Cardiac MRI: Clinical Application to Disease

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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
Planned from Pseudo SA and 2 Chamber

4 chamber
Planned from Pseudo SA and 2 Chamber

4 chamber

True short axis
LVOT
Left ventricular outflow tract
Planned off of pseudo SA

LVOT\textsubscript{1} and LVOT\textsubscript{2}

Trans-aortic valve view
Planned off LVOT\textsubscript{1} and LVOT\textsubscript{2}

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

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

Function and viability
- Delayed enhancement = 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 localization, 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

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Reggie White

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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

- Really thick myocardium

Cardiac Amyloidosis delayed enhancement

- 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
Myocarditis

- 3-plane loc, axial haste
- Cine bright blood (SSFP) – 2C, SA, 4C
- Evaluate cardiac function – usually reduced
- T2-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 T1-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

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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

Hypertrophic Cardiomyopathy

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

**Screening teens for hypertrophic cardiomyopathy**

On October 15, 2008 New York Rangers draft pick, Daniel cheperos, suffers a fatal heart attack and dies during a hockey game. Only 19 years old. Cheperos is the latest in a long line of young male athletes who have lost their lives to hypertrophic cardiomyopathy (HCM), a genetic heart condition.

Hypertrophic Cardiomyopathy

- 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!!

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Belloni E et al. AJR 2006;187:1722-1730

Hypertrophic Cardiomyopathy

- Patchy delayed enhancement = scar
  - Can be source of arrhythmia

Belloni E et al. AJR 2006;187:1722-1730
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 TRUF – set up sequence
- HTR cine RV-axial and RV-sagittal
  - High attention to RV – aneurysm, dyskinesia

ARVC

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 Regurgitation
Aortic valve- regurgitation

- 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 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 this year.”
Pericarditis

Way too thick!  Way to bright!

Double IR  Delayed Enhancement

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)
- $T_1$, $T_2$, and contrast images for tissue characterization

Thank You

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