



Nasjonalt Senter for Gastroenterologisk Ultrasonografi

National Centre for Ultrasound in Gastroenterology
Haukeland University Hospital, Bergen, Norway

Ultrasound of diffuse liver diseases and elastography

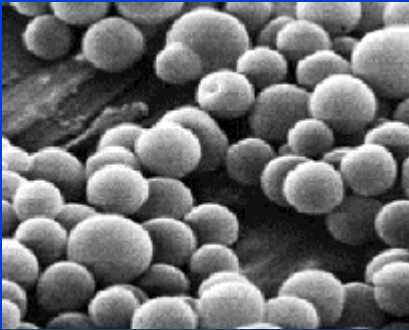
Odd Helge Gilja, MD, PhD

Professor

Department of Medicine

Haukeland University Hospital

Bergen, Norway

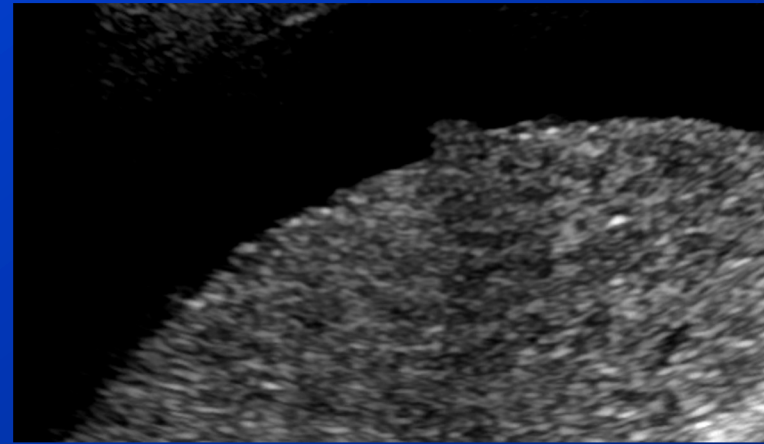




Ultrasound of the Liver

-What do we look for ?

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

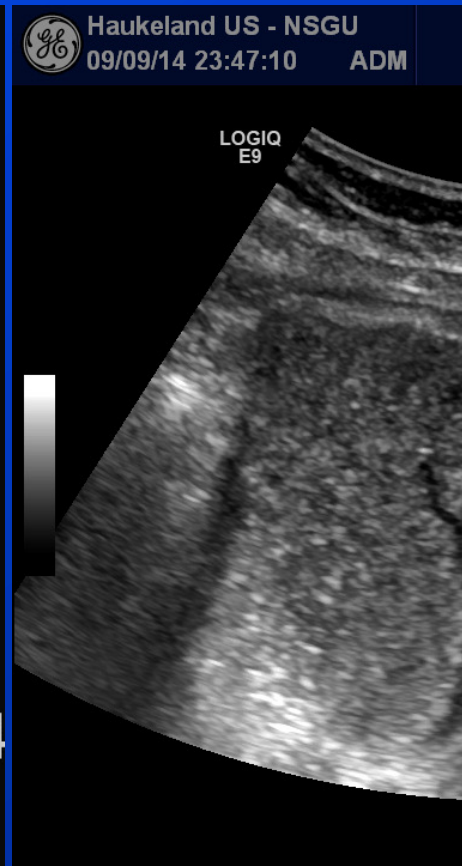




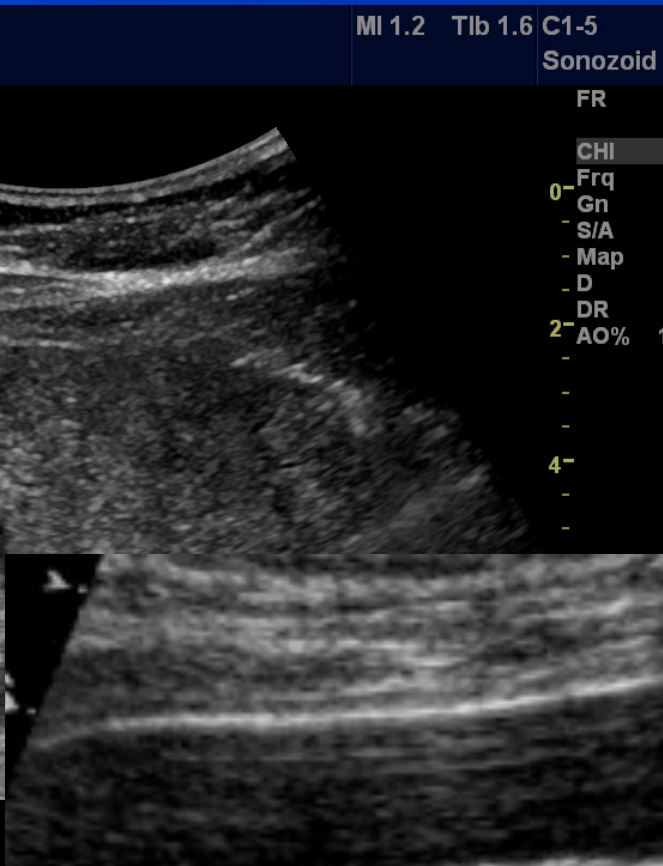
The Liver capsule



Normal



Cirrhosis



Use high frequency (9-12 MHz)

Haukeland US - NSGU
09/09/14 23:47:10 ADM

MI 1.2 Tib 1.6 C1-5
Sonozoid

FR
CHI
0- Frq
- Gn
- S/A
- Map
- D
2- DR
- AO%
-
-
4-
-

4

4



The Portal vein



Haukeland US
09/29/10 09:20:35 ADM

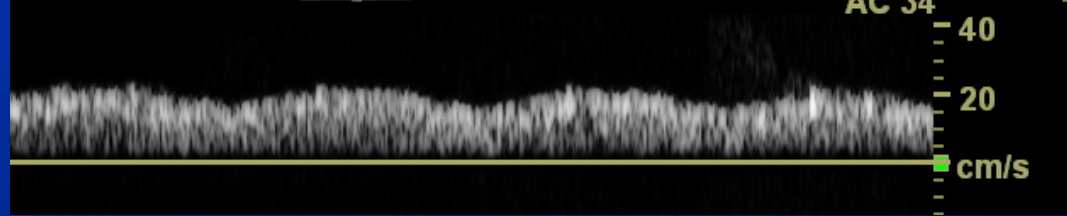
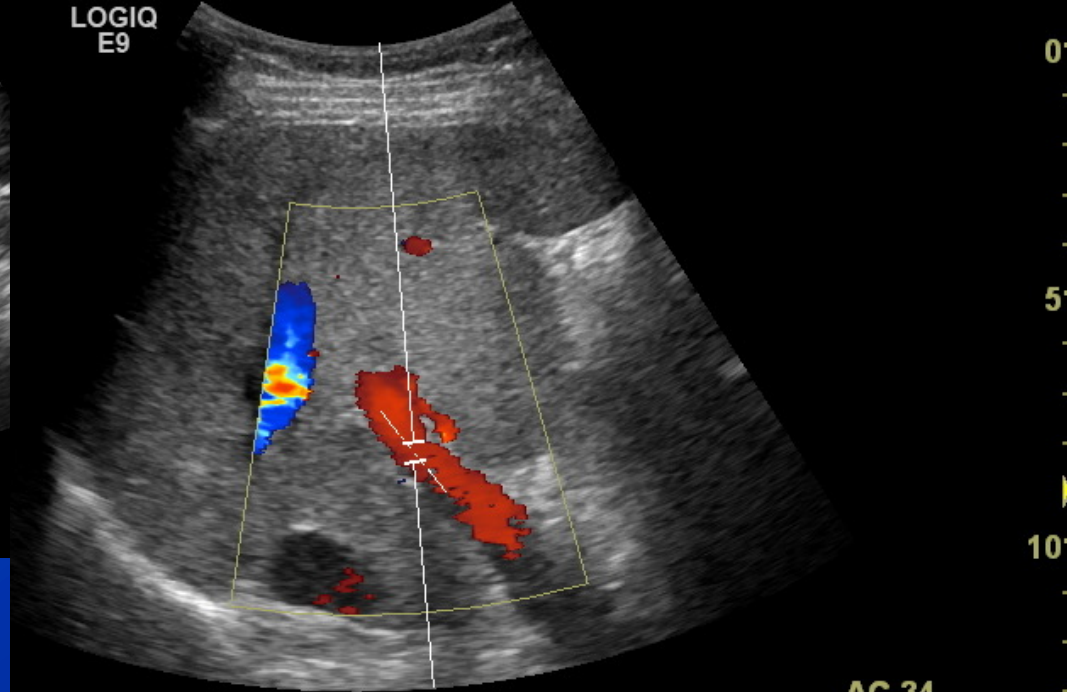
MI 1.2 Tls 1.7 C1-5
GASTRO

FR 24
CHI
0-Frq 5.0
Gn 64
-S/A 1/1
Map F/1
-D 12.0
DP 66

LOGIQ
E9

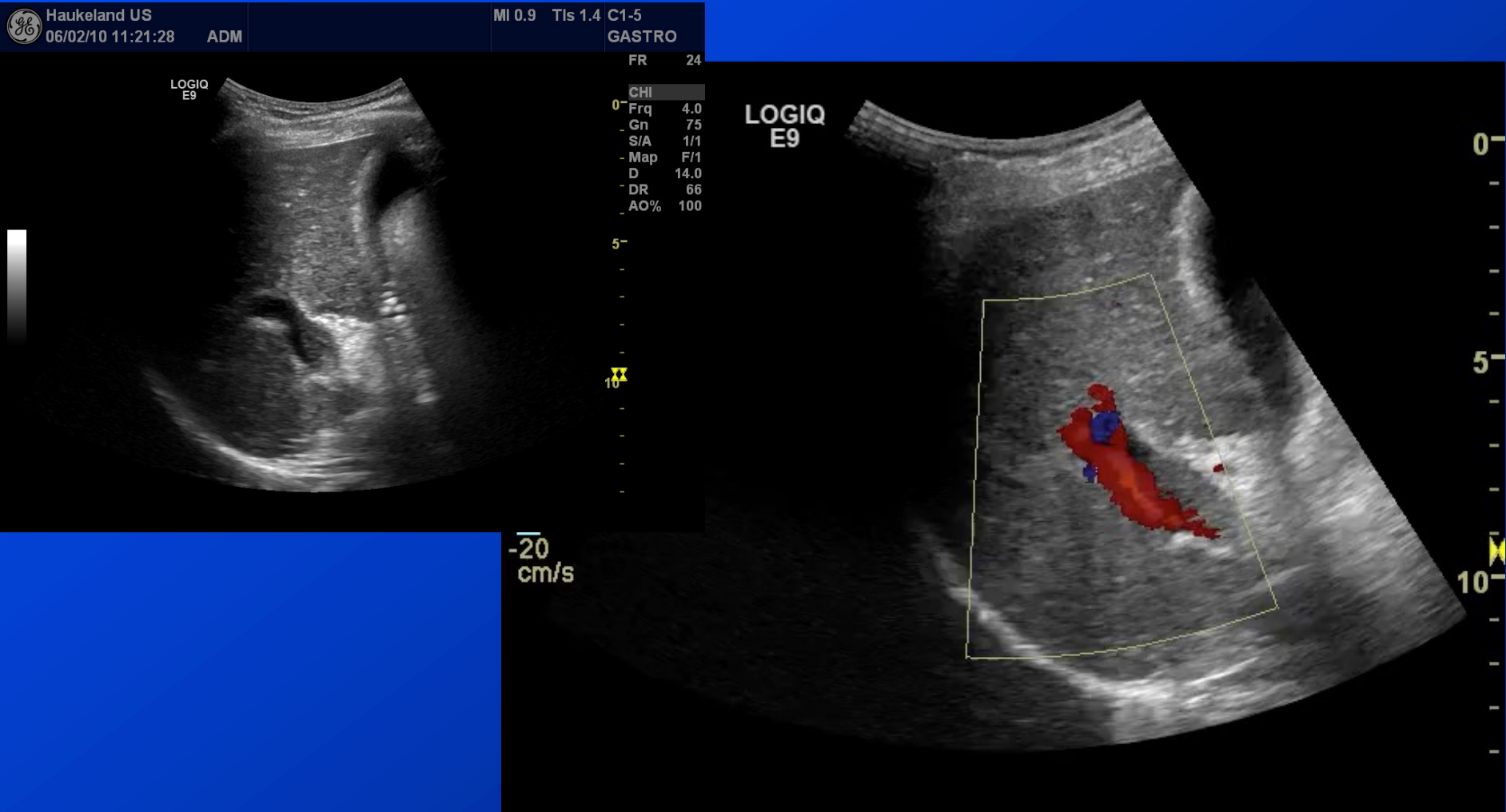


LOGIQ
E9





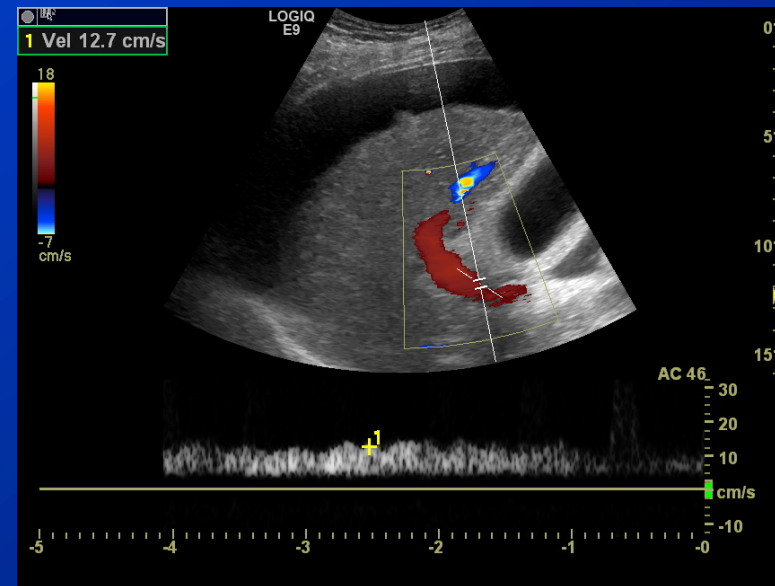
Color Doppler flow in real-time





Ultrasound better than CT

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





Diffuse liver diseases

Chronic liver disease

Viral hepatitis

Iron overload

Nonalcoholic fatty liver disease

Liver fibrosis and cirrhosis

Drug toxicity

Metabolic disease

Autoimmune hepatitis





Ethiology of cirrhosis

Inflammation

Viral

Hepatitis B (15 percent)

Hepatitis C (47 percent)

Schistosomiasis

Autoimmune (types 1, 2, 3)

Sarcoidosis

Toxic

Alcohol (18 percent)

Methotrexate

Genetic/congenital

Primary biliary cirrhosis

α_1 -antitrypsin deficiency

Hemochromatosis

Nonalcoholic fatty liver disease

Wilson disease

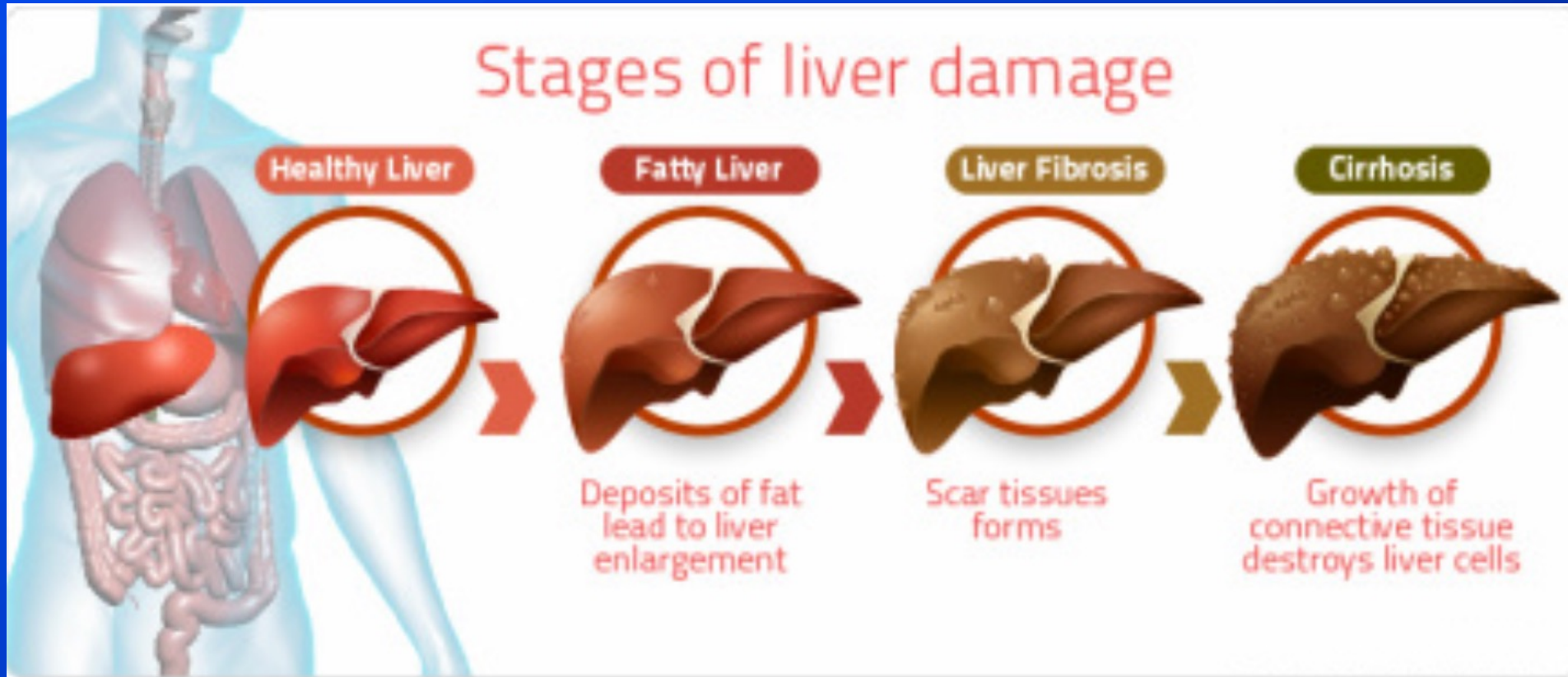
Congestive heart failure (chronic passive congestion)

Venoocclusive disease (Budd-Chiari syndrome)

Unknown (14 percent)



From a healthy liver to cirrhosis





Agenda

- Steatosis
- Fibrosis
- Cirrhosis



Fatty liver – Dangerous !





Steatosis with acoustic attenuation

GE Healthcare
02/03/10 10:39:37 ADM

MI 0.9 TIs 1.4 C1-5
GASTRO

FR 24

CHI
Frq 4.0
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

ADM

MI 0.8 TIs 0.8 C1-5
GASTRO

FR 25

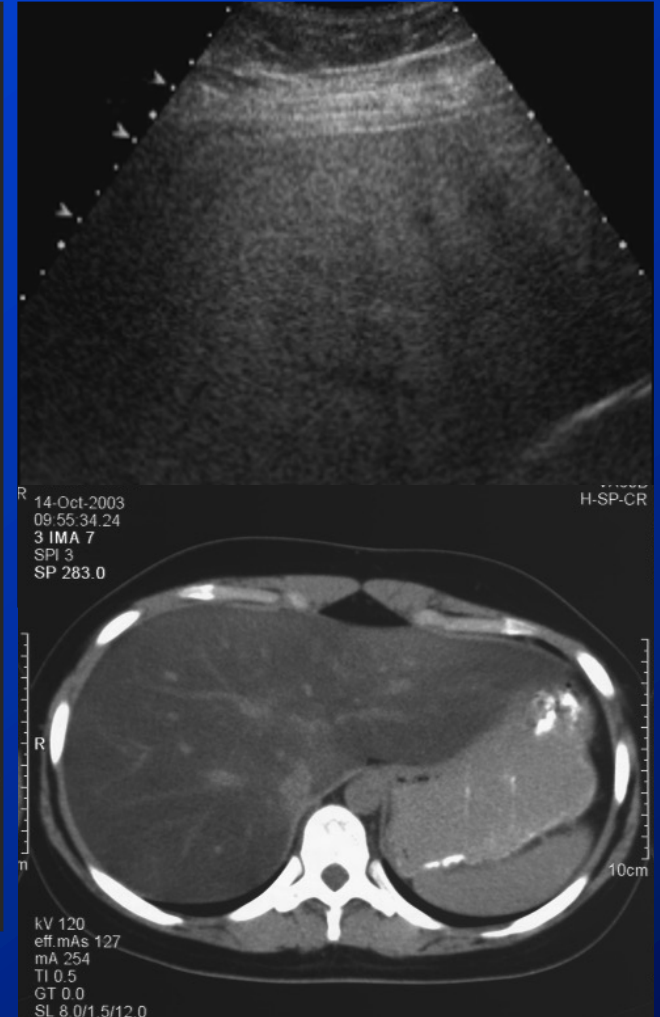
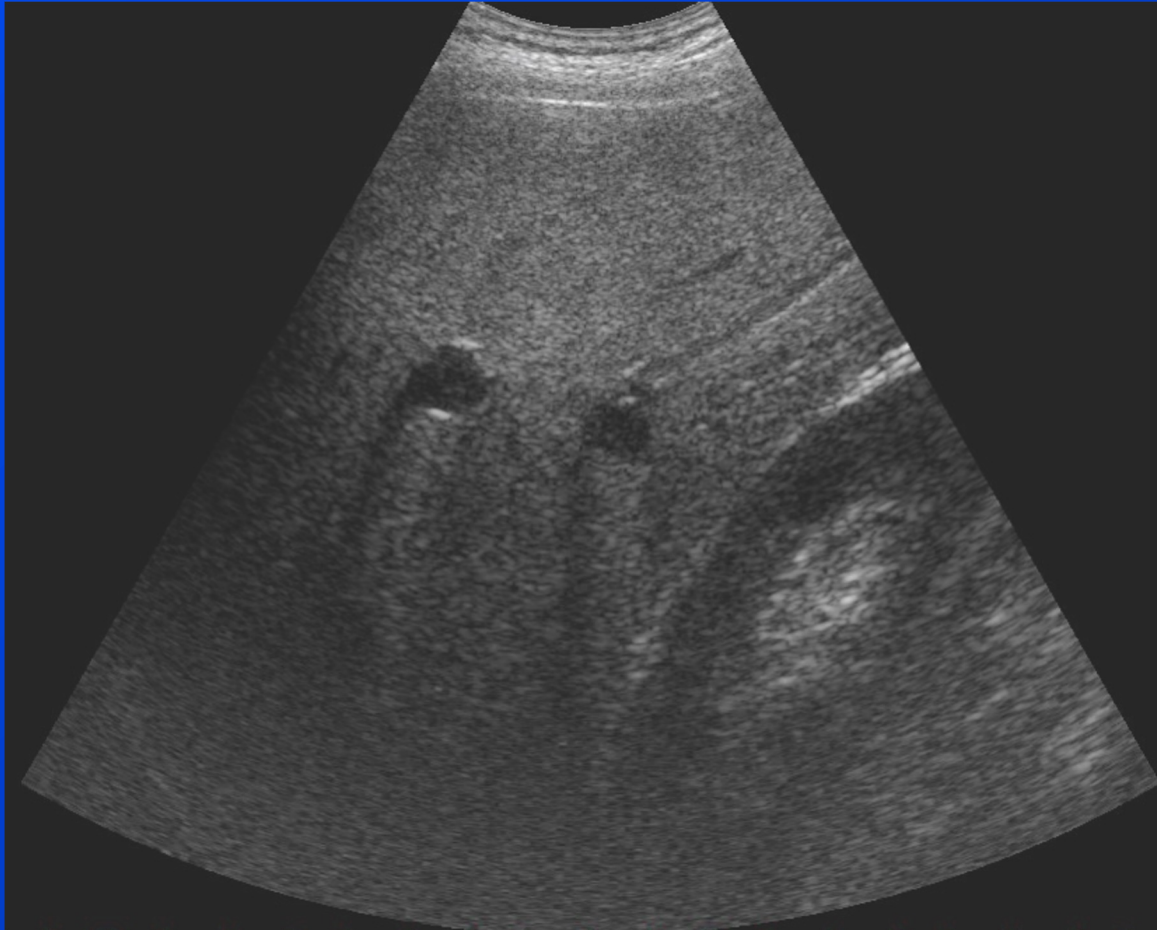
CHI
Frq 3.0
0-Gn 71
S/A 1/1
Map F/1
D 13.0
DR 66
AO% 100

LOGIQ E9

1 EL -33.2 dB
2 EL -41.9 dB
+ d 7.82 cm
EL 0.0 dB

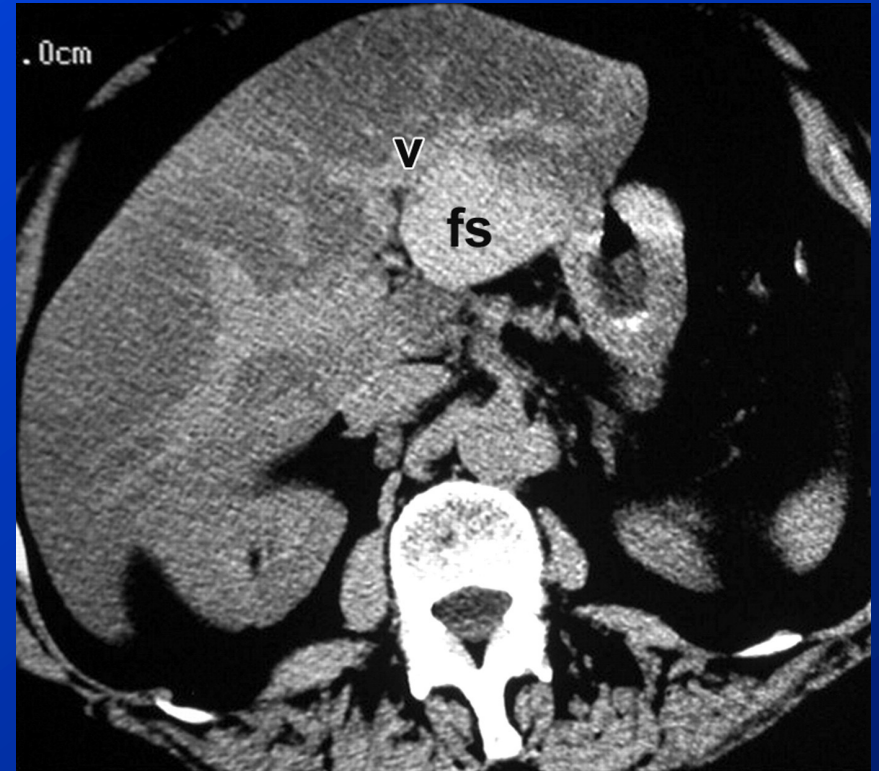
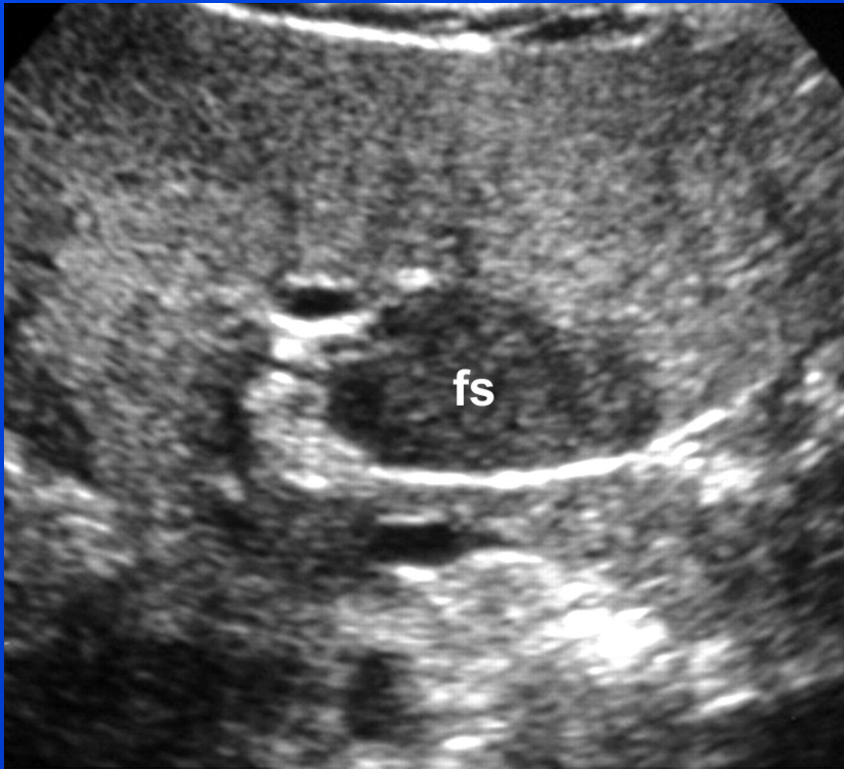


Steatosis grade 3



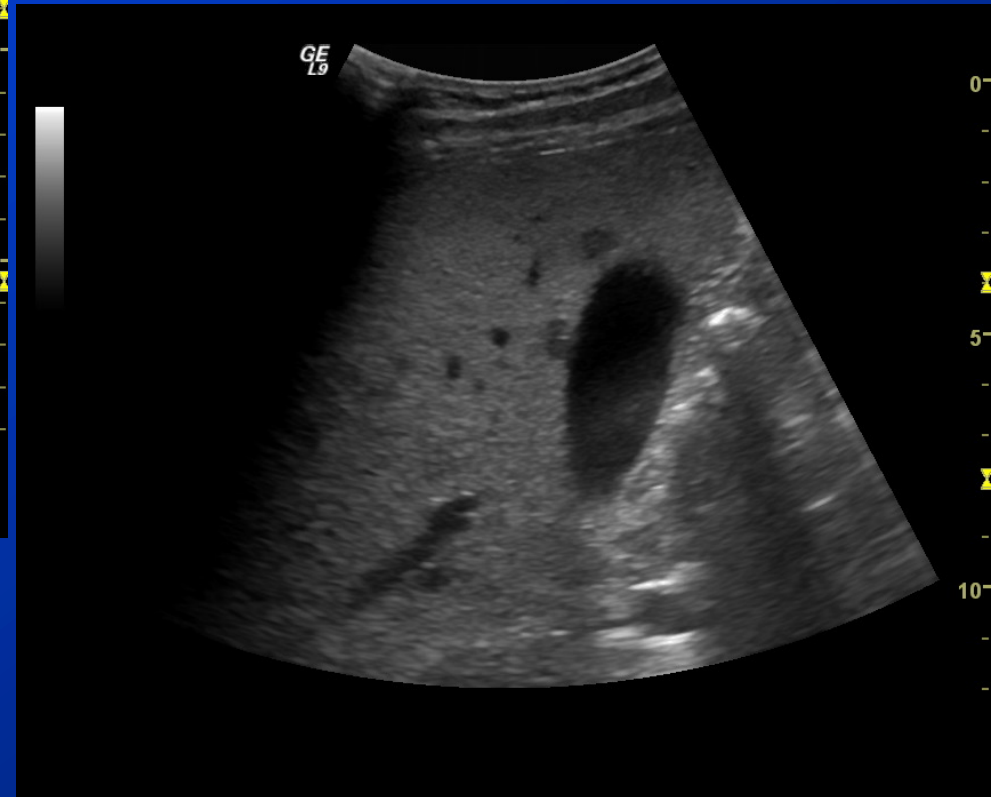
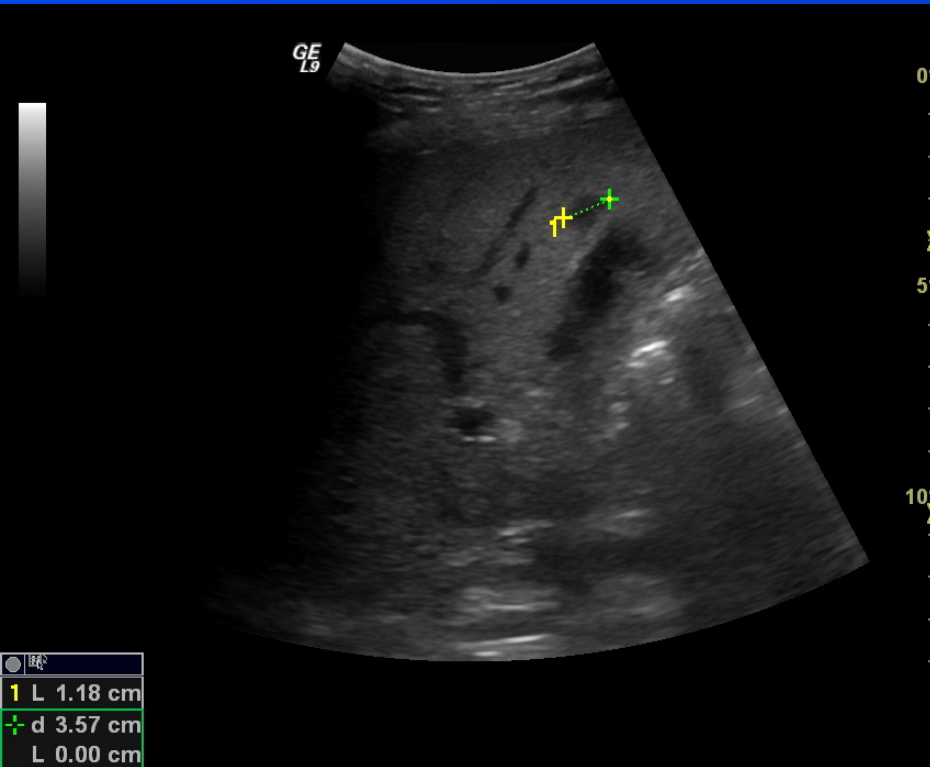


Fatty liver with "focal areas of sparing"



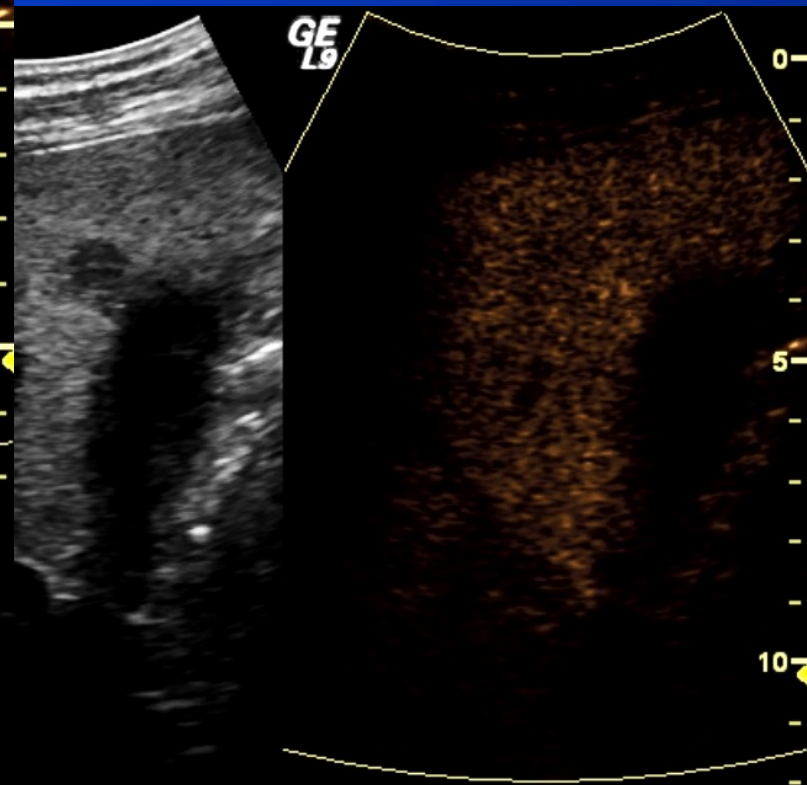
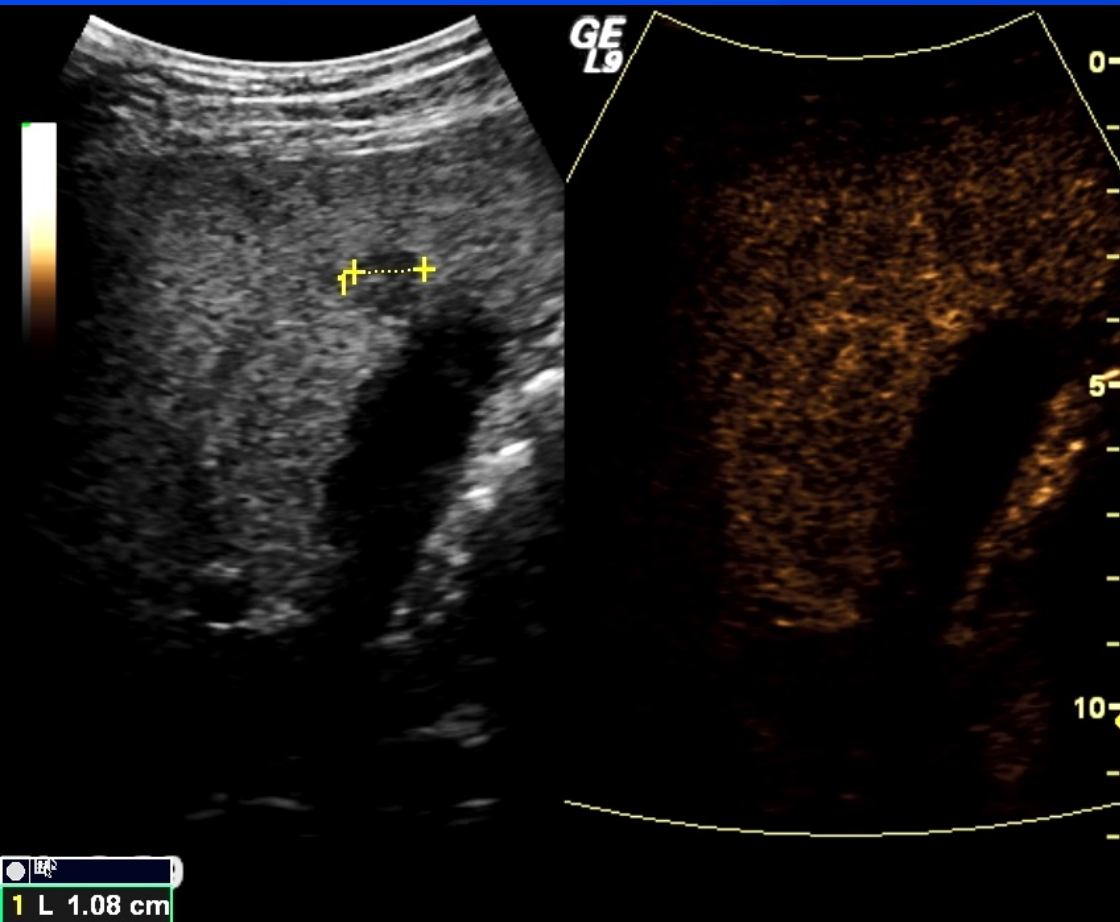


A common problem: Focal Lesions in Fatty Livers





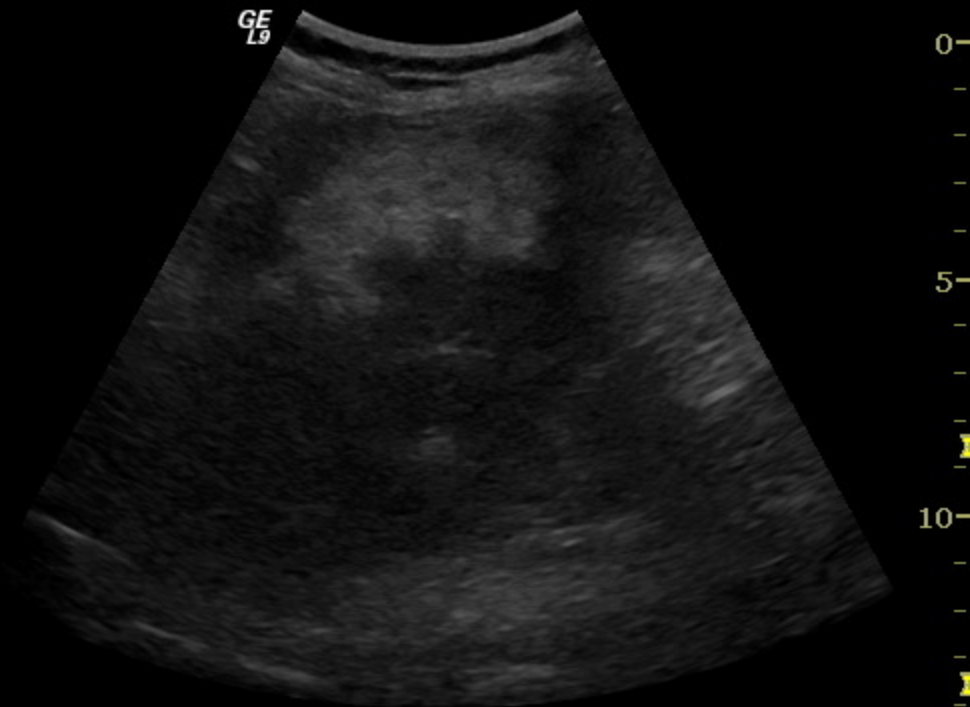
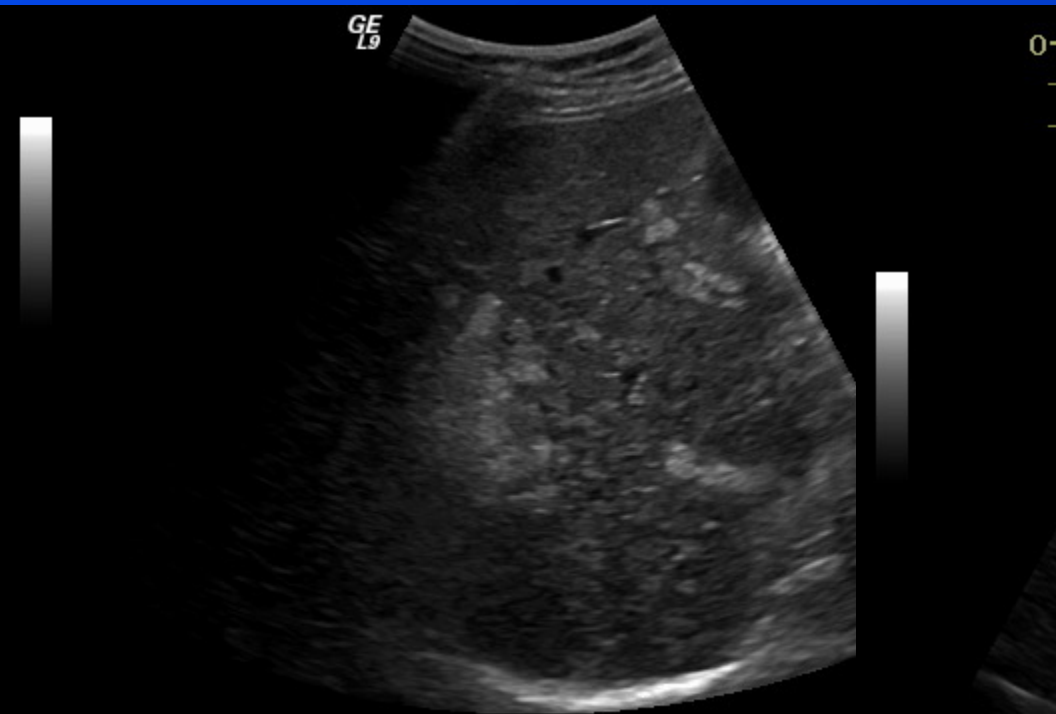
CEUS in Fatty liver



T1: 3:18

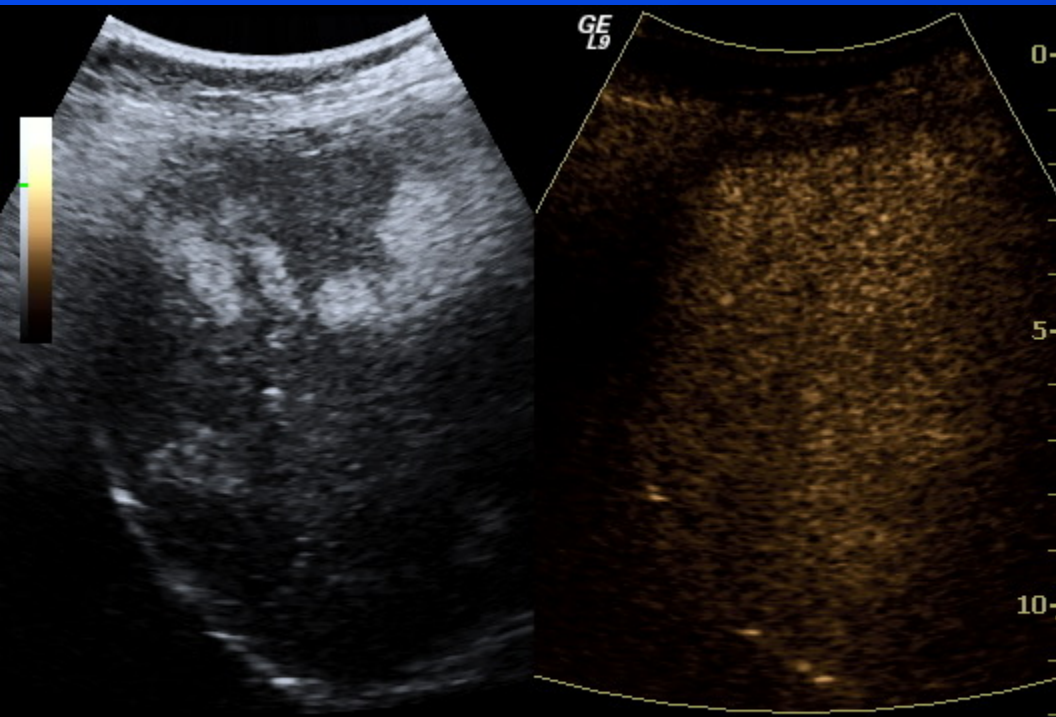


Hyperechogenic lesions in a young female of 20 years

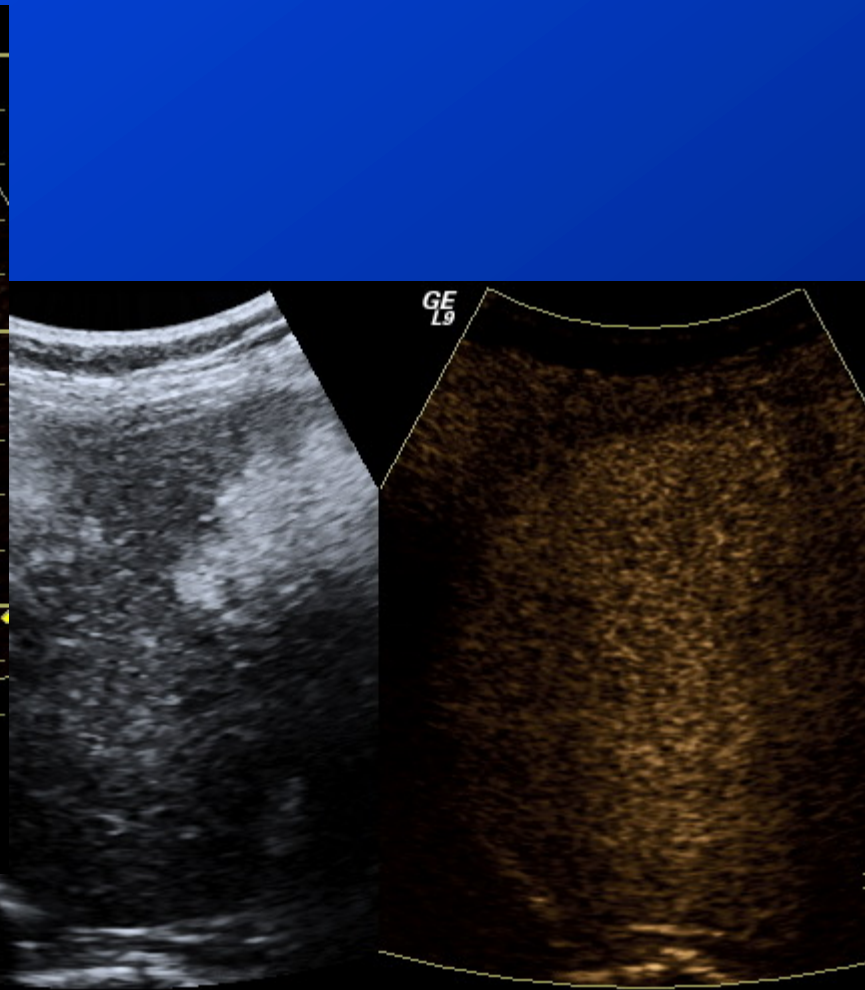




CEUS



T1: 2:43

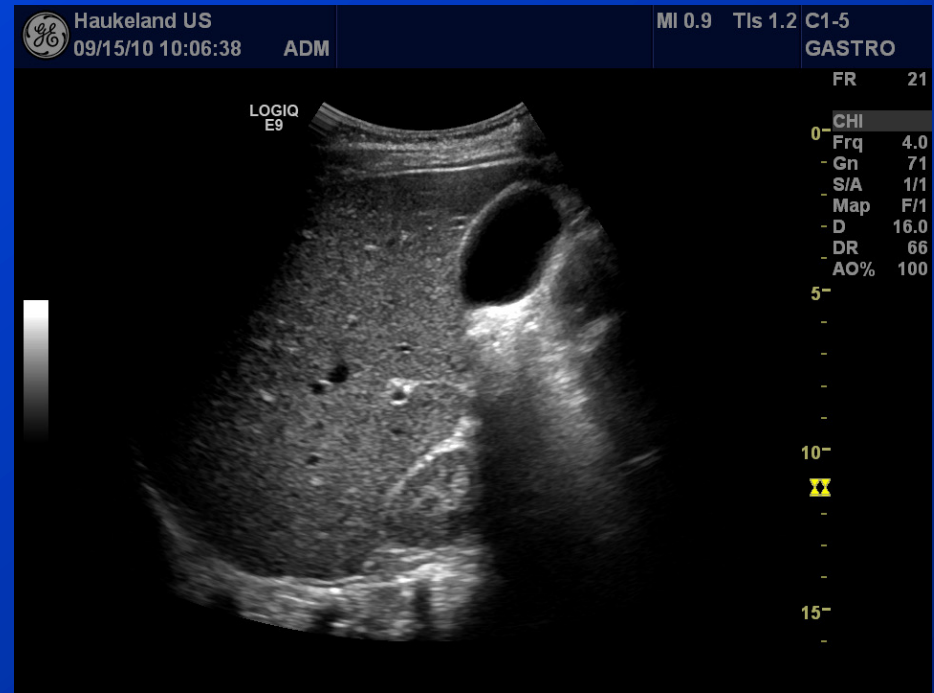
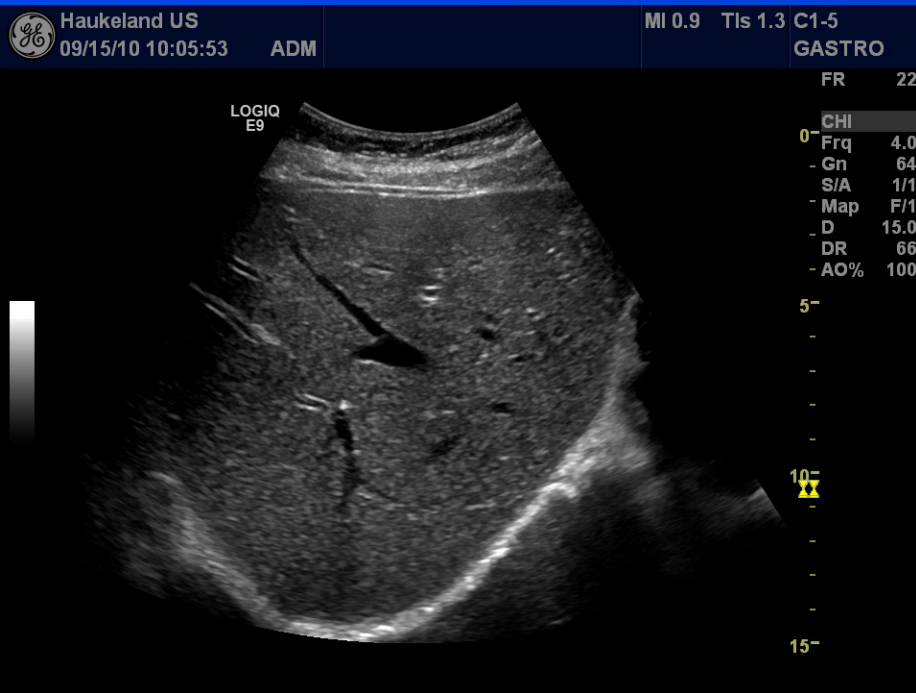


T1: 3:51

Biopsy showed fatty tissue

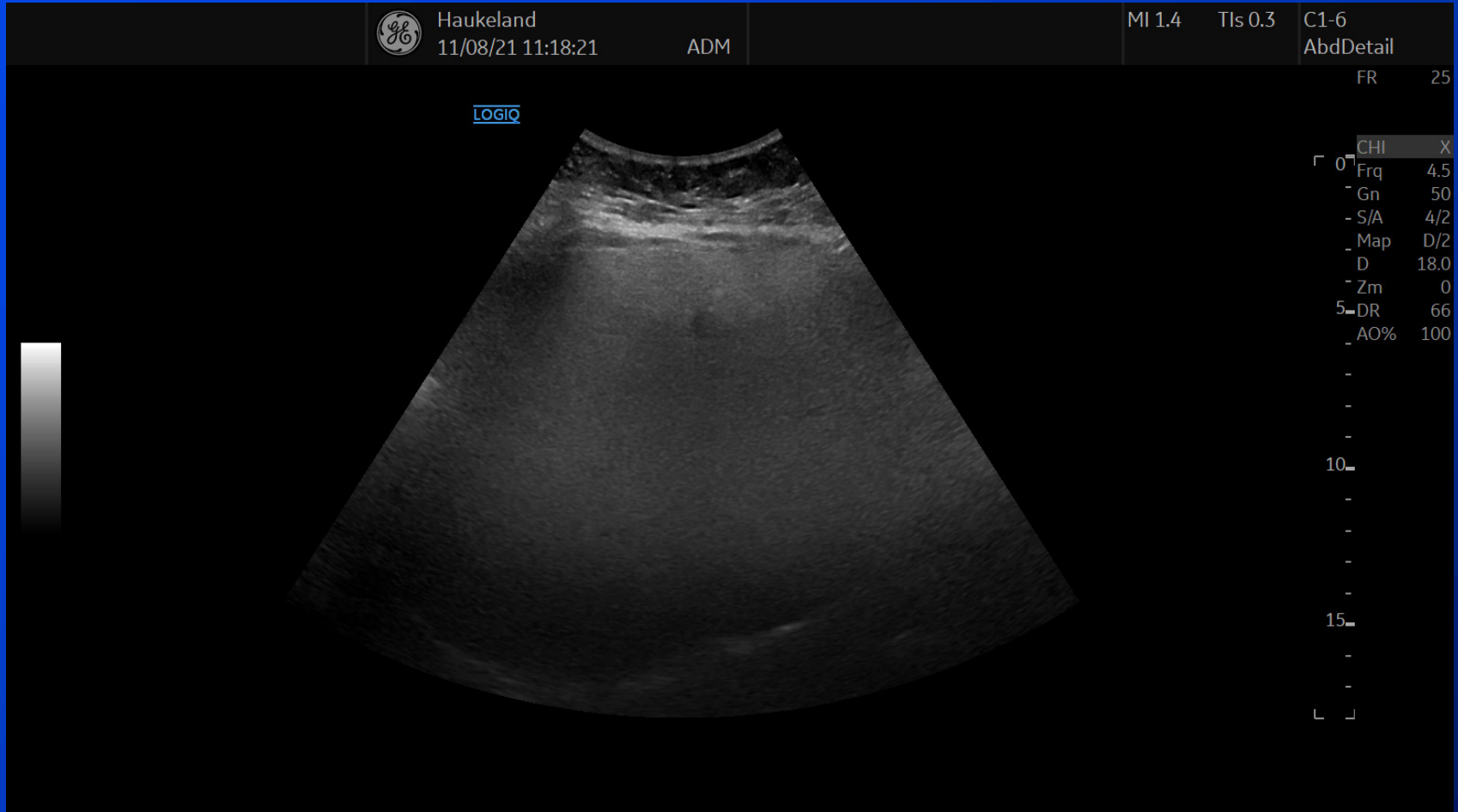


2 Years after





Alcoholic steatosis





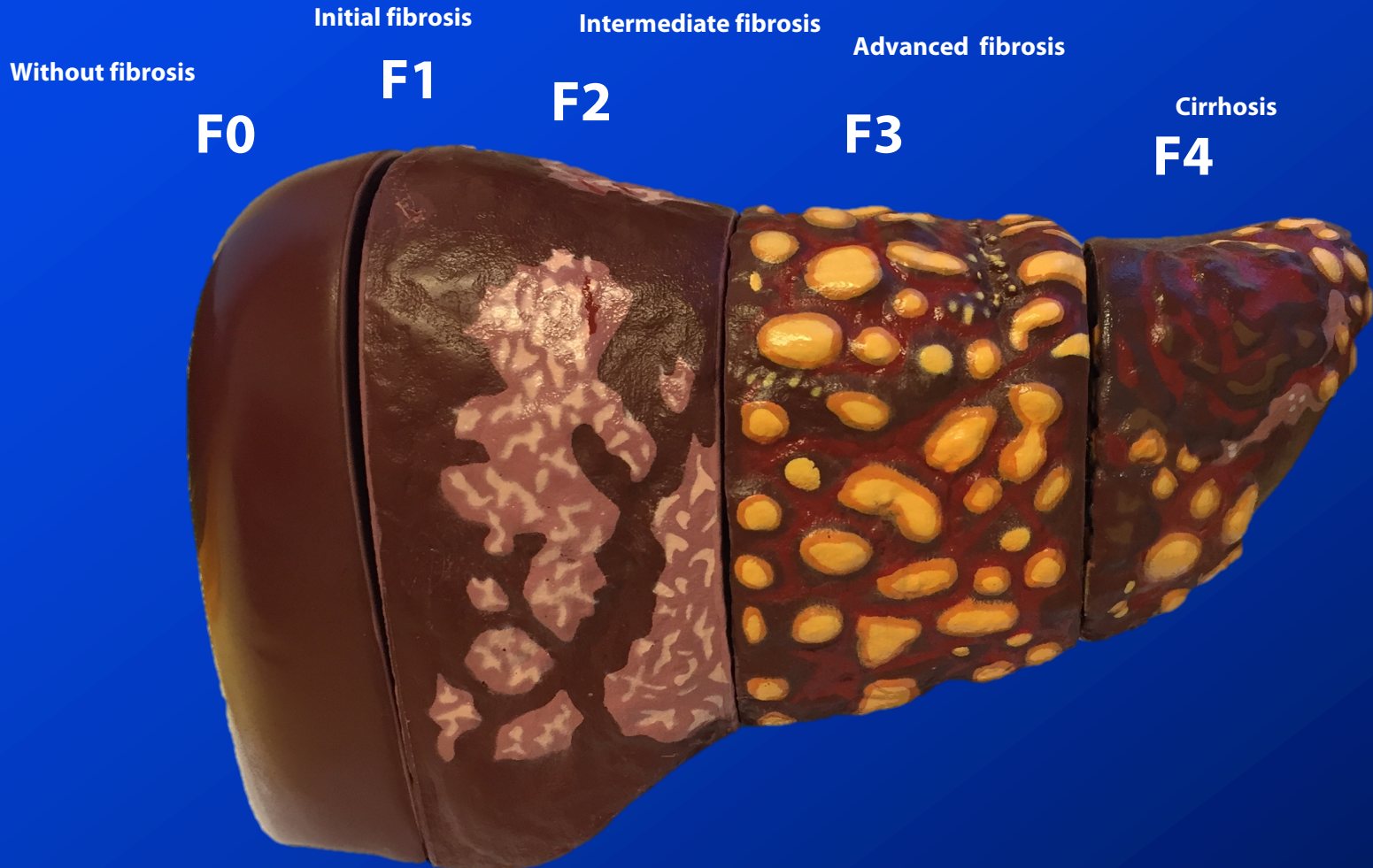
”Doctor, I drink only 1 glass
per day !”





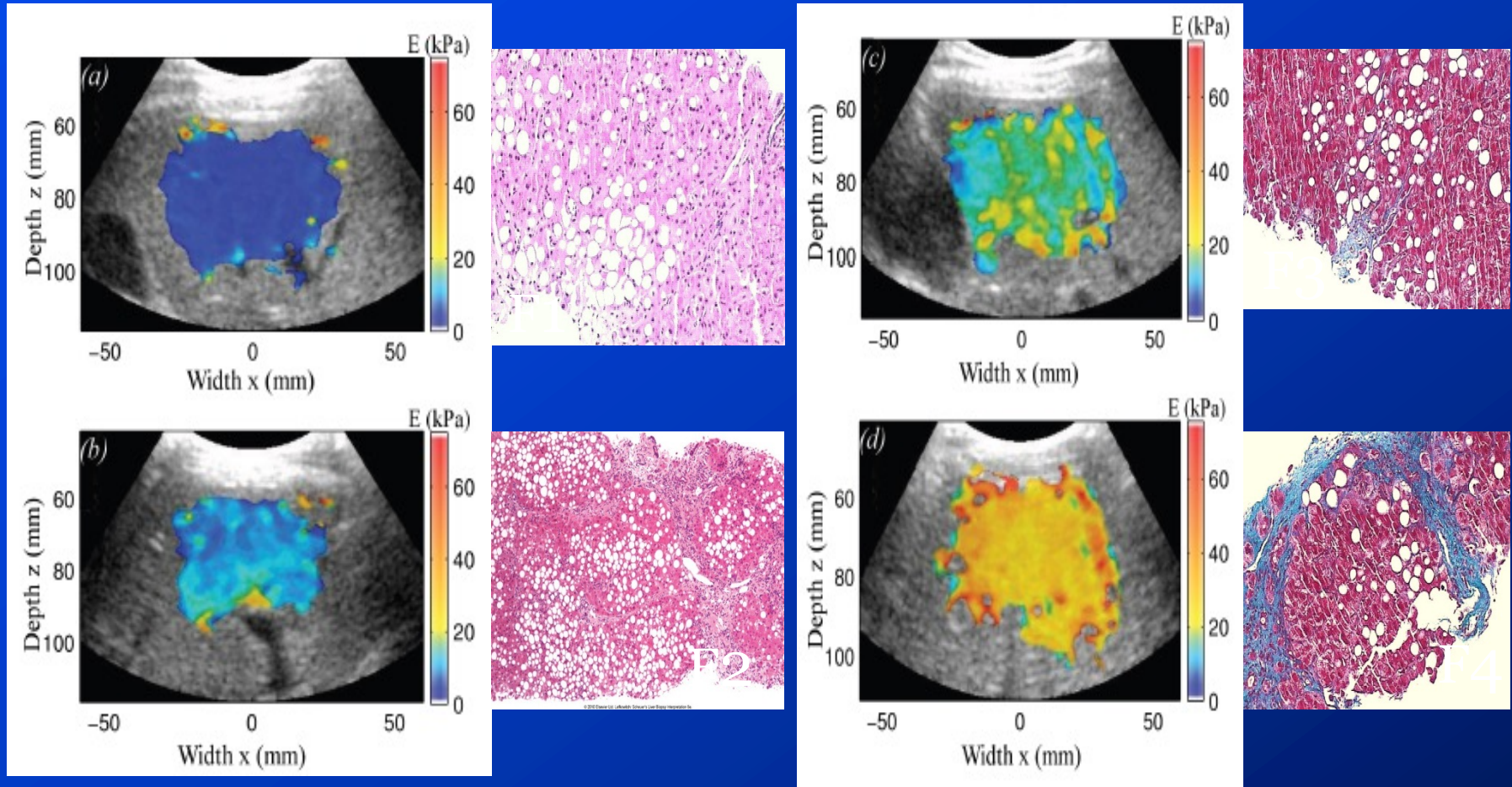
Fibrosis staging

The Metavir Score





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

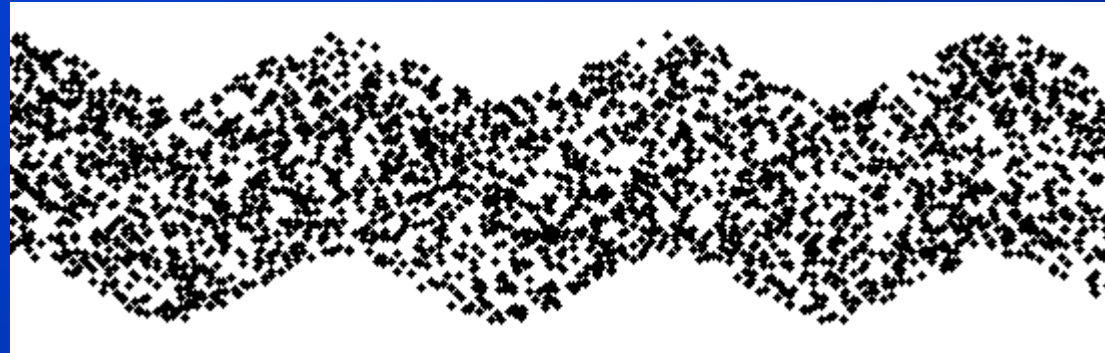
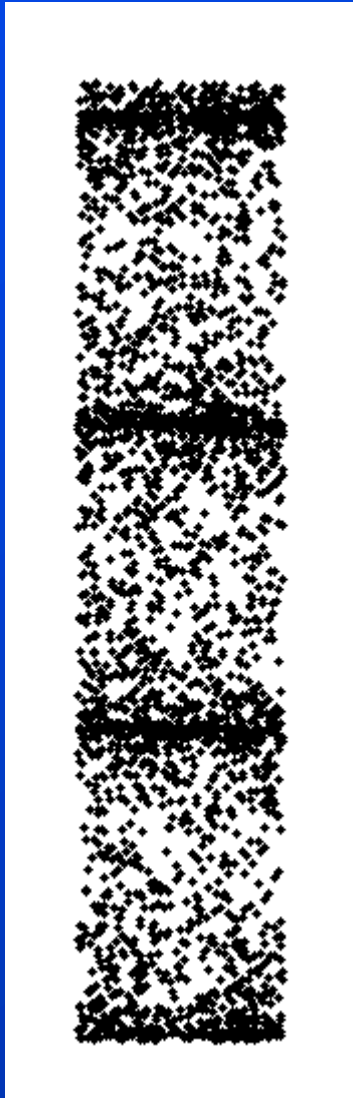


Longitudinal and Shear Waves

Ultrasound
Wave

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

$c_l \sim 1540$ m/s
in tissue



Shear Wave

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

$c_t = 1-10$ m/s in tissue



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

**Christoph F. Dietrich^{1,2}, Jeffrey Bamber³,
Annalisa Berzigotti⁴, Simona Bota⁵, Vito Cantisani⁶,
Laurent Castera⁷, David Cosgrove⁸, Giovanna Ferraioli⁹,
Mireen Friedrich-Rust¹⁰, Odd Helge Gilja¹¹,
Ruediger Stephan Goertz¹², Thomas Karlas¹³, Robert de
Knegt¹⁴, Victor de Ledinghen¹⁵, Fabio Piscaglia¹⁶,
Bogdan Procopet¹⁷, Adrian Saftoiu¹⁸, Paul S. Sidhu¹⁹,
Ioan Sporea²⁰, Maja Thiele²¹**

13 Department for Internal Medicine, Division of Gastroenterology and Rheumatology, University Hospital Leipzig, Leipzig, Germany

14 Department of Gastroenterology and Hepatology, Erasmus MC University Medical Center, Rotterdam, the Netherlands

15 Non-invasive diagnosis of liver fibrosis centre, Haut-Leveque hospital, Bordeaux University Hospital, Pessac, France

16 Unit of Internal Medicine, Dept. of Medical and Surgical



SWE in Hepatitis C and B

RECOMMENDATION 18

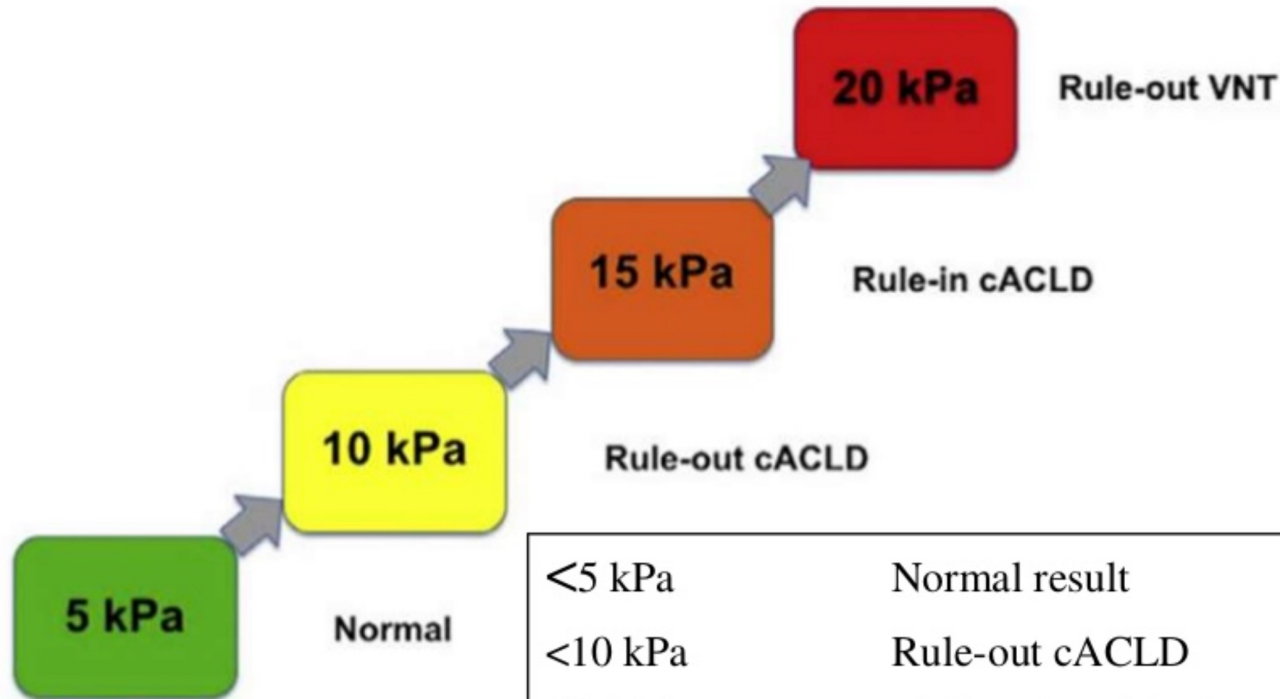
2D-SWE as demonstrated with SSI can be used as a first-line assessment for the severity of liver fibrosis in patients with chronic viral hepatitis C. It performs best with regard to the ruling out of cirrhosis (LoE 1b, GoR A) [139, 158, 159]. Broad consensus (17/0/1, 94%)

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%)



Rule of 5 in Elastography



<5 kPa	Normal result
<10 kPa	Rule-out cACLD
10-15 kPa	cACLD (need further confirmation)
15-20 kPa	Rule-in cACLD
> 20 kPa	Rule-in clinically significant PHT

cACLD: compensated advanced chronic liver disease – kPa: kilopascal

VNT: varices needing treatment

de Franchis R, Baveno VIF. J Hepatol 2015;63:743–752.



SWE guidelines

Table 2: Recommendation for Interpretation of Liver Stiffness Values Obtained with ARFI Techniques in Patients with Viral Hepatitis and NAFLD

Liver Stiffness Value	Recommendation
≤ 5 kPa (1.3 m/sec)	High probability of being normal
< 9 kPa (1.7 m/sec)	In the absence of other known clinical signs, rules out cACLD. If there are known clinical signs, may need further test for confirmation
9–13 kPa (1.7–2.1 m/sec)	Suggestive of cACLD but need further test for confirmation
> 13 kPa (2.1 m/sec)	Rules in cACLD
> 17 kPa (2.4 m/sec)	Suggestive of CSPH

Note.—ARFI = acoustic radiation force impulse, cACLD = compensated advanced chronic liver disease, CSPH = clinically significant portal hypertension, NAFLD = non-alcoholic fatty liver disease.



Elastography – F0 - normal



Haukeland
26/04/22 11:06:42

ADM

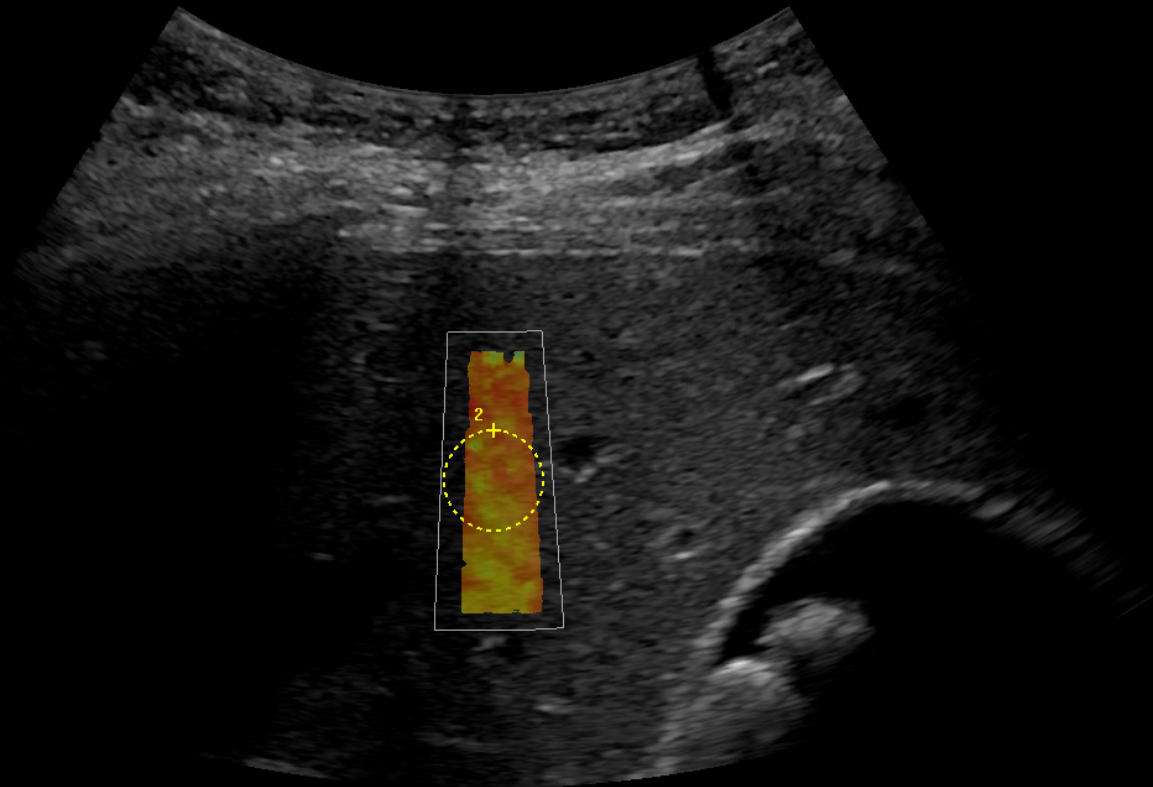
MI 1.4

TIs 1.0

C1-6
AbdDetail

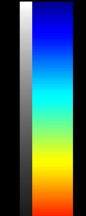
FR 1

LOGIQ



CHI	
Frq	6.5
Gn	44
D	7.0
AO%	100
E	
Gn	55
T	8
SVD	3.9
PO%	100
TO%	100
f50-400Hz	
Gen	

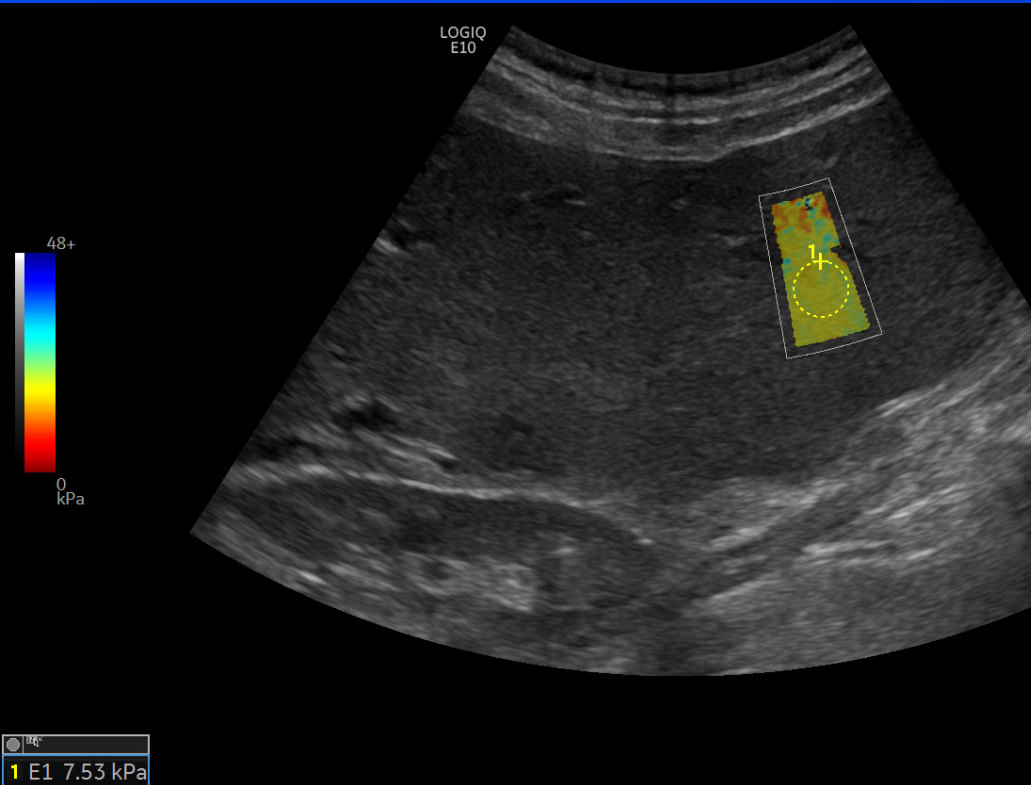
48+



3	E3	3.36 kPa
4	E4	3.39 kPa
5	E5	3.41 kPa
6	E6	3.31 kPa
7	E7	3.63 kPa
8	E8	3.46 kPa
9	E9	3.61 kPa
1	E10	3.81 kPa
2	E1	3.67 kPa



Elastography – F1



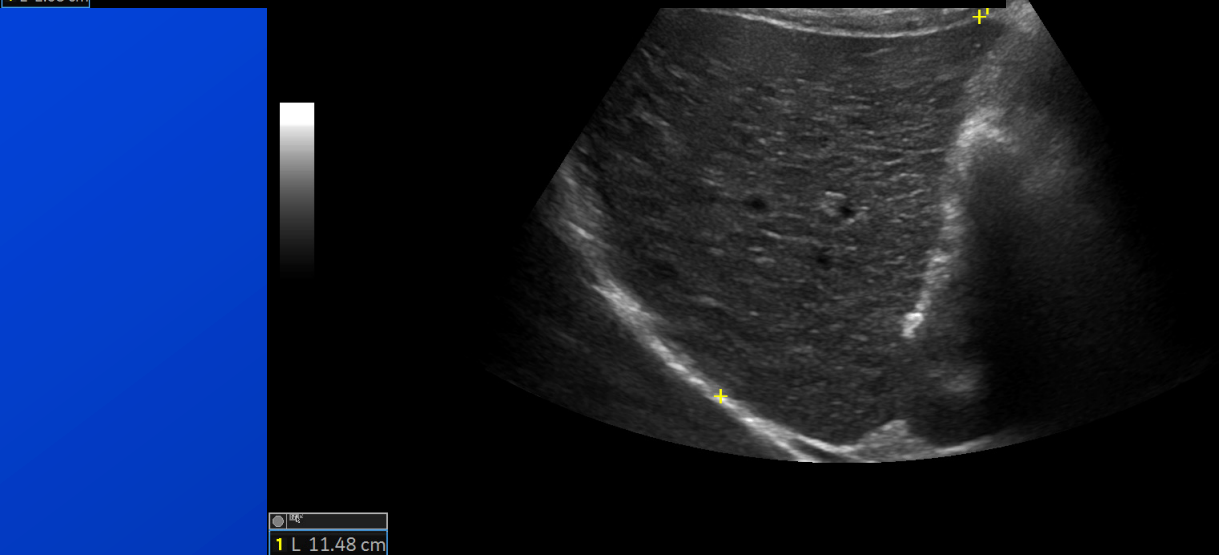
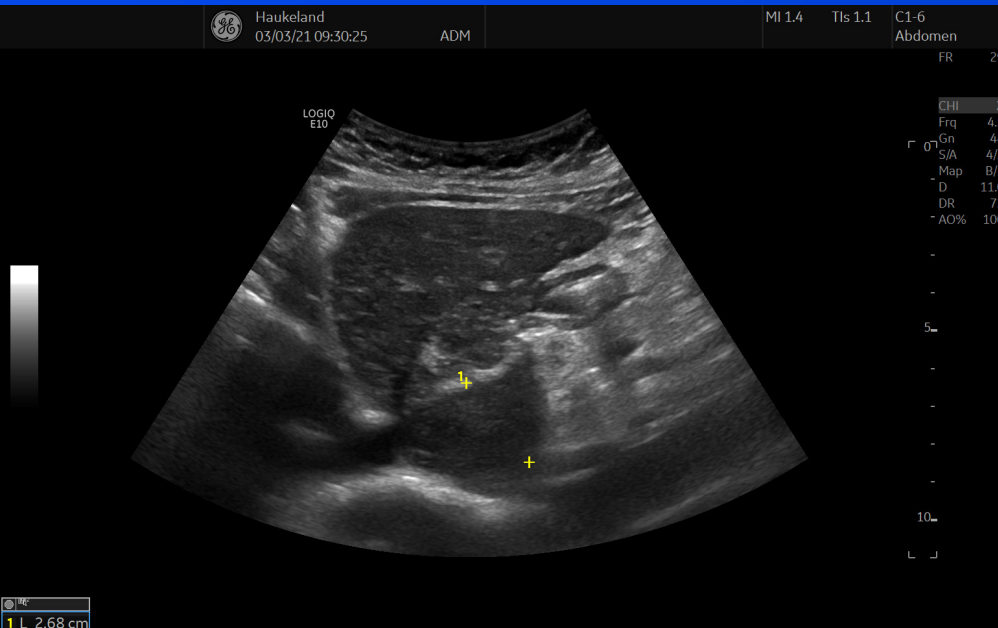
Haukeland
03/03/21 09:50:20

ADM

Parameter	Value	m1	m2	m3
B Mode Measurements				
Stiffness, kPa				
E1	7.30 kPa	7.53	7.30	
E2	7.49 kPa	7.49		
E3	7.73 kPa	7.73		
E4	7.18 kPa	7.18		
E5	7.54 kPa	7.54		
E6	7.88 kPa	7.88		
E7	7.81 kPa	7.81		
E8	7.83 kPa	7.83		
E9	7.93 kPa	7.93		
E10	7.86 kPa	7.86		
E Median	7.77 kPa			
E IQR	0.35 kPa			
E IQR/Median	4.5 %			



Liver fibrosis - F3



Parameter	Value	m1
B Mode Measurements		
Stiffness, kPa		
E1	9.24 kPa	11.45
E2	7.46 kPa	7.46
E3	10.90 kPa	10.90
E4	11.87 kPa	11.87
E5	10.11 kPa	10.11
E6	10.93 kPa	10.93
E7	11.86 kPa	11.86
E8	11.18 kPa	11.18
E9	8.72 kPa	8.72
E10	11.25 kPa	11.25
E Median	10.91 kPa	
E IQR	1.78 kPa	
E IQR/Median	16.3 %	



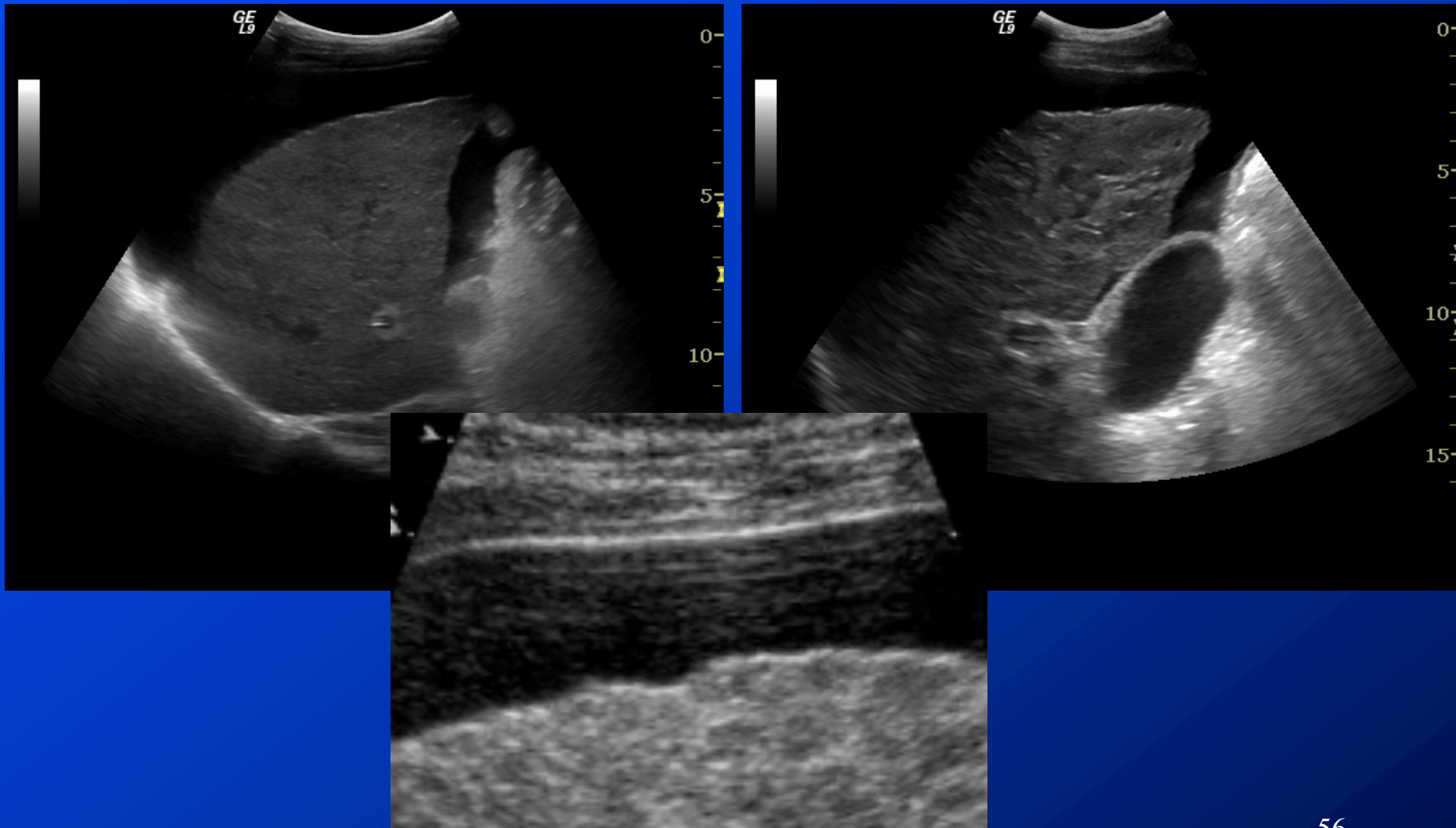
Ultrasound elastography

- 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

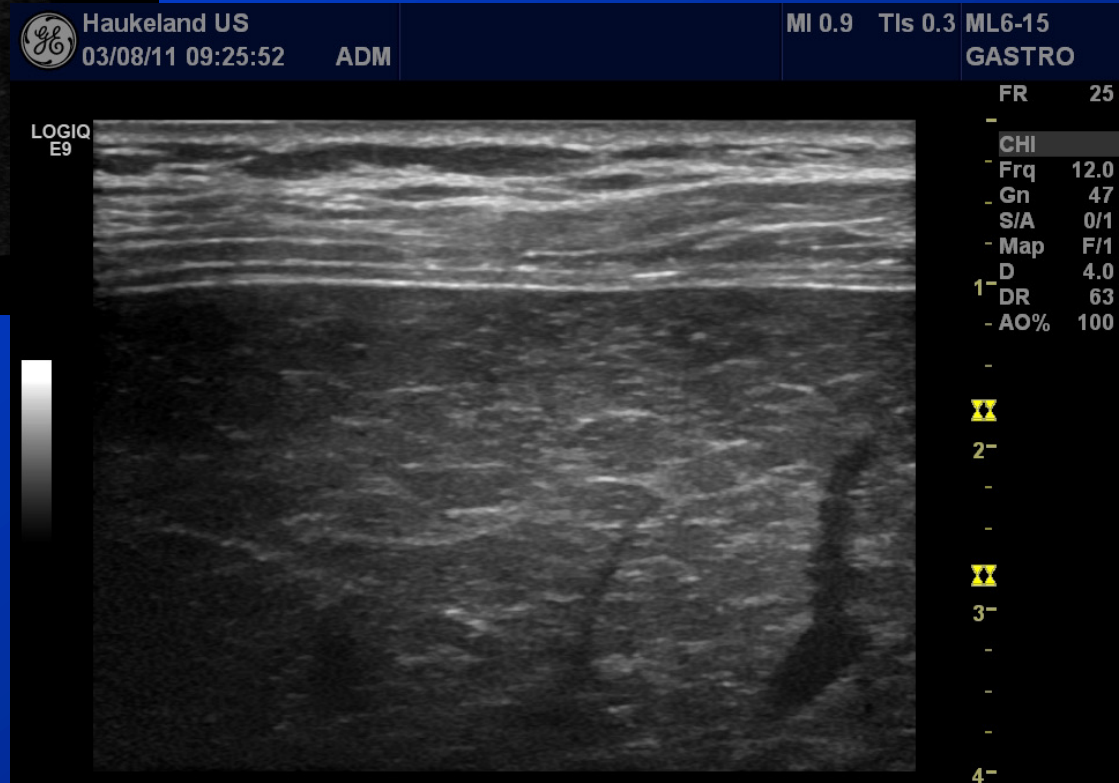
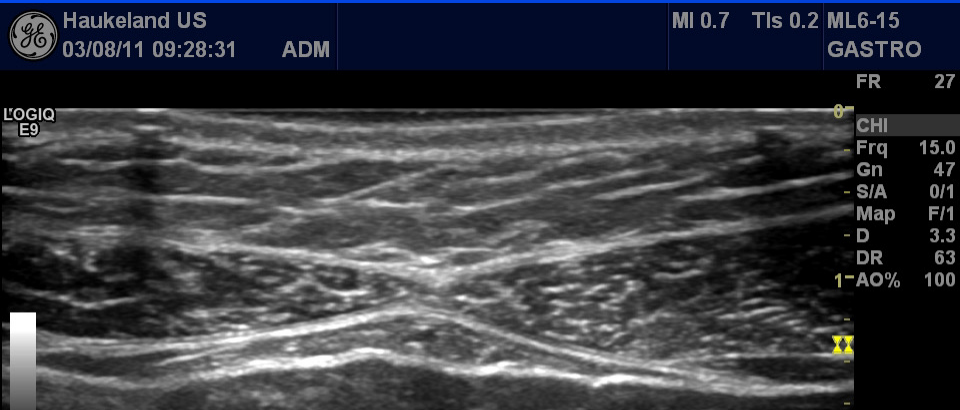


Liver cirrhosis





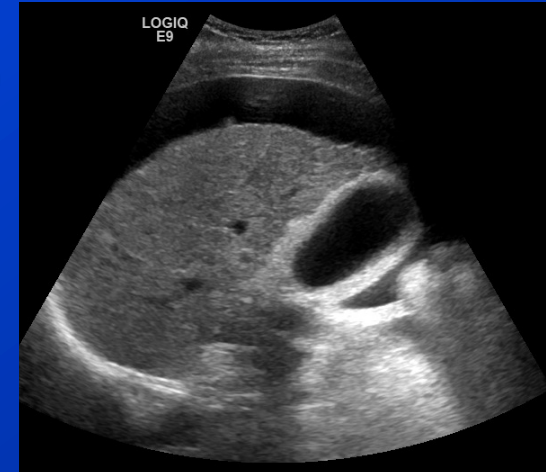
Look at details with high frequency





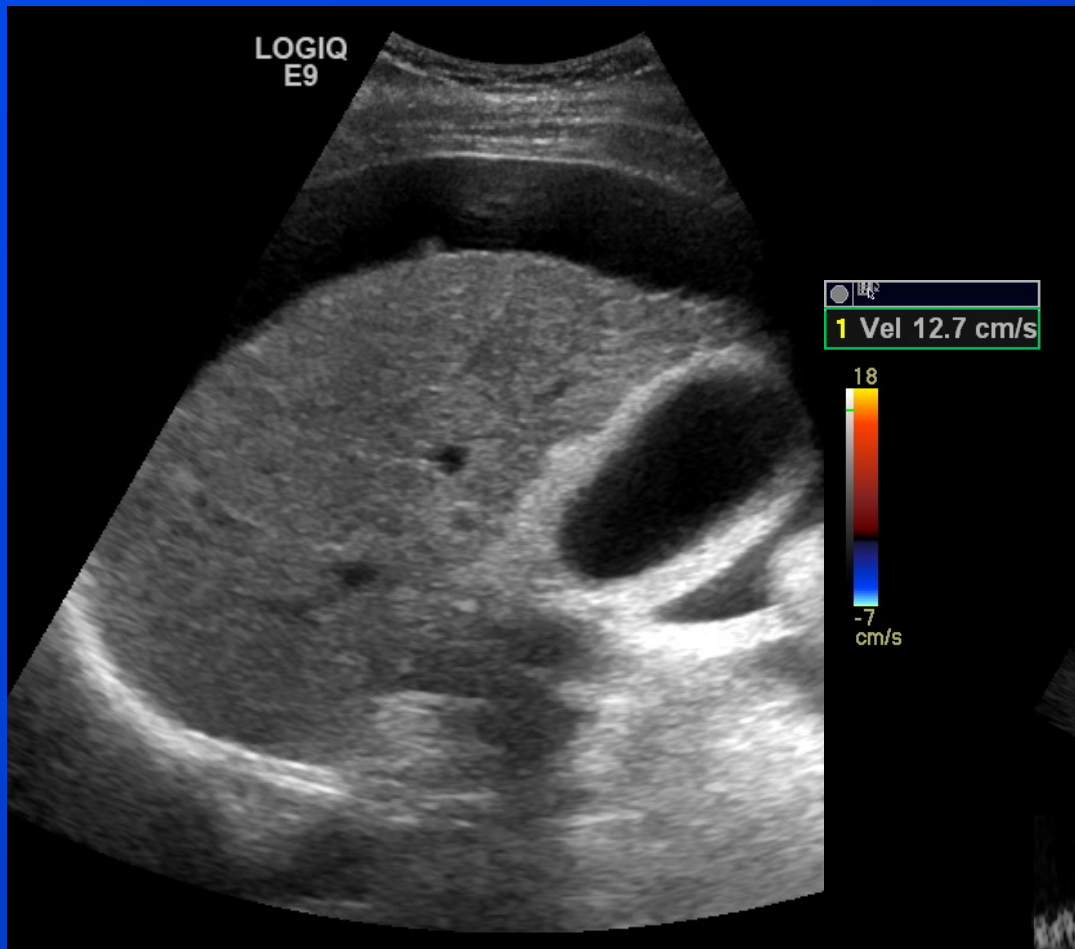
Ultrasound in the evaluation of cirrhotic livers

- Size of liver
- Size of left lobe and caudate lobe
- Capsule smoothness
- Ascites
- Echogenicity, homogeneity, 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**

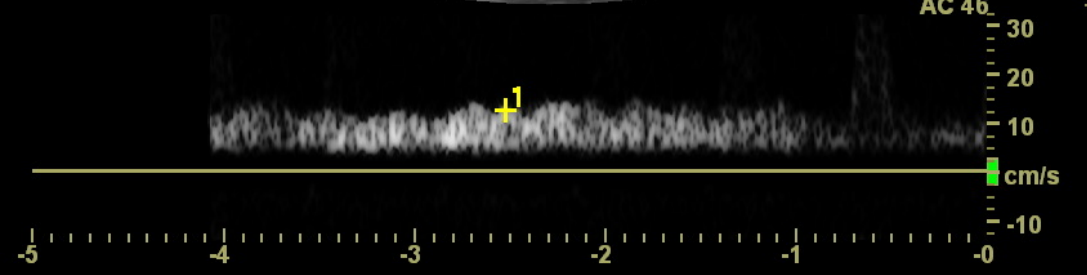
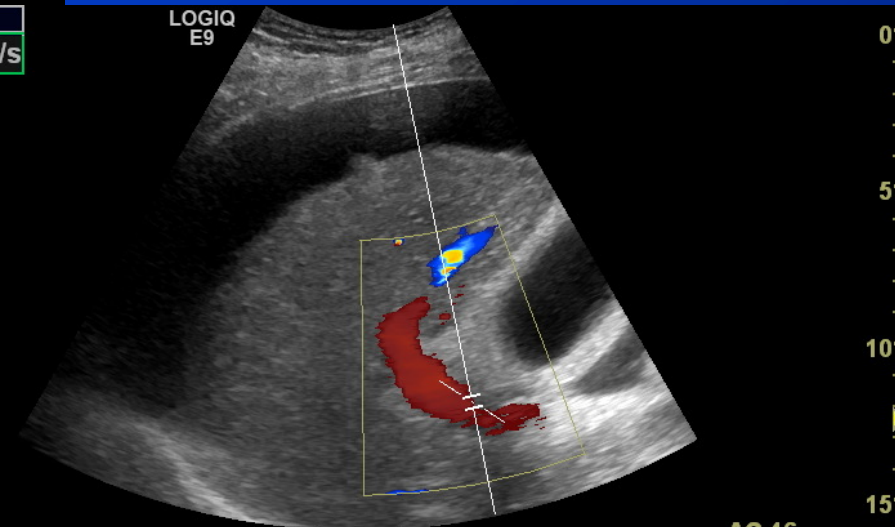




Liver Cirrhose

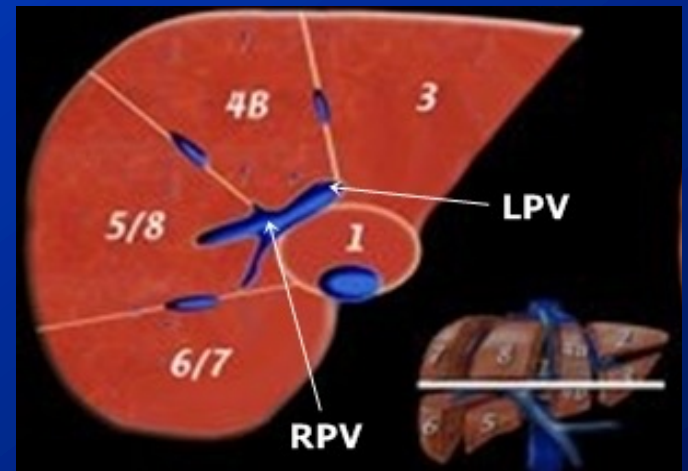
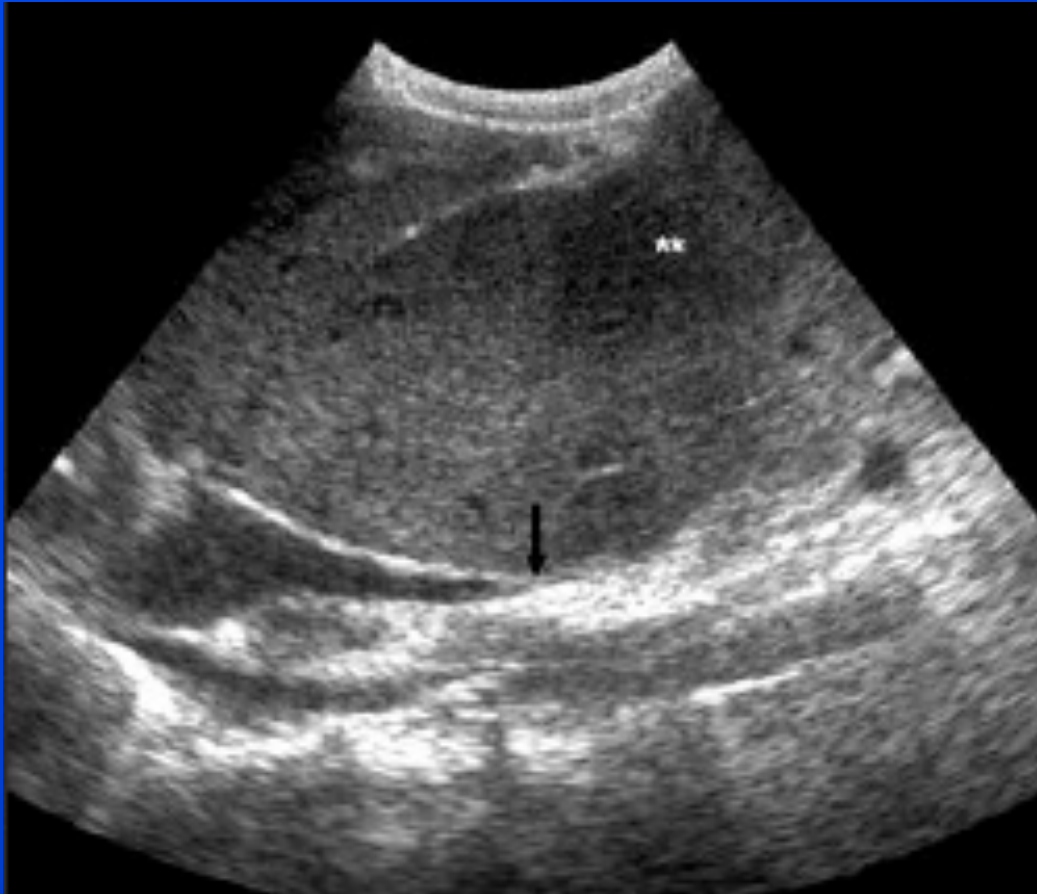


1 Vel 12.7 cm/s





Enlarged caudate lobe

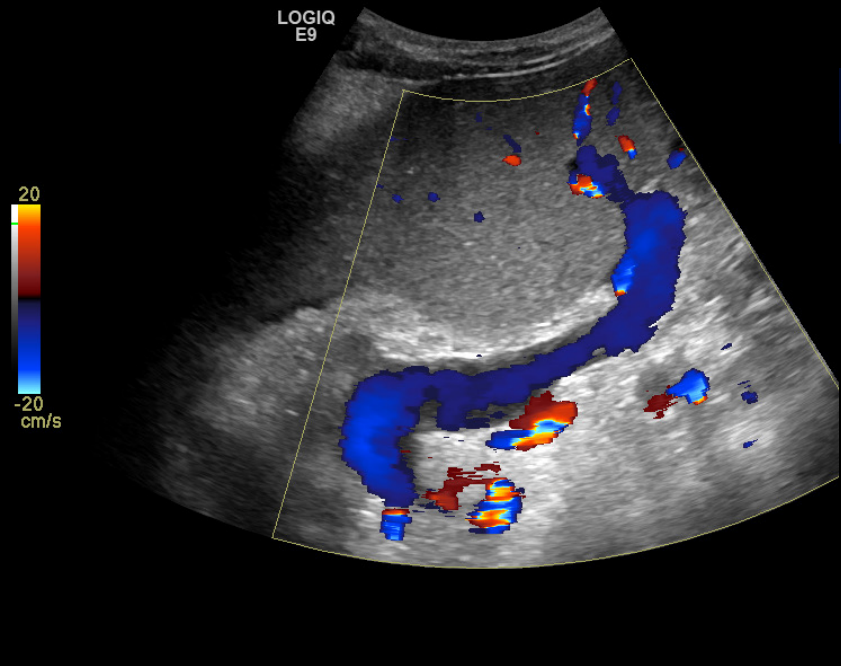




Dilated splenic vein in Portal HT

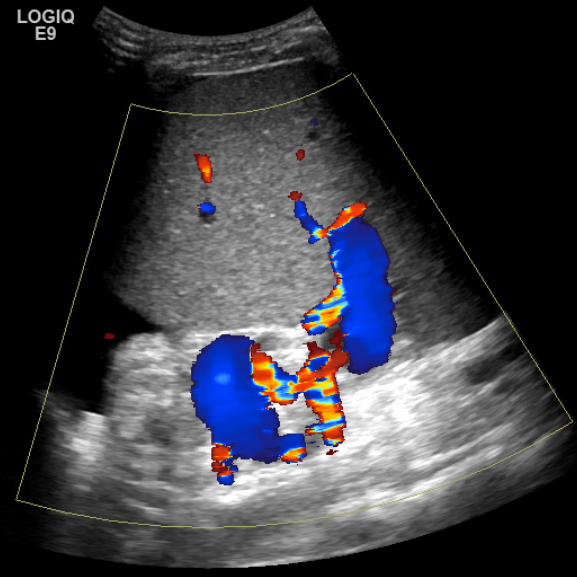
GE Healthcare
02/10/10 10:20:42 ADM MI 1.1 TIs 1.0 C1-5
GASTRO

FR	9
CHI	
Frq	4.0
Gn	59
D	14.0



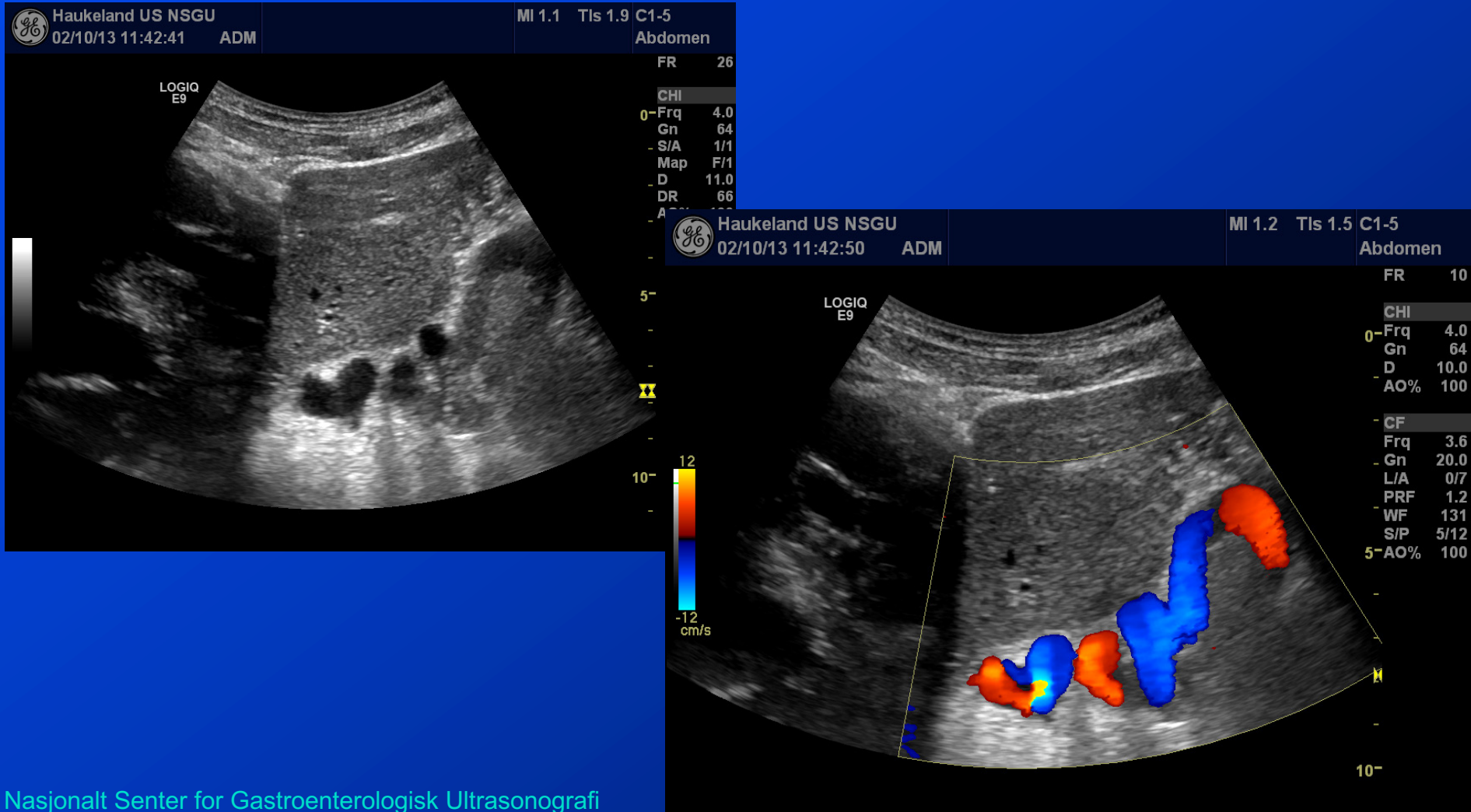
GE Healthcare
02/10/10 10:20:01 ADM MI 1.0 TIs 0.9 C1-5
GASTRO

FR	9
CHI	
Frq	4.0
Gn	59
D	16.0
AO%	100
CF	
Frq	2.5
Gn	14.0
L/A	0/7
PRF	1.3
WF	147
S/P	5/12
AO%	100





Esophageal Varices





Portal Vein Thrombosis

Haukeland US 06/02/10 11:21:28 ADM MI 0.9 TIs 1.4 C1-5 GASTRO



FR 24
CHI
0- Frq 4.0
- Gn 75
- S/A 1/1

Haukeland US 06/02/10 11:20:36 ADM MI 0.9 TIs 1.2 C1-5 GASTRO



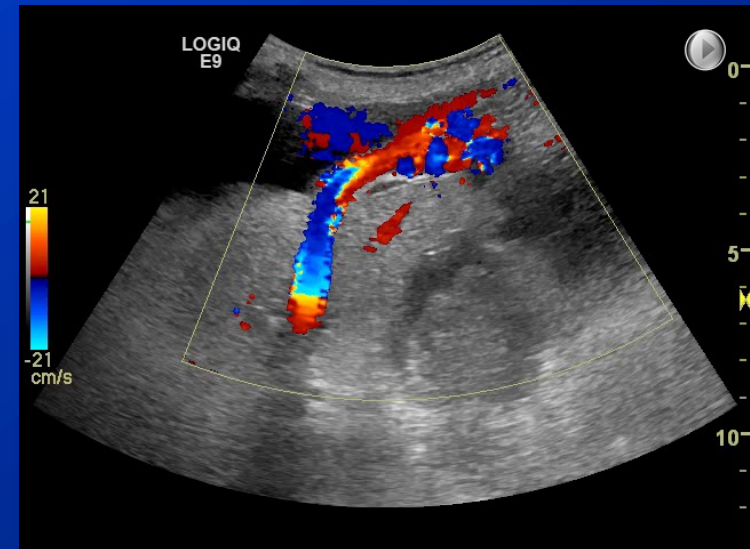
20
-20
cm/s

FR 12
CHI
0- Frq 4.0
- Gn 75
- D 14.0
- AO% 100
- CF
- Frq 3.6
- Gn 20.0
5- L/A 0/7
- PRF 1.9
- WF 140
- S/P 5/12
- AO% 100



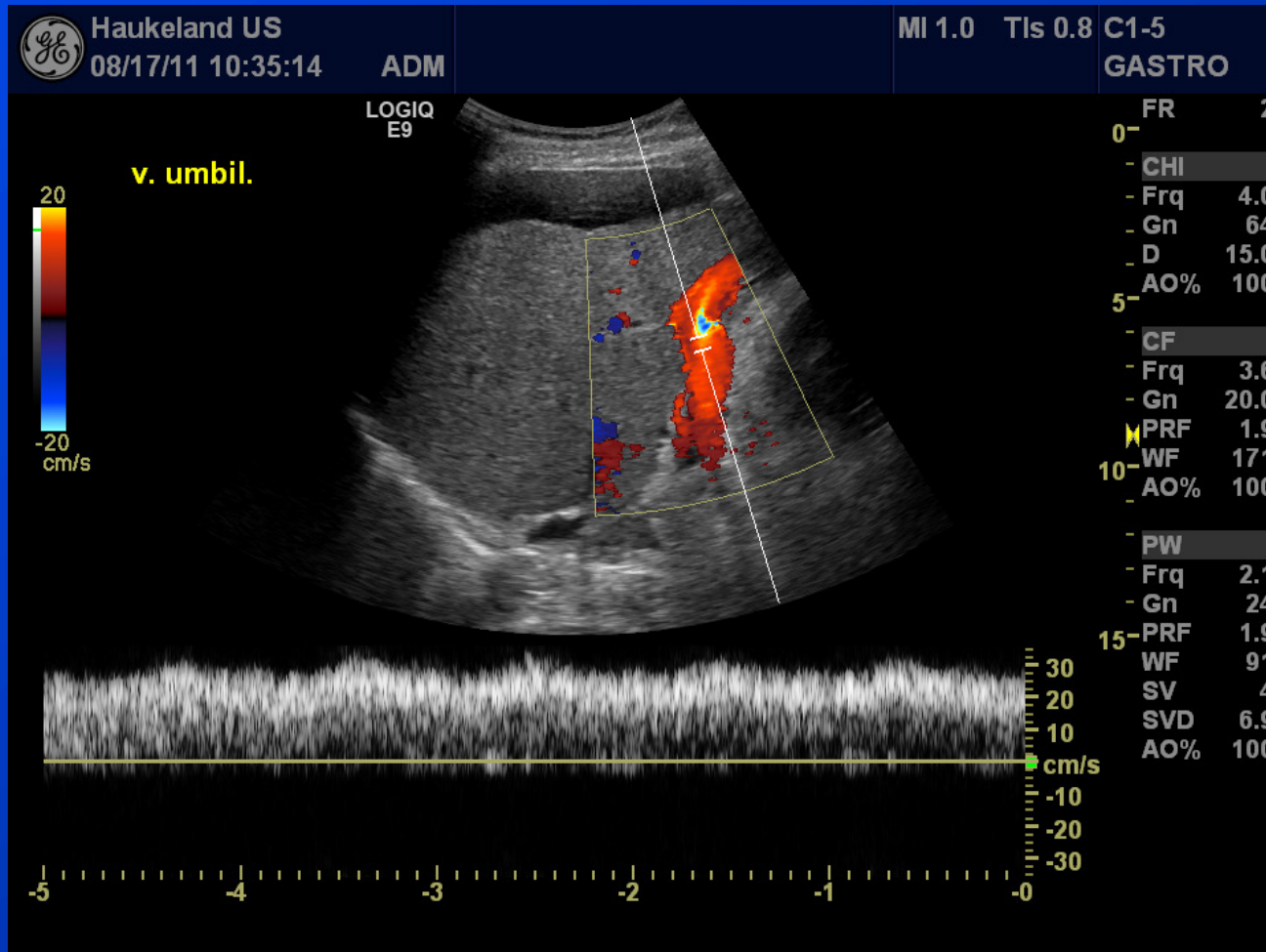
Signs (indirect) of portal hypertension seen by US

- Dilated portal vein (>13 mm)
- Decreased velocity in portal vein (<13 cm/sec)
- Reversed flow in portal vein
- Dilated splenic vein (> 10 mm)
- Shunts in the splenic hilum
- Recanalization of umbilical vein
- Enlarged spleen
- Esophageal varices
- Hypertensive gastropathy



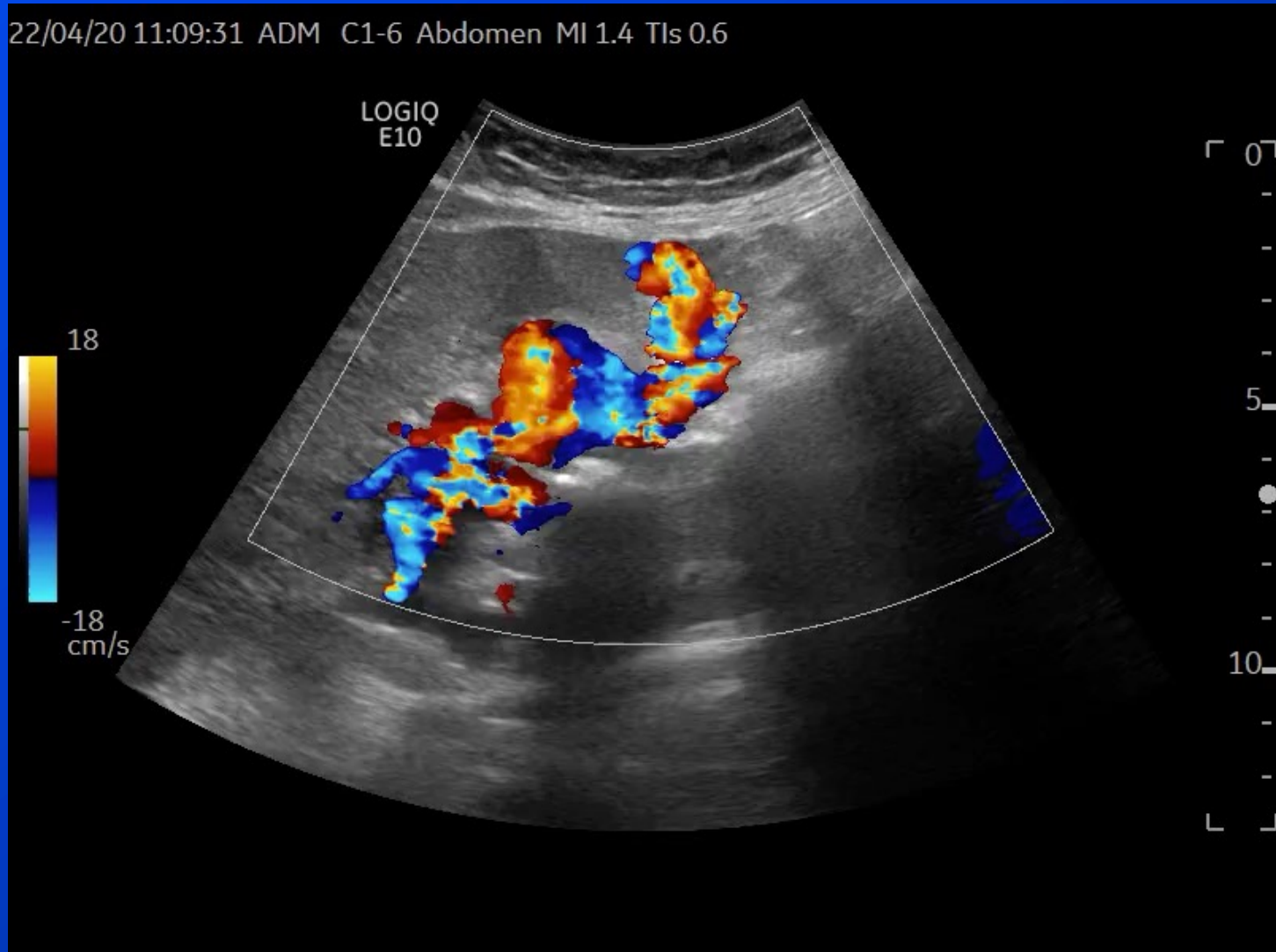


Persistent umbilical vein



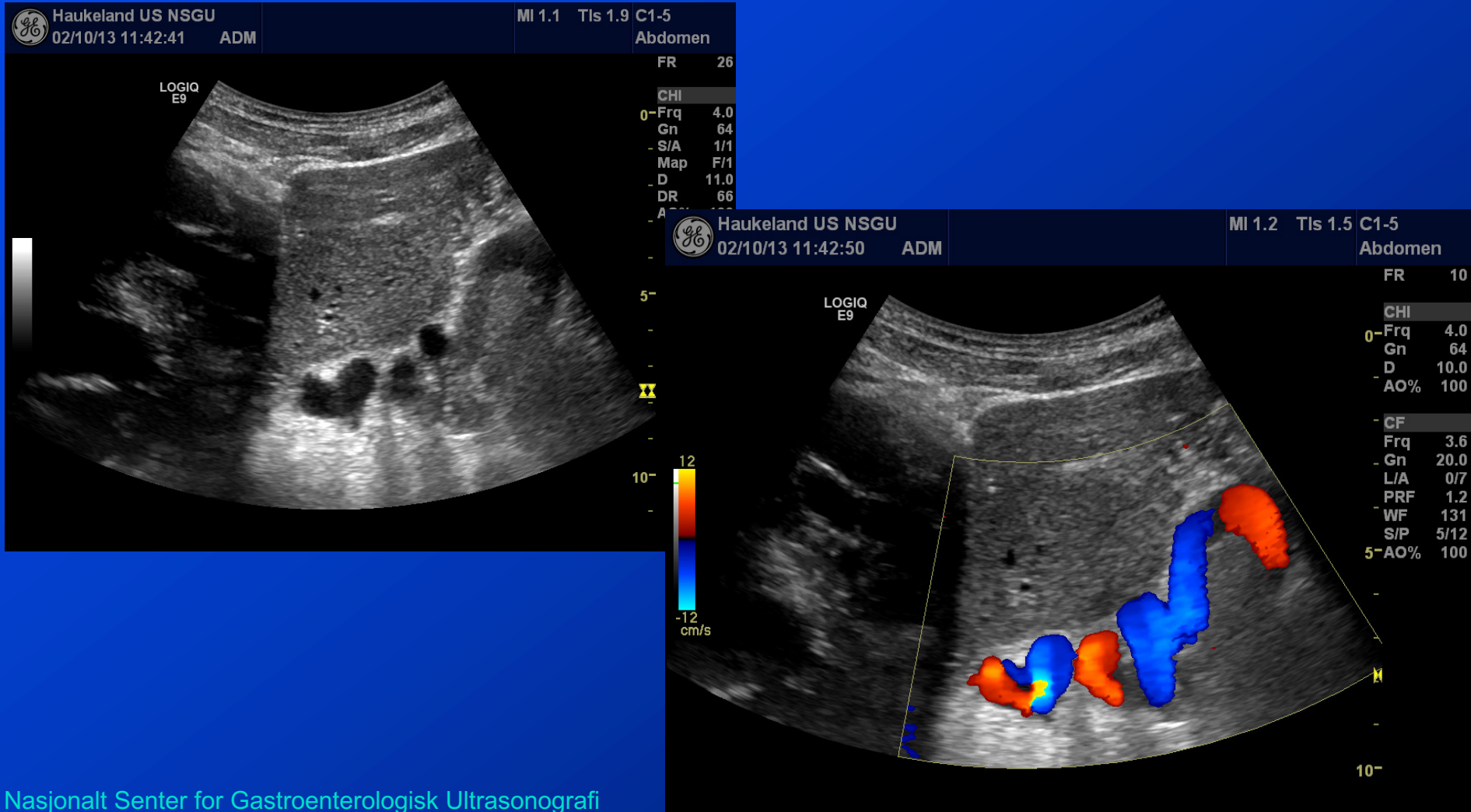


Splenic shunts





Esophageal Varices detected with transabdominal ultrasound





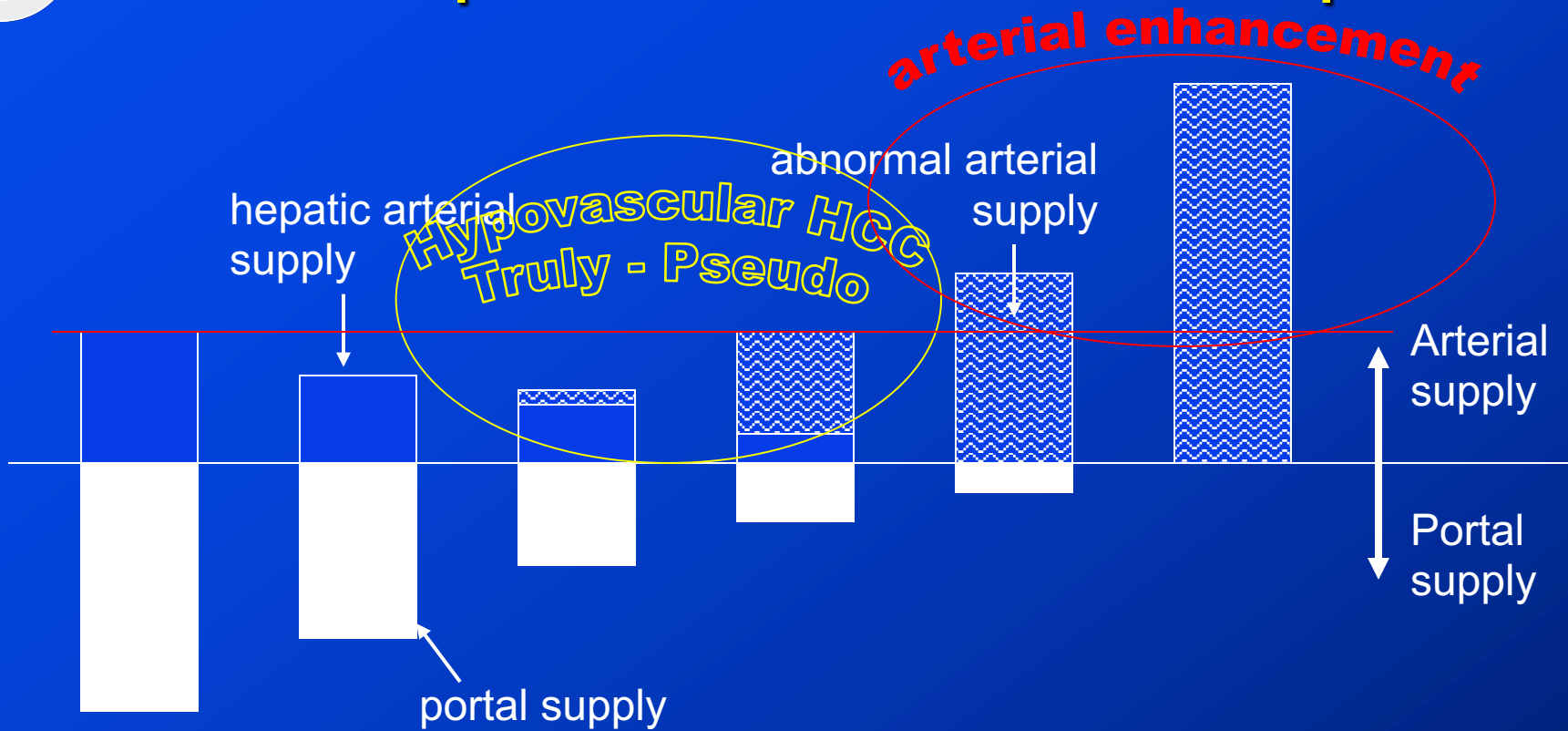
HCC facts

HCC – The great imitator

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



The Sequence of HCC Development



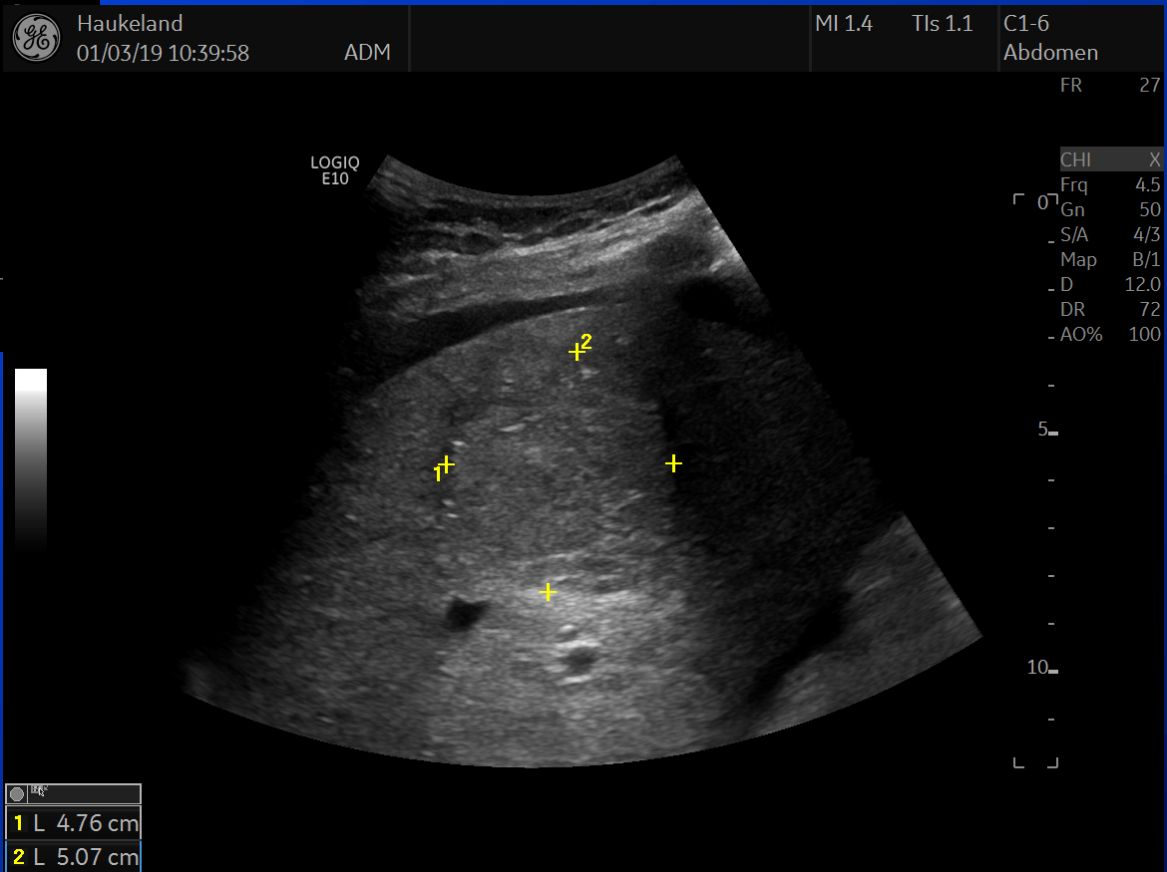
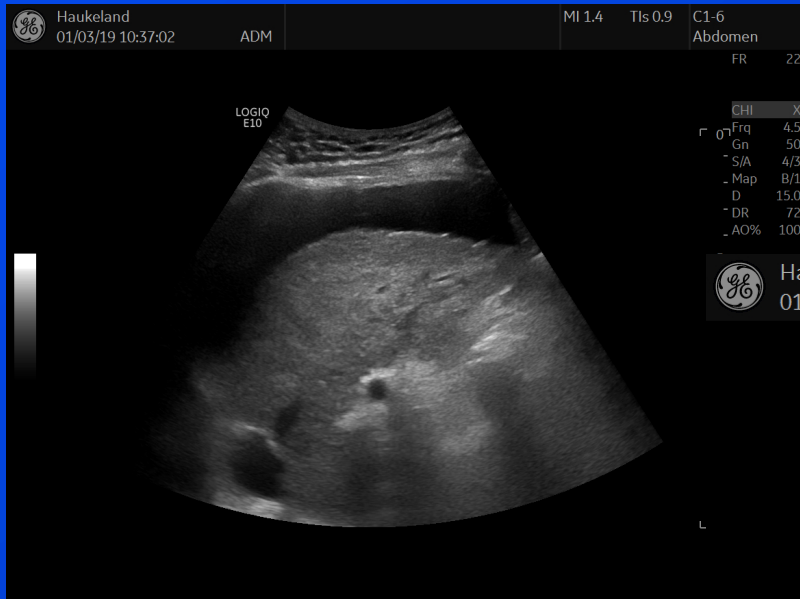
LRN ~ LGDN ~ HGDN ~ e-HCC ~ wdHCC ~ classical HCC

early HCC

*from: Matsui, Clin Hep Gastro, 2005.
(based on CT-arteriportal-angiography)*

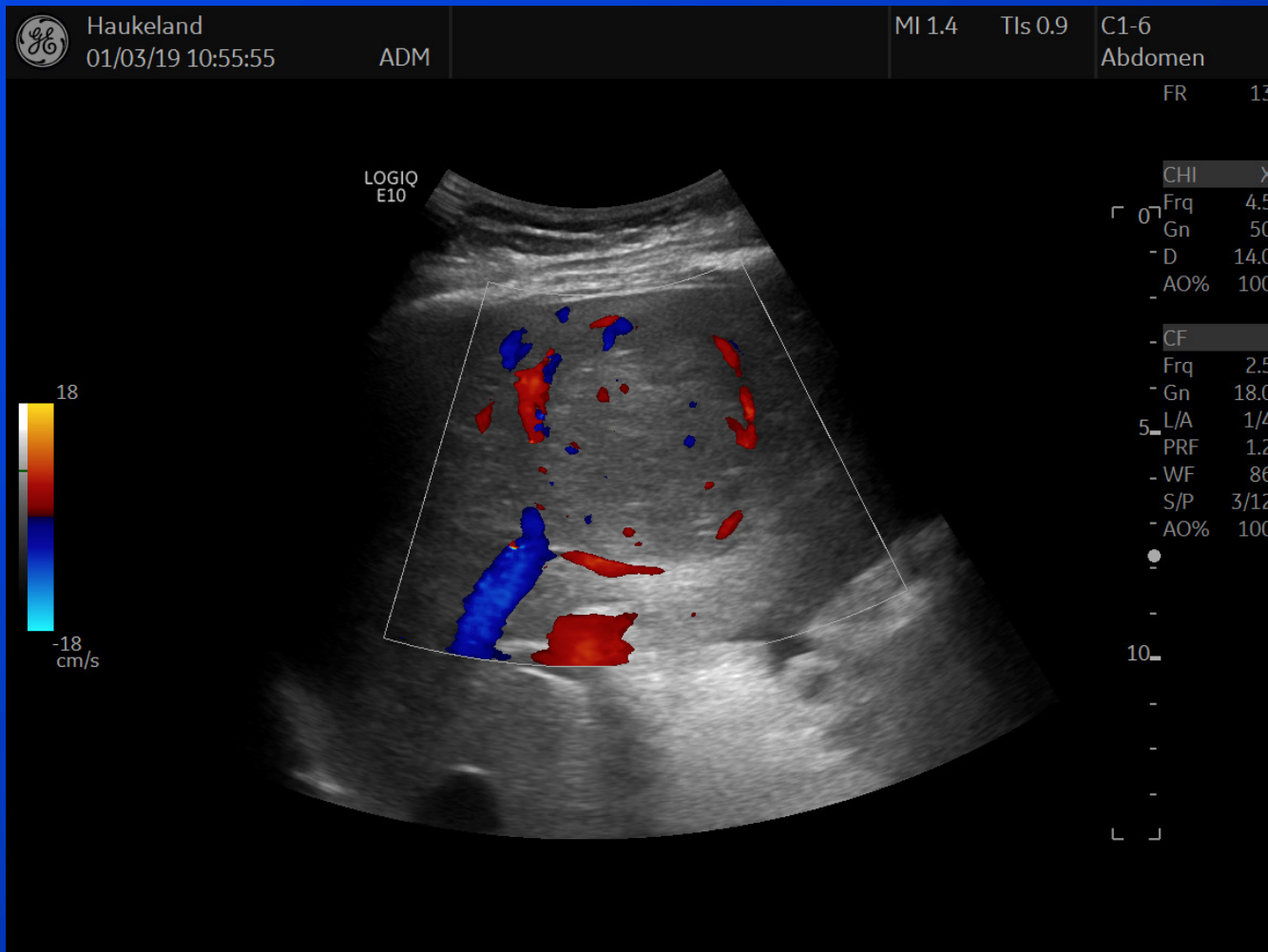


A patient with cirrhosis





«The Basket Sign»





One stop shopping

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

