CONTRAST-ENHANCED ULTRASOUND OF THE LIVER:

ELECTRONIC ATLAS OF NORMAL ANATOMY, COMMON & UNCOMMON PATHOLOGY, & GUIDANCE FOR PROCEDURES

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DISCLOSURES

• This presentation discusses the off-label use of DEF Infinity® (Perflutren Lipid Microsphere) Injectable Suspension from Lantheus Medical Imaging
• The authors have no disclosures
GOALS AND OBJECTIVES

• This presentation is intended for radiologists, clinicians, and technologists
• Understand the principles of contrast-enhanced ultrasound (CEUS) and its function/benefits in hepatic imaging
• Familiarize clinicians with the appearance of normal anatomy and liver pathology on CEUS
• Illustrate examples of the appearance of common and uncommon pathology
• Highlight how CEUS aids in diagnosis, including when CT and MRI are nondiagnostic
• Provide guidance on the utility of CEUS in procedures
INTRODUCTION

- Ultrasound (US) is an essential modality in imaging the liver.
- However, there are limitations to conventional US compared to contrast-enhanced CT and MRI.
- Contrast-enhanced ultrasound (CEUS) has recently emerged as a useful modality in hepatic imaging, although its use is still off-label in the United States.
- It is important to become familiar with the appearance of liver pathology on CEUS.
CEUS: HOW IT WORKS

- US contrast consists of agitated tiny microbubbles of perfluorocarbon or nitrogen gas
- The bubbles are approximately the size of red blood cells and can pass through the microcirculation safely
- Bubbles are injected intravenously into the patient and real-time imaging is obtained
- The gas bubbles increase reflection of soundwaves back to the transducer, creating a signal that is used as contrast
CEUS: CONSIDERATIONS

- HCC is the 3rd most common cause of cancer death in the world
- Metastatic disease often presents in the liver
- Focal liver lesions occur in 5-10% of the general population
- Conventional US is limited by inability to evaluate lesion enhancement, and echogenicity is not a definitive indicator of whether a lesion is benign or malignant
- Multi-phase CT or MRI is expensive, requires normal renal function, ability to fit in the scanner, and no contraindication to contrast or MRI
CEUS: BENEFITS

• Same day exam - can help characterize a newly visualized lesion immediately
• Safe - very little risks or side effects and no labs are required prior to use
• No radiation exposure
• Real-time imaging - can troubleshoot and optimize image quality and continuously evaluate enhancement
• Multiple injections in one exam can be given, allowing for thorough evaluation and troubleshooting
• Cost-effective compared to other modalities
CEUS: TECHNICAL ASPECTS

- Requires software for processing
- IV access with three-way stopcock
- Contrast must first be agitated
- Contrast injected (0.2-0.3 cc), followed by rapid 10 cc normal saline flush
- Real-time imaging obtained as video
- Quantitative parameters such as wash-in kinetics and peak intensity can also be calculated
NORMAL ANATOMY OF THE LIVER ON CEUS
TIMING

CEUS relies on parametric imaging. Dynamic vascular enhancement patterns of the liver and various liver lesions are observable. Normal liver parenchyma enhances most in the portal venous phase.

Parametric imaging shows avid arterial phase enhancement of the kidney prior to portal venous enhancement of the liver (*)
HEPATIC ANATOMY: ARTERIAL ANATOMY

Three separate timing phases can be used to evaluate the liver: arterial, portal venous, and delayed phases. Hepatic arterial enhancement begins at approximately 10-20 seconds after injection and lasts approximately 10-15 seconds.

Image obtained in the arterial phase of the right hepatic lobe demonstrates avid enhancement of the right hepatic artery.
HEPATIC ANATOMY: PORTAL VEIN AND HEPATIC VEIN

The portal venous phase begins after the arterial phase (30-45 seconds after injection) and lasts approximately two minutes. Delayed imaging begins after the portal venous phase and lasts up to 6 minutes after injection.

Image of the right hepatic lobe in the portal venous phase (left) demonstrates enhancement of the right and main portal vein.

Image of the right hepatic lobe in the portal venous phase (right) demonstrates enhancement of the right hepatic vein.
COMMON LIVER PATHOLOGY
FOCAL NODULAR HYPERPLASIA

- Focal nodular hyperplasia (FNH) is the second most common benign liver tumor.
- On CEUS, typical FNH demonstrates early arterial centripetal fill-in with a classic “spoke wheel” appearance with centripetal filling distinguishing it from adenoma.
- Capture of real-time images in the early arterial phase after contrast injection is important, as the classic early filling pattern may be missed on MRI or CT.

*Early arterial, arterial, and delayed imaging of a typical focal nodular hyperplasia*
HEPATOCELLULAR CARCINOMA (HCC)

- Patient presenting with Hepatitis C and no known history of cirrhosis found to have new hepatic masses demonstrating enhancement patterns typical for HCC
- On CEUS, HCC demonstrates a typical enhancement pattern of rapid arterial enhancement compared to normal liver parenchyma and rapid washout on delayed images, similar to multi-phase CT or MR
- CEUS can be an important aid in screening in patients with chronic liver disease as new lesions can be evaluated during the same exam, shortening time to diagnosis and treatment

Greyscale, arterial, and delayed imaging of hepatocellular carcinoma
HEMANGIOMA IN HEPATIC STEATOSIS

Hemangiomas are typically hyperechoic lesions on greyscale US.
In the setting of hepatic steatosis, they can appear as hypoechoic lesions on US, which may raise concern for a malignant lesion.
On CEUS, a hemangioma demonstrates peripheral enhancement with central fill-in that persists to remain hyperechoic to normal liver parenchyma on delayed images.

Greyscale, early, and delayed CEUS imaging of an hemangioma.
• 54-year-old male with history of hepatocellular carcinoma, status post chemoembolization two months prior with concern for recurrence
• Predominantly hypoechoic on US
• CEUS demonstrates the same lesion with irregular peripheral arterial enhancement, delayed imaging follows
• Delayed CEUS imaging of the same lesion shows subtle subsequent washout with respect to the previously hyperenhancing component on arterial phase after contrast, consistent with incompletely treated HCC with remaining peripheral tumor
UNCOMMON LIVER PATHOLOGY
DIFFUSE LARGE B-CELL LYMPHOMA

- Patient with iodinated contrast allergy evaluated for hernia repair with noncontrast CT with incidental large liver mass
- US shows a hypoechoic, lobulated lesion and CEUS showed early arterial enhancement with robust, rapid washout, which was concerning for fibrolamellar HCC
- The patient underwent left hepatectomy, with pathology showing diffuse large B cell lymphoma
HEMORRHAGIC CYST

- US scan for thoracentesis planning (left) showed an incidental complex hepatic mass
- CEUS performed the same day (below) demonstrated enhancement of a thin septation (arrow) within the lesion but no other enhancement, consistent with a complex hemorrhagic cyst
- CEUS obviated need for CT or MR
PORTAL VEIN THROMBUS WITH HEPATIC INFARCTS

- 43-year-old female referred for ultrasound-guided biopsy of presumed hepatic metastases of unknown primary
- Patient was found to have a right portal vein (PV) thrombus which was evaluated on CEUS and CT
- The liver masses were also evaluated with CEUS (next slide)
PORTAL VEIN THROMBUS WITH HEPATIC INFARCTS (CONTINUED)

- Multiple wedge-shaped, peripheral masses seen on CT (above) with no enhancement on CEUS
- Felt to be consistent with infarcts due to bland PV thrombus and avoided biopsy
- CEUS is excellent for differentiation of malignant (arterialized internal flow) v. benign PV thrombus (no arterialized flow)

Images courtesy of Hisham Tchelepi, MD
HEPATIC ABSCESS

CEUS, greyscale, and CEUS kinetics of a right hepatic abscess

- History of indeterminate liver lesion on MRI (right), which was favored to be hematoma or abscess
- The patient was not able to receive CT or MRI contrast
- CEUS was done which showed relative decrease in size and lack of enhancement centrally. Kinetics showed that the lesion remained hypoechoic with respect to the liver, consistent with involuting abscess

MRI shows low T₁/high T₂ signal with a high T₁/low T₂ peripheral rim
• Status post MVC
• Linear hypoechoic region perpendicular to the liver surface seen on grey-scale US
• CEUS demonstrates a linear area of hypoenhancement with respect to the liver parenchyma compatible with laceration without active extravasation
• CT correlate shows a wedge-shaped area of hypoattenuation within the right hepatic lobe

Images courtesy of Edward Grant, MD
PROCEDURE GUIDANCE
BIOPSY GUIDANCE – HYPERVASCULAR LIVER METASTASIS

- Patient presented with 2 weeks of RUQ pain, found to have a heterogeneous liver mass on CT
- CEUS was performed to evaluate the mass and aided in targeting the most vascular part of the lesion for biopsy
- Pathology was consistent with metastatic cholangiocarcinoma

Contrast-Enhanced CT

Hypoechoic lesion

Greyscale US

Lesion with progressive arterial enhancement, followed by rapid washout (below, left)

CEUS

Needle

CEUS

Biopsy Image
HEPATOCELLULAR CARCINOMA ABLATION

- 70-y.o. male with multifocal HCC, s/p right hepatic lobe resection with residual tumor in segment 3
- Predominantly hypoechoic lesion on greyscale US corresponds to the enhancing lesion on CEUS
- After microwave ablation, CEUS demonstrates no residual enhancing tumor
- Additional ablation was not needed. Follow up CT scans (not shown) at 2 mos & 1 yr showed no recurrence

Images courtesy of Ilya Lekht, MD
CEUS: CLINICAL IMPLICATIONS

- CEUS is emerging as an important modality for imaging the liver, especially in patients with renal disease, contrast allergy, and contraindication to MRI.
- CEUS provides important and diagnostic information in real-time, often obviating the need for additional or follow-up imaging.
- CEUS can be used to guide difficult liver biopsies as well as target areas of residual tumor during ablations.
REFERENCES


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