IMAGING OF LIVER, BILIARY TREE, PANCREAS

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Learning Points

• The *methodology* for imaging the LBP (liver, biliary tree, and pancreas)
• The normal appearances and the spectrum of abnormal imaging findings of the LBP on various imaging modalities
• The imaging diagnosis of some common diseases of the LBP
I. Imaging Methodology
I. Methods of Imaging Examination

1. Plain film
2. Contrast enhanced X-ray Exam
3. Digital Subtraction Angiography (DSA)
4. Computed Tomography (CT)
5. Magnetic Resonance Image (MRI), Magnetic Resonance Cholangiopancreatography (MRCP)
I. Methods of Imaging Examination

6. Ultrasonography (USG)

7. Endoscopic Retrograde Cholangiopancreatography (ERCP)

8. Percutaneous Transhepatic Cholangiography (PTC)
The X-ray examination has very limited value in the imaging of the LBPS for all of the abdominal organs manifest as soft tissue.
2. **Contrast Enhanced X-ray Examination**

- Oral or intravenous cholecystography
- Oral or intravenous cholangiography
- T-tube retrograde cholangiography, etc

**Limitations**

- Inconvenient; indirect; low sensitivity & specificity

- These two methods were replaced by US or/and MRCP for display the biliary tree and gallbladder
3. Digital Subtraction Angiography (DSA)

- Selective celiac arteriography
- Superselective hepatic arteriography
- Direct / indirect portography, etc.

- Invasive procedure
- Identify blood supply, vascularity & perfusion characteristics – the nature of the lesion
- Interventional therapy
Selective Celiac Angiography
4. CT

1. CT Scan Techniques

- Unenhanced CT Scan
- Contrast-enhanced CT Scan
On the unenhanced image, the lesion can not be displayed.
2. **Methods**

- *Duo- or multiphase helical CT scan*
- *CT angiography: combination of CT technique and angiography*  
  CTHA, CTAP
Duo-phase Helical CECT

Based on the double blood supply of the Liver

- **Hepatic arterial supply (25%)**
- **Portal venous supply (75%)**
Hemodynamics of the liver

The pathway of the contrast medium flow after injection by venous

The contrast material arrive to the liver by the hepatic artery earlier about 20 to 25 seconds than via the portal vein.
CECT Scan Time Schedule

- **HA phase:** 20 – 25 second
- **PV phase:** 45 – 60 second
- **Equilibrium phase:** 100 – 120 second
- **Delay phase:** 3 – 5 min

The time is from the beginning of contrast medium injection to the start of CT scan.
Contrast Agent for CECT

- **Iodine material:** ironic vs. non-ironic
- **Allergic test:** unnecessary!
- **Injection route:** transvenous
- **Injection rate:** 3 – 5 ml/s
Merits and Diagnostic Values of CT

1. Perfect spatial resolution –
   
   fine anatomic images

   • Improve the Identification of small lesions
   • Correct and meticulous assess the extent of lesions
   • Evaluate the invasion of surrounding structures
   • Detect if metastasis exists in peritoneal cavity, retroperitoneal space and distant organs
Merits and Diagnostic Values of CT

2. Duo/multiphase scan

- For characterization of blood supply and status of microcirculation of lesions
- Determine the nature of lesions
- Assessment of the biological behavior of lesions and monitoring the response to treatment
Limitations of CT

- with the state-of-the-art, multi-detector row spiral CT, many of the technical limitations have been overcome, such as coronal/sagittal image reconstruction, slice misregistration phenomenon, motion artifact, etc.

- High energy X-ray may be potentially harmful, especially for children and pregnant women.
Special features of MR imaging

- Super tissue contrast, good for both lesion detection and characterization
- MR hydrography (MRCP) for non-invasive depiction of the biliary tree and gallbladder
- Functional MR imaging can provide functional and metabolic information of organs and lesions
MR Imaging Techniques

- **Pulse sequences**
- **MR angiography**
- **Fat saturation**
- **MR hydrography (MRCP)**
- **Functional MR (DWI, SWI, ASL, et al)**
- **MR spectroscopy**

\{ Spin-echo (SE) \\
Gradient-echo (GE) \}
**MR Sequences for LBPS Imaging**

- **T1WI unenhanced + contrast enhanced scan**
  - Organ anatomy and tissue characteristics
  - Blood supply and extent of lesions

- **T2WI unenhanced scan**
  - Very sensitive to changes of water content, so very good for lesion detection, especially for the small lesions
  - But not good at displaying the characteristics of specific tissue texture.
MR Imaging Sequences

Reasonable combination of several MR imaging sequences is crucial to the early detection and characterization of LBP abnormalities!
MRI, the sequences of unenhancement
VIBE
contrast enhanced
dynamic scanning
MRCP

1. The Principle

- MR hydrography
- Hollow organs with abundant water are depicted nicely – the bile duct and the pancreatic duct
- 2D or 3D reconstruction images to clearly illustrate the spatial relationship
MRCP

2. Diagnostic Values

- To determinate the location and extent and causes of obstructive jaundice non-invasively
- To help identify necrosis, liquefaction and pancreatic duct disruption in acute pancreatitis
Merits and Diagnostic Values of MRI

- Multiple scanning sequences can generate more diagnostic information

MRI is superior to CT in the following aspects:

- Early depiction of certain lesions, especially depiction the small HCC in the cirrhosis liver
- Ability to characterize lesions
Merits and Diagnostic Values of MRI

- Multi-directional imaging are suitable for evaluating the anatomic location of lesions and relationship with surrounding structures, such as vessels, organs, peritoneal spaces, ligments, et al.

  Though the spatial resolution of MRI is lower, but MRI is equal to CT in aspects of:

  ✓ Displaying vascular invasion of tumors
  ✓ Preoperative tumor staging

To help select the therapy methods such as surgery or conservative treatment and to evaluate the resectability of lesions.
Merits and Diagnostic Values of MRI

- Harmless, no radiation hazard to human body
MRI Limitations

- Relatively longer data acquisition time compared to MSCT, and motion artifact affects image quality.
- Not sensitive enough to calcification.
Patients with cardiac pacemaker and certain magnetic metallic implants cannot or cautiously be examined with MRI.

Critically ill patients better not to be examined with MRI, for:

① Time-consuming

② Metallic instrument for resuscitation can not be placed in MR room
6. **Ultra-sonography**

1. **Diagnostic Values**

- Able to show lesions in all directions
- Useful for determinate the origination and localization of lesions
- Good at visualizing cystic conditions and bile stones (cholelithiasis)
- Cheap and easy to perform
6. **Ultra-sonography**

2. **Limitations**

- *Not good for obesity*
- *Bowel gas influence for imaging the pancreas and imaging the lower half of CBD*
- *Highly operator-dependent*
7、ERCP
8. PTC
Selection of Imaging Techniques

1. Liver:

- **USG**: for screening and general exam purposes
- **CT vs. MR**: Each has respective applications.
  - *MR is superior to CT in detection and characterization of lesions (especially in patients with cirrhotic background)*
- **DSA**: mainly used for interventional procedures, its role as an imaging diagnostic tool is downplaying
Selection of Imaging Techniques

2. **Biliary System**

- **USG**: The method of choice to exam the gallbladder; Valuable in biliary diseases (especially cholelithiasis)
- **CT & MR**: of great value in determining the extent of biliary carcinoma and accurate preoperative staging
- **MRCP**: the method of choice in displaying biliary tree and pancreatic duct
- **ERCP & PTC**: valuable, but invasive
Comparison of ERCP and MRCP
Selection of Imaging Techniques

3. Pancreas:

- CT and MR are of great value in displaying pancreatic abnormalities. The value of USG is limited.
- MRCP can clearly show the pancreatic duct, thus can replace ERCP and PTC for most circumstances.
- DSA is powerful and the final resort in qualitative diagnosis of pancreatic island endocrine tumors.
II. Normal Imaging Appearance of liver, biliary tract, pancreas and spleen
On T2WI the gallbladder appears very high signal as bright lamp bulb, and on T1WI it looks as low signal or miscellaneous signal.
III. IMAGING APPEARANCES OF COMMON DISEASES
Hepatic Diseases

1. Liver Cirrhosis
2. Hepatic Neoplasm
3. Hepatic Cyst
4. Hepatic Abscess
1. Liver cirrhosis

- **Liver size**
  - **Early stage**: smooth
  - **Advanced**: nodular

- **Contour**: the contour was smooth on the early stage and became nodular gradually as the disease developing.

- **Lobar or segmental deformity**

- **Widening of hepatic fissures**

- **Changes secondary to portal hypertension**
  - **Splenomegaly**
  - **Collateral varices**

- **Ascites**

- **Regenerative nodules**
Liver cirrhosis, the contour of the liver is nodular and the hepatic fissures was widening with portal hypertension and ascites.

The paraumbilical vein and the superficial epigastric veins and the left branch of portal vein were dilatation.
2. Tumors of Liver

- **Malignant tumors**
  - primary malignant tumor
  - metastatic tumor

- **Benign tumors**
  - cavernous hemangioma
  - adenoma
MALIGNANT TUMORS

- Primary liver cancer
  - hepatocellular carcinoma
  - cholangiocarcinoma

- Secondary or metastatic liver malignant tumor
Hepatocellular Carcinoma (HCC)

**CT appearance:**

- Liver cirrhotic background
- On unenhanced CT scanning, the lesion appears as well-defined or obscure, round or irregular lower density area than the relatively normal liver parenchyma
HCC

CT appearance:

- Enhanced Scan:

HAP --- heterogeneous enhancement; many enhancing patchy or dots within large tumor mass; dilated and tortuous arterial branches to the mass; necrotic low density areas within the lesion without enhancement.

Rich & dominant arterial supply
HCC

CT appearance:

*Enhanced Scan:*

PVP --- quickly return to hypodensity relatively to the neighboring liver parenchyma

Wash-in and wash-out enhancement pattern
CT appearance:

Secondary changes

(1) Abnormal blood perfusion around the lesion (displays as markedly enhancement of the parenchyma nearing the lesion)

(2) Tumor thrombosis of PV and hepatic veins and IVC

(3) Metastasis (hematogenic/seeding/lymphatic):

The mets include the daughter foci in the liver and the metastatic lesions in the peritoneal cavity and other organs.
Dual-phase Scanning of HCC
HCC in right lobe with tumor emboli in the right branch of portal vein
On unenhanced CT scan the lesion cannot be differentiated definitely for it appears as isodense as the adjacent liver parenchyma and the lesion can be seen easily on hepatic artery phase for it was enhanced markedly and the density of the lesion became lower than the adjacent liver parenchyma on portal venous phase.
HCC

MRI appearance:

- **Mosaic pattern on T2WI**
- **MRI is comparable to CT in the diagnosis of large HCC lesions (>3 cm); but is superior to CT in the detection and characterization of small HCC nodules, especially in the cirrhotic liver**
- **very good for HCC staging**
HCC

GE T1WI-PVP

Tumor thrombus

GE T1WI
Mosaic Pattern

SE T2W
**Cholangiocarcinoma**

**CT appearance:** The lesion was enhanced heterogeneously as lace-like with intrahepatic bile duct dilatation

![HAP](image1.png)  ![PVP](image2.png)
Cholangiocarcinoma

**MRI Findings:** The mass was irregular as lobular with heterogeneous low signal at T1WI and heterogeneous high signal at T2WI. And the intrahepatic bile ducts were dilatation.
Metastatic Liver Carcinoma

**CT appearance:** always multiple lesions with periphery enhancement and obscure margin

Mets from Breast Cancer
Mets from colorectal carcinoma
Cavernous Hemangioma

CT appearance:

- Low density area with smooth and clearly margin
- Initial peripheral nodular enhancement
- Gradual centripetal push-on enhancement
- Isodense fill-in at delayed scan

The lesion was enhanced remarkable as periphery nodular at the hepatic artery phase and centripetal push-on enhancement gradually with the time delay of contrast injection and the lesion may become isodense at delay time scanning imaging
Enhancement evolution over time
Cavernous Hemangioma

MR appearance: The enhancement characteristics of the lesion in MR imaging is similar to that of CT scan. The lesion was enhanced centripetal gradually from the HAP to PVP and EP.
3. **Liver Cyst**

**CT appearance:** The liver cyst appears as round or oval shape of low density without enhancement and the margin is clear and regular.
CT appearance: The lesion was enhanced lace-like with periphery edema and the rest area of the liver parenchyma was normal.
Biliary Tree Diseases

1. Cholelithiasis

2. Obstructive jaundice
   - Cholangiocarcinoma
   - Bile Duct Carcinoma
   - Gallbladder Carcinoma
1. **Gall Stone**

CT density and MR signal vary based on the compositions of stones (calcium, bilirubin, steroid):

- **CT**
  - high density stones
  - low density stones
  - isodense stones
  - mixed density

- **MR**
  - T1W: low or high signal, some isointense
  - T2W: always low signal
Cholecystitis with gallstone

The gallbladder wall was edema with obscure margin
Cholelithiasis

2. Choledocholithiasis

T2W MR
On MRCP, the stone appears as filling defect as low signal with bile duct and gallbladder dilatation moderately.
2. **Obstructive jaundice**

**Cholangiocarcinoma**

**CT appearances:**

- Dilatation of bile duct proximal to the obstruction lesion, abrupt narrowing or stenosis at the site of the tumor
- Nodule protruding to bile duct lumen
- Mild to moderate enhancement of the thickened bile duct wall and intraluminal nodule on PVP
Hilar cholangiocarcinoma appears as bile duct wall thicken with moderate enhancement at PVP and the intrahepatic bile duct dilatation markedly.
Obstructive Jaundice

Bile Duct Carcinoma

**MR**

- Display size, extent and surroundings of mass, superior to CT
- **MRCP:** able to display subtle morphological changes, comparable to ERCP or PTC
CBD carcinoma

The low segment of the CBD wall thicken and enhanced moderately with proximal CBD dilatation.
Pancreatic Diseases

1. Pancreatitis
   - Acute pancreatitis
   - Chronic pancreatitis

2. Pancreatic carcinoma
1. Acute Pancreatitis

**CT appearance:** AP appears as pancreatic edema with inflammation effusion in the retroperitoneal space and the effusion extend along the mesentery. The irregular low density area in pancreas neck and body indicate pancreas necrosis.
AP with retroperitoneal spreading
2. Chronic Pancreatitis

CT appearance:

- Atrophy of parenchyma
- Dilatation or stricture of pancreatic duct
- Stones or calculi within pancreatic duct
Chronic pancreatitis with a lot of calculi in pancreatic duct and parenchyma and there is a pseudocyst on the neck of pancreas with active bleeding
3. **Pancreatic Carcinoma**

**CT appearances:** An irregular low density mass on the head of pancreas which encase the celiac truck and its branches, and there is a mets on right lobe of the liver
Thank you for listening!