Incidental Findings Not to Be Missed on Cardiac MRI

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Learning Objectives

• To raise awareness and educate cardiologists and radiologists on the importance of screening different image series on cardiac MRI (CMR) studies for incidental findings
• To illustrate the spectrum of clinically relevant extracardiac findings that may be incidentally found on CMR
Introduction

- General prevalence of extracardiac findings on CMR may be as high as 81%\(^1\)
- Clinically significant incidental findings may occur in 17% of CMR\(^1\)
- The Society for Cardiovascular Magnetic Resonance recognizes that although CMR is tailored for assessing the cardiovascular system, extracardiac findings should routinely be part of the CMR report\(^2\)
How To Approach?

- **Sequence-oriented**
  - Based on the strengths of each pulse sequence
  - Dependent on local protocol set up

- **Anatomy-oriented**
  - Stepwise and systematic approach following anatomic sectors
  - Time consuming

- In practice, usually a combination of both

→ *Let's examine the strengths and weaknesses of different pulse sequences*
Black-Blood Single-Shot FSE*

- Highlights:
  - Motion insensitive
  - Lung and pleural disease
  - Mediastinum
  - Chest wall
- Faster acquisition
- Image blurring
- Black-blood
- T1 or T2-weighted

*FSE: Fast spin-echo

Axial T2-weighted single-shot FSE (SS-FSE) without contrast. A set of axial images covering the whole chest was acquired during a single apnea. Note the absence of signal inside the vessels (*). Some blurring is related to the high turbo factor and half-Fourier reconstruction.
Steady-State Free Precession

- **Highlights:**
  - Detailed anatomy
  - Vascular assessment

- **Faster acquisition**

- **↑ signal-to-noise ratio**

- **Bright-blood**

- **Combined T2/T1-weighting**

Axial steady-state free precession (SSFP) without contrast. The blood demonstrates spontaneous high signal intensity (*), facilitating vascular analysis. Note the favorable signal-to-noise ratio and the detailed anatomic information.
Double Inversion-Recovery FSE

- Highlights:
  - Anatomic detail
  - Vessel wall
  - Lung and pleural disease
  - Mediastinum
  - Chest wall
- Slower acquisition
- High spatial resolution
- Black-blood
- T1- or T2-weighted

Axial T1-weighted double inversion-recovery FSE without contrast. Note the increased spatial resolution in comparison with the single-shot acquisition. However, each image is acquired during a single apnea. The double-inversion recovery pulse is responsible for nulling the blood signal (*). Arrows demonstrate axillary lymphadenopathy.
Triple Inversion-Recovery FSE

- Highlights:
  - Fat-suppression
  - Mediastinum
  - Hila
  - Chest wall
- Slower acquisition
- High spatial resolution
- Fat-suppressed
- Black-blood
- T2-weighted

Axial T2-weighted triple-inversion recovery FSE without contrast. The triple inversion-recovery pulse sequence is tailored to suppress the blood signal (*), as well as the fat signal (#). One breath-hold per image.
3D-Gradient Recalled Echo

- Highlights:
  - Vessels
  - Mediastinum
  - Lung and pleural disease
  - Chest wall
- Faster acquisition
- Usually fat-suppressed
- Pre or Post contrast
- T1-weighted

Axial contrast-enhanced T1-weighted fat-suppressed 3D-spoiled gradient recalled echo demonstrating excellent definition of the chest anatomy. The injection of contrast facilitates the visualization of vessels and enhancing lesions.
Anatomy-Oriented Approach

Search by Sector

Lungs ➔ Pleura

Lower Neck ➔ Vessels ➔ Mediastinum and Hila

Upper Abdomen ➔ Chest Wall ➔ Thoracic Spine
Lungs

22-yo female, with corrected congenital heart disease, presenting with chest pain and leukocytosis, CMR to assess for pericarditis

Axial 2D-Black-Blood SS-FSE (a) and 2D-SSFP (b) at the same level. Note an increased in signal intensity of the basal posterior segment of the left lower lobe on both sequences (*), consistent with lung consolidation or atelectasis. A small pleural effusion is better demonstrated on the SSFP acquisition (arrow)

TEACHING POINT: Assess for lung pathology on SSFSE or SSFP images. This was the first imaging modality to suggest pneumonia. The patient was treated with antibiotics, with resolution of symptoms. A 1 month follow up radiograph (not shown) was normal
Lungs

67-yo female, connective tissue disorder and secondary pulmonary hypertension, CMR to assess RV volumes and function

Axial 2D-Black-Blood SS-FSE (a) and CT chest WO contrast (b) at the same level. Note the presence of bilateral reticular (arrows) and groundglass (*) opacities in this patient with fibrotic interstitial lung disease (ILD)

**TEACHING POINT:** Although this patient had already been diagnosed with ILD, note that parenchymal abnormalities in the lungs can be also seen on MRI — indeed, MRI may be, at times, the initial modality to raise awareness about lung disease
57-yo female, eosinophilia and shortness of breath, CMR to assess for Loeffler endocarditis

Axial 2D-Black-Blood SS-FSE (a) and CT chest W contrast, mediastinal (b) and lung (c) windows. Note the presence of bilateral pleural effusions (*). Arrows in (a) and (c) demonstrates groundglass opacities consistent with pulmonary edema. Note endomyocardial thickening with obliteration of the cardiac apex in (b) (arrow), a feature of Loeffler endocarditis

TEACHING POINT: Pleural effusions and pulmonary edema are common complications of heart failure and should not be overlooked
**Mediastinum and Hila**

39-yo male with sarcoidosis and paroxysmal atrial fibrillation, CMR to assess cardiac involvement

Axial 2D Black-Blood SS-FSE (a) and CT chest W contrast (b) at the same level. Hilar (arrows) and mediastinal (*) lymphadenopathy is noted in (a) and confirmed in (b) in this patient with path proven sarcoidosis

**TEACHING POINT:** Look for mediastinal and hilar masses on SS-FSE. Sarcoidosis commonly manifest as hilar and mediastinal lymphadenopathy, and may involve the heart causing arrhythmias.
Vessels

44-yo male with routine evaluation for non-compaction cardiomyopathy seen on prior Echo, past medical Hx positive for “thrombosis in the right leg”

Axial scout 2D-SSFP (a) and CTA (b) at the same level. Filling defects in the lobar branches of the pulmonary artery were demonstrated on both MR and CTA images (arrows in a and b)

TEACHING POINT: SSFP images should be routinely evaluated for major vascular abnormalities. This patient with hypercoagulable state was proven to have asymptomatic, albeit extensive PE, confirmed by a CTA on the next day
Vessels

38-yo male with PMHx of drug abuse, presenting with chest pain and hemoptysis, CMR ordered to assess cause of dilated cardiomyopathy seen on Echo

Sagittal 2D-Black-Blood SS-FSE (a), short-axis dynamic first-pass perfusion at peak pulmonary artery enhancement (b), and coronal 2D-SSFP through the right atrium (c). Note the wedge-shaped consolidation in the left lower lobe in (a) (arrows), corresponding to a perfusion defect in (b) (dotted line). A filling defect noted in the right atrium (arrow in c) corresponds to the embolic source (bland versus septic thrombus)

TEACHING POINT: A large pulmonary embolism may cause lung infarction, which manifests as a wedge-shaped consolidation with segmental or subsegmental distribution
Lower Neck

73-yo female, HIV infection and hypertension, EKG changes suggesting ischemia, a stress CMR was ordered

Coronal scout 2D-SSFP (a) and follow-up axial CT neck W contrast (b) showing an anterior mediastinal mass (arrows in a), extending to the neck and showing heterogeneous attenuation with coarse calcifications (arrows in b)

TEACHING POINT: This neck/mediastinal mass could easily be overlooked if scout images were not reviewed — differential diagnoses include nodular goiter, thyroid neoplasms, thymoma, and lymphoma, the latter being of particular concern in patients with HIV infection. Subsequent US-guided FNA confirmed a benign follicular lesion
Upper Abdomen

49-yo female with congestive heart failure, CMR ordered to assess for constrictive pericarditis

Axial 2D-Black-Blood SS-FSE (a) and follow-up axial CT abdomen W contrast (b) showing lobulated hepatic contours and relative increase in size of left and caudate lobes. A nodular pattern of enhancement is noted on the arterial phase CT (*, b). A small amount of ascites secondary to portal hypertension is noted (arrows)

TEACHING POINT: Use SS-FSE images to look for abdominal pathology. Cirrhosis may be caused by chronic passive venous congestion
Upper Abdomen

69-yr-old male, hypertrophic cardiomyopathy referred for CMR to assess cardiac morphology and delayed enhancement.

TEACHING POINT: Use the good anatomical detail of cine-SSFP to screen for extracardiac abnormalities. Cholelithiasis is a prevalent disease in the adult population.
Chest Wall

66-yr female with newly diagnosed left breast cancer, CMR ordered to assess LV hypertrophy noted on pre surgical Echo

Axial 2D-Black-Blood SS-FSE (a) and dedicated axial breast MRI W contrast (b). Note a complex mass in the left breast in (a), with a cystic/necrotic component (*) and axillary lymphadenopathy (arrow). The same findings were observed on the dedicated breast MRI obtained just 2 weeks before.

**TEACHING POINT:** Breast cancer is the worldwide leading cause of cancer death in women. Screen for breast masses.
Chest Wall

50-yo female with PMHx of poliomyelitis in childhood, CMR to assess pericardial thickening seen on Echo

Axial (a) and coronal (b) T1-weighted 2D double inversion-recovery FSE showing diffuse fatty atrophy of the chest wall musculature. Arrows in (a) showing fatty atrophy of both serrati anterior muscles and arrows in (b) showing atrophy of the pectoralis muscles

TEACHING POINT: Neuropathies and muscular dystrophies may be associated with fatty atrophy of the chest wall musculature, always screen anatomic images for chest wall abnormalities
Thoracic Spine

30-yo male with beta-thalassemia, follow-up CMR to assess for cardiac iron overload

Axial 2D-SSFP (a) and short-axis GRE (b). Note bilateral paravertebral soft tissue masses with intermediate signal intensity in (a) (arrows), corresponding to foci of extramedullary hematopoiesis. The markedly low liver signal intensity in (b) (*) represents hepatic hemosiderosis due to multiple prior blood transfusions. Myocardial T2* measurements did not reveal cardiac hemosiderosis

**TEACHING POINT:** Extramedullary hematopoiesis may be found in patients with chronic anemias being assessed for transfusion iron overload on CMR. Also screen the thoracic spine for metastatic lesions, especially in patients with solid or hematologic malignancies.
Conclusions

• A multitude of abnormalities may be incidentally encountered on CMRs, some with clinical implications

• A systematic search pattern for extracardiac findings should be pursued, combining inherent strengths and weaknesses of pulse sequences with an anatomic-based approach

• Critical findings (e.g., pulmonary embolism and aortic dissection) should be promptly conveyed to the ordering physician

• Appropriate follow up recommendations should also be provided as required
References


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