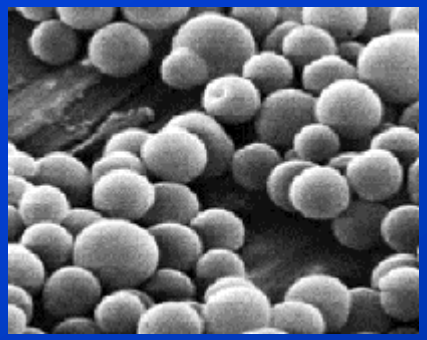
Nasjonalt Senter for
Gastroenterologisk Ultrasonografi

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

Ultrasound of the liver - FLLs



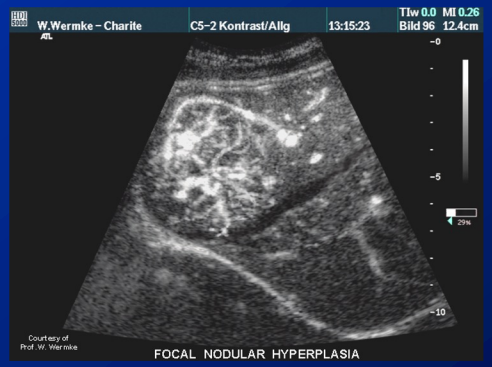
Odd Helge Gilja, MD, PhD

Professor

Department of Medicine

Haukeland University Hospital

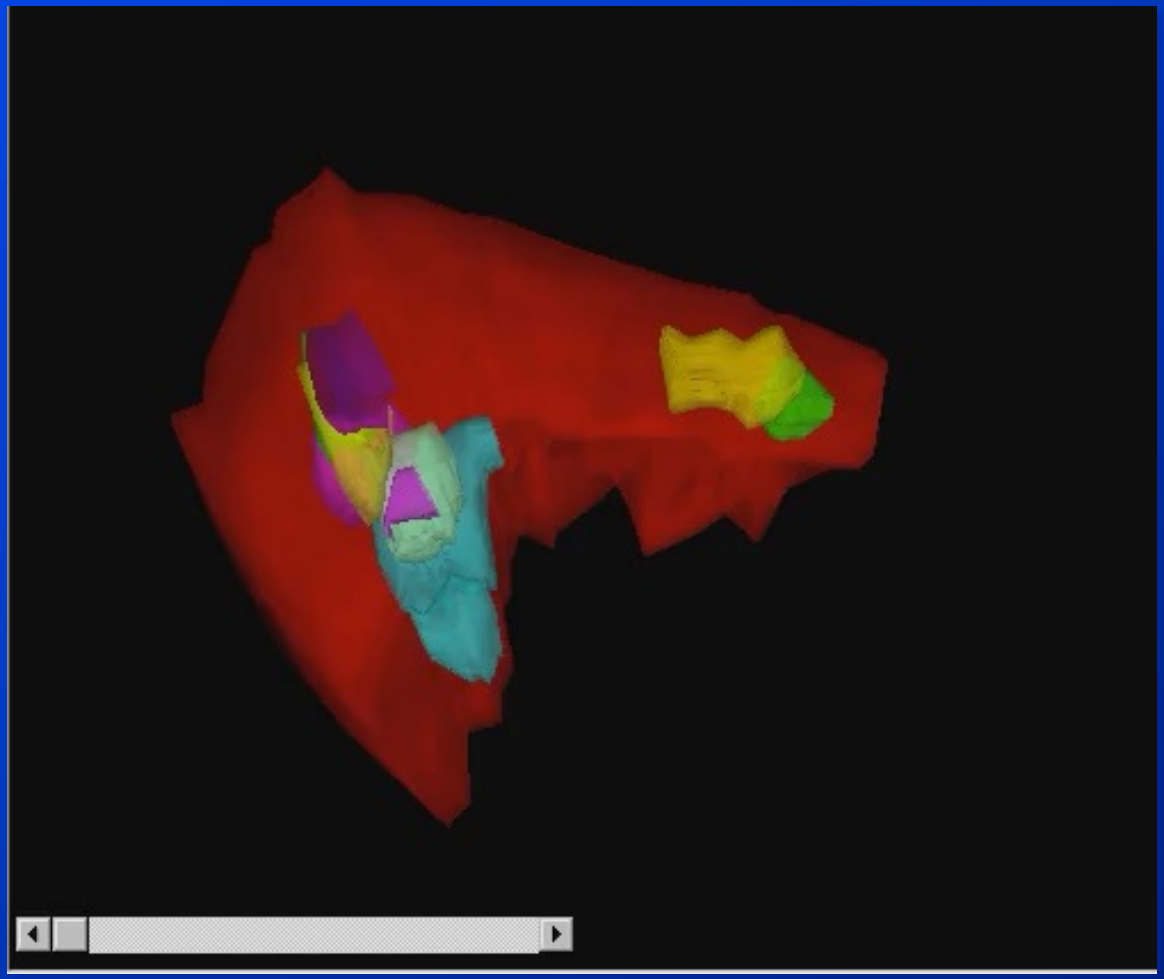
Bergen, Norway



Agenda

- General aspects of liver US
- Diffuse Liver diseases
  - Fatty liver disease
  - Fibrosis of the liver
  - Liver cirrhosis
- Focal Liver diseases
  - Benign focal liver lesions
  - Malignant liver diseases
    - Hepatocellular carcinoma
    - Liver metastases
- CEUS (Contrast Enhanced UltraSound)
- Elastography – Strain Imaging

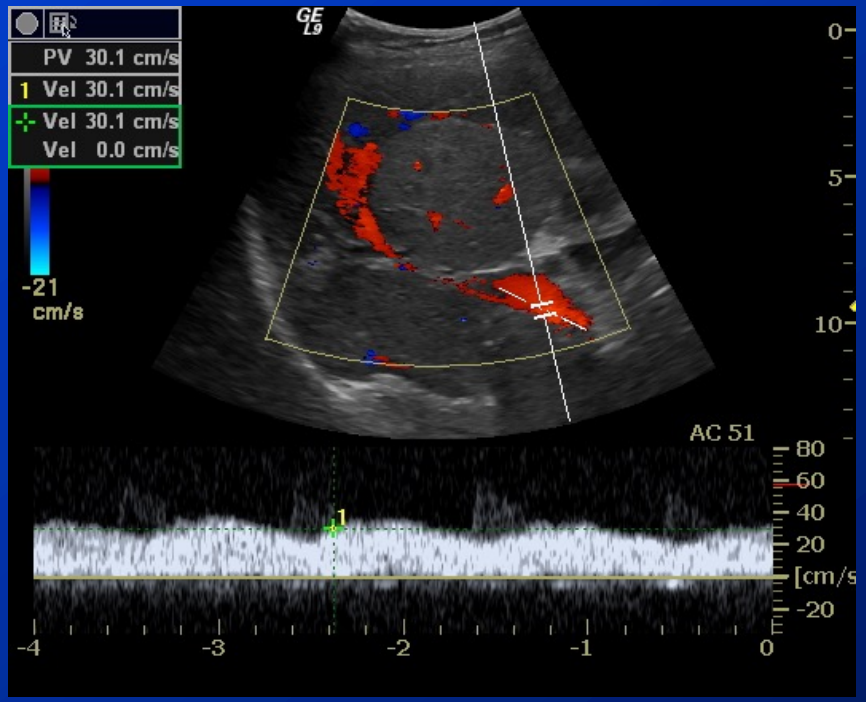
Detection and characterization of Focal Liver Lesions



Hausken, Gilja et al., 1999

Ultrasonographic work-up

- Ultrasound of liver
  - 2D og 3D
  - Doppler
    - Color Doppler
    - Pulsed Doppler
  - Elastography
    - Strain imaging
    - Shear wave
  - Contrast-US (CEUS)

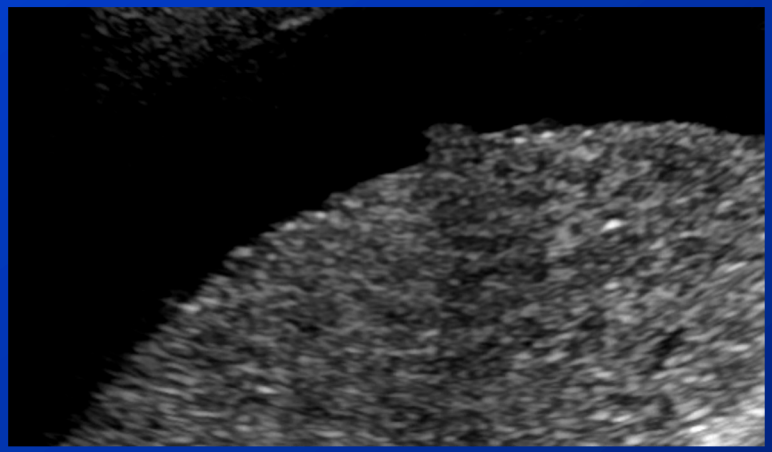


- US-guided liver biopsy (Menghini and Pistol)
- US-guided ablation techniques

Ultrasound of the Liver

-What do we look for ?

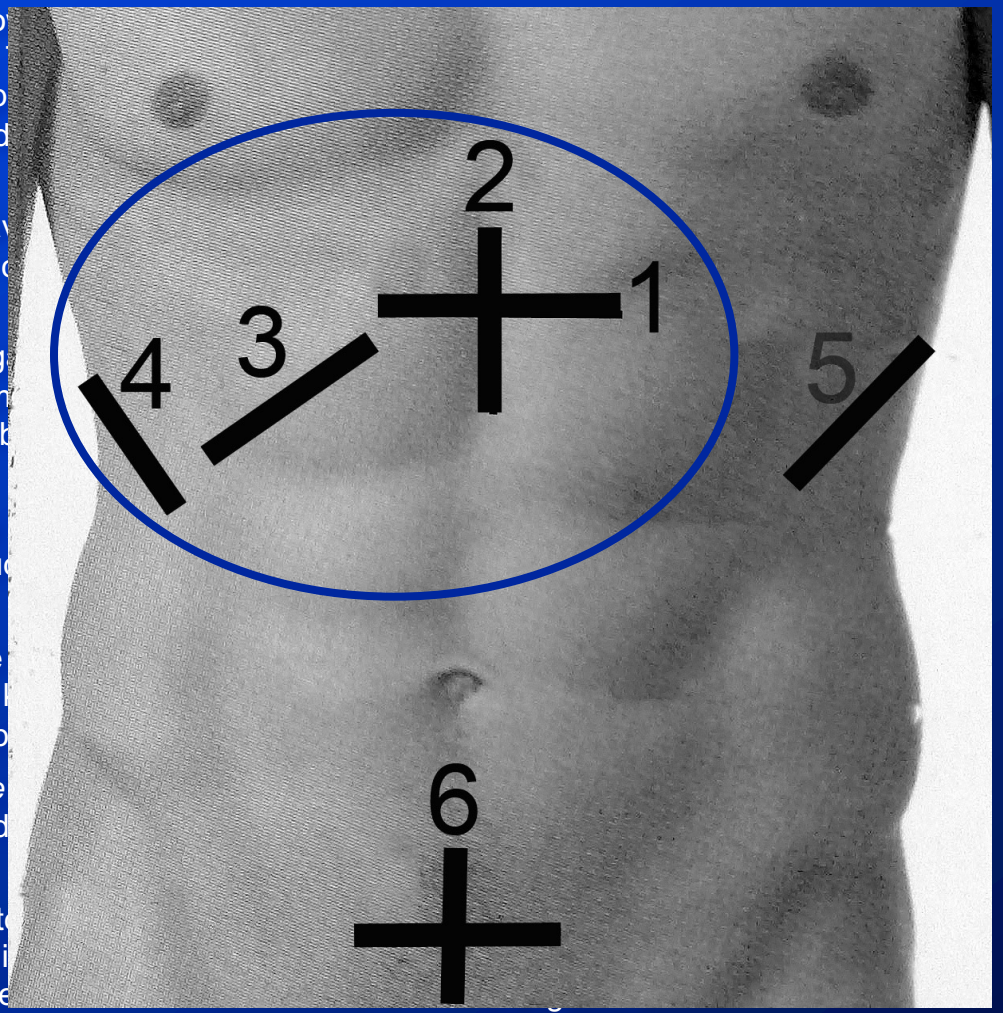
- Echogenicity
- Size, capsule and form
- Any lesions?
- Liver veins
- Portal vein
- Arteria hepatica
- Intrahepatic bile ducts



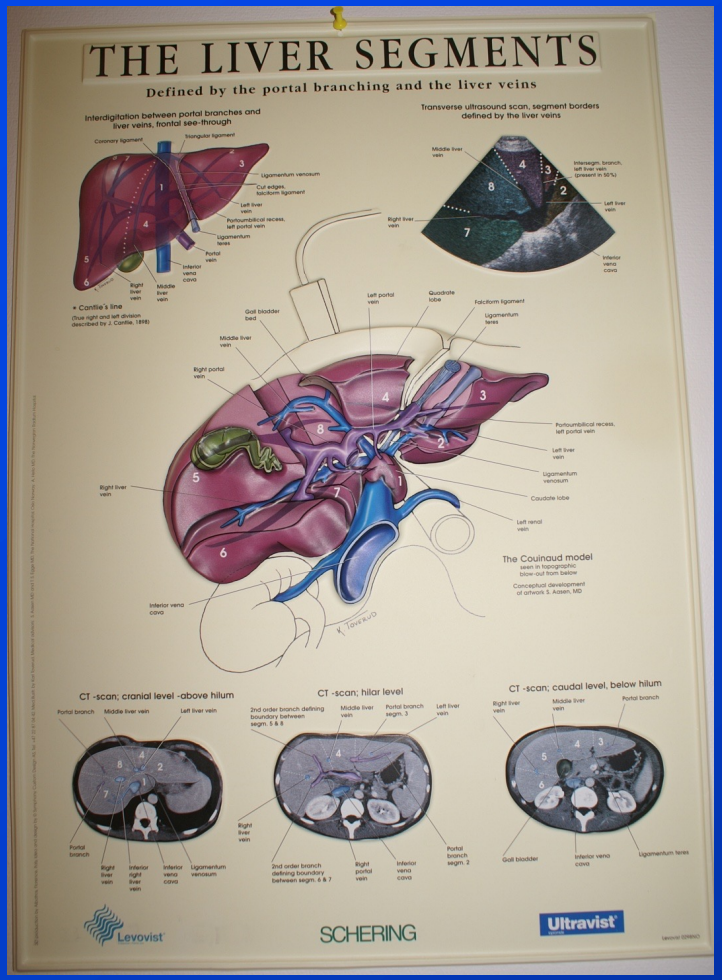
6+

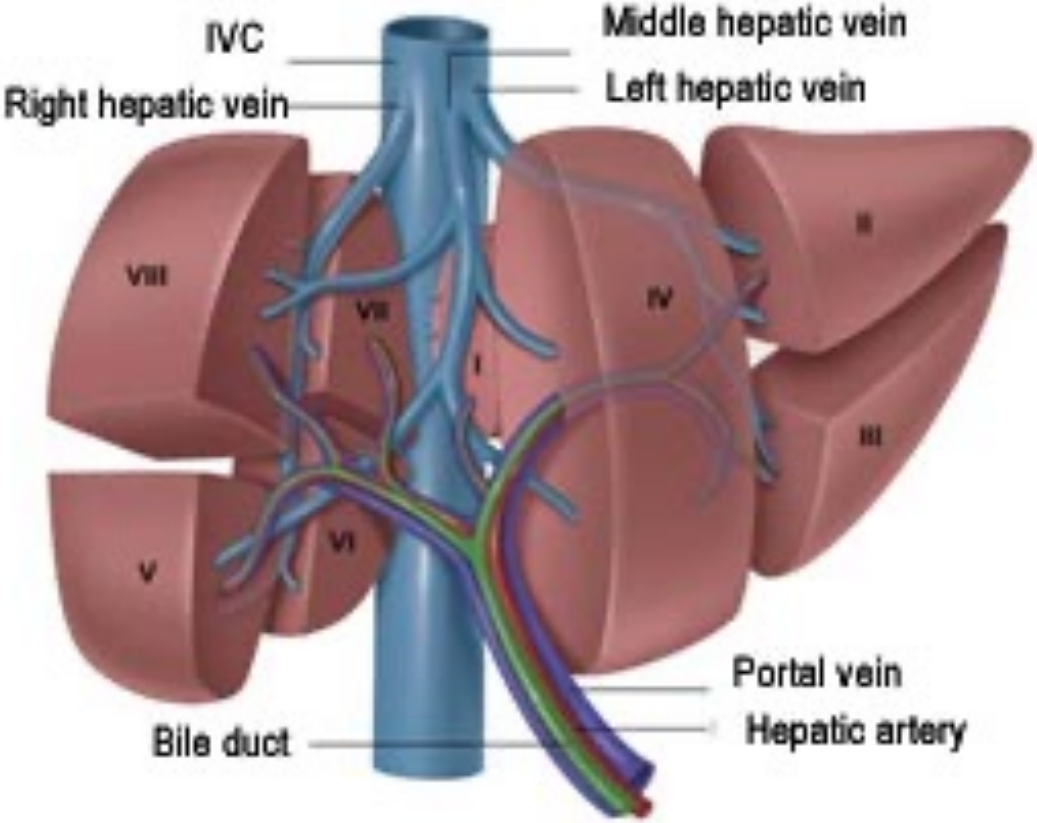
A systematic examination of abdominal organs

- **Station 1** *Epigastric transverse scanning.* Identify the kno
vena cava, art. mesenterica superior, pancreas and liver.
the liver and pancreas. For a better view of the liver and p
the patient during breath-hold or ask the patient to distend
of water to improve the view of the pancreas.
- **Station 2** *Epigastric longitudinal scanning.* Examine v. ca
lymph nodes holding the probe in a vertical position. You
section.
- **Station 3** *Subcostal oblique section*. The location of the g
difficult to locate. The patient should be fasting when exa
the gallbladder and liver when scanning from a ventral sub
side (Station 4).
- **Station 4** *Transversal and longitudinal scanning from the*
handgrip and start scanning the liver, portal triads, bile du
position.
- **Station 5** *Scanning from the left lateral section.* Move the
spleen intercostally behind the mid-axillary line. Scan the
You can also scan the tail of the pancreas by using the sp
- **Station 6** *Transversal- and longitudinal section above the*
pelvis is when the urinal bladder is full. Through a full blad
the sex of the patient, the prostate, uterus and ovaries.
- **Station +** Sometimes it is relevant to scan the intestines t
thickened bowel wall. You can start the scan in the right ili
optionally the appendix. Then, follow the colon from the ce



Segmentation of the liver





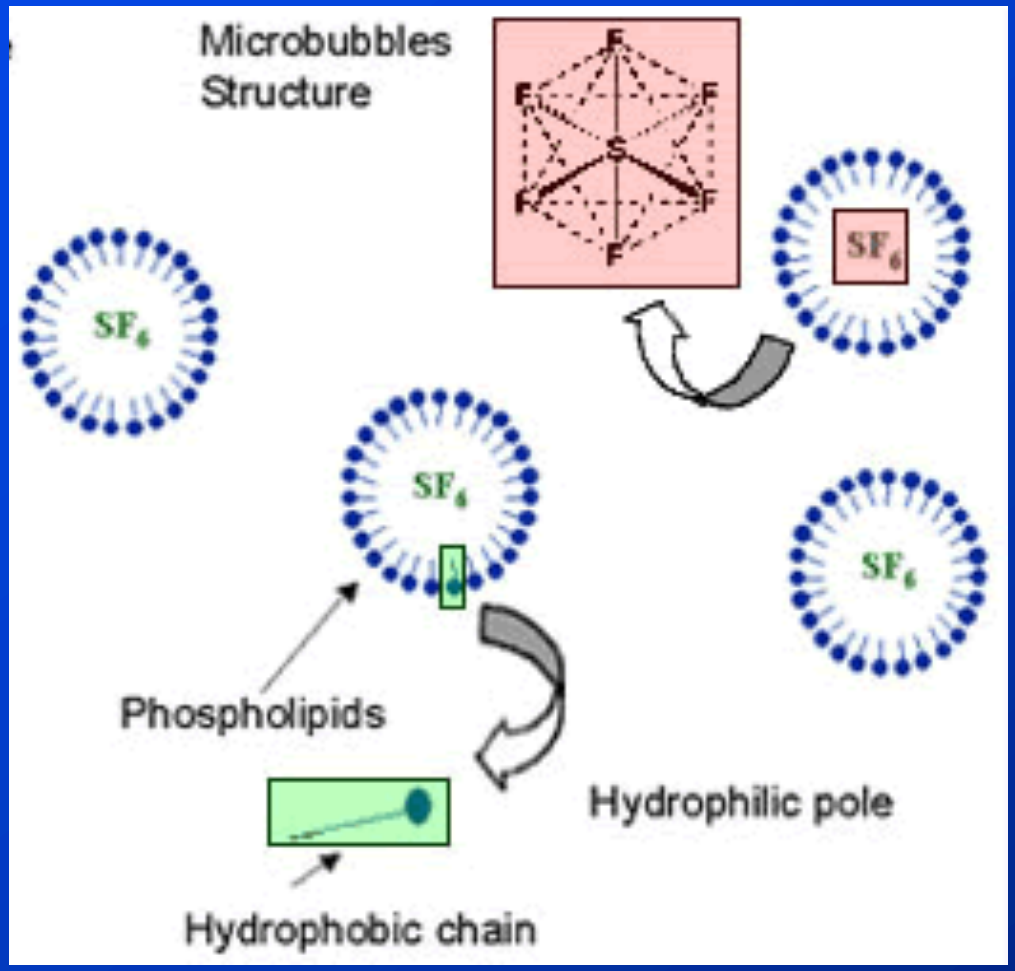
The liver's eight-segment division. Patients undergoing surgery for liver cancer will have a section(s) of their liver removed in which the tumor(s) resides. Following surgery, this section grows back.

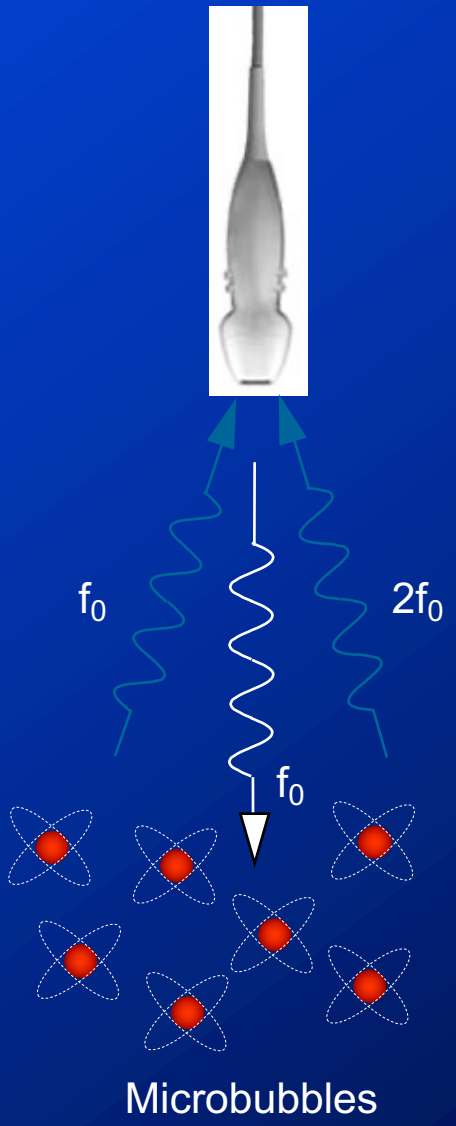
SONOVue®

Sulphur Hexafluoride

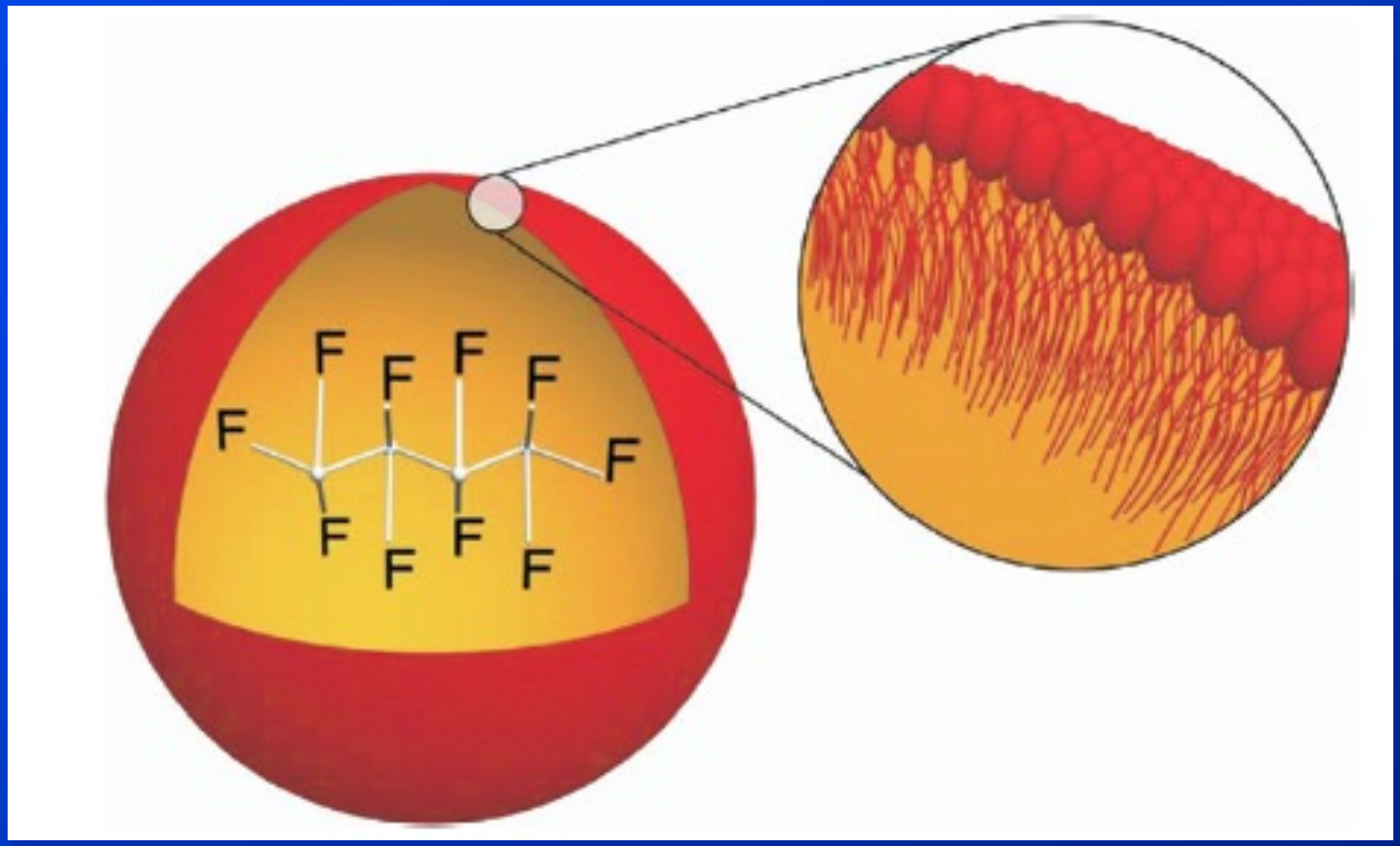
BRACCO

THE IMAGE OF INNOVATION



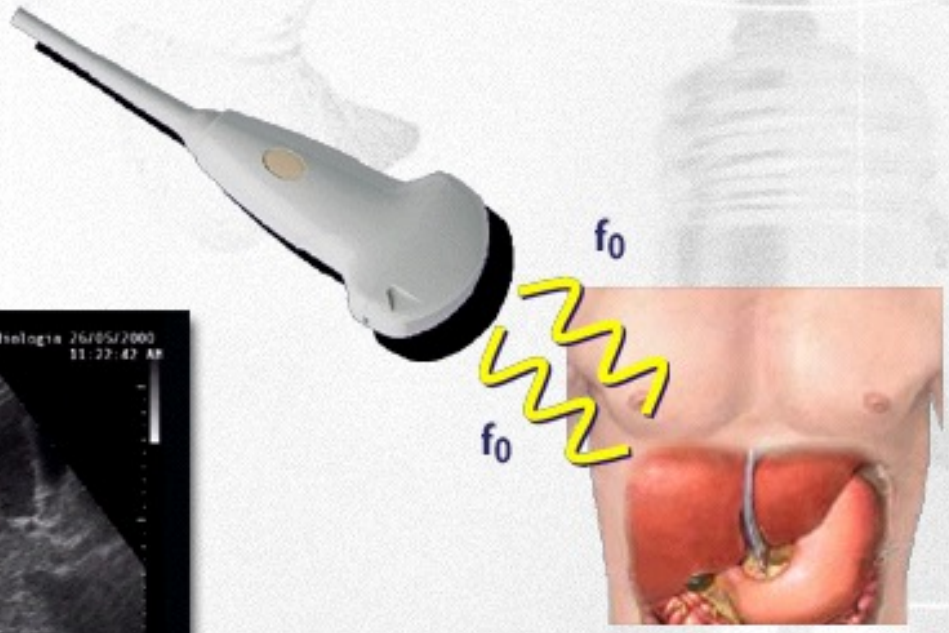


Sonazoid



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

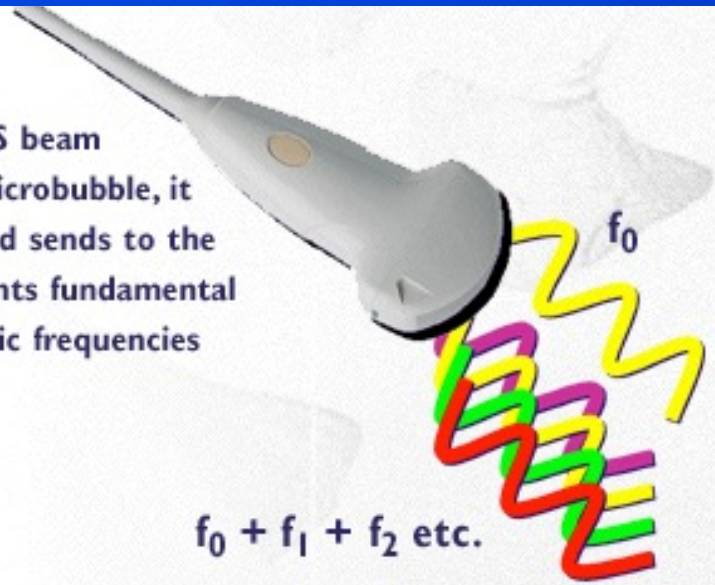
Fundamental Imaging



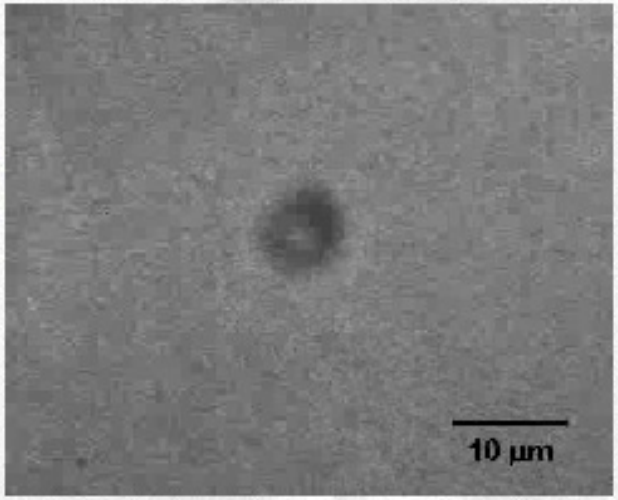
In fundamental imaging US images are built up on signals with the same frequency f_0 of the insonating US beam

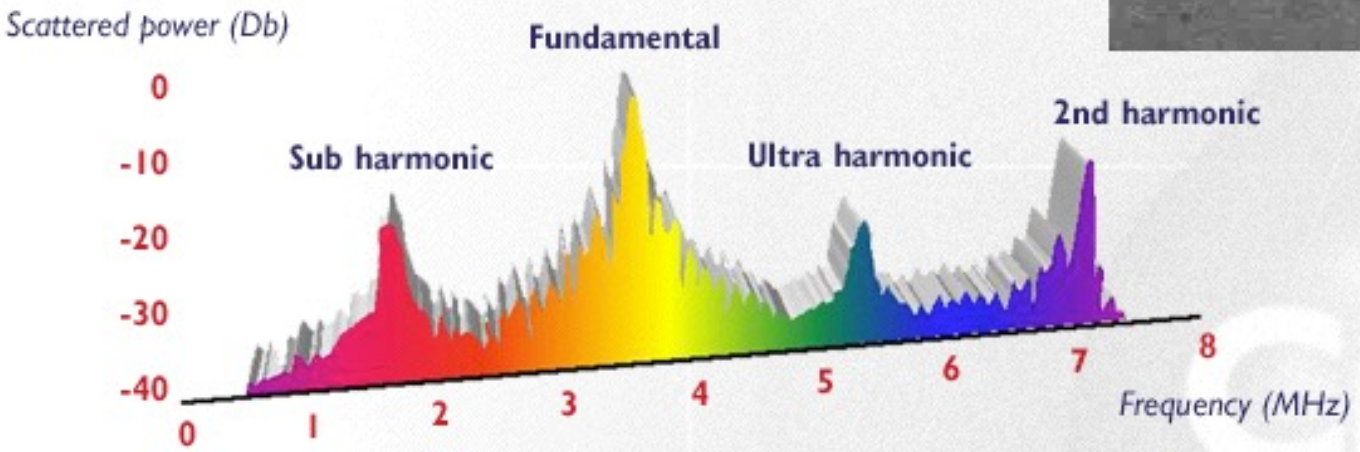
Harmonic Contrast Imaging

When the US beam reaches a microbubble, it oscillates and sends to the US equipments fundamental and harmonic frequencies

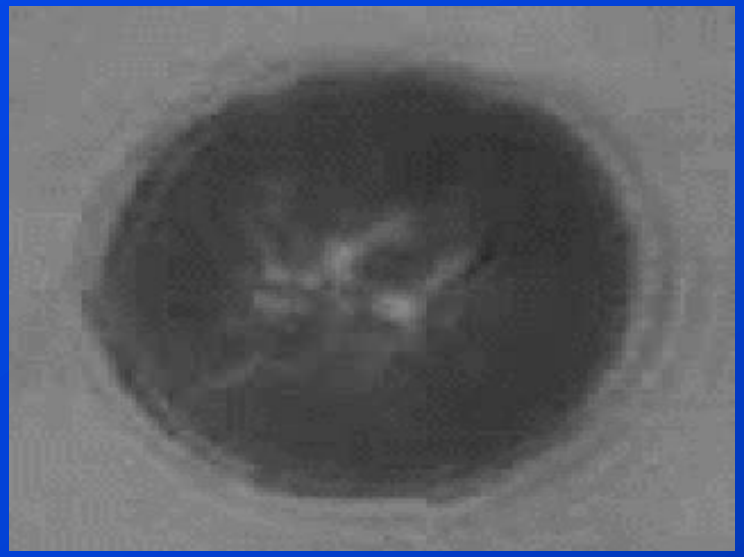


Courtesy of Nico de Jong - Thorax center
Rotterdam - The Netherlands





Fine tuning the Instrument by adjusting the MI



Non-linear response from microbubbles is based on two different mechanisms:
– non-linear response from microbubble oscillations at low acoustic pressure, chosen to minimize disruption of the microbubbles. ”Low MI” Imaging.
– high energy broadband non-linear response arising from microbubble disruption.

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

Over 30 clinical applications

Cited 1359 times

Ultraschall Med / EJU Aug. 2011

New liver CEUS guidelines 2020

ELSEVIER

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0301-5629/$ - see front matter

https://doi.org/10.1016/j.ultrasmedbio.2020.04.030

● *Review Article*

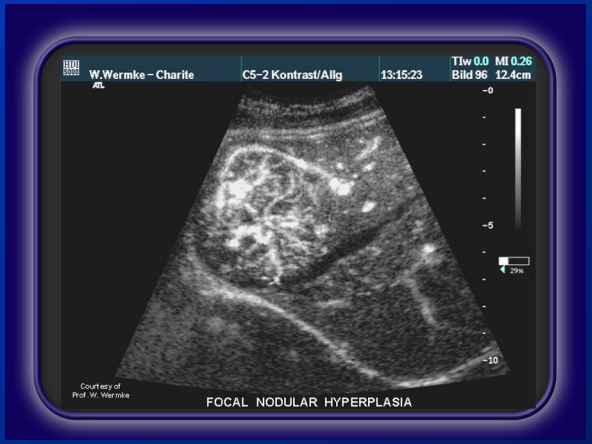
GUIDELINES AND GOOD CLINICAL PRACTICE RECOMMENDATIONS FOR CONTRAST-ENHANCED ULTRASOUND (CEUS) IN THE LIVER–UPDATE 2020 WFUMB IN COOPERATION WITH EFSUMB, AFSUMB, AIUM, AND FLAUS

CHRISTOPH F. DIETRICH,[*,†2] CHRISTIAN PÁLLSON NOLSØE,[‡,2] RICHARD G. BARR,[§,¶] ANNALISA BERZIGOTTI,[‖] PETER N. BURNS,[#] VITO CANTISANI,[**] MARIA CRISTINA CHAMMAS,[††] NITIN CHAUBAL,[‡‡] BYUNG IHN CHOI,[§§] DIRK-ANDRÉ CLEVERT,[¶¶] XINWU CUI,[‖‖] YI DONG,[##] MIRKO D'ONOFRIO,[***] J. BRIAN FOWLKES,[†††] ODD HELGE GILJA,[‡‡‡] PINTONG HUANG,[§§§] ANDRE IGNEE,[¶¶¶] CHRISTIAN JENSSEN,[‖‖‖] YUKO KONO,[###] MASATOSHI KUDO,[****] NATHALIE LASSAU,[††††] WON JAE LEE,[‡‡‡‡,§§§§] JAE YOUNG LEE,[¶¶¶¶] PING LIANG,[‖‖‖‖] ADRIAN LIM,[####] ANDREJ LYSHCHIK,[*****] MARIA FRANCA MELONI,[†††††] JEAN MICHEL CORREAS,[‡‡‡‡‡] YASUNORI MINAMI,[§§§§§] FUMINORI MORIYASU,[¶¶¶¶¶] CARLOS NICOLAU,[‖‖‖‖‖] FABIO PISCAGLIA,[#####] ADRIAN SAFTOIU,[******] PAUL S. SIDHU,[††††††] IOAN SPOREA,[‡‡‡‡‡‡] GUIDO TORZILLI,[§§§§§§] XIAOYAN XIE,[¶¶¶¶¶¶] and RONGQIN ZHENG[‖‖‖‖‖‖]

Ultrasound Med Biol 2020

3 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

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	

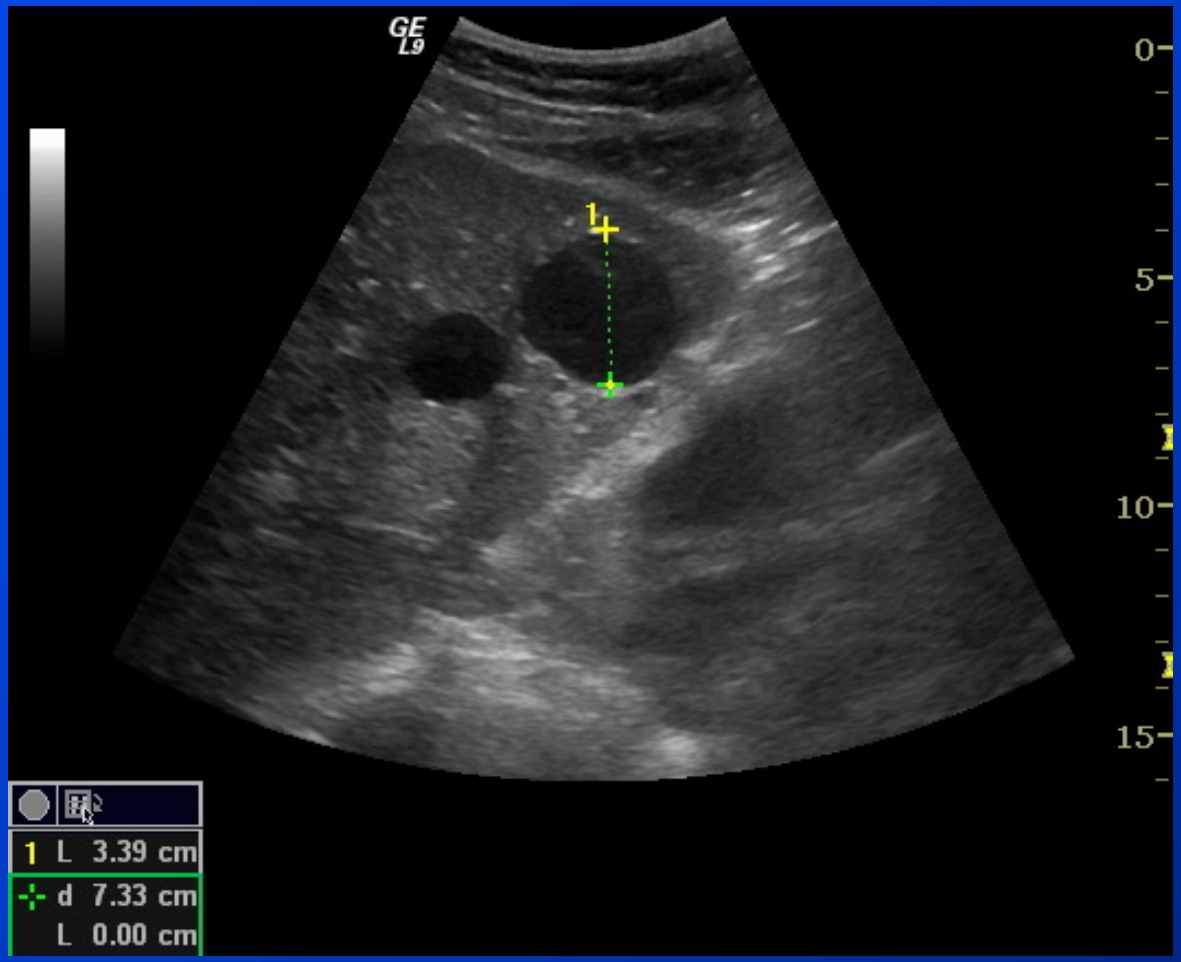
Liver cysts

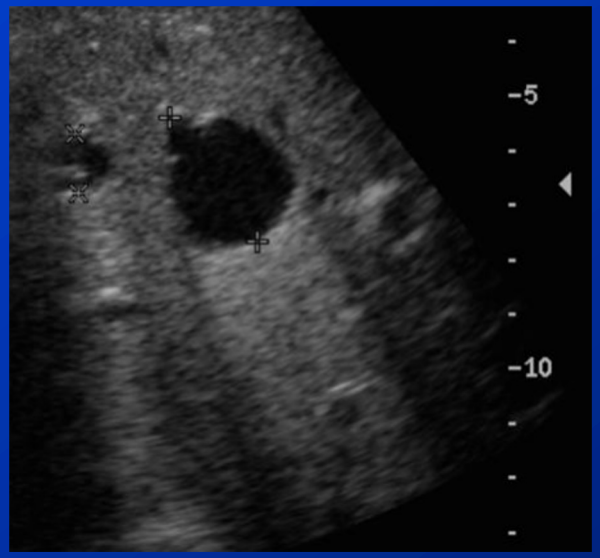
- ultrasound is highly accurate in diagnosing liver cysts
- anechoic with a clear posterior demarcation (but no wall)
- posterior enhancement
- often round in shape and smooth
- occasionally RUQ pain due to mass effect or bleeding

- DD: abscess, echinococcal cysts, tumours with central necrosis, hematomas

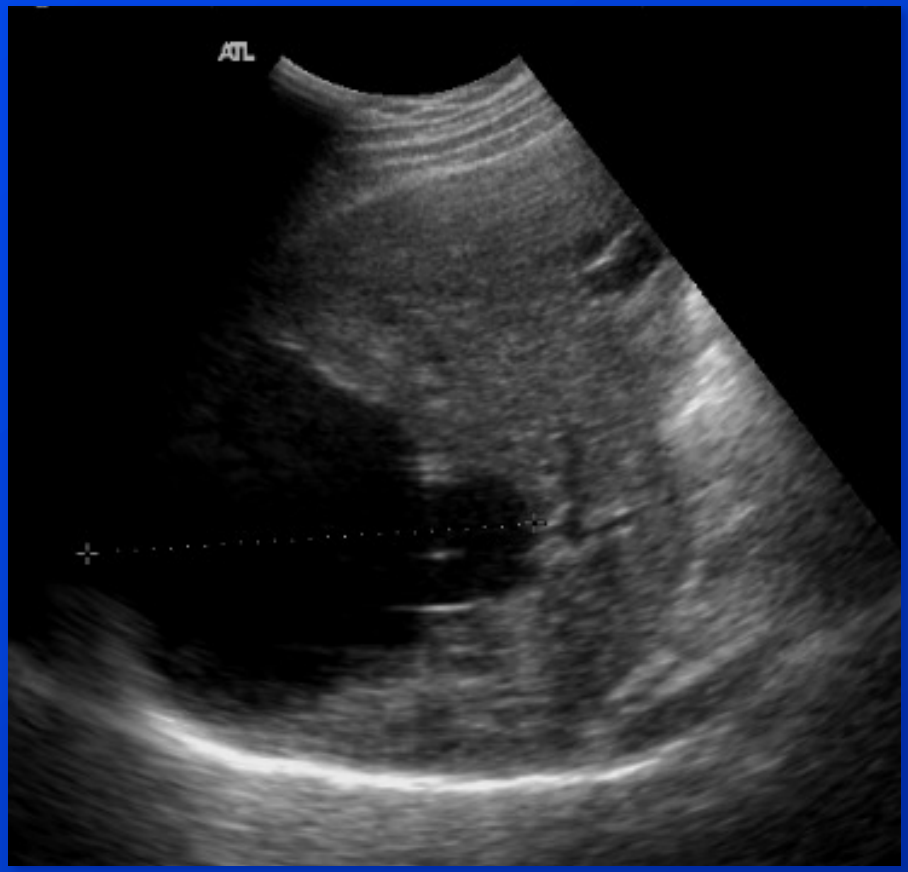
- **polycystic liver disease**
  - autosomal dominant disorder
  - often multiple renal cysts (>50%)
  - variation in size and shape
  - hepatomegaly, cholestasis and portal hypertension (PHT)

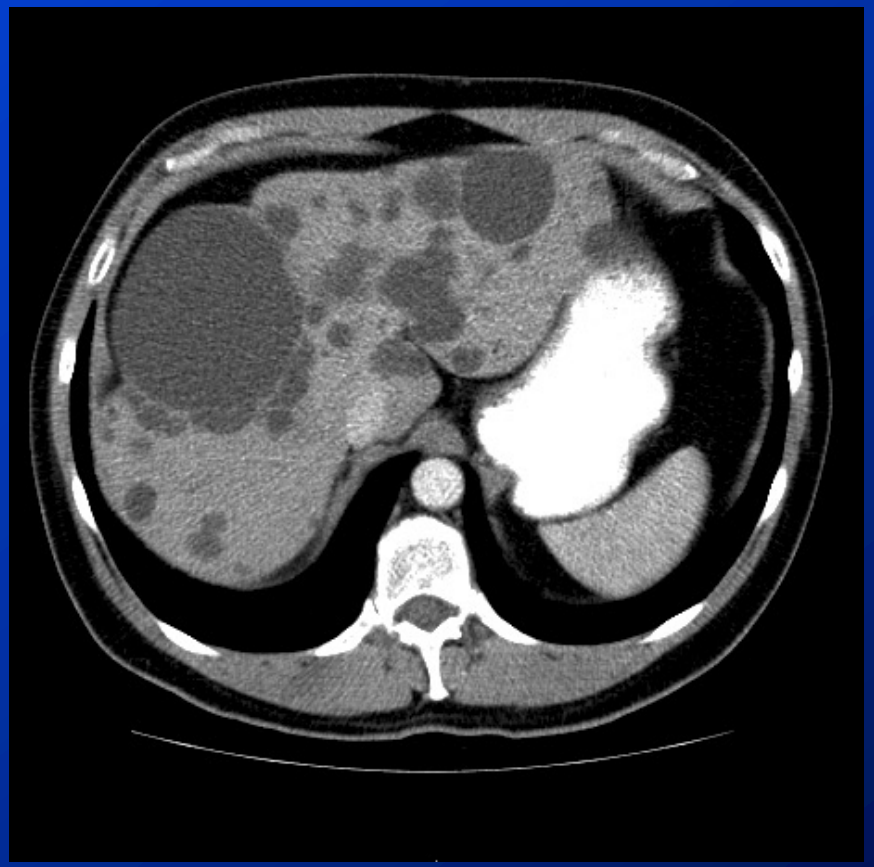
Liver cysts



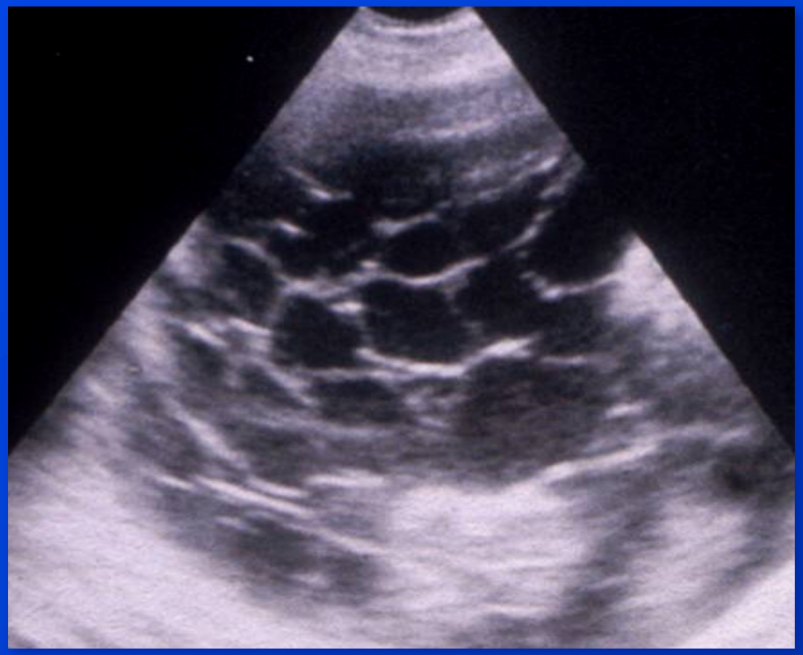


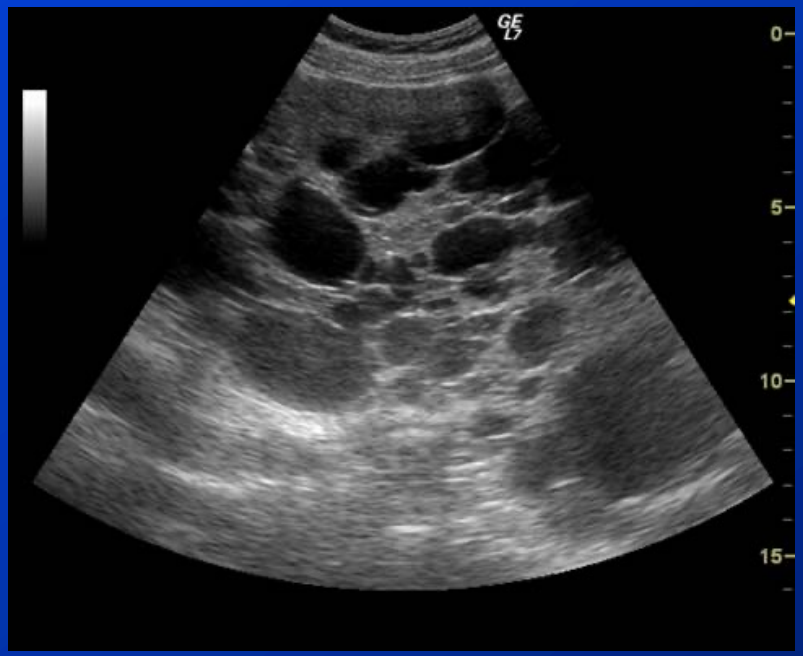
Liver cysts



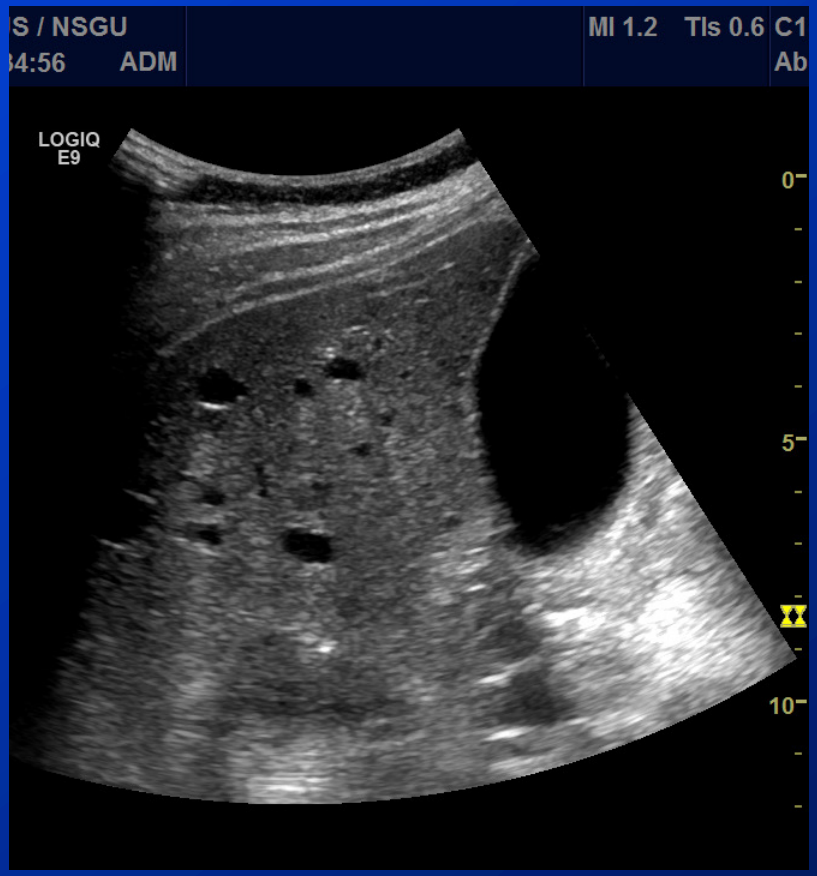


Polycystic liver disease



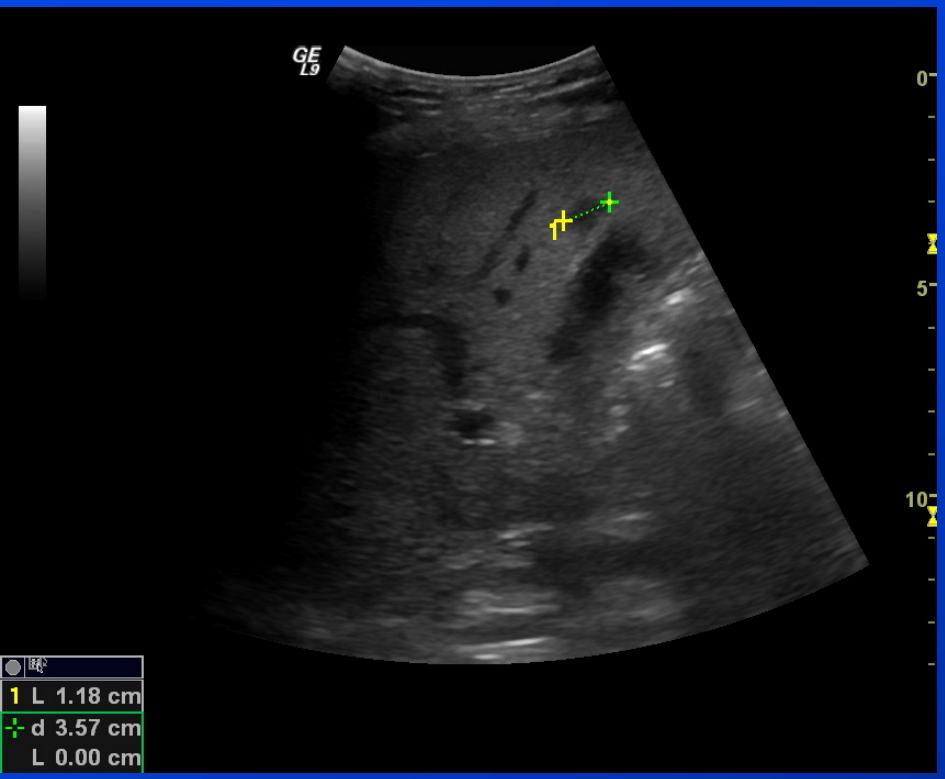


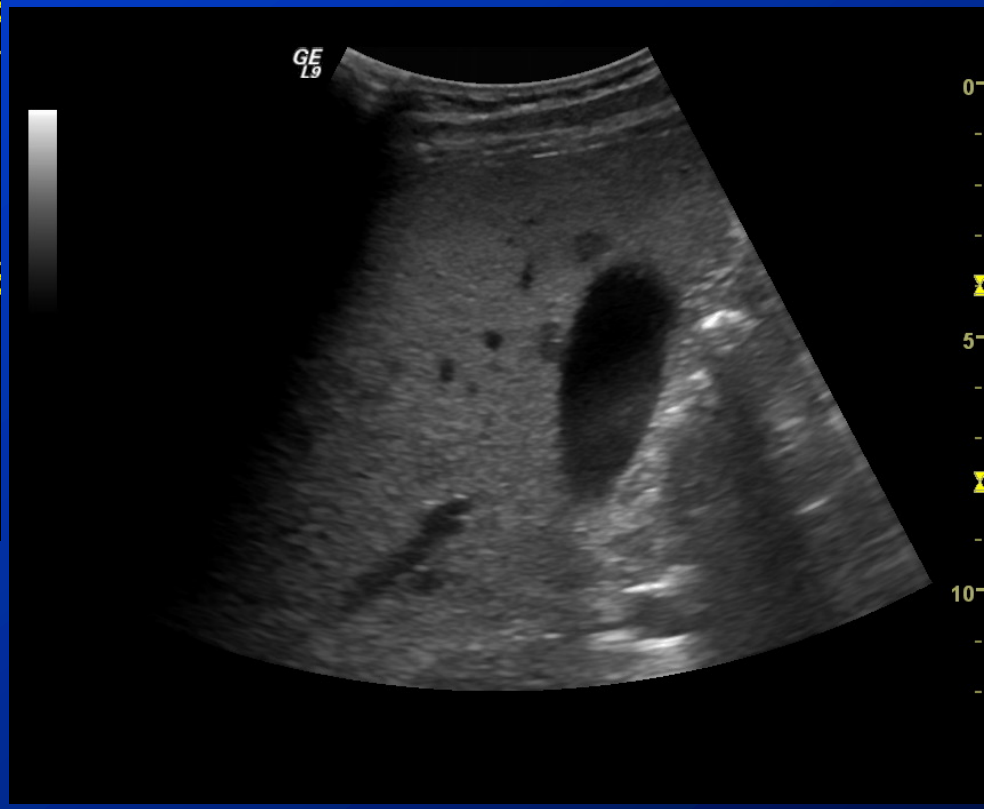
Ultrasound better than CT in small cysts



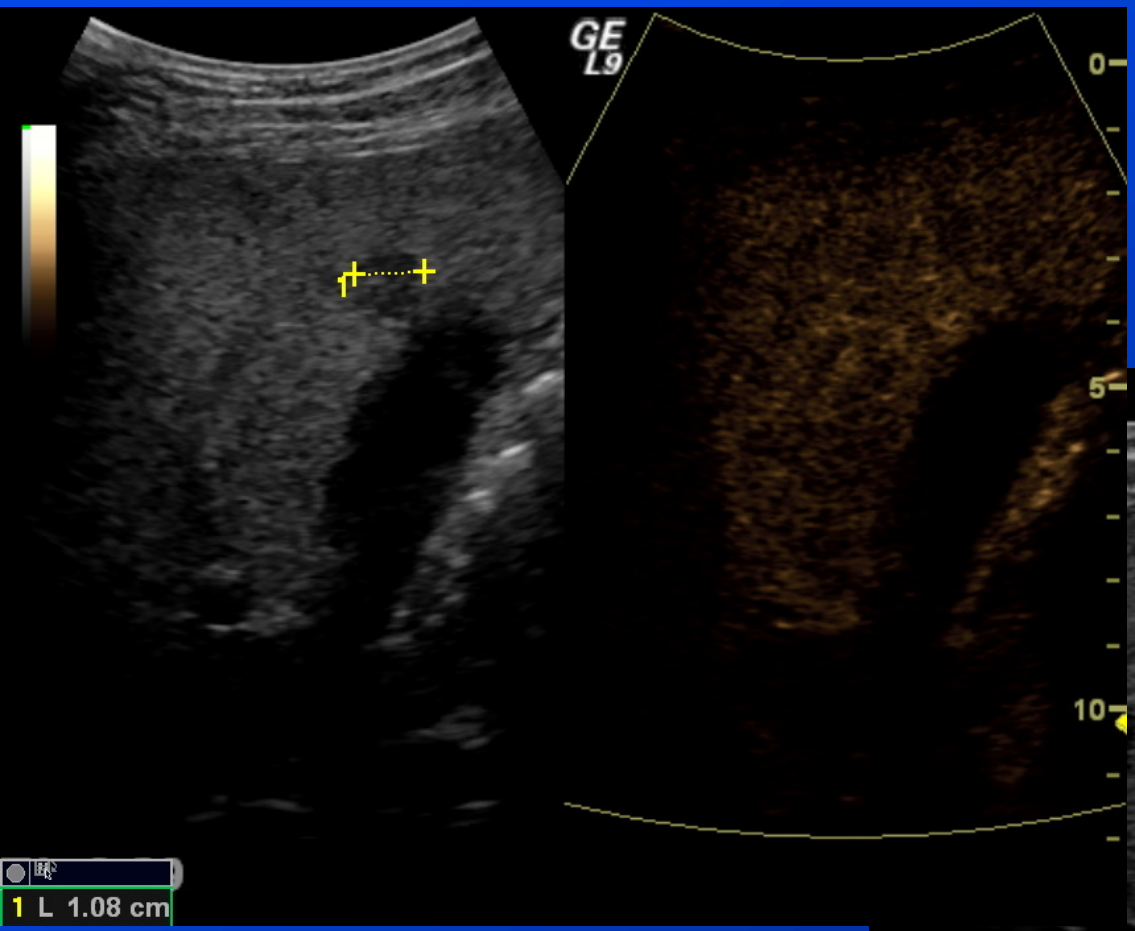
Fatty liver – Dangerous !

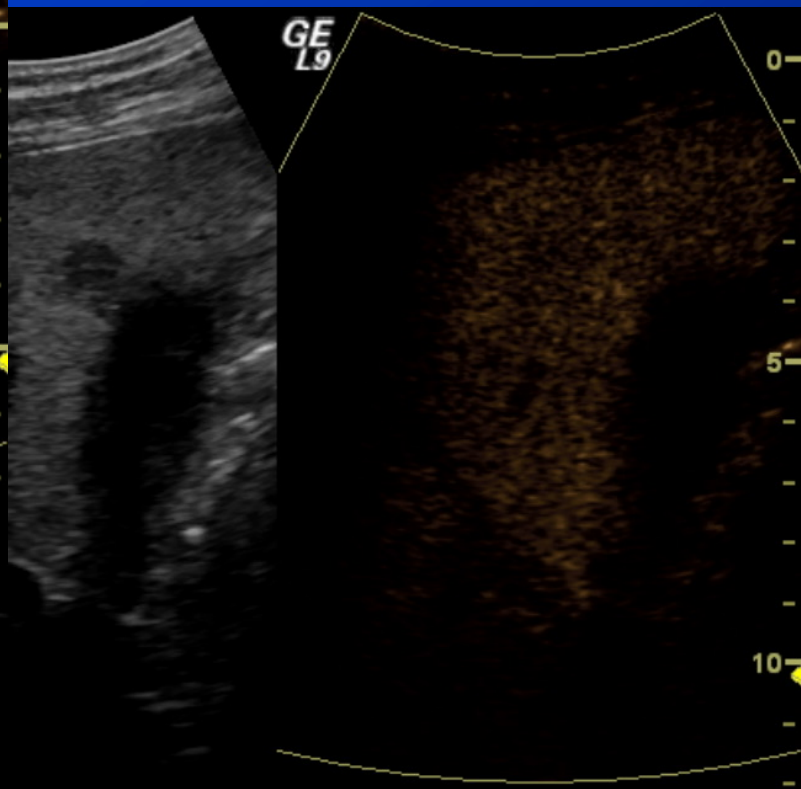
A common problem:
Focal Lesions in Fatty Livers



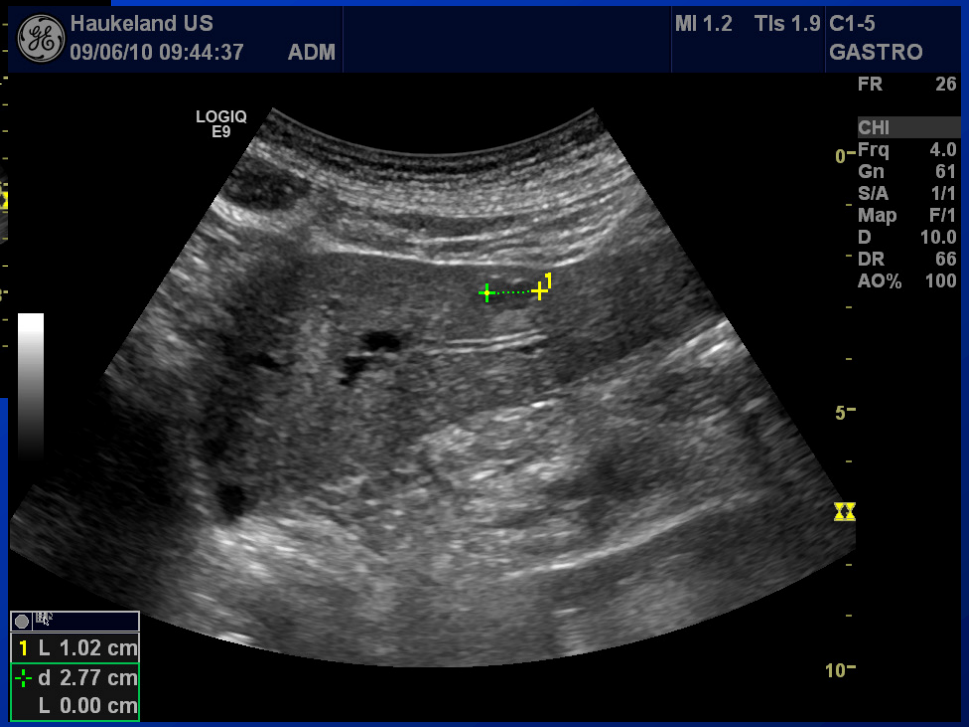


CEUS in FLL



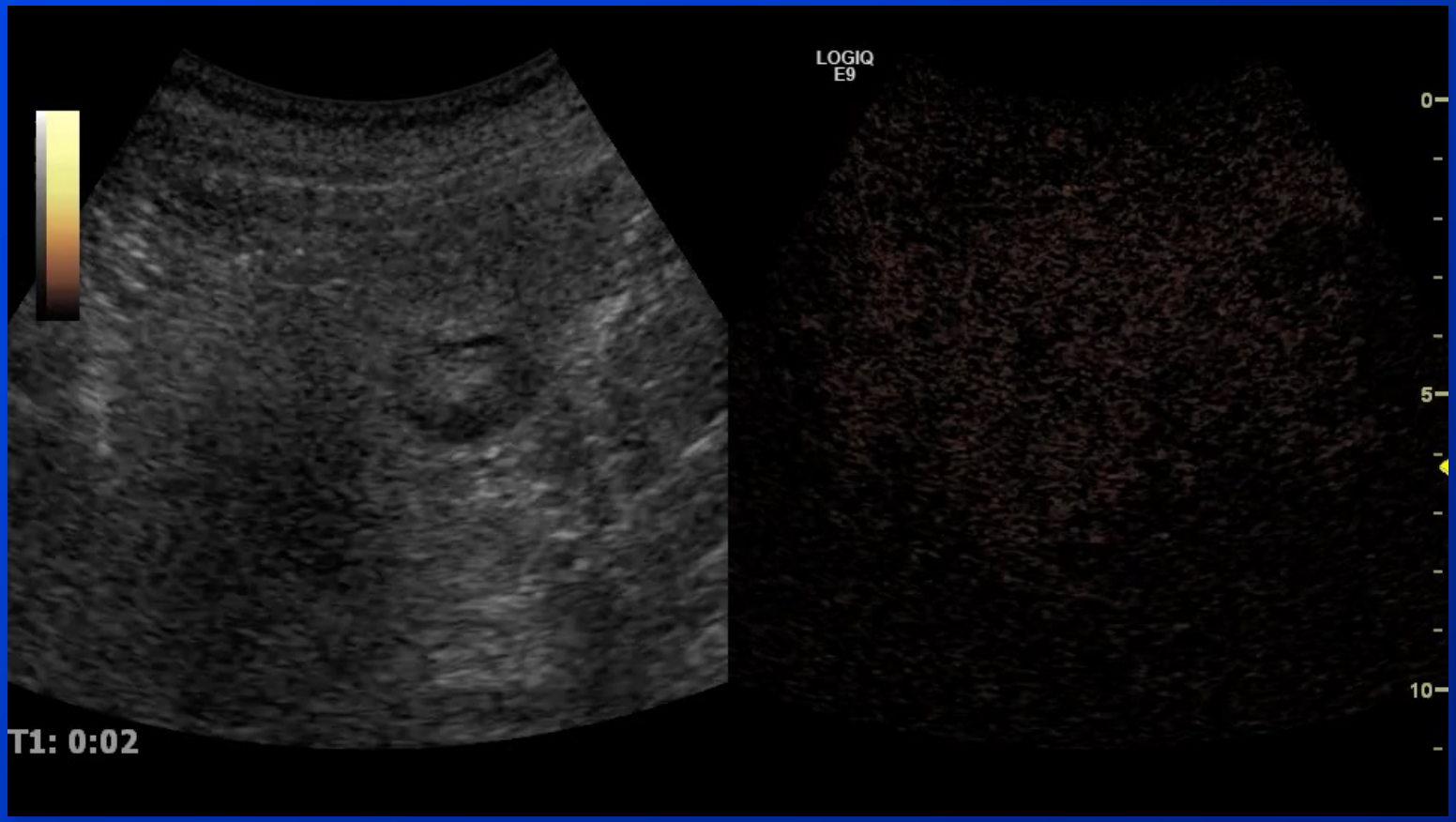


A patient with cysts and various lesions

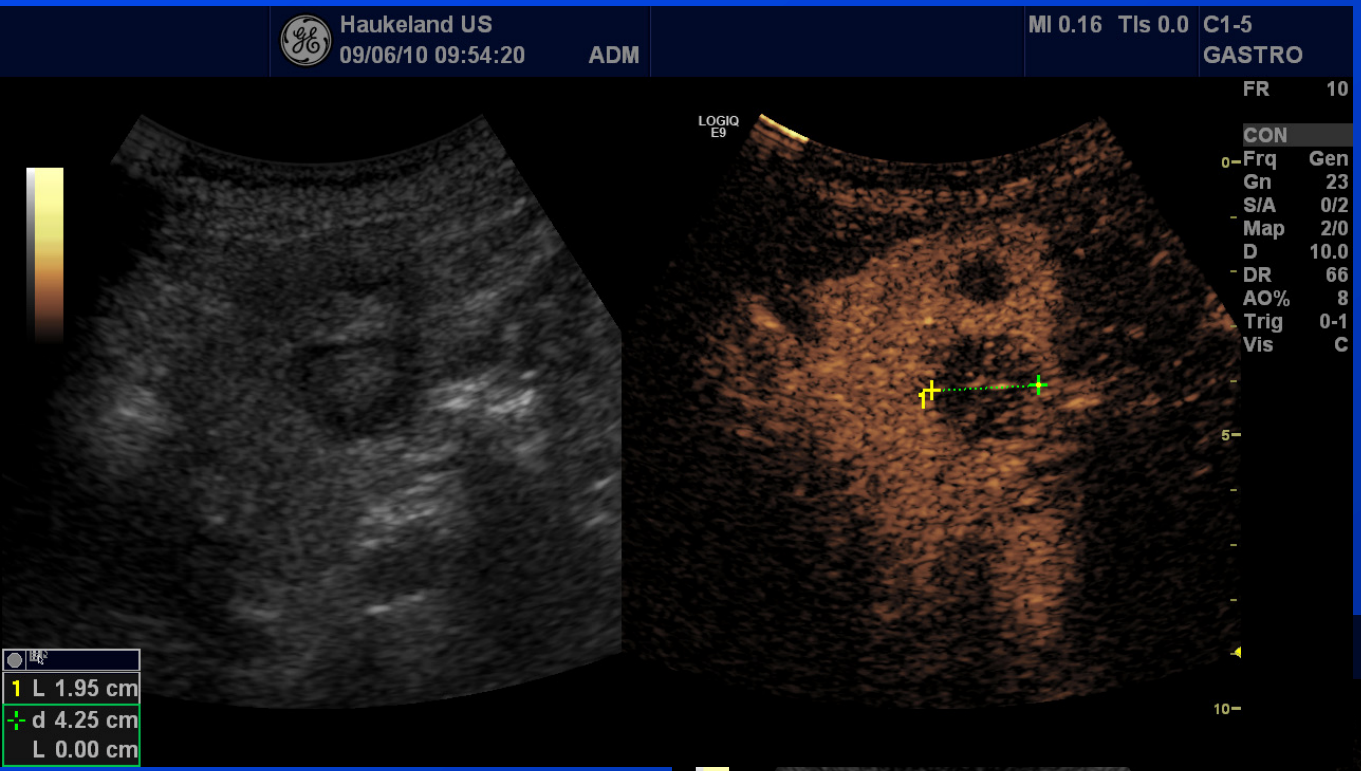


When in Doubt -
Sound it out !

When in Doubt - Sound it out !



Late Phase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C1-5
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LOGIQ
E9
FR 10
CON
Frq Gen
Gn 23
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Trig 0-1
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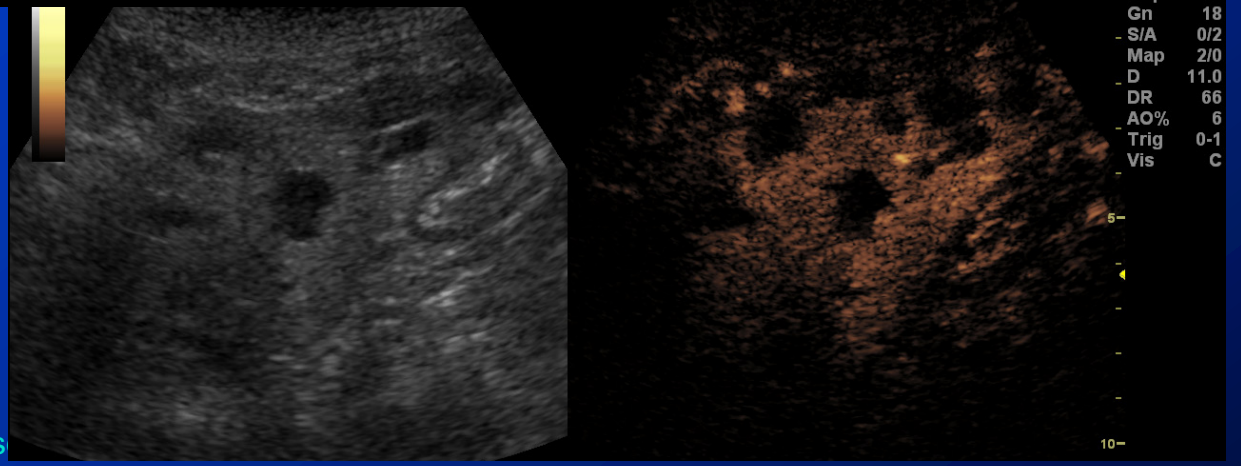
d 4.25 cm
L 0.00 cm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FR 10
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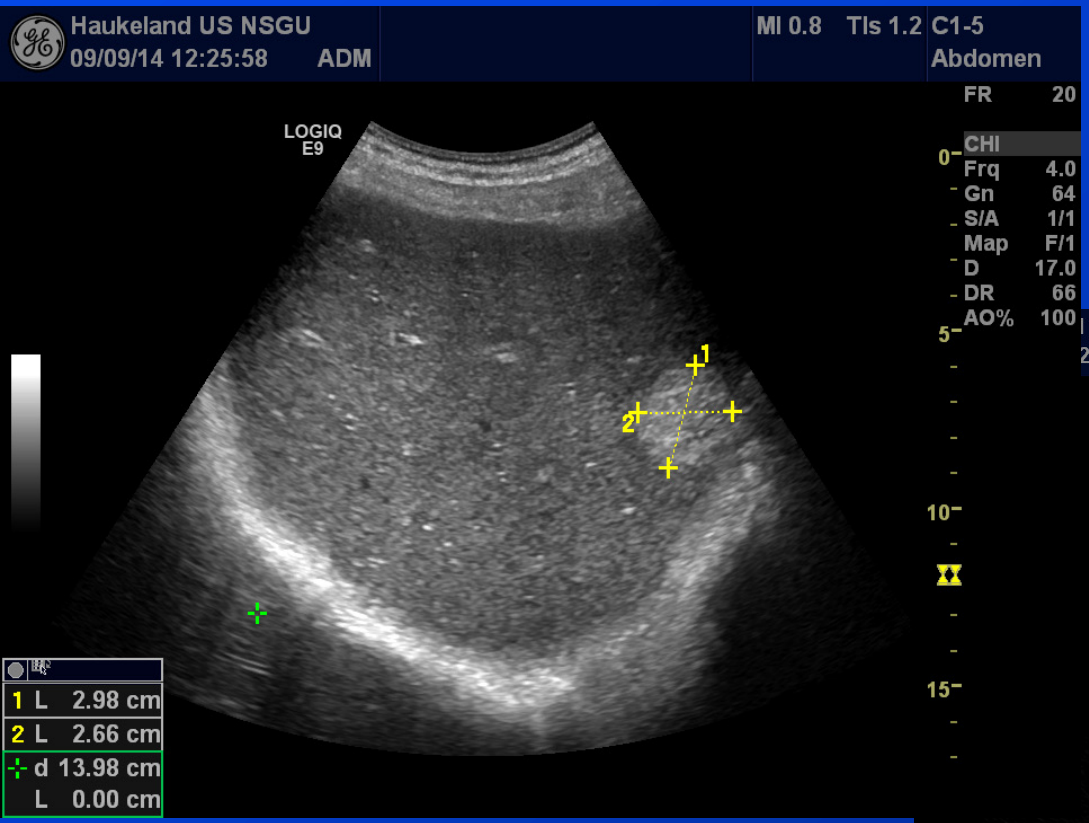
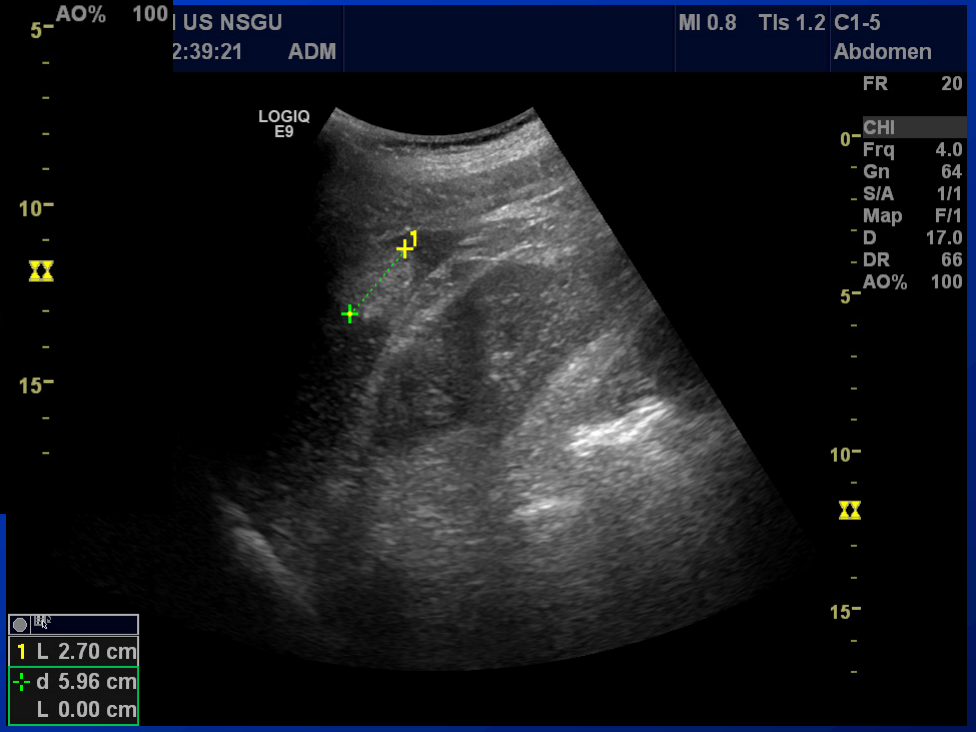
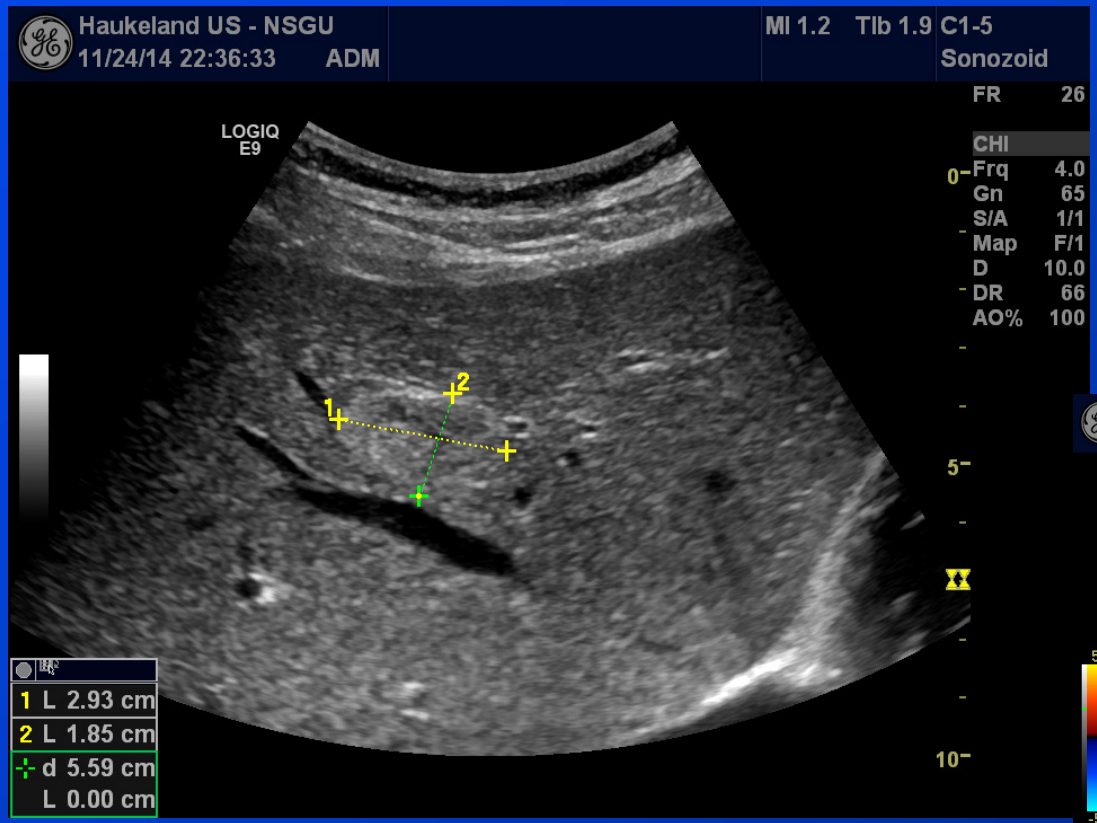
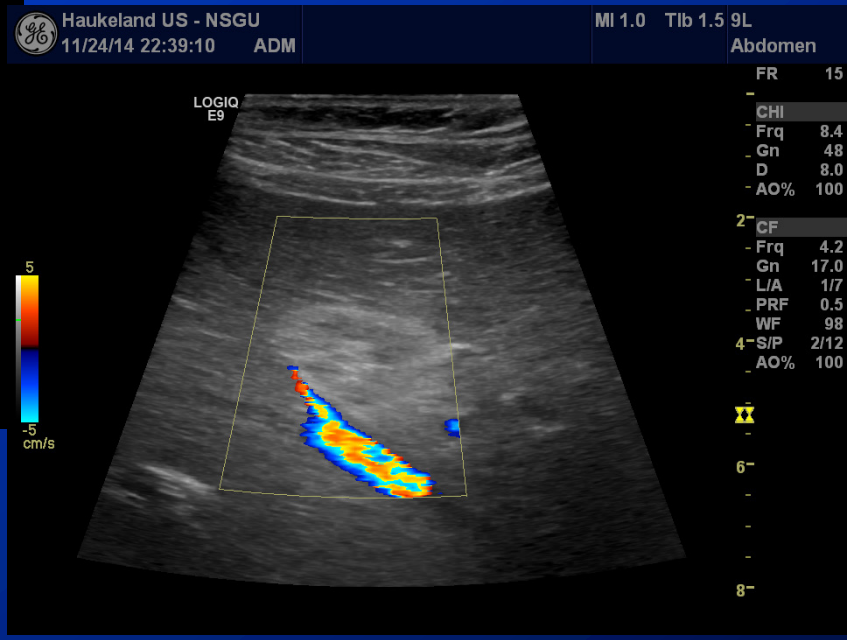
Lesion in Liver – S7



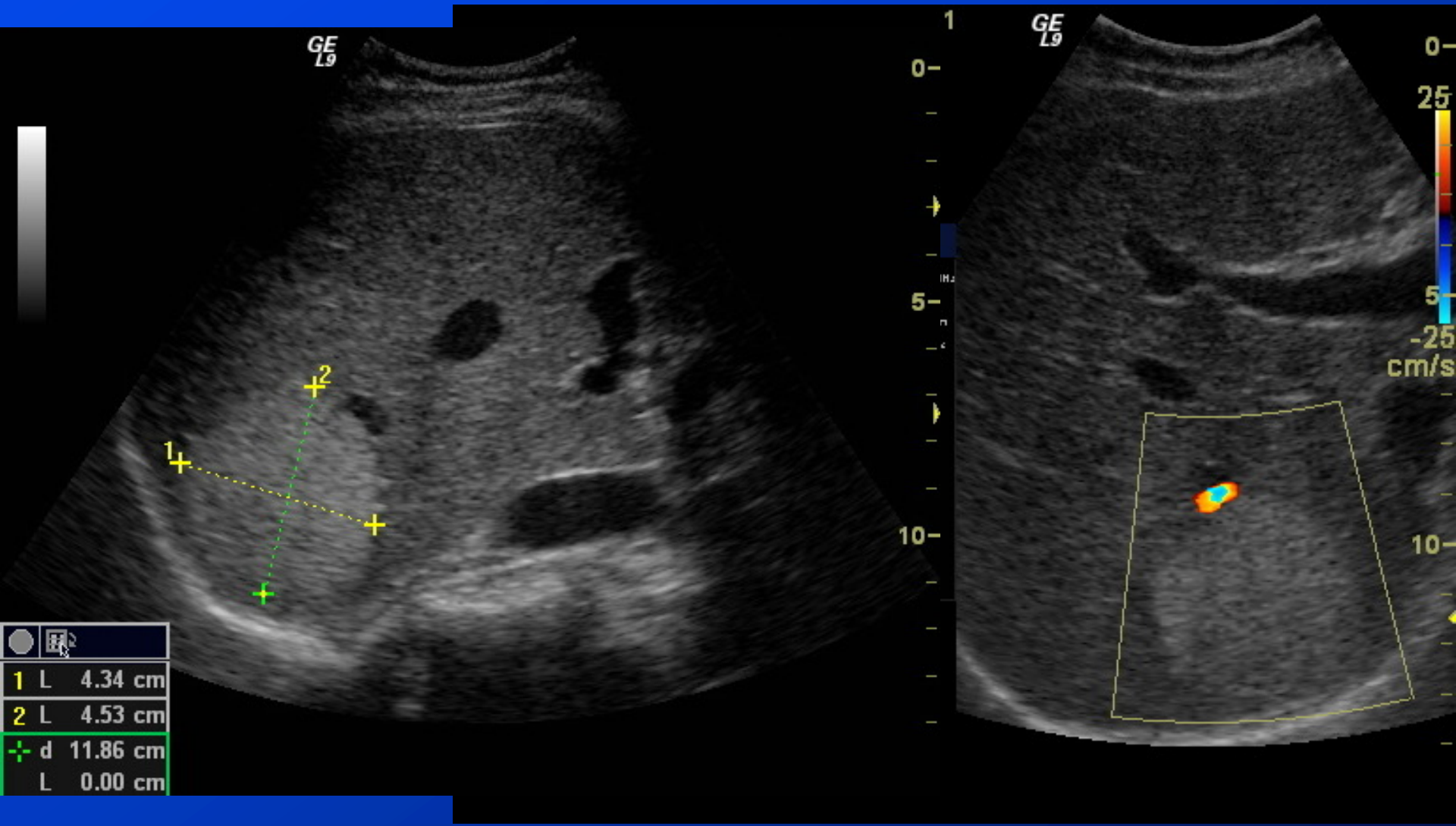


Hyper-echoic Tumor

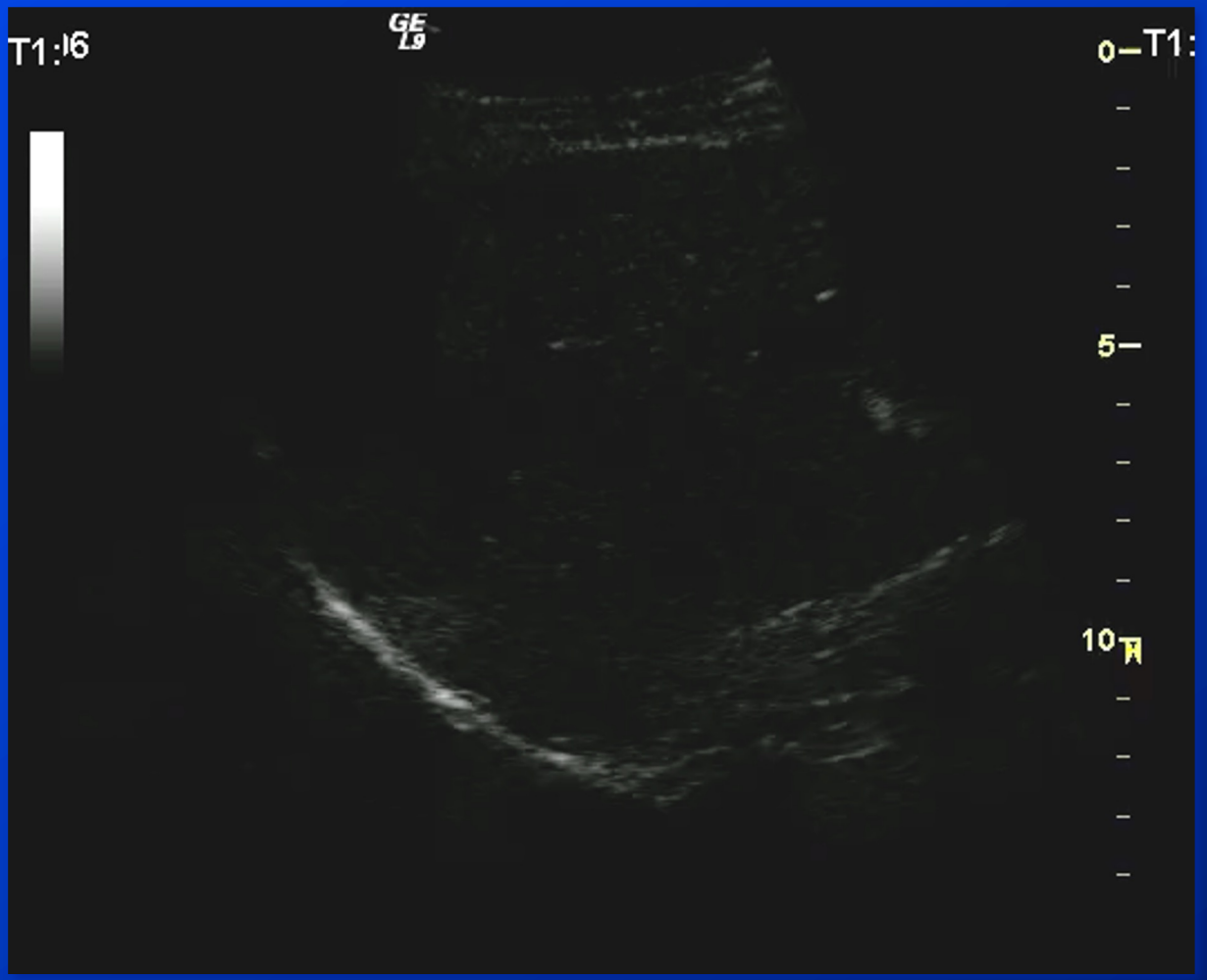




Referred from the CT-Lab
Haemangioma ?

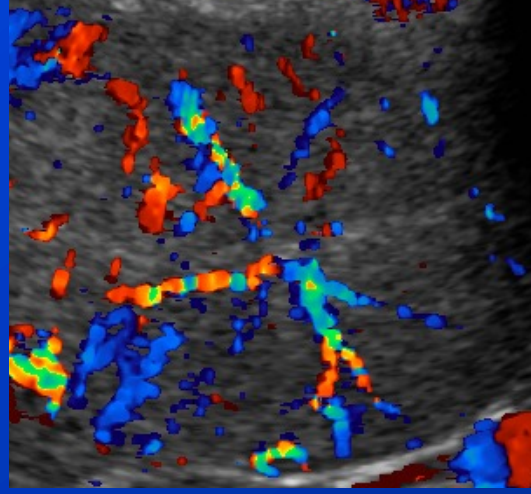


Peripheral Globular Enhancement



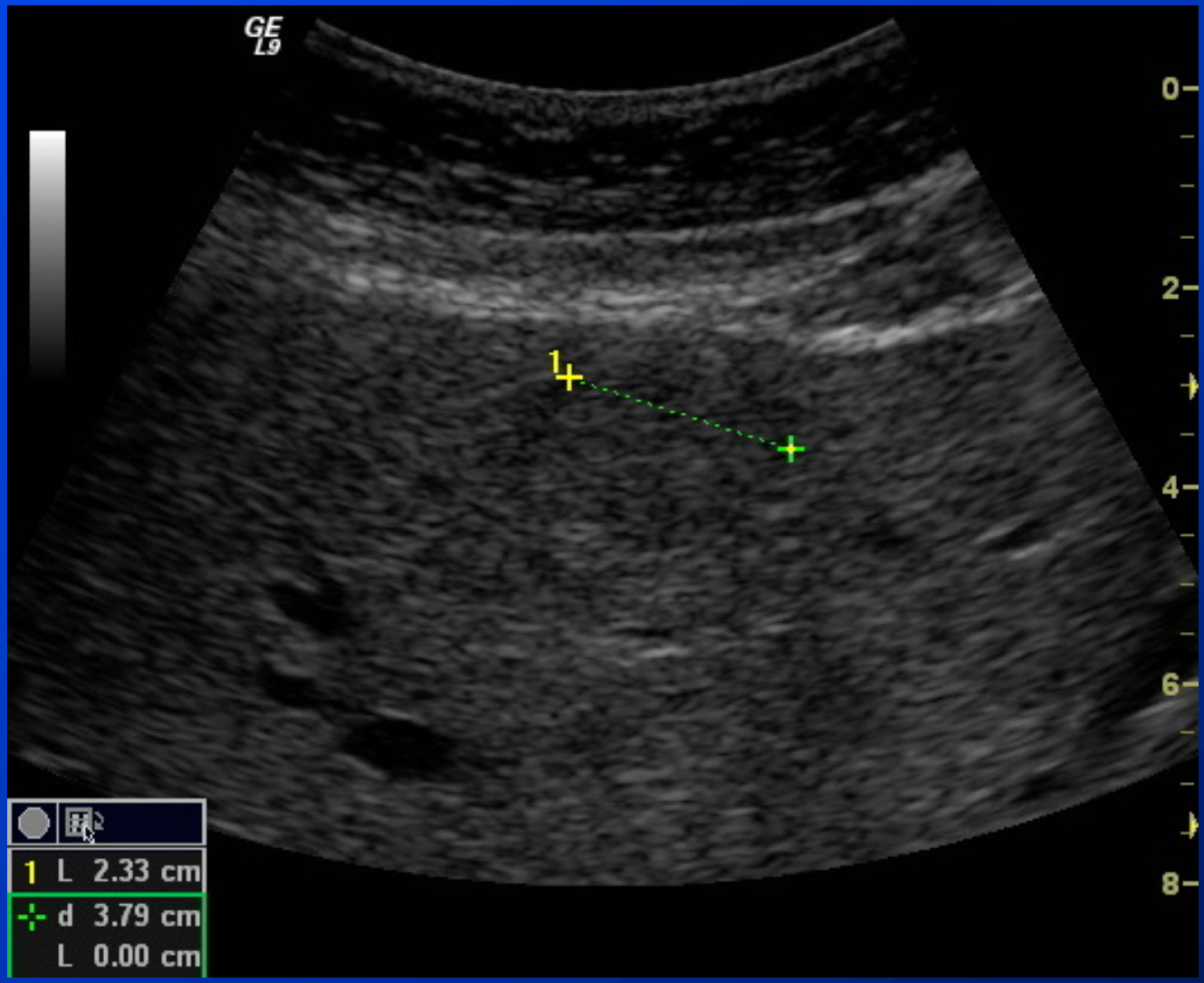
…with slow sentripetal filling

Focal Nodular Hyperplasia - FNH

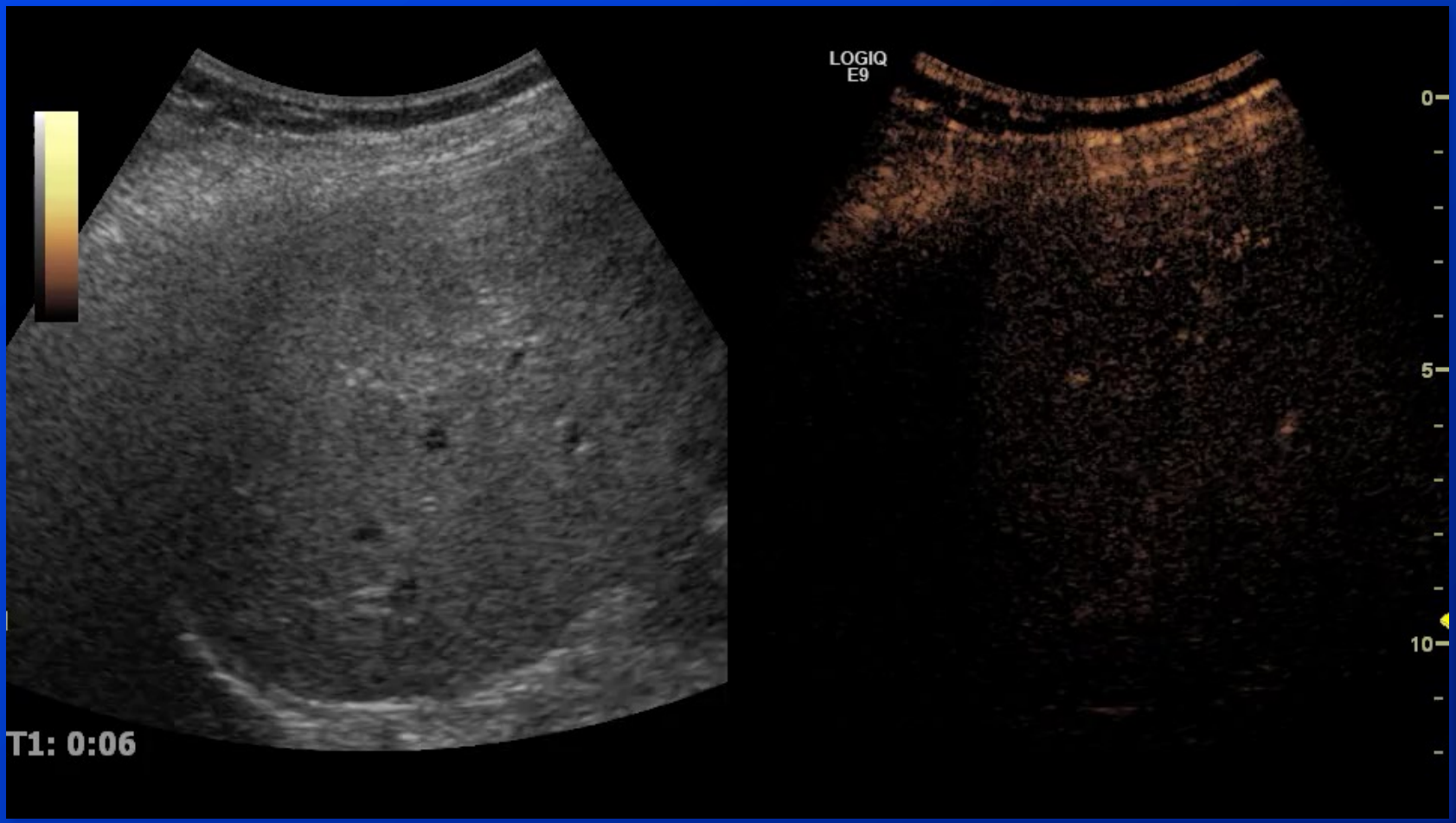


- FNH- a centrifugal stellate branching in early arterial phase
- Spoke wheel pattern in approx 40%
- Intense homogenous uptake
- Iso- or hyperechoic lesion is seen in portal venous phase.
- With these characteristic features:
  - sensitivity and specificity of contrast-enhanced low MI real-time US are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

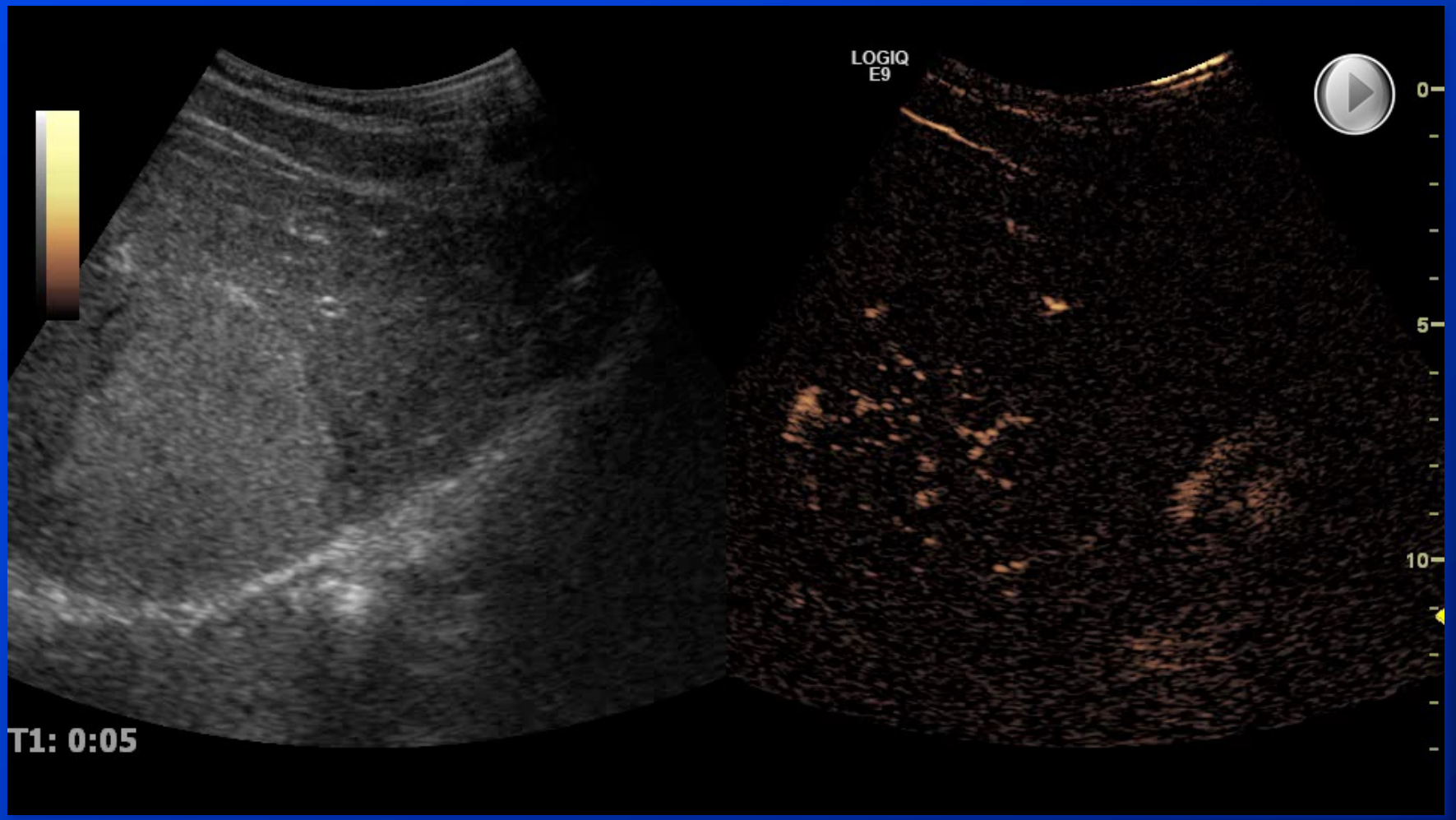
FNH,- often isoechoic



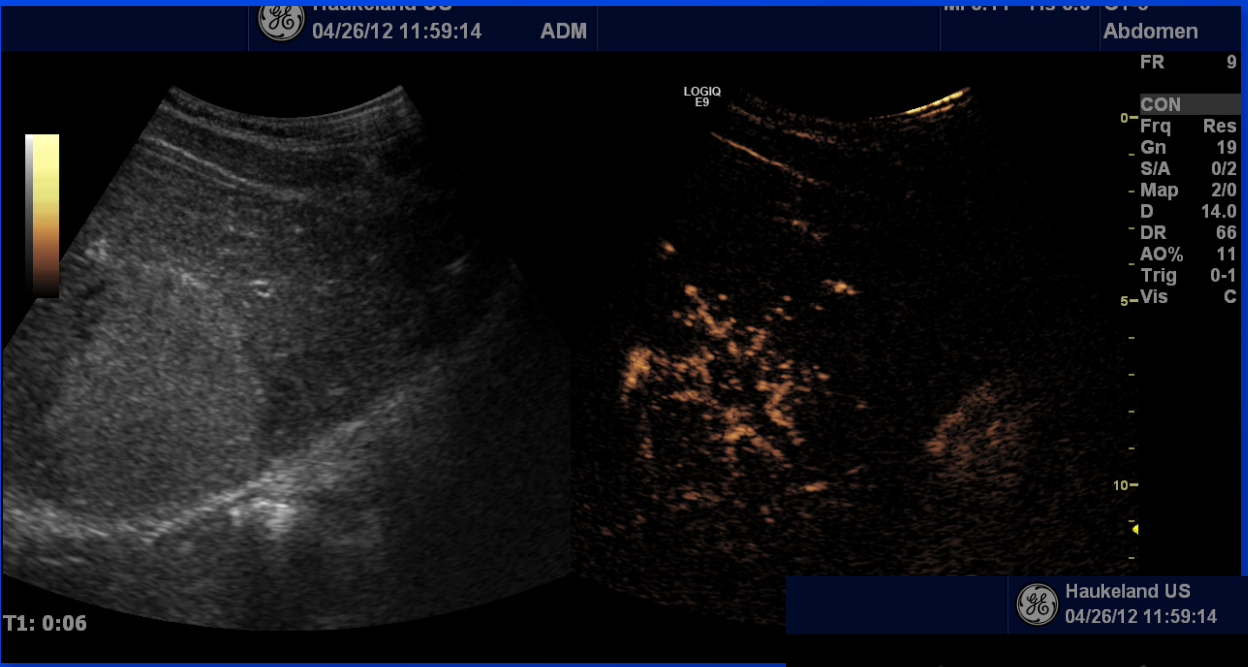
FNH - CEUS

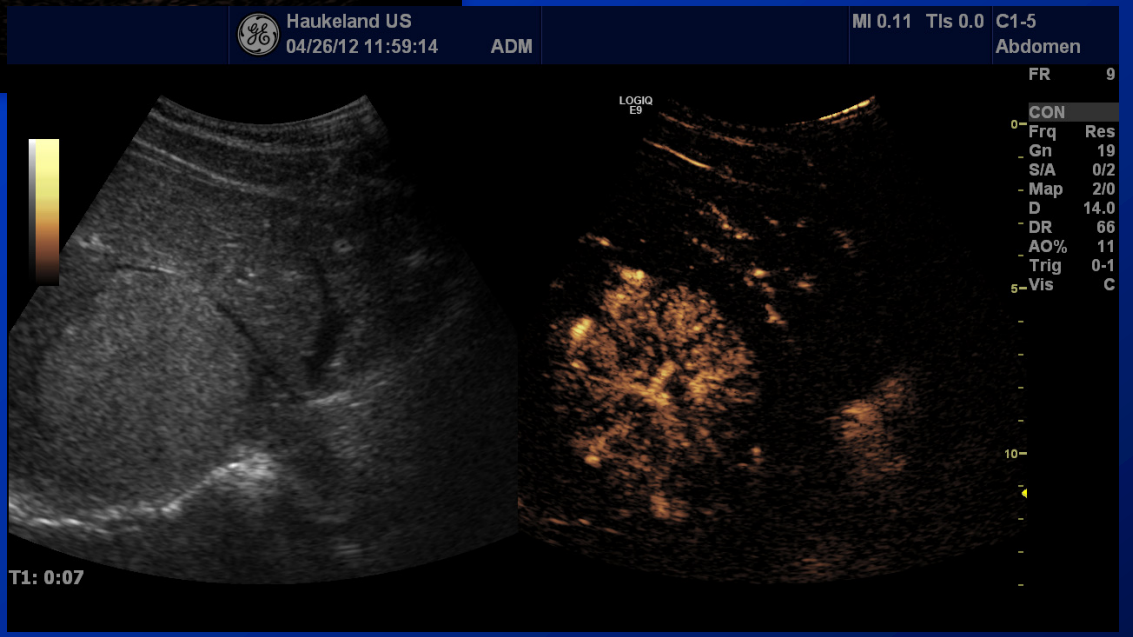


FNH- Arterial Phase



FNH


04/26/12 11:59:14
ADM
Abdomen
FR 9
LOGIQ E9
CON
Frq Res
Gn 19
S/A 0/2
Map 2/0
D 14.0
DR 66
AO% 11
Trig 0-1
Vis C
T1: 0:06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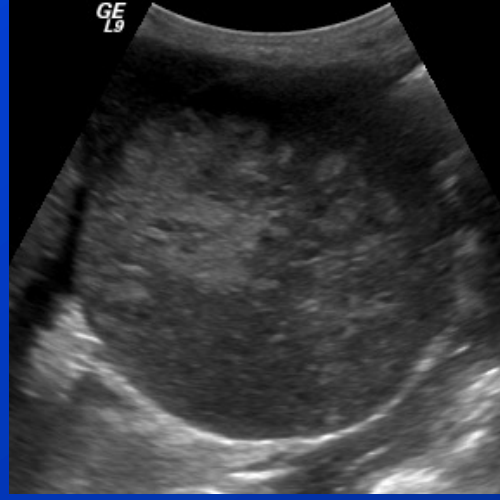
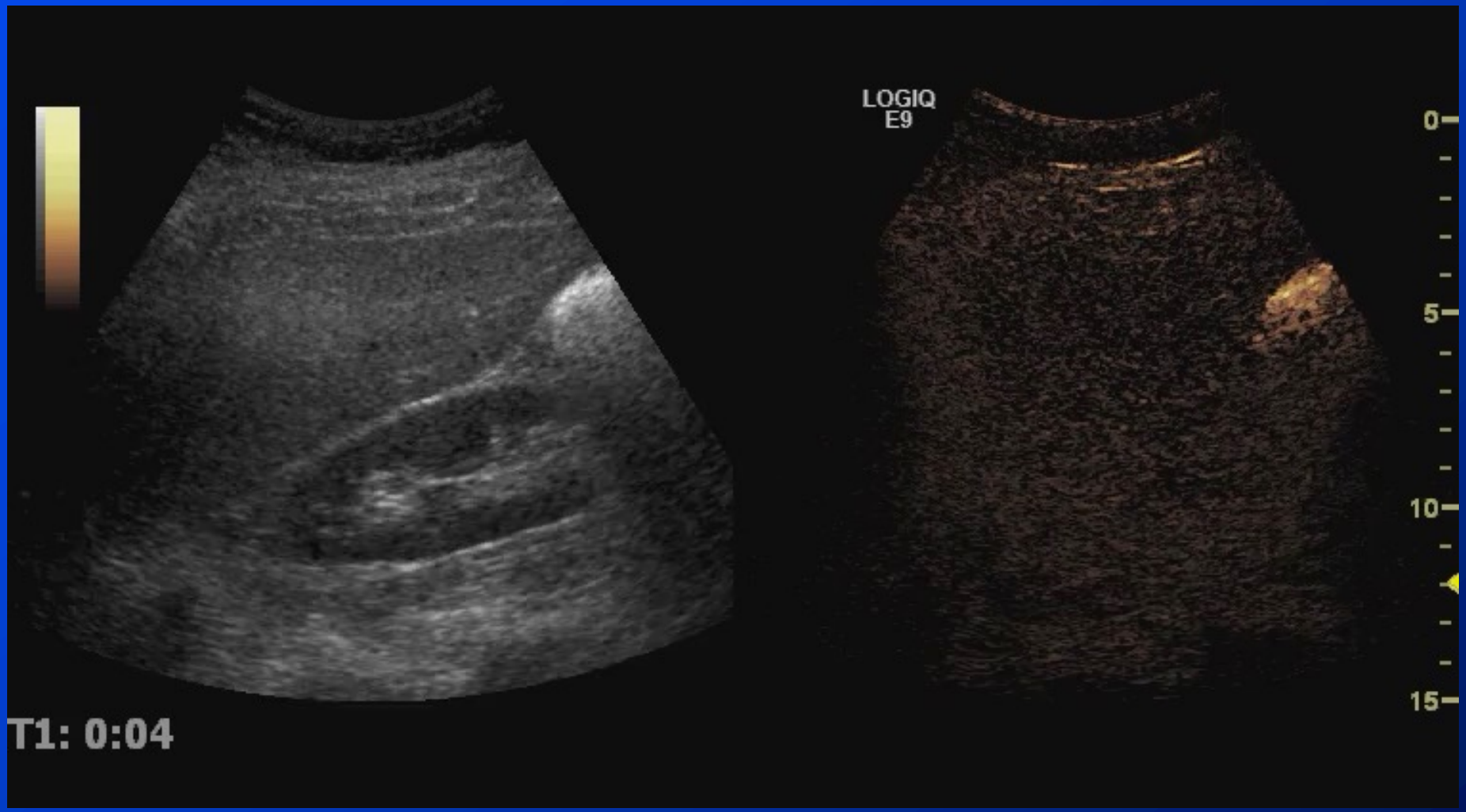
T1: 0:07



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 flow
- 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

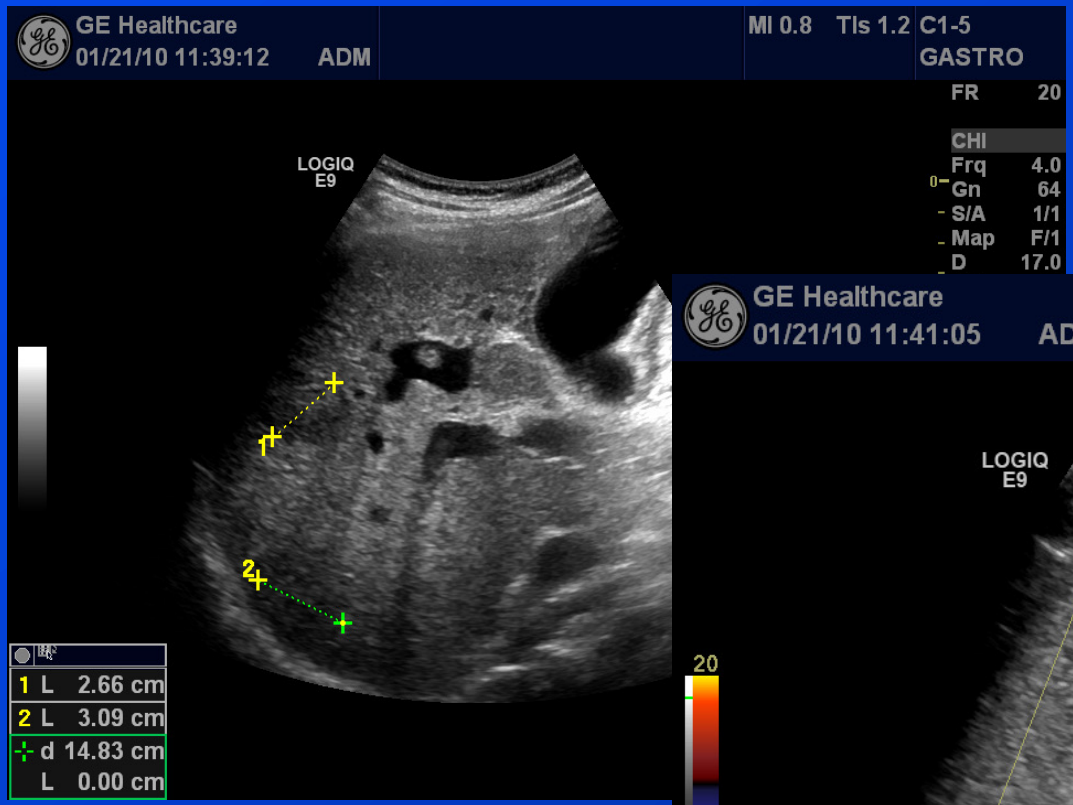
US-Diagnosis of HCC

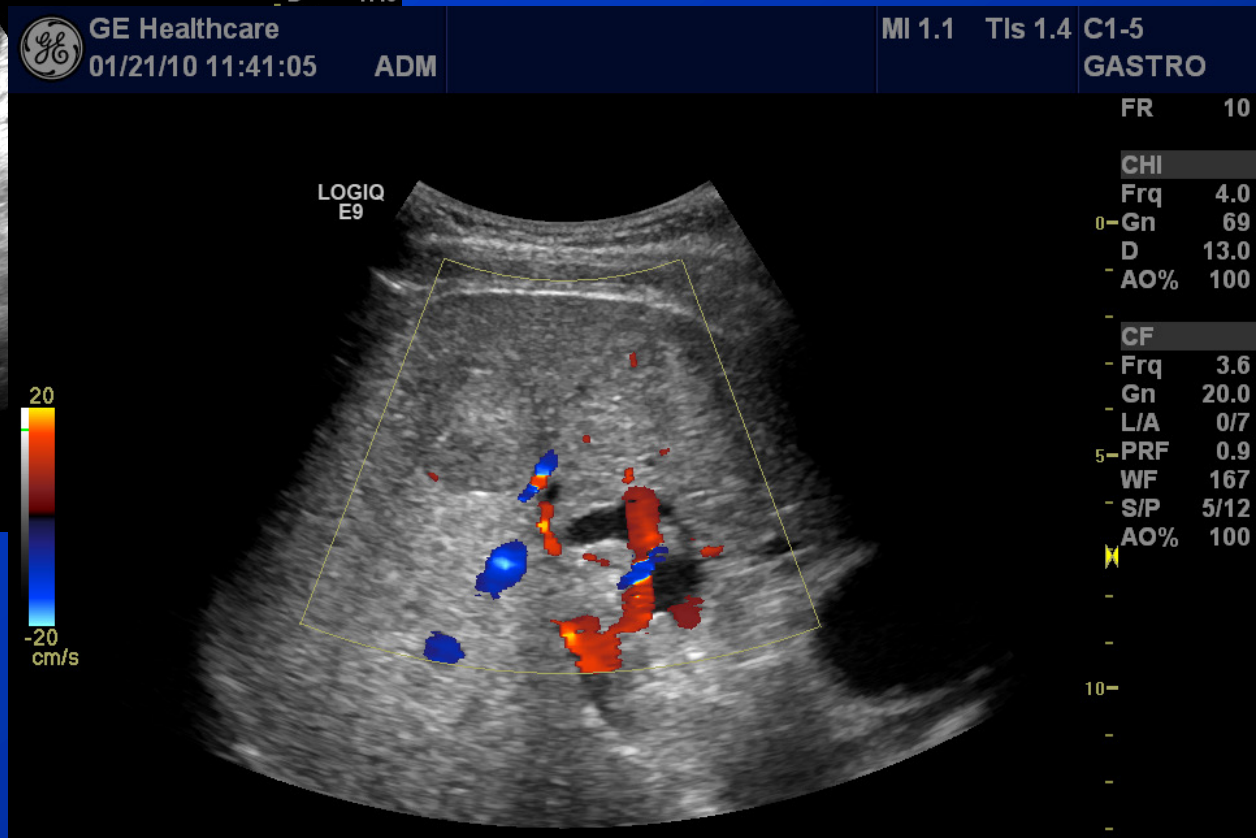
- The ultrasound appearance with conventional B-mode of hepatocellular carcinoma:
  - hypoechoic in 48 %
  - isoechoic in 9 %
  - hyperechoic in 19 %
  - in 25 % a mixture between hyper- and hypoechoic appearance was found compared to the surrounding liver tissue.

Ignee et al, Z Gastroenterol 2005; 43: 289-294

HCC – The great Imitator

Tumors in Cirrhotic liver

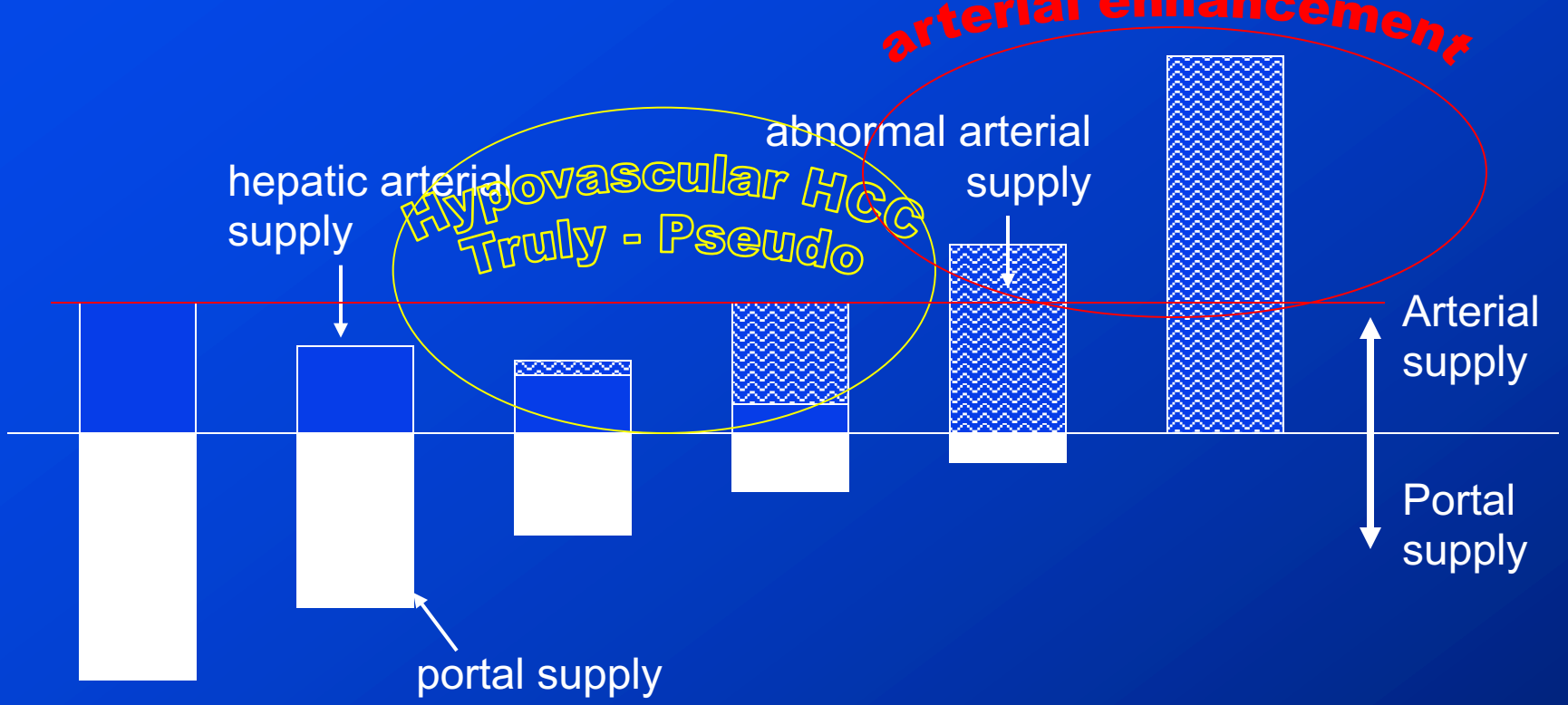




Cirrhotic liver and FLL - HCC?

- Common clinical problem
- Increasing incidence world-wide
- AFP has limited sensitivity
- US (and CT) without CA has low ability to detect and characterize lesions

The Sequence of HCC Development



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

early HCC

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

Probability of HCC in Cirrhosis

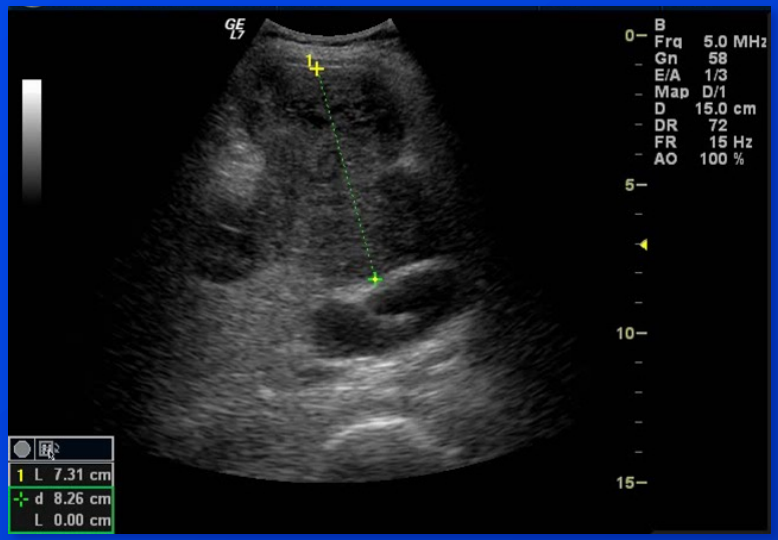
Which nature is expected to have a focal liver lesion newly detected in a cirrhotic liver?

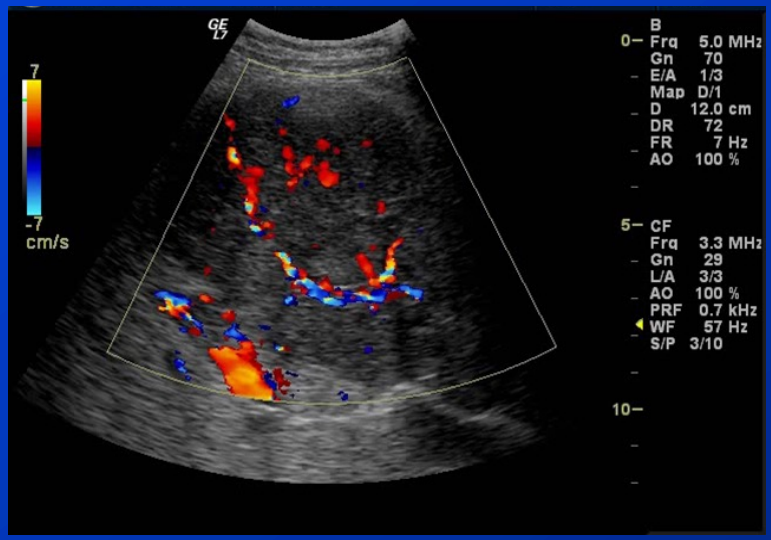
From a likelyhood approach:
65% HCC if 1-2cm,
85% HCC if 2-3cm,
>90-95% if >3 cm

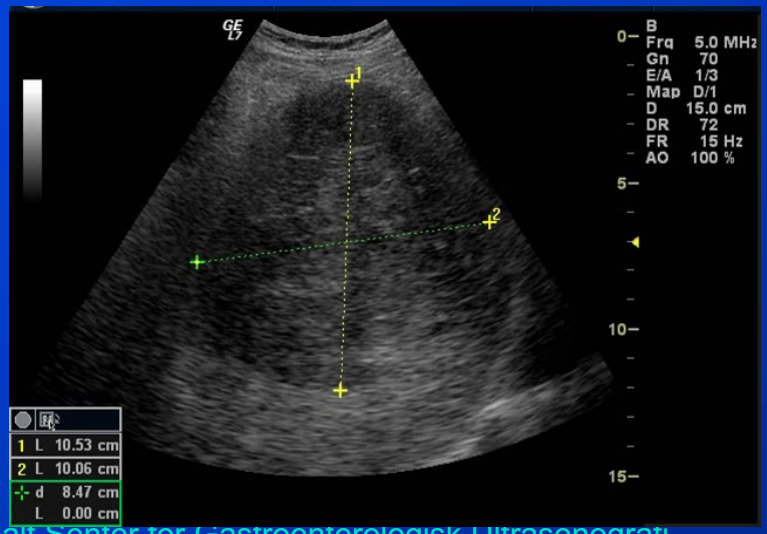
<u>If not an HCC, consider:</u>

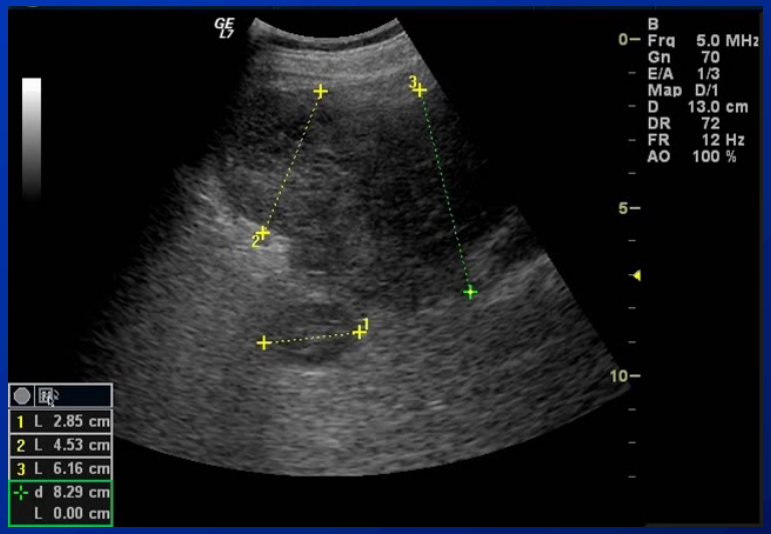
1.Regenerative dysplastic nodule
2.Hemangioma
3.Cholangiocellular carcinoma
4.Lymphoma

HCC -male 53 years of age with chronic HBV and AFP=3000 (Ethiopia 2012)

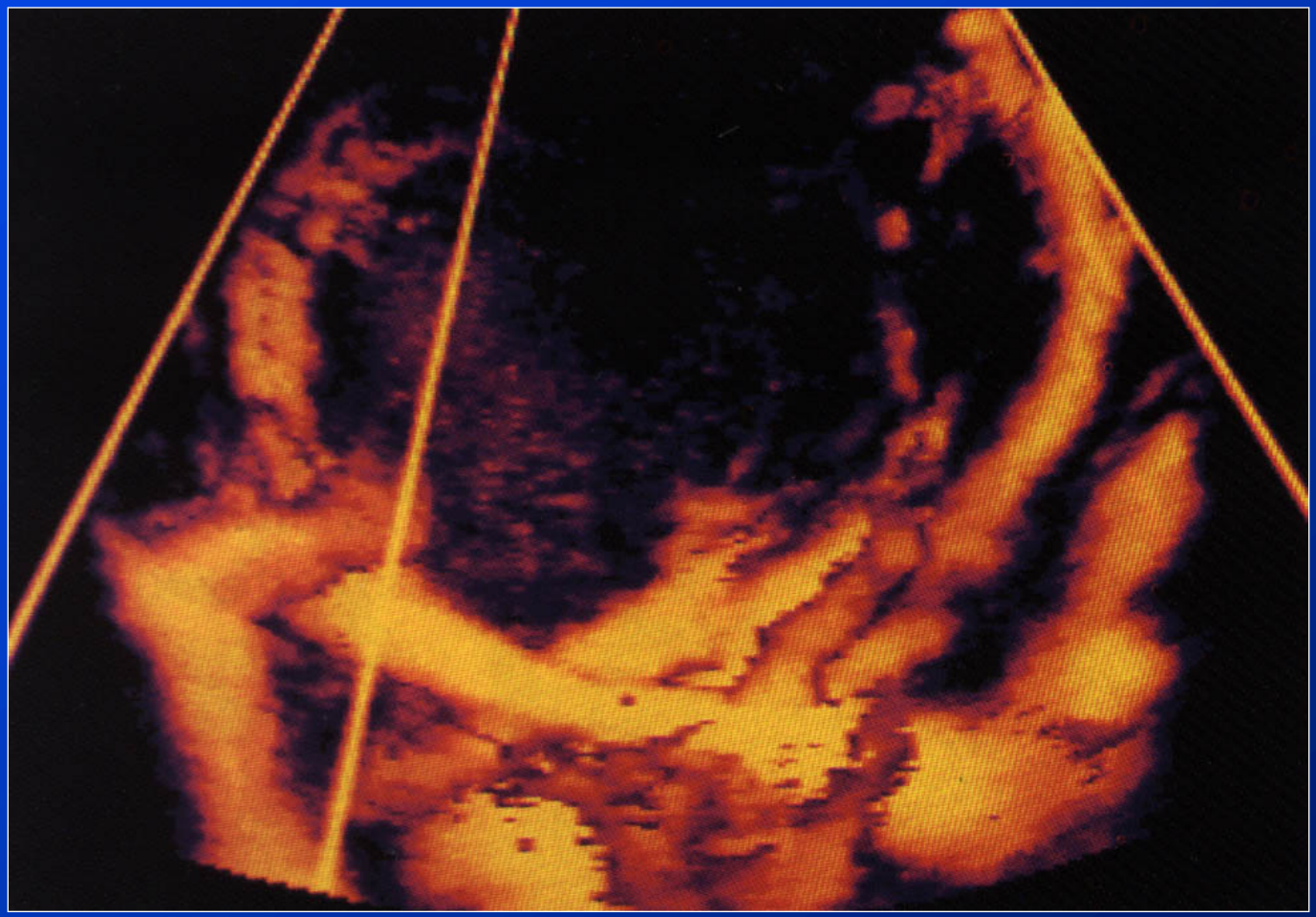






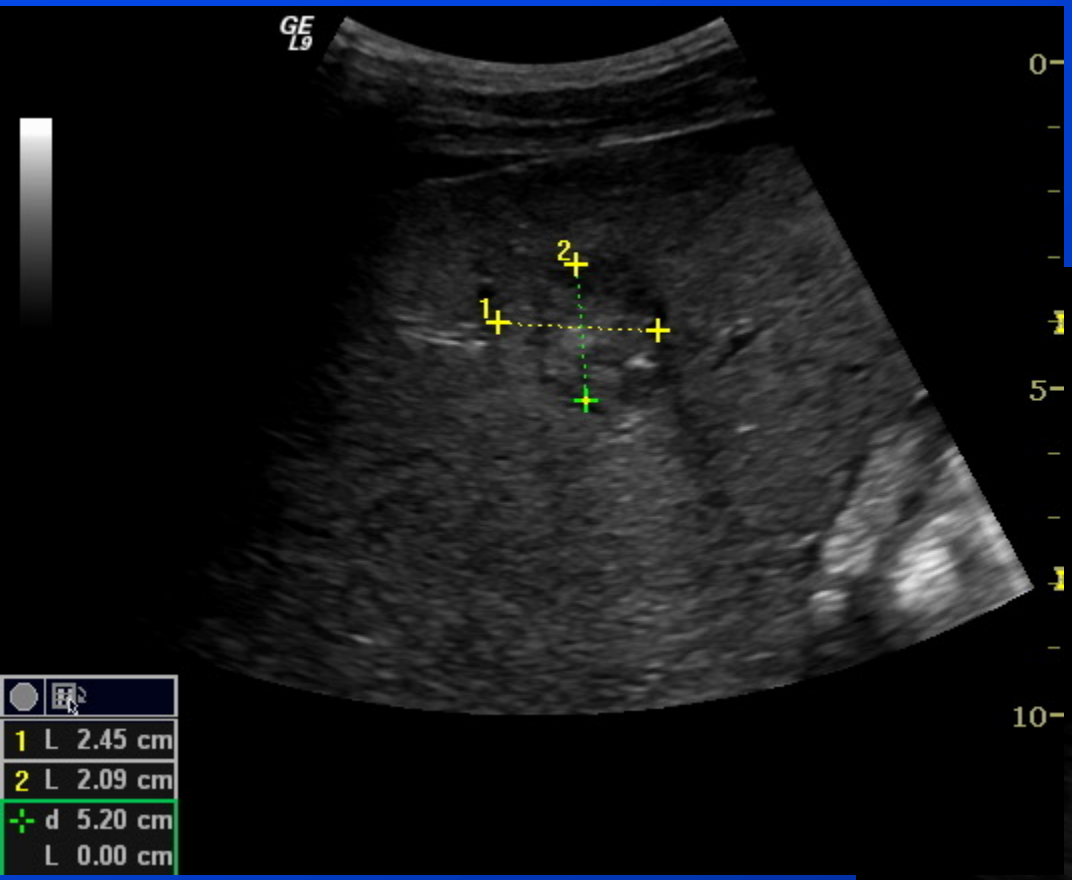


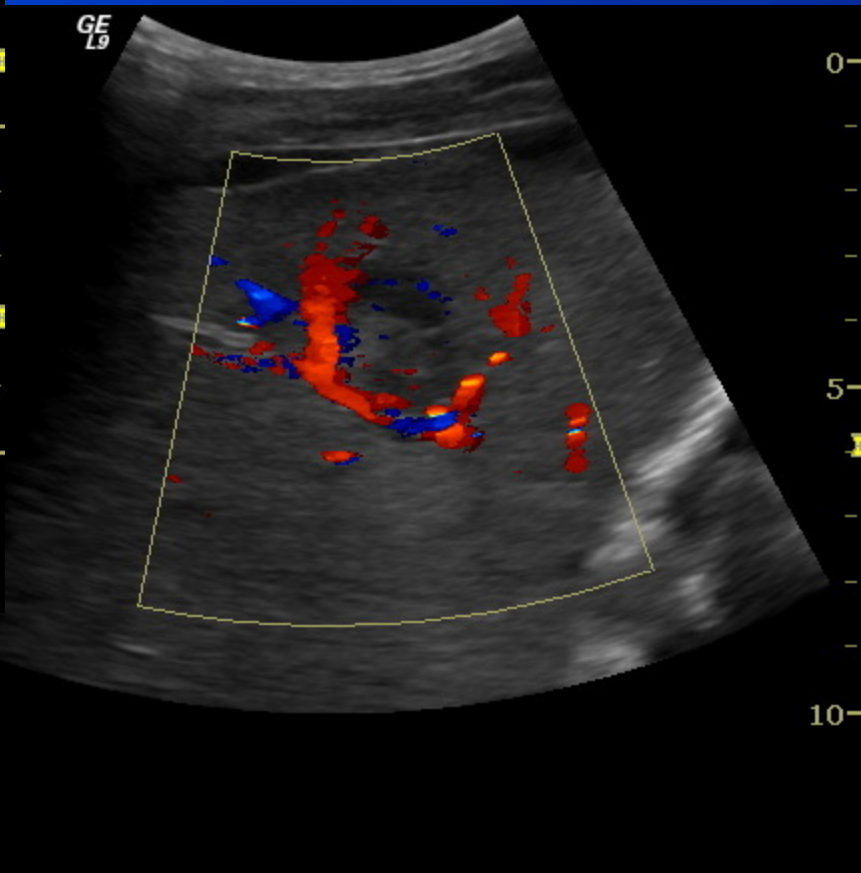
Three-dimensional power Doppler US of tumor vascularity in hepatocellular carcinoma



Ohishi H et al. J Ultrasound Med 1998;17:619-622

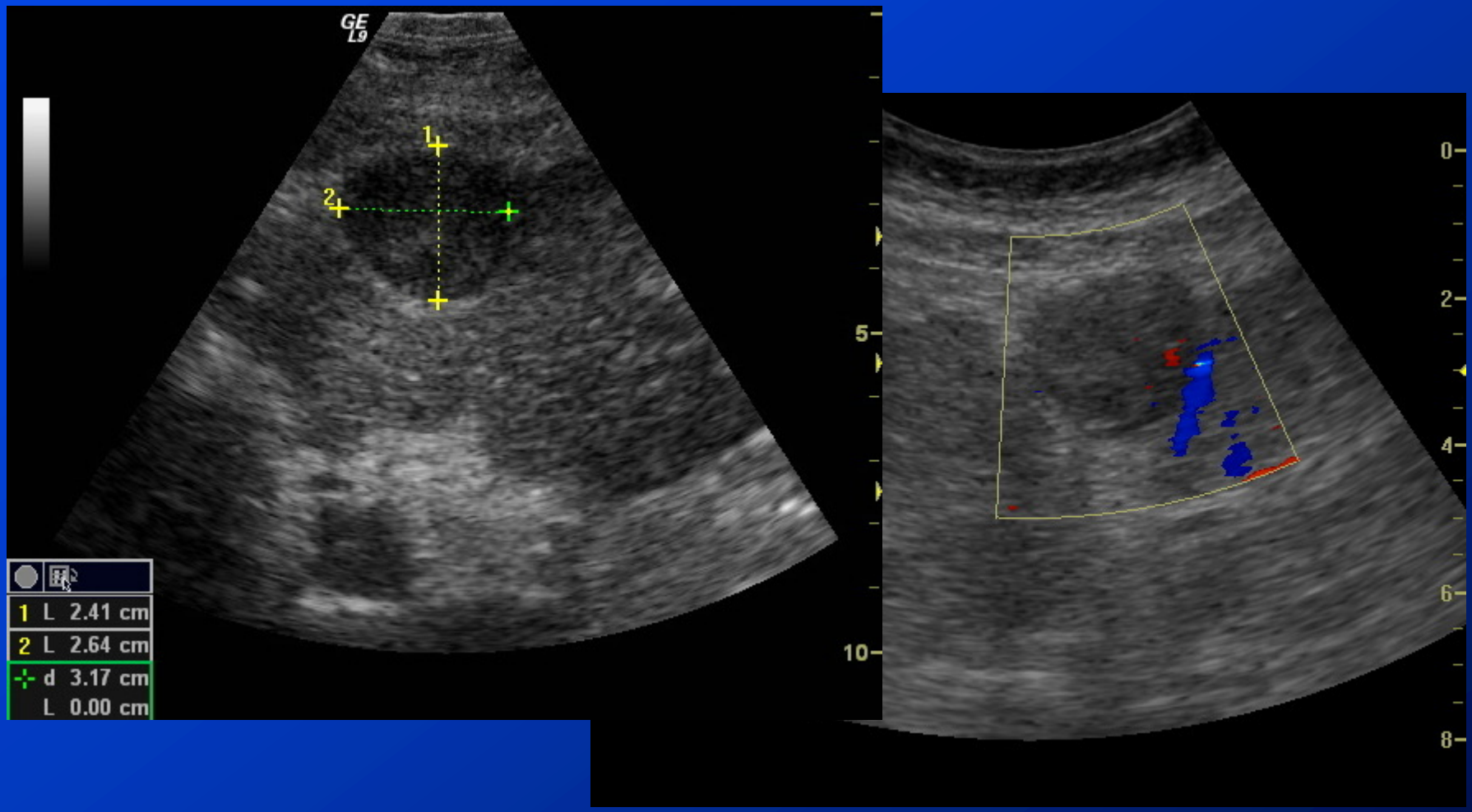
Doppler and Basket sign in HCC



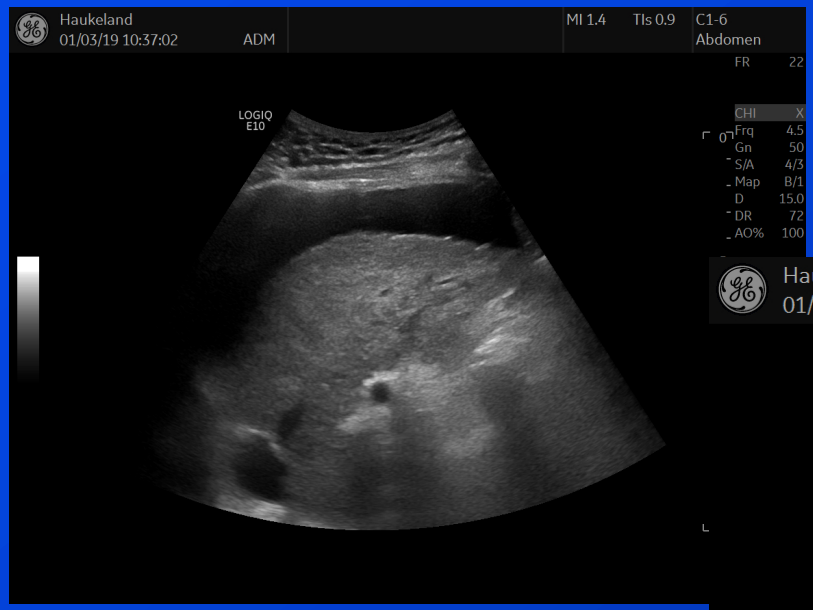


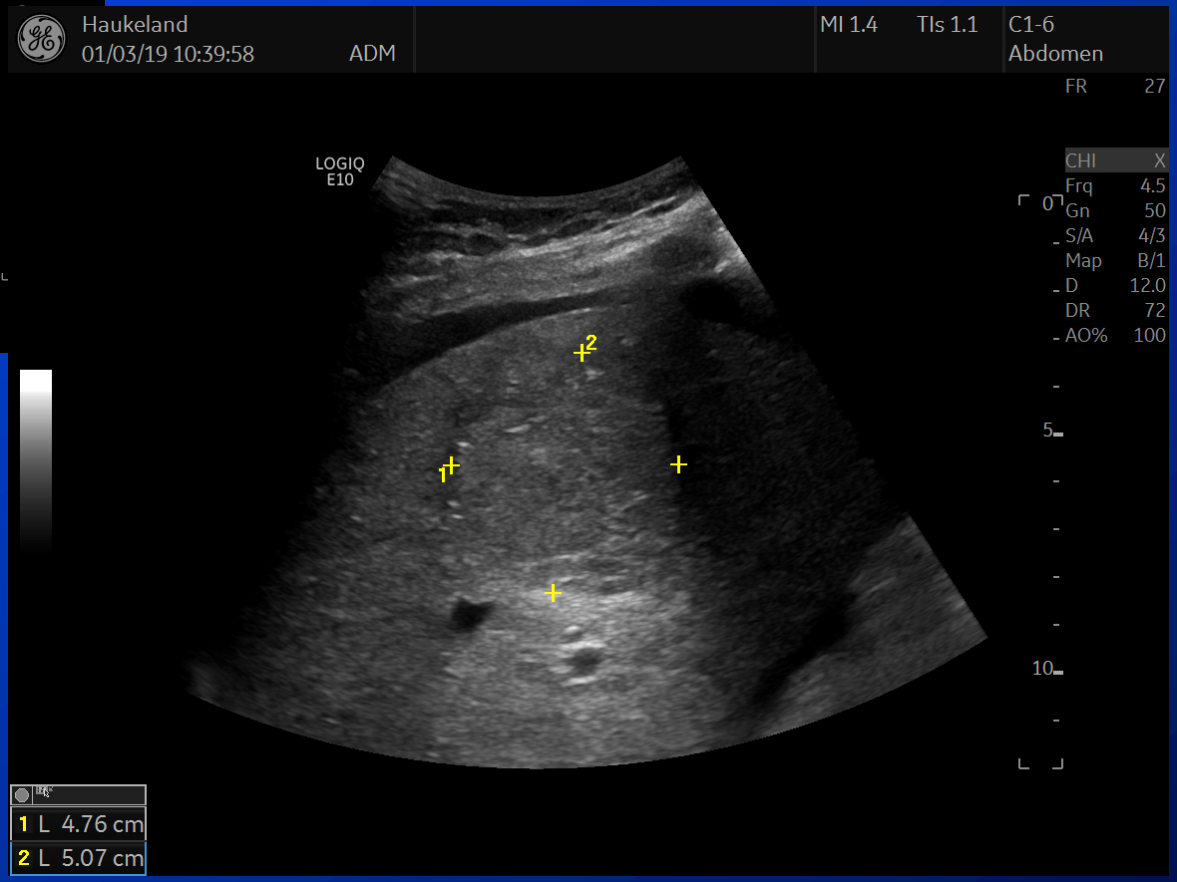
A 61 year old man with cirrhosis and encephalopathy

Tumor Characterisation

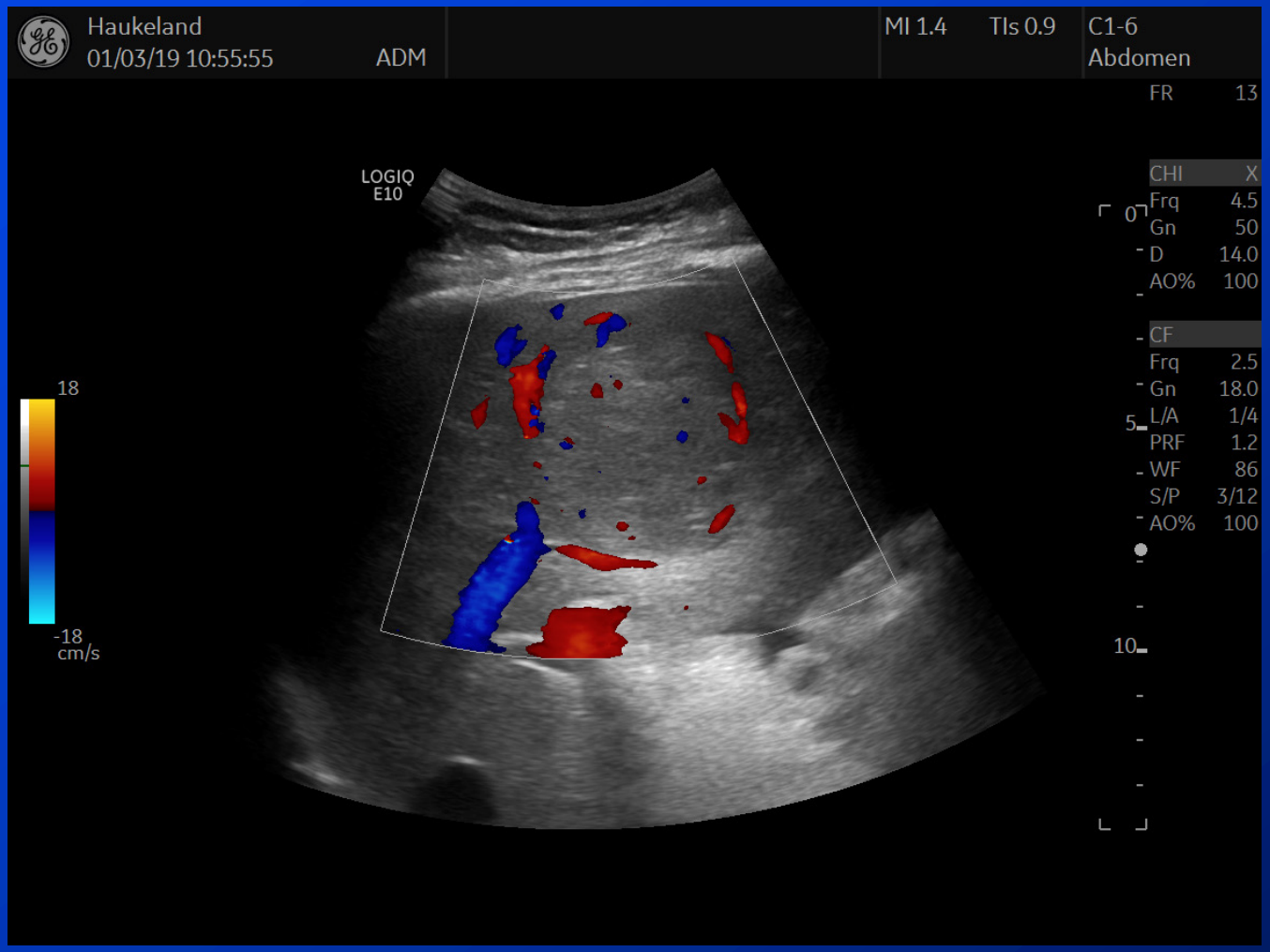


A patient with cirrhosis

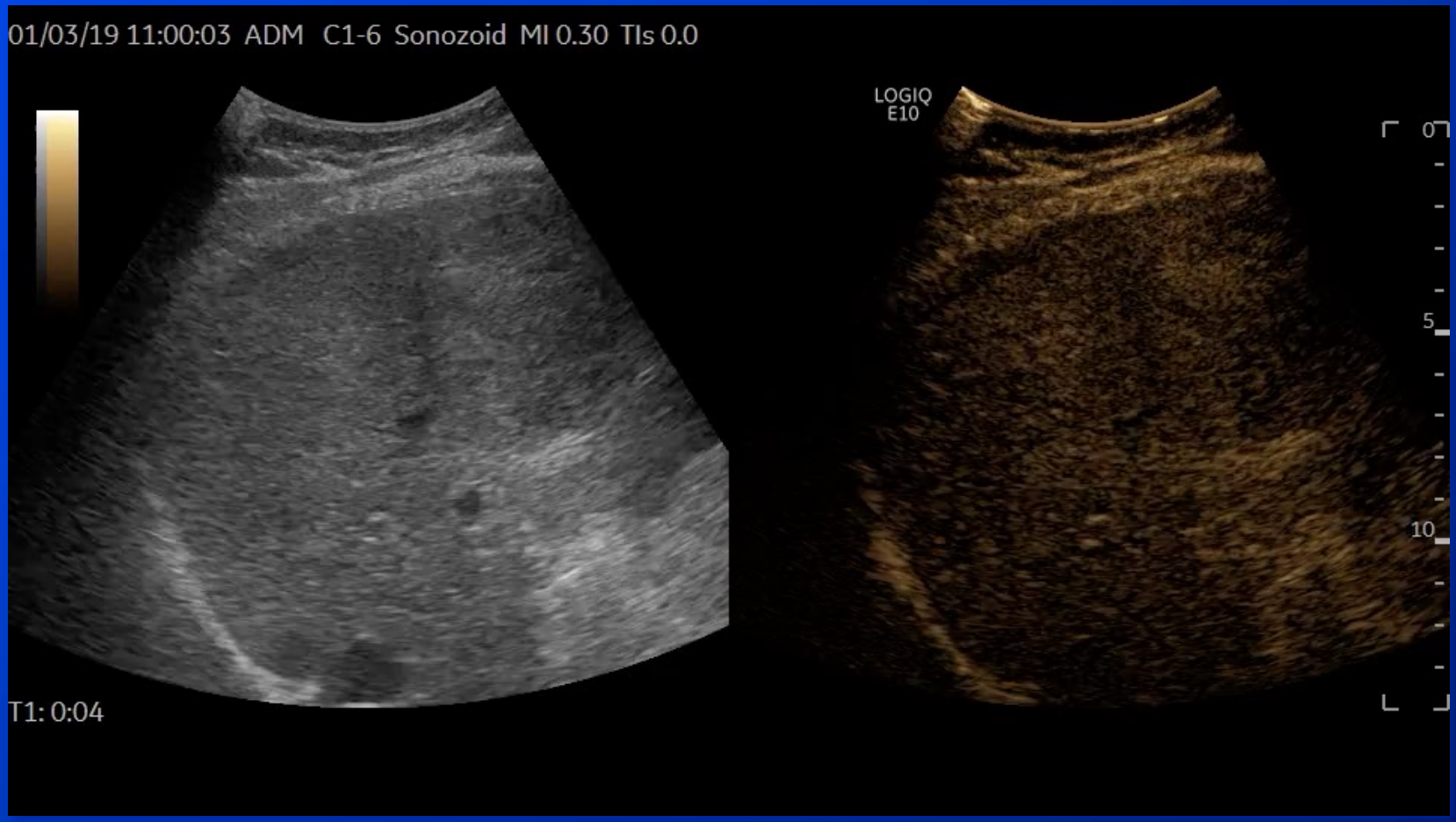




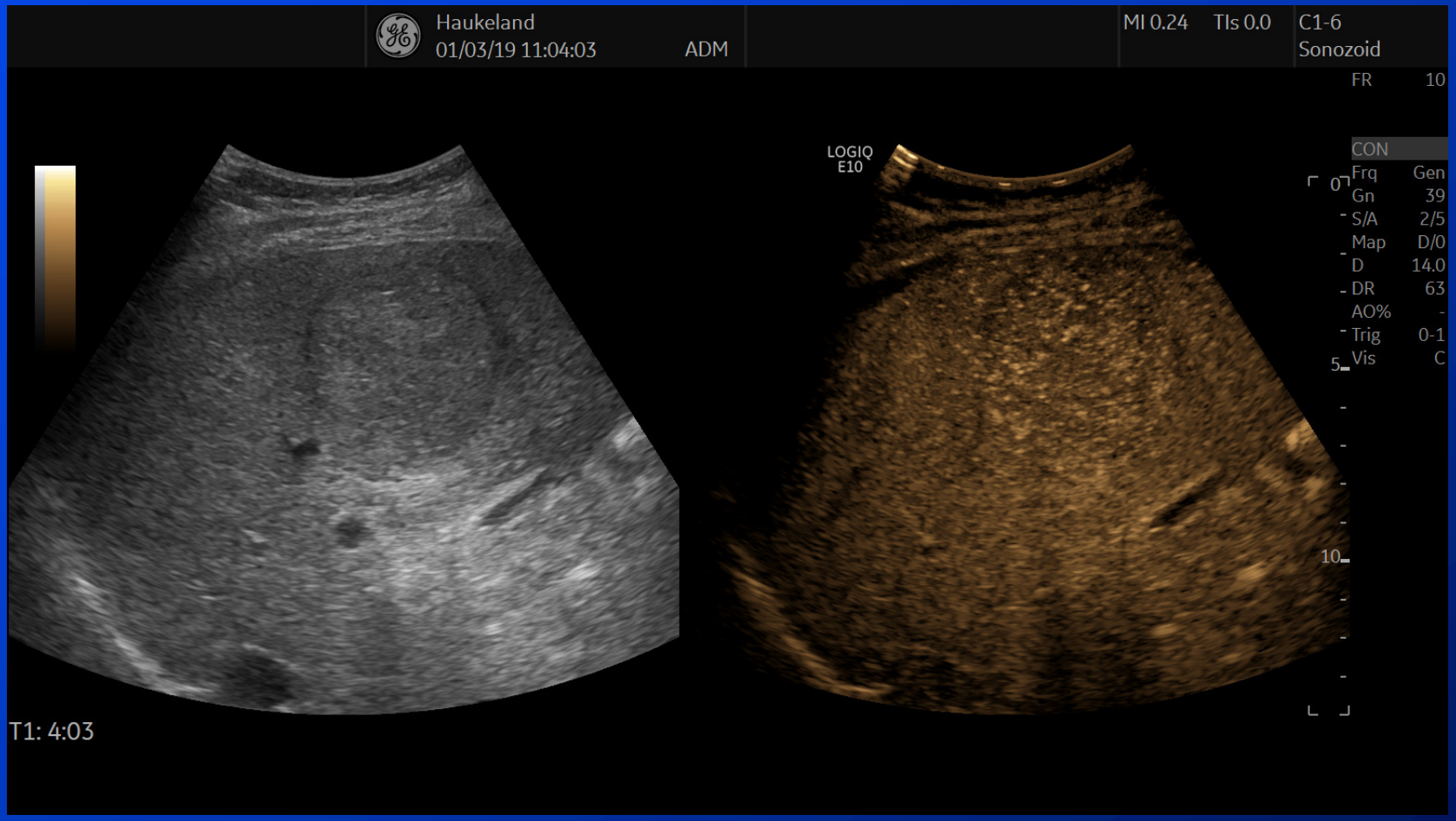
«The Basket Sign»



CEUS of liver tumor



Any wash-out in late phase ?



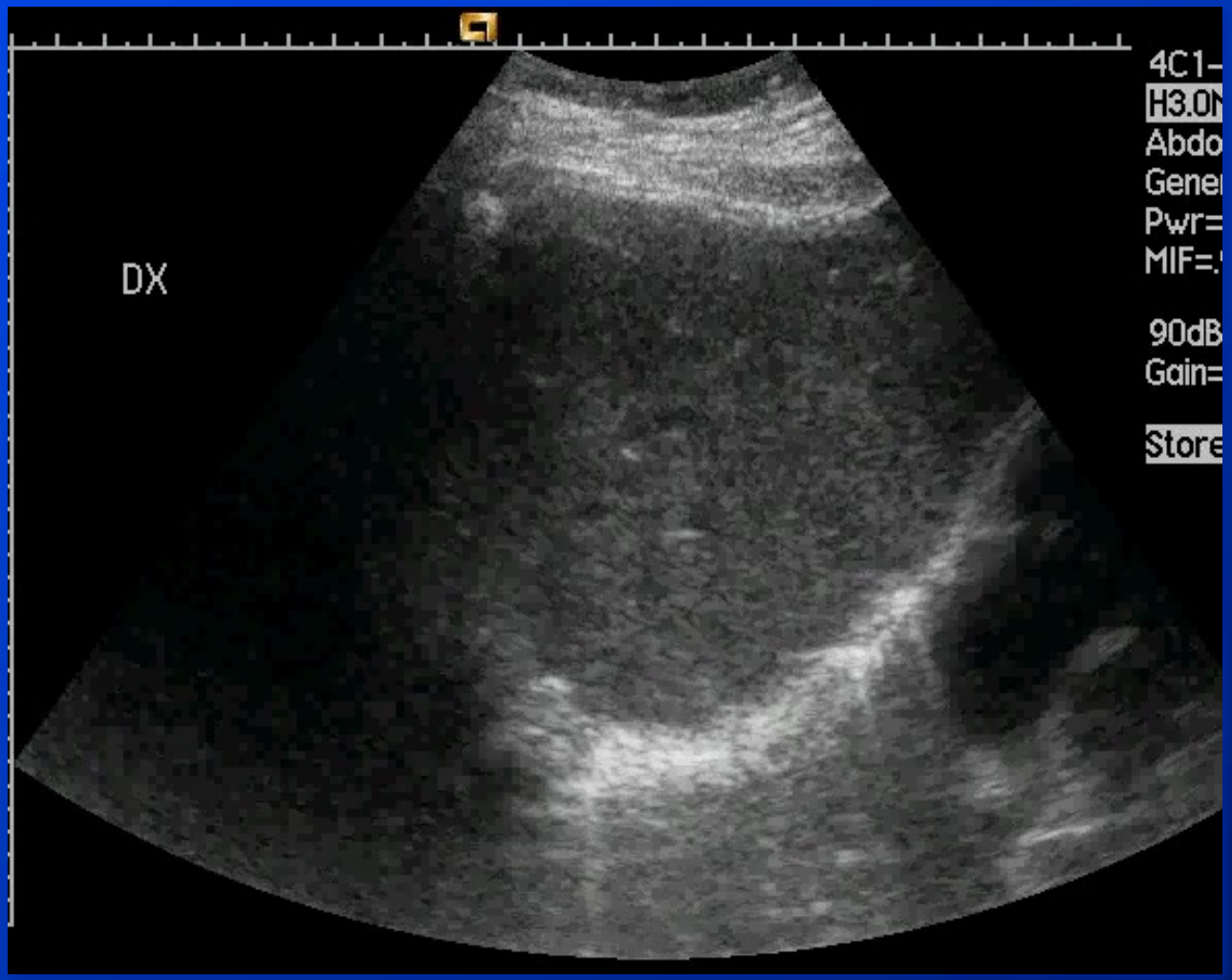
FNH versus HCC

FNH

HCC

Liver Metastasis ?

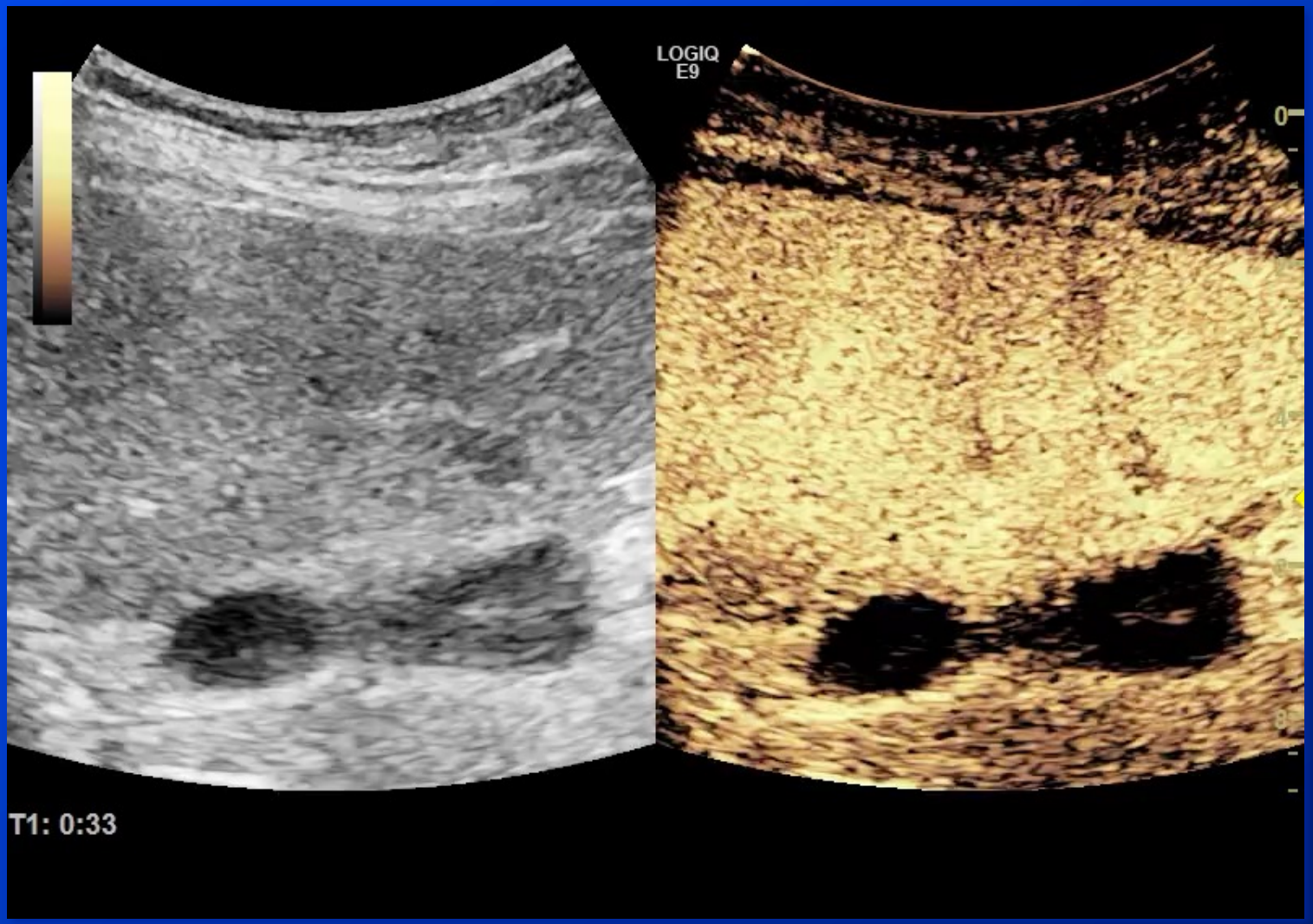
Before contrast injection



Liver Metastasis ?

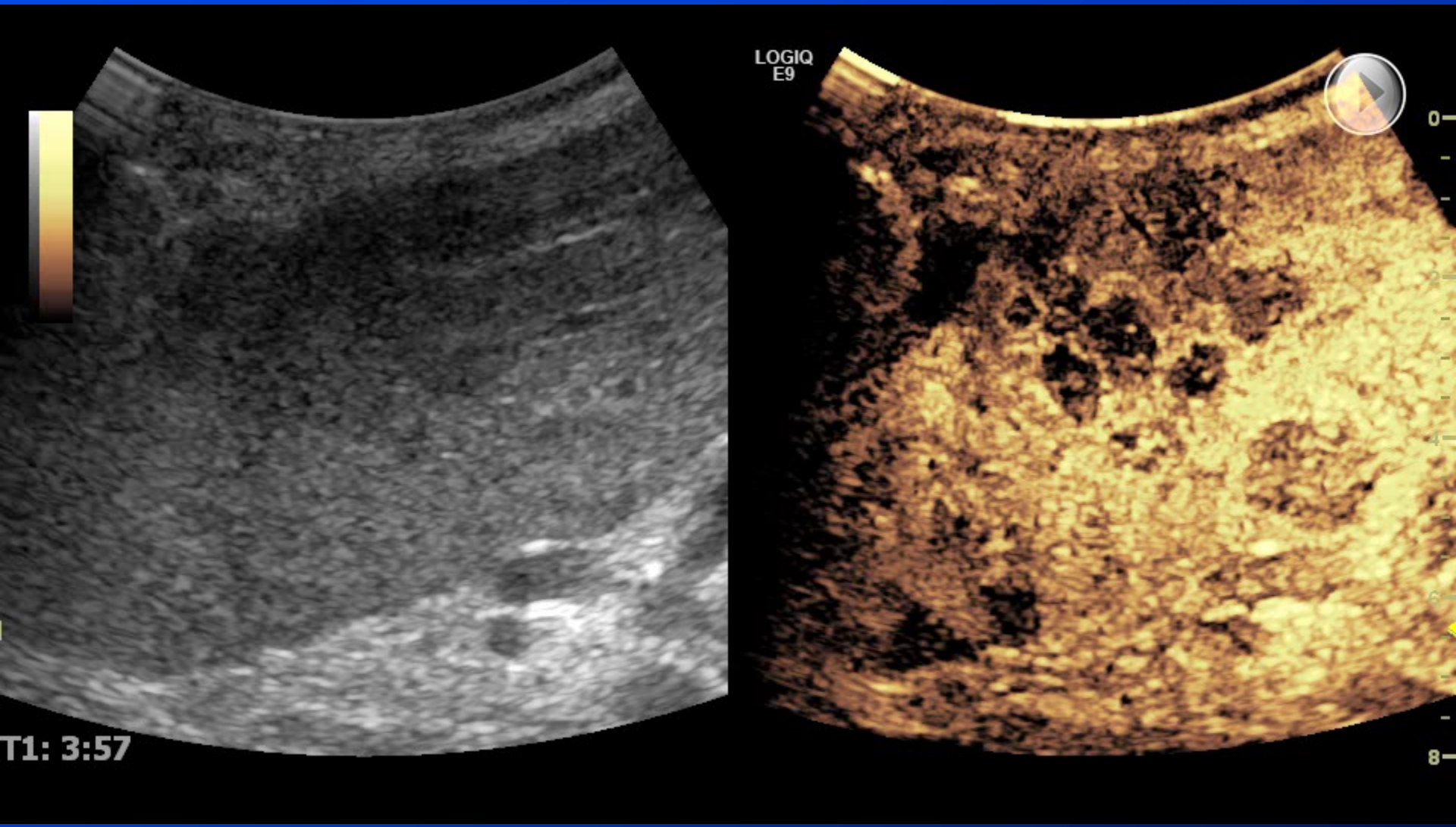
After contrast injection in late phase

Early wash-out typical for mets

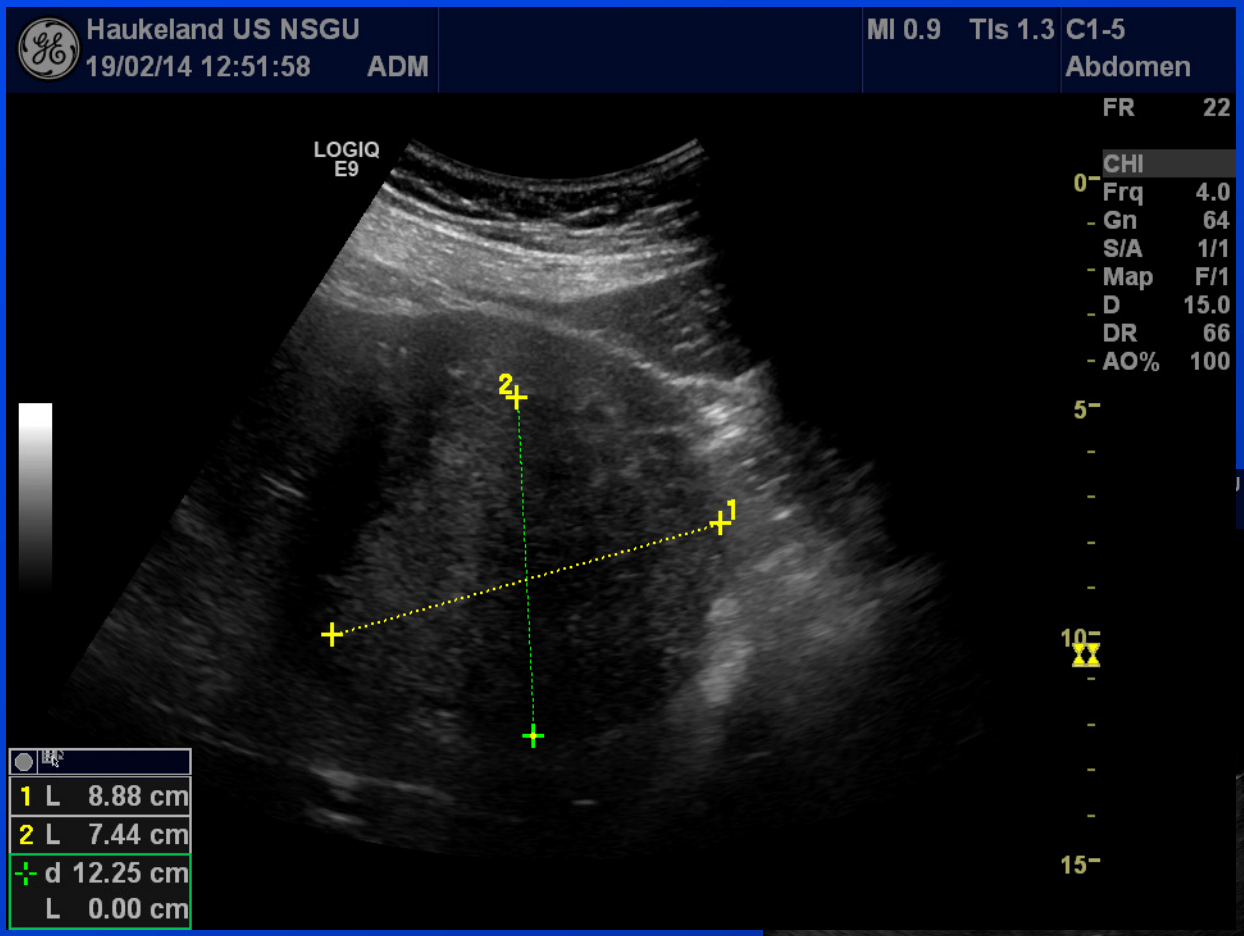


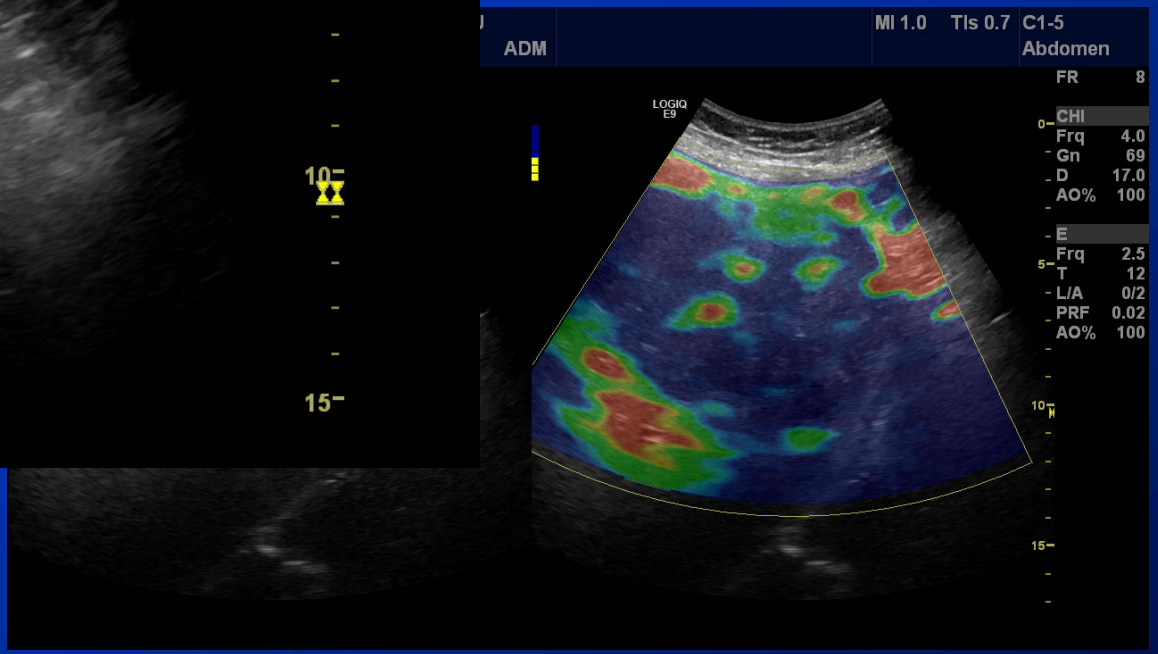
Not easily observed on CT and MRI

Parenchymal Phase (4 min)

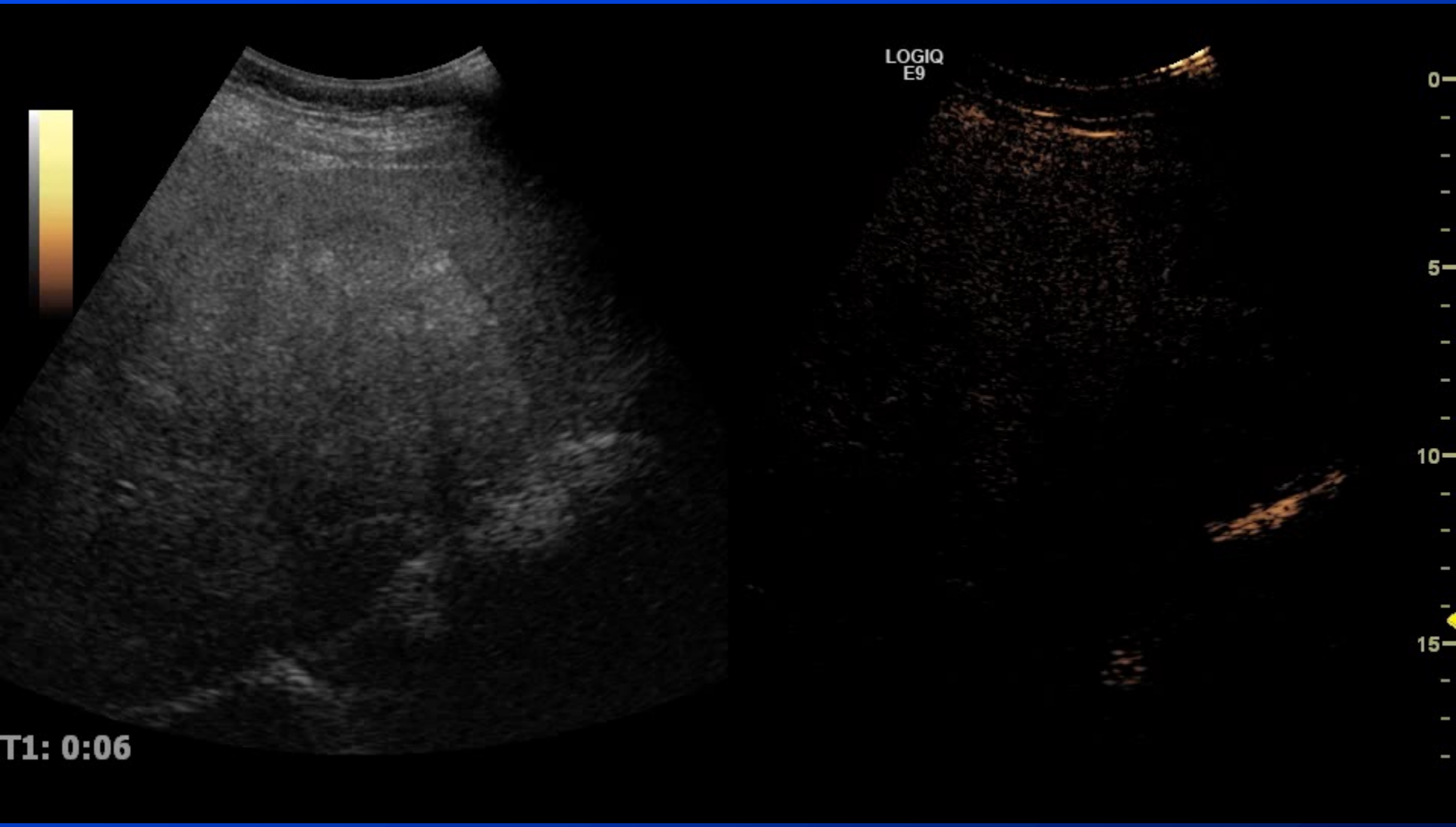


Cholangiocarcinoma

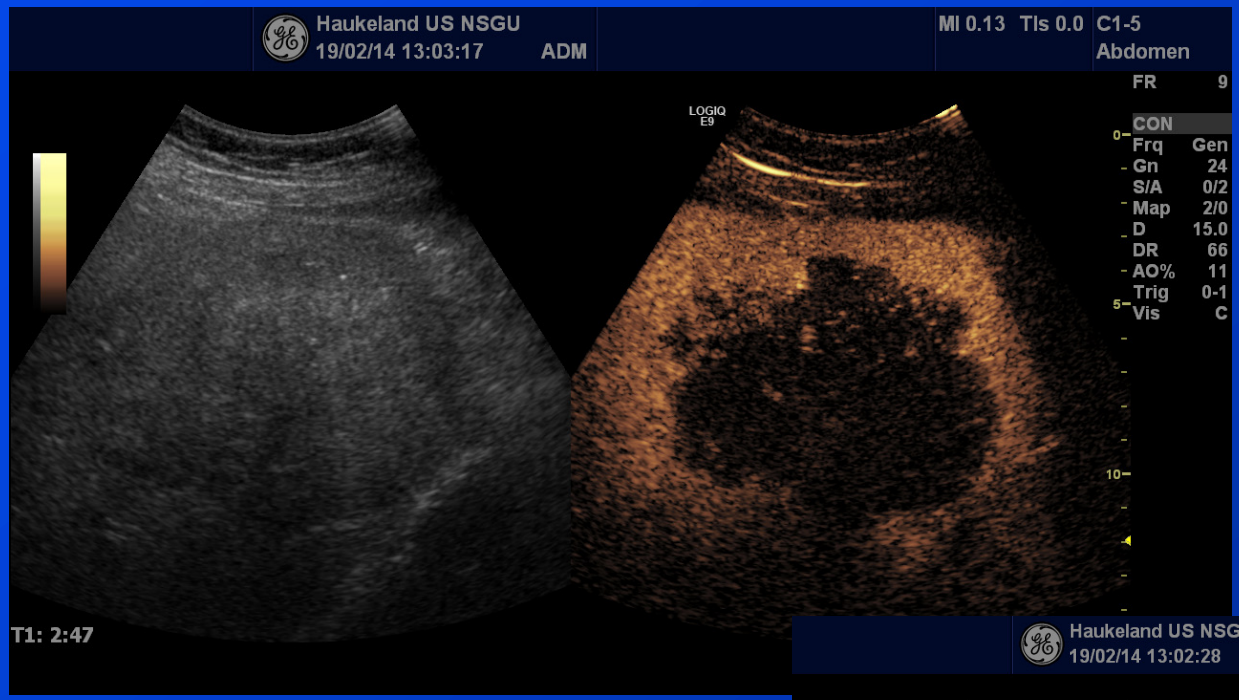


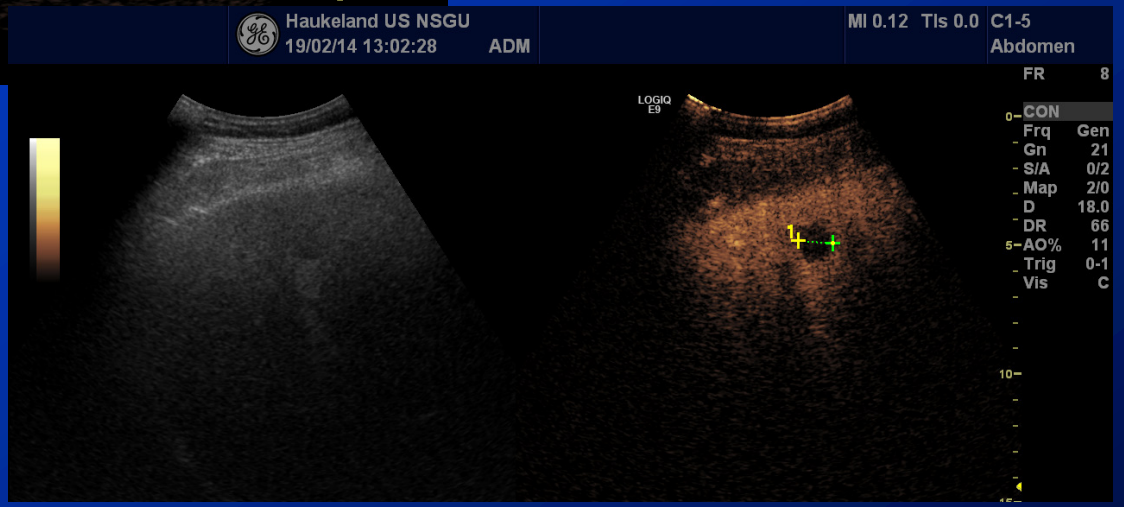


Cholangiocarcinoma

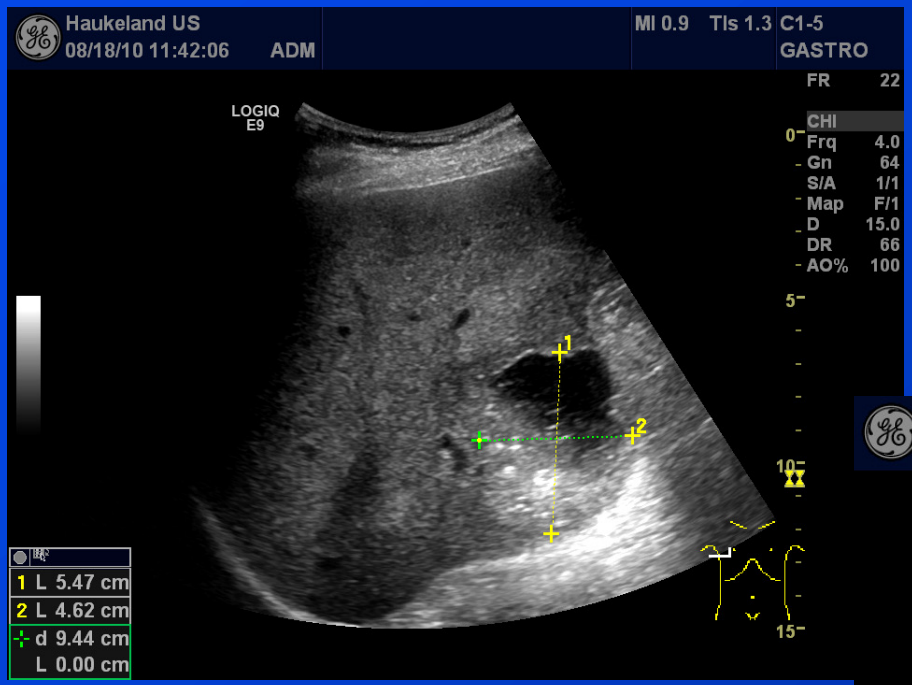


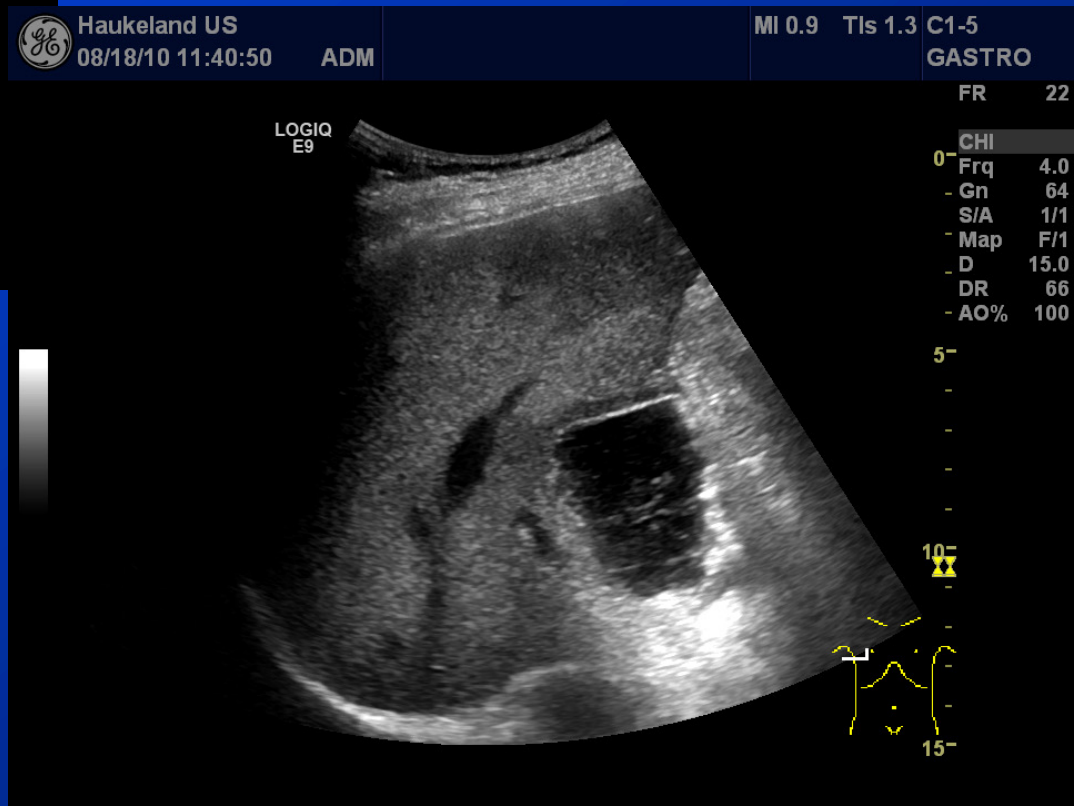
Cholangiocarcinoma – Late Phase





Abcess


Haukeland US
08/18/10 11:42:06 ADM
MI 0.9 TIs 1.3
C1-5
GASTRO
LOGIQ E9
FR 22
CHI
Frq 4.0
Gn 64
S/A 1/1
Map F/1
D 15.0
DR 66
AO% 100
1 L 5.47 cm
2 L 4.62 cm
d 9.44 cm
L 0.00 cm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C1-5
GASTRO
LOGIQ E9
FR 22
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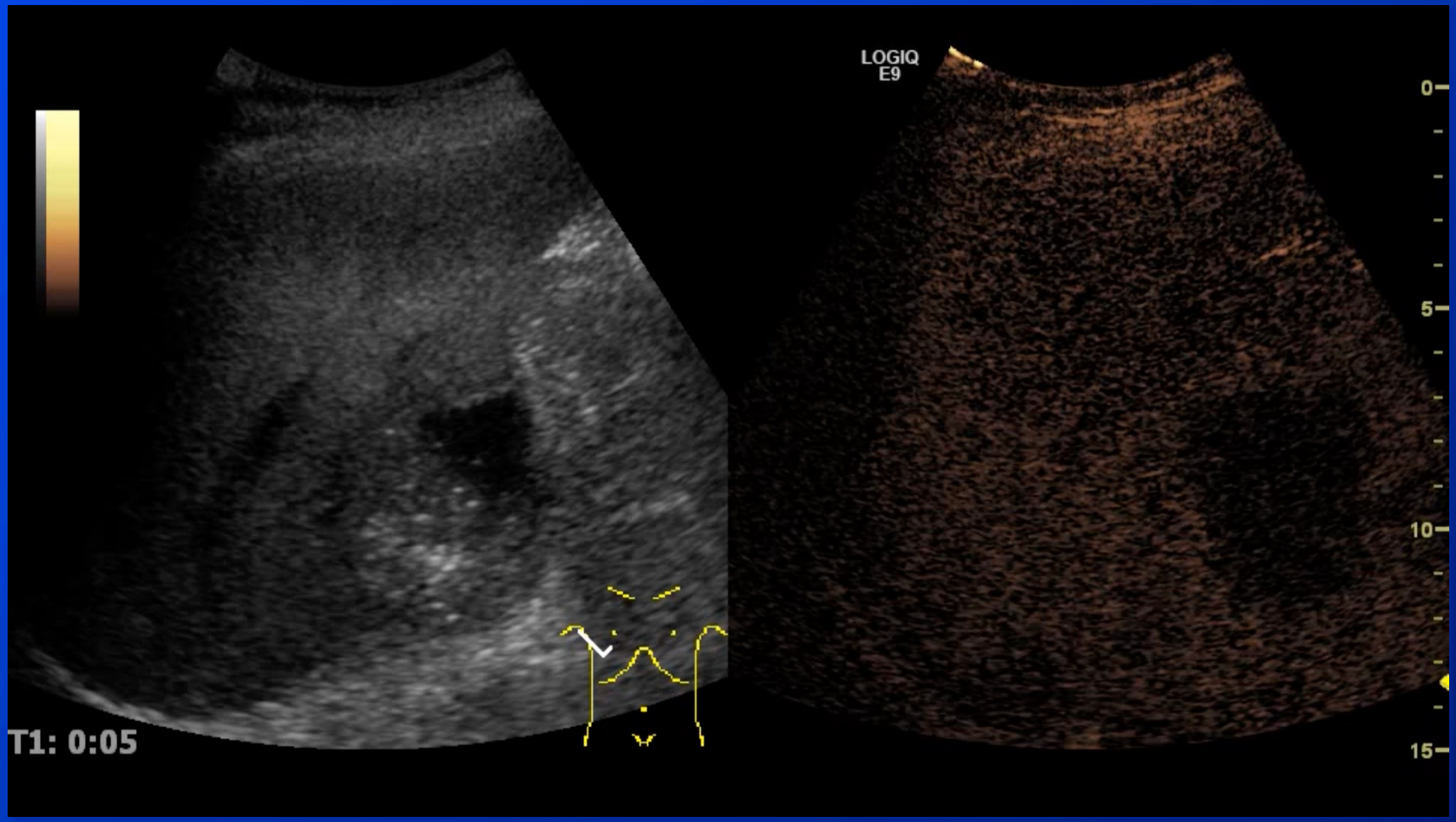
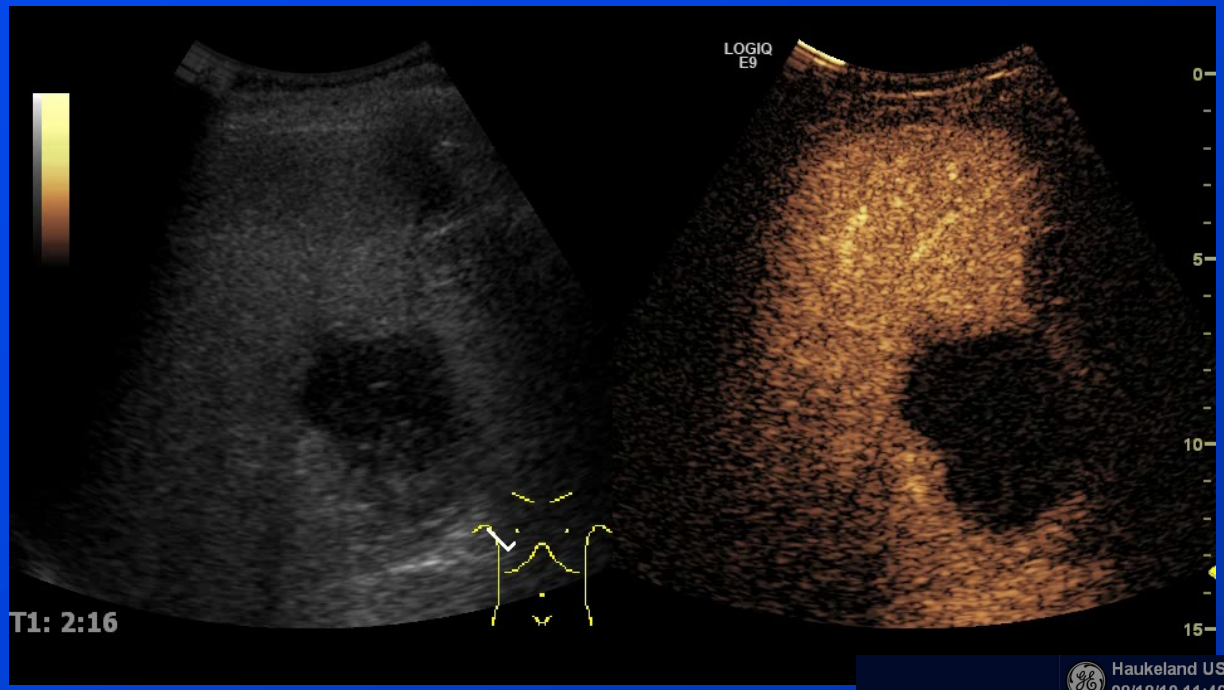
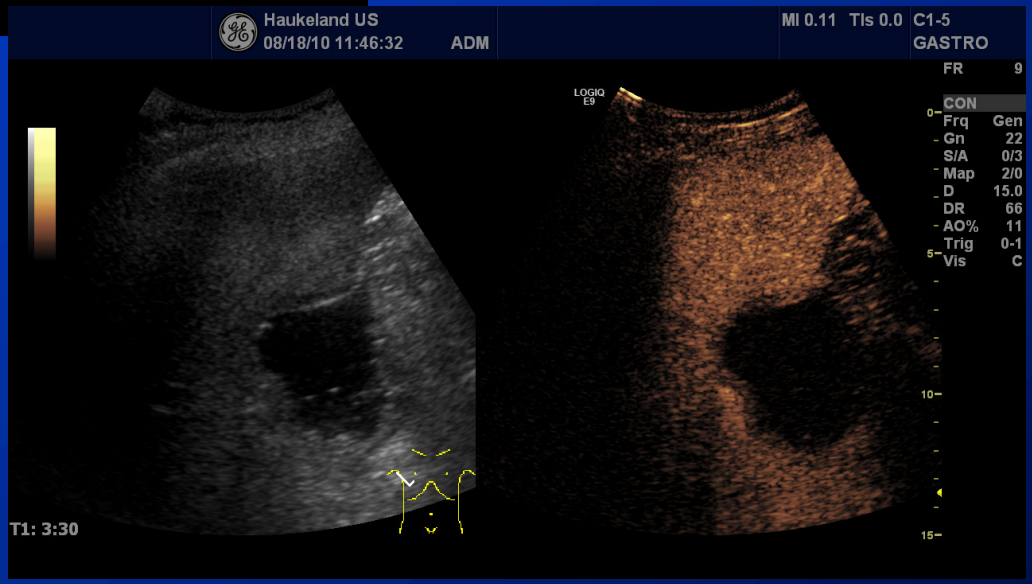
Frq 4.0
Gn 64
S/A 1/1
Map F/1
D 15.0
DR 66
AO% 100

Abscess in Arterial Phase



Abcess – Late Phase





Culture: Staph. Aureus

Safety Considerations

- In general, UCA are extremely safe with a low incidence of side effects
- They are neither nephrotoxic nor cardiotoxic
- The incidence of hypersensitivity or allergic events are much lower than current X-ray or MR contrast agents
- It is not necessary to perform laboratory tests of renal function before administering them
- Contraindications: Known allergic reaction to the agent, pregnancy

Summary

- Ultrasound with microbubbles enables detection and characterization of many different liver lesions
- CEUS of the liver is well established
  - Charcterization of benign lesions
  - Detection of malignant lesions
- Assessment of nodules in liver cirrhosis
- CEUS is sensitive to detect abscesses

US and CEUS
One stop shopping in hepatology

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