SONOGRAPHY of the HEPATOBILIARY SYSTEM

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LIVER SONOGRAPHY

- Normal liver
- Doppler of hepatic vessels
- Diffuse liver diseases patterns
- Portal hypertension
- Focal liver masses

THE NORMAL LIVER

- Size
- Shape
- Echogenicity
- Echotexture
- Technique
  - Smooth TGC
  - Diaphragm
  - Vessel lumens
  - Clear all margins

LIVER TECHNIQUE

Always clear 2-3 cm beyond the margin of any organ to avoid exophytic or adjacent masses

PARENCHYMAL ORGAN ECHOGENICITIES

Renal medulla < cortex < liver
Liver < spleen
Liver < pancreas
Pancreas < renal sinus & retro fat

THE NORMAL LIVER

- Sonographically, the vessels visible within the parenchyma of the liver are:
  - the portal and hepatic veins
- Hepatic arteries and bile ducts are not visible within the liver, unless abnormally dilated
  - They are seen in the porta hepatis
THE NORMAL LIVER
- Porta hepatis: portal vein, bile duct, artery
- Portal triads maintained throughout the liver
- Hepatic veins are separate

PORTAL VEINS
- Echogenic / “bright” walls
  - Used for evaluation of liver parenchymal echogenicity
- Enter liver through the porta hepatis
- Largest portal veins divide in the middle of liver
- More horizontally oriented
- Within lobes and segments
- Flow into liver

PORTAL VEINS
REASONS FOR BRIGHT WALLS
1. Portal triad
   - portal vein
   - hepatic artery
   - bile duct
2. Glisson’s capsule
3. Lymphatics, nerves
4. Connective tissue

HEPATIC VEINS
Imperceptible margins
Enlarge toward IVC
More vertically oriented
“Umbrella” configuration
Between lobes & segments
- Used as anatomic dividers of the liver
Flow out of liver

HV: UMBRELLA CONFIGURATION

EXCEPTIONS TO THE RULE
Some portal veins may not show echogenic walls: parallel to beam
Some hepatic veins may show echogenic walls: large veins perpendicular to beam
Angle dependence
**LIGAMENTUM TERES**
- The obliterated fetal remnant of the umbilical vein in the fissure for ligamentum teres
- Joins the umbilical segment of the left portal vein
- May recanalize in portal hypertension
- Not to be mistaken for a mass or calcium
- Divides LT lobe

**LIGAMENTUM VENOSUM**
- The obliterated fetal remnant of the ductus venosus
- Lies within the fissure for ligamentum venosum
- Does not recanalize in adults
- Separates the left lobe from the caudate lobe ("tail")

**CAUDATE LOBE**
- Functionally autonomous segment, spared in liver dz
  - Blood supply from right and left portal veins
  - Direct venous drainage into IVC
- Pseudomass

**ENLARGED CAUDATE LOBE**
- Caudate to right lobe ratio increases > 0.65

**TRANSVERSE LIVER SCANS**
**ANATOMIC LANDMARKS**
- **UPPER:** Large hepatic veins join IVC
- **MID:** Large central portal veins (Left higher than right portal)
- **LOWER:** No large veins
  - Falciform ligament
  - Ligamentum teres

**HEPATIC & PORTAL VEINS**
- Basis of modern lobar & segmental anatomy
- Hepatic veins drain peripherally
  - Interlobar, intersegmental
  - Used as dividers
- Portal veins feed centrally
  - Intralobar, intrasegmental
  - Used to name segments
HEPATIC VEINS: ANATOMIC DIVIDERS
MHV divides the liver into right & left lobes
RHV divides RL into anterior & posterior segments
LHV divides LL into medial & lateral segments (cranially)

PORTAL VEINS: DEFINE SEGMENTS
- Feed the segments
- Name the segments
- Define the segments

LEFT LOBE ANATOMIC DIVIDERS
Into medial and lateral segments
- High sections: left hepatic vein
- Mid sections: umbilical segment LPV
- Low sections: falciform ligament, fissure for ligamentum teres

MORE DIVISIONS OF THE LIVER
- The level of the division of the MPV is the divider of the liver into superior and inferior parts

ANATOMIC LIVER SEGMENTS
I: Caudate lobe
II: Left posterolateral
III: Left anterolateral
IVa: Left superomedial
IVb: Left inferomedial
V: Right anteroinferior
VI: Right posteroinferior
VII: Right posterosuperior
VIII: Right anterosuperior

Name the subsegment with the cyst
- Transverse
- Sagittal
Main Portal Vein: Normal Doppler
- Continuous, forward flow
- Low velocity (15-28 cm/s)
- Hepatopetal flow
- Undulating pattern
  - Respiratory variation
    - ↑ flow on inspiration
  - May reflect cardiac variation
  - Slightly turbulent, "rough", low rumble
  - Location between 2 capillary beds (mesenteric & hepatic)

Main Portal Vein: Abnormal Doppler
- Pulsatile flow is abnormal
  - May resemble HV pulsatility
  - ↑ RT heart pressures
  - Transmission of pressure thru hepatic sinusoids
  - Tricuspid regurgitation
  - Moderate to severe RT heart failure, pericarditis
- Exception: child, young person
  - Very soft, pliable liver
  - Periodicity is pronounced

Main Portal Vein: Abnormal Doppler
- Flattened waveform is abnormal
- Continuous
- Loss of phasicity
- Associated with
  - Cirrhosis
  - Hepatic fibrosis

Hepatic Artery: Normal Doppler
- Rapid systolic acceleration
- Continuous forward flow throughout cardiac cycle
  - low impedance
- Same direction as MPV
- Resistive index 0.5 – 0.7

Hepatic Artery and Portal Vein
- Main portal vein and hepatic artery have same direction/color of blood flow
- Blood flow to liver
  - PV 70-80%
  - HA 20-30%
- Homeostatic mechanism for maintaining hepatic perfusion
  - ↓ PV flow → ↑ HA flow

Hepatic Artery: Abnormal Doppler
- Increased resistance, low diastolic flow
  - Postprandial
  - Portal HTN
  - Transplant rejection
**Hepatic Artery: Abnormal Doppler**

- Low resistance pattern
  - Tardus parvus waveform in OLT
  - Decreased upstroke (prolonged SAT)
  - Downstream from hepatic artery anastomosis stenosis

**Hepatic Veins: Normal Color Doppler**

- Toward IVC and heart
- Away from transducer
- Characteristic pulsatile flow

**Hepatic Veins: Normal Doppler**

- Reflects respiratory phases
- Reflects variations in central venous pressure transmitted from the RA
- Reflects compliance of liver parenchyma
- Triphasic pattern
- Deep inspiration or Valsalva may reduce pulsatility of waveform in normals

**Hepatic Veins: Abnormal Doppler**

- Non-triphasic flow
  - Elevated RT heart pressure
  - ↓ Pulsatility or amplitude of phasic oscillations
  - Loss of the reversed phase
  - Monophasic: abnormal
  - Flattened waveform
  - Resembles PV flow
  - Stiff, noncompliant liver

**SONOGRAPHIC LIVER PATTERNS**

- Normal
- Centrilobular
- Fatty-fibrotic

**CENTRI-LOBULAR PATTERN**

- Decreased echogenicity of liver parenchyma
- Increased visualization of PV walls
  - increased brightness
  - increased number
- Acute hepatitis, acute RT heart failure, leukemia/lymphoma, toxic shock, 2% normals
FATTY-FIBROTIC PATTERN

- Increased echogenicity of liver parenchyma
- Decreased definition of PV walls
- Echotexture
  - homogeneous (fine)
  - heterogeneous (coarse)
- Posterior sound attenuation
- Fatty infiltration, chronic hepatitis, cirrhosis, acute alcoholic hepatitis

FATTY LIVER

- Posterior sound attenuation
- Enlarged liver
- Tends to have fine homogeneous echotexture

FOCAL FATTY LIVER CHANGES

- Focal fatty infiltration
- Focal fatty sparing

LIVER CIRRHOSIS

- Fatty-fibrotic pattern
  - heterogeneous echotexture
  - coarse “motheaten”
  - almost no posterior attenuation
- Shrunken liver
- Nodular surface
- Elevated caudate:right lobe ratio (>0.73 has 99% specificity for cirrhosis)

LIVER CIRRHOSIS

- Accounts for > 90% of all portal hypertension
- Distorted liver architecture
  - Fibrosis
  - Regenerating nodules
  - Distorted vascular channels
PORTAL HYPERTENSION

† hepatic resistance, † portal venous pressure, eventually ↓ portal flow, reversed portal flow
Prognostication for risk of hemorrhage

PORTAL HYPERTENSION

Sonographic Signs

• Ascites
• Dilated MPV, SV, SMV
• Collaterals
• Splenomegaly
• Various Doppler findings

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PORTAL HYPERTENSION

Collateral Vessels

• Gastroesophageal
• Coronary
• Umbilical
• Gastrosplenic
• Splenorenal/gastrorenal
• Perisplenic
• Intestinal
• Retroperitoneal

PORTAL HYPERTENSION

Collateral Vessels

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PORTAL HYPERTENSION

DOPPLER in PORTAL HYPERTENSION

• Portal veins:
  – loss of respiratory variation
  – decreased velocity MPV
  – hepatofugal (reversed) flow
• Hepatic veins:
  – loss of normal pulsatility
  – non-triphasic flow
  – flattened waveform
• Hepatic arteries:
  – enlarged hepatic arteries

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PORTAL HYPERTENSION

Enlarged Hepatic Arteries

A cause of intraparenchymal "double duct" sign
FOCAL LIVER MASSES

• US is excellent in detecting focal liver lesions
• US is specific for liver cysts > 1 cm
• Not good in differentiating among pathologic entities
  – Very few US features are characteristic
• Not good in distinguishing between benign and malignant masses
• Triple phase Liver CT and MRI are excellent
• US is very helpful for diagnosis in the proper clinical setting, for follow-up and as guidance for biopsy

SIMPLE CYSTIC LESIONS

• Cyst
• Old hematoma
• Abscess (hydatid)
• Biloma / seroma
• Vascular
  – aneurysm
  – fistula (a-pv, p-hv)

COMPLEX CYSTIC LESIONS

• Hemorrhagic cyst
• Infected cyst
• Hematoma
• Abscess
• Biloma / seroma
• Biliary cystadenoma
• Cystic/necrotic malignant tumors

LIVER ABSCESS

• May cause difficulty in diagnosis

CHARACTERISTIC LESION

Echinococcal cyst with laminated membrane

Benign versus Malignant

Echinococcal cyst
Metastases
HYPOECHOIC MASS

**BENIGN**
- Abscess
- Adenoma
- Focal nodular hypoplasia
- Hemangioma
- Microabscesses
- Focal fatty sparing

**MALIGNANT**
- Metastasis
- Hepatocellular carcinoma
- Lymphoma

CHARACTERISTIC LESION
- Focal nodular hyperplasia with a central scar
- But not diagnostic

CENTRAL SCAR IN LESION

**Hepatocellular carcinoma, Fibrolamellar type**

**Giant hemangioma**

CHARACTERISTIC LESION
- Hyperechoic hemangioma

ATYPICAL HEMAGIOMAS

HYPERECHOIC MASS

**BENIGN**
- Hemangioma
- Abscess
- Adenoma
- Focal nodular hypoplasia
- Focal fat
- Hemorrhagic cyst

**MALIGNANT**
- Metastasis
- Hepatocellular carcinoma
- Lymphoma
- Thyroid cancer metastasis
MULTIPLE SOLID MASSES

- Metastases
- Regenerating nodules in cirrhosis
- Lymphoma
- Multiple hemangiomas
- Microabscesses

CHARACTERISTIC METASTASES

- Colon metastases
- Also seen with cancers of ovary, breast, stomach, pancreas, osteosarcoma, leiomyosarcoma, chondrosarcoma, teratocarcinoma

LIVER METASTASES: COMPLICATIONS

- Biliary duct obstruction
- Vascular invasion
- Necrosis
- Hemorrhage
- Infection

US GUIDANCE

- Usefulness of sonography
- For aspiration, biopsy and drainage

SONOGRAPHY of the GALLBLADDER
GALLBLADDER TECHNIQUE

• 5 MHz or higher transducer
• 8-12 hour overnight fast (minimum 6-8 hours)
• Scan in morning
• Patient position:
  – Supine or left posterior oblique and one other position (lateral decubitus, erect or prone)

NORMAL GALLBLADDER

The gallbladder is a standard of reference for simple fluid in the right upper quadrant (hepatic, renal masses)

NORMAL VARIANTS

1. Echogenic focus
2. Acoustical shadow
3. Mobility

GALLSTONES

Sonographic criteria
1. Echogenic focus
2. Acoustical shadow
3. Mobility

To avoid errors and false diagnosis:
• Image a gallstone in two perpendicular planes
• Demonstrate shadowing
• Demonstrate mobility of stone
• Check cystic duct carefully

GALLSTONES

FALSE GALLSTONE

Transverse Longitudinal
GALLSTONES & SHADOWS

All gallstones (>1mm), regardless of chemical composition, shadow. This requires optimization of technique, which is not always possible in vivo. Doppler twinkling artifact may help.

TWINKLING ARTIFACT

- Color Doppler artifact
- Occurs behind a calculus
- Implies calcification with rough interface

SHADOW PRODUCTION

Optimization of technique:
1. Higher frequency ≥ 5MHz
2. Lower power/gain
3. Focal zone

Use position change to pile up small stones that collectively shadow and make a visible shadow.

DDx NON-VISUALIZATION OF GB

- Cholecystectomy
- Chronic cholecystitis ± stones
- Air in duodenum
- Gallbladder carcinoma
- Obstruction of biliary tree proximal to cystic duct
- Congenital absence of GB

NON-VISUALIZATION OF GB

What to do?
- Use main lobar fissure
- Wall-echo-shadow sign
- Examine type of shadow: “clean” vs “dirty”
- Change patient position to shift gas
- Administer water into duodenum to displace gas

WALL-ECHO-SHADOW SIGN

WES Sign
ACOUSTICAL SHADOWS
• Calculi generate a characteristic "clean", sharp, black shadow
• Air and gas cause "dirty", gray shadows full of reverberations

NON-SHADOWING ECHOGENIC FOCI IN GB
• Tiny calculi
• Polyps
• Sludge balls
• Cholesterol crystals

SUSPICIOUS POLYPS
• Size >8-10mm
• Irregular surface
• Broad-based

CHOLESTEROL CRYSTALS
• Ring-down artifact
• “Comet-tail”
• Cholesterol polyps
• Adenomyomatosis
  – Wall thickening
  – Crystals deposit in Rokitansky-Aschoff sinuses

SLUDGE
• Echogenic material in gallbladder lumen
• Calcium bilirubinate granules and cholesterol crystals in thick, viscous bile
• Does not shadow
• Layers in dependent portion of gallbladder
• Signifies poor emptying and bile stasis
• May fill entire lumen (hepatization)

TUMEFACTIVE SLUDGE
• Sludge may form masses
  – "Sludge balls"
  – Non-shadowing
  – Possible precursor to stone
  – Differentiate from GB cancer
• Doppler findings
  – No blood flow in sludge
  – If there is blood flow, consider tumor mass
**GALLBLADDER CARCINOMA**

- No blood flow

**Acute Cholecystitis**

**Sonographic Findings**

- Gallstones
  - Only 1/3 get acute cholecystitis
- Pain directly over gallbladder
  - Sonographic Murphy’s sign
- Thickened gallbladder wall
- Enlarged gallbladder

**Diffuse GB Wall Thickening**

- Non-fasting
- Cholecystitis – acute, chronic, acalculous
- Ascites: edema, hypoalbuminemia
- Liver disease - hepatitis, cirrhosis
- Renal disease - failure, uremia
- Heart failure
- Inflammatory states
- AIDS cholangiopathy
- GB varices

**Acute Cholecystitis**

- Pericholecystic fluid
- Striated wall
- Pericholecystic hyperechogenicity due to infiltration of fat
- Color Doppler: flow, nonspecific

**Gangrenous Cholecystitis**

- Gas-forming bacteria
- Ulceration & sloughing of mucosa
- Necrosis
- Hemorrhage
- Pus
- Microabscesses
- Intramural gas
- Intraluminal gas
- Perforation

**Gangrenous Cholecystitis**

- Striated wall thickening
- Intraluminal membranes
- Mass-like protrusions into gallbladder
- Larger pericholecystic collections
- Internal echoes due to pus
ACALCULOUS CHOLECYSTITIS
- Signs of acute cholecystitis (except gallstones)
- Clinical setting
  - Major surgery
  - Severe trauma
  - Severe burns
- Multifactorial etiology
  - Ischemia
  - Infection
  - Chemical toxicity
  - Obstructed duct

SCLEROSING CHOLANGITIS
- Types
  - Primary
  - Secondary: with inflammatory bowel disease: UC, Crohn's
- Smooth or irregular wall thickening
- More likely to affect bile ducts
- Lack of gallbladder distension
  - small lumen

GALLBLADDER CARCINOMA
- Elderly patients, poor prognosis
- Chronic irritation from longstanding gallstones and chronic cholecystitis
- Polypoid mass, irregular outline
- Invasive through wall and into surrounding tissues
- Doppler signals

Color Doppler Echoes Must Be Confirmed With Spectral Tracing
- False echoes
- Cannot be confirmed

GALLBLADDER METASTASES
- Rare
- Late manifestation of disease
- Other metastases are usually present
- Primary tumors:
  - Melanoma
  - Breast
  - GI
  - Lung
- May also be local invasion of tumor
LOCAL INVASION OF GB
Peritoneal carcinomatosis ovarian cancer

SONOGRAPHY OF THE BILE DUCTS

EXTRAHEPATIC BILE DUCTS

PORTAL TRIADS

COMMON DUCT ANATOMY
Proximal CD Anterior to MPV in Porta
Mid CD Posterior to duodenum
Distal CD Posterior to panc head

COMMON DUCT MEASUREMENTS
Common hepatic duct < 6 mm*
Common bile duct < 8 mm*
* Add 1mm per decade after 50
**Biliary Obstruction**

**Sonographic Determination**
- Presence of obstruction
- Level of obstruction
- Cause of obstruction

**Common Duct Dilatation**
- Before intrahepatic ducts dilate
- Often before bilirubin rises
- Obstruction vs. physiologic distension
  - Fatty meal

**False Positives**
- False positives: not all patients with common duct dilatation have mechanical obstruction
- False negatives: not all patients with mechanical obstruction have a dilated common duct

**False Negatives**
- Intermittent or partial obstruction
- Acute, early obstruction
- Diseased duct that cannot dilate
  - Sclerosing cholangitis
- Infiltrative or fibrotic liver disease
- Obstruction proximal to CD
  - Klatskin tumor

**Intrahepatic Ductal Dilatation**

**Sonographic Signs**
- Central ducts: “Too many tubes sign”
  - Tortuous, dilated, central, tubular, stellar configuration
- Peripheral ducts: “double ducts”
  - Double channel sign
  - Parallel channel sign
  - Double barrel shotgun sign
  - Railroad track sign
QUERY

What can cause the appearance of “double ducts” in the liver besides dilated intrahepatic bile ducts?

“DOUBLE DUCTS” IN THE LIVER

• May be due to enlarged hepatic arteries
  – cirrhosis, portal HTN
• Usually due to dilated bile ducts
• Each portal triad contains a portal vein, a hepatic artery and a bile duct
• Use color Doppler

BILIARY OBSTRUCTION: ETIOLOGY

• Choledocholithiasis
• Neoplasms
• Pancreatitis
• Strictures
• Portal nodes
• Ascariasis

CHOLEDCHOCHOLITHIASIS

Must follow the CBD into head of pancreas

MIMICKERS OF CHOLEDCHOCHOLITHIASIS

• Air in adjacent bowel
• Hepatic artery indentation or calcification
• Surgical clips
• Bile duct air
• Liver calcifications
• Pancreatic calcification

NEOPLASMS CAUSING BILIARY OBSTRUCTION

• Pancreatic CA
• Bile duct CA
• Gallbladder CA
• Hepatic tumor
• Duodenal tumor
• Portal masses
CHOLANGIOCARCINOMA

• Primary bile duct carcinoma, rare
• Origin: usually in the extrahepatic bile ducts, however may be in the intrahepatic ducts
• Sonographic findings:
  – Bile duct wall thickening & narrowing
  – Intraluminal polypoid mass
  – Diffuse sclerosing type
  – Solitary or multiple liver masses
  – Intrahepatic ductal dilatation

CHOLANGIOCARCINOMA RISK FACTORS

• Inflammatory bowel disease
  – Ulcerative colitis, Crohn's disease
• Sclerosing cholangitis
• Choledochal cysts
• Caroli's disease
• Hepaticolithiasis
• Choledochoenteric anastomoses
• Clonorchis sinensis
• Occupational exposure

KLATSKIN TUMOR

• Cholangiocarcinoma at confluence of ducts
• Other causes, same site
  - gallbladder CA
  - hepatoma
• Dilated intrahepatic ducts
• Normal size CD
• Non-visualization GB
• Tumor, metastases seen in 50%

DDx BILE DUCT WALL THICKENING

• Sclerosing cholangitis
• Cholangiocarcinoma
• AIDS cholangiopathy
• Ascending cholangitis
• Choledocholithiasis
• Pancreatitis
• Oriental cholangiohepatitis

SCLEROSING CHOLANGITIS

• Young men
• Fibrotic thickening of bile duct wall, periductal fibrosis, cholestasis, cholangitis, pericholangitis
• Eventual cirrhosis, portal hypertension, liver failure

SCLEROSING CHOLANGITIS

• Associated with inflammatory bowel disease
  – Ulcerative colitis
  – Crohn's disease
• "Beaded" or "pruned tree" appearance
• Can involve gallbladder
SEGMENTAL BILIARY OBSTRUCTION
- Stricture
- Calculus
- Cholangiocarcinoma
- Sclerosing cholangitis
- Hepatic tumor
  - primary or metastatic
- Portal nodes

CHOLEDOCHAL CYST
- Rare malformation of bile ducts: anomalous junction of CBD and pancreatic duct
- Reflux of pancreatic enzymes
- ↑ incidence cholangiocarcinoma
- Presents in children, some adults
- Females more common

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CHOLEDOCHAL CYST TYPE 4
- Focal intrahepatic biliary dilatations
- Fusiform dilatation CBD

CHOLEDOCHAL CYST TYPE 4
- Focal intrahepatic biliary dilatations
- Associated renal polycystic disease

CHOLEDOCHAL CYST TYPE 5
- Caroli’s Disease
- Normal CBD
THE END

Thank you for your attention!