Fusion Ultrasound: Characterization of Abdominal Masses with MR, CT, PET, and Contrast Ultrasound

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Disclosures

- This presentation discusses the off-label use of DEFINITY® (Perflutren Lipid Microsphere) Injectable Suspension from Lantheus Medical Imaging

- Mollie Rashid, MD
  - Nothing to disclose

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Goals and Objectives

- This presentation is intended for radiologists who perform ultrasound (US) examinations of the abdomen
- Explain the fusion US modality and its applications in abdominal imaging
- Highlight the use of both contrast-enhanced and fusion US and their strengths for the evaluation of benign and malignant abdominal masses
- Elucidate case examples of fusion imaging of abdominal masses and correlation with other cross-sectional imaging such as CT, MRI, and PET
- Share our experience thus far and to postulate how the modality may continue to evolve
Introduction

• Abdominal masses often propose a diagnostic challenge to both radiologists and clinicians

• Traditionally, US, contrast-enhanced CT, PET/CT, and MRI have been the modalities used to characterize these masses

• Determining the characteristics of these masses and obtaining tissue samples (if needed) can be difficult in specific clinical situations

• Fusion US is an emerging modality that can be used in the characterization of these masses
Fusion Ultrasound Imaging: The Basics

- Fusion imaging allows direct comparison of volumetric data from prior imaging (CT/PET/MRI) with real-time US images to evaluate specific areas of interest.
- This allows for evaluation of a target area of interest seen on prior imaging to further characterize a finding or perform a procedure.
- Soft tissue differentiation under US is enhanced by fusion imaging.
- This technology is particularly useful when a lesion is not easily resolved on US or difficult to locate.
Fusion Imaging: How it Works

Fusion imaging relies on a similar principal to GPS to sync images

- Multiple GPS satellites circle the earth emitting radiofrequency signals
- A GPS receiver locates at least 4 of these satellites’ signals to determine how far away each satellite is and uses this information to calculate its own position
- The satellites’ positions are always known due to their predictable orbits
Fusion Imaging: How it Works

Instead of circling satellites, fusion imaging uses a fixed transmitter that emits a known set of magnetic field patterns.

Instead of a GPS unit, a pair of electromagnetic sensors are attached to the US transducer. These sensors detect the emitted magnetic field.

The US unit monitors the position and orientation of the transducer.
Fusion Imaging: Comparison Datasets

- The imaging data set from the comparison imaging (MR, PET, CT) must be uploaded into the US system, either from PACS or direct imported via CD.

- To register the real-time US image with prior imaging, common anatomical points are manually identified on the data set and on US. The software uses these common points to build a transformation matrix (TM).

- This TM is used to display the Multiplanar Reconstructed (MPR) image from the 3D data set that corresponds to the live US image.

![Example of registration process with US image and color Doppler overlaid over CT image for better registration (above) and sample greyscale US fused image (below).]
Fusion Imaging: Target Lesions

• The ability of fusion imaging to set a Target Lesion is particularly helpful when trying to characterize an abdominal mass

• Using the imported dataset, one can set an area of interest as the target using the original reference images

• A target box then appears on the real-time US image, which changes size and becomes smaller the closer the US image is to the target location
Case Examples Using Fusion Ultrasound
Clinical History

40-year-old male with history of Hepatitis B and left hepatic lobe lesion seen on MRI.
Fusion images of MRI abdomen with sequential contrast-enhanced US demonstrate a hypoechoic lesion (likely due to background of hepatic steatosis). There is peripheral nodular enhancement with progressive complete filling, with enhancement relative to background parenchyma, consistent with hemangioma. The hemangioma enhancement pattern was better seen on US compared with MR.
Clinical History

64-year-old male with nausea, dark urine, and other clinical signs of obstructive jaundice. The patient had undergone two prior nondiagnostic biopsies.
Fused images of a PET-CT and grayscale US demonstrate a predominantly hypoechoic right hepatic lobe lesion which is not well seen on US \( (T) \). This correlates exactly with is metabolically active mass with central necrosis on PET-CT.

The lesion demonstrated peripheral enhancement on contrast-enhanced US and fused images.
Biopsy images demonstrate the value of fusion US in targeting the hypermetabolic component on PET CT when the lesion was not well seen on US. Samples were diagnostic for cholangiocarcinoma.
Clinical History

53-year-old male with abdominal pain and leukocytosis. CT Abdomen/Pelvis showed an ill-defined, complex, cystic lesion in the left kidney.
Case 3: Renal Abscess

Fusion grey-scale US images (A) with a prior CT (B) demonstrate a predominantly hypoechoic left renal lesion with some solid components.

CEUS demonstrates a single thin internal septation, but otherwise no internal enhancement of the lesion.
Case 3: Renal Abscess (continued)

Given the lack of enhancement on contrast-enhanced US, this was felt to be a non-vascular lesion, most consistent with renal abscess. A drain was then placed under US, allowing for immediate management of the abscess.
Clinical History

48 year-old female with history of endometrial stroma sarcoma, status post chemotherapy with no evidence of metastatic disease. Patient presents with no complaints for staging CT and is found to have new findings.
Case 4: Metastatic Disease

Contrast-enhanced CT slice of the pelvis (LEFT) demonstrates an enhancing left pelvic mass.

Contrast-enhanced CT slice of the abdomen (RIGHT) also demonstrates a filling defect within the left renal vein.
Fusion was used to image the left renal vein thrombus (ABOVE), which appeared as hyperechoic filling defect within the left renal vein. Contrast was also used, which demonstrated early enhancement (B/C) and rapid washout before the venous phase (D), consistent with tumor thrombus, rather than bland thrombus.
Fusion US was also used to interrogate the pelvic mass, which showed a predominantly hypoechoic lesion which demonstrates rapid arterial enhancement on CEUS (below).

This mass was later biopsied and found to be a spindle cell neoplasm, most consistent with metastatic low-grade endometrial stromal sarcoma.
Clinical History

58-year-old male with history of treated lymphoma presenting with abdominal pain and new onset bilateral lower extremity edema.
Case 5: Mesenteric Biopsy

Axial CT of the abdomen (left) shows increased soft tissue encasing the celiac axis.

The mass was hypovascular and hypoechoic on US (above).

Fusion US (right) shows better soft tissue definition of the mass and its surrounding structures. The mass appears hypoechoic on US and is more prominent on US compared to fused CT images.
Case 5: Mesenteric Biopsy (continued)

Fusion US was used to biopsy the lesion (RIGHT), allowing for confirmation that the lesion seen on CT was being correctly targeted.

Grayscale US images of the biopsy (left) demonstrate an additional biopsy image. Pathology showed recurrent diffuse large B cell lymphoma.
Fusion Imaging: The Benefits

• Real-time US fusion is helpful for problem solving when characterizing abdominal masses, especially when prior exam are inconclusive

• No radiation exposure compared to other modalities

• Can be done with the patient positioned comfortably in bed and is less expensive than other modalities

• When paired with contrast, is ideal in situations where MR or CT contrast cannot be used: allergies, renal failure, no recent labs

• When performing procedures, fusion aids in targeting lesions and with better soft tissue resolution and improved accuracy
Current Limitations of Fusion Imaging

- Requires technical training for the user and is operator dependent
- Requires US machines to be compatible with fusion software
- Can be time-consuming
- Errors with registration can occur
- Requires patient cooperation
Clinical Implications and Future Directions

- Fusion imaging is an exciting new application in US.
- Pairing real-time US images with other cross-sectional imaging including MRI, CT, PET, and Contrast-enhanced US, can allow for better diagnostic and procedural accuracy.
- Our initial experience with this modality has been positive.
- Further studies and more widespread training with this modality are necessary.
References


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