



# Assessing the pulmonary arteries: angiography, CT scan, MRI



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- Pulmonary arterial (PA) tree is a complex 3 dimensional structure
- Flow and pressure in the pulmonary arteries is affected by the right ventricle, pulmonary valve, vessel lumen, arborization of the branches, source of flow, adjacent structures, and the pulmonary veins....
- Assessing the PA tree can be difficult and may require multiple imaging modalities
  - Angiography (static, rotational)
  - CT
  - MRI

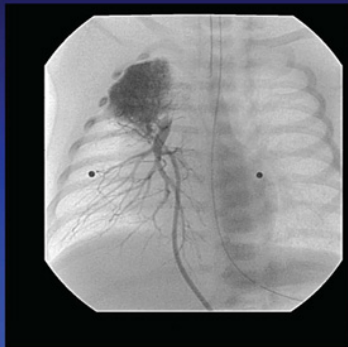
- Assessing “absent” pulmonary arteries
  - Aortic angiograms
  - Pulmonary vein wedge angiograms
- Assessing adjacent structures
  - Levophase
  - Simultaneous injections
- “Rotational” angiography

# Congenital absence of RPA?

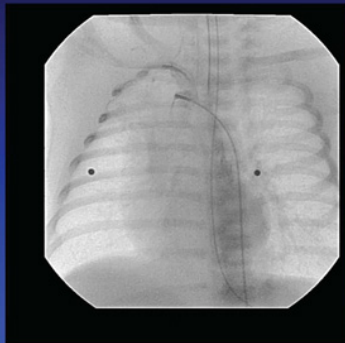


# Isolated RPA off right occluded ductus

RUPV wedge angiogram



Tiny remnant ductus off  
base of right subclavian



# F/U cath 2 years after unifocalization

RPV wedge



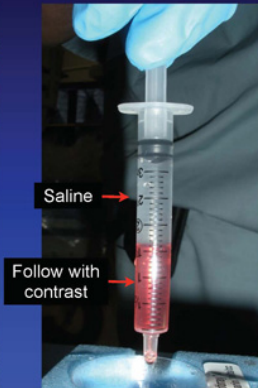
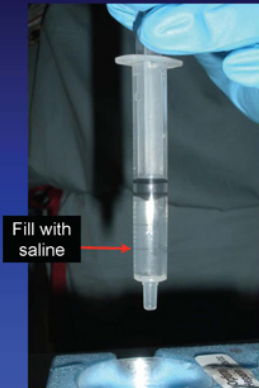
Stent ductus



Growth of RPA

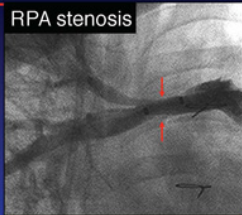


# Technique for wedge angiograms

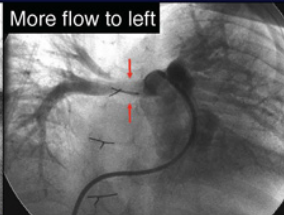


# Branch PS due to external compression

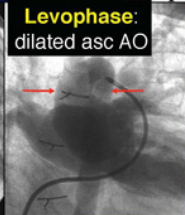
RPA stenosis



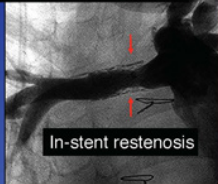
More flow to left



Levophase:  
dilated asc AO

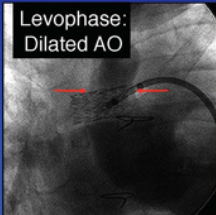


Stented RPA-f/u cath

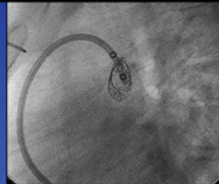


In-stent restenosis

Levophase:  
Dilated AO



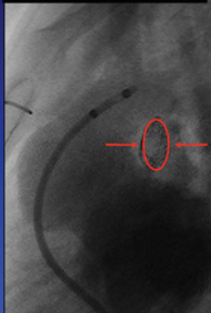
LAT: Stent compressed



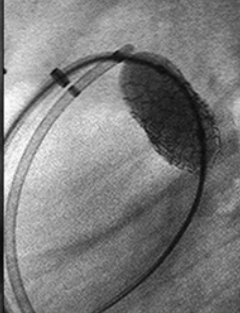


# Second stent added to provide additional support

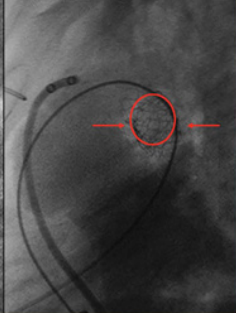
Stent compressed by dilated anterior ascending aorta



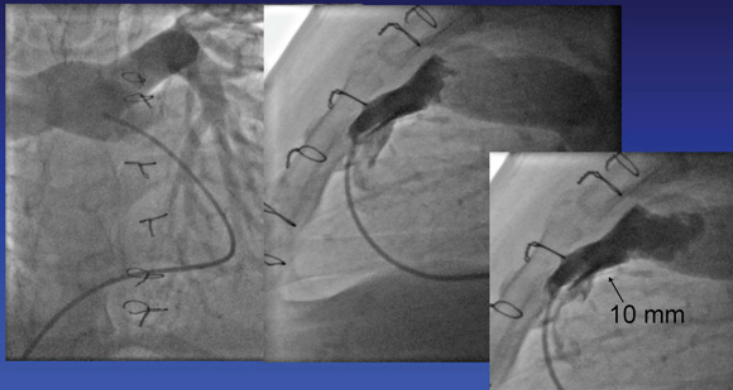
2nd stent telescoped into 1st stent



Post

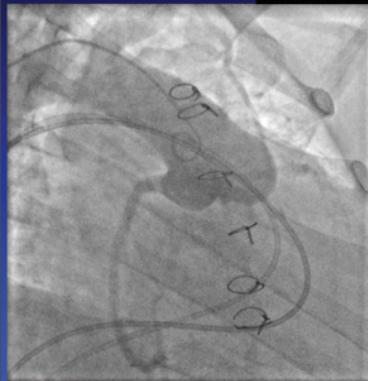


# Conduit stenosis (52 mmHg gradient)

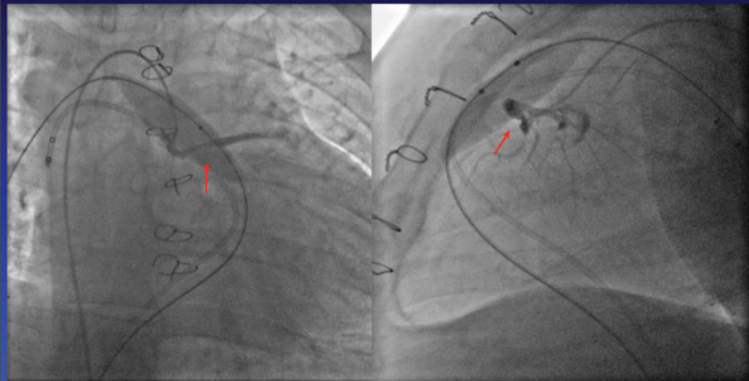


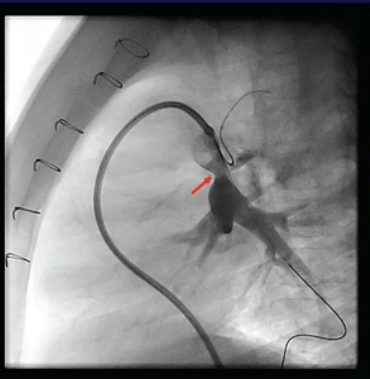
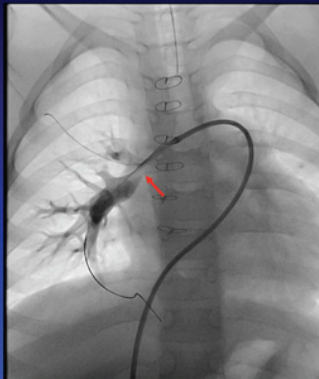
# Aortogram to assess coronary course

Leave catheter in RVOT



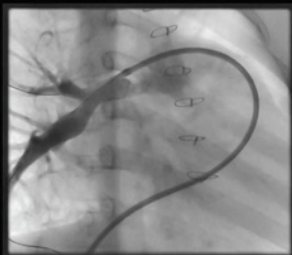
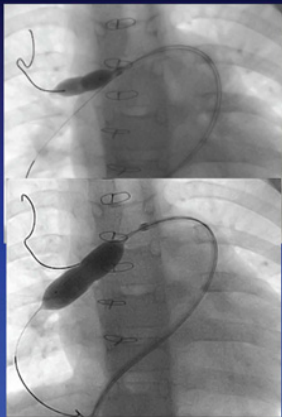
# Balloon test inflation and selective coronary injections





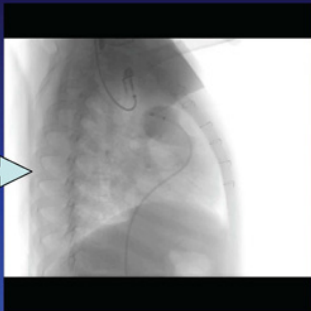
Courtesy of Dr. Henri Justino

# Angioplasty of RPA/RUL

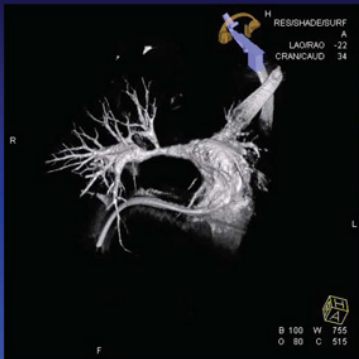
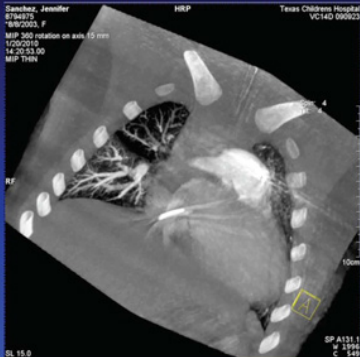


Stent and jailed RUL?  
Risk obstructing flow to RUL?

# Rotational angiography in cath lab

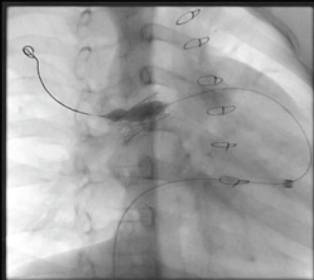


# 3D reconstruction

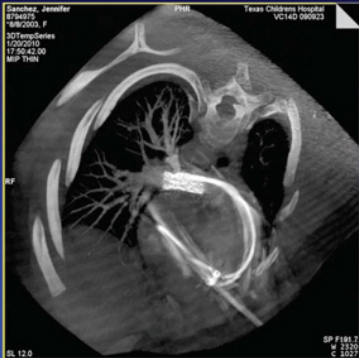




# Stent RPA stenosis & balloon RUL through side of stent



# Post-stent rotational angiogram



Rotate on radial-axis of stent



Rotate on oblique-axis of stent

Mild RPA stenosis



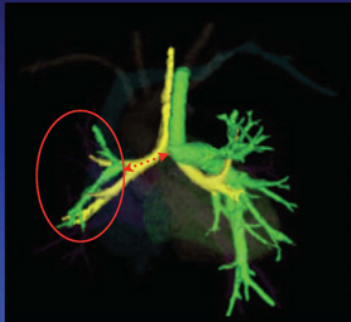
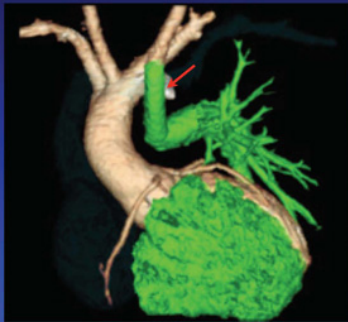
Central shunt to isolated LPA



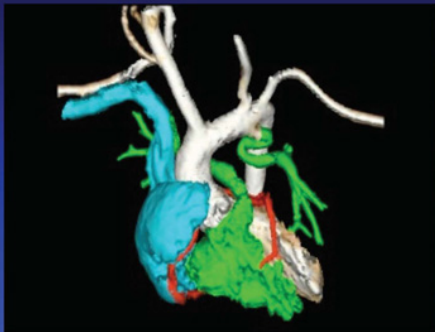
Courtesy of Dr. James Mathewson

# Innominate artery shunt to LPA

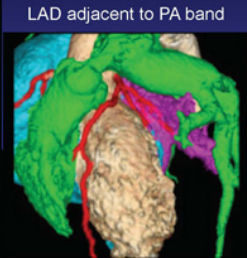
RPA is hypoplastic and isolated



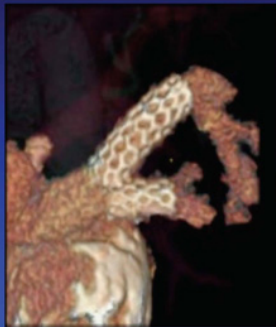
# TOF with discontinuous PAs



# Banded PA



Stents in situ



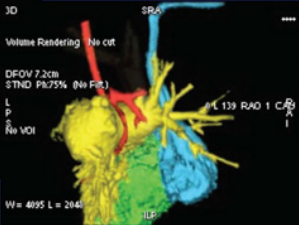
LPA stent with neo-intima formation  
(each slice 0.5 mm)





# TOF with absent pulmonary valve

Marked dilated LPA



Left main bronchus deviated to right and compressed by dilated LPA



W = 4095 L = 2048

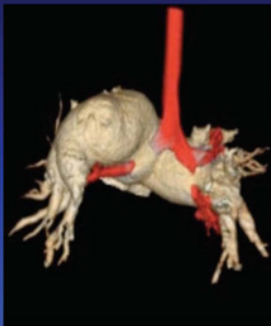


# TOF with absent pulmonary valve

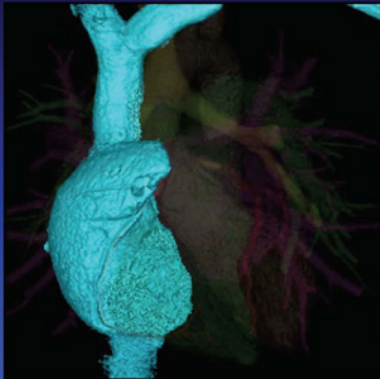
Posterior view-near occlusion of  
right main stem bronchus (red)



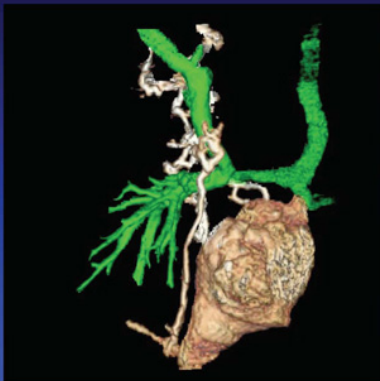
Dilated PAs completely occluded both right  
& left main stem bronchi with patient supine



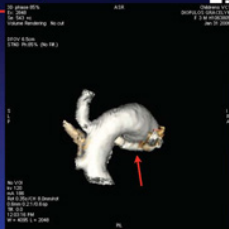
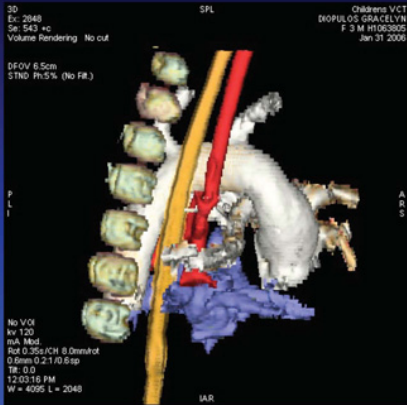
# Building the heart



# Heterotaxy w/ dextrocardia & bilat Glenn shunts



# S/P unifocalized PAs/ central shunt (4-D)

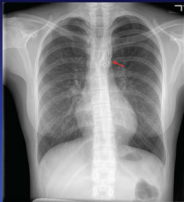


- Non-invasive
- No radiation
- Excellent temporal resolution
  - Limited by heart rate (overcome by longer scan time)
  - Useful for functional analysis
- Excellent spatial resolution
  - 750 microns (0.75 mm)
- Bright blood vs. Black blood
- Static vs. cine images / multiple planes
- Unaffected by body size, implanted devices

# Cardiac MR Disadvantages

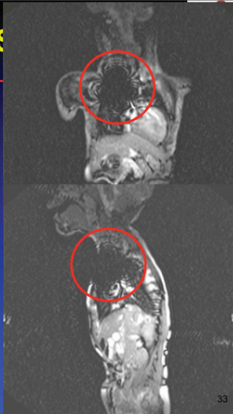
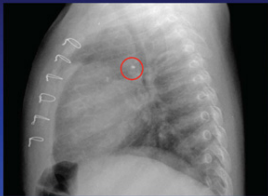
- Time consuming to image and post-process
  - Longer acquisition time than CT
  - Avg acquisition time: 50 minutes
- Temporal resolution inferior to echo
- Spatial resolution inferior to CT
- Need sedation in young children
- Artifacts-stents, devices create local artifacts; coils obscures larger area

# Artifacts - Stents



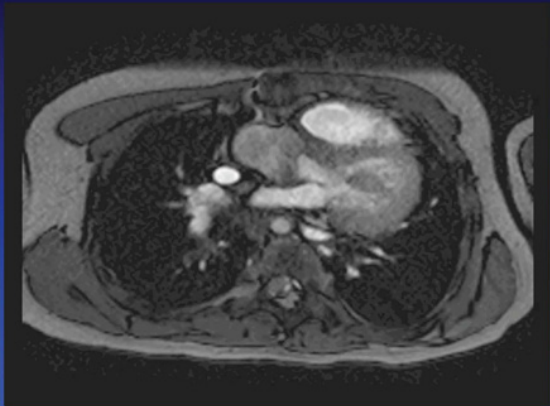
Courtesy of Dr. Tim Slesnick<sup>32</sup>



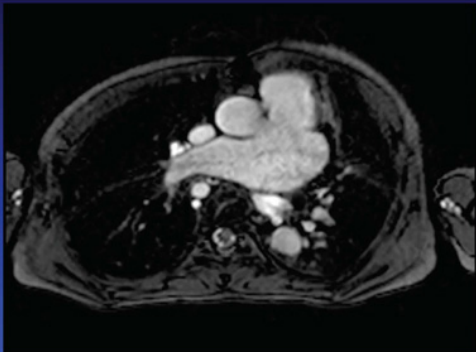


- Bright blood cine images
- Gradient echo images (GRE)
- Thin slices (down to 2mm)
- Evaluate vasculature
- Full stack covering entire chest in 5-8 minutes

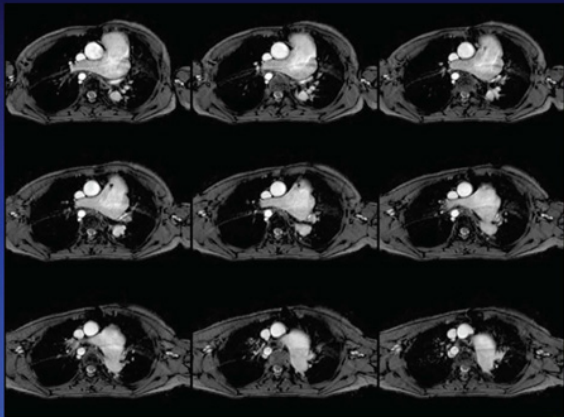
# Axial GRE Images TOF/LPA stenosis due to fold



# Axial GRE Images TOF/absent pulmonary valve



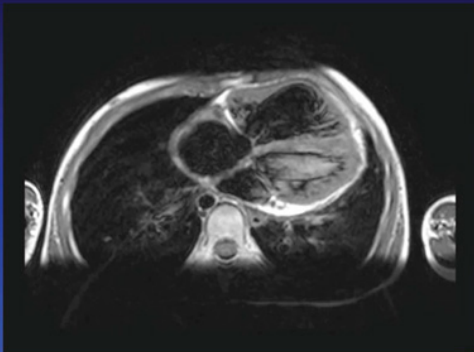
# Full stack of "slices" of images

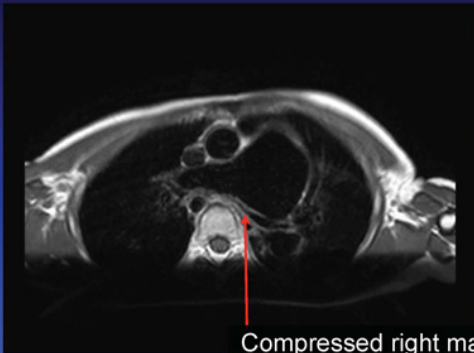


# Black blood imaging

- Black blood, static images
- Slices down to 2 mm
- Rapid imaging sequence (stack covering chest in 3 min)
- Useful to see trachea and carina

# Black blood imaging TOF absent PV

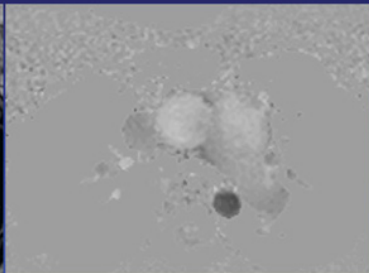
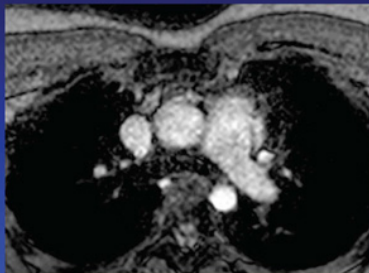




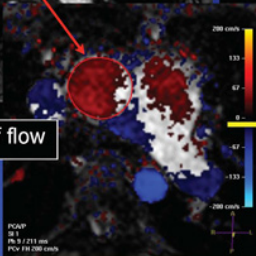
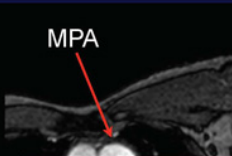
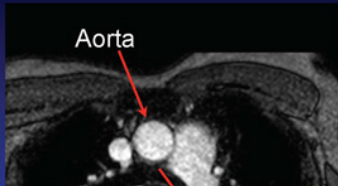
Compressed right mainstem  
bronchi by dilated RPA



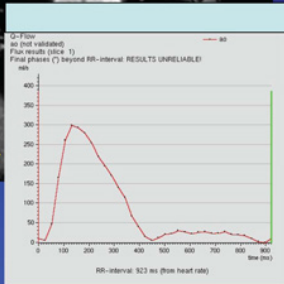
- PC, Q-flow, flow velocity imaging; Detect & analyze flow



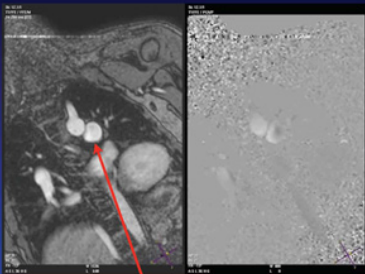
# Phase contrast analysis (CI, Qp/Qs)



• Analysis of flow



# Differential pulmonary flow



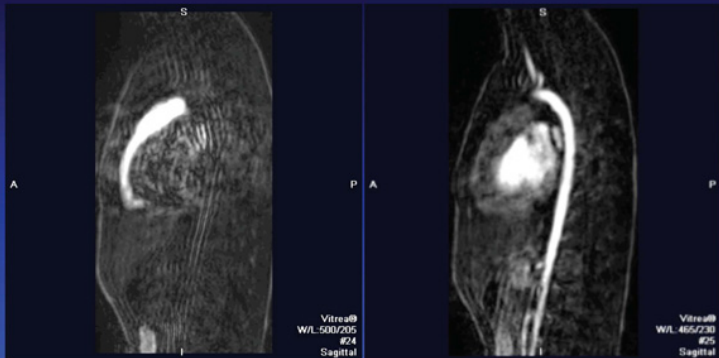
LPA



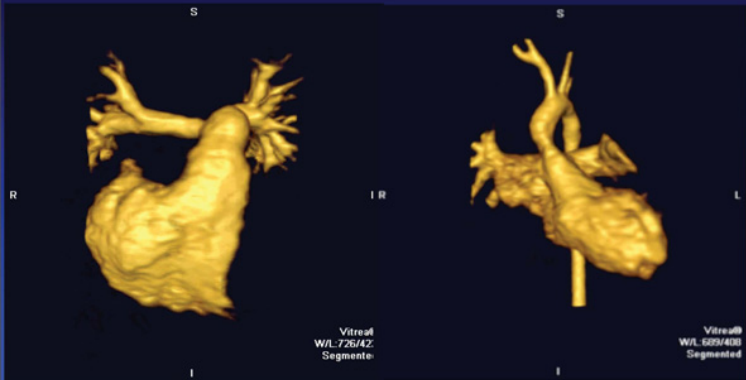
RPA

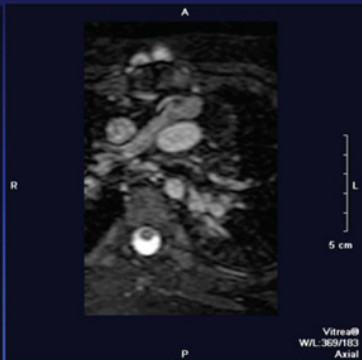
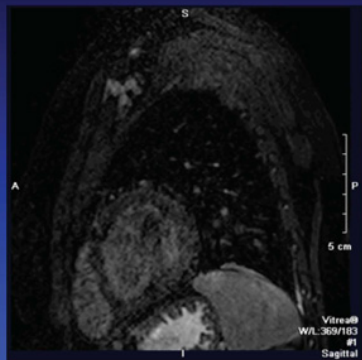
# Contrast enhanced MR Angiography

- Bolus injection of Gd, 0.2 mmol/kg
- Obtain 3-D volume of cardiovascular system.
- Manipulate in any plane of interest
- Useful to evaluate pulmonary and systemic arteries as well as venous dynamics



# 3D Reconstruction





- Multiple imaging modalities are available to assess the pulmonary arterial tree
  - Conventional “static” angiography
  - “Rotational” angiography
  - CT angiography
  - Cardiac MR imaging
- Using a combined approach, the pulmonary arterial tree can be precisely evaluated for diagnostic and interventional purposes



