Cardiac Applications of Hybrid PET/MRI

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Cardiac Imaging Modalities

- Positron Emission Tomography (PET) and Cardiac Magnetic Resonance Imaging (CMR) are widely used imaging techniques for acquiring anatomic and physiologic information with regard to the heart

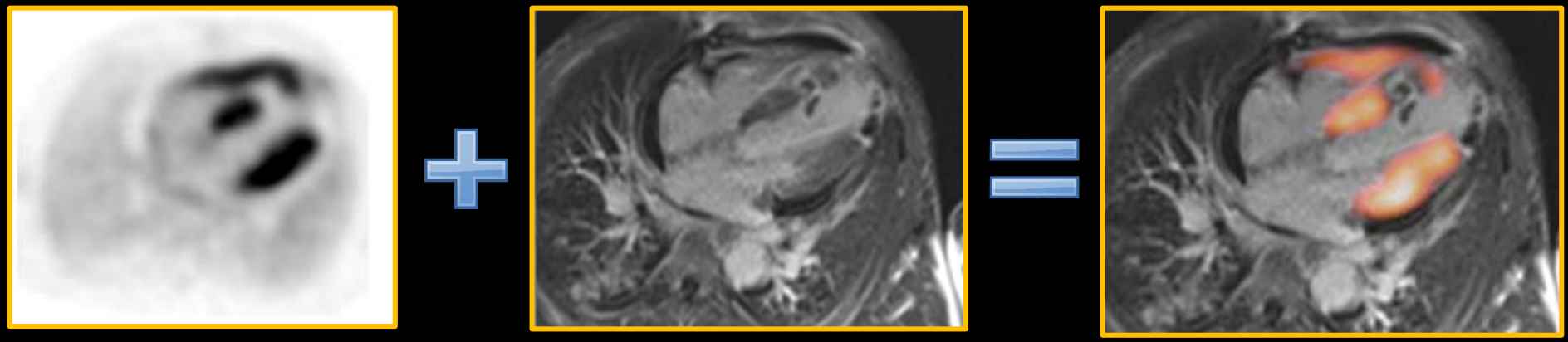
- Combining the information obtained from these two imaging modalities provides an opportunity for a more complete evaluation of cardiac pathology

- This exhibit will provide current and potential applications for a combined PET/CMR imaging technique

Methods for combining PET and CMR

Image co-registration via software

- PET and CMR images can be acquired separately and post-processing software can be used to combine imaging data



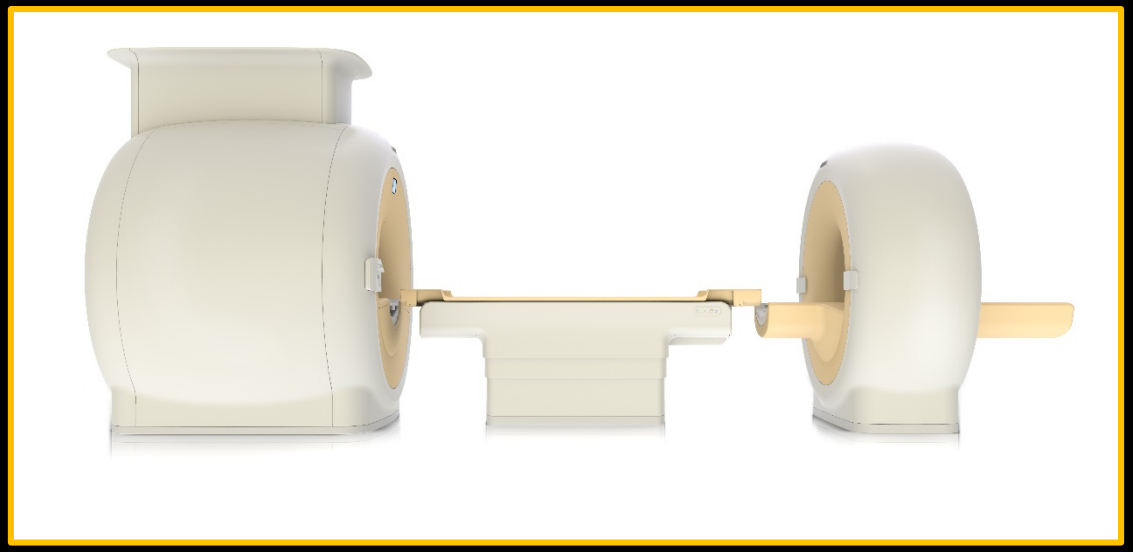
Advantage
- No need to purchase new equipment

Disadvantage
- Possible misregistration artifact
- Additive time to acquire PET and MRI data

Methods for combining PET and CMR

Serial Acquisition

- PET and MR scanner in close proximity
- Patient table is transitioned directly from PET to MRI scanner



Advantage
- Misregistration artifact is limited

Disadvantage
- Additive time to acquire PET and MRI data
- New equipment required

Methods for combining PET and CMR

Concurrent Acquisition

- Full integration of PET and MR equipment
- Simultaneous data acquisition

Advantage

- Misregistration artifact eliminated
- Decreased total time to acquire PET and MRI data

Disadvantage

- New equipment required

Clinical Applications

Myocardial Perfusion

- Single photon emission tomography remains the most common imaging technique for evaluating myocardial perfusion
  - However, it has drawbacks related to limited resolution
- Multiple PET agents have been used for myocardial perfusion with high sensitivity and specificity (~90%)
- CMR also has excellent sensitivity and specificity to quantify myocardial perfusion
- Combining PET with CMR provides multiple methods to evaluate perfusion along with additional functional data and tissue characterization provided by CMR

Clinical Applications

Myocardial Viability

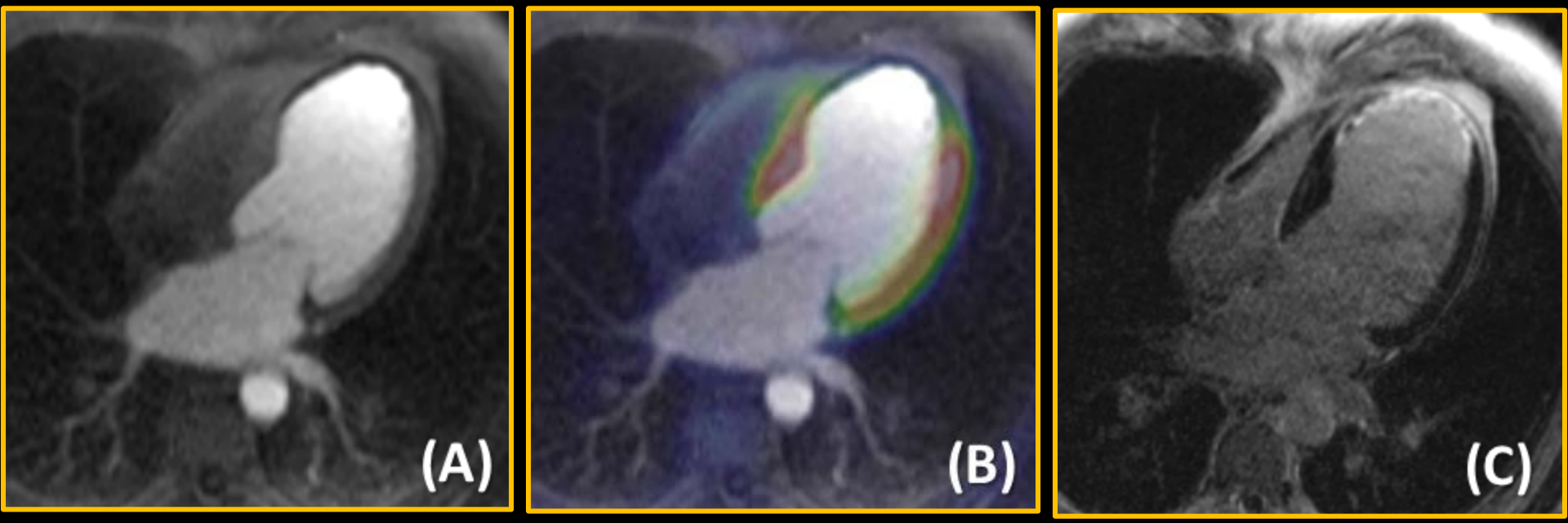
- F-18 fluorodeoxyglucose (FDG) - PET results have been shown to predict functional recovery after revascularization by detecting metabolically active cells

- Late-gadolinium enhancement (LGE) on CMR has also been show to predict functional recovery by detecting increased extracellular space in scar tissue

- Combining these two modalities provides similar information via different methods, potentially providing more accurate and objective assessment of myocardial viability

Clinical Applications

Myocardial Viability



Patient with coronary artery disease and transmural infarct. (a) Horizontal long axis perfusion CMR image shows a perfusion abnormality in the left ventricular apex. (b) Fused FDG PET data shows lack of metabolic activity which corresponds to the perfusion defect. (c) Correlation with LGE images confirm location and severity of the injury.

Clinical Applications

Non-ischemic Cardiomyopathies

Myocarditis

- CMR is a robust tool for evaluation of myocarditis
  - Myocardial edema can be detected on T2-weighted images
  - LGE images can show areas of necrosis or scar formation
- FDG PET can detect increased metabolic activity due to accumulation of inflammatory cells in areas of active inflammation
- FDG PET and CMR together can provide tissue characterization and metabolic information in the same examination, potentially increasing diagnostic accuracy and providing a method to monitor disease progression

Clinical Applications

Non-ischemic Cardiomyopathies

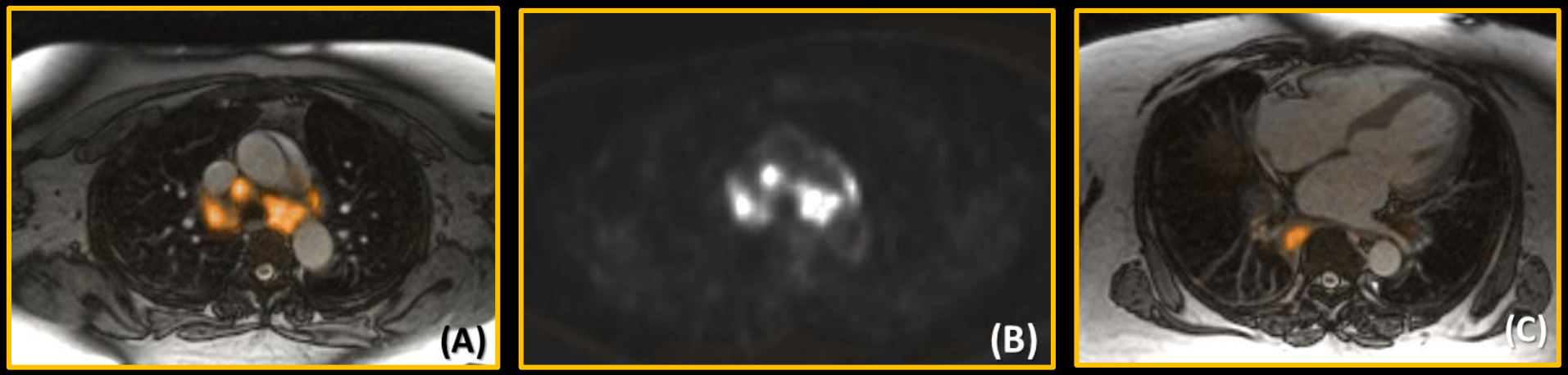
Sarcoidosis

- CMR is the modality of choice to evaluate for suspected cardiac sarcoidosis (CS)
  - Presence of LGE is a strong predictor of future adverse outcomes
- FDG PET is also used to evaluate for CS by detecting increased metabolic activity in active granulomas
  - FDG uptake can also be used to monitor response to therapy
- CMR and FDG PET detect CS by different mechanisms and combining the two modalities gives additional information that could be useful for diagnosis and management

Clinical Applications

Non-ischemic Cardiomyopathies

Sarcoidosis

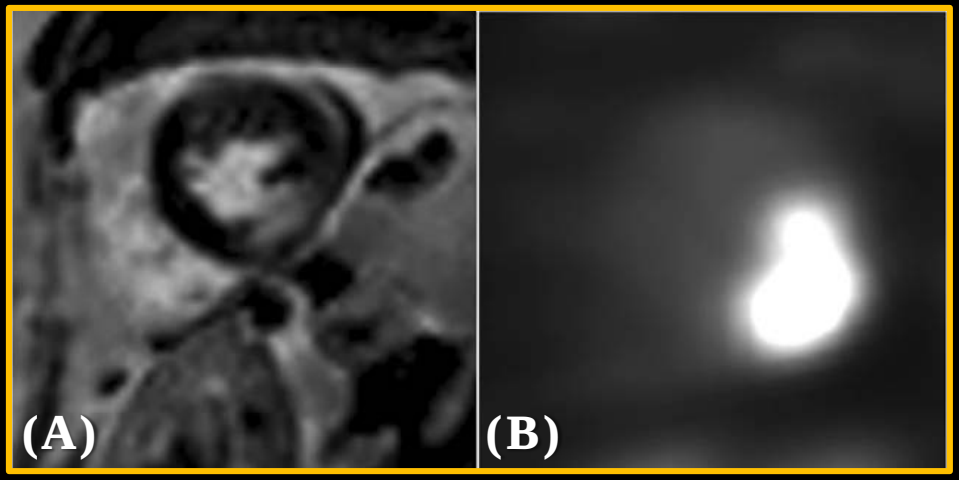


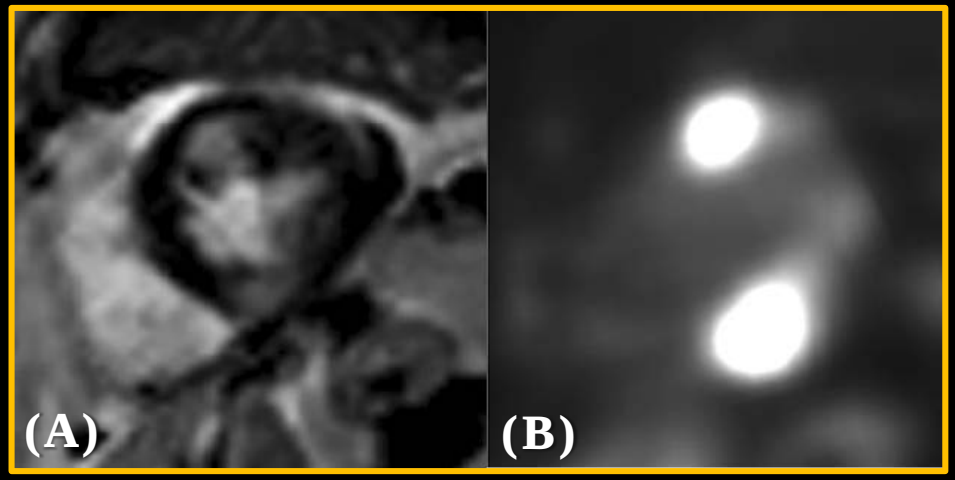
Patient with known pulmonary sarcoidosis and decreased left ventricular function. (a) Fused steady state free precession (SSFP) MR and FDG-PET and (b) FDG-PET data shows multiple metabolically active mediastinal lymph nodes. (c) Horizontal long axis fused image show no evidence of cardiac involvement by FDG activity.

Clinical Applications

Non-ischemic Cardiomyopathies

Sarcoidosis





Patient with pulmonary sarcoidosis and new arrhythmia. (a) Short axis contrast-enhanced inversion recovery LGE images show patchy areas of mid-myocardial enhancement. (b) Short axis images from FDG-PET study following a high fat, high protein, low carbohydrate diet preparation to suppress physiologic FDG uptake show focal areas of increased metabolic activity corresponding to the areas of enhancement, reflecting active cardiac sarcoidosis.

Clinical Applications

Non-ischemic Cardiomyopathies

Hypertrophic Cardiomyopathy (HCM)

- CMR is an effective tool to evaluate myocardial thickness, function, flow dynamics, and LGE in patients with HCM

- FDG-PET is not widely used to evaluate patients with HCM, but has shown value in certain circumstances
  - Decreased FDG uptake following septal ablation for left ventricular outflow obstruction
  - Decreased FDG uptake in areas of LGE can help confirm scar formation as the cause of LGE

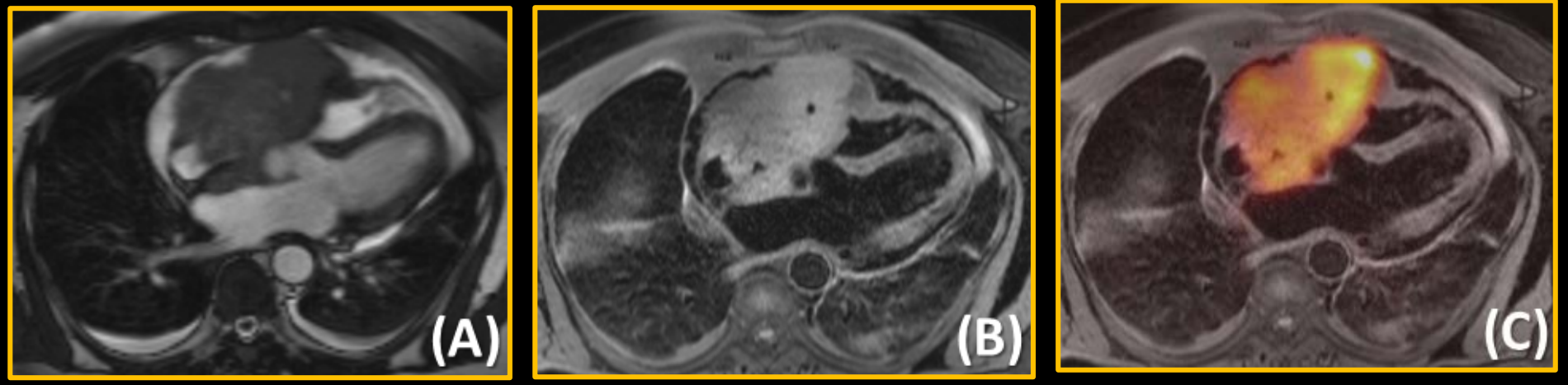
Clinical Applications

Cardiac Tumors

- CMR provides excellent anatomic information and tissue characterization
  - This can be used to characterize certain cardiac tumors
- FDG PET can provide metabolic information, with hypermetabolism being a marker for malignant potential
- FDG PET is commonly used to evaluate for metastatic disease, and combining with CMR could be useful in patients with known or suspected cardiac metastases

Clinical Applications

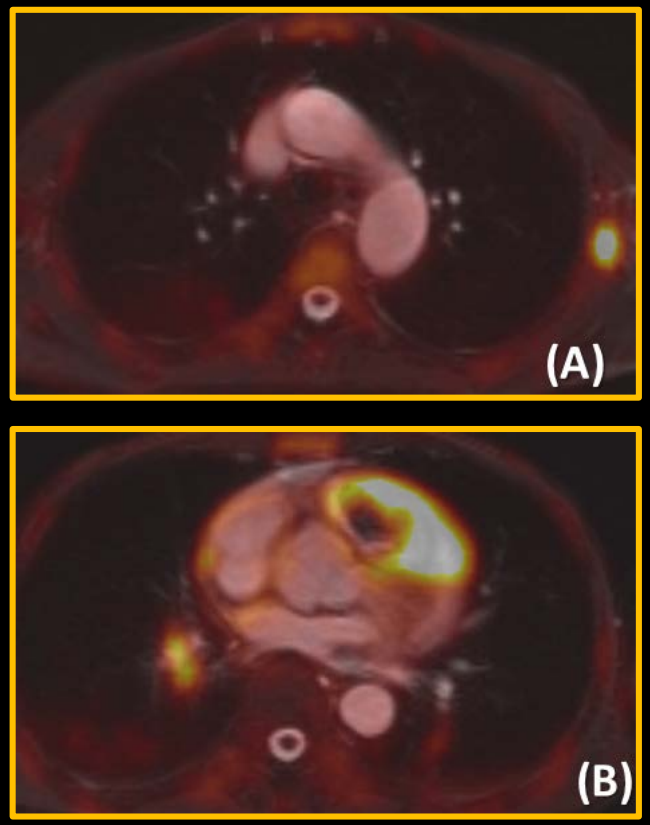
Cardiac Tumors

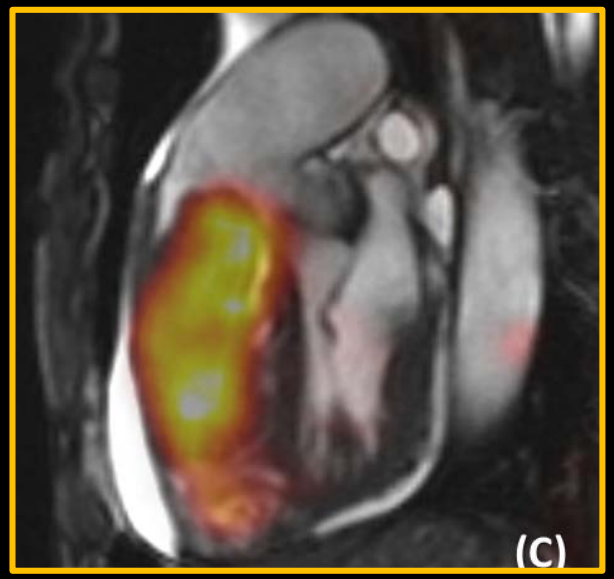


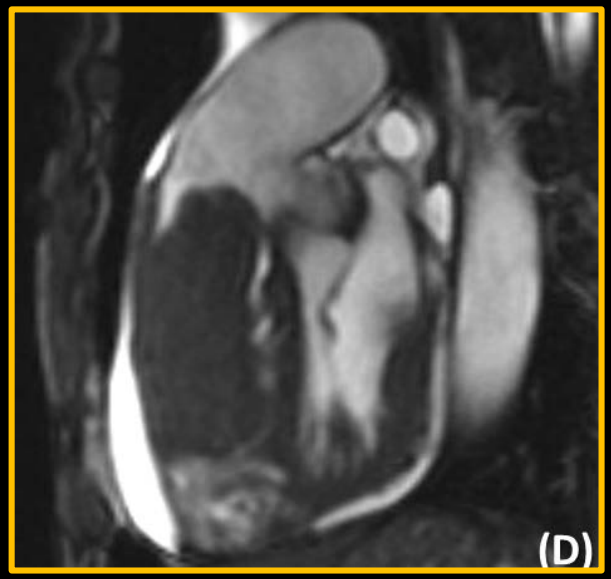
(a) Axial SSFP, (b) axial T1-weighted fat saturation image, and (c) fused FDG-PET MR image shows a heterogeneous mass in the right atrioventricular groove which invades into the right ventricle and right atrium. There is a moderate pericardial effusion.
Intracardiac biopsy showed poorly differentiated neuroendocrine tumor.

Clinical Applications

Cardiac Tumors







Patient with metastatic adrenocortical carcinoma. (a,b) Fused axial SSFP and FDG PET images demonstrate metabolically active chest wall nodule and right hilar lymphadenopathy. A partially imaged hypermetabolic mass is seen in the right ventricle. (c,d) Fused sagittal oblique SSFP and FDG PET images demonstrate a mass in the right ventricle, extending into the right ventricular outflow tract.

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