Objectives
MRI Thorax, Chest Wall, Breast

RADT 4643
Compare and contrast the advantages and disadvantages of MRI imaging of the chest for diagnostic purposes.

- Advantages- Tissue contrast and ability to differentiate structures and pathology.
- Disadvantages- Motion (respiratory, cardiac)

- CT is great for detail and motion suppression, but lacks in tissue differentiation.
- MRI is just the opposite.
CT versus MRI Imaging

CT was the “Gold Standard”.
Great resolution. No Breathing Artifacts.
Can see calcifications well.

MRI has better tissue differentiation.
Better at Interstitial Fibrosis and Atelectasis.
Better at Pleural Effusion and Edema.
Better at visualizing “invasion” into other tissues and body cavities.
Detail !!
IV Contrast gives it tissue differentiation

MRI=Tissue Differentiation
T1 or PD ?
Review the normal CT and MRI images of the chest for anatomy and surrounding structures.
Chest Anatomy

- Mediastinum
- Heart
- Lung
- Liver
- Aorta
- Spleen
Discuss mediastinal abnormalities by compartment.

- **Superior-** Pancoast Tumors, Superior Sulcus Tumors
- **Anterior-** Sarcoma, Lipoma
- **Middle-** Bronchogenic Carcinoma
- **Posterior-** Sarcoma, Lipoma
- **Multiple-** Invasive Tumors
Discuss methods of reducing respiratory motion in MRI.
Methods of reducing respiratory motion.

1. Respiratory Gating
2. Cardiac Gating
3. Prone or “Pathology down” Positioning
4. Breath Hold Imaging
Name pulse sequences that are typically used when imaging the chest wall.

1. T1 FSE (TSE)
2. T2 Fat sat FSE (TSE)
3. Stir (FSE)
4. 3D SPGR (Spoiled Gradient Recall)
Describe the advantages and disadvantages of visualizing pleural plaques using MRI.

MRI better at differentiating extent of disease. Invasion and edema of surrounding area. CT = calcification.

Benign = Hypointense or Isointense on T1 and Hypointense on T2 Fatsat.

Malignant = (Inhomogeneous) Hypointense or Isointense on T1 and Hyperintense on T2 Fatsat.
Describe the advantages and disadvantages of imaging pleural effusion and pleural fluid levels using MRI.

MRI is very good at seeing Pleural Effusion. Unfortunately, MRI may be too sensitive. Fluid levels are hard to quantify because of patient positioning (Prone / Supine). We see a lot of “Benign” fluid in chest during normal CT and MRI Imaging. Lungs and surrounding tissue are “Wet” T2 Fatsat and Stir “sensitive” to water.
Describe the following benign chest wall lesions:

a. Adipose tissue tumors
b. Vascular Tumors
c. Peripheral Nerve Tumors
d. Tumors of Bone or Cartilage

Adipose Tissue Tumors- Just “Fat”. Can be small or large. MRI Fatsat or CT Hounsfield numbers (-50, -100) to DX. Lipoma

Vascular Tumors- Cavernous Hemangioma Peripheral nerve tumors.

Schwannomas, Neurofibromas, arise from Schwann cells, nerve sheath tumors.
Describe the following malignant chest wall lesions.
a. Sarcomas
b. Askin’s Tumor
c. Pancoast Tumor
d. Bronchogenic Carcinoma

- **Sarcomas** - arise from connective tissue. Form from middle layer (mesoderm). Mesoderm forms cartilage and bone.
- **Sarcomas** = Osteo, Chondro, Leiomyo,
- **Askins** - Rare **Primitive Neuroectodermal Tumor**. Soft tissue.
- **Pancoast** - Pulmonary Apex Tumor
- **Bronchogenic Carcinoma** - Lung Cancer
Osteochondromas. Most common. Usually occurs near the end of bones.

“Cartilage Cap” Tumors, 10% become malignant.

Endochondroma. Metaphyseal-diaphyseal region of the bone.

Chondroblastoma. Arises from epiphysis.

Most of these benign bone tumors show up in young people.
Breast MRI
Compare and contrast the sensitivity of MRI Breast imaging vs. the sensitivity of mammography.

- Mammography is essential for the baseline.
- With DCIS mammography shows calcifications which are an indicator of DCIS. (Ductal Carcinoma In Situ)
- MRI is very sensitive and needs to be read along side Mammography to come to a conclusion of the real disease process.
- Mammography is high resolution and has a longer diagnostic history than MRI. (Radiologist are comfortable with DX from Mammo)
Clinical Indications for BMRI

- Staging of patients with known Breast CA.
- Palpable lumps, Pain, Nipple retraction, Rash, Skin thickening.
- Abnormal Mammogram
- Strong Family History
- BRCA 1 or 2 +
- Silicone Implant Rupture
Factors that affect the quality of results when imaging the breast with MRI.

- Positioning.
- Patient cooperation.
- Manipulation of “Manual Prescan”
- Field and coil homogeneity.
- Timing of bolus (Gad injection)
Limitations of BMRI

• Body Habitus (Large or Small)
• Metal ?
• Mastitis
• Radiologist
• Menstral Cycle (Luteal Phase)
• Hormone Replacement Therapy
BMRI as a screening tool

- Breast MRI should not be used as a screening tool.
- Must follow “Continuity of Care” model.
- Mammo, Ultrasound, Bi-Rads.
- BMRI is quite sensitive, False positives.
Things to consider

Phase and Frequency Direction
Where's the artifact coming from and what will it obscure? What about Post Contrast?
INHOMOGENEITY
Must do Manual Pre Scan
T2 Fat sat, hard to have consistency with large FOV- Do breasts individually.
Single Breast using only half the coil.

4 coils out of 8.
Silicone Implants

For silicone implant rupture we must run a “Water sat” Inversion Recovery sequence.

This is pretty close to a regular STIR, but we need to “Center” our Frequency on WATER.

Water

Fat 220 hz

Silicone 330 hz

90 hz
Silicone Implants

- Silicone will dominate the signal.
- Silicone will **not** be Black on T1.
- Silicone “will” be bright on STIR.
- Silicone Rupture Protocol is the **same** as Breast Cancer Protocol.
- All implants will “Mask” out on post processed images.
Post Processed 3D silicone implants
Water Sat STIR- notice the Fat.
Saline Implants on T1 Vibrant Post
Notice how dark they are “Water”
Silicone Implants on T1 FSE.
Notice how they are not dark
Same Patient. Water Sat STIR Centered on Water, So water is nulled But Fat is too close to silicone.
Post silicone implant rupture with new “saline” implants. Water sat STIR
Same patient. Coronal STIR
Water bright, silicone not so much
Lymph Nodes
How does Breast MRI find CA

Tumor mediated **Angiogenesis**

Most malignant Breast CA directs the vascularity towards the tumor. Thus MRI with dynamic contrast can see angiogenesis.
Angiogenesis
Kinetics
Kinetic Curve- Washout Malignant

Kinetic curve over 7 minute scan will show “flush in Flush out”
Plateau Kinetics-Benign
Persistent- benign
Invasive Lobular- Check out the Lymph nodes.
Left side CA-Right side Parenchymal enhancement
Must be care of Menstrual Cycle Must be day 7-14 from start. Otherwise “Parenchymal enhancement.”
Types of Breast Cancer

- Ductal Ca in situ - Stays in ducts
- Lobular Ca in situ - In ducts lobular
- Invasive
- Mucinous
- Lymph node involvement
Dense Breasts.
Cardiovascular MRI - CMRI

- CMRI involves the heart and great vessels.
- Most important aspects are:
  - Gating
  - Breathholds
  - Imaging planes
Describe imaging techniques for imaging the thoracic aorta.

- All techniques are prescribed from the axial heart image.
- Prescribed parallel to the ascending and descending aorta to get a “candy cane” view.
- Can use:
  - Timing Bolus
  - Flouro Trigger
  - Time Resolved Imaging. Tricks/ Twist
  - GRE SSFP or FISP w/ contrast bolus @ 2 cc pr/sec
Candy Cane- Thoracic Aorta
Aortic Arch Anomalies

Coarctation
Aortic Aneurysm

A = ascending aortic aneurysm, B = Descending aortic aneurysm

Aorta exiting heart
Thoracic aorta
Artery to kidney
Abdominal aorta
Abdominal aortic aneurysm
Thoracic aortic aneurysm
Aortic Dissection

Usually from trauma. Can be visualized using CT, but may be affecting blood flow to the kidneys thus causing damage with CT contrast.
Review the normal CT and MRI images of the heart anatomy and vascular anatomy and surrounding structures.
How the pump works.

- Divided into Right and Left side.
- Beats 100,000 times per day
- Pumps 5 quarts of blood per day.
- Blue blood (no oxygen) returns to the heart thru the Rt. Atrium into the Rt. Ventricle.
- Then the heart contracts (systole) forcing blood into the Pulmonary artery and into the lungs.
- This oxygenates the blood, which is forced into the Lt. Atrium and into the Lt. Ventricle.
- The blood is then sent to the rest of the body.
- 4 Valves keep the blood flowing in the right direction. Tricuspid, Mitral, Pulmonary, and Aortic Valve.
Cardiac Cycle
Cardiac Pump
Diastole (Retract) Systole (Contract)
Flow- Jetting
Review the normal CT and MRI images of the coronary arteries.
Coronary Artery

The Coronary Artery originates from the ascending aorta and feeds oxygenated blood to the cardiac muscle (myocardium).
Cardiac Gating Cycle
Gating is Everything

- Q R S T
- We trigger off of the R wave.
- But the scanner likes to scan after the T wave when the heart is still.
- Also have Segmented scanning where the scanner only “sees” certain parts of the Cardiac cycle.
- Retrospective Gating
Heart Muscle

pseudoaneurysm
Cardiac Atypical Thrombus
Double IR- Bright Fat and Bright Water
Results in Nulled blood- Black Blood

Triple IR- Dependent on IR Time
TI 120 = Bright Water, Dark Fat
TI 300 = Dark Water, Bright Fat
TI 500 = Bright Water, Bright Fat

Thus Bright Blood
Describe the advantages and disadvantages of the following MRI sequences and give examples of each type.

a. Black blood

b. Bright blood.

- Black blood imaging is used to depict anatomy, pericardial and mediastinal abnormalities, and extraluminal aortic disease.
- Bright blood imaging is used to demonstrate flow and motion and to image valvular disease.
Black Blood

- Black blood imaging includes ECG-gated true spin-echo or fast spin-echo imaging or inversion-recovery (IR) half-Fourier single-shot turbo fast-spin-echo sequences. Spin-echo sequences generate black blood due to time-of-flight effects of flowing blood that vary with the echo time (TE).
Bright Blood

- Bright blood cine sequences include segmented-k-space small-flip-angle gradient-echo sequences or fast imaging with steady-state precession or refocused steady-state free precession (SSFP).
Short Axis Black Blood
Short Axis Image- Black and Bright
Bright Blood
4 Chamber
Describe the different imagine planes for cardiac MRI and explain how you would position for each plane.

- Important MR imaging views include the true planar, two-chamber scout, short axis, long axis, four-chamber, and true two-chamber. The true planar view may be seen in axial, sagittal, or coronal sections. To achieve a two-chamber scout view, a true axial view through the left ventricle should be obtained, and then an oblique coronal scout view should be positioned parallel to the interventricular septum.
Imaging Planes

- 2 Chamber
- 3 Chamber
- 4 Chamber
- Shot Axis
- Long Axis
Four Chamber Heart

Rt. Atrium

Rt. Ventricle

Lt. Ventricle

Lt. Atrium

Mitral Valve
Four Chamber
Figure 2. Normal two-chamber view.
2 Chamber View
Cut plane bisects LV apex (1) & mitral valve (2) in 4-C view.
Through mid LV chamber (3) in short axis view.
Parallel to ventricular septum in both views.
Move the plane (blue) defining the left 2-chamber view to the right side of the heart. Slightly adjust the plane to get it parallel with the septum if needed. Cut precisely through the tricuspid valve.
Left Aortic Outflow Tract (LVOT) View

Bisect ascending aorta and aortic valve on 3-chamber view
Short axis planning
Short Axis Slice Set up
3 Chamber
4 Chamber
Cut plane parallel to long axis in 2-C view, bisecting mitral valve and apex
Through mid LV chamber and RV apex (1) in mid short axis view
Avoid LV outflow tract (2) in basal short axis view
Explain the rationale for using MRI to image the heart. What are some of the benefits of imaging the heart with MRI over CT? Angiography?

- CT is quickly being replaced by MRI for most Cardiac imaging.
- CT is still best for Coronary Artery.
- CT is still better for Pulmonary Embolism.
• MRI can be effectively gated.
• Can use segmentation.
• Can differentiate tissues.
• Can see scar or fibrosis of the myocardium.
• Can see motion of heart wall.
• Ejection/Fraction.
When imaging the heart, what disease processes would be beneficial to image using MRI? Explain why for each.

- MRI beats CT in:  
  - Cardiac Function  
  - Regurgitation  
  - Congenital Defects  
  - Transposition of great vessels  
  - ASD-Atrial Septal Defect  
  - Fontam- One Ventricle  
  - Viability Studies  
  - Post Ablation Studies  
  - Sudden Death
Cardiac Neoplasms

- Myxoma: Left Atrium
- Fibroma: Left Ventricular Septum
- Lipoma: Left and Right Atrium
- Rhabdomyoma: Left and Right Ventricle
- Papillary Fibroelastoma: Aortic, Mitral, Pulmonic Valves
- Angiosarcoma: Right Atrium, Pulmonary Artery
- Hemangioma: Left Ventricle
- Paragangliomas: Left Atrium Roof, Spine
- Pericardial Mesothelioma: Pericardium