Gad-enhanced MRA: Aorta and Great Vessels

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AORTA

The aorta remains the most common MRA study at our institution. Patients with known or suspected aneurysms, aortic dissections, and vasculitis are referred for aortic MR angiography.

Techniques

Imaging protocols are rapidly evolving. In order to image the aorta in the recent past, we commonly performed several sequences including axial and sagittal oblique T1 weighted fast spin echo (FSE), axial "bright blood" GRE, and a gadolinium-enhanced 3D MRA. Currently we normally perform only two imaging sequences, an ECG-triggered axial double inversion recovery and a gadolinium-enhanced 3D MRA.

Depending on the patient history and medical stability the protocol is tailored for most examinations. In critically ill patients, who we do not wish to keep in the scanner for a prolonged period of time, we perform a very limited exam, often including only a 3D Gad MRA. This will usually provide enough information in an exam that takes only 5-10 minutes. While the 3D MRA studies are very rapid, they do not give information about the aortic wall itself, therefore we also like to perform the axial images to look for intramural dissections, wall thickening, and other extra vascular pathology such as hematomas, masses, and adenopathy.

Aortic MRA – Indications

- Aortic Aneurysm
- Aortic Dissection
- Vasculitis Evaluation
- Proximal Great Vessel Pathology

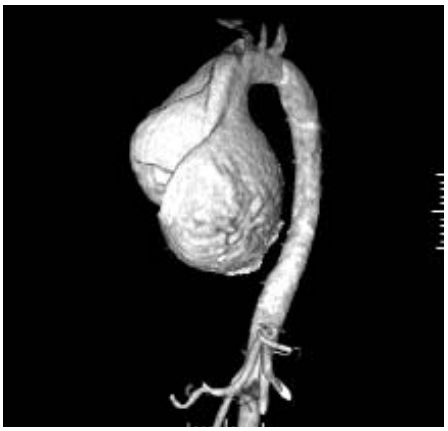

Fig 1. *A gadolinium-enhanced 3D MR angiogram of the thoracic aorta in a patient with cystic medial necrosis and a very large ascending aortic aneurysm.*

- Congenital Anomalies
- Post Surgical Follow-up
- Contraindication to CT

Axial FSE or DIR images are performed routinely and give the best "lay of the land" impression. Radiologists and other physicians are accustomed to viewing axial cross-sectional images through the thorax. The sagittal oblique images, oriented through the plane of the aorta, give a "candy-cane" view of the vessel and are useful for evaluating coarctation and dissections. The second FSE sequence does add time to the exam so we frequently omit this sequence unless there is a specific question that it may answer.

The "bright blood" GRE images are very useful for assessing the patency of small vessels and surgical shunts. These can also be performed as a "multiphase" sequence where up multiple images are acquired throughout the cardiac cycle. These are then rapidly displayed in a cine-loop and give the impression that the heart is beating and blood is flowing. This is especially useful for assessing the aortic valve for stenosis or regurgitation.

Many patients with aortic dissections or other aortic pathology can be routinely followed with MRA safely. They are not exposed to ionizing radiation or nephrotoxic contrast agents. Patients with allergy to iodinated contrast can also under go MR and most frequently can receive gadolinium with reaction or need for premedication.

Applications

Aortic dissections involve a disruption of the tunica media. Flowing blood enters the "false lumen" via an intimal tear "entry tear". It may continue to flow and exit via "reentry tear"; or thrombose. The are associated with hypertension and Marfan´s disease.

Complications include hemopericardium and tamponade, aortic valve disruption and aortic insufficiency, MI from coronary artery occlusion, exsanguination from rupture into mediastinum and chest and aortic branch occlusion; stroke, renal failure, mesenteric ischemia.

Aortic aneurysm may be fusiform aneurysms taper proximally and distally, involve entire aorta or saccular aneurysms that "balloon out" from a focal region. True aneurysm involves dilatation of all layers of aortic wall, false "pseudo" aneurysm involves part of wall; adventitia and surrounding fibrous tissue. Multiplanar MR accurately measures true dimension (external dimension best; thrombus does not provide strength). Cine-GRE MR evaluates for AI.

Aortitis leads to wall thickening and lumen narrowing/constriction. MR is useful for evaluation of branch vessel patency (aortography difficult). It also follows effect of therapy noninvasively.

Aortic Dissection – Classifications

Debakey 1965

Type I: Intimal tear in ascending Ao; terminates distal to innominate a.
Type II: Intimal tear in ascending Ao; terminates prox to innominate a.
Type III: Tear at or distal to LSCLA

"Stanford" (Daily 1970)

Type A: Involves ascending aorta +/- descending Ao; needs immediate surgery
Type B: Involves descending aorta only. Managed via medical control of HTN

Aortic MRA – Protocol

Body or torso phased-array coil, ECG Gating

Basic Protocol

- Coronal SSFSE (HASTE) scout
- Axial T1 FSE or double IR images
- 3D Gad-enhanced MRA

Additional Sequences

- Sag Obl T1 FSE
- Multiphase (Cine) Axial "bright blood" GRE
- Axial "bright blood" GRE

GREAT VESSELS

The carotid arteries and subclavian vessels are also frequently imaged with MR angiography. We commonly perform a comprehensive evaluation of the extracranial great vessels using a gadolinium-enhanced 3D MRA approach which uses both a dedicated neurovascular coil as well as a new elliptical centric phase encoded 3D sequence. The elliptical encoded sequence fills the critical central portion of k-space during the first several seconds of the exam and then "spirals" out to fill the peripheral portions. This necessitates that the patient hold perfectly still only during the initial part of the acquisition. The resulting images have relatively high spatial resolution as compared to prior techniques (see Huston J et al Radiology 1999 for additional information)

While non-contrast MRA of the carotid

bifurcation is an accurate exam, it does have some fairly well known limitations, including intravoxel dephasing and motion artifacts. The exam also does not include the carotid or vertebral origins that can have concurrent disease in a small but significant number of cases.

Gadolinium-enhanced MR angiography is a promising technique for the evaluation of patients with carotid occlusive disease because it rapidly images the carotid arteries from the aortic arch to the skull base and eliminates some of the artifacts that degrade 2D TOF MR angiography.

References

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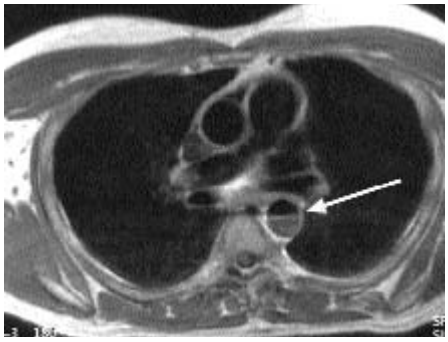

Fig 2. *Axial double inversion recovery (DIR) image depicts a flap in the descending aorta.*

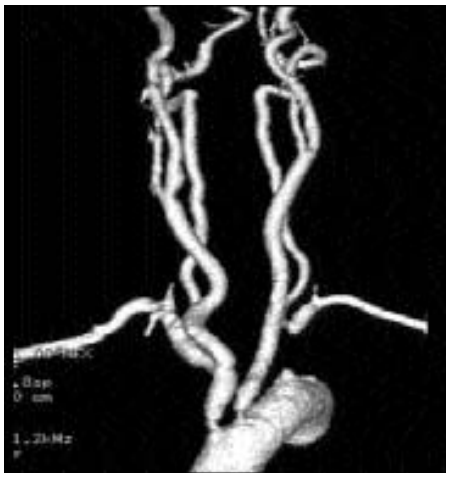

Fig 3. *A gadolinium-enhanced 3D MR angiogram depicts left subclavian occlusion and left carotid and innominate artery stenoses.*

Fig 4. *Gad-enhanced carotid MRA. Neuro-vascular coil was used for this study which depicts vessels well from the arch to the circle of Willis (below).*

THORACIC AORTA MRA

System GE LXi Software version 8.0

POSITION
Position: Supine
Patient Entry: Feet First
Coil: Torso
Series: EFGRE3D

IMAGING PARAMETERS
Plane: Sagittal
Mode: 3D
Pulse Sequence: Vas TOF SPGR
Options: VBw, Fast, MPh, ZIP512, ZIP2

SCAN TIMING
TE: Minimum
Flip Angle: 45
Bandwidth: 42

SCAN RANGE
FOV: 36-44
Slice Thickness: 1.6-2.4
Locs per slab: 32-40

ACQUISITION TIMING
Freq: 256
Phase: 160-192
NEX: 0.5
Phase FOV: 0.6-0.8
Freq Dir: S/I
Auto Cent: Water

ADDITIONAL PARAMETERS

User CV´s	**Multiphase**	**Sat Bands**
Turbo	**No Phases:** 3	none
	Delay: Minimum	

CONTRAST: 20-30 cc @ 2cc/sec followed by NS 20 cc @ 2 cc/sec

TIMING: Acquisition delay after start of Gad = Time peak enhancement - (cc Gad/2) + (Acq time/2)

TIPS:
Arms at side
FOV should include lower neck to upper abdomen
Do a second post gad run immediately after first, allowing for a quick 5 sec breathhold

Other Series
Cor SSFSE Scout
Axial Double IR
Axial 2d FIESTA or Fast Cine
Optional Oblique 2d FIESTA or Fast Cine
Timing Run
3d Series, 1 pre and 2 post

CAROTID MRA

System GE LXi Software version 8.0

POSITION
Position: Supine
Patient Entry: head First
Coil: NV array
Series: EC Gad

IMAGING PARAMETERS
Plane: Coronal
Mode: 3D
Pulse Sequence: Vas TOF SPGR
Options: Fast, ZIP512, ZIP2

SCAN TIMING
TE: Minimum
Flip Angle: 45
Bandwidth: 31.25

SCAN RANGE
FOV: 26
Slice Thickness: 1.6
Locs per slab: 44

ACQUISITION TIMING
Freq: 256
Phase: 224
NEX: 1
Phase FOV: 0.9
Freq Dir: S/I
Auto Cent: Water

ADDITIONAL PARAMETERS

User CV´s
Turbo: 1
Ellipitical Centric 1.0

Multiphase

Sat Bands
none

CONTRAST: 20-30 cc @ 2cc/sec followed by NS 20 cc @ 2 cc/sec
TIMING: Acquisition delay after start of Gad = Time peak enhancement (at carotid bulb)
TIPS: Timing critical
Time at carotid bulb
Breath hold first 10-20 sec
Protocol: varies