Cardiac MRI: Clinical Application to Disease

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Slides courtesy of Stacy Rissing, MD
Outline

- Imaging planes

- Disease findings
  - Pulse sequences used for each indication
  - Pathophysiology being evaluated
Imaging planes
3 Plane localizer
Axial Haste
2 Chamber

Planned from axial images- usually HASTE
2 Chamber
Planned from axial images- usually HASTE
Pseudo short axis
Planned from 2 chamber cine
Pseudo short axis
4 chamber

Planned from Pseudo SA and 2 Chamber
4 chamber
True short axis
LVOT
Left ventricular outflow tract
Planned off of pseudo SA
LVOT₁ and LVOT₂
Trans-aortic valve view

Planned off $\text{LVOT}_1$ and $\text{LVOT}_2$
Trans-aortic valve view
Trans-aortic valve view
What are we looking for?
CMR for Myocardial Disease

- Coronary artery disease
  - Is there viable myocardium? Function and viability study
- Infiltrative myocardial disease
  - Sarcoidosis and Amyloidosis
- Myocarditis
  - Most idiopathic, some cases with viral etiology
- Cardiomyopathy
  - Dilated CMO, Hypertrophic CMO, and ARVC
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Coronary Artery Disease
The “Function and Viability Study”

- Usual clinical question: Would this patient benefit from CABG?
- Goal is to distinguish myocardium that has the ability to contract versus myocardium that is replaced by fibrosis or scar.
- Fibrosis and scar will not regain function after CABG
Coronary Artery Disease
The “Function and Viability Study”
The Basic Protocol

- 3 plane localizer
- Axial haste
- Cine bright blood (SSFP) – 2C, SA, 4C
- Delayed enhancement – SA, 2C, 4C
  - Key sequence, looking for scar
  - Pattern is subendocardial
Function and viability

Delayed enhancement = scar

Scar!
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Infiltrative myocardial disease

Cardiac Sarcoidosis

- Presence of non-caseating granulomas in the pericardium, **myocardium**, or endocardium → leading to clinical sequelae
- Myocardial granulomas have been associated with cardiac arrhythmia and even **sudden death**
Sarcoidosis
MR Protocol

Function and viability study + T2WI

- 3-plane loc, axial haste
- Cine bright blood (SSFP) 2C, SA, and 4C
  - Focal areas of myocardial thickening, wall motion abnormality, aneurysm formation
- T2-weighted images – SA +/- 4C or 2C
  - Myocardial edema and active inflammation
- Delayed enhancement in SA, 2C, and 4C
  - Inflammation and/or granulomatous involvement
  - Non-ischemic pattern (not confined to coronary distrib)
  - Patchy” or “mid-myocardial” in distribution
Cardiac Sarcoidosis

Delayed enhancement, short axis images

Courtesy Ricardo Cury
Cardiac Sarcoidosis

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Cardiac Amyloidosis

- Amyloid proteins are abnormally deposited within heart, especially myocardium
- Nobody famous 😞
- Imaging findings: LV wall thickening, atrial enlargement, pericardial effusion, patchy or diffuse LV delayed enhancement
Cardiac Amyloidosis

MR protocol

- Essentially function and viability study
- 3-plane loc, axial haste
- Cine SSFP – 2C, SA, 4C views
  - Cardiac function – often reduced
  - Myocardial wall thickness and mass
- Delayed enhancement – SA, 2C, 4C views
  - Eval for infiltrative myocardial process
Infiltrative disease

Amyloidosis

Figure 3a.
Cardiac amyloidosis in a 75-year-old man with multiple myeloma.

Cummings K W et al. Radiographics 2009;29:89-103
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Cardiac Amyloidosis
delayed enhancement

Classic, diffuse subendocardial

More typical, patchy
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Myocarditis

- Inflammation of the myocardium with necrosis of the adjacent myocytes; usually infectious

- Classic diagnostic picture:
  - Suddenly decreased systolic function
  - Big dilated heart
  - Otherwise healthy person
  - Shortly after viral illness

Rachel Hunter

The model told Hello! magazine: 'I had a cold and I just felt out of breath and a little bit weird. I went to a friend and said, 'Look, you need to take me to the emergency room'. I was diagnosed with myocarditis and pericarditis, which can happen when you have the flu.'
Myocarditis

- 3-plane loc, axial haste
- Cine bright blood (SSFP) – 2C, SA, 4C
  - Evaluate cardiac function – usually reduced
- T$_2$-weighted images – SA and 4C
  - Myocardial edema and inflammation
  - Relative to skeletal muscle
    - Want plenty of skeletal muscle in the FOV – get that arm!
- Pre and post contrast T$_1$-weighted images – SA and 4C
  - Ratio myocardial enhance to skeletal muscle enhance
    - RE-RUN if possible!!
  - Hyperemia and inflammation
- Delayed enhancement images – SA, 4C, 2C
  - Inflammation and scar
Myocarditis

Pre contrast

We do a similar measurement for T2-weighted images

Post contrast
Myocarditis

Patchy mid myocardial delayed enhancement
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Cardiomyopathy
Dilated Cardiomyopathy

- Disease of the myocardium
- LV becomes enlarged (dilated) and cannot pump blood as effectively to the body (heart failure)
- Can have no symptoms → end stage heart failure
- Usually idiopathic – need to r/o other causes
  - Viral infxn, genetic, CAD, metabolic, lots more
Dilated Cardiomyopathy
MR protocol

- Basic function and viability
- 3-plane loc, axial haste
- Cine SSFP – 2C, SA, 4C
  - Evaluate function and chamber sizes
- Delayed enhancement – SA, 2c, 4C
  - Evaluate for infarct
Dilated Cardiomyopathy

LV too big
Poor LV function
Hypertrophic Cardiomyopathy

- Disease of the myocardium
  - Myocardial thickening, hypertrophy
- Leading cause sudden cardiac death in young athletes

Screening teens for hypertrophic cardiomyopathy

On October 13, 2008 New York Rangers draft pick, Alexei Cherepanov, suffered a fatal heart attack and died during a hockey game. Only 19 years old, Cherepanov is the latest in a long line of young elite athletes who have lost their lives to Hypertrophic Cardiomyopathy (HCM), a genetic heart condition.
Hypertrophic Cardiomyopathy

MR Protocol

- 3-plane loc, axial haste
- SSFP 2C, SA, 4C
  - LV wall thickness, chamber size, function
- LVOT₁, LVOT₂
  - LV outflow tract obstruction (important)
- +/- cine AV and FQ aortic valve
  - Aortic valve – appearance and function
- Delayed enhancement – SA, 2C, 4C
  - Myocardial scarring, fibrosis - prognosis
Hypertrophic Cardiomyopathy

Muscle too thick!!
Hypertrophic Cardiomyopathy

Patchy delayed enhancement = scar
Can be source of arrhythmia
Arrhythmogenic Right Ventricular Cardiomyopathy

- ARVC
- Fibrofatty infiltration of the right ventricle
- Arrhythmia and possible sudden cardiac death
ARVC
MR Protocol

- Much shorter protocol now!
- 3 plane loc, axial haste
- Cine SSFP 2C, SA, 4C
  - RV size and wall thickness, function
- Coronal single shot TRUFI – set up sequence
- HTR cine RV-axial and RV-sagittal
  - High attention to RV – aneurysm, dyskinesia
ARVC

Indian Pacing Electrophysiol. J. 2010;10(11):503-514
Valve disease
Looking for stenosis or regurgitation

- Aortic
- Mitral
- Tricuspid
- Pulmonic
Aortic valve

- Stenosis or regurgitation
- Morphology- cusps?
- Helpful sequences to obtain:
  - Cine SSFP LVOT and trans-aortic valve
    - Look for the “jet” of aortic regurgitation
  - Phase contrast (Flow quant)
Aortic valve - regurgitation
Aortic valve- regurgitation
Aortic valve- stenosis
often seen with bicuspid aortic valve
Mitral valve

- Stenosis or regurgitation
- Cine bright blood (SSFP/SPGR)
  - SA, 2C, 4C, and LVOT
- Phase contrast – not as helpful for MV
Mitral valve- regurgitation
Pericardial disease

- Pericarditis

- Pericardial constriction

- Pericardial effusion
  - Simple, blood, or malignant
Pericarditis

- Pericardial inflammation
  - Usually due to infection
- Double IR images
  - 4C and SA views
  - Evaluate for pericardial thickening
- Early and delayed enhancement
  - Evaluate for pericardial inflammation

Bob Dylan, the singer and songwriter, has been released from a hospital where he was treated for pericarditis, a sometimes serious heart condition, a publicist said yesterday.

Mr. Dylan was quoted as saying he had no specific plans for the recuperation period. "I'm just glad to be feeling better," he was quoted as saying. "I really thought I'd be seeing Elvis soon."
Pericarditis

Way too thick!

Double IR

Way to bright!

Delayed Enhancement
Pericarditis
Pericardial Constriction

- Thickened, fibrotic pericardium forms a non-compliant shell around the heart, which prevents heart from expanding when blood enters
- Most common in US = radiation therapy and surgery
- Most common worldwide = infection (TB)
- Key sequences:
  - Double IR – Pericardial thickening
  - High temporal resolution SA cine – Septal bounce
  - Delayed enhancement - Pericardial inflammation
  - TAG LINES!! – Tethering of pericardial layers
Pericardium - normal
Pericardial constriction
Pericardial constriction
Pericardial fluid
Take home points

- Practice your cardiac imaging planes
- Help build MR protocol for specific diseases
- Cine SSFP is your workhorse
- Delayed enhancement for inflammation, infiltration, or infarction
- Phase contrast for flow quantification (valves)
- T1, T2, and contrast images for tissue characterization
Thank You

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• How many people do cardiac MRI at place
• Radiologist or cardiologist present for the study
• Do they give you a tailored protocol or run same protocol for all hearts?