

Liver Ultrasound - Beyond the Basics

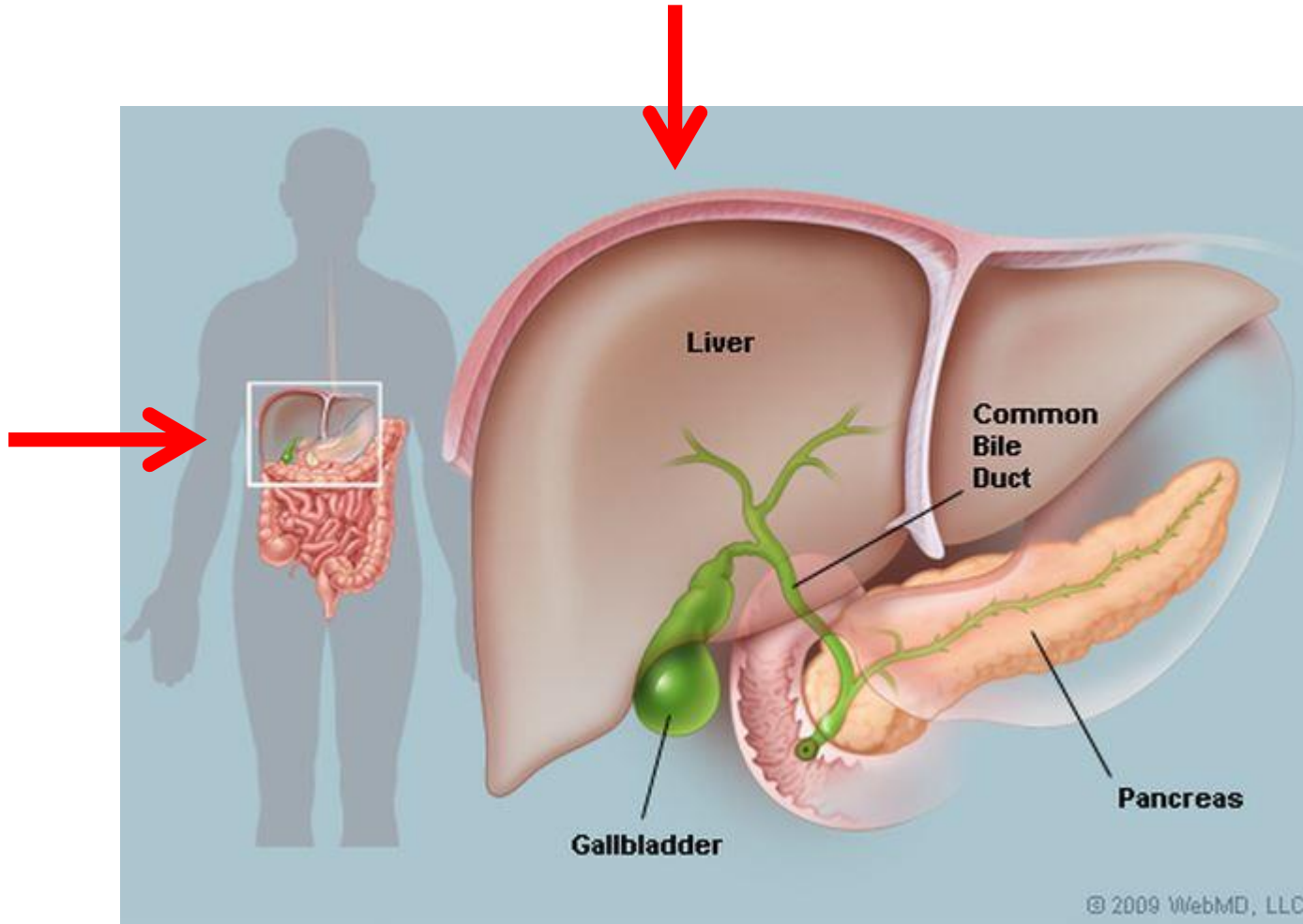
Pamela Parker
Lead Sonographer



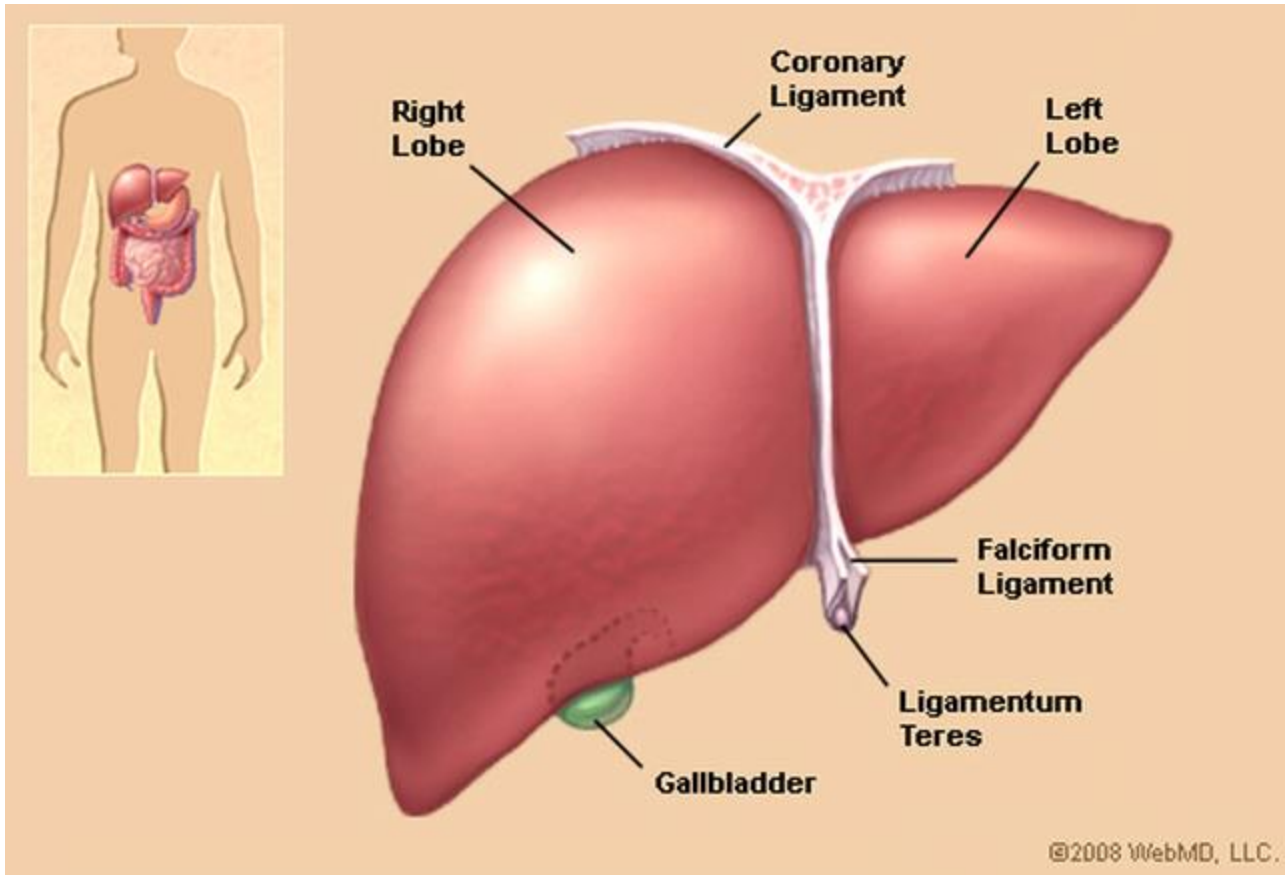
Aims

- Review what we know about the liver
- Reasons for imaging
- Focal lesions
- Diffuse disease
- Can we do more?

The Liver

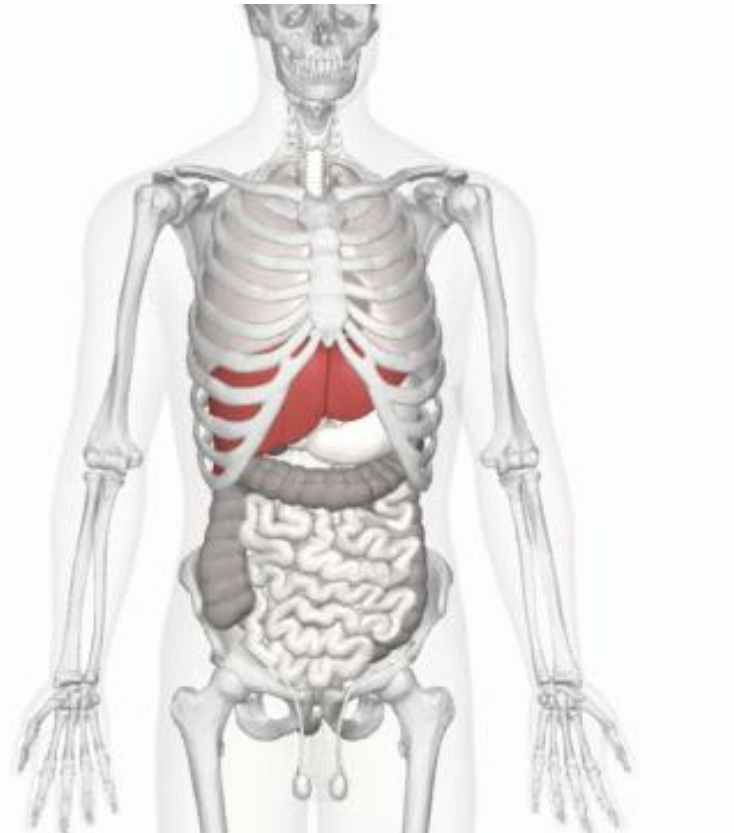


The Liver



The Liver

- Weighs approximately 1.5 kg
- Holds approximately 13% (0.57 litres) of total blood supply
- Non-palpable
- LLL may extend across spleen
- Riedels lobe of RLL

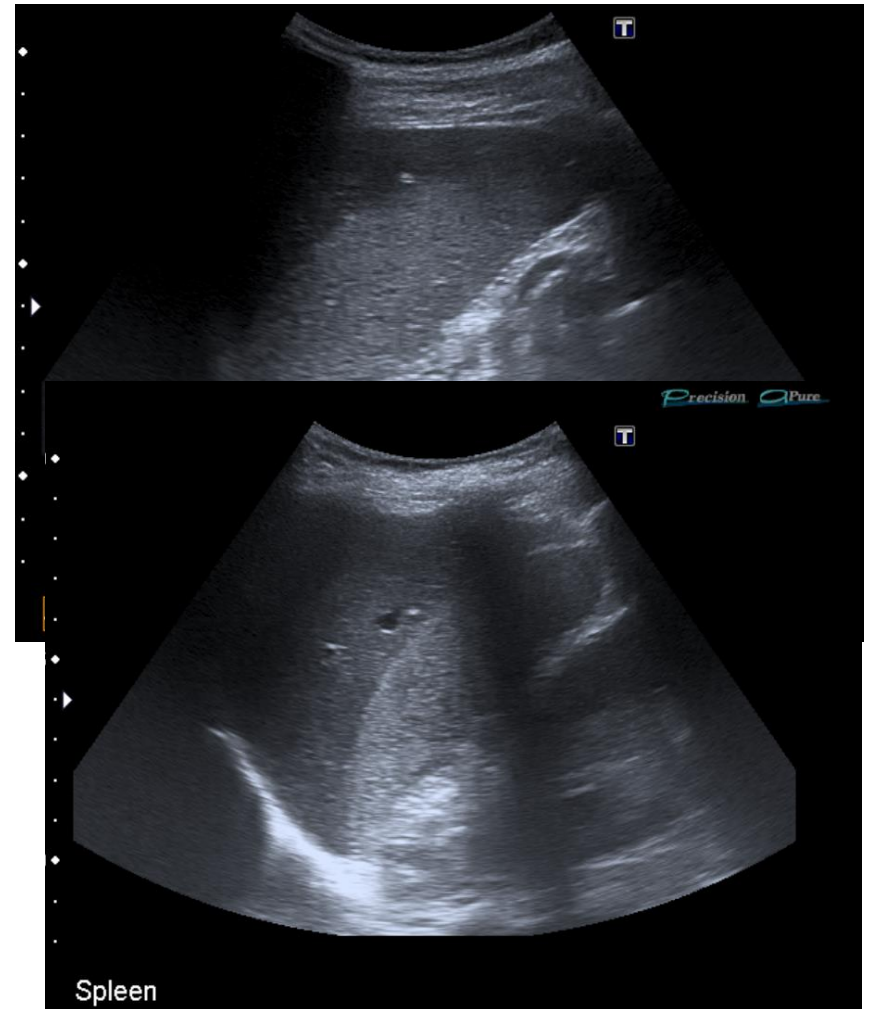


The Liver

The liver has a wide range of functions:

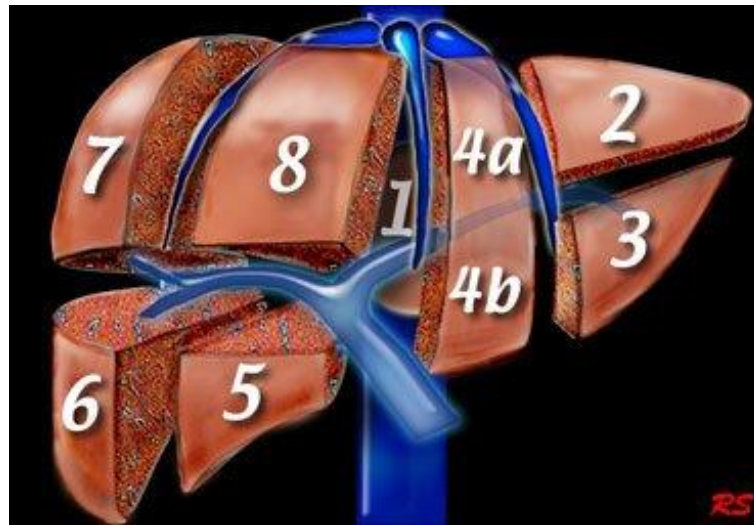
- [accessory digestive gland](#) and produces [bile](#)
- [detoxification](#)
- [protein synthesis](#)
- production of [biochemicals](#) necessary for [digestion](#)
- a role in [metabolism](#),
- regulation of [glycogen](#) storage
- decomposition of [red blood cells](#)
- [hormone](#) production

Normal Variants

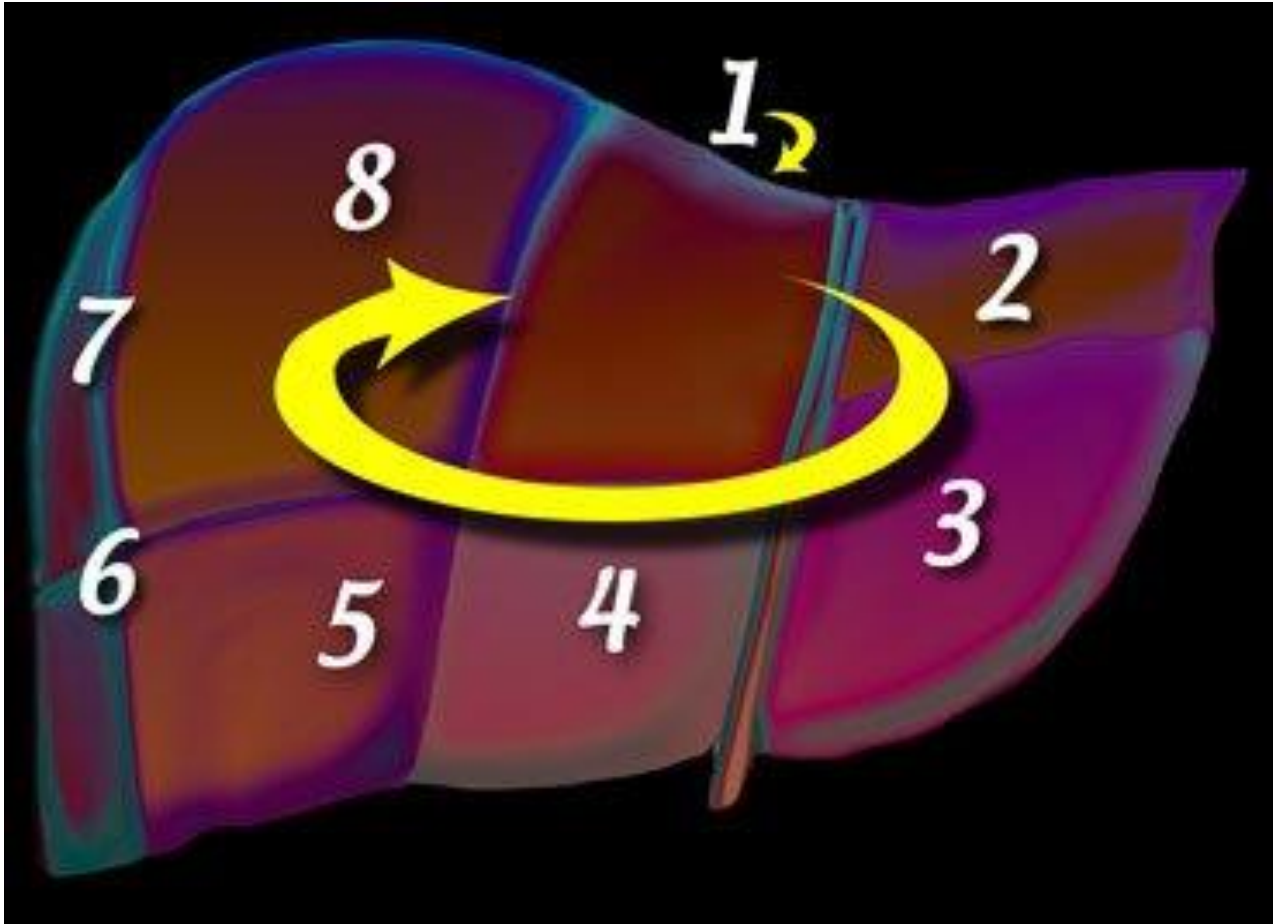


Liver anatomy

- Eight independent segments
- Their own vascular inflow, outflow, and biliary drainage.

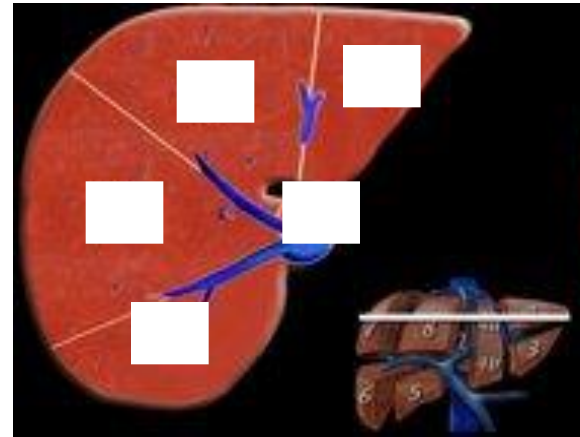


The numbering of the segments is in a clockwise manner

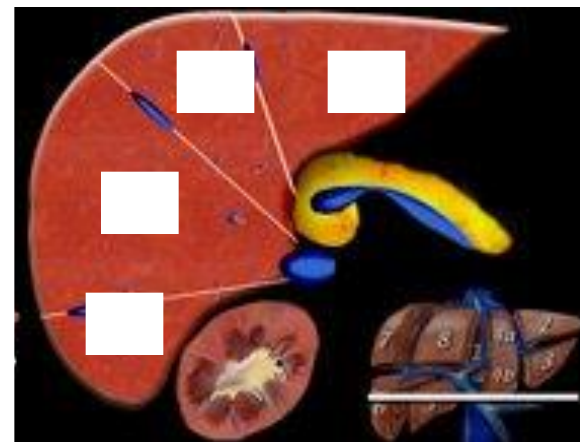


Axial sections (Liver segments)

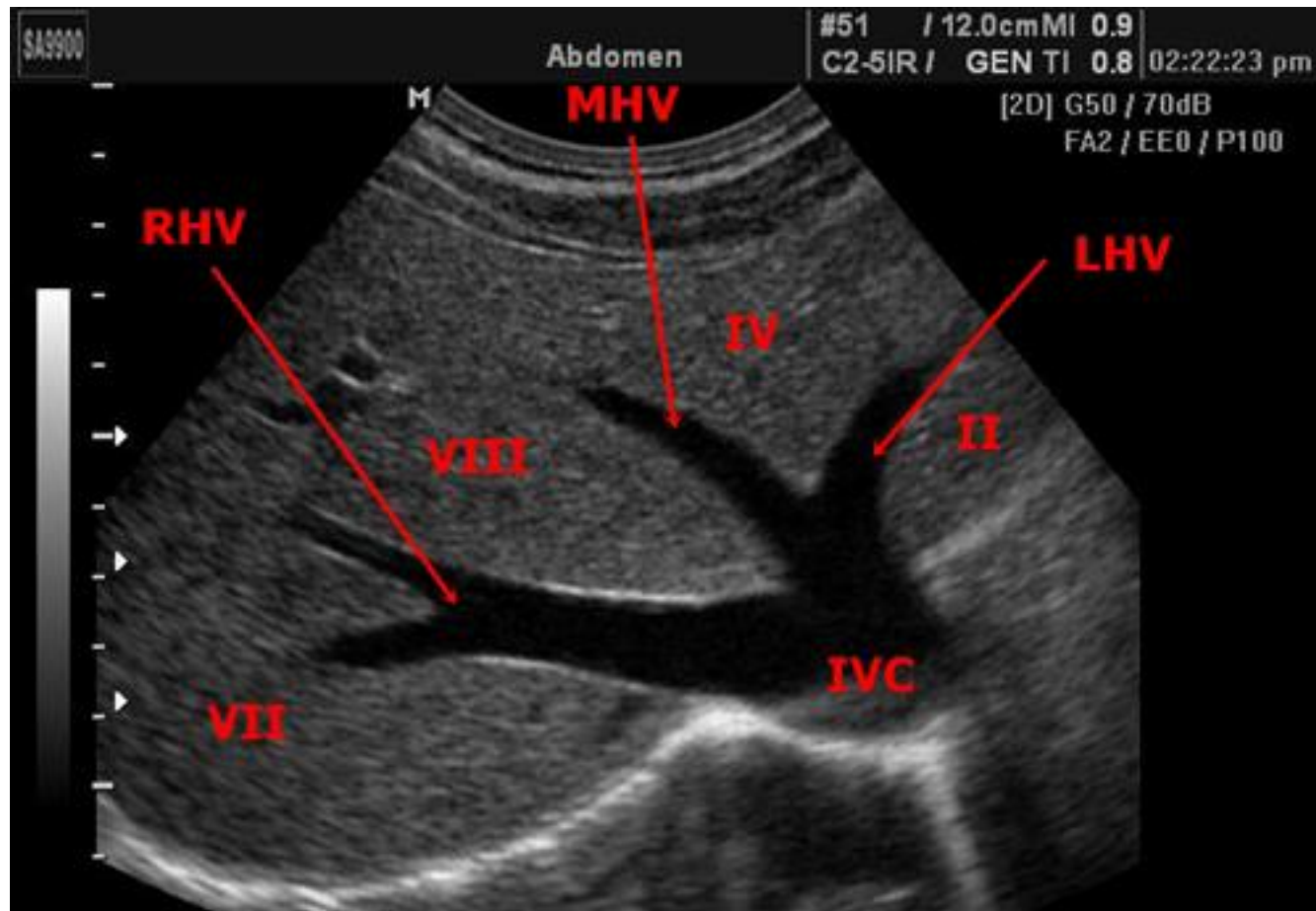
- Superior to portal vein

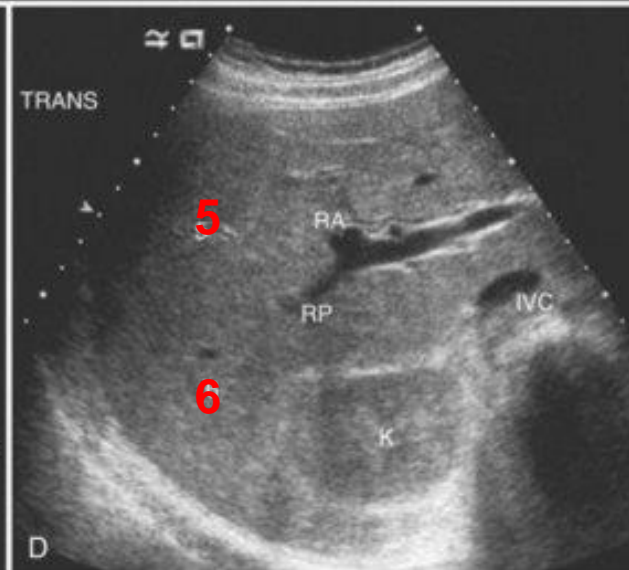
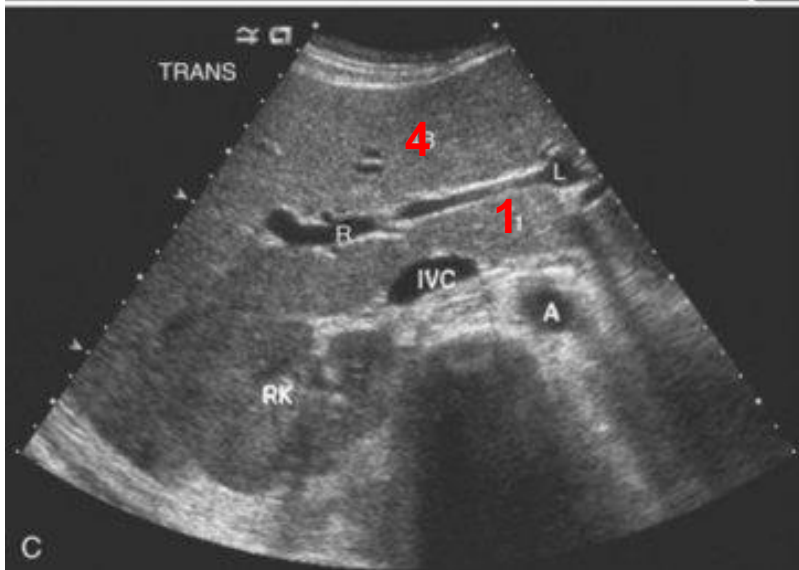
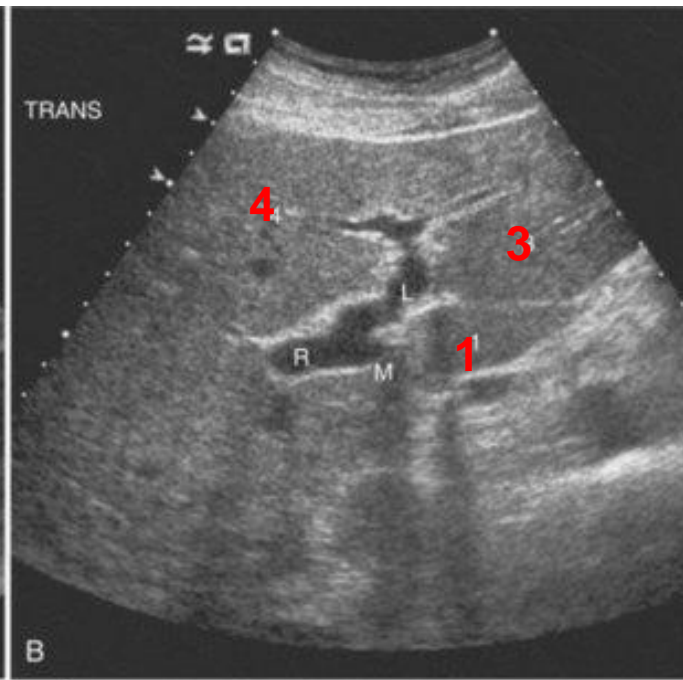
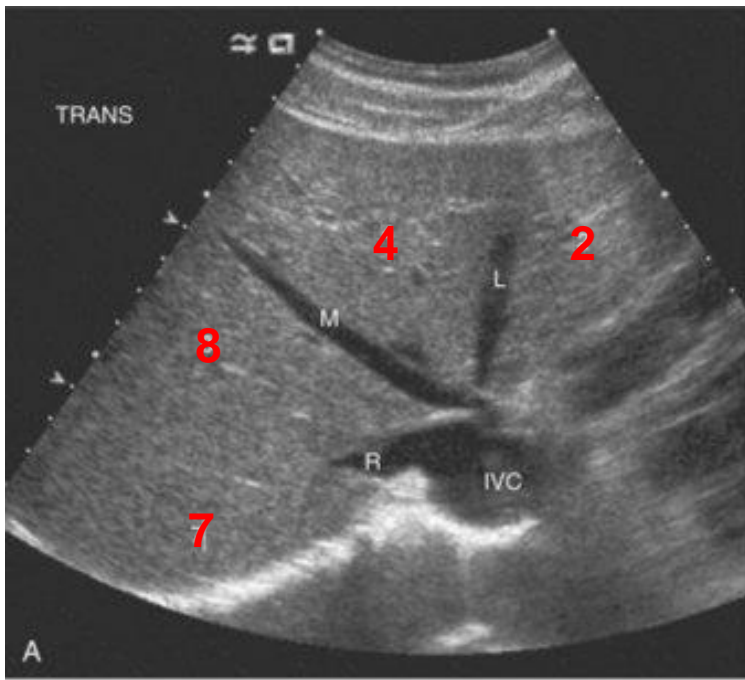


- Inferior to portal vein



Segments





Hepatic Conditions

- Cirrhosis
- Liver cancer
- Liver failure
- Ascites
- Gallstones
- Haemochromatosis
- Primary sclerosing cholangitis
- Primary biliary cirrhosis:

Liver Imaging

Focal Liver Lesions

- Cysts
- Haemangioma
- Adenoma
- Focal Nodular Hyperplasia (FNH)
- Metastases
- Primary cancer (HCC)

Diffuse Disease

- Fatty liver
- Cirrhosis
- PSC
- PBC

Focal Liver Lesions

- The distinction between benign and malignant lesions helps to determine the prognosis and subsequent treatment strategy.
- Benign asymptomatic liver lesions, which comprise as many as 70–75% of the focal liver lesions assessed
- 3200 people in the UK are diagnosed with primary liver cancer each year
- 90,000 people are diagnosed with liver metastases

Focal Liver Lesions

- Approx. 85% of people diagnosed with primary liver cancer have a hepatocellular carcinoma.
- A major risk factor for developing hepatocellular carcinoma is underlying cirrhosis
- Primary liver cancer in adults has a poor prognosis
 - 20% one year survival rate
 - 5% five year survival rate

Focal Liver Lesions

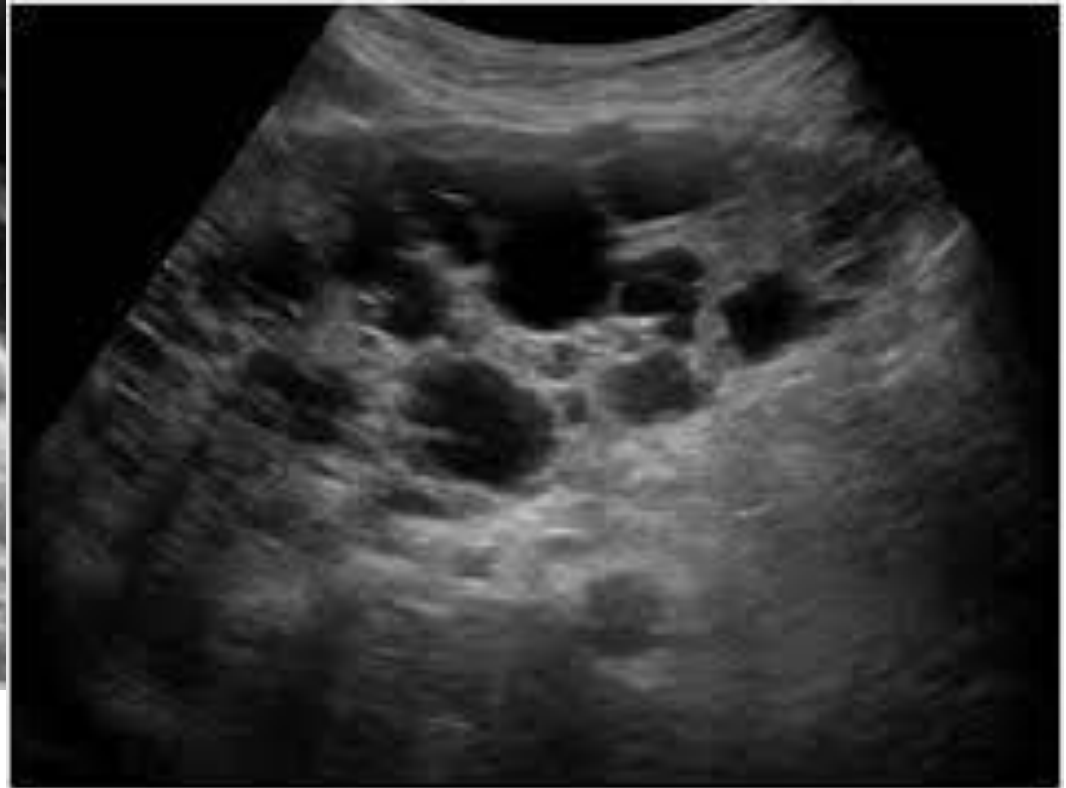
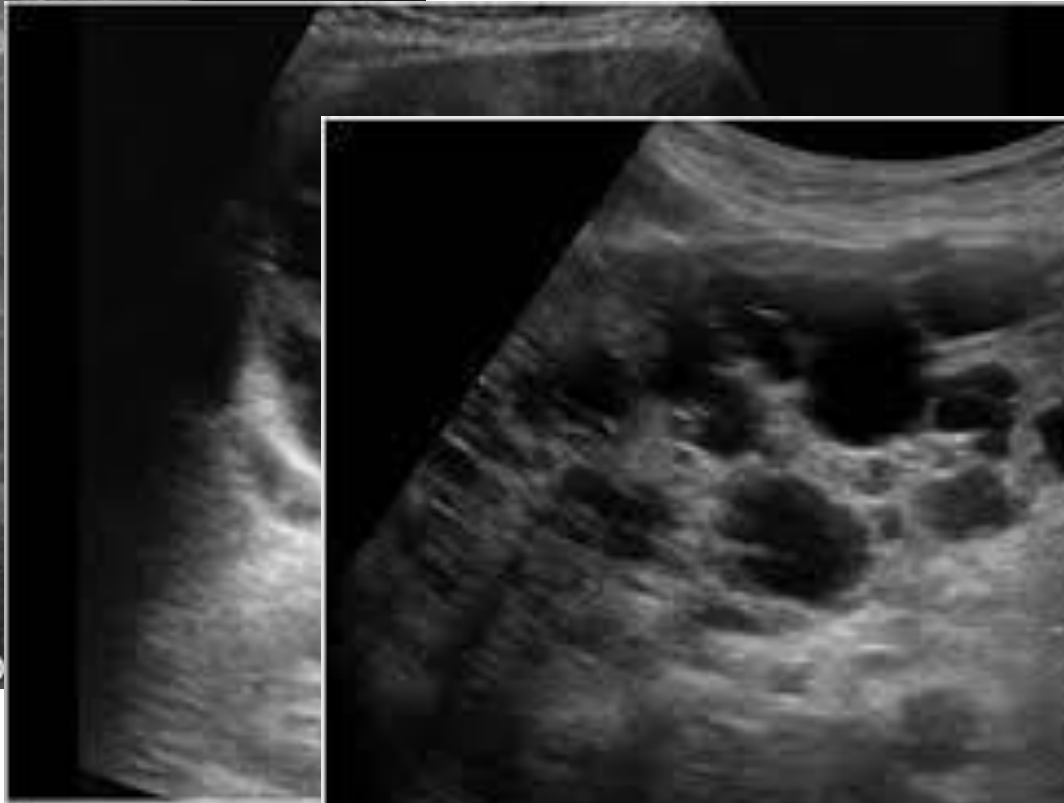
- Cancers which commonly metastasise to liver are breast, lung and bowel (colorectal).
- Origin of the primary cancer is important because the cells of the liver metastases are the same as those of the primary cancer, and liver metastases are likely to be treated according to the cell type of the primary cancer.
- Prognosis of liver mets depends on the extent of the disease and comorbidities.
- For example, 40–60% of people with stage 4 colorectal cancer with resectable liver metastases will live for 5 years after surgery.

FLL – Diagnosis

- Care pathways for people with liver cancer are guided by prognosis.
- Prognosis depends on both the extent of the tumour and on comorbidity.
- Improvements in survival as a result of treatment largely depend on the disease stage at diagnosis:
 - the earlier the diagnosis is made, the greater the chance for successful treatment

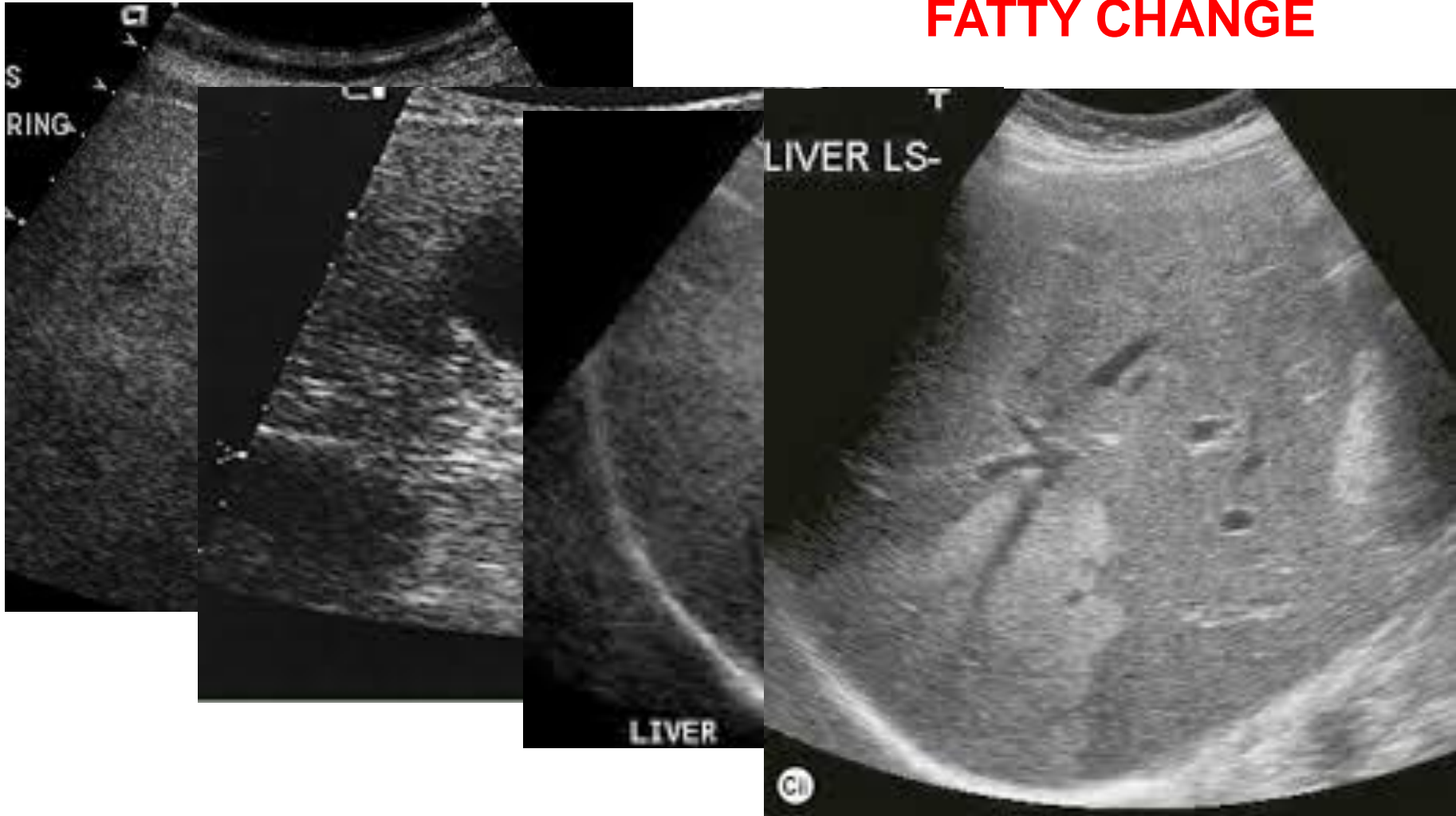
FLL Diagnosis

CYSTS



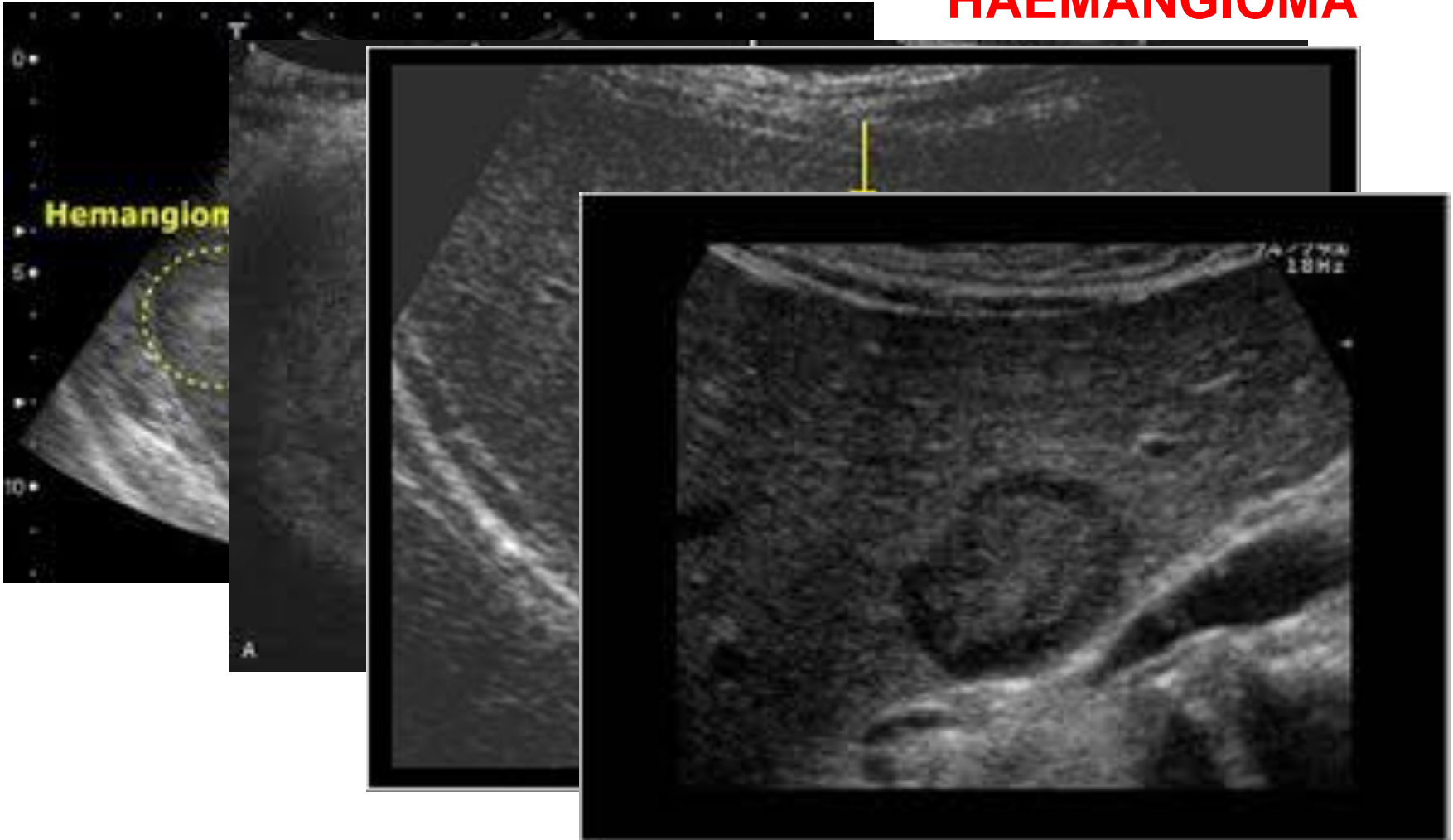
FLL Diagnosis

FATTY CHANGE



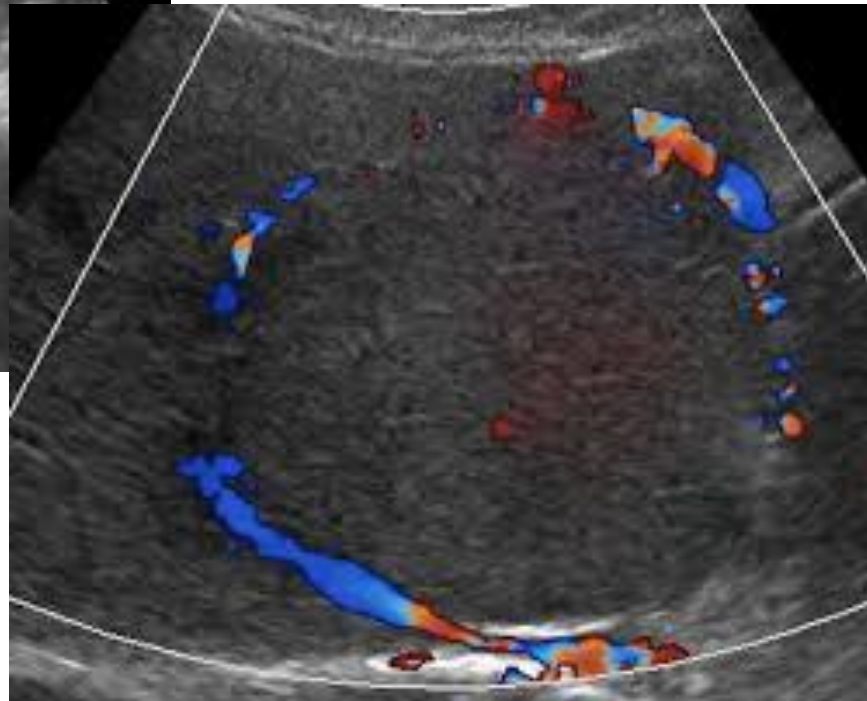
FLL Diagnosis

HAEMANGIOMA



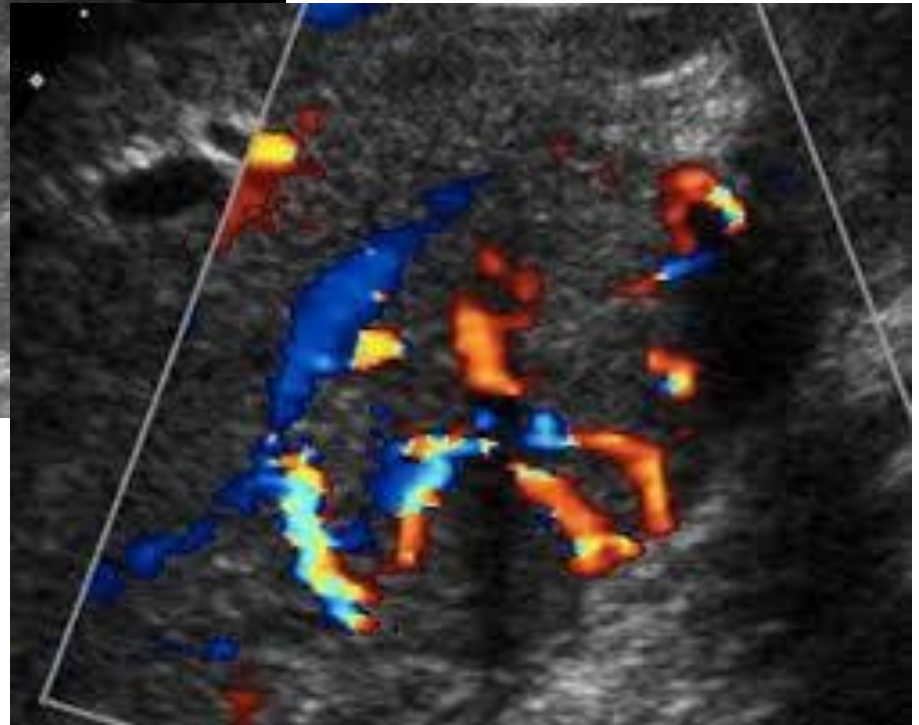
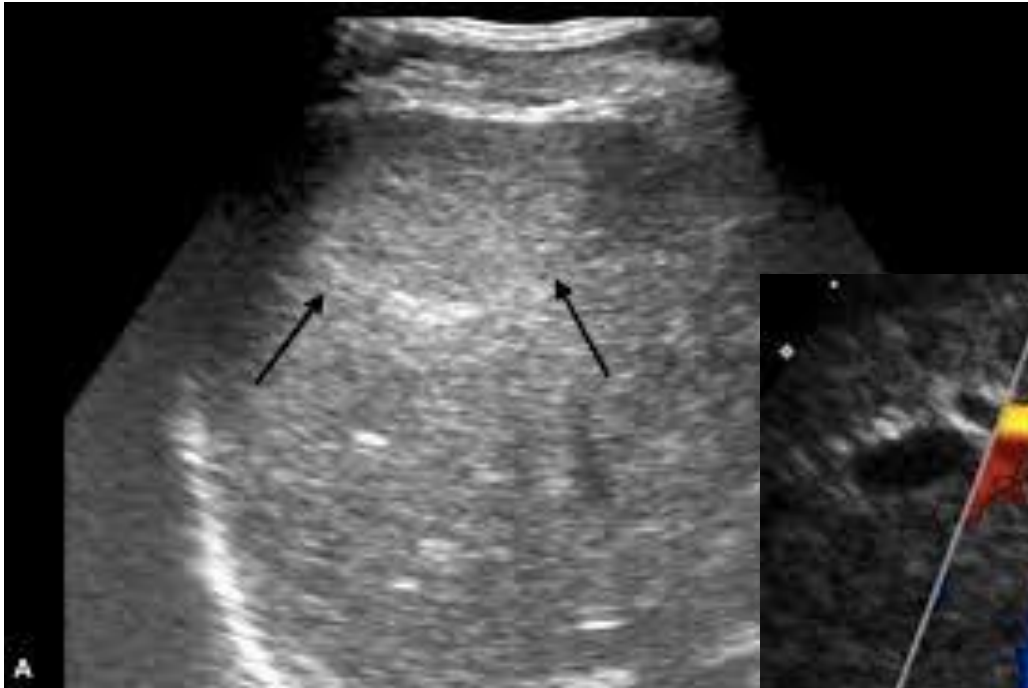
FLL Diagnosis

ADENOMA



FLL Diagnosis

FNH



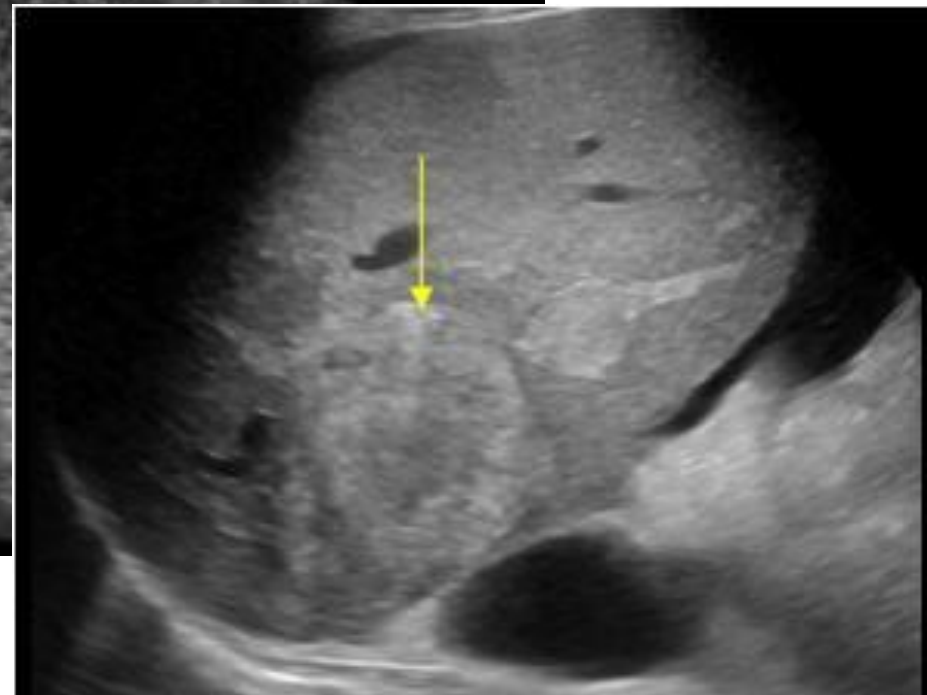
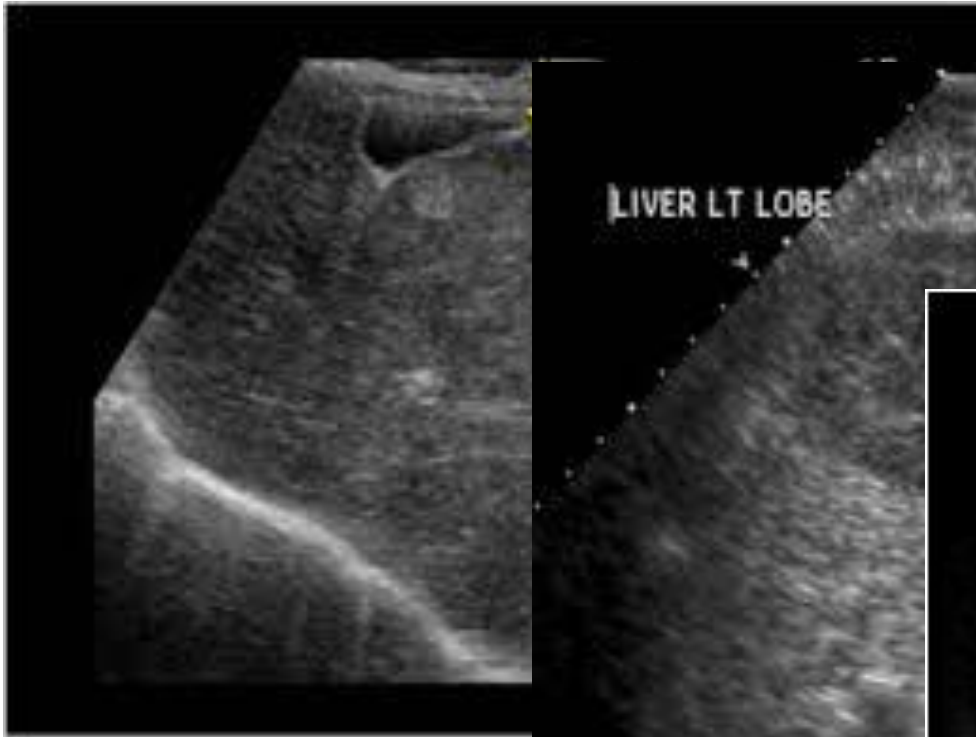
FLL Diagnosis

METASTASES

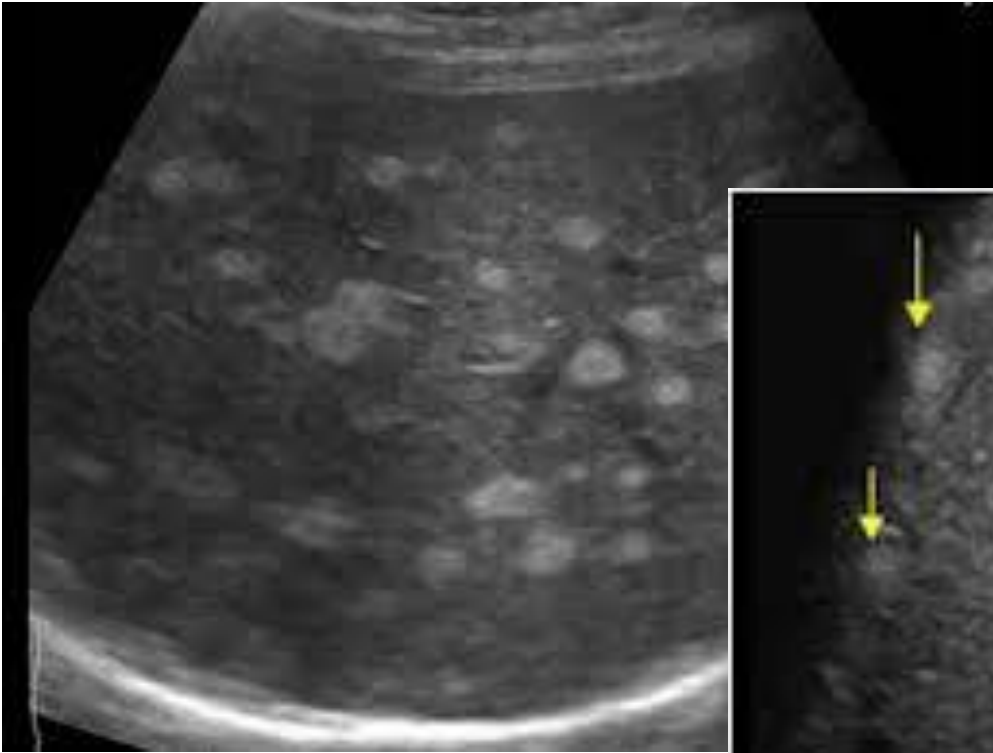


FLL Diagnosis

HCC



Feeling Confident?



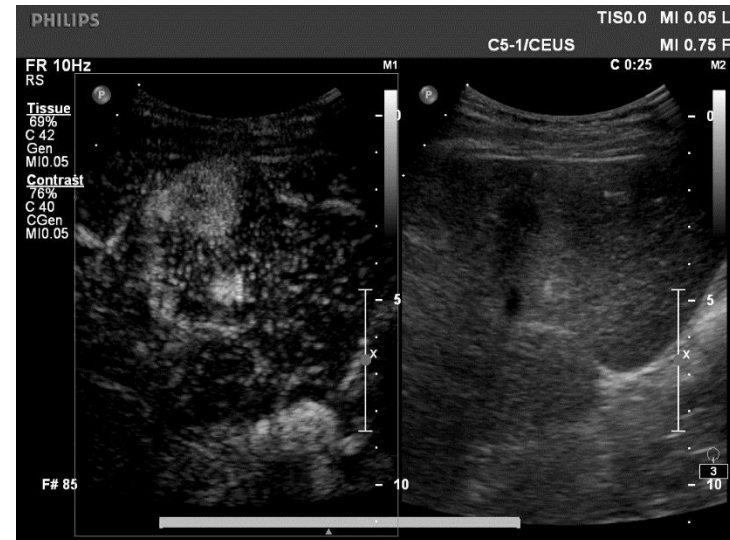
HAEMANGIOMA



METASTASES

FLL – Now What

- So you find a focal lesion
- What next?



Rationale for CEUS

- Differentiating benign or malignant lesions helps to determine the prognosis and subsequent treatment pathway
- 70–75% of the focal liver lesions assessed are benign asymptomatic liver lesions and usually do not need treatment.

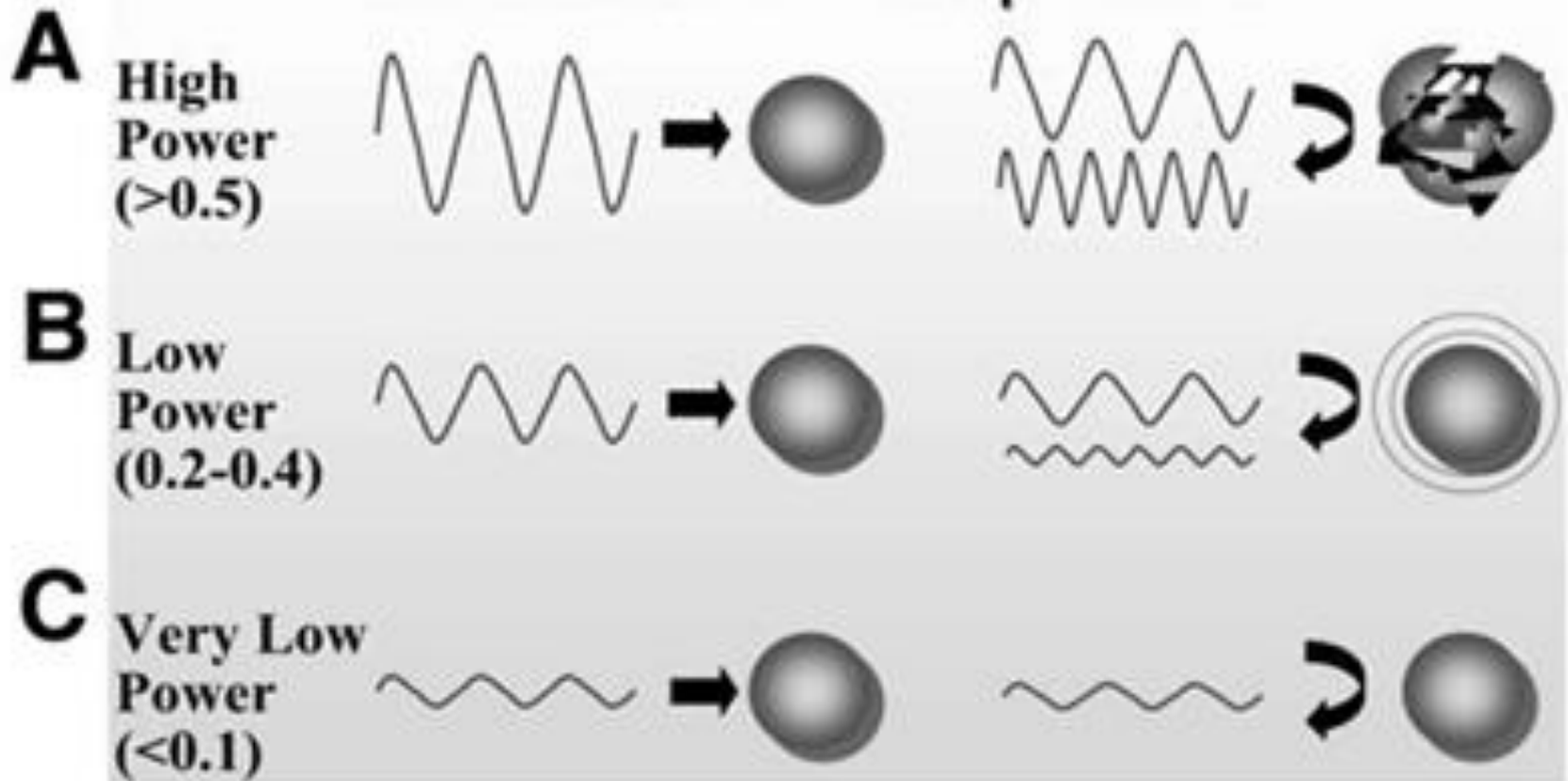
How?

- Ultrasound contrast agents rely on the different ways in which sound waves are reflected from interfaces
- Commercially available contrast media are gas-filled microbubbles
- Microbubbles oscillate in low MI US wave and produce non linear reflection

Non-Linear Reflection

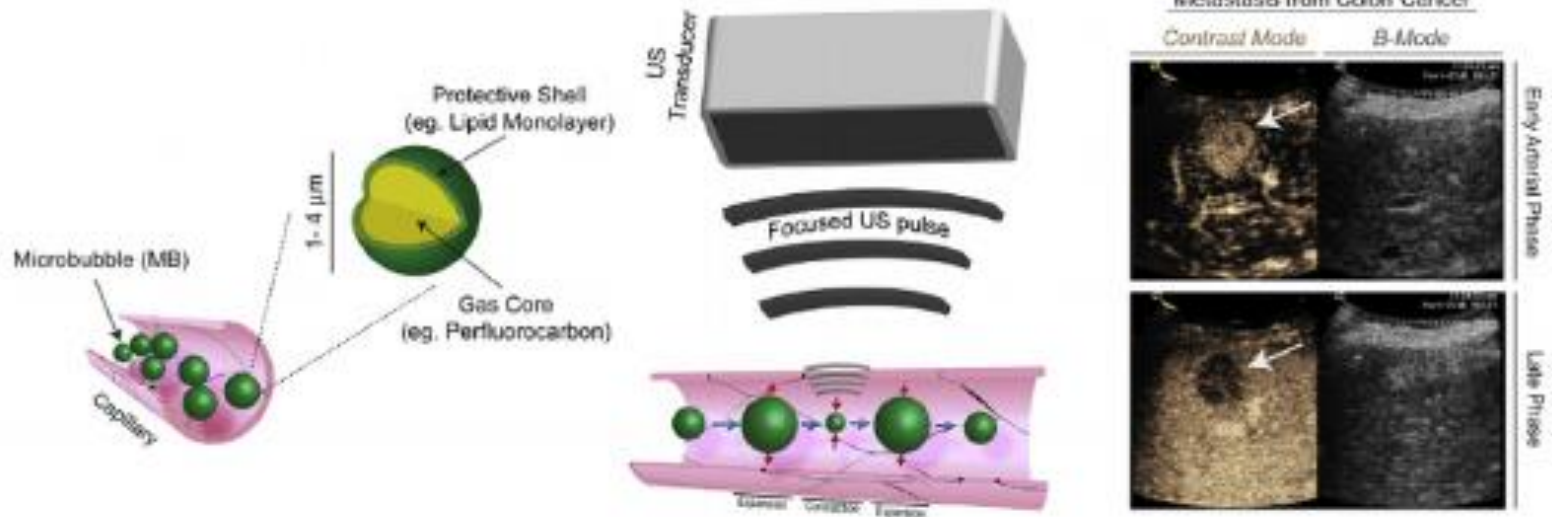
- 2 signals are sent down a single scan line and the second is a mirror image of the first.
- Echoes from both pulses are collected by the transducer and summed.
- Linear reflectors, such as normal tissue, produce no net signal.
- Nonlinear reflectors, such as microbubbles, produce echoes that are asymmetric and do not sum to zero
- The resultant echo is displayed.

Acoustic Power and Microbubble Responses

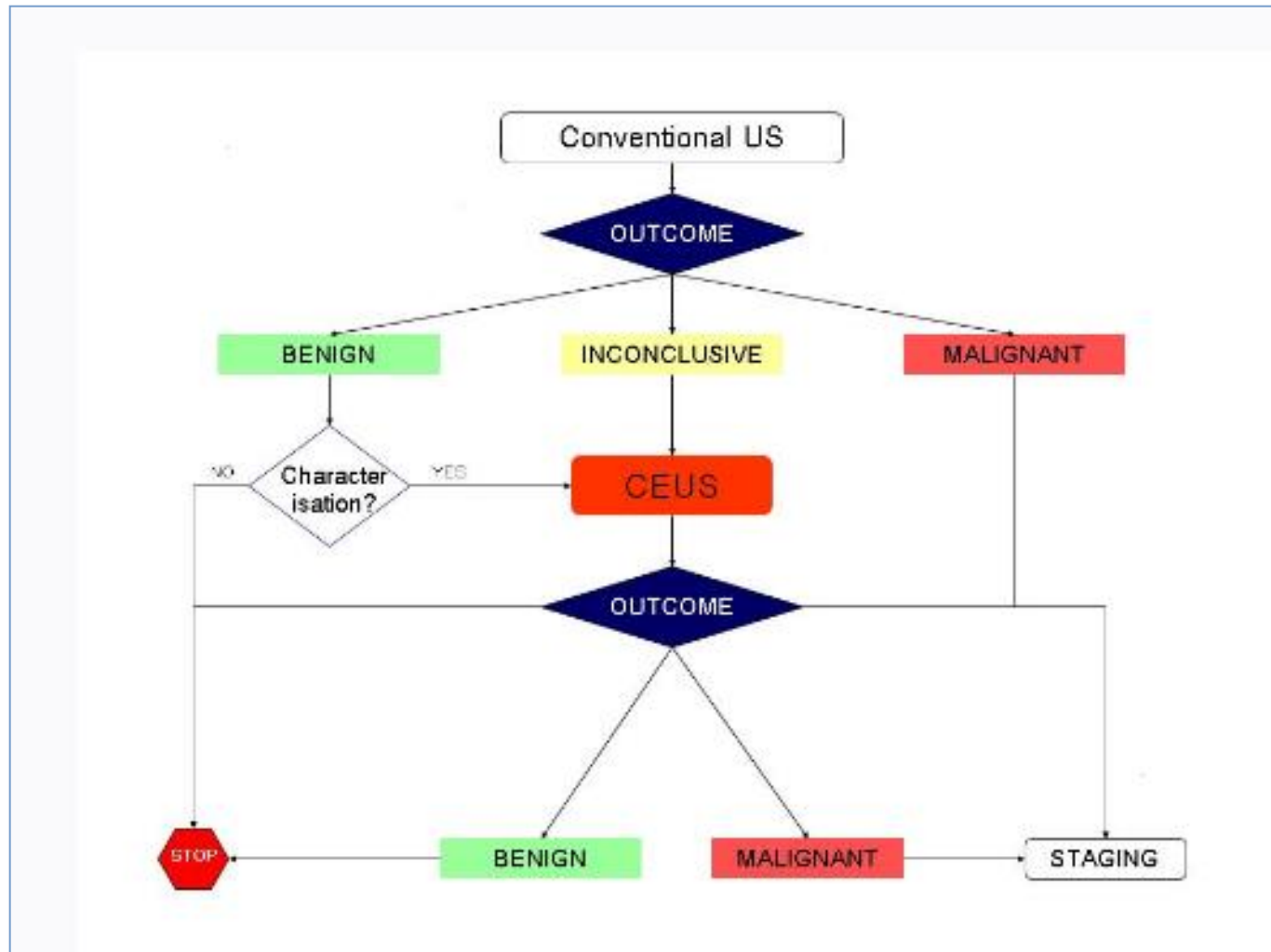


Contrast Enhanced US (CEUS)

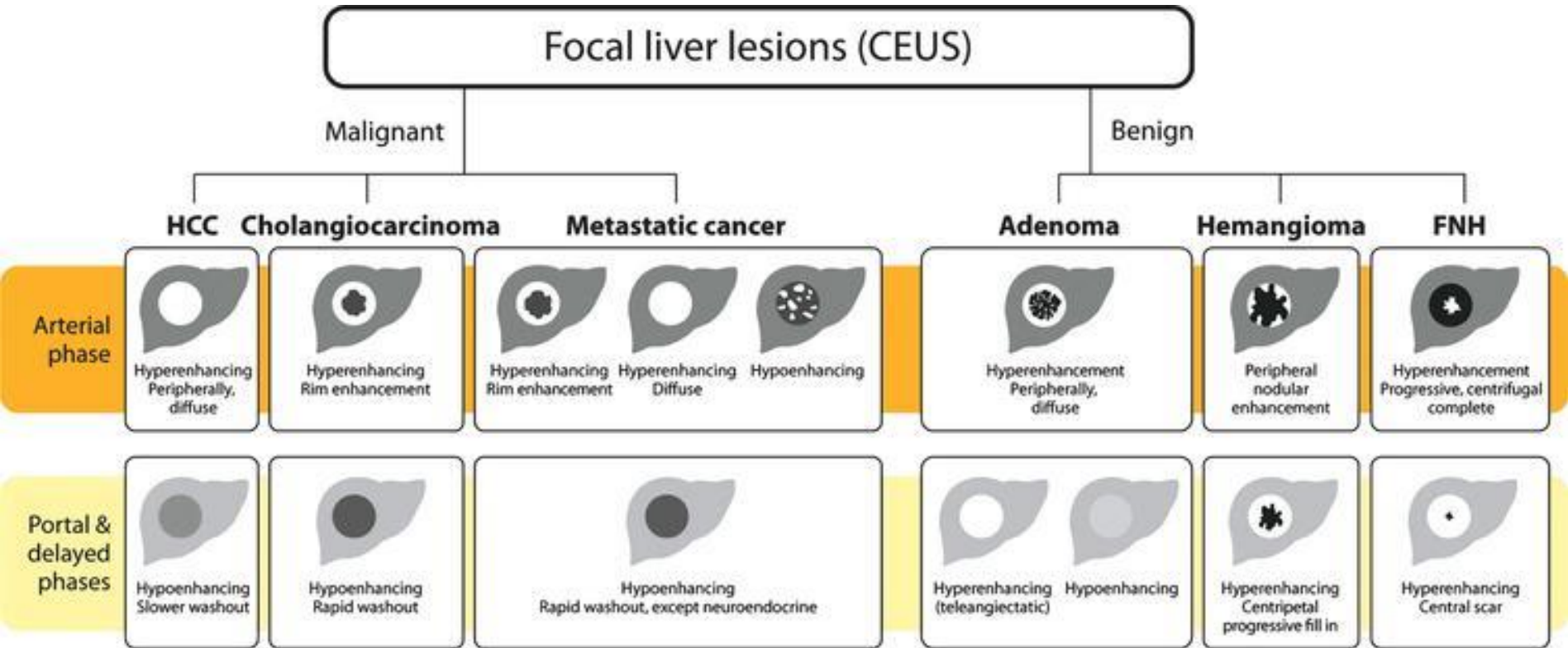
A Contrast-Enhanced Ultrasound Using a Microbubble Contrast Agent



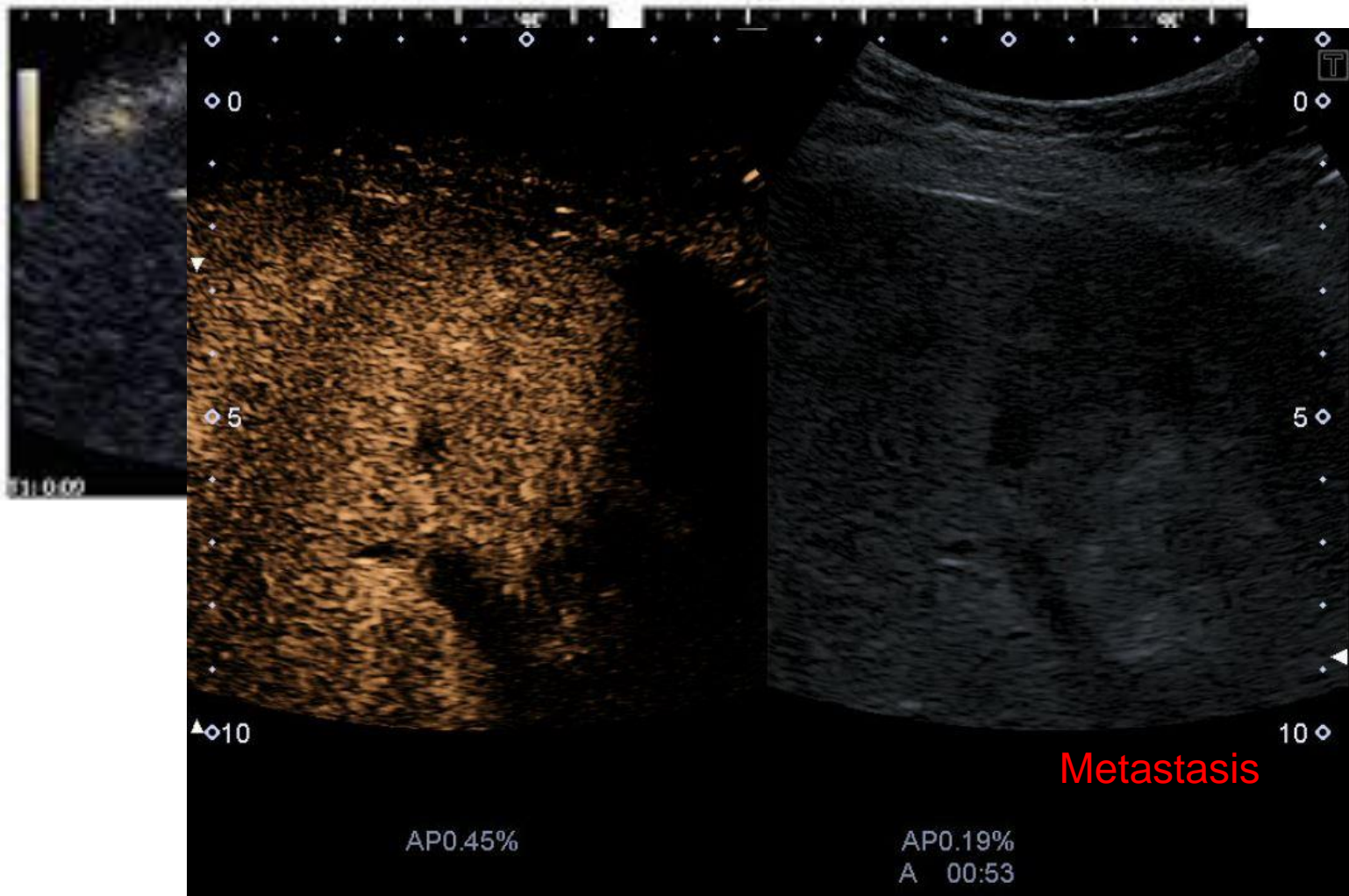
Can we do more?



CEUS



CEUS

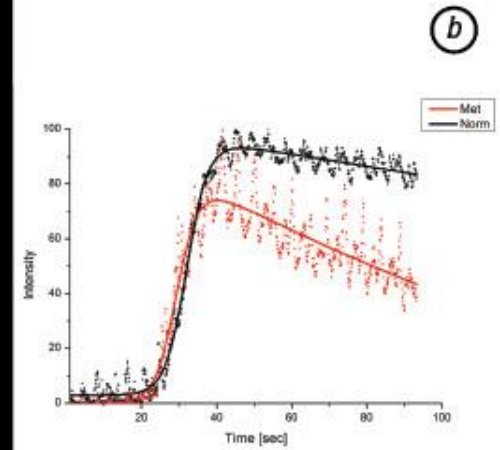
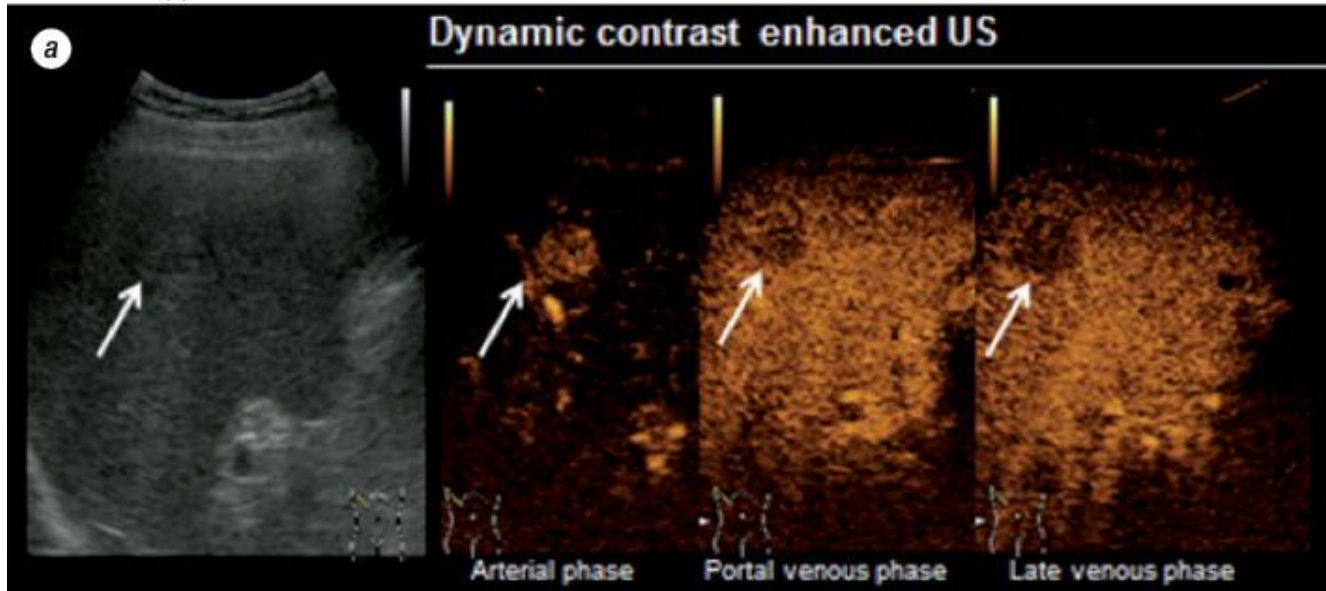


CEUS

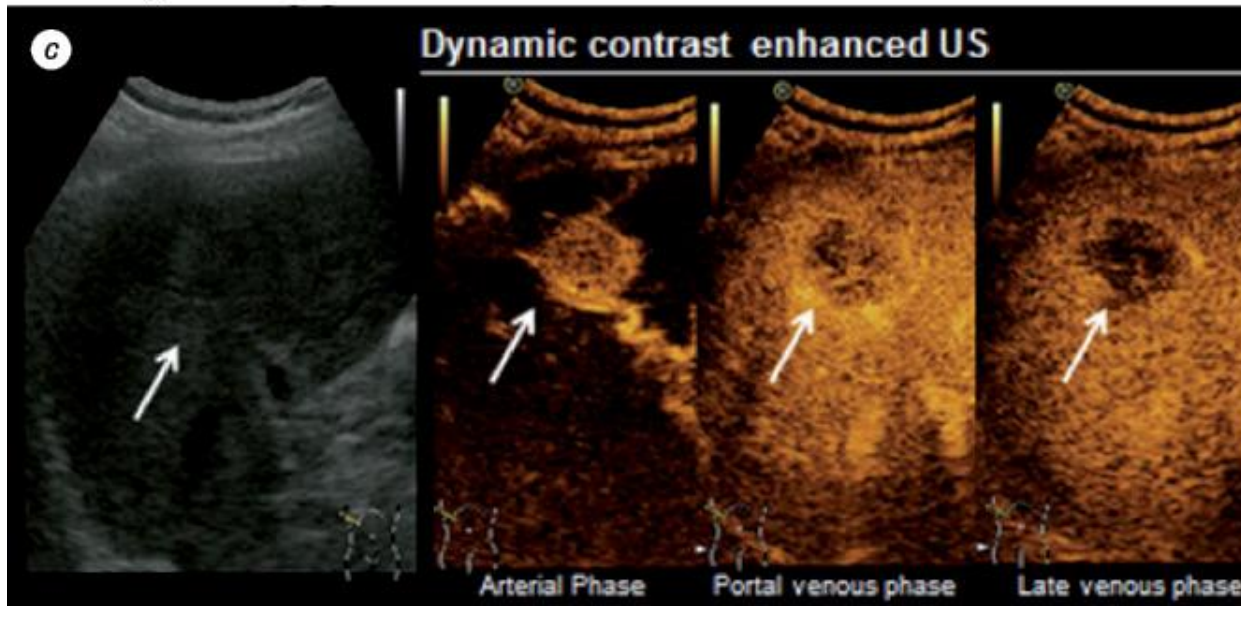
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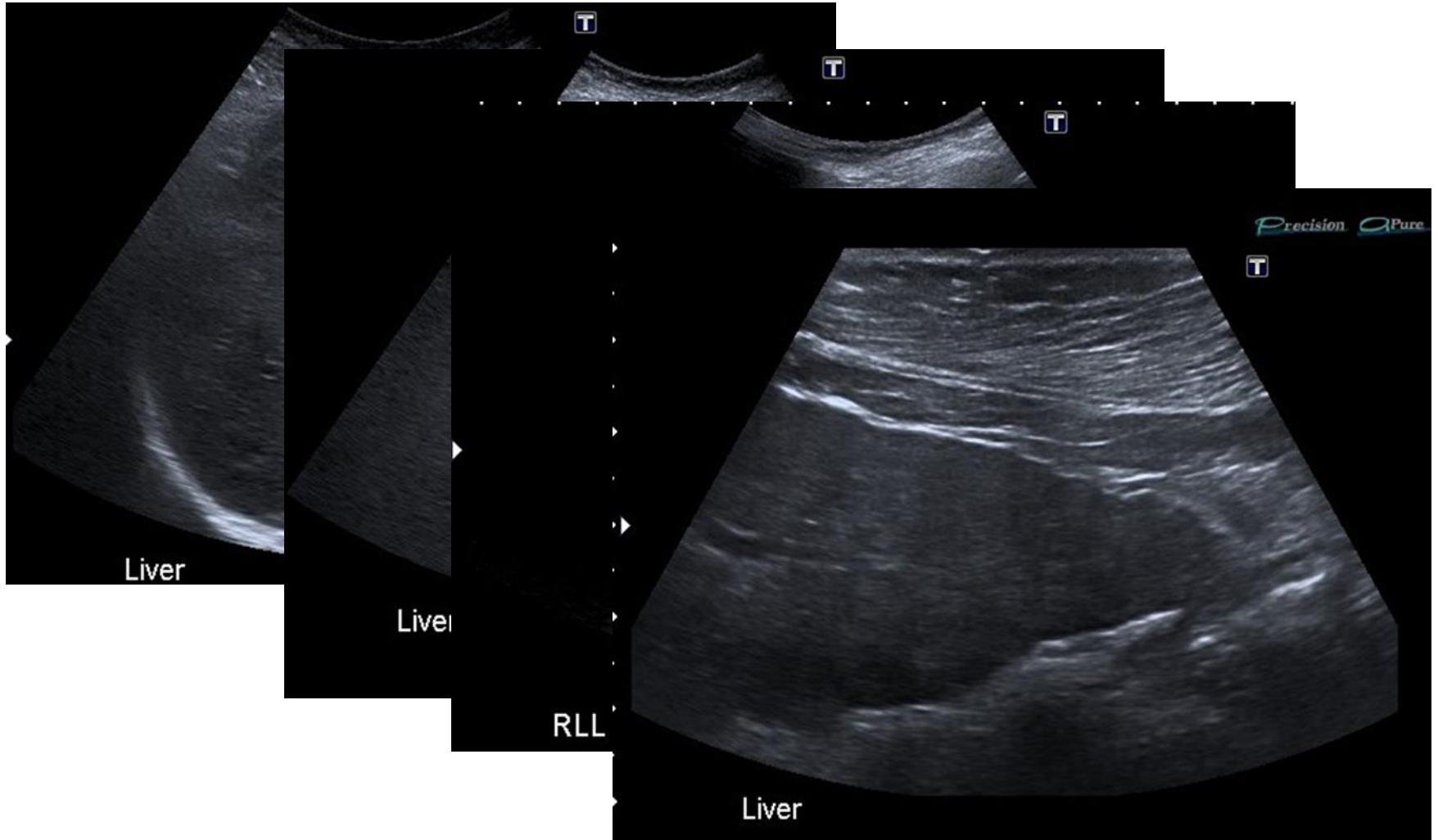
Prior to therapy



After therapy



Diffuse Disease

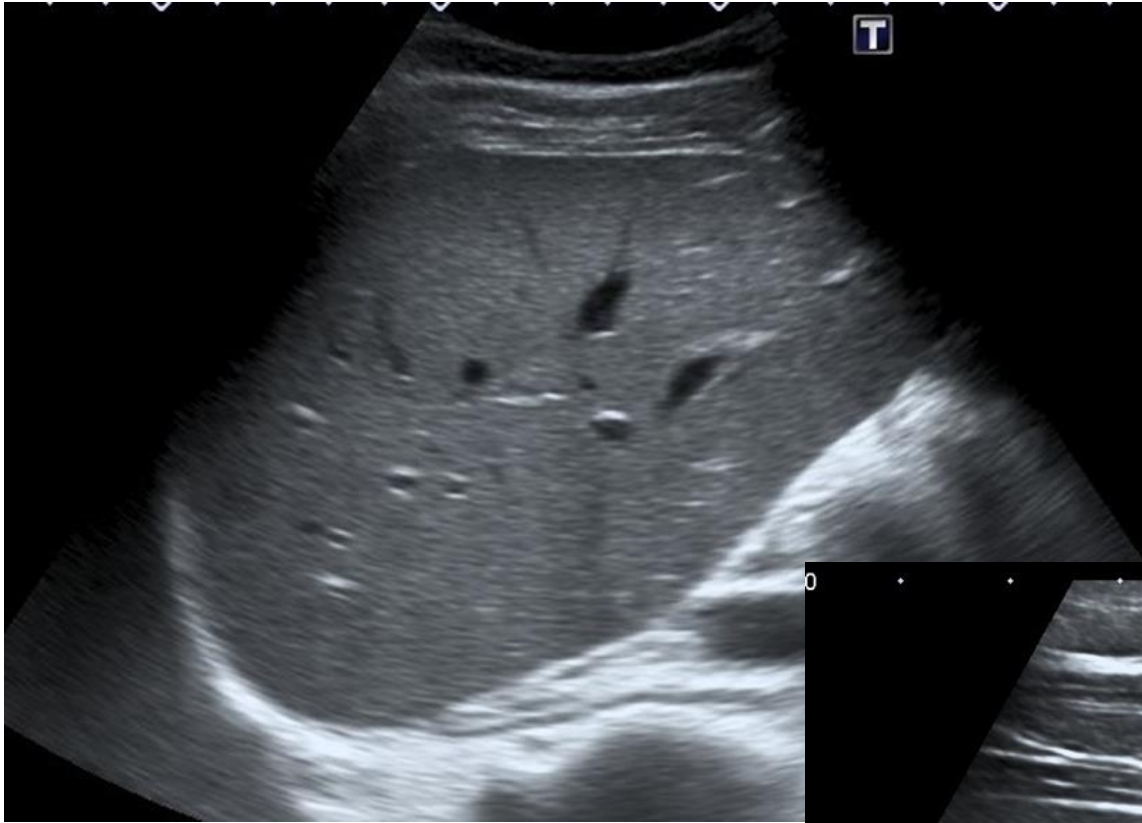


What is Liver Disease?

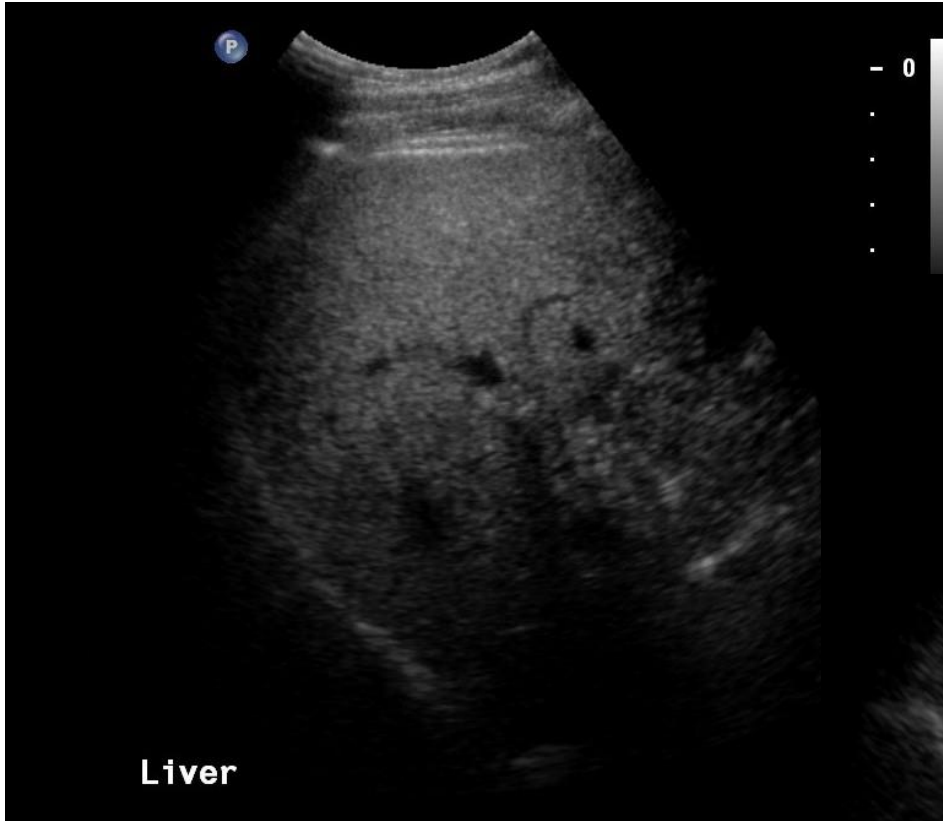
- Non-alcoholic fatty liver disease (NAFLD)
- Non-alcoholic steato-hepatitis (NASH),
- Alcoholic liver disease (ALD)
- Inherited liver diseases
- Liver failure
 - common causes of chronic liver failure include hepatitis B, hepatitis C and long-term alcohol consumption.



Beetroot - Normal



Burger - FATTY



Booze - COARSE



Liver Disease

- Most recent statistics indicate half a million adults in the UK already have cirrhosis
- 10 – 20% of the UK population are at risk of liver disease
- In the 40 -49 years age group 1 in 10 deaths are due to liver disease, mostly alcoholic liver disease
- Increasing number of individuals with the complications which result from end-stage liver disease

Liver Disease

- Liver disease is the only major cause of death still increasing year-on-year
- Liver disease is the fifth 'big killer' in England & Wales, after heart, cancer, stroke and respiratory disease
- Deaths from liver disease are predicted to double in 20 years.
- Liver disease kills more people than diabetes and road deaths combined

<http://www.britishlivertrust.org.uk/about-us/media-centre/facts-about-liver-disease/>

The Real Problem

- Reported incidence is likely an underestimation of the true scale of the problem given that early disease, often asymptomatic and therefore undiagnosed
- An American study of asymptomatic patients, US was performed with subsequent liver biopsy in those found to have a fatty liver.
- This revealed that **59.4%** had either NAFLD or NASH

Healthy Lifestyles

- Many of the underlying risk factors for liver disease; obesity, hepatitis C, hepatitis B and alcoholism are preventable but still all increasing in incidence



(National End of Life Care Intelligence Network, 2012).

Not A Chance!



- World Health Organisation reports an alcohol use disorder rate of 16.3%, (8.7% dependence) in males
- 6.0% alcohol use disorder (3.2% dependence) in females in the UK.
- UK average alcohol use disorder and dependence are both higher than equivalent European

Alcohol and Liver Disease

- The process is silent, but when liver disease has developed it presents as an acute illness with a **25-50% immediate mortality.**
- There are over 800,000 hospital admissions directly related and attributable to alcohol each year.
- The cost to the NHS of alcohol misuse has been estimated at £2.7 billion each year.

Hepatitis B

- Hepatitis B is one of the world's most common and serious infectious diseases and the most common and serious liver infection in the world.
- Hepatitis B affects approx 2 billion people worldwide.

Hepatitis C

- Some estimates are that up to 500,000 people have the virus in the UK.
- Majority of people are unaware of their infection and are not tested.
- The number of people with HCV-related end stage liver disease continues to rise. Between 1996 and 2005 the number of new cases increased by **100%**
- only **29%** of diagnosed patients were treated with NICE approved antiviral therapy

Cirrhosis

- Cirrhosis is scarring of the liver as a result of continuous, long-term liver damage.
- The damage caused by cirrhosis can't be reversed
- Cirrhosis can be fatal if the liver fails. **However treatment can help slow its progression.**

Why is this important?

- NAFLD is now the most common chronic liver disease
- Advanced treatment of causes of cirrhosis
- Better management of the complications of portal hypertension and end stage liver disease
- Antiviral therapies in hepatitis C have been proven to stabilise and even reverse disease progression

LFT's

- Patients with liver disease are likely to present with abnormal liver function tests (LFTs) or jaundice
- Numerous biochemical markers have been developed
- Clinicians should be mindful however that routine tests cannot quantify the fibrosis processes in 50% of patients

Diagnosis

- LFT's
- Ultrasound
- Doppler assessment
- Liver Biopsy

Ultrasound



- Features of a normal or fatty liver are well defined, specific and easily recognised
- The pathological processes which contribute to fibrosis, and cirrhosis, become more difficult to distinguish.

Liver Doppler

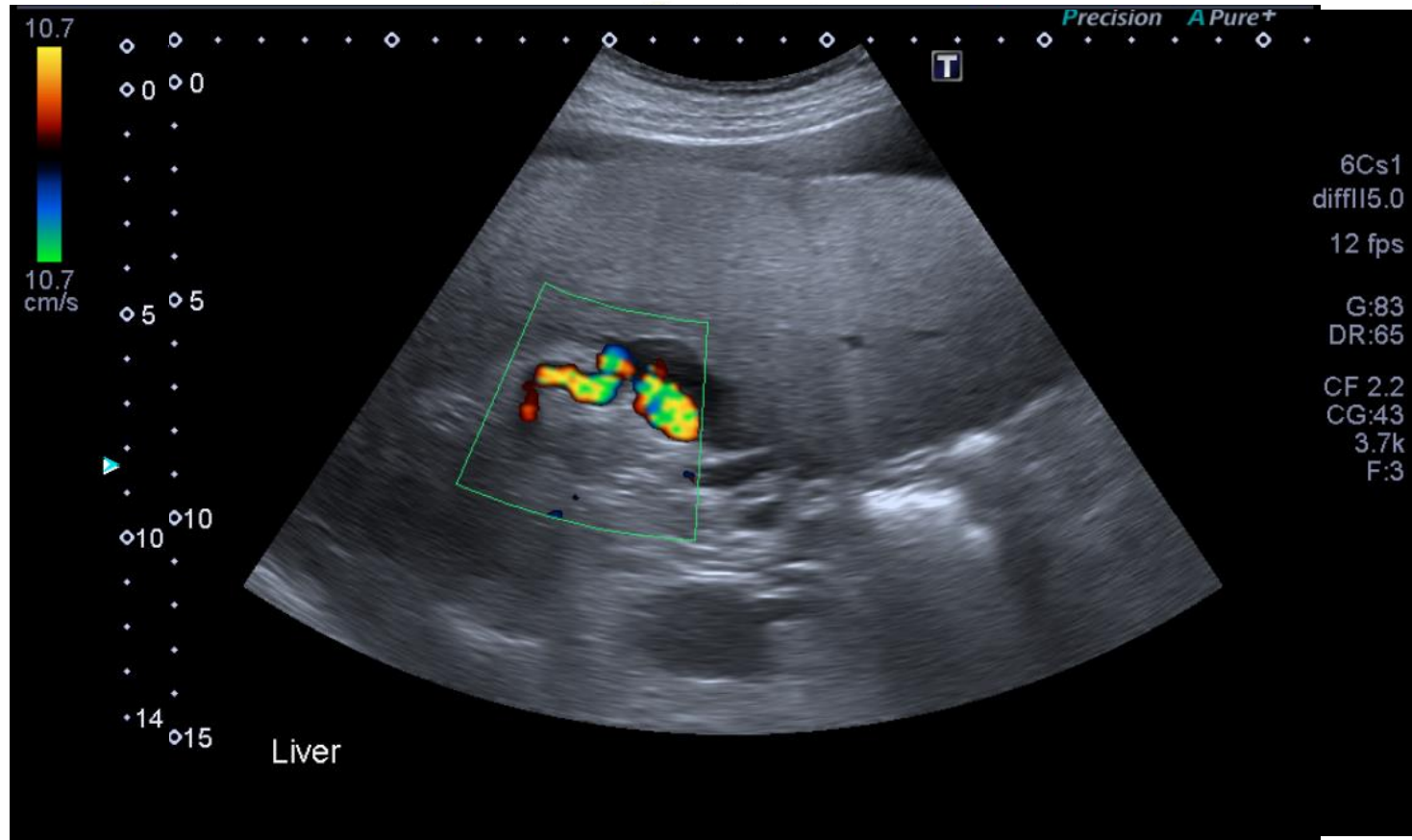
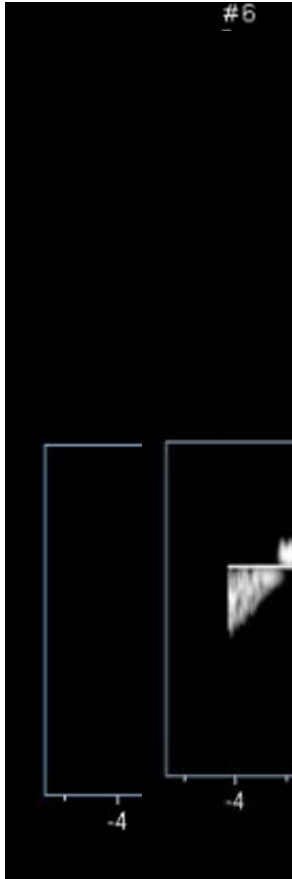
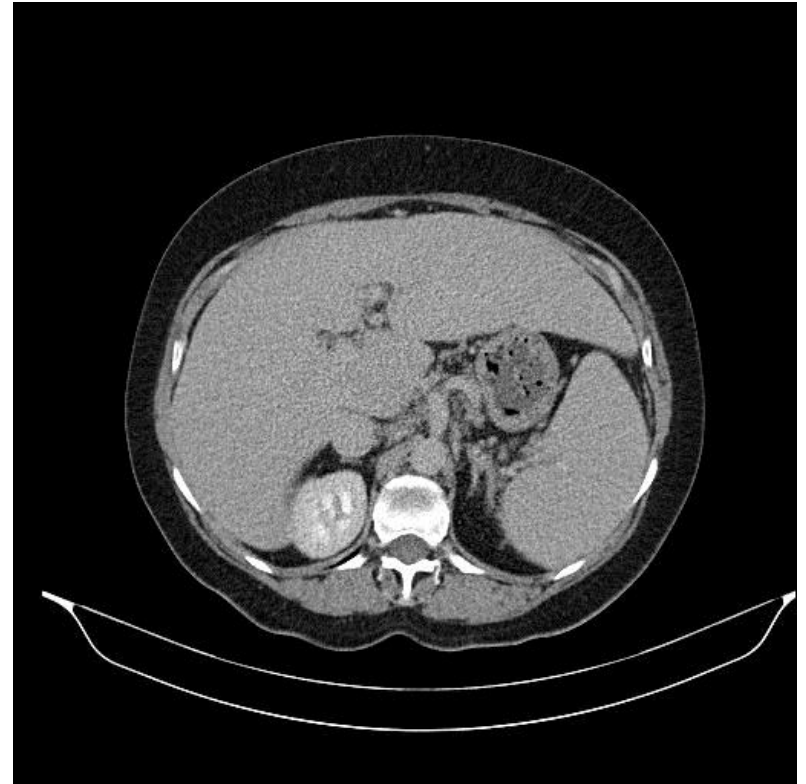


Figure 4.22 (Cont'd) (g) Collaterals in portal hypertension (schematic representation).

Cirrhosis – Making the Diagnosis

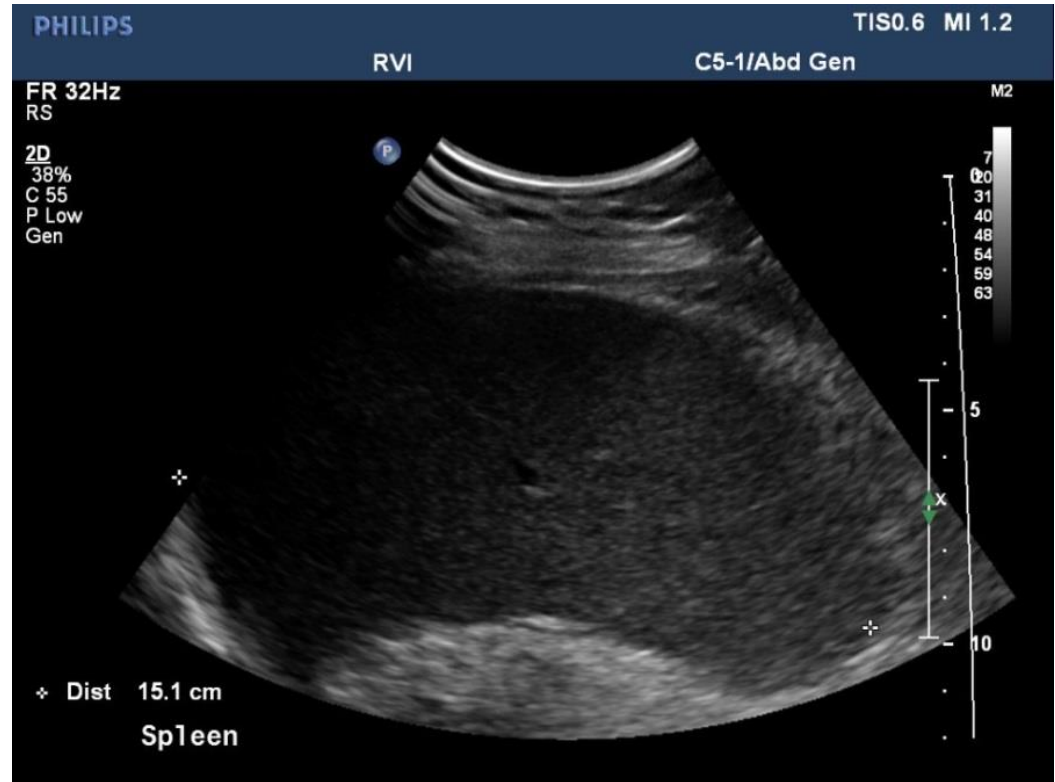
- surface nodularity: (88% sensitive, 82-95% specific)
- overall coarse and heterogeneous echotexture
- segmental hypertrophy/atrophy (see above)
 - caudate width: right lobe width >0.65 (43-84% sensitive, 100% specific)
 - reduction of the transverse diameter (<30 mm) of the medial segment of the left lobe (segment IV)

Cirrhosis

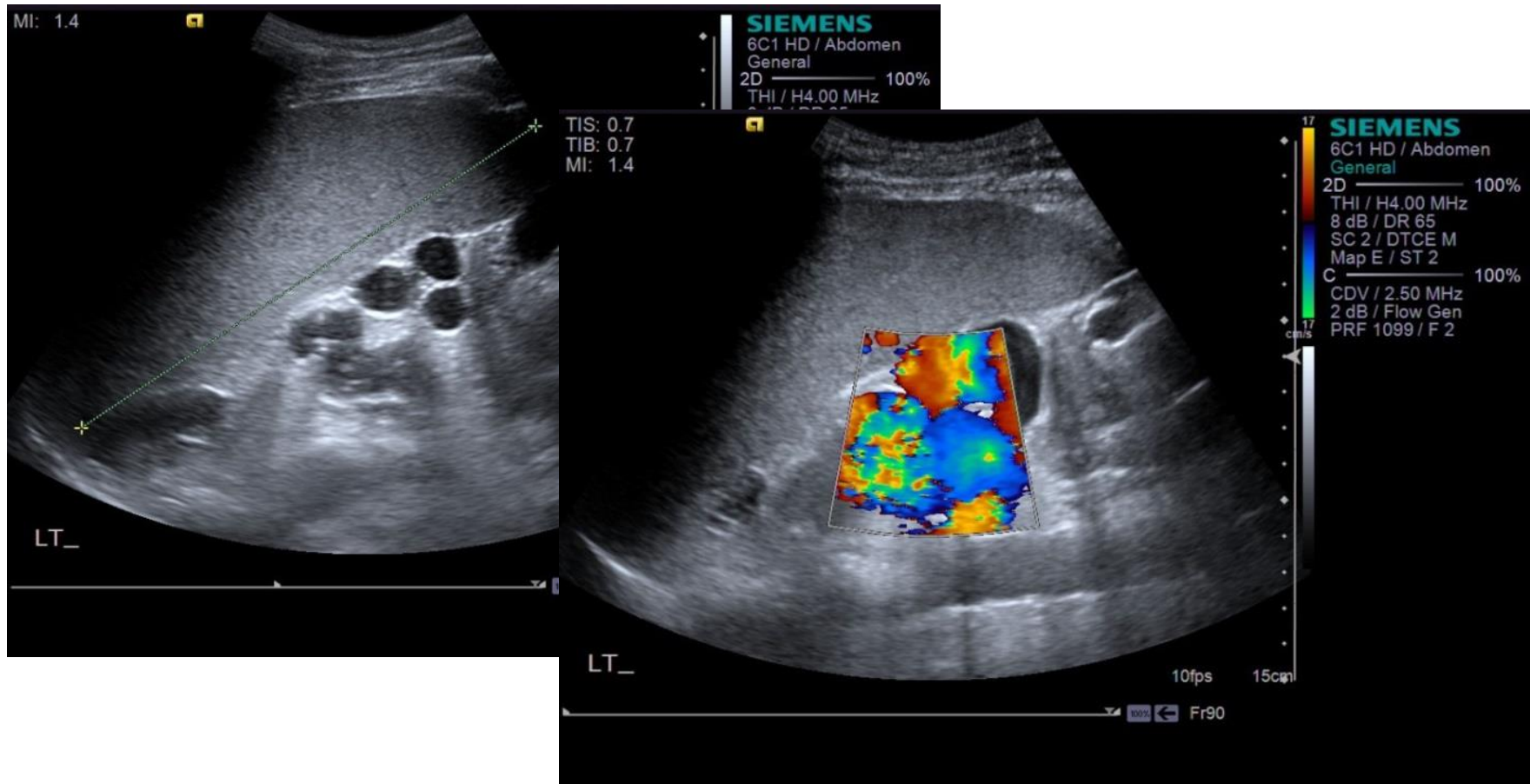


Portal Hypertension

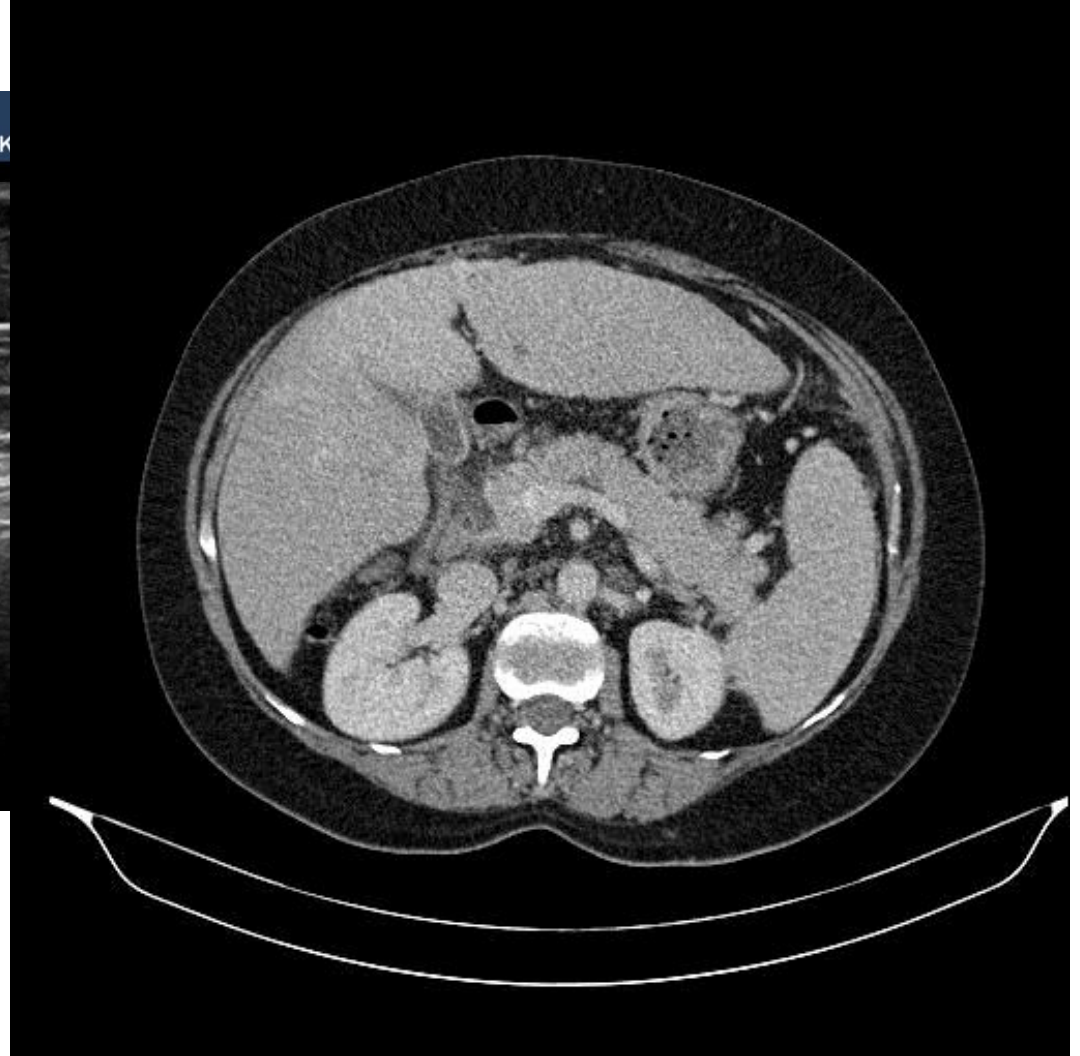
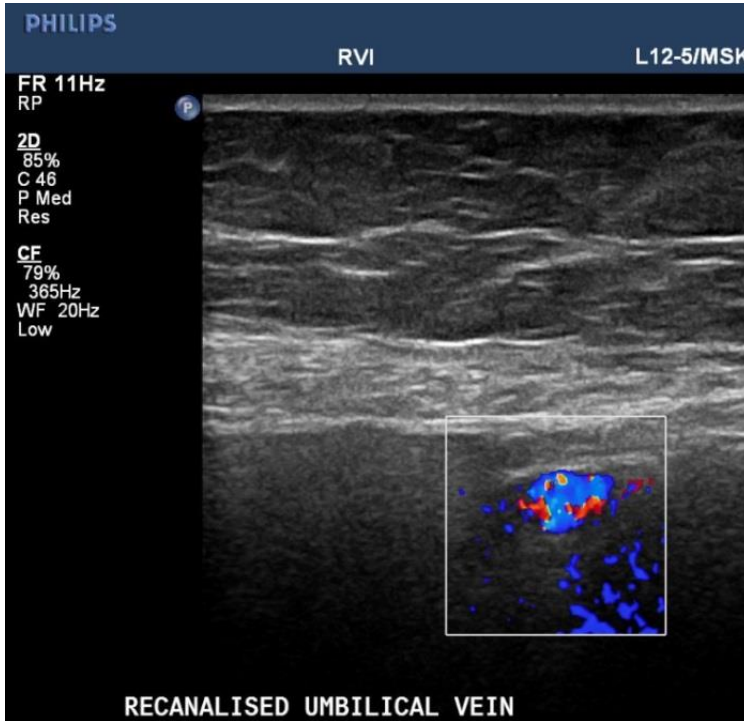
- Ascites
- Splenomegaly (13cm)
- Varices



Portal Hypertension



Portal Hypertension



Liver Biopsy

- Complications may include:
 - minor pain (<30%),
 - severe pain (<3%),
 - vasovagal hypotension (<3%),
 - significant haemorrhage (<0.5%),
 - haemobilia (<0.1%),
 - puncture of another organ (<0.1%),
 - death (<0.1%)

Liver Biopsy

- Limitation of liver biopsy due to potential histological and sampling errors
- Only 1/50,000 of the liver sampled
- May result in a sample of the unaffected tissue underestimating disease severity,
- Short sample size of 2.5cm could result in a 25% chance of misdiagnosis
- Need for a safe non-invasive alternative to be developed

History !



Fig. 1. Liver hand palpation: "The living are soft and yielding; the dead are rigid and stiff", Lao Tzu, (6th century BCE).

Alternatives

- Elastography
 - Quantifies hepatic stiffness
 - Quantifies degree of fibrosis
 - Non-invasive
 - Undertaken in conjunction with routine liver imaging

EFSUMB Guidelines and Recommendations on the Clinical Use of Ultrasound Elastography.

Part 2: Clinical Applications

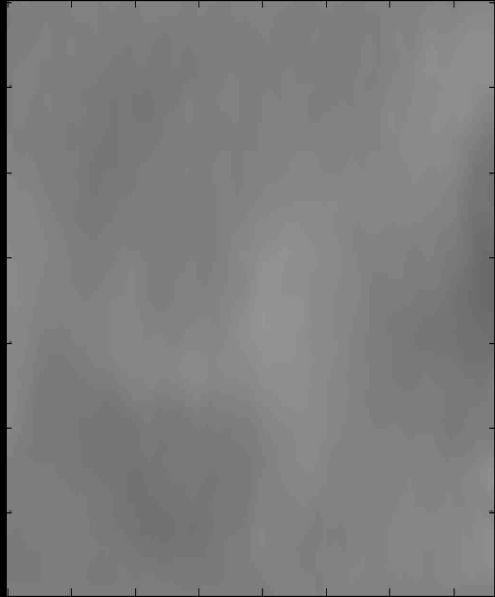
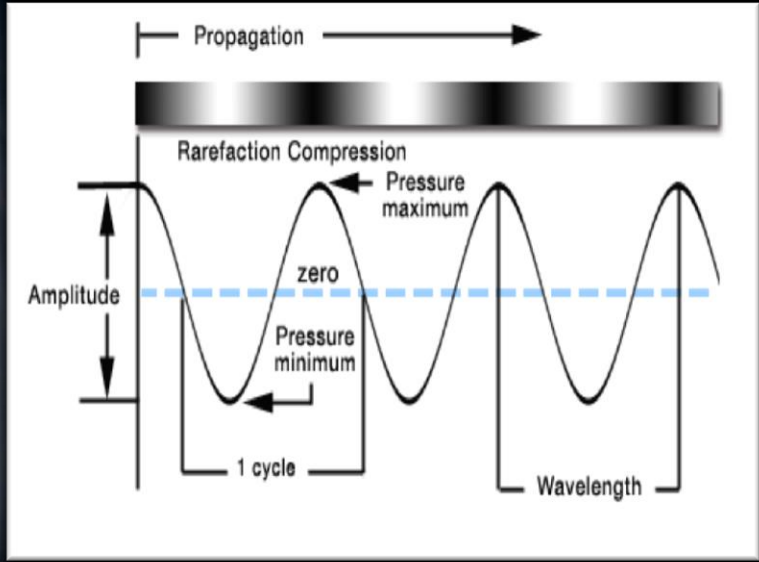
2012

Recommendations

- ▶ TE can be used to assess the severity of liver fibrosis in patients with chronic viral hepatitis, provided that confounding factors are taken into account, and especially to distinguish patients with nil/mild fibrosis from those with significant fibrosis and to identify those with cirrhosis.
- ▶ TE is useful for assessment of liver fibrosis in patients with NAFLD, alcoholic liver diseases, and in patients co-infected with human immunodeficiency virus (HIV) and hepatitis C virus. Other types of chronic liver disease might also be investigated, but the evidence is more limited.
- ▶ TE is useful for assessment of liver fibrosis in patients with post-transplant recurrence of chronic hepatitis C.
- ▶ TE has some value for predicting the occurrence of complications of liver cirrhosis, portal hypertension, HCC and liver-associated mortality. It cannot replace upper gastrointestinal endoscopy for identifying patient with varices.

Update

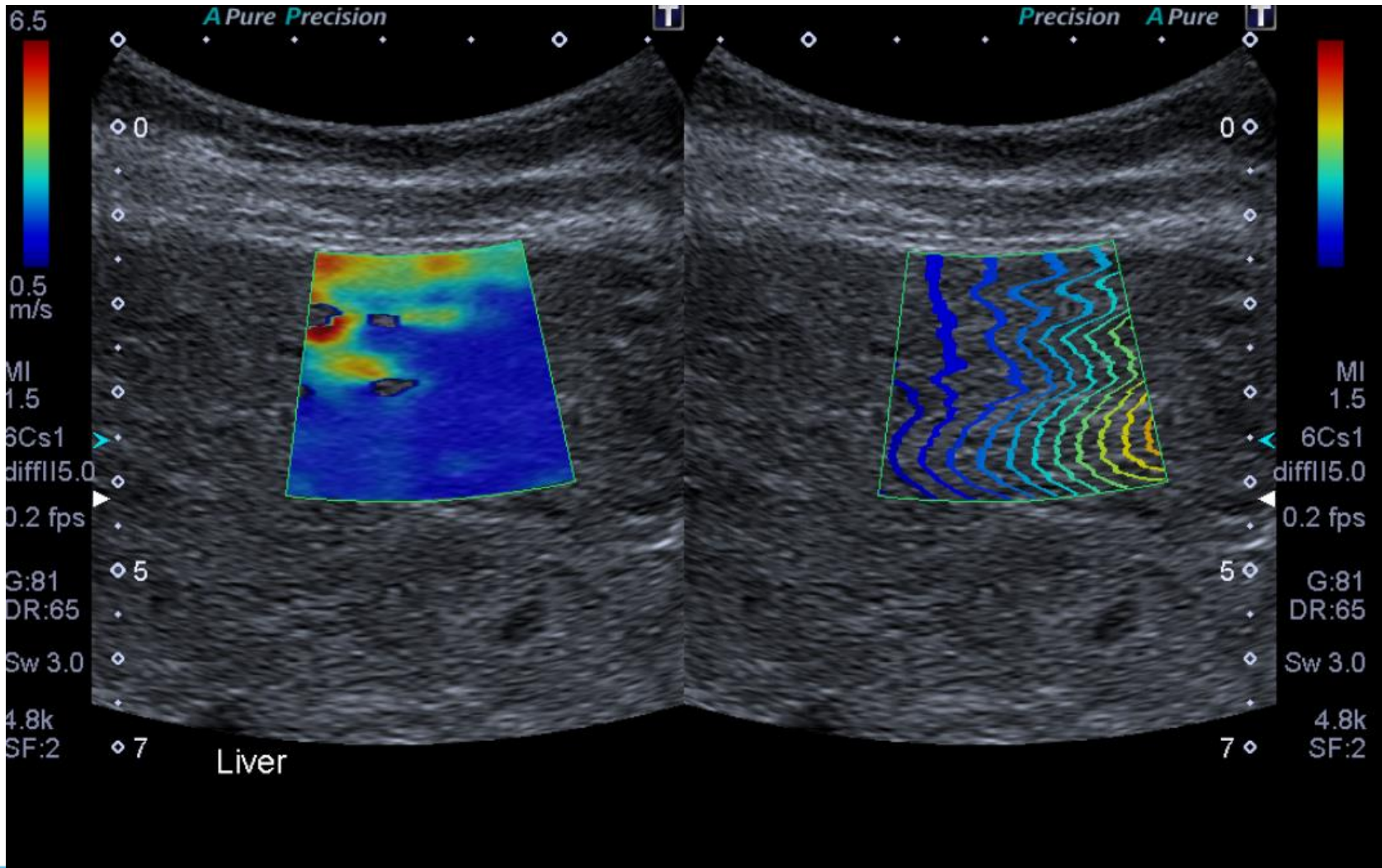
EFSUMB Guidelines and Recommendations on the Clinical Use of Liver Ultrasound Elastography, Update 2017



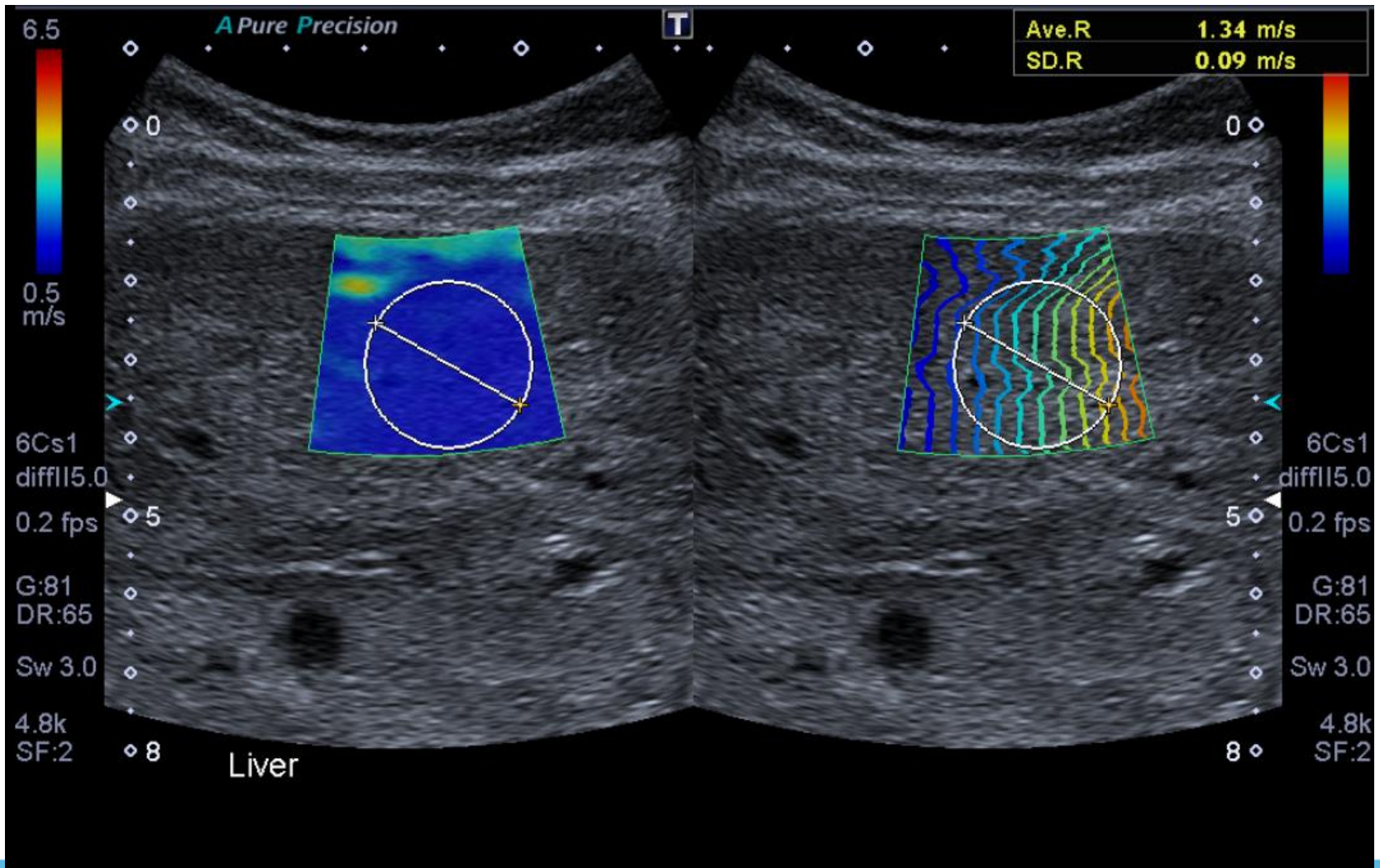
Elastography Principle

- The stiffer the tissue (organ or lesion) the faster the shear wave (transverse wave) travels
- The pressure of the shear wave increases with tissue stiffness
- The shear wave can be expressed in terms of speed (m/s) or pressure (kPa)

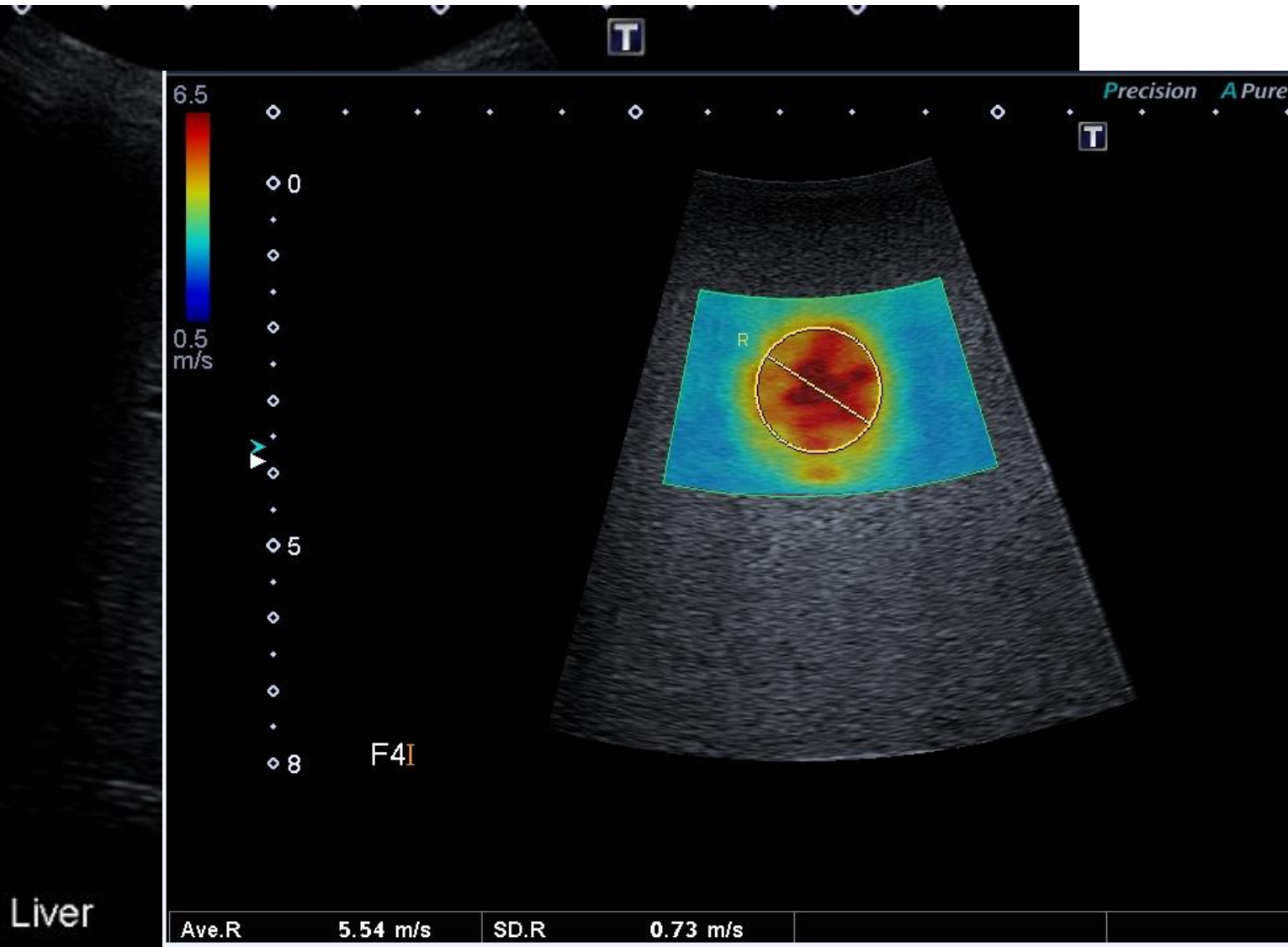
Shear wave properties



Toshiba Shear wave



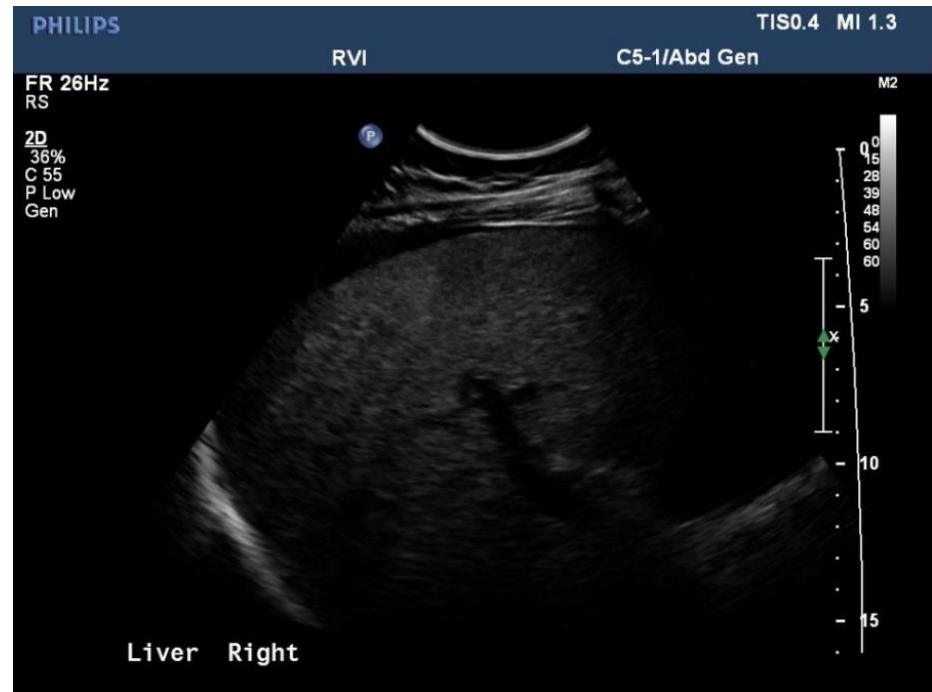
Soft vs Hard



Fat vs Fibrosis

Role of shear wave elastography

- Evidence of reasonable performance in chronic hepatitis
- Jury most definitely out for others
- Evidence of underestimation of advanced fibrosis in NAFLD (24%)



Liver Ultrasound – Beyond the basics

- **Fantastic**
 - Normality
 - Identifying FLL
 - Diffuse disease
- **Tricky**
 - Characterising FLL without use of CEUS
 - Staging diffuse disease without use of elastography
- **Think beyond fundamental US techniques**

Learning Points

- Ultrasound is an invaluable tool in assessing liver lesions and diffuse disease
- US can be improved with use of contrast for FLL and elastography for diffuse disease
- Consider improving US diagnosis with use of additional techniques and technologies
- Review pathways with clinicians to aid implementing techniques

Any questions?

