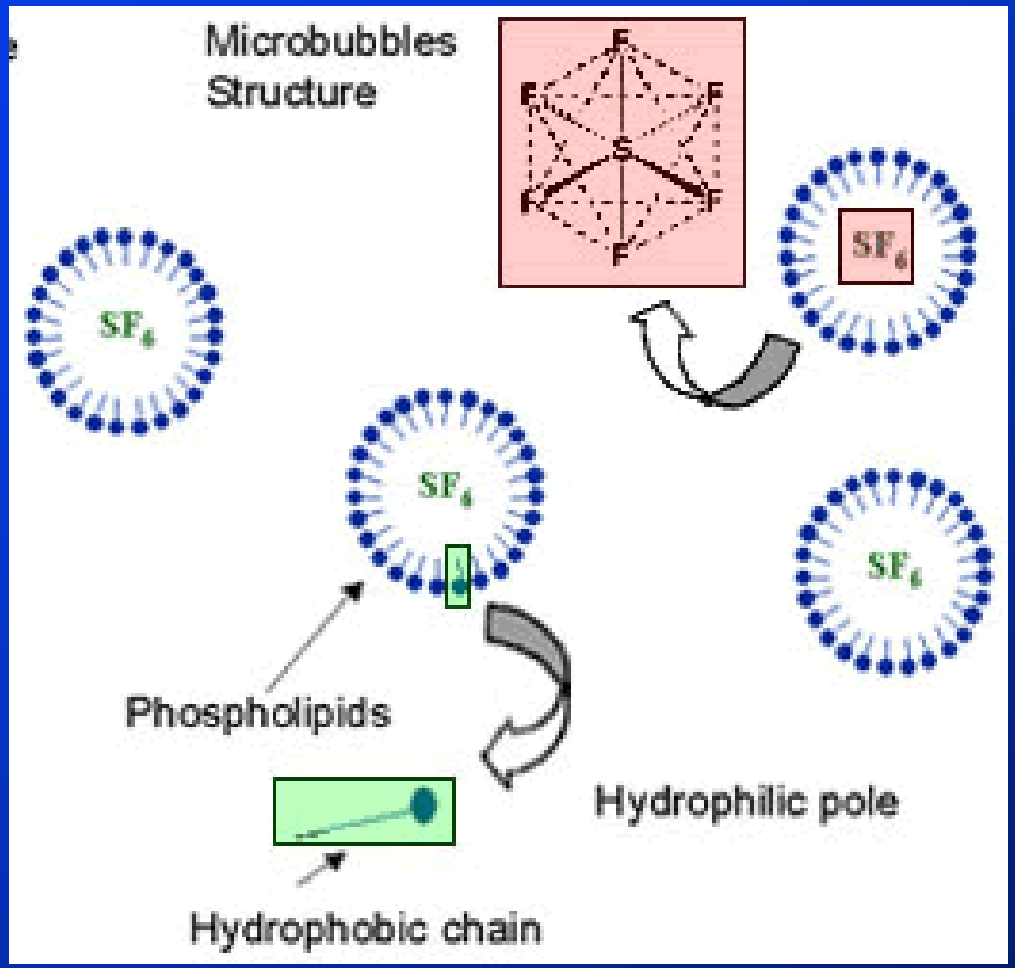


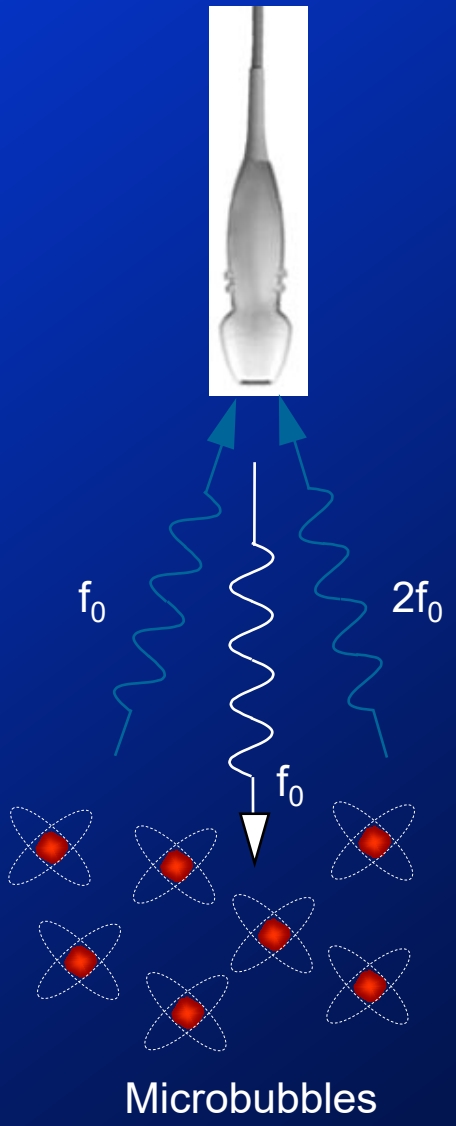
SONOVue®

Sulphur Hexafluoride

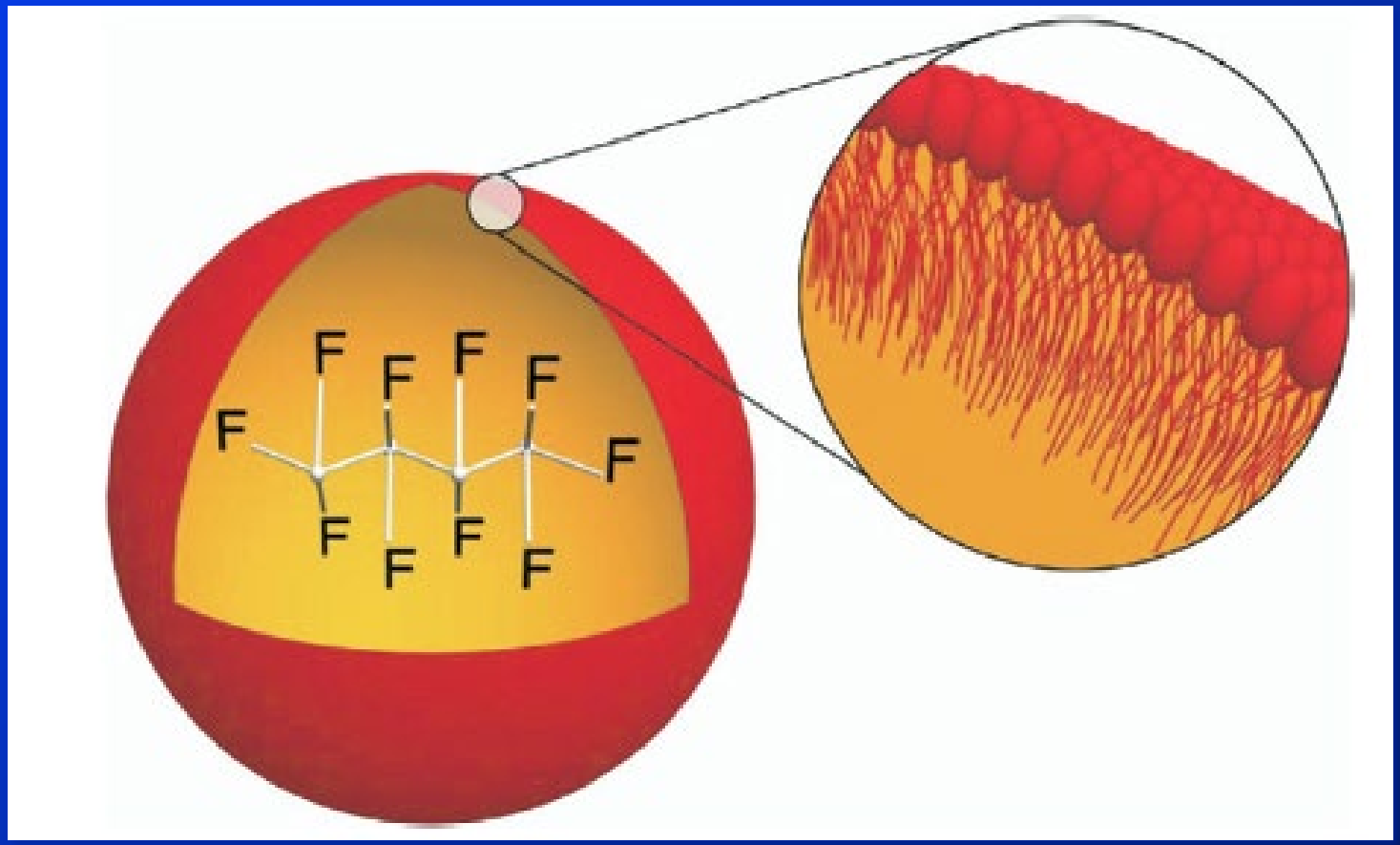
BRACCO

THE IMAGE OF INNOVATION





Sonazoid



- Membrane is hydrogenated egg phosphatidylserine sodium (HEPSNa)
- The gas is perfluorobutane (PFB)

New Guidelines for CEUS 2011

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.

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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

Ultraschall Med / EJU Aug. 2011

Indications - Liver

- Characterization of benign FLLs
  - FNH, hemangiomas, adenomas
- Detection of focal lesions
  - Metastasis
- Study FLL in cirrhosis
- Guiding of biopsies
- Guiding of intervention,- e.g. ablation

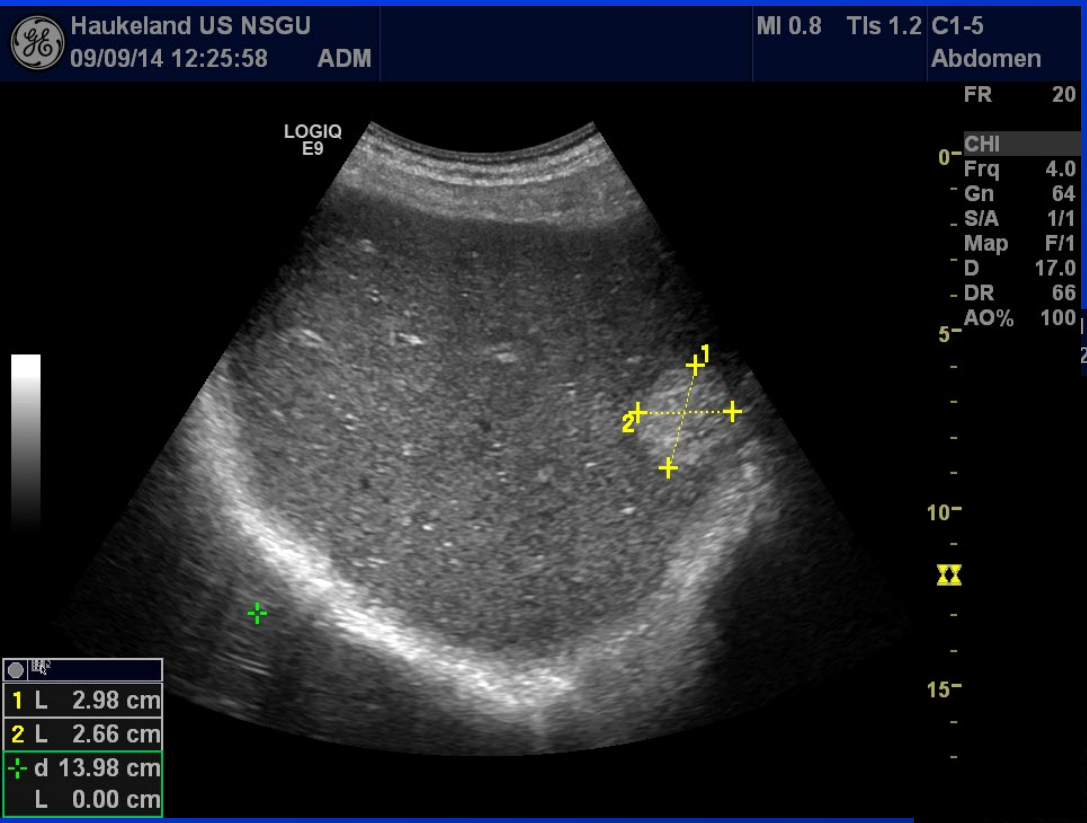
3 (4) Phases in liver perfusion

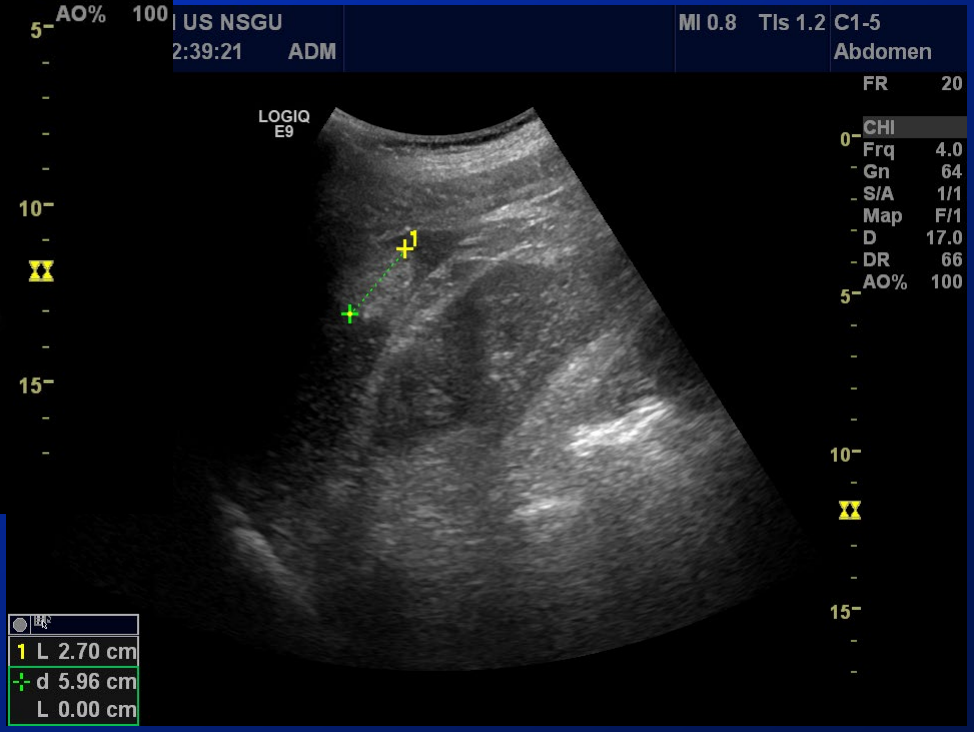
- Arterial phase
  - 0-30 sec.
- Portal phase
  - 30-120 sec.
- Sinusoidal phase
  - 2-4 min
- Post-vascular phase
  - 4-30 min

Focal Liver Lesions

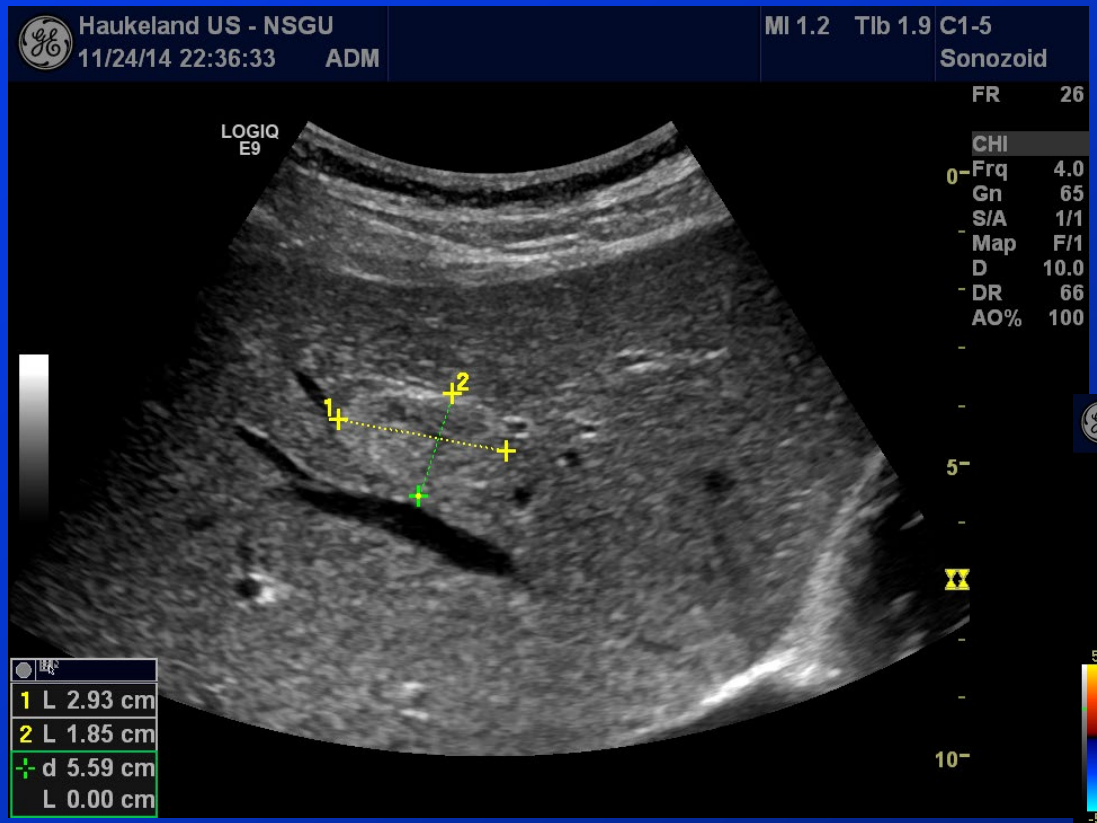
	Type of lesion	Arterial phase	Portal phase	Sinusoidal phase (parenchimal)
Benign	Haemangioma	Globular enhancement from the periphery	Centripetal filling	Progressive enhancement (iso to hyperechoic)
	Focal Nodular Hyperplasia	1. Strongly hyperechoic 2. In 40% of cases spoke and wheel pattern	Moderately hyperechoic or Isoechoic	Moderately hyperechoic or Isoechoic (central scar visible in 40% of cases)
	Adenoma	Strong homogeneous enhancement of short duration (capsular vessels)	Isoechoic	Isoechoic
Malignant	Hepato-cellular Carcinoma	Enhancement 1.Homogeneous 2.Inhomogeneous	Slightly hypoechoic	Slightly or strongly hypoechoic
	Hypervascular Metastases	1. Hyperechoic 2. Possible central area of necrosis in large lesions	Slightly hypoechoic	Strongly hypoechoic
	Hypovascular Metastases	1.No enhancement 2.Peripheral rim	Slightly hypoechoic	Strongly hypoechoic

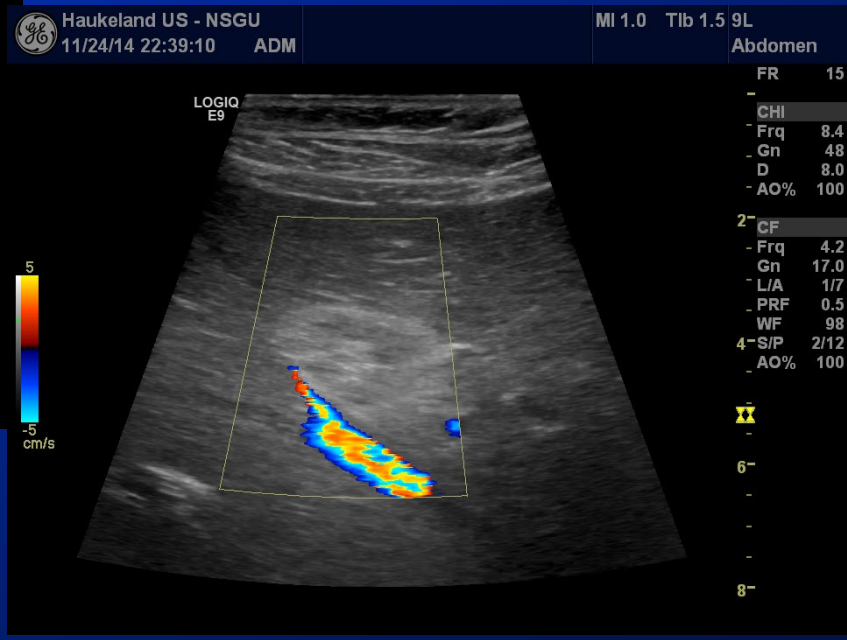
Lesion in Liver – S7



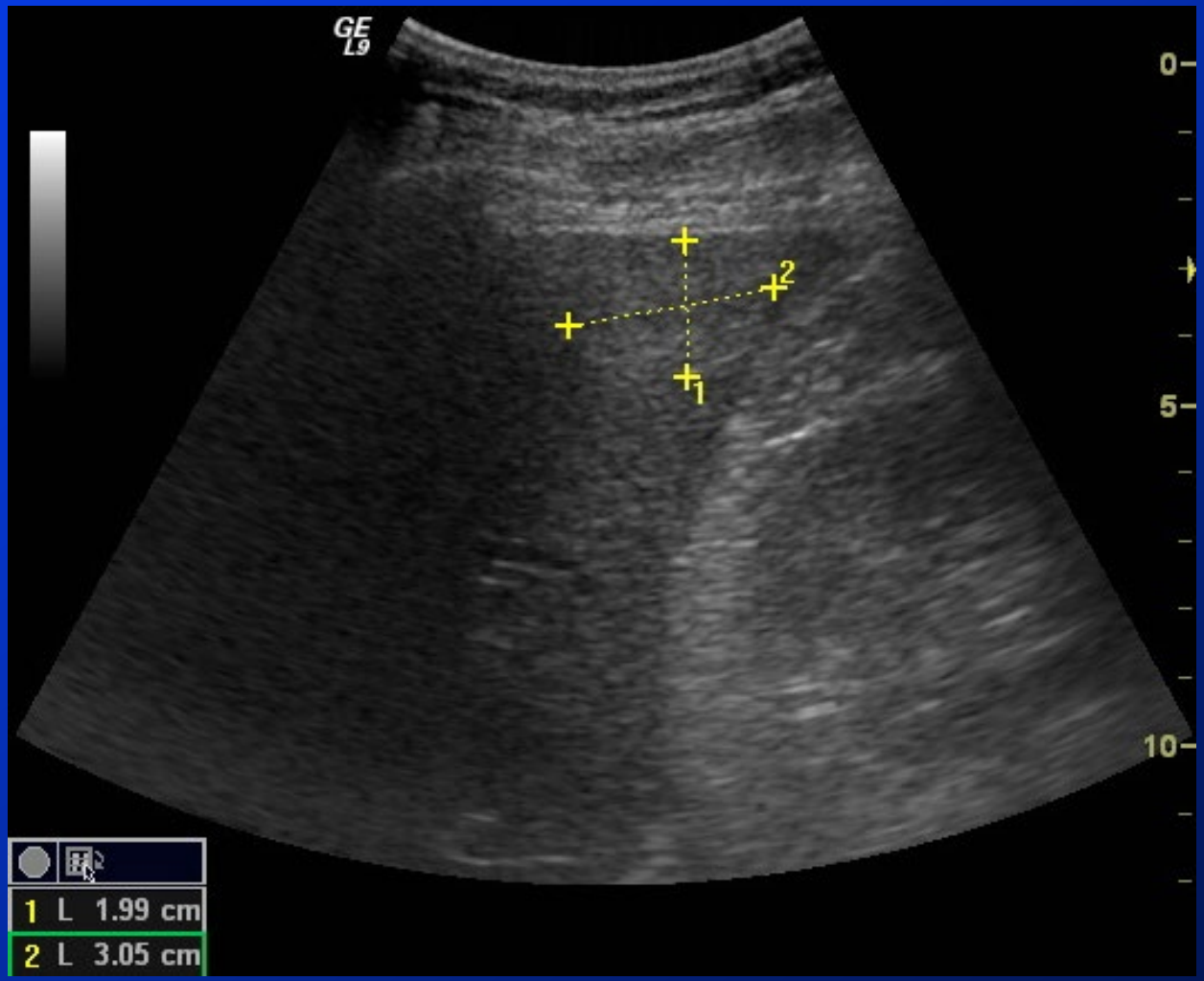


Hyper-echoic Tumor

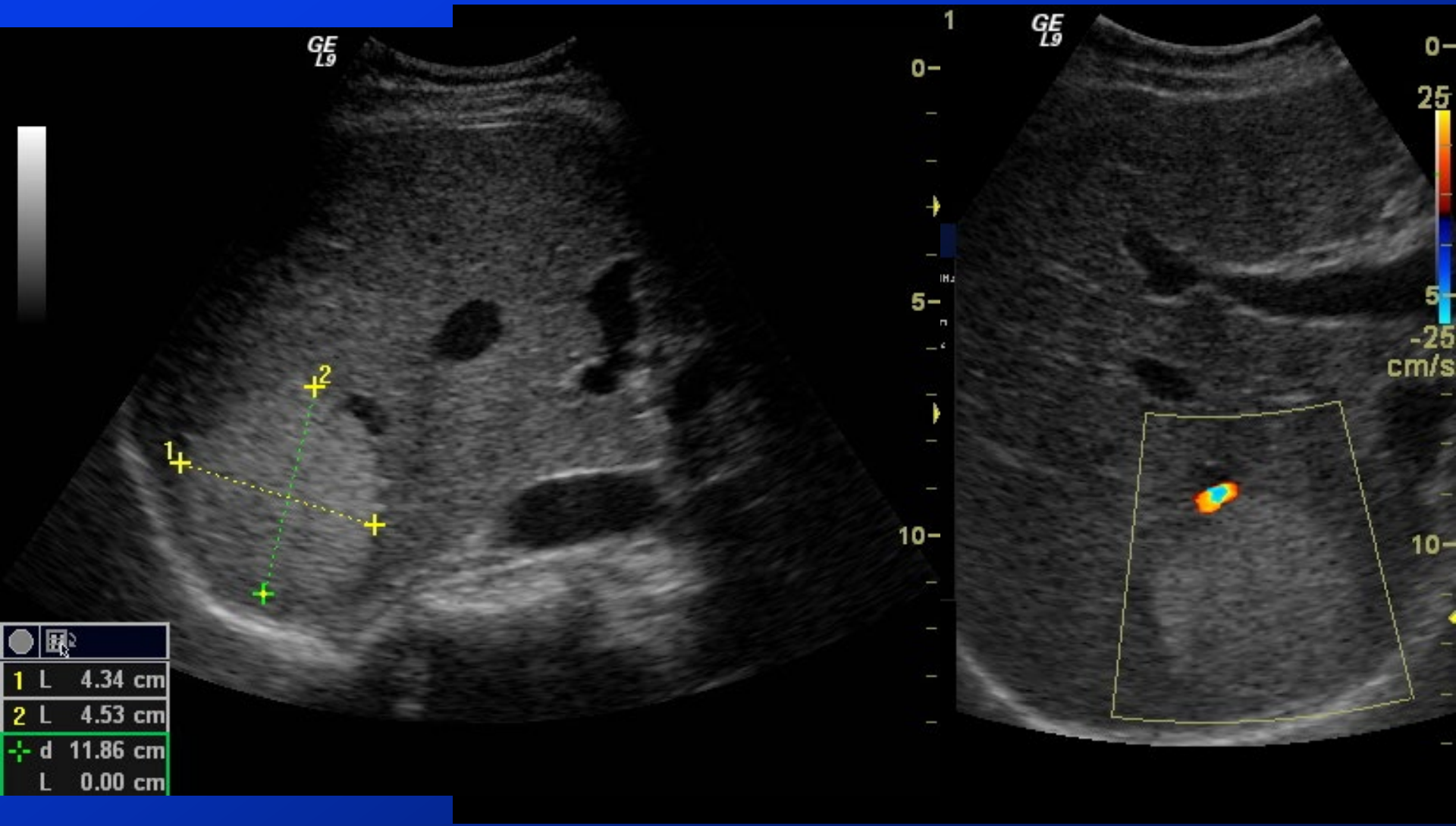




Typical location: By the capsule or by an hepatic vein



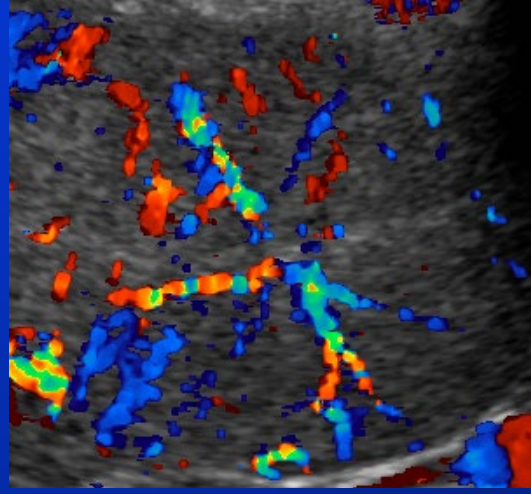
Referred from the CT-Lab
Haemangioma ?



Peripheral Globular Enhancement

…with slow sentripetal filling

Focal Nodular Hyperplasia - FNH



- FNH- a centrifugal stellate branching in early arterial phase
- Spoke wheel pattern in approx 40%
- Intense homogenous uptake
- Iso- or hyperechoic lesion is seen in portal venous phase.
- With these characteristic features:
  - sensitivity and specificity of contrast-enhanced low MI real-time US are 87.6% and 94.5%, respectively
    - Di Stasi 1996

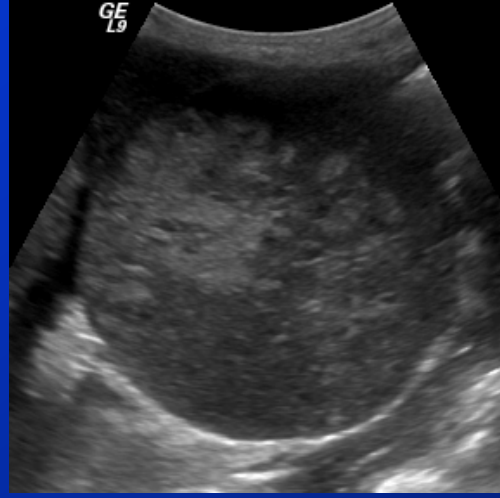
CEUS – Sonazoid - FNH

Arterial Phase: 12 sec.

Arterial Phase: 13 sec

Arterial Phase: 13 sec

Arterial Phase: 15 sec



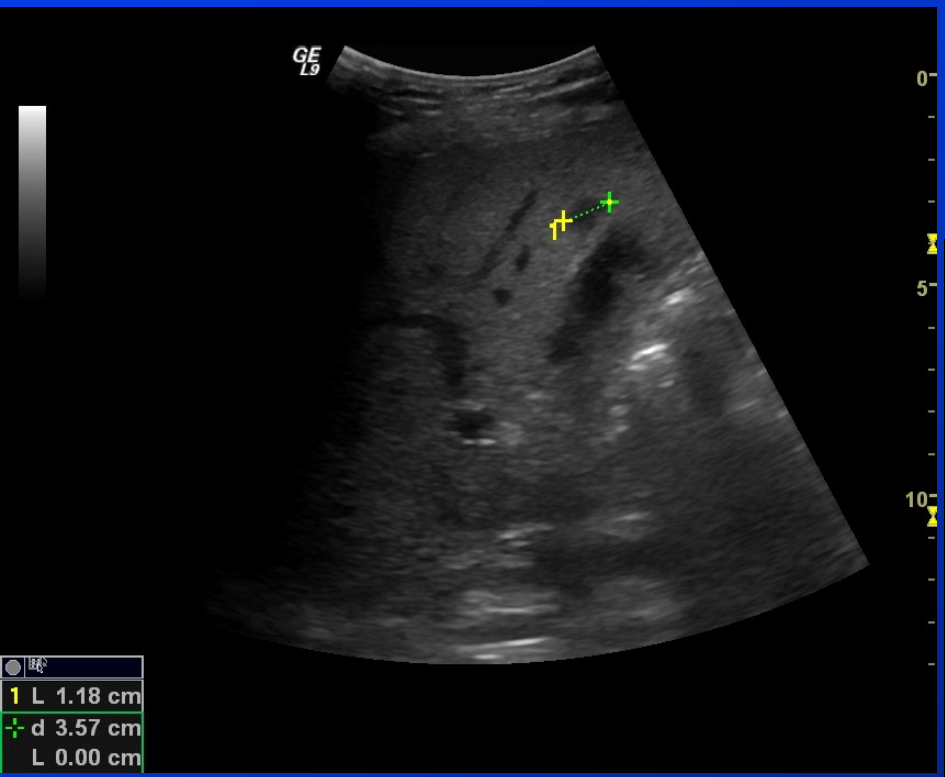
Liver cell adenoma

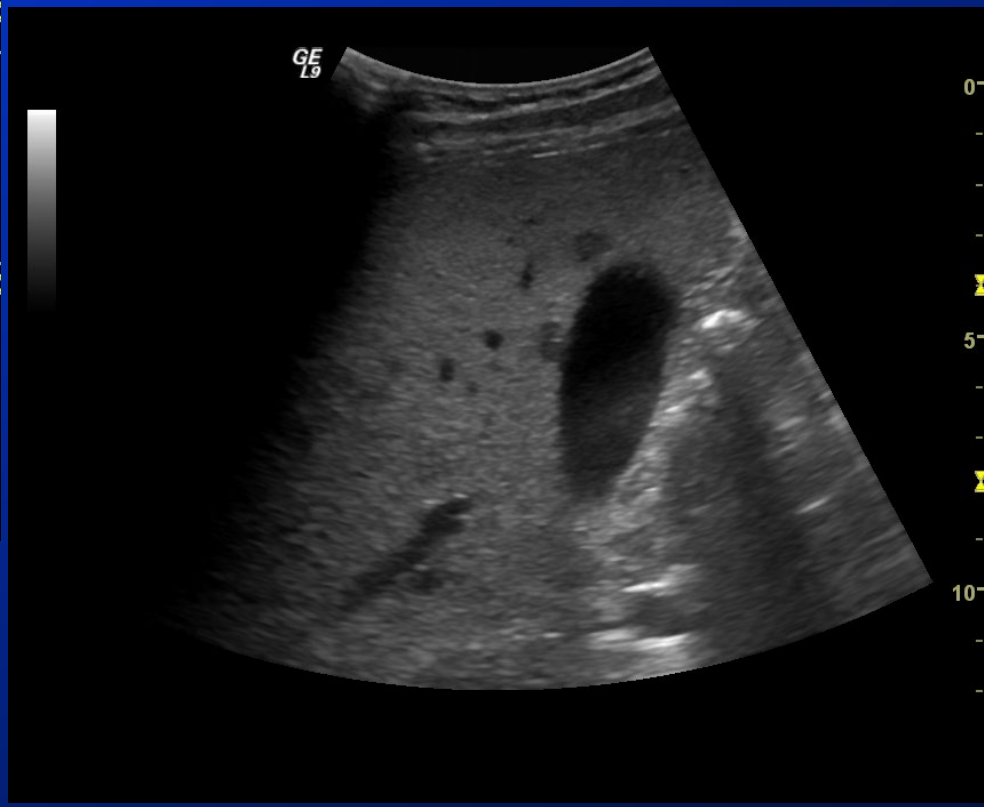
- Liver cell adenoma (LCA) is a rare primary benign neoplasm found mainly in young women with a history of oral contraceptive use
- The hypervascularity of adenomas can be demonstrated on Doppler,- sentripetal
- CEUS identification of the early and homogeneous hyperechoic enhancement in the periphery of the tumor, reflecting the presence of the subcapsular feeding arteries.
- The enhancement of LCA in the portal and late phases is nearly comparable with that of liver parenchyma, but LCA can remain slightly hypoechoic in relation to the adjacent liver

CEUS - Real-time Perfusion

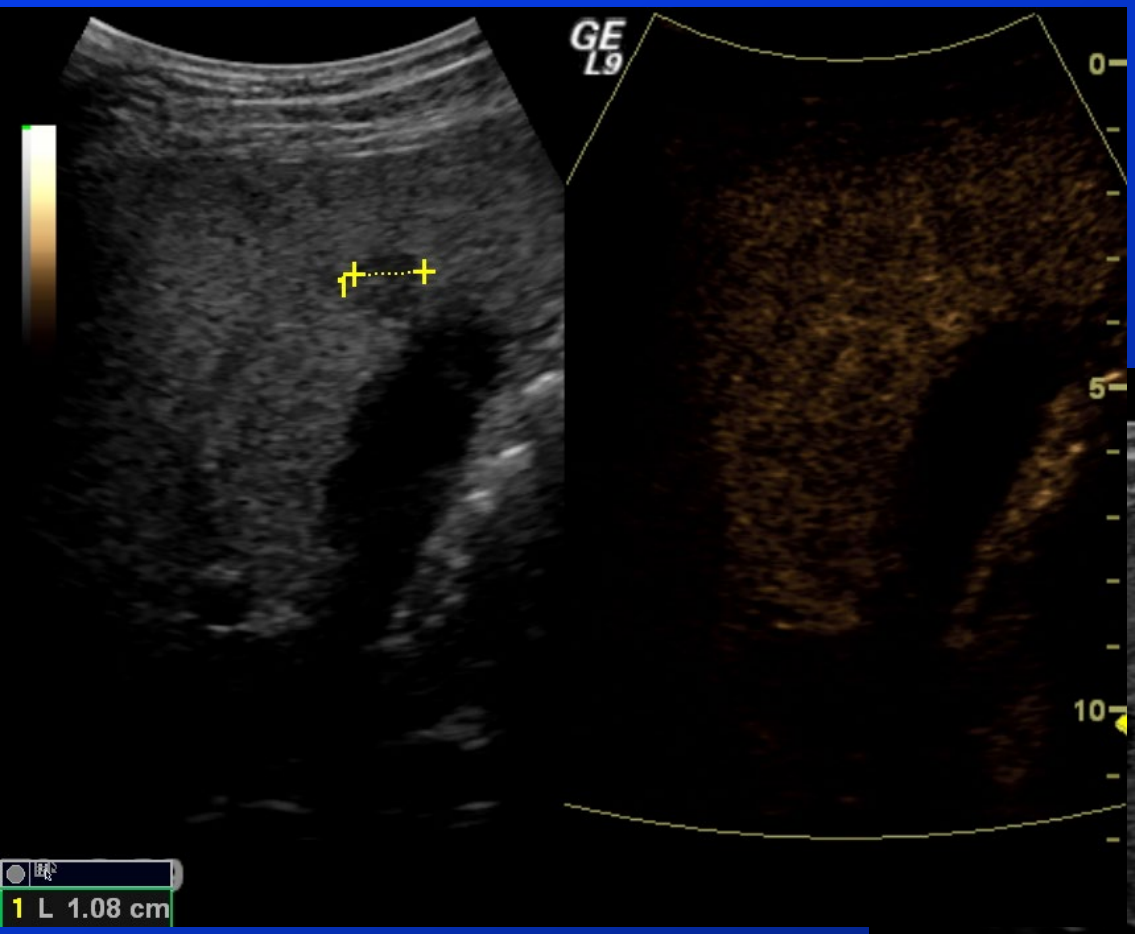
Dynamic abilities outperforms CT and MR

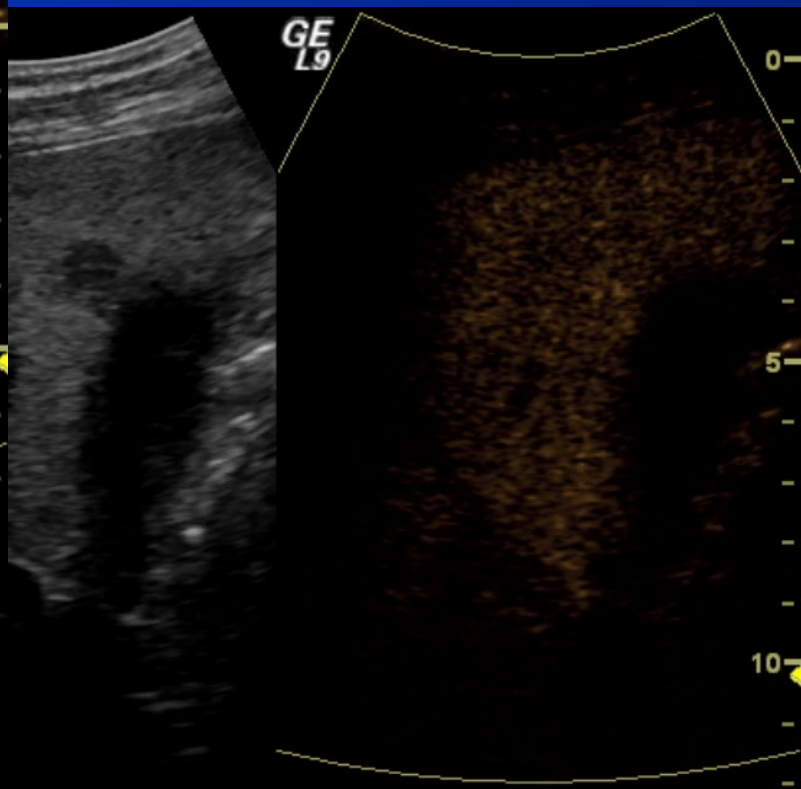
A common problem:
Focal Lesions in Fatty Livers





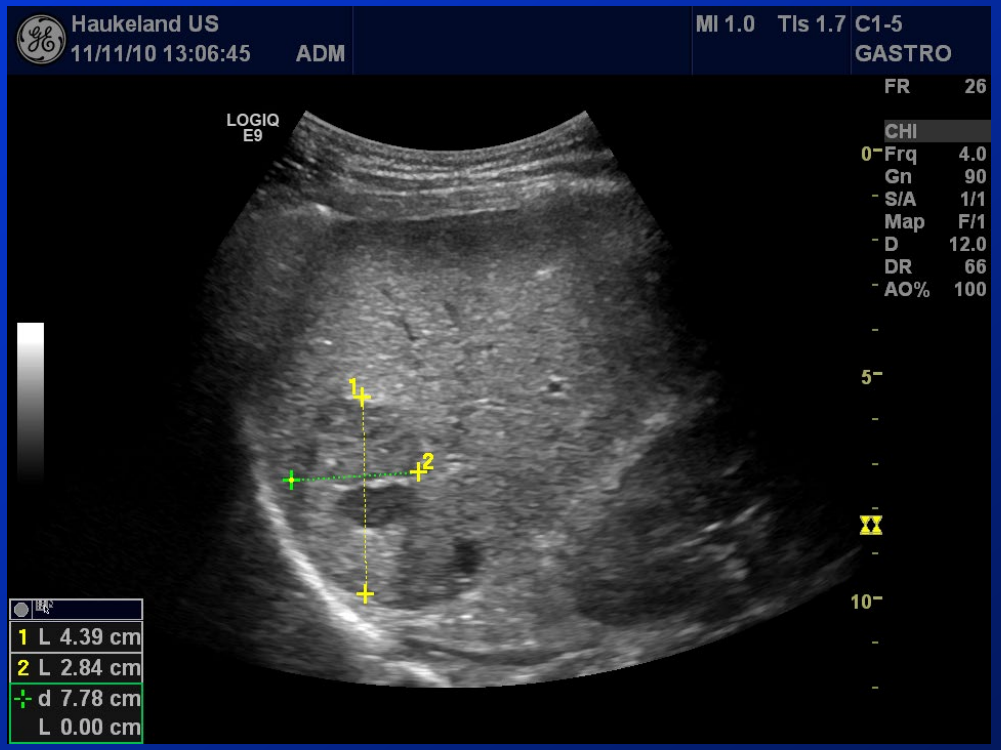
CEUS in FLL





T1: 3:18

Ultrasound in HCC

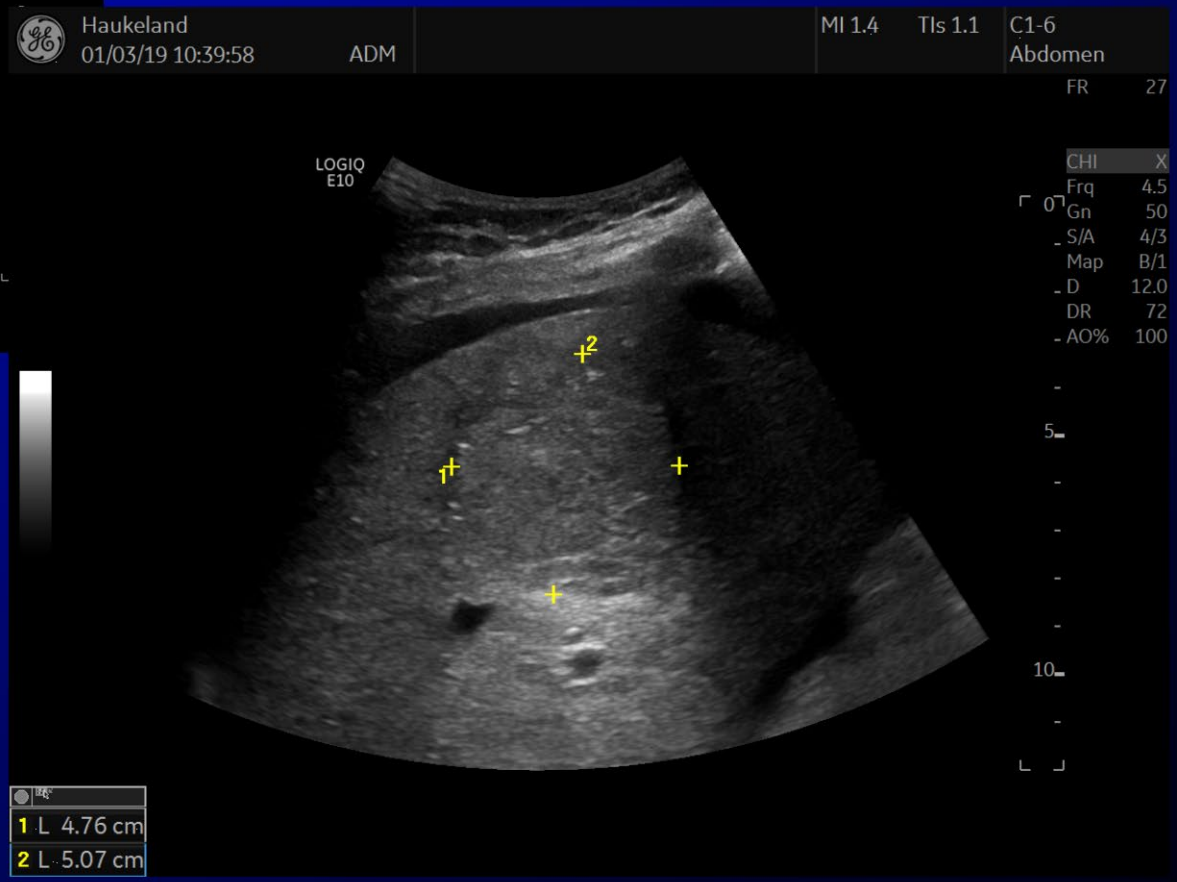


- Diagnosis
  - B-mode
  - Doppler
  - CEUS
- US-guided biopsy
- Per-operative guiding of ablation
- Follow-up and monitoring of treatment
- Surveillance / Screening

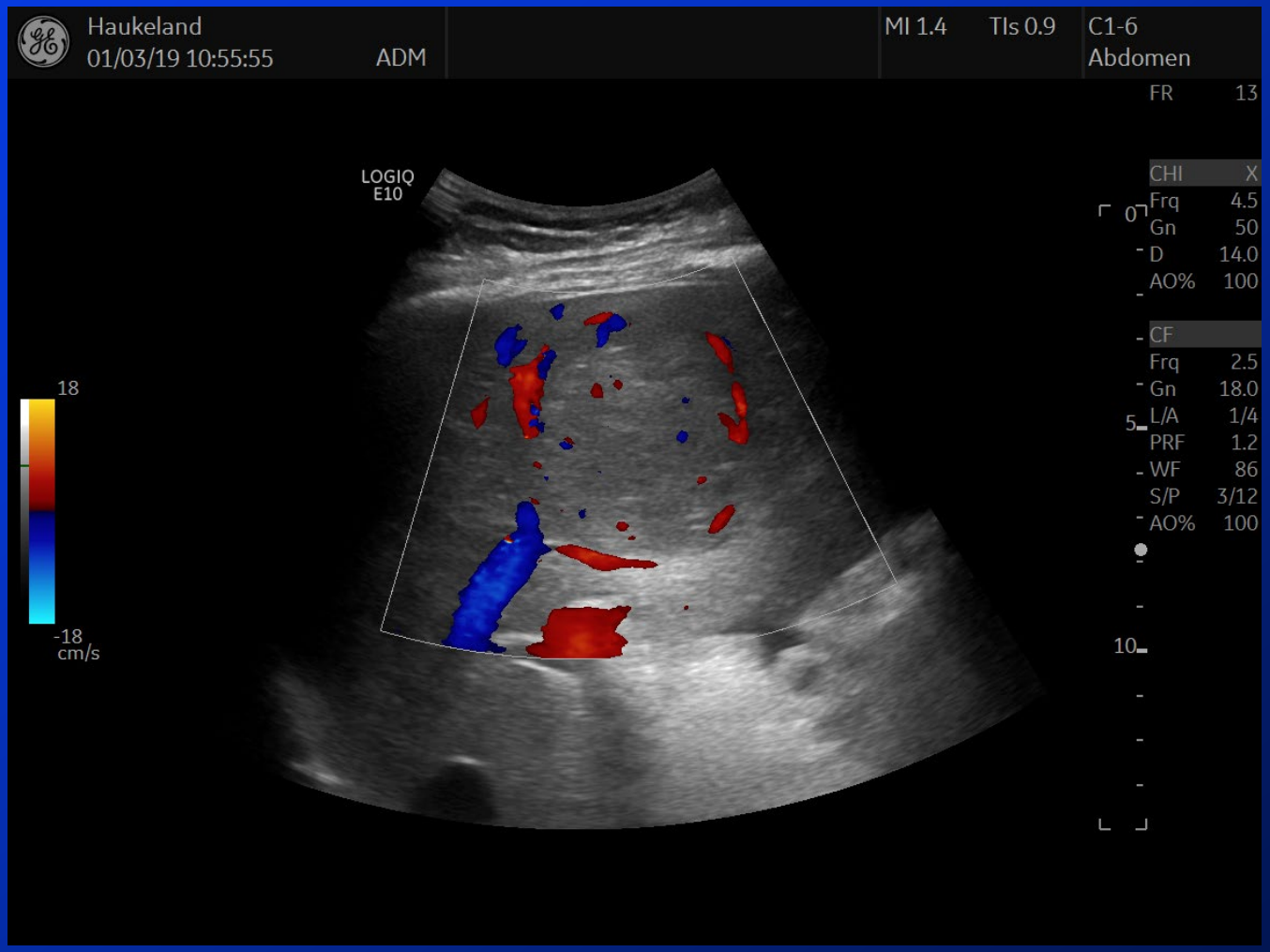
HCC facts
HCC – The great imitator

- Increasing incidence world-wide
- 90% has known ethiology
- AFP has limited sensitivity (approx. 60%)
- Most frequent: Alcohol (25%) and HCV
- NASH is increasing in incidence, thus feeding the HCC growth
- Barcelona criteria: 2 independant imaging methods are needed to avoid biopsy

A patient with cirrhosis

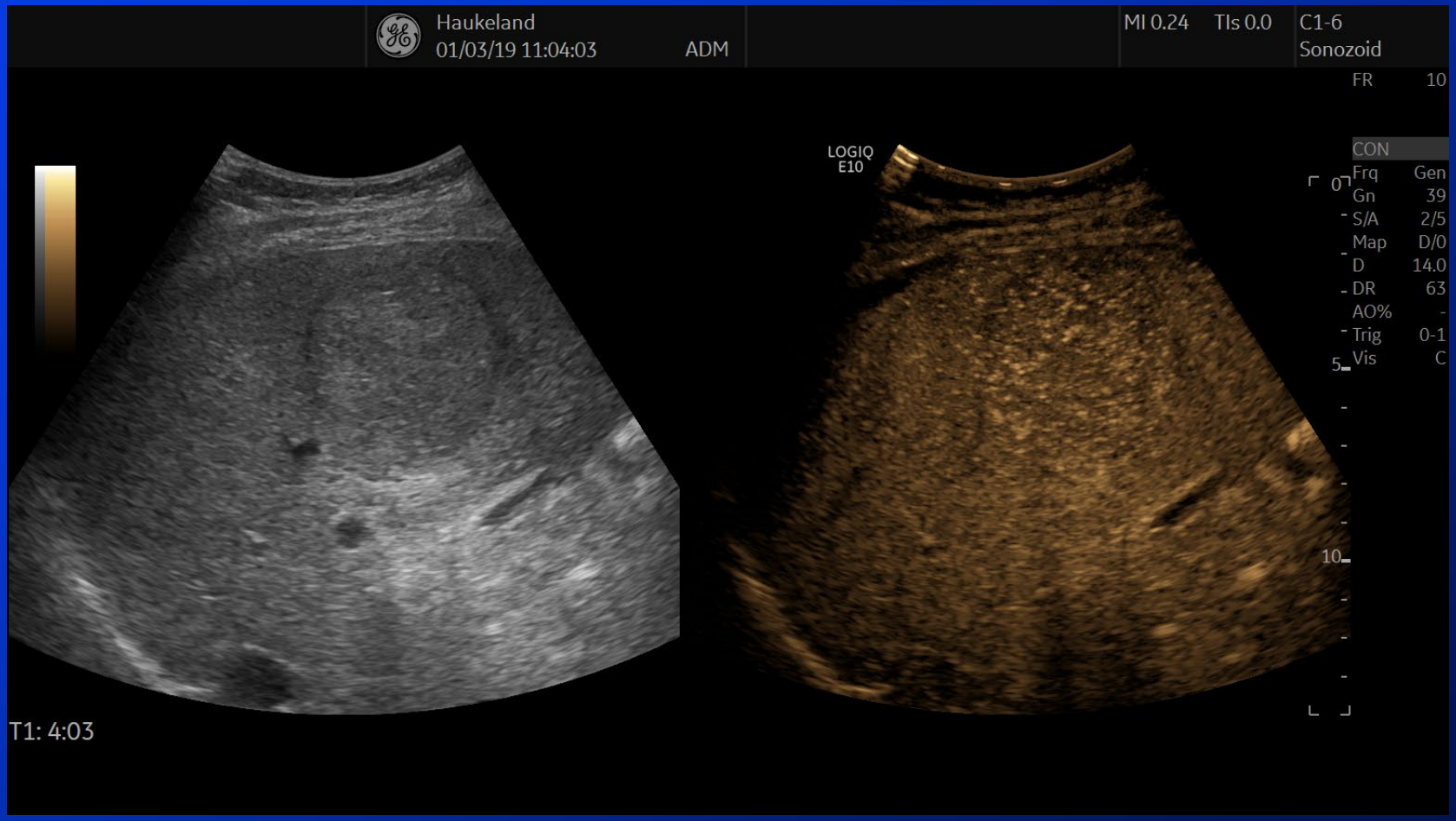


«The Basket Sign»



CEUS of tumor

Any wash-out in late phase ?



FNH versus HCC

FNH

HCC

Liver Metastasis ?

Before contrast injection

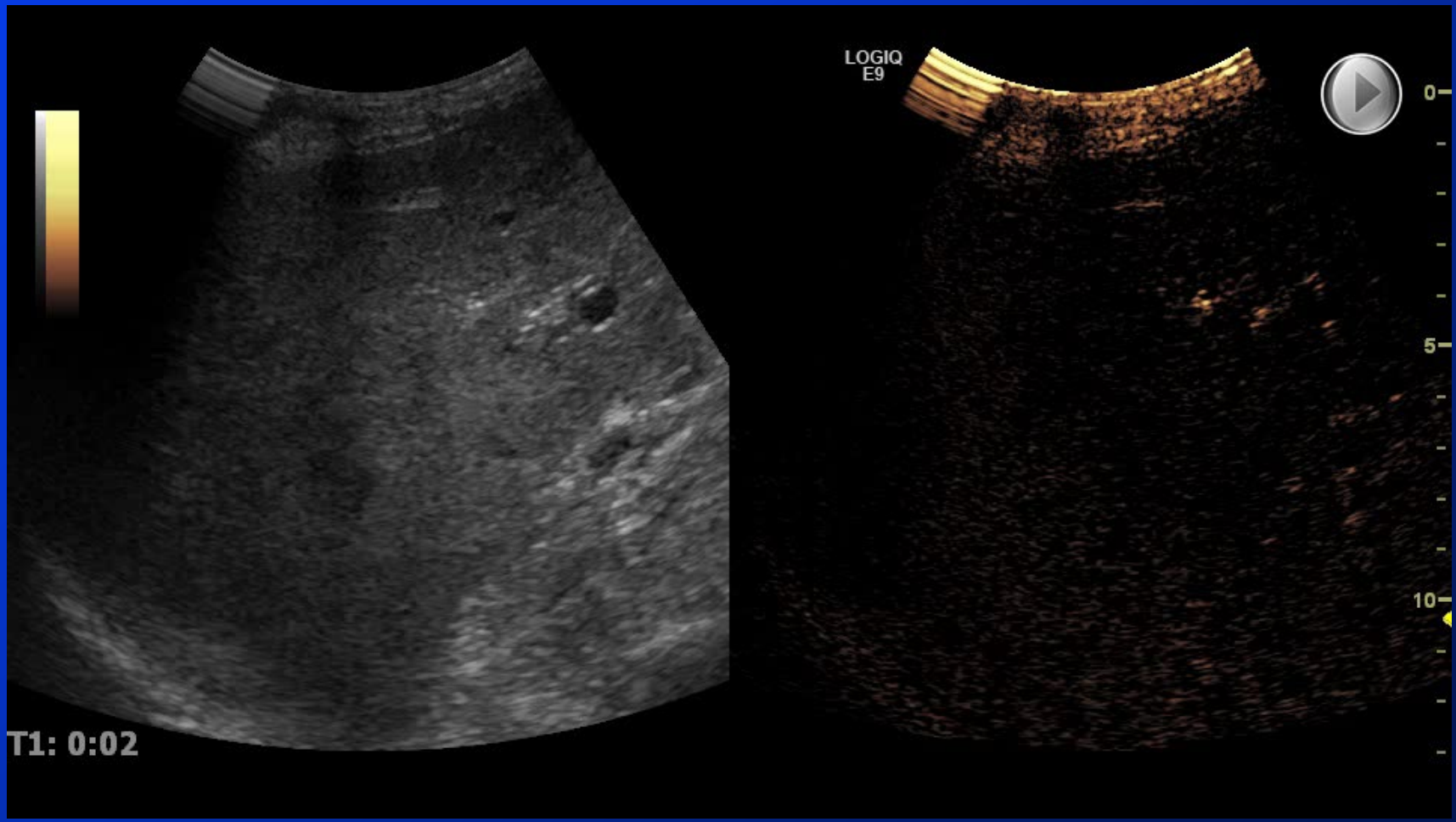
Liver Metastasis ?

After contrast injection in late phase

Early wash-out typical for mets

Not easily observed on CT and MRI

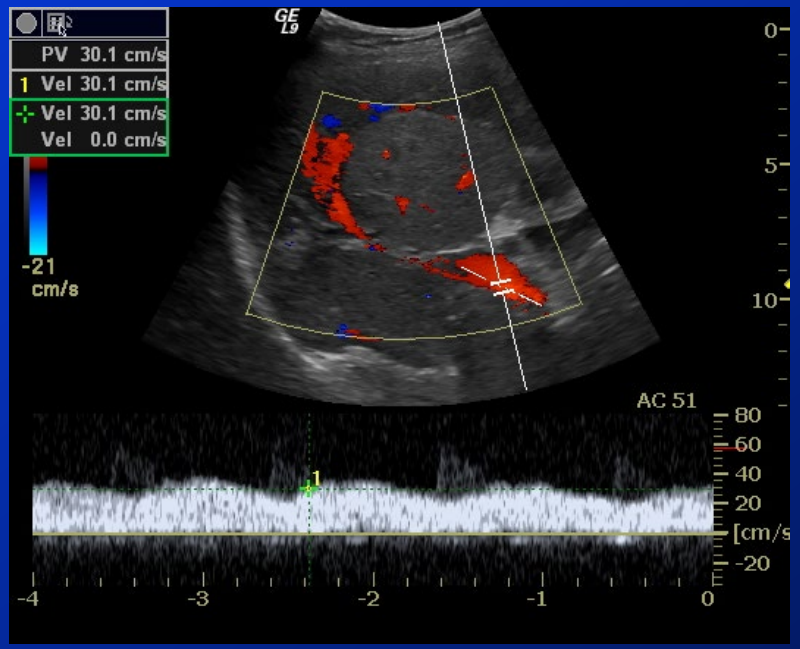
Mets from Rectal Cancer

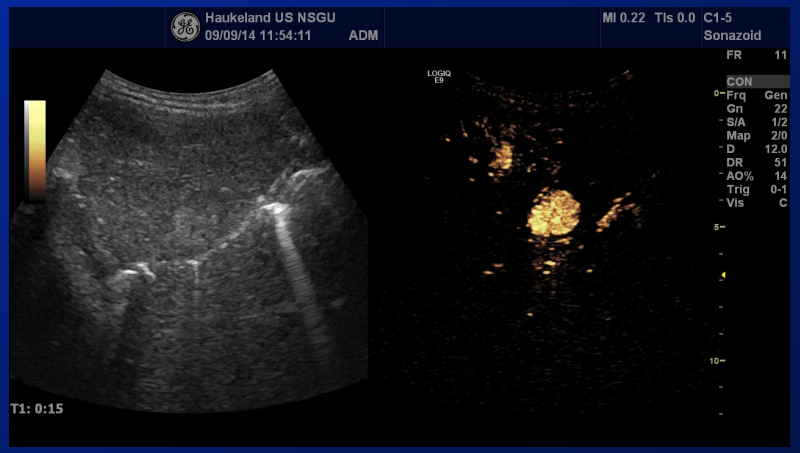


High-Frequency 9 MHz LA probe
Post-vascular phase (Kupffer)

One stop shopping

- US B-mode
- Doppler
  - Color flow
  - Pulsed Doppler
- Elastography
  - Shear wave
  - Strain imaging
- CEUS
- US-guided biopsy





”Yes, we scan”

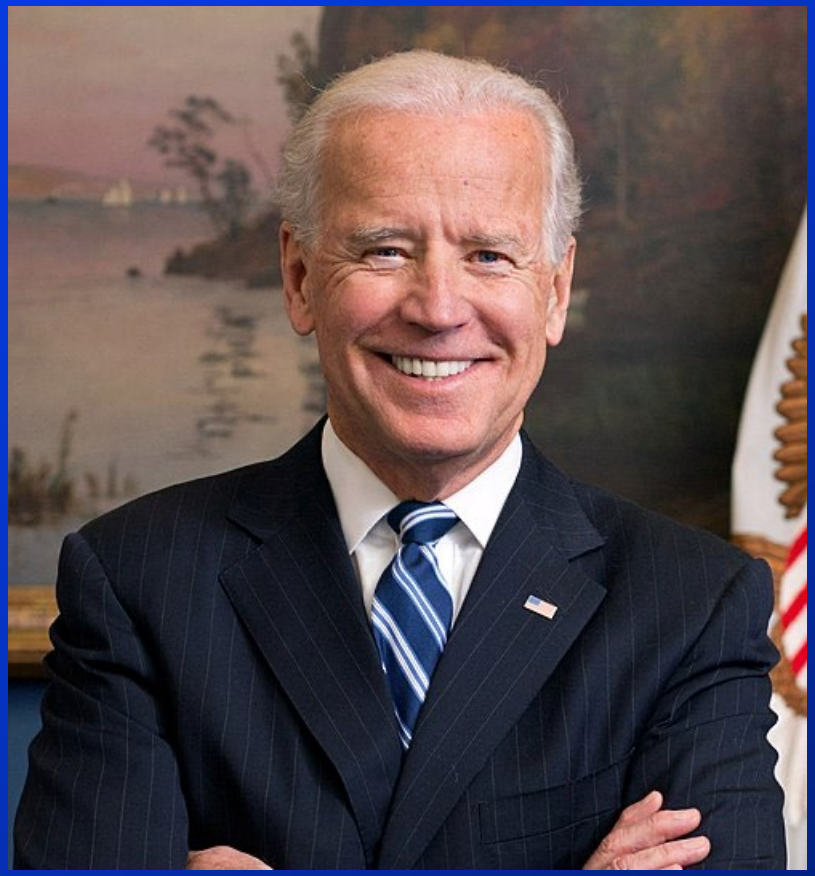
US first = Ultrasound first…

”This is NOT fake news !”

Biden ?

- …

«Green Deal»



Ultrasound is “green”:

- No radiation
- Safe to repeat
- Low cost
- Widely available
- Short travel