Cardiac MRI: Clinical Application

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Outline
- Pulse sequences
- Routine imaging planes
- Clinical application to disease
  - Pulse sequences
  - Planes
  - Key disease findings

Pulse Sequences

Pulse sequences
- Black blood- anatomy
  - Spin echo (SE)
- Bright blood- dynamic and angiography
  - Gradient echo (GE)
- Phase contrast (PC)- quantify flow
Pulse sequences
- Delayed enhancement - infarct/inflammation/infiltration
  - 2D TrueFISP with IR prep
- Gadolinium MRA - angiography
  - 3D fast spoiled GE
- Tagging - physiology
  - Composite pulse sequence based on FLASH

Black blood - spin echo
- Traditional T1 and T2 weighted
- Double inversion recovery
  - R-R interval determines TR - proton density
- Triple inversion recovery
  - Fat suppressed - poor signal
  - Prefer double IR with fat sat
- HASTE

Bright blood - gradient echo
- FLASH
  - Spoiled and unbalanced gradient echo
  - Signal is influenced by flow velocity
  - Workhorse on 3T because of SAR
- TrueFISP
  - SSFP with balanced gradients
  - Signal is fairly uniform regardless of flow velocity
  - Workhorse on 1.5T and hopefully in future at 3T

Phase contrast
- Magnitude and phase images
  - Key for quantitative measurements of flow
    - Velocities and volumes
Phase contrast

Magnitude Image  Phase Image

Delayed enhancement

- 2D TrueFISP with IR prep
  - Evaluate abnormal myocardial tissue
  - Infarction/inflammation/infiltration
  - Contrast distributed in extra-cellular space

Delayed enhancement

SA View

4 Chamber View

Gadolinium MRA

- 3D Fast Spoiled GE (Time Resolved- shared data)
  - Angiographic evaluation
  - Vessel anatomy
  - Stenosis
Gadolinium MRA

Tagging

- Composite pulse sequence based on FLASH
- RF interference pattern
- Physiology evaluation
- Grid or lines - usually only use lines

Imaging Planes
Imaging planes
- Axial, coronal, and sagittal
- 2 chamber
- Short axis
- 4 chamber
- Left ventricular outflow tract (LVOT)
- Trans-aortic valve
- Candycane

3 Plane localizer

Axial Haste

2 Chamber
- Planned off of axial images—usually HASTE
Pseudo short axis
- Planned off 2 chamber cine

Pseudo short axis

4 chamber
- Planned off Pseudo SA and 2 Chamber

4 chamber
True short axis

LVOT
- Planned off of pseudo SA

LVOT1 and LVOT2

Trans-aortic valve view
- Planned off LVOT1 and LVOT2
Trans-aortic valve view

Candycane
- Planned off axials using 3 point tool

Clinical Application to Diseases
Myocardial Disease

- CAD- function and viability
- Infiltrative disease/restrictive cardiomyopathy
  - Sarcoid and Amyloid
  - Myocarditis- infection
  - Cardiomyopathy
  - Dilated, Hypertrophic, and ARVC

CAD- function and viability

- 2 chamber, 4 chamber, and SA cine
- Delayed enhancement

Infiltrative- sarcoid

- Granulomas which can result in death from arrhythmia
- T2 weighted images- edema/inflammation
- Delayed enhancement- inflammation/granulomas
Infiltrative- amyloid

- Thickening of the myocardium- poor function
- SA cine- evaluation myocardial wall thickness/mass
- Delayed enhancement- see infiltration

Myocarditis

- Inflammation of the myocardium- usually infection
- T2 weighted- edema/inflammation
- Pre and post contrast- global relative enhancement from hyperemia/inflammation
- Delayed enhancement- inflammation/scar
Myocarditis

Cardiomyopathy - dilated
- Usually idiopathic - need to rule out other causes
- 2 chamber, 4 chamber, SA cine - evaluate function and chamber sizes
- Delayed enhancement - evaluate for infarct

Cardiomyopathy - hypertrophic
- Need to evaluate myocardial thickness
- 2 chamber, 4 chamber, SA cine - evaluate function and chamber sizes including possible obstruction
- Delayed enhancement - evaluate for scar or infiltration
Cardiomyopathy- hypertrophic

Cardiomyopathy- ARVC

- T1 (with and without fat sat)- evaluate for fibrofatty infiltration of RV
- 4 chamber and SA cine- evaluate for aneurysm and dyskinesis of the RV wall
- Delayed enhancement- fibrofatty tissue

Cardiomyopathy- ARVC
Valve disease

- Aortic
  - Stenosis or regurgitation
- Mitral
  - Stenosis or regurgitation
- Tricuspid and pulmonic
  - Stenosis or regurgitation

Aortic valve

- Stenosis or regurgitation
- Morphology - cusp?

- LVOT and Trans AV cine
- Phase contrast
- +/- short axis cine LV, SE, GE, or MRA images of the aorta to evaluate associated changes

Aortic valve - regurgitation
Aortic valve- stenosis

Aortic valve- stenosis

Mitral valve

- Stenosis or regurgitation
- Short axis, 2 chamber, and 4 chamber cine
- Phase contrast

- Regurg=SV-Aorta forward flow

Mitral valve- regurgitation
Tricuspid and pulmonic valve

- Stenosis or regurgitation
- Short axis, 4 chamber, RVOT cine
- Phase contrast
- TR=SV-Pulmonary forward flow

Tricuspid regurgitation

Pulmonic regurgitation

Pericardial disease

- Pericarditis
- Pericardial constriction
- Pericardial fluid
  - Simple, blood, or malignant
Pericarditis

- Inflammation usually due to infection
- Double IR - evaluate thickening
  - 4 chamber or SA
- Delayed enhancement - inflammation

Pericardial constriction

- Can be post infectious
- US - radiation or surgery; World - TB
- Double IR - evaluate thickening
- High temporal resolution SA cine - septal bounce
- Delayed enhancement - inflammation
- Tag lines - evaluation motion of layers of pericardium

Pericardium - normal
Pericardial constriction

Pericardial constriction

Pericardial fluid

- Double IR and T2 weighted - increased pericardial space; characterize

- 2 chamber, 4 chamber, SA cine - show fluid

- Delayed enhancement - worried about tumor
Pericardial metastatic dz

Coronaries

- 3D whole heart (3D SSFP)
- Coronary anatomy - anomalous vessels and aneurysms
- CAD - maybe in future
Great vessels

- Aorta
- Pulmonary arteries
- SVC
- IVC

Great vessels

- Anatomy, dilatation, or stenosis
- Non-contrast technique
  - Double IR and Single shot TrueFISP
  - Gadolinium MRA technique
  - 3D Fast GE
  - Phase contrast- significance of stenosis

Aorta aneurysm

Aorta- dissection
Aorta - dissection

Great vessels - aortitis

Great vessels - coarctation

Great vessels - pulmonary veins

- Prior to ablation - anatomy
- After ablation - evaluate for stenosis
Great vessels - pulmonary veins

Tumors

- Thrombus
- Benign tumors
- Malignant tumors
  - Primary
  - Metastatic

Tumors

- T1 and T2 weighted for tissue characterization
- Pre and post contrast for tissue characterization
- Cine/real time images for invasion and motion

Tumors - thrombus

- Most common heart mass
- Left atrial appendage most common location
- In ventricle usually associate with wall motion abnormality
Tumors- thrombus

Tumors- benign
- Most common is myxoma
  - Usually in atrium most commonly LA
  - Mobile on a stalk- can obstruct valve
- Fibroelastoma
  - On valve
  - Usually small and very hard to see

Tumors- malignant
- Mets 20-40 times more common
- Usually sarcoma is primary
  - Most common is angiosarcoma

Tumors- primary angiosarcoma
Take home points

- Pulse sequences
  - SE for anatomy and GE for physiology
  - PC for quantitative
  - Delayed enhancement for inflammation/scar

- Clinical indications with key sequences

Thank You

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