RC429: Optimize Your Body MR Practice:

Optimize Your Body MR
Imaging Protocols: Cardiovascular

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• Andrew Arai, MD
• Tom Foo, PhD, GEMS
• Christine Lorenz, PhD, Steve Shea, PhD, Siemens

Topics

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<th>Vascular:</th>
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LV Function

Steady state free precession (SSFP) cine
balanced FFE – Philips
TruFISP – Siemens
Fiesta – GE

ALL THE SAME

Fast GRE (16 sec) SSFP (6 sec) Real time SSFP

T. Foo, GEMS
LV function

1. HLA chamber cine
2. Short axis cine
   - 8 mm thick, 2 mm spacing
3. VLA cine
4. 5 chamber cine (optional, for HOCM)

15 minutes (use parallel imaging n=2)

Imaging planes

4D SSFP: use parallel imaging

Full 3d recon + cine; 1 breath-hold

LV Function - Segmentation

Regional Wall Motion Analysis

<table>
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<th>LEFT VENTRICULAR VOLUME RESULTS</th>
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<tr>
<td>Body Surface Area: 1.89 m²</td>
</tr>
<tr>
<td>ED volume: 307.85 ml</td>
</tr>
<tr>
<td>ES volume: 189.04 ml/m²</td>
</tr>
<tr>
<td>LV mass ED: 175.24 g</td>
</tr>
<tr>
<td>LV mass ED/BSA: 92.62 g/m²</td>
</tr>
<tr>
<td>PER: 281.68 m/s</td>
</tr>
<tr>
<td>PER/EDV: 0.79 EDV/s</td>
</tr>
<tr>
<td>TPER: 400.00 ms</td>
</tr>
<tr>
<td>TPER phase number: 5</td>
</tr>
<tr>
<td>PFR: 203.55 ml/s</td>
</tr>
<tr>
<td>PFR/EDV: 0.57 EDV/s</td>
</tr>
<tr>
<td>TFF: 300.00 ms</td>
</tr>
<tr>
<td>TFF phase number: 11</td>
</tr>
</tbody>
</table>

Data courtesy of Fujita Health University, Aichi, Japan
Cardiac Protocols

- LV function
- Viability
- Perfusion
- Cardiac Mass
- Pericardium
- ARVD

Viability Protocol

- Purpose: evaluate delayed washout of gadolinium in infarction, inflammation, infiltrative disease

Viability Protocol

**Time**

15 min

1. LV Function protocol
   - Long, short axis cine images
2. Administer 0.15-0.2 mmol/kg gadolinium*, wait...
3. TI scout
4. Delayed images, short and long axis, begin 10 min after gad was given

IR-prepared segmented fast GRE

- Segmentation factor: 24 OR single shot SSFP
- **TD:** 300 ms (diastole)
- **TI:** 200-250 ms (adjust)
- 2 NEX
- 8 mm thick/0 mm spacing.
- Acquire images ~10-20 min after 0.2 mmol/kg gadolinium, 12 hb/slice

Adjust the TI time for each patient

- Optimal TI time depends on clearance of gadolinium from the normal myocardium
- Typical range: 175-250 msec
- Lower TI time when more gad is present:
  - Decreased renal function
  - CHF
“TI Scout”

Single breath-hold, 50 phases, 20 msec temporal resolution

“TI Scout”

Images every 20 msec

Phase Sensitive Inversion Recovery

Magnitude Reconstruction

Phase Sensitive Reconstruction

TI 100 150 200 250

3D Viability Sequence

Septal MI Antero- Septal MI

Foo et al, Radiology 2004; 230:845

Viability Protocol: Increasing Dyspnea

14% EF
EDV 210
LV mass 232g

RCA Infarct (old)

14% EF
EDV 210
LV mass 232g
Viability Protocol: also for Nonischemic Cardiomyopathy

- Hypertrophic cardiomyopathy
- Myocarditis – inflammation
- Amyloid
- Sarcoid
- Drug toxicity
- Chagas disease (fibrosis)

Hypertrophic Cardiomyopathy: Septum

HOCM: Myocardial Fibrosis

Cine

Delayed contrast

Progressive RV failure

Giant Cell Myocarditis
Myocarditis with scar

Cardiac Protocols
- LV function
- Viability
- Perfusion
  - Cardiac Mass
  - Pericardium
  - ARVD

Adenosine Stress MRI - requirements
1. Equipment
   - Infusion pump
     - 2 IV’s (gadolinium and adenosine)
2. Patient prep: withhold caffeine, methylxanthines
3. Antidote (AV block, T1/2 = 2 min)
   - (aminophylline 125 mg IV over 3 min)

MRI perfusion
- 0.05-0.1 mmol gad, 5 ml/sec
- (Notched-interleaved) EPI-FGRE acquisition
- 6-8 images / 2 R-R
- 128x128 matrix
- 8 mm thick, 2 mm gap
- 40 phases

Protocol – Stress Portion
- Localize short axis:
  - 3 min adenosine @140 ug/kg/min OR,
  - 2 min dipyridamole @0.56 mg/kg over 4 min
- 0.05 mmol/kg gadolinium bolus, 5 ml/sec
- Short axis perfusion for 1 min

Protocol – Rest Portion
- Administer additional 0.1 mmol/kg gadolinium
- ~15 min delay:
  - LV function protocol
- Viability protocol
- Optional: Repeat perfusion at rest, 0.1 mmol/kg gadolinium @ 5 ml/sec (optional)
Cardiac Protocols

- LV function
- Viability
- Perfusion
- Cardiac Mass
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Cardiac mass protocol

1. Axial T1 images (find the mass!)
2. Axial T2 images
3. +/- fat suppressed T1 images
4. Axial cine images
5. Pre/post gadolinium T1 images
   - fat sat double IR FSE (1x gadolinium) or “viability” T1 images with 2x dose gadolinium

Primary benign tumors:

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

(clot)

Syncope, mass by echo: myxoma

Axial T1
Axial SSFP cine

Emergency transfer for cardiac mass on echo

Axial T1
Emergency transfer for cardiac mass on echo

Axial T1 images with fat suppression

Axial STIR images (fat is dark, edema is bright)

Pulmonary hypertension, RV dysfunction

cine SSFP

viability image

Malignant tumors:

Secondary tumors 20x more common:

Metastatic disease, lymphoma

Primary:

1. Angiosarcoma 31%
2. Rhabodmyosarcoma 20%
3. Other sarcoma 16%
4. Mesothelioma 15%
5. Primary Lymphoma 6%

Leiomyosarcoma metastasis

T2

CHF, soft tissue mass by CT

Axial T1

Axial T2, fat sat

CHF, soft tissue mass by CT: angiosarcoma
**Pericardium - Protocol**

1. LV mass protocol
2. Short axis cines for constriction quantitate LV/ RV function
3. Axial tagging

**Constrictive pericarditis**

- ≥4mm pericardial thickness
- Equalization of left/right heart pressures
- Tubular right ventricle
- Reduced diastolic filling
- Enlarged right atrium, IVC

**MRI tagging, axial images, stripe tags**

**Cardiac Protocols**

- ✓ LV function
- ✓ Viability
- ✓ Perfusion
- ✓ Cardiac Mass
- ✓ Pericardium
- ✓ ARVD

**Pericardial line + mediastinal fat (chemical shift artifact)**

**Arrhythmogenic RV Dysplasia**

- Fibrofatty infiltration of RV resulting in ventricular tachycardia
- Palpitations, syncope, sudden death
- Age 33 ± 14 yrs.
- 30-50% cases are familial. MR screening of family members?

**RV dysplasia - Protocol**

1. Axial/short axis “T1” images, blood suppression (double IR FSE)
   - 5 mm slice thickness, ETL 24-32
   - Anterior coil, FOV 24-28
2. same as (1), with fat suppression
3. Cine: axial and short axis, HLA
4. Delayed gadolinium images, form the viability protocol, axial and short axis
**Black blood images**

- Axial “T1” images, blood/\(\pm\)fat suppression
  - TE min, ETL 24-32, 256x256, ZIP
  - 5x3 mm
  - Anterior coil, FOV 24-28

**Common protocol questions:**

1. What about prone imaging?
   - not necessary with breath-hold imaging.
   - difficult for patients to sustain for the duration of this protocol (45 + minutes).

2. We have a double IR single shot sequence (ssfse, HASTE) that is much faster – should I use this?

**“Double IR” single shot (HASTE) FSE**

2 sec per image – do not use for heart MRI

**ARVD: morphology**

38 yo F athlete, ventricular tachycardia

**Right ventricle fat**
RV and Pulmonary outflow tract enlarged, poor function

Right ventricular aneurysm

Delayed Gadolinium Enhancement
- Delayed enhancement present in 8/13 (61%) of ARVD patients.
- 7 patients had biopsy, all showed fibrosis.
- All of patients had other RV abnormalities (wall motion, morphology)

Tandri, JACC 2005; 45

RV delayed enhancement

RV delayed enhancement

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- Heart:
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  - ARVD
- Vascular
  - Coronary
  - Chest
  - Abdomen
  - Peripheral vascular
Coronary MRA Protocols

1. Targeted MRA (VCATS)
   - breath-hold 3d SSFP technique
   - double oblique images, oriented along the course of each coronary artery

2. Whole heart coronary MRA

Breath-hold 3D SSFP of RCA

- Advantages: quick, 20 sec, repeatable
- Disadvantages: breath-hold time limits resolution, difficult at high heart rates, complex for technologist

Multicenter Coronary MRA Study 1.5T:
targeted MRA with navigator

Aarhus  Berlin  Boston  Leiden
Koln  Texas  Leeds  Zurich

Whole Heart 3d MRA

Vascular Protocols

- Coronary
- Chest
- Abdomen
  - Peripheral vascular

Abdomen, Chest Protocols

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Chest</th>
<th>Abdomen</th>
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<tr>
<td>3D MRA</td>
<td>≤ 3mm</td>
<td>≤ 2mm (fat suppression)</td>
</tr>
<tr>
<td>Pre</td>
<td>Ax, Sag T1 (gated)</td>
<td>SSFSE (cysts, fluid)</td>
</tr>
<tr>
<td>Post</td>
<td>Post T1 (fat sat, gated)</td>
<td>VIBE, 3d T1 GRE (liver, kidney, etc)</td>
</tr>
</tbody>
</table>

MRI/A Chest: Contrast allergy

History: septic emboli, cardiac failure

- Black Blood: double IR breath-hold FSE
- Option: single shot technique

MRI/A Chest: combine with function

Cardiac Fiesta cine 3d Gad MRA

Thrombosed Aortic Dissection

“double IR” black blood FSE
Aortic Dissection - intraluminal view

Takayasu arteritis

Takayasu arteritis

Renal MRA (3T): with 3d T1

Vascular Protocols

- Coronary
- Chest
- Abdomen
- Peripheral vascular

Bolus Chase: Stepping Table MRA

1. 9 - 12 sec
2. 9 - 11 sec
3. 11-13 sec x 2 runs

F. Scott Pereles MD
Hybrid pMRA Approach

3 stations BUT 2 Injections

- Calf and foot station
  - 20 ml Gad and 2 or 3 acquisitions
- Pelvis & Thigh stations with step table
  - 25 – 35 ml Gad bolus chase style
- Improved resolution at all stations
- Avoids venous contamination in the feet and calves.

F. Scott Pereles MD

Hybrid Approach

3 stations BUT 2 Injections

- 2 separate timing runs (pelvis & calves)
  - Axial timing run, proximal calf
    2 ml Gad @ 2 ml/sec (20ml saline flush @ 2ml/sec)
  - Axial timing run, aortic bifurcation
    2 ml Gad @ 2 ml/sec (20ml saline flush @ 2ml/sec)

F. Scott Pereles MD

Time Resolved MRA (TREAT, TRICKS)

F. Scott Pereles MD

Summary

Heart:
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Vascular:
- Coronary
- Chest
- Abdomen
- Peripheral vascular

Thank you