RC229A: Optimize Your Body MR Practice:

Optimize Your Body MR Imaging Protocols: Cardiovascular

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Disclosures

- Off-label: gadolinium MRI of the heart and vessels, adenosine MRI
- Research support: Epix Medical
- Consultant: GE Healthcare, Berlex

Topics

Heart:	Vascular:
- LV function	- Coronary
- Viability	- Chest / Abdomen
- Perfusion	- Peripheral vascular
- Cardiac Mass / Pericardium	
- ARVD	

www.rad.jhmi.edu/mri/MRI_Info_RSNA.htm

Cardiac Protocols

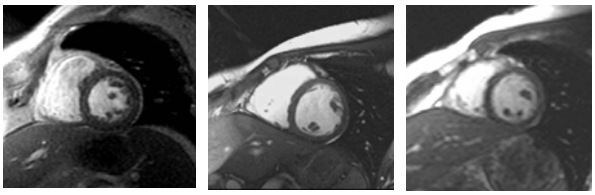
- ✓ LV function
- Viability
- Perfusion
- Cardiac Mass / Pericardium
- ARVD

www.rad.jhmi.edu/mri/MRI_Info_RSNA.htm

Steady state free precession (SSFP) cine

balanced FFE – Philips
TruFISP – Siemens
Fiesta – GE

ALL THE SAME

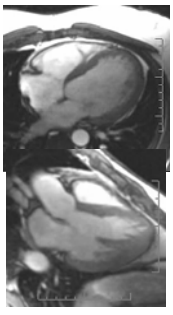


Fast GRE (16 sec) | SSFP (6 sec) | Real time SSFP

T. Foo, GEMS

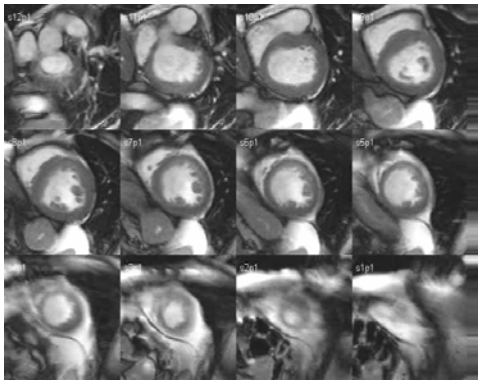
LV function

1. HLA chamber cine
2. Short axis cine
   8 mm thick, 2 mm spacing
3. VLA cine
4. LV outflow tract

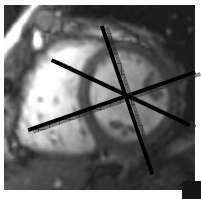


10 minutes (use parallel imaging n=2)

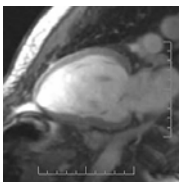
LV Function



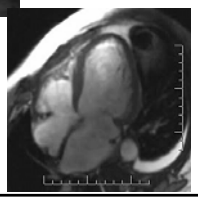
Imaging planes

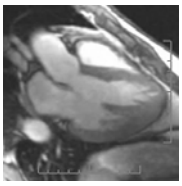


VLA



HLA

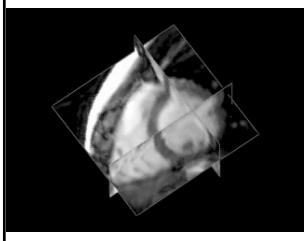


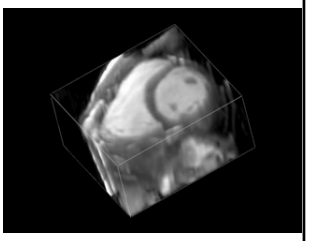


LV outflow tract

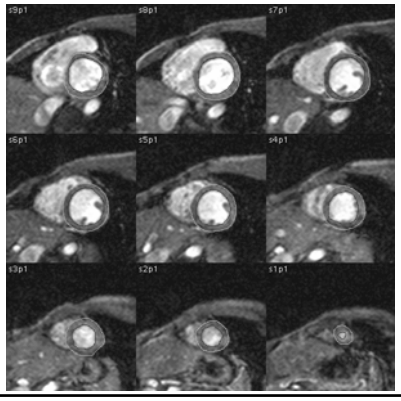
4D SSFP: use parallel imaging

Full 3d recon + cine; 1 breath-hold

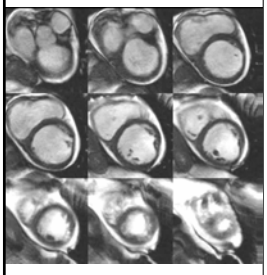




LV Function - Segmentation



LV volume analysis



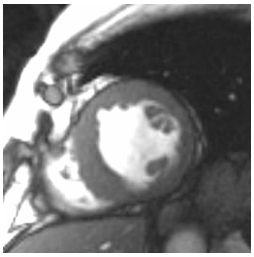
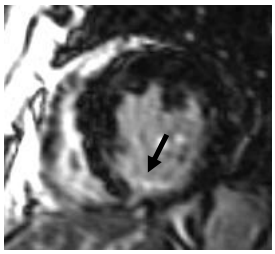
Body Surface Area:	1.89 m²
ED volume:	357.65 ml
ED volume/BSA:	189.04 ml/m²
ES volume:	241.32 ml
ES volume/BSA:	127.55 ml/m²
Stroke volume:	116.33 ml
Stroke volume/BSA:	61.49 ml/m²
Ejection fraction:	32.53 %

Cardiac Protocols

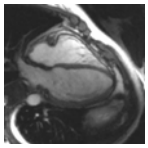
- ✓ LV function
- ✓ Viability
- Perfusion
- Cardiac Mass / Pericardium
- ARVD

Viability Protocol

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

Viability Protocol



Time

5 min 1. Long axis cine images

2. Administer 0.15 mmol/kg gadolinium

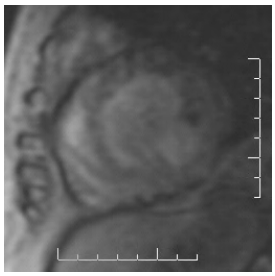
15 min { 3. Short axis cines, then *TI scout*

4. Delayed gad images, short and long axis, begin ≥10 min after gad was given

Delayed Gad: adjust TI for each patient

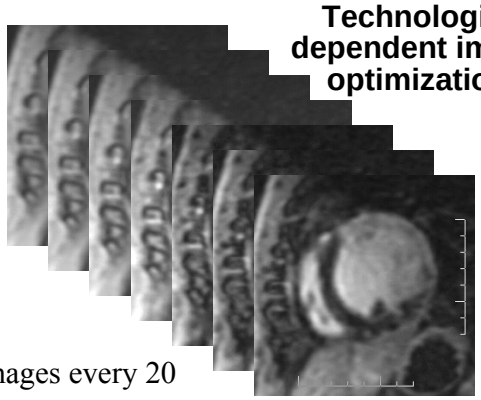
- Optimal TI time depends on clearance of gadolinium from the *normal* myocardium
- Typical range: 175-250 msec
- Lower TI time when more gad is present:
  - decreased renal function
  - CHF

"TI Scout" "Look-Locker"



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

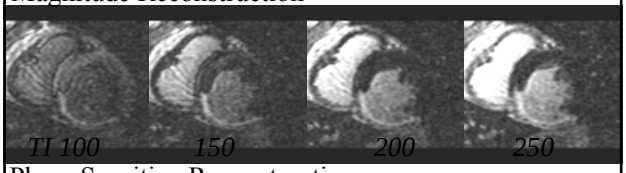
Technologist dependent image optimization



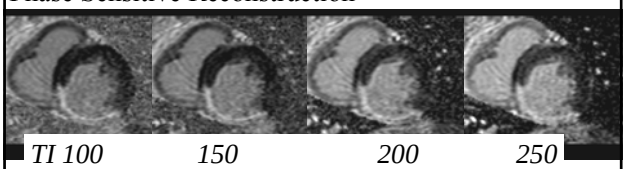
Images every 20 msec

Phase Sensitive Inversion Recovery

Magnitude Reconstruction



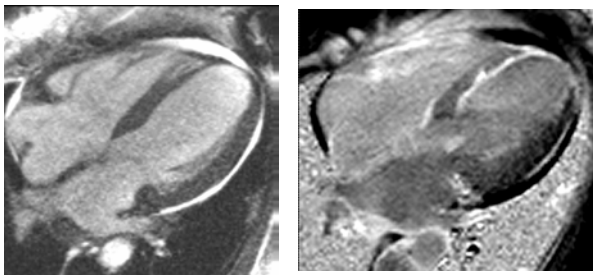
Phase Sensitive Reconstruction



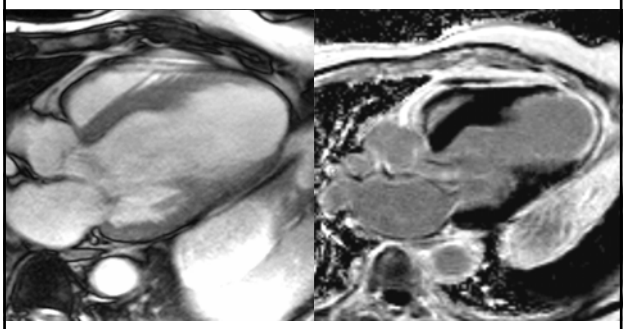
Arai, AHA 2002

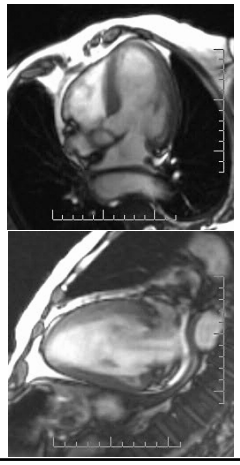
cine

phase sensitive reconstruction

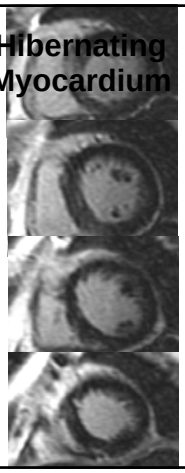


Viability Protocol: Increasing Dyspnea





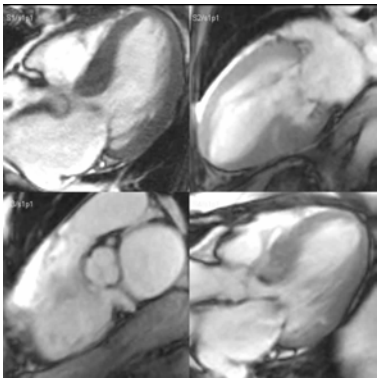
Hibernating Myocardium



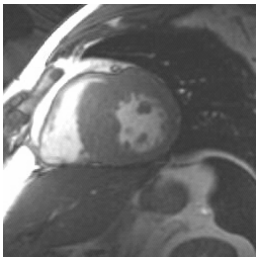
Viability Protocol: also for Nonischemic Cardiomyopathy

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

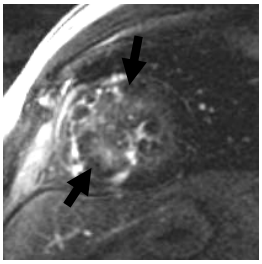
Hypertrophic Cardiomyopathy: Septum



HOCM: Myocardial Fibrosis

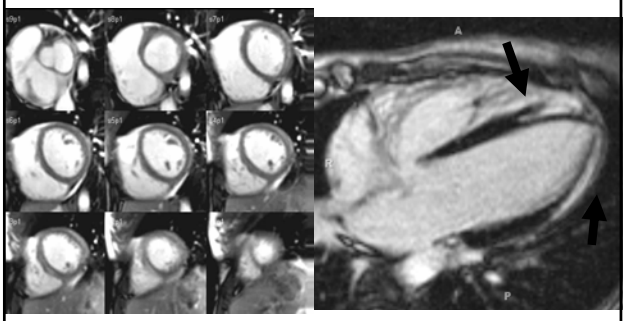


Cine



Delayed contrast

Myocarditis with scar

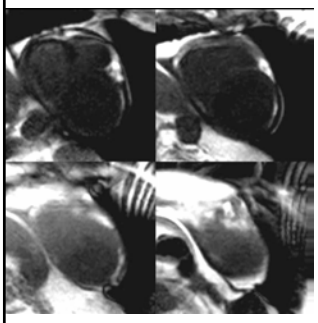


Cardiac Protocols

- ✓ LV function
- ✓ Viability
- ✓ Perfusion

Cardiac Mass /
Pericardium
ARVD

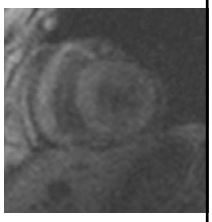
MRI perfusion



- 0.05 mmol gad, 4-5 ml/ sec
- EPI-GRE or SSFP acquisition
- 4-8 images / 2 R-R
- 96 x128 matrix
- 8 mm thick, 6-8 mm gap
- 30-40 phases

Protocol – Stress Perfusion

- 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
- Repeat at rest + viability

Cardiac Protocols

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

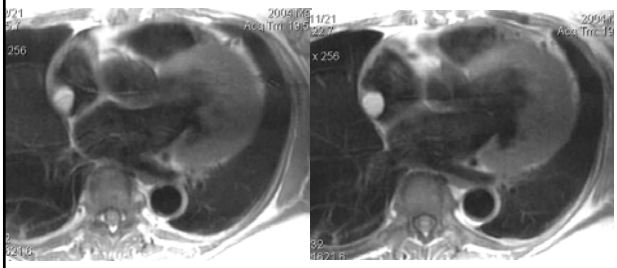
}

ARVD

Cardiac mass protocol

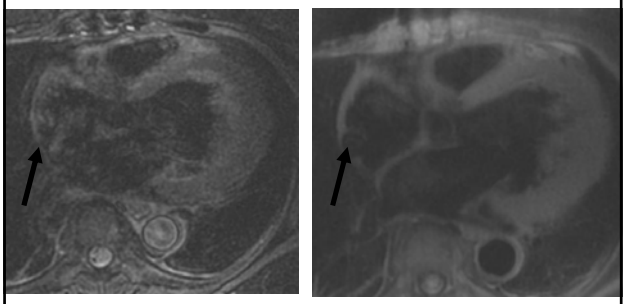
1. *Axial* T1 images (find the mass!)
2. *Axial* T2 images
3. +/- fat suppressed T1 images
4. *Axial* cine images
5. Pre/ post gadolinium T1 images
   - fat sat double IR FSE (1x gadolinium) or "viability" T1 images with 1.5-2x dose gadolinium

Emergency transfer for cardiac mass on echo



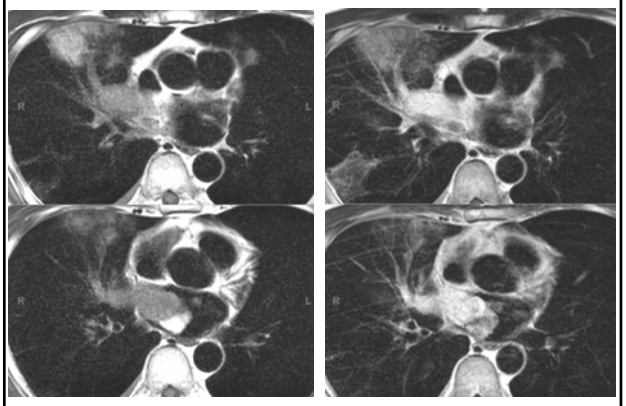
Axial T1 Axial T1

Emergency transfer for cardiac mass on echo



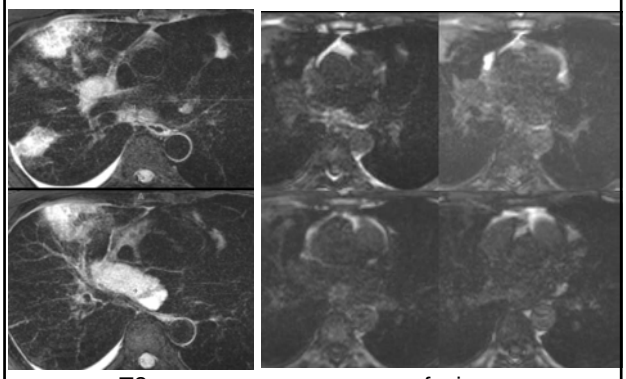
Axial STIR images (fat is dark, edema is bright)

Axial T1 images with fat suppression



T1 pre T1 post

Metastatic chondrosarcoma



T2 perfusion

Cardiac Protocols

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

Arrhythmogenic RV Dysplasia

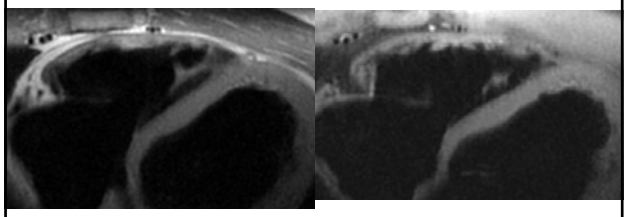
- Fibrofatty infiltration of RV resulting in ventricular tachycardia
- Palpitations, syncope, sudden death
- Age 33 ± 14 yrs
- 30-50% cases are familial. MR screening of family members

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. *axial / short axis* cine images
4. *axial / short axis* delayed gadolinium images

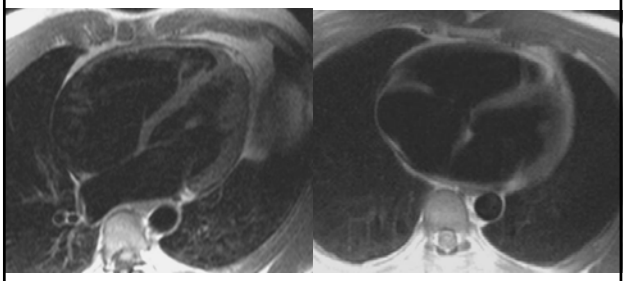
Black blood images

- Axial "T1" images, blood/ **±fat suppression**
  - TE min, ETL 24-32, 256x256, ZIP
  - 5x3 mm
  - Anterior coil, FOV 24-28

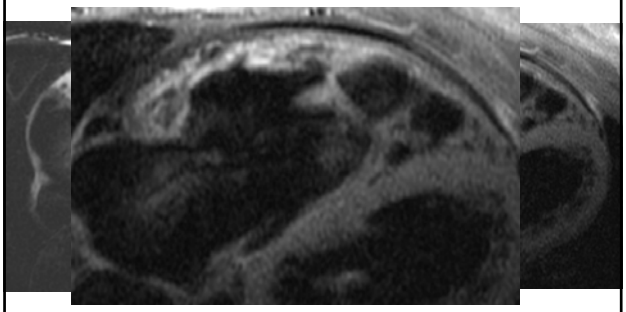


"Double IR" single shot (HASTE) FSE

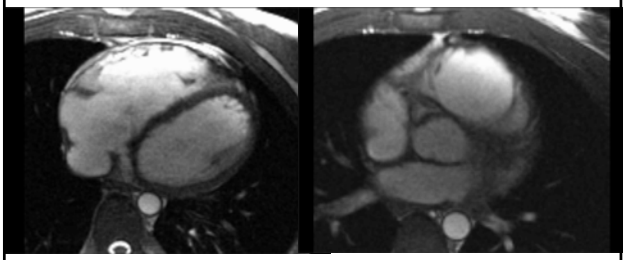
2 sec per image – *do not use for heart MRI*



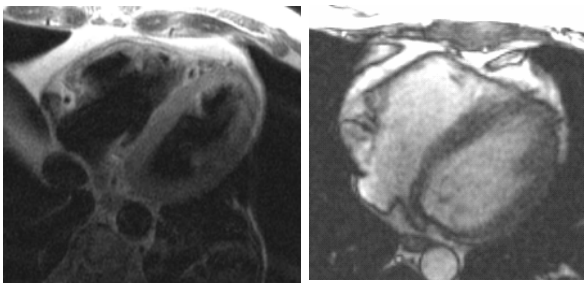
Right ventricle fat



RV and Pulmonary outflow tract enlarged, poor function

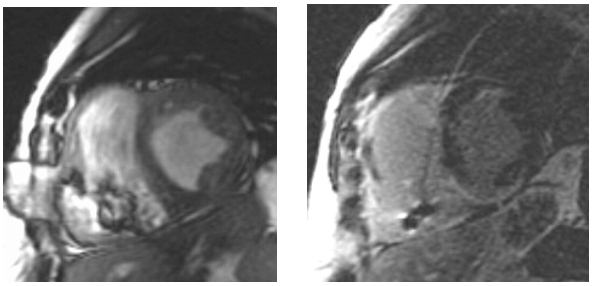


Right ventricular aneurysm



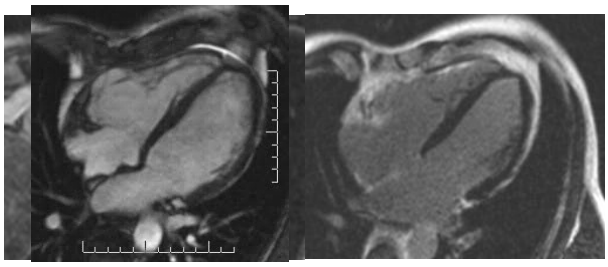
Typical ARVD

RV delayed enhancement



**AICD, investigational*

RV delayed enhancement



Delayed enhancement present in about 2/3 of ARVD patients

Topics

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

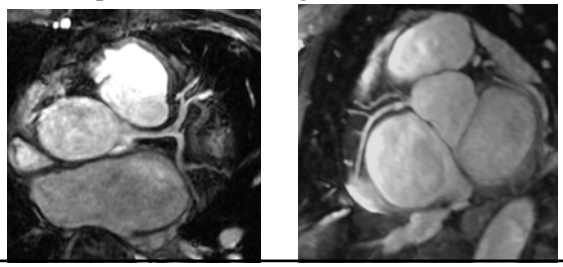
•Vascular
- Coronary
- Chest
- Abdomen
- Peripheral vascular

Coronary MRA Protocols

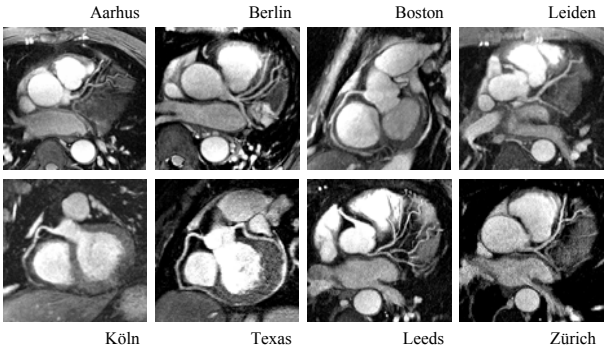
1. *Targeted* MRA of each artery
   - breath-hold or navigator 3d SSFP technique
   - double oblique images, oriented along the course of each coronary artery
2. *Whole heart* coronary MRA

Targeted Breath-hold 3D SSFP MRA

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



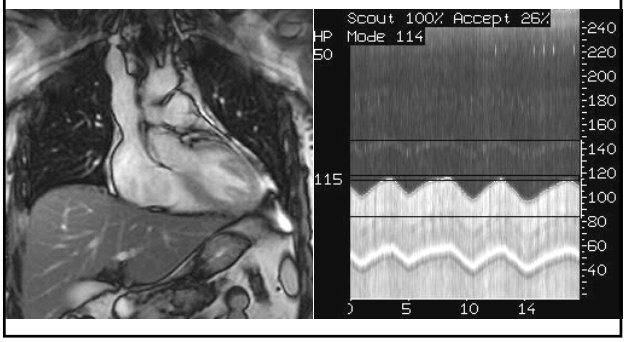
Multicenter Coronary MRA Study 1.5T: targeted MRA with navigator (non-breath-hold)



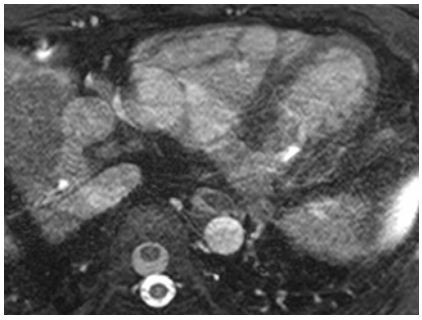
Kim WY et al.: N Engl J Med;345(26):1863-1869 (2001).

Whole Heart 3d axial MRA:

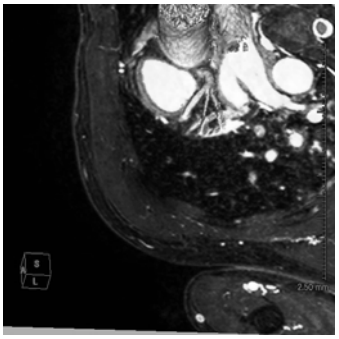
Navigator echoes are used to track the diaphragm and reduce motion artifacts



Whole Heart 3d MRA



2mm thick slices, 5-15 min



Courtesy, Dr. Hajima Sakuma, Aze

Vascular Protocols

- ✓ Coronary
- ✓ Chest
- ✓ Abdomen

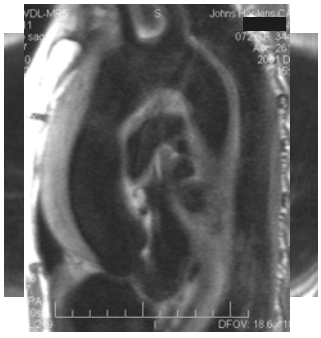
} Peripheral vascular

Abdomen, Chest Protocols

Sequence	Chest	Abdomen
3D MRA	≤ 3mm	≤ 2mm (fat suppression)
Pre	Ax, Sag obl. T1 (gated)	Ax SSFSE or SSFP (cysts, fluid)
Post	Ax post T1 (fat sat, gated)	Cor 3d T1 GRE (liver, kidney, etc)

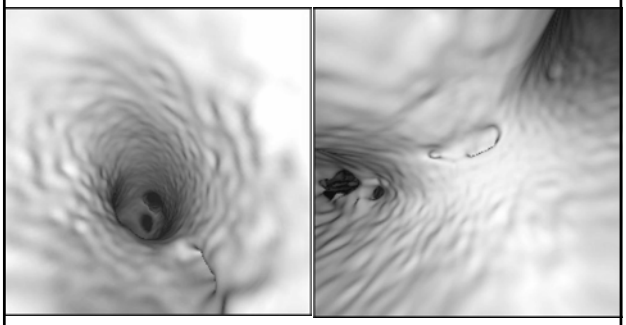
Thrombosed Aortic Dissection

MRA

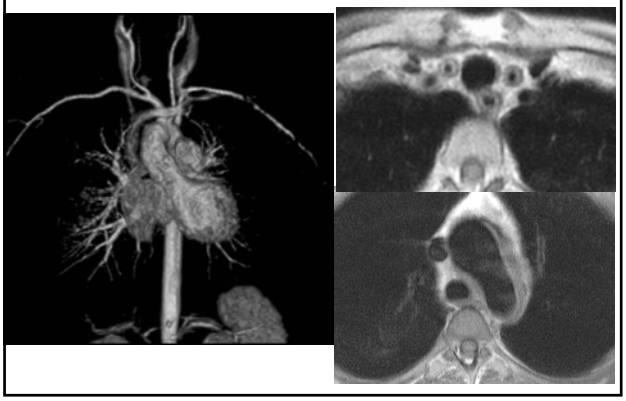


"double IR" black blood FSE

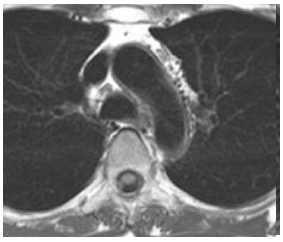
Aortic Dissection - intraluminal view



Takayasu arteritis

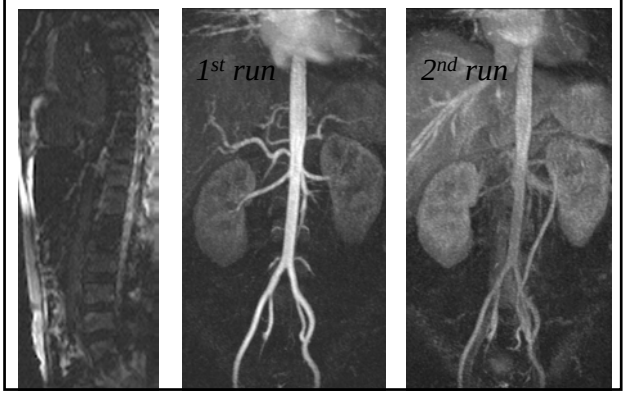


Takayasu arteritis



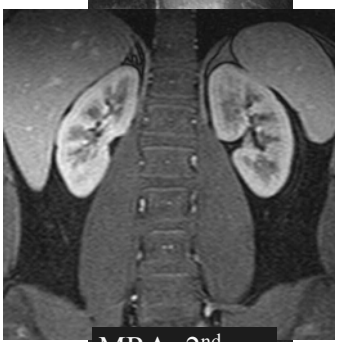
T1 double IR

Flouroscopic MRA trigger

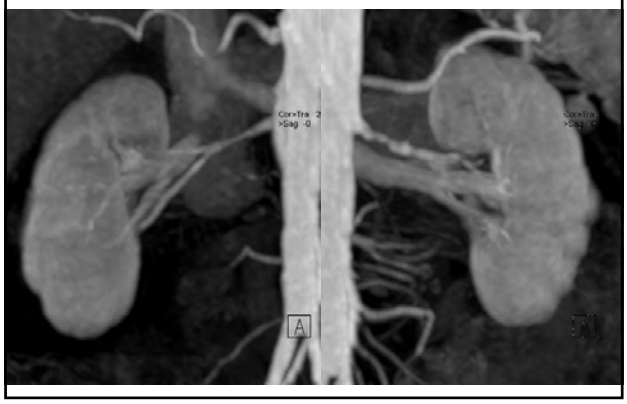


MRA: Venous phase

3d VIBE, Lava, Thrive



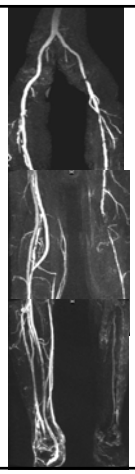
MRA - Aorta



Vascular Protocols

- ✓ Coronary
- ✓ Chest
- ✓ Abdomen
- ✓ Peripheral vascular

Bolus Chase: Stepping Table MRA



1 — 9 - 12 sec

2 — 9 - 11 sec

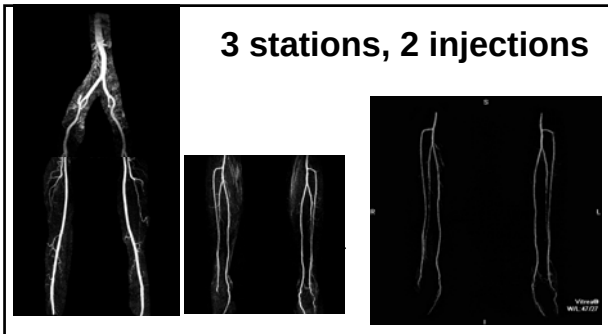
3 — 11-13 sec x 2 runs

F. Scott Pereles MD

Peripheral MRA: 3 stations, 2 injections

- Calf and foot station
  - 20 ml Gad, and 2 - 3 acquisitions
- Pelvis & thigh stations with step table
  - 25 – 35 ml Gad bolus chase style
- Avoids venous contamination in the feet and calves.

3 stations, 2 injections



2nd Acquisition, better visualization of foot vessels

F. Scott Pereles MD

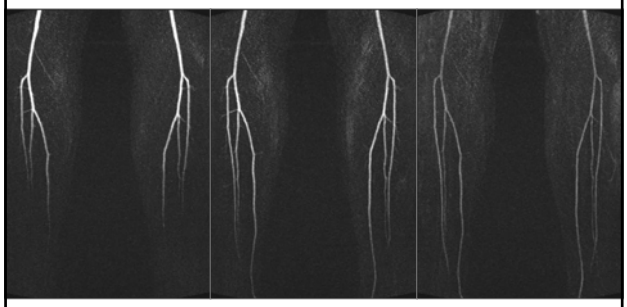
Peripheral MRA: 3 stations, 2 injections

2 separate timing runs (abdomen & calves)

1. Axial timing run, proximal calf
   2 ml Gad @ 2 ml/sec (20ml saline flush @ 2ml/sec)
2. Axial timing run, aortic bifurcation
   2 ml Gad @ 2 ml/sec (20ml saline flush @ 2ml/sec)

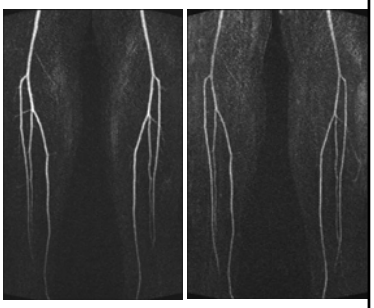
F. Scott Pereles MD

Time Resolved MRA, 20 cc gad (TREAT, TRICKS)



33 sec 38 sec 43 sec

Time Resolved MRA
(TREAT, TRICKS)



Summary

Heart:
- LV function
- Viability
- Perfusion
- Cardiac Mass/ Pericardium
- ARVD

Vascular:
- Coronary
- Chest / Abdomen
- Peripheral vascular

Thank you!

www.rad.jhmi.edu/mri/MRI_Info_RSNA.htm

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