Hepatic Geography: Navigating the Islands and Continents of Diffuse Liver Disease

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Disclosures

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Objectives

After completing this educational exhibit, the learner will be able to:

1. Understand the role of current imaging modalities in evaluating diffuse liver disease
2. Utilize specific imaging techniques to optimally detect various causes of diffuse liver disease
3. Interpret characteristic imaging presentations of diffuse liver disease
4. Recognize common pitfalls in the imaging of diffuse liver disease
Diffuse liver disease occurs secondary to global alteration in normal hepatic parenchymal function, which may be secondary to vascular, infectious, inflammatory, metabolic, or infiltrative processes.

These processes may be either benign or malignant, with highly variable prognoses and therapeutic options depending on the underlying cause.

The purpose of this exhibit is to provide the learner with an understanding of the pathophysiologic principles and spectrum of imaging manifestations, and common imaging pitfalls of diffuse liver disease.

- Biliary insult
- Vascular compromise
- Direct hepatocyte toxicity

Irreversible damage
**Imaging Modalities**

**US (Ultrasound)**
- Examination can be performed in real-time
- No radiation exposure
- Techniques such as color and pulsed Doppler, contrast-enhanced US, and elastography can augment detection of pathology
- Examination quality depends on patient compliance and operator technique

**CT (Computed Tomography)**
- Short examination time
- Good spatial resolution
- Large field of view provides opportunity to detect alternative diagnoses
- Relatively high radiation exposure

**MR (Magnetic Resonance)**
- Exquisite soft tissue contrast
- Can perform multiphasic examinations without radiation exposure
- Multiple contrast types, which can be used alone or in combination to assess hepatic function
- Long examination time, reliant on patient cooperation and tolerance

**Abbreviations:**
- US = ultrasound
- CT = computed tomography
- MR = magnetic resonance
Imaging Techniques – US

- **Grayscale**
  Evaluates the liver parenchyma, biliary tree, and perihepatic spaces. Normal liver parenchyma should be iso- to mildly hyperechoic to the adjacent right kidney.

- **Color Doppler**
  Evaluates the major intrahepatic vessels, splenic vein, inferior vena cava, and aorta. Can also assess for vascularity within detected focal lesions or segmental abnormalities.

- **Pulsed Doppler**
  Assesses waveforms within interrogated vessels. Normal waveform signatures include antegrade phasic in the portal vein, low-resistance arterial in the hepatic arteries, and triphasic in the hepatic veins.

- **Elastography**
  Assesses for liver stiffness. The transducer is used to propagate a shear wave through the liver, and B-mode imaging is used to quantify the amount of displacement of the liver tissue.

- **Evaluates the major intrahepatic vessels, splenic vein, inferior vena cava, and aorta.**
  Can also assess for vascularity within detected focal lesions or segmental abnormalities.
Imaging Techniques – US Pitfalls

**Transducer selection:** A low frequency probe (e.g. 1-6 MHz curved) may be necessary for evaluating the deeper portions of the liver. A high frequency probe (e.g. 5-12 MHz linear) is better at evaluating the liver surface for nodularity.

**Patient positioning:** Supine and left lateral decubitus positions are typically used when imaging the liver. Imaging usually begins using a subcostal acoustic window, with transition to an intercostal approach as needed to evaluate the entire liver.

Pitfall: Normal hepatic parenchyma in the setting of diffuse liver disease can be mistaken for a focal abnormality. Grayscale US images (C-D) show a well-circumscribed hypoechoic pseudolesion (circled) adjacent to the gallbladder fossa. The liver (square) is diffusely hyperechogenic relative to the kidney (triangle). Coronal portal venous phase CT image (E) confirms a steatotic liver with a relatively hyperattenuating area consistent with focal fatty sparing (arrowheads).

Pitfall: Attenuation of the US beam in the setting of diffuse liver disease can limit sensitivity for focal lesions. Transverse grayscale US image of the liver (A) demonstrates a diffusely coarse and heterogeneously hyperechogenic liver in a patient with severe hepatic steatosis. The deep portions of the liver are not well imaged due to attenuation of the sound waves by the infiltrated liver. Contrast-enhanced US image of the liver in a different patient with diffuse liver disease (B) demonstrates enhancement of an initially obscured lesion (arrow).
CT examination of the liver can be performed with and/or without intravenous contrast. The liver is perfused by both the hepatic artery (20%) and portal vein (80%) and will have a variable imaging appearance dependent on contrast phase. The hepatic arterial phase demonstrates contrast predominantly within the hepatic artery and may be early (approximately 25 seconds post-injection) or late (approximately 35 seconds post-injection). The late arterial phase should demonstrate some early opacification of the portal vein. The portal venous phase occurs approximately 70 seconds after contrast injection. Maximal hepatic parenchymal enhancement occurs during the portal venous phase.

Non-contrast and post-contrast arterial and portal venous phase imaging are three of the most routinely performed studies for evaluation of the liver at our institution. Multiple phases can be performed during one examination to tailor the study to the appropriate clinical scenario (example protocols on next slide).
Imaging Techniques – CT Protocols

Examples of CT protocols:

1. Single phase:
   - Non-contrast: if iodinated contrast is contraindicated
   - Portal Venous: no specific condition suspected

2. Biphasic:
   - Late Arterial + Portal Venous: evaluation for metastasis in the setting of known primary hypervascular neoplasm
   - Portal Venous + 12-minute Delayed: evaluate for fibrosis or cholangiocarcinoma

3. Triphasic:
   - Late Arterial + Portal Venous + 3-minute Delayed: for evaluation of hepatocellular carcinoma per UNOS criteria

Non-contrast: Image left from a patient with steatohepatitis shows severe hypoattenuation of the affected right hepatic lobe in contrast to the normal left hepatic lobe. Image right from a patient with amiodarone toxicity shows diffuse hyperattenuation throughout the liver. (ROIs circled, attenuation in HU in center.)

Late Arterial Phase: Images from a biphasic examination in a patient with known metastatic neuroendocrine tumor. Image left in the arterial phase demonstrates innumerable arterially enhancing lesions diffusely throughout the liver. Image right shows that these lesions are occult in the portal venous phase.

Delayed Phase: Images from a patient with cholangiocarcinoma. Image left in the portal venous phase shows a hypoattenuating lesion (circled) in the central liver. Image right obtained after a 12-minute delay shows progressive enhancement of this lesion (circled) relative to the background liver, characteristic of cholangiocarcinoma.

Abbreviations:

ROI = region of interest
HU = Hounsfield units
Imaging Techniques – MR

Pre-contrast:
1. **T1**: Liver is mildly hyperintense relative to the spleen and kidneys.
2. **T2**: Liver is hypointense relative to the spleen and kidneys. The biliary tree is hyperintense. Flow-voids are seen in patent vessels.

Contrast types routinely used at our institution:
1. **Extracellular agents** (e.g. gadobenate dimeglumine): Distribute in the interstitial space. Preferred for characterization of lesions using dynamic imaging, such as hepatocellular carcinoma.
   - gadobenate dimeglumine can be used as a hepatobiliary agent (4-5% biliary excretion)
2. **Hepatobiliary agents** (e.g. gadoxetate disodium): Taken up by functioning hepatocytes and excreted in bile and urine. Used to evaluate biliary pathology or lesions in non-cirrhotic livers (e.g. hepatic adenoma versus focal nodular hyperplasia).
3. **Blood pool agents** (e.g. gadofosveset trisodium): Remain in the intravascular space. Can be combined with other agents to increase sensitivity.

Abbreviations:
- HBP = hepatobiliary phase
- BPA = blood pool agent
**Imaging Techniques – MR**

**Fat and iron quantification:** Proton density fat fraction maps reflect the triglyceride concentration within the liver. \( \text{R}^2 \) maps measure the rate of signal decay, which is directly proportional to iron concentration. Regions of interest drawn on these maps can be used to quantify fatty infiltration or iron overload.

**Opposed phase imaging:** Differences in signal intensity between in- and out-of-phase images may indicate infiltrative liver diseases. Decreased signal on out-of-phase relative to in-phase images is seen with fatty infiltration, while increased signal on out-of-phase images indicates increased susceptibility artifacts which can be seen with hemosiderin deposition.

**MR elastography:** Sinusoidal mechanical waves are generated in the liver, and the propagating waves are used to generate a stiffness map. Regions of interest are drawn on the stiffness map to calculate shear stiffness, which has a strong direct correlation with severity of hepatic fibrosis.

**Diffusion-weighted imaging:** Increased signal on diffusion weighted imaging with concomitant hypointensity on ADC map indicates restricted random motion by water molecules, which can be seen in the setting of hypercellular processes. DWI is also sensitive for detecting lymphadenopathy (note the hyper- and hypointensity of the spleen on DWI and ADC map, respectively).

**Abbreviations:**
- PDFF = proton density fat fraction
- DWI = diffusion-weighted imaging
- ADC = apparent diffusion coefficient
Case 1: 25M with new jaundice and rising serum liver enzymes after dapsone therapy for eczema.

Right upper quadrant grayscale US (A) demonstrates an coarse echogenic liver (star) with a nodular surface contour (arrowheads). T2-weighted MR image of the upper abdomen (B) demonstrates bridging confluent hyperintense periportal bands (arrows). Portal venous phase MR image at the same level (C) confirms that the periportal bands progressively enhance following administration of contrast (arrows). Note the lobulated configuration of the liver with large regenerative nodules (squares).

Dx: Confluent Fibrosis
Case 2: Two patients with chronic liver disease and rising serum liver enzymes.

Patient 1: 51F with history of non-alcoholic fatty liver disease. Transverse grayscale US image (A) demonstrates a diffusely heterogeneous and nodular liver. Axial non-contrast CT image (B) demonstrates a macronodular liver, with multiple hyperattenuating nodules (black squares) compatible with siderotic nodules. T2-weighted (C) and post-contrast portal venous phase (D) MR images of the liver confirm that these nodules are T2 hypointense and relatively hypoenhancing following contrast administration (squares).

Patient 2: 61M with history of heavy alcohol use. Transverse grayscale US image (E) demonstrates a heterogeneous, diffusely nodular liver. Pulsed Doppler image of the middle hepatic vein (F) demonstrates a flattened waveform (arrow) with loss of normal phasicity, suggestive of decreased hepatic venous compliance. T2-weighted MR image (G) reveals multiple small T2 hypointense nodules with intervening T2 hyperintense lace-like bands compatible with fibrosis. Post-contrast arterial phase MR image (H) also shows a mottled enhancement pattern with innumerable nodules.

Dx: Cirrhosis
Cirrhosis

Final common pathway of chronic liver disease:
- extracellular matrix deposited in the liver ->
- fibrosis increases portal venous resistance ->
- hepatocyte death ->
- separation into regenerating nodules

Prognosis: “irreversible” (may be reversible early), mortality depends on stage (ranging from 1-57% 1-year mortality)

Causes: hepatitis B/C, alcoholic liver disease, cryptogenic (usually secondary to non-alcoholic steatohepatitis)

Imaging:
- fibrosis: thick, lace-like, or confluent T2 hyperintense bands on MR, progressive enhancement on more delayed images due to contrast pooling
- nodules:
  - siderotic: hyperdense on non-contrast CT, T2 hypointense on MR
  - regenerative: T1 hyperintense, T2 hypointense on MR
- HCC: arterially enhancing with washout on delayed phases

Abbreviations:
HCC: hepatocellular carcinoma
Case 3: 55F with metabolic syndrome, abdominal pain, and elevated serum liver enzymes.

Axial (A) and coronal (B) contrast-enhanced portal venous phase CT images demonstrate a geographic region of homogeneous hypodensity relative to background liver parenchyma throughout the left hepatic lobe (outlined regions). Note sparing of the subcapsular liver (arrowheads).

Dx: Hepatic Steatosis
Hepatic Steatosis

Alteration of hepatocellular lipid metabolism causes accumulation of triglycerides

Epidemiology:
- ~15% in the general population but up to 75% in obese patients
- associated with diabetes mellitus, alcohol abuse, and obesity

Imaging:
- US: liver hyperechoic to the renal cortex
- CT: <45 HU if unenhanced, >20 HU less than the spleen on portal venous phase
- MR: signal drop out on out-of-phase relative to in-phase imaging

Quantification: liver biopsy still considered gold standard, but MRI can quantify fat fraction non-invasively

<table>
<thead>
<tr>
<th>Patterns of Fat Deposition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffuse Deposition</td>
<td>homogeneous fat deposition</td>
</tr>
<tr>
<td>Focal Deposition with Focal Sparing</td>
<td>characteristically adjacent to the falciform ligament or ligamentum venosum, porta hepatis, and gallbladder fossa</td>
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<tr>
<td>Multifocal Deposition</td>
<td>may appear round, mimicking nodule</td>
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<tr>
<td>Perivascular Deposition</td>
<td>halos of fat surrounding the hepatic veins, portal veins, or both</td>
</tr>
<tr>
<td>Subcapsular Deposition</td>
<td>in patients with both insulin-dependent diabetes and renal failure (insulin added to peritoneal dialysate exposes subcapsular hepatocytes to insulin and results in subcapsular fat deposition)</td>
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</table>
Case 4: Two patients with markedly elevated serum ferritin levels.

Patient 1: 58M with rapid onset of hyperpigmentation. Opposed phase MR imaging of the upper abdomen demonstrates markedly increased signal diffusely throughout the liver on out-of-phase images (A) relative to in-phase images (B). Fat-saturated axial T2-weighted MR image (C) demonstrates conspicuously decreased signal intensity diffusely throughout the liver secondary to susceptibility effects. The pancreas is also hypointense on T2-weighted images (star).

Dx: Hemosiderosis

Patient 2: 28M with aplastic anemia requiring recurrent blood transfusions. Right upper quadrant grayscale US image (D) demonstrates increased echogenicity of the liver parenchyma (square) relative to the adjacent right kidney (triangle). Non-contrast CT image of the upper abdomen (E) reveals a markedly hyperattenuating liver (HU ~110), which was otherwise morphologically normal. T2-weighted MR image (F) demonstrates markedly low signal intensity of the liver and spleen secondary to T2* effects.

Dx: Primary Hemochromatosis
Case 5: 62F with chronic fatigue presenting with acute left-sided abdominal pain.

Multiple portal venous phase contrast-enhanced CT images from the same study are shown. Axial image at the level of the upper abdomen in liver windows (A) demonstrates diffuse hypoattenuation throughout the liver and spleen. Note relative sparing of the liver periphery (arrowheads) and hyperattenuation of segment IVb of the liver (square). The anterior spleen is markedly hypointense (star), suggestive of superimposed splenic infarct. Axial image at the level of the inferior pole of the spleen in soft tissue windows (B) demonstrates splenic rupture with complex fluid tracking along the left paracolic gutter, compatible with blood products. Coronal image in soft tissue windows (C) demonstrates hepatosplenomegaly and diffuse parenchymal hypoattenuation. Note additional complex fluid in the perisplenic region (dotted arrow).

Dx: Hepatic Amyloidosis
Case 6: 45F with history of type 1 glycogen storage disease and innumerable liver masses.

Transverse grayscale US image of the liver (A) demonstrates a diffusely coarse and heterogeneous liver. Calipers demonstrate a slowly enlarging right hepatic lobe mass. Post-contrast arterial phase CT image (B) demonstrates numerous avidly enhancing hepatic lesions. Short-term follow-up contrast-enhanced MRI using gadoxetate disodium in the hepatobiliary phase (C) demonstrates innumerable foci of contrast retention, even more than initially expected on the original CT.

Dx: Hepatic Adenomatosis
Deposition Diseases

Abnormal deposition of substances such as protein (amyloidosis), glycogen (most commonly von Gierke’s disease), medications (amiodarone toxicity), copper (Wilson’s disease), and iron (hemochromatosis) can lead to hepatic injury, cirrhosis, and organ malfunction.

Hemochromatosis: most common deposition disease
- Iron catalyzes conversion of hydrogen peroxide into free radicals; excess iron stored in the liver can lead to hepatic injury
  - iron deposition without organ damage is considered hemosiderosis

Etiology:
- primary: autosomal recessive disorder resulting in increased iron absorption, typically involves the pancreas
- secondary: increased iron intake such as in patients requiring recurrent blood transfusions; involves the reticuloendothelial system including the spleen

Imaging:
- CT: increased attenuation (> 70 HU) on non-contrast
- MR: marked T2 hypointensity, signal dropout on in-phase images relative to out-of-phase images due to T2* effects of iron
Case 7: 51M with history of prior bone marrow transplant presenting with recurrent fever.

Axial contrast-enhanced portal venous phase CT image (A) demonstrates numerous small round hypoattenuating lesions diffusely throughout a non-cirrhotic liver. Axial T2-weighted MR image of the liver (B) shows these lesions are T2 hyperintense. Post-contrast arterial phase image of the liver (C) demonstrates that several of these lesions demonstrate an apparent thin rim of enhancement (arrowheads). A laparoscopic wedge biopsy was performed which showed numerous microabscesses, and staining confirmed presence of yeast-like organisms. One-month follow-up CT (not pictured) demonstrated complete resolution of these lesions following treatment with antifungal therapy.

Dx: Hepatic Candidiasis
Hepatic Candidiasis

Manifestation of disseminated candidiasis in immunocompromised patients

Presentation:
- fever unresponsive to antibiotics
- 30% mortality despite treatment

Differential diagnosis: other infections (tuberculosis, bartonellosis), leukemia and lymphoma, diffuse metastases, sarcoidosis

Imaging: diffuse hepatosplenic microabscesses with or without central debris

- US: multiple hypoechoic lesions, may see alternating hypo- and hyperechoic rings ("wheel-within-wheel" or "bull’s-eye" appearance)
- CT: small non-enhancing hypodense lesions, occasional central hyperattenuating foci may represent pseudohyphae
- MR: T1 hypointense, T2 hyperintense, can see rim-enhancement (if sufficient immune response) or restricted diffusion
Case 8: 64M with incidental elevated alkaline phosphatase and findings of decompensated cirrhosis.

Multiple axial MR images of the upper abdomen are shown. T2 image (A) demonstrates extensive hyperintense periportal fibrosis (arrowheads). There is a small volume of perihepatic ascites (arrow). Arterial phase post-contrast MR image (B) demonstrates transient hyperintensity differences with hypoenhancement of the central liver and hyperenhancement peripherally. Portal venous phase post-contrast MR images (C-D) demonstrate heterogeneity of the splenic parenchyma (star). Numerous serpentine collateral vessels (circled) are noted below the inferior margin of the liver. US-guided biopsy was performed and demonstrated granulomatous hepatitis with associated fibrosis.

Dx: Hepatic Sarcoidosis
Sarcoidosis

Idiopathic, multisystem disorder characterized by caseating granulomas within affected organs

Most common abdominal manifestation is hepatosplenomegaly

Hepatic syndromes:
- chronic intrahepatic cholestasis: granulomatous cholangitis -> ductopenia
- portal hypertension: granulomatous inflammation -> small portal vein branch occlusion
- Budd-Chiari syndrome: external compression or infiltration of hepatic veins

Extrahepatic involvement: chest (most common), GI tract (usually gastric), GU tract (usual renal calculi), lymphadenopathy

Imaging: may see diffuse heterogeneity or multinodular pattern in the liver and/or spleen
- CT: small low density nodules
- MR: T2 hypointense nodules or T2 hyperintense fibrotic bands
Case 9: 47F with history of ulcerative colitis and rising alkaline phosphatase of 584 (normal 40-150).

ERCP image (A) demonstrates cannulation of the common duct and absent opacification of the right intrahepatic biliary tree (circled). Coronal T2-weighted MR image (B) demonstrates a diffusely fluid-filled and dilated right intrahepatic biliary tree (circled). Axial T2-weighted MR image (C) demonstrates asymmetric hyperintensity of the right hepatic lobe (left of dashed line), with a central hyperintense mass (arrow). Post-contrast hepatobiliary phase MR image (D) demonstrates lack of significant gadoxetate disodium uptake in the right hepatic lobe (left of dashed line). Note excreted contrast within left biliary tree (arrowhead), which is not seen within the right biliary tree.

Dx: Biliary Obstruction
**Biliary Obstruction**

Degree of hepatic involvement depends on site of obstruction
- intrahepatic < porta hepatitis < extrahepatic

**Common etiologies:**
- benign: choledocholithiasis, iatrogenic stricture, parasitic infestation
- malignant: pancreatic ductal carcinoma, cholangiocarcinoma, metastases

**Findings suggestive of malignant obstruction:** abrupt transition in bile duct caliber, eccentric bile duct wall thickening, mass in or near the bile ducts

**Imaging:** may see segmental or diffuse signal abnormalities on MR secondary to cholestasis
- T1: may be hyperintense secondary to deposition of paramagnetic materials (e.g. iron, copper, manganese)
- T2: hyperintense
- post-contrast hepatobiliary phase: relative decreased signal intensity due to hepatocyte dysfunction and poor uptake
Case 10: 76M status post open cholecystectomy complicated by iatrogenic portal venous injury.

Axial contrast-enhanced portal venous phase CT image (A) demonstrates a wedge-shaped area of hypoattenuation in segment V/VIII of the liver (star). Trace perihepatic ascites and pneumoperitoneum (arrow) are within normal postoperative limits. Coronal image from the same CT (B) demonstrates sparing of the hepatic capsule (arrowheads). Sagittal grayscale (C) and color Doppler (D) images of the right hepatic lobe demonstrate a region of hypoechogenicity (square) relative to normal liver parenchyma (circle). Note the minimal to absent color flow to the hypoechoic region in image D.

Dx: Hepatic Infarct
Case 11: 36F with polycythemia vera presenting with abdominal pain and dyspnea on exertion.

Axial contrast-enhanced portal venous phase CT image (A) demonstrates mild heterogeneity of the liver parenchyma. Diffusely heterogeneous enhancement and macronodular morphology is seen to better advantage on subsequent contrast-enhanced portal venous phase MR of the abdomen (B). Split-screen grayscale and Color Doppler US image (C) depicts intermediate echogenicity and absent color flow within the middle hepatic vein (stars), consistent with occlusive thrombus. Oblique MIP image from an MRA of the abdomen (D) demonstrates extent of thrombus with involvement of the right, middle, and left hepatic veins (arrows).

Dx: Budd Chiari
Case 12: 17M with incidentally identified liver lesions during evaluation of right lower quadrant pain.

Axial contrast-enhanced portal venous phase MR image at the level of the porta hepatis (A) demonstrates an engorged proper hepatic artery (arrow) and congenital absence of the portal vein. Hepatobiliary phase MR image with gadoxetate disodium (B) demonstrates contrast uptake in innumerable rounded lesions consistent with focal nodular hyperplasia. In addition, a sub-5 cm hepatocellular carcinoma was identified in hepatic segment IVb (not pictured). Coronal oblique MIP MRA image (C) demonstrates a dilated vessel (dotted arrow) crossing over the aorta (Ao) and draining into the inferior vena cava (IVC).

Dx: Abernathy Malformation
Hepatic Vascular Abnormalities

Hepatic inflow: portal vein (80%) and hepatic artery (20%)

Hepatic outflow: hepatic veins
  - note: the caudate lobe drains directly into the inferior vena cava

Abnormalities:
- portal vein: portal hypertension, portal venous thrombosis, portosystemic shunting
- hepatic artery: hepatic artery thrombosis, hepatic arterial injury
- hepatic veins: hepatic vein thrombosis (Budd-Chiari), hepatic venoocclusive disease

Imaging:
- pulsed Doppler is crucial for evaluating waveforms in suspected vascular disease
- stigmata of portal HTN: splenomegaly, varices, portosystemic shunts, ascites
- Budd-Chiari: enhancing regenerative nodules without washout, “flip-flop” pattern (early enhancement of the caudate lobe and parenchyma adjacent to the inferior vena cava, followed by decreased central/increased peripheral enhancement on later phases)
Case 13: 24F with chronic abdominal discomfort and fatigue.

Axial contrast-enhanced portal venous phase abdominal CT (A) demonstrates a confluent, predominantly hypoattenuating mass (star) in the peripheral liver extending to the capsule. Note the nodular contour along the margins of the mass (arrowheads). There is also a focal area of capsular retraction anteriorly (arrow). PET image (B) confirms that this mass is markedly FDG-avid (black star). Axial MIP image from a chest CT (C) demonstrates multiple pulmonary nodules bilaterally (black arrowhead), consistent with metastatic disease.

Dx: Hepatic Hemangioendothelioma
Hepatic Hemangioendothelioma

Low-grade primary malignancy of the hepatic vasculature

**Epidemiology:** rare (incidence of < 0.1 per 100,000), age range of 25-58 years (average 43.5 years)

Most common sites of metastasis are lungs, peritoneum, lymph nodes, bone

**Imaging:** usually in liver periphery, tends to occur in multiples and coalesces to form large confluent masses

- US: predominantly hypoechoic
- CT: homogeneously hypoattenuating on NECT, avascular outer rim with enhancing inner rim (halo/target sign) on post-contrast CT
- MR: alternating hyper- and hypointense rings on T2 and post-contrast T1 images
- PET: increased FDG avidity

**Treatment:**
- no extrahepatic involvement = resection
- extrahepatic spread = liver transplant
Case 14: 60M with hepatitis C with weight loss and elevated serum AFP of 11,440 ng/mL (normal 0-8).

Post-contrast late arterial phase CT image of the abdomen (A) demonstrates a large, ill-defined, arterially enhancing lesion in the right hepatic lobe (circle). The same region becomes iso- to hypoattenuating (black circle) relative to the background liver parenchyma during the portal venous phase (B).

Dx: Hepatocellular Carcinoma
Case 15: 64F with ascites, jaundice, and mild abdominal pain.

Portal venous phase contrast-enhanced CT image (A) shows an ill-defined, heterogeneously hypoenhancing region in the central liver (shaded region). There is associated widening of the intrahepatic fissure (solid arrow), capsular retraction (dotted arrow), and biliary dilation (white arrowheads). There are numerous centrally necrotic periportal and retroperitoneal lymph nodes (circle). 12 minute delayed post-contrast CT image (B) demonstrates subtle contrast retention (outlined region) relative to background liver parenchyma (star). Coronal portal venous phase CT image (C) demonstrates enhancing peritoneal nodules (black arrowheads) consistent with peritoneal carcinomatosis.

Dx: Metastatic Intrahepatic Cholangiocarcinoma
Hepatocellular Carcinoma and Cholangiocarcinoma

**Hepatocellular carcinoma:** most common primary visceral malignancy in the world

**Imaging:** often diagnostic, tissue confirmation not usually needed
- late arterial phase: heterogeneously hyperenhancing lesion; hyperdense wedge-shaped areas suggest perfusion abnormality from portal vein tumor thrombus
- portal venous and delayed phase: washout of contrast relative to background liver +/- enhancing pseudocapsule

**Treatment:**
- < 3 cm: curable with resection, ablation, or transplantation
- Milan criteria for transplantation: 1 lesion <= 5 cm or 3 lesions <= 3cm
- multifocal non-resectable tumor: transarterial chemoembolization, Yttrium-90 radioembolization

**Cholangiocarcinoma:** usually presents in 50-60s but seen in younger patients with primary sclerosing cholangitis or choledochal cysts

**Imaging:** look for biliary ductal dilation, capsular retraction
- arterial phase: early rim enhancement with central patchy enhancement
- delayed phase: persistent enhancing tumor secondary to fibrous stroma

**Treatment:** surgical resection (+ adjuvant chemotherapy) is only potential cure
- distal: Whipple procedure
- peripheral: hepatectomy
- perihilar: resection + hepaticojejunostomy
- other treatment modalities: transplantation, radiation therapy, laser therapy, palliative stenting
Case 16: 57M with sarcomatoid esophageal neoplasm, rising total bilirubin, and abdominal pain.

Portal venous phase contrast-enhanced CT image (A) demonstrates innumerable rounded hypoattenuating lesions throughout the liver. Note the focal contour bulge on the liver surface (arrowheads) due to subcapsular lesions. Transverse grayscale US image (B) again demonstrates a diffusely nodular and heterogeneous liver. The aforementioned surface nodularity is seen to better advantage (arrowheads).

Most common malignant lesion in the liver
- 18x more common than primary hepatic malignancies
- > 50% of patients with known malignancy are found to have hepatic metastases at autopsy

Etiology: colorectal is most common (~50%, due to splanchnic drainage into the portal vein)
- other common sources include lung, breast, pancreatic, gastric, melanoma, or neuroendocrine tumors

Imaging: appearance is variable and depends on characteristics of the primary tumor (e.g. hyper-versus hypovascular, cystic, centrally necrotic, calcified)
- morphology can be mass-like or infiltrative

Dx: Diffuse Metastases
Case 17: 64M with chronic hepatitis C presenting with refractory ascites and hepatic encephalopathy.

Transverse grayscale US image of the liver (A) demonstrates multiple round hypoechoic lesions throughout the liver (circled). Portal venous phase contrast-enhanced CT of the upper abdomen in liver windows (B) reveals numerous round hypoattenuating lesions (arrowheads) in the liver and spleen. Note the nodularity of the liver surface. Axial T2-weighted MR image at the same level (C) demonstrates innumerable hyperintense lesions throughout the liver to better advantage. Perihepatic and perisplenic ascites is noted. Coronal T2-weighted MR image of the abdomen (D) demonstrates extensive retroperitoneal lymphadenopathy (rectangle). Diffuse ascites and cirrhotic morphology of the liver are again seen. Percutaneous biopsy of these lymph nodes was diagnostic for diffuse large B-cell lymphoma.

Dx: Hepatic Lymphoma
Leukemia and Lymphoma

Group of hematologic malignancies of lymphoid or myeloid origin

**Lymphoma:** primary hepatic lymphoma is rare (< 1% of non-Hodgkin’s lymphoma), look for additional sites of disease such as lymphadenopathy
- non-Hodgkin’s is more likely than Hodgkin’s lymphoma to involve abdominal viscera
- liver is involved in approximately 50% of non-Hodgkin’s lymphoma

**Leukemia:** soft tissue masses in solid viscera are usually secondary to acute myeloid leukemia

**Imaging:** may present as a solitary mass, multiple masses, or diffuse infiltration
- US: affected areas usually hypoechoic
- CT: hypodense and poorly enhancing, can mimic hepatic steatosis if diffusely infiltrating
- MR: T2 hyperintense, may restrict diffusion due to increased cellularity (black stars on middle image on right)
- PET: very sensitive for disease prior to and following treatment, FDG avidity depends on degree of differentiation/aggressiveness
US, CT, and MR have distinct advantages and drawbacks in the evaluation of diffuse liver disease.

A complete assessment of diffuse liver disease frequently relies on a combination of these imaging modalities.

Each modality has specific techniques that can be employed to tailor the examination for the appropriate clinical scenario.

A disease process may be well visualized using one technique but can be occult if the wrong technique is chosen.

Both benign and malignant insults can share similar imaging appearances due to the liver’s common pathophysiologic response to injury.

Maintaining a broad differential is crucial to appropriately guiding patient care.
References


Thank you for viewing our exhibit. Please contact Brian Chan at bchan@uwhealth.org for comments or questions.