**Case Based Review of Cardiovascular MRI**

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**Disclosures**

Consultant: Berlex, GE-Healthcare
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Off-label use: gadolinium enhanced MRI of the heart and vessels

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**Which is the current best method for obtaining T1 or T2 weighted images of the heart?**

1. Spin echo
2. Double inversion recovery fast / turbo spin echo
3. Diffusion MRI
4. SSFP cine (eg, TruFISP)

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**“Double IR” black blood FSE/TSE**

Breath-hold high resolution, intracardiac detail

- “T1” weighted, where TR = 1 R-R interval
- PD (TR 1000, TE 20), T2 weighted (TR 2000, TE 80)

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**You are evaluating a suspected RV cardiac mass and protocol a long axis double IR black blood image – but the blood is not black: why?**

1. Usually this is due to poor technologist scanning.
2. The tech gave gadolinium; its impossible to get black blood after gad.
3. Blood flow must be perpendicular for this sequence to work.

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**Blood flow on the long axis image is in-plane (slow flow)**

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Review of Cardiac MRI

- MR cardiac pulse sequences
- **Evaluation of myocardial mass**
- Evaluation of coronary heart disease
- Evaluation of the right ventricle

67 yr old female with LV cardiac mass: which is most likely?
1. Myxoma
2. Blood clot
3. Rhabdomyosarcoma
4. Metastasis

Primary malignant tumors:
1. Angiosarcoma 31%
2. Rhabdomyosarcoma 20%
3. Other sarcoma 16%
4. Mesothelioma 15%
5. Primary Lymphoma 6%

Metastasis 20x more common than primary disease.
Leiomyosarcoma metastasis

43 yo woman with TIA’s, mass discovered on echocardiography. Most likely diagnosis?

1. Myxoma
2. Blood clot
3. Rhabdomyosarcoma
4. Metastasis

Myxoma

- interatrial septal attachment
- 4:1 left vs. right sided
Primary benign tumors:

1. Myxoma 41%
2. Lipoma 14%
3. Papillary fibroelastoma 13%
4. Rhabdomyoma 11%

23 yo female, ambulance transfer from community hospital for RA mass on echocardiography. Which is not bright on T1?

1. Blood clot
2. Myxoma
3. Melanoma met
4. Lipoma
5. Proteinaceous cyst

5 high signal masses on T1:

1. Blood clot
2. Melanoma met
3. Lipoma
4. Proteinaceous cyst
5. Gadolinium enhanced mass

Right atrial lipoma

- T1 fat sat is diagnostic
- Associations: obesity, steroid use

Review of Cardiac MRI

- MR cardiac pulse sequences
- Evaluation of myocardial mass
- Evaluation of coronary heart disease
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62yo with prior non-Q wave myocardial infarction. Where is the abnormality?

1. Anterior
2. Inferior
3. Septal
4. Lateral
62yo with prior non-Q wave myocardial infarction. Where is the abnormality?

- Anterior
- Lateral
- Septal
- Inferior

Myocardial Delayed Enhancement (MDE)
Delayed washout (@10-20 min) of gadolinium in areas of infarction/scar.

80 yo, CHF, best diagnosis

1. Hibernating myocardium
2. Left main infarction
3. LAD infarction
4. RCA infarction

What are the inversion times at 1.5 T for fat (STIR) and CSF (FLAIR sequences)

1. 160 msec (fat), 2500 msec (CSF)
2. 160 msec for both fat and CSF
3. 2500 msec for both fat and CSF
Using an inversion pulse to suppress normal myocardium

If gadolinium level in the heart/blood pool is higher (eg, renal failure), what value of TI is needed to suppress the myocardium?

1. a smaller (shorter) TI
2. a larger (longer) TI
3. makes no difference

72yo male with heart failure: delayed gadolinium images

• Typical range: 175-250 msec
• Smaller (shorter) TI time when more gad is present:
  - decreased renal function
  - CHF
  - shorter delay time

72yo male with heart failure

Diagnosis:
1. Prior RCA infarction
2. Prior LAD infarction
3. Prior myocarditis
4. Nonspecific cardiomyopathy

73 yo male, increasing dyspnea

14% EF
EDV 210
LV mass 232g

Best diagnosis
1. Old RCA infarction
2. Old LAD infarction
3. Prior myocarditis
4. Nonspecific cardiomyopathy
65 yo female

Best diagnosis
1. Pseudoaneurysm of the left ventricle (rupture)
2. True LV aneurysm
3. Mycotic aneurysm

Which is typical of true aneurysm:
1. “wide” neck with diameter comparable to the aneurysm diameter
2. Typically RCA distribution
3. Late rupture is common

Which is typical of pseudo aneurysm:
1. Disruption of all myocardial layers; contained by pericardium
2. Narrow (≤40% of diameter) neck appearance
3. 45% incidence of rupture

Typical of pseudo aneurysm:
1. Disruption of all myocardial layers; contained by pericardium
2. Narrow (≤40% of diameter) neck appearance
3. 45% incidence of rupture

65 yo female, new onset CHF

Most appropriate next step:
1. Immediate surgery
2. Repeat cardiac cath for stenting
3. MRI with contrast (delay)
4. MRI with hemosiderin sensitive sequences
Delayed long axis images after 0.2 mmol gad

65 yo female, CHF

Best diagnosis
1. Pseudoaneurysm of the left ventricle (rupture)
2. True LV aneurysm
3. Mycotic aneurysm

65 yo female, CHF

Additional finding:
- clot formation in the aneurysm
- suggests long standing aneurysm
- MRI the most sensitive method for clot detection

Elderly male, CHF, 9% EF, 820 ml EDV

What is the dark area in the aneurysm?
1. Thickened infarct
2. Blood clot
3. High concentration of Gad

Delayed Gadolinium Image

Delayed gad T1
63 yo female, CHF

- Known diffuse coronary artery disease
- ECG: nonspecific T wave changes
- MRI ordered for treatment planning

63 yo female, CHF, diffuse CAD

Delayed Gadolinium Images

63 yo female, CHF, known CAD, low ejection fraction, no delayed enhancement that would otherwise be seen in infarction

Best diagnosis:

1. Prior myocarditis or other nonischemic cardiomyopathy
2. Small infarcts too small to be seen on MRI
3. Hibernating myocardium

Hibernating Myocardium

- reduced contraction at rest
- chronically reduced blood flow
- function can improve after CABG or stent revascularization
**Acute infarct with microvascular obstruction (at the infarct core)**

1st pass image  
Filling in  
Infarct

- 25 sec
- 40 sec
- 10 min

Microvascular obstruction + Myocardial necrosis

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**Microvascular Obstruction (MO)**

MO predicts significantly increased rate of cardiovascular complications after MI (unstable angina, reinfarction, CHF, embolic stroke, death).


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**52 yo male, acute chest pain, emergent cath/ stent. MRI for extent of disease.**

- 1st pass image
- Filling in
- Infarct

- Short axis cine after gadolinium administration

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**52 yo male, acute chest pain, emergent cath/ stent. MRI for extent of disease.**

- 1st pass image
- Resting perfusion

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**52 yo male, acute chest pain, emergent cath/ stent. MRI for extent of disease.**

- 15 min delayed gadolinium

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**52 yo male, acute chest pain, emergent cath/ stent. MRI for extent of disease.**

- 15 min delayed gadolinium

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Best diagnosis:
1. RCA infarct with microvascular obstruction
2. Old RCA infarction 6 months ago
3. Hibernating myocardium
33 yo OF, transferred for suspected right heart failure and arrhythmia

- Palpitations, syncope, ER with VT
- Cath: normal coronaries
- Echo: normal LV, poor RV function
- LVgram: hypokinetic LV, 30% EF
- RVgram: global dysfunction

MRI obtained to evaluate the right ventricle, in particular to consider ARVD (arrhythmogenic right ventricular dysplasia).

LV EF: 48%, RV EF: 25%

Delayed images after gadolinium (15 min)
Best Diagnosis

1. ARVD
2. Sarcoidosis
3. Chagas
4. Non specific myocarditis

Giant Cell Myocarditis

- Path: giant cells, inflammatory infiltrate
- Average age in largest series: 37-48 yrs
- 81% occur in otherwise healthy persons
- 89% mortality in 3 yrs
- CHF, refractory arrhythmia
- 8% had IBD
- 88% whites

Cooper LT NEJM 1997;336

Delayed Gadolinium enhancement of the heart is not specific for infarction:

- Fibrosis (old MI)
- Myocardial necrosis (acute MI)
- Tumor
- Inflammation – myocarditis
- Amyloid
- Sarcoid
- Chagas disease (fibrosis)

Gadolinium is a nonspecific contrast agent

- ischemic
- nonischemic

Hunold, J. Barkhausen, AJR 2005; 184

25 yo, acute chest pain 2 mos previously

25 yo, 1 yr f/u. Persistent elevated ESR.

phase sensitive IR
IR – turbo flash delayed gadolinum
25 yo, 1 yr f/u. Persistent elevated ESR.

Best diagnosis:
1. Circumflex infarction
2. ARVD
3. Myocarditis
4. Congestive heart failure

phase sensitive IR

Acute Onset Ventricular Tachycardia, Fever, Malaise

Patchy epicardial enhancement, noncoronary distribution

(45 yo male, dialysis, abnormal echo)

Acute fever, malaise, arrhythmia

Best diagnosis:
1. Sarcoid
2. Myocarditis
3. Chagas
4. Amyloid

(courtesy, J. Freeby, MD)
45 yo male, dialysis, abnormal echo

Best diagnosis:
1. Sarcoid
2. Myocarditis
3. Chagas
4. Amyloid

Essentials of Cardiac MRI

- MR cardiac pulse sequences
- Evaluation of myocardial masses
- Evaluation of coronary heart disease
- Evaluation of the right ventricle

19 yo woman

- Syncope, irregular heart beat
- Hx: significant for high level of physical activity (triathlon participation)
- ECG has TWI in V1 to V3, no epsilon wave
- Stress testing: had rare PVCs with LBBB
- Echo was normal, SAECG normal

RV EF 52%, EDV 172 ml (155)
19 yo female, arrhythmia: best diagnosis

1. Sarcoidosis
2. Anomalous coronary artery
3. ARVD (arrhythmogenic RV dysplasia)
4. Amyloidosis

Arrhythmogenic RV Dysplasia

- Fibrofatty infiltration of RV resulting in ventricular tachycardia
- Palpitations, syncope, sudden death
- Age $33 \pm 14$ yrs.
- 30-50% cases are familial. MRI used to screen family members.

"McKenna" Criteria:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Severe dilatation and reduction of RV EF</th>
<th>Localized RV aneurysms</th>
<th>Severe segmental dilatation of RV</th>
<th>QRS prolongation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abnormal structure/function by echo, ventriculography</td>
<td>MRI or nuclear</td>
<td>MRI or nuclear</td>
<td></td>
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<tr>
<td>ECG</td>
<td>Repolarization or depolarization/abnormalities</td>
<td>Repolarization or depolarization/abnormalities</td>
<td></td>
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<tr>
<td>Family history</td>
<td>Confirmed at necropsy or autopsy</td>
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Which is the least common reason for RV enlargement?

1. ARVD
2. Pulmonary Hypertension
3. PAPVR
4. Intracardiac cardiac shunt or valve dysfunction
Which best describes fat association with ARVD?

1. Fibrofatty RV replacement tissue is a histologic criterion for ARVD
2. RV fat always indicates ARVD
3. RV fat is a normal variant
4. LV fat is seen only with ARVD

What is the potential role of gadolinium MRI in ARVD?

1. RV enhancement supports ARVD diagnosis
2. RV enhancement does not occur (fat does not enhance)
3. It is not a McKenna criterion, and thus there is no role for gadolinium MRI
4. If I knew the answer, I would not be in this seminar...

RV delayed enhancement

*ICD, investigational

• 39-year old male with a 3-year history of highly symptomatic paroxysmal atrial fibrillation, referred for catheter ablation.
• AF ablation was performed using the segmental ostial ablation.
• No reduction of AF as a result of this procedure; ablation was repeated.

• Evening of hospital discharge, the patient started to cough up bright red blood; went to local ER
• Chest X-ray performed showed an infiltrate in the right lower lobe.
• Spiral CT scan showed no evidence of pulmonary embolism
• Presumptive diagnosis of pneumonia; the patient was discharged on antibiotic therapy.
• Returned to our institution: V/Q scan performed: segmental perfusion defect in the RLL. Normal ventilation

Best Diagnosis
1. Esophageal perforation
2. Aspiration pneumonia
3. Pulmonary vein stenosis
4. Congenital pulmonary vein absence

Inferior pulmonary venous ostia

Chest pain after PV ablation
Best Diagnosis
1. Esophageal perforation
2. Aspiration pneumonia
3. Pulmonary vein stenosis
4. Congenital pulmonary vein absence

45 yo female:
- Insulin dependent diabetes, hypertension
- Hx significant for bilateral lower extremity and upper extremity deep venous thrombosis
- She was admitted to another hospital with left sided chest pain, left arm numbness and dyspnea 5 months before.
- Her cardiac enzymes and ECG were normal.

45 yr old female, chest pain:
triple rule out: aortic mass on CT
**45 yr old female, aortic mass**

- cine
- MRA

**45 yr old female, transesophageal MR coil**

- pre-contrast
- post contrast

**Best diagnosis:**

1. Gadolinium enhancement indicates malignant lesion
2. Floating aortic thrombus
3. Metastatic disease
4. Primary leiomyosarcoma of the aorta

**Protein S deficiency**

Clinical course:
- Anticoagulated for 4 weeks
- Repeat MRI: similar findings
- Surgery to remove aortic clot

Subsequent multiple readmissions for both upper extremity clots despite concurrent warfarin therapy

**Vascular Aunt Minnies**

**2 cases, same diagnosis**
Case 2:

Best diagnosis:

1. Takayasu vasculitis
2. Syphilitic aortitis
3. Intramural hematoma

36 yo adult male

- Increasing short of breath
- History of valvular repair at age 2
- CXR: small right hemithorax
- Suspect arch abnormality
Best diagnosis:

1. Absent pulmonary artery
2. Coarctation
3. Scimitar syndrome (PAPVR)

Acute Chest Pain

Best diagnosis:

1. Aortic dissection
2. Aortic rupture
3. Intramural hematoma

Last case...

- 61 yo male with H/N cancer
- Prior neck radiation
- Now with skin breakdown over the left chest, persistent fever
- MRI to assess for disease extent, source of fever and complications.
Best diagnosis:

1. Post-op seroma
2. Nodal metastasis
3. Pseudoaneurysm innominate artery

Thank you!