

# MRI of the Abdominal Aorta and Renal Arteries

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## ABDOMINAL AORTA MR ANGIOGRAPHY

The abdominal aorta is well imaged with MR angiography. The approach is similar to the thoracic aorta, although ECG-gating is not required. We usually perform a combination of axial T1 weighted GRE and gadolinium-enhanced 3D MRA. The studies are performed rapidly, normally in 15 minutes or less. Because of set-up and room turn-around considerations we schedule patients for 30-minute slots on our MR systems.

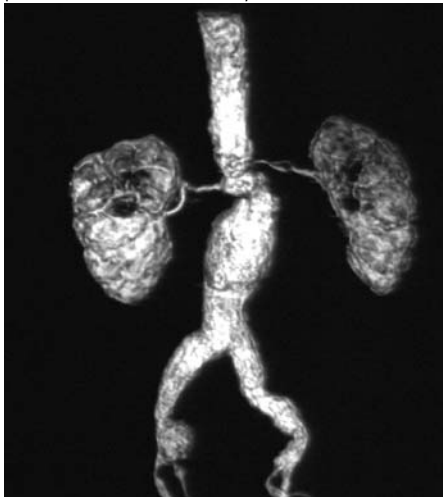
The exam is performed for numerous indications, including dissection, aneurysm, and vasculitis. The branch vessels are well depicted by MRA, especially the renal arteries, celiac, and SMA arteries. We often screen patients who are potential renal donors, or who have abdominal aortic aneurysms and are being evaluated for stent graft placement.

The abdominal aorta is best imaged in the coronal plane on contrast-enhanced 3d MRA. This allows for inclusion of the iliac system, the renal, superior and inferior mesenteric, and celiac arteries.

### Abdominal Aortic MRA – Indications

- Aortic Aneurysm
- Aortic Dissection
- Vasculitis Evaluation
- Presurgical planning - AAA, stent-grafts
- Post-surgical Follow-up
- Contraindication to CT/iodine allergy/renal failure

Focused studies of the celiac axis and the superior mesenteric arteries are also performed accurately with contrast



**Fig 1.** A gadolinium-enhanced 3D MR angiogram of the abdominal aorta.

enhanced 3d MRA. When imaging these vessels, we reduce the field of view to maximize resolution of these smaller arteries.

A coronal imaging slab is positioned to include the entire aorta and iliac vessels. Often the aorta takes a very ectatic course or an aneurysm may extend far anteriorly into the front of the abdomen, so careful review of the axial T1 GRE images, acquired before the 3d Gad-MRA, needs to be performed so that critical anatomy is not excluded during the acquisition. The common iliac arteries are the most posterior of the imaged vessels, so the slab must be positioned with this in mind. We have inadvertently excluded these vessels in the past which are critical for surgical or interventional planning.

Once the 3d sequence is set up and a timing method determined (see Gad-MRA Intro), the post-contrast images are acquired and post processed. We always perform two concurrent post contrast acquisitions, separated by a quick breathhold. The second post-contrast acquisition can be very useful in the abdomen in several instances; if there is an aortic occlusion, contrast may take a longer amount of time to reach the iliac vessels via collaterals, and these may not be depicted on the immediate post contrast images. Venous structures will usually be well enhanced on the second acquisition, which may be clinically important in some cases.

### Abdominal Aortic MRA

Torso phased-array coil

#### Basic Protocol

- Coronal SSFSE/HASTE Scout

- Axial T1 GRE
- Timing Exam (Optional)
- 3D Gad-Enhanced MRA
  - Unenhanced – Check Positioning
  - Post-Gad X 2 Acquisitions
- Post Contrast Axial T1 GRE

#### Additional Sequences

Axial “bright blood” GRE

In pre surgical or interventional cases, the 3d images can be used to determine sizes of all the critical anatomy, e.g., the length and diameter of an aneurysm, the position of the aneurysm neck in relation to the renal arteries etc. We rely on the T1 GRE images for measuring the outer diameter of an aneurysm since this is not well depicted on the 3d Gad-MRA images.

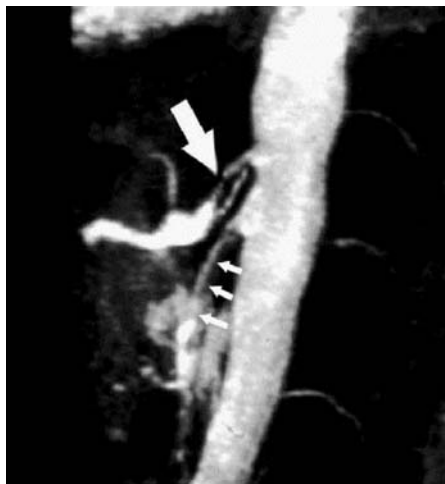
## RENAL MR ANGIOGRAPHY

Renal MRA remains the most commonly performed gadolinium-enhanced MRA in our practice, followed closely by carotid imaging. Renal MRA is used most commonly for the evaluation of potential renovascular hypertension and renal insufficiency. Like abdominal aortic MRA, renal MRAs are performed quite rapidly, the entire study uses approximately 15 minutes of MR “table time” and patients are generally scheduled in 30-minute time slots.

The evaluation of renal vascular hypertension is a complex issue. Other screening modalities, including duplex sonography and nuclear medicine exams are not always reliable. Renal CEMRA has reported sensitivity and specificity in excess of 90% (see table) and makes an excellent screening exam if performed correctly. It is

### Aortic MRA Parameters

| Sequence                   | 3d gradient echo (EFGRE GE Users) |
|----------------------------|-----------------------------------|
| Coil                       | Torso                             |
| Field of view (FOV)        | 24 - 40 cm rectangular 70-90%     |
| Matrix (phase x frequency) | 160-192 x 256-512                 |
| Bandwidth                  | 32-64 kHz                         |
| TR                         | Minimum ~4-6 msec                 |
| TE                         | Minimum ~1-2 msec                 |
| Flip angle                 | 30-45 degrees                     |
| Partition thickness        | 1.6 - 3 mm                        |
| Number of partitions       | 24 - 40                           |
| Number of acquisitions NEX | 0.5                               |
| Acquisition time           | 18-32 sec                         |
| Other options              | Zip x 2, Zip 512                  |



**Fig 2.** Gad enhanced 3d MRA depicts a clot within the celiac axis (large arrow) and a nearly occluded superior mesenteric artery (small arrows) in a patient with Protein S deficiency syndrome.

performed safely in patients with renal insufficiency unlike renal CTA which uses nephrotoxic contrast media.

**Renal MRA Studies**

| Author       | Sens. | Spec. |                           |
|--------------|-------|-------|---------------------------|
| De Cobelli   | 100   | 97    | Radiology 1997<br>205:689 |
| Bakker et al | 97    | 92    | Radiology 1998<br>207:497 |
| Tello et al  | 100   | 98    | JMRI 1998<br>8:421        |
| Hany et al   | 93    | 98    | Radiology 1997<br>204:357 |

The clinical consequences of renal artery stenosis include renal vascular hypertension and ischemic nephropathy. RAS is the cause of hypertension in 1% to 5% of patients with elevated blood pressures. An estimated 16% of patients with end stage renal disease have ischemic nephropathy. Atherosclerosis is the cause of 75% of RAS; the remainder is due to fibromuscular dysplasia. Atherosclerosis typically affects older patients while FMD presents in younger patients.

Because of resolution limitations of current techniques, the evaluation of suspected FMD or branch renal artery stenosis is not optimal with MRA and conventional angiography should be considered. In cases of FMD, moderate or high-grade stenosis is easily depicted, but more subtle disease, or disease involving the segmental arteries may be missed. For the same reason, small intrarenal vascular changes as seen with PAN will also likely be missed with renal MR angiography.

**Renal MRA – Indications**

**Ideal Candidates**

- Renovascular Hypertension
- Post Surgical / Angioplasty Follow-up

**Evaluation**

- Renal Insufficiency
- Renal Artery Dissection
- Renal Vein thrombosis
- Renal artery aneurysms

**Use with caution**

- Young HTN pt with possible segmental stenosis
- Fibromuscular dysplasia

The examination is very rapid when contrast-enhanced technique is used. We perform coronal and axial precontrast images to accurately determine the kidney position prior to the 3D GRE CEMRA. With accurate positioning, a small field of view is used to maximize image resolution. Placing the patient's arms above their heads helps prevent wrap in the phase encoding



**Fig 3.** Right renal artery stenosis and a normal left renal artery and right accessory renal artery.

direction.

Unlike conventional angiography, determination of an accurate percentage stenosis is not possible with CEMRA. We normally report categories of stenosis; normal, minimal (0-25%), moderate (25-75%), severe (75-90%), or high grade (90-99%), and occlusion (100%). Patients with moderate or higher stenosis are referred for conventional angiographic evaluation (and potentially therapeutic intervention if clinically appropriate).

In cases where the degree of stenosis is difficult to determine on the 3d Gad-MRA study, the addition of a phase contrast (PC) angiogram is reported to be useful (Prince et al). They found that if there is actual signal loss on the PC images, the stenosis is hemodynamically significant. We have not found it necessary to incorporate this technique in our routine studies.

**Renal MRA Protocols**

**Basic Protocol**

- Coronal SSFSE scout
- Axial T1 GRE (pre and post gad)
- 3D Gad-enhanced MRA

**Additional Sequences**

- T2 FSE
- Phase Contrast Angiography

Pitfalls of renal MRA include its unknown accuracy for evaluating small accessory renal arteries. The resolution of most

currently used renal MRA techniques is approximately 1-5 to 2.5 mm. While this is quite useful when evaluating a normal size main renal artery, it is potentially problematic when assessing a 2mm accessory vessel.

The presence of accessory renal arteries can be reliably depicted, but determination of a stenosis of one of these small vessels may be difficult. For the same reason, segmental arteries are not well evaluated with MRA. Other pitfalls on renal MRA include artifacts from stents, clips, and vena caval filters – each can cause artifactual signal loss that could be misconstrued as a stenosis.

We work closely with our referring physicians to make sure this new modality is used appropriately. This involves giving educational presentations to physician groups that stress the indications, limitations, and contraindications of the modality. We also solicit feedback after a patient is imaged; both from our interventional radiologists who may study and/or intervene on these patients as well as surgeons and cardiologists.

## References

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### Renal MRA Parameters

| Sequence                     | 3d gradient echo (EFGRE GE Users) |
|------------------------------|-----------------------------------|
| Coil                         | Torso                             |
| Field of view (FOV)          | 22-36 cm rectangular 70-90%       |
| Matrix (Phase x frequency)   | 160-192 x 256-512                 |
| Bandwidth                    | 32-64 kHz                         |
| TR                           | Minimum ~4-6 msec                 |
| TE                           | Minimum ~1-2 msec                 |
| Flip angle                   | 30-45 degrees                     |
| Partition thickness          | 1.6 - 2.4 mm                      |
| Number of partitions         | 24 - 40                           |
| Number of acquisitions (NEX) | 0.5                               |
| Acquisition time             | 18-26 sec                         |
| Other options                | Zip x 2, Zip 512                  |

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## RENAL MRA

System GE LXi Software version 8.0

### POSITION

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

### IMAGING PARAMETERS

**Plane:** Coronal  
**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:** 28-36  
**Slice Thickness:** 1.6-2.4  
**Locs per slab:** 32-40

### ACQUISITION TIMING

**Freq:** 256      **Freq Dir:** S/I  
**Phase:** 160-192      **Auto Cent:** Water  
**NEX:** 0.5  
**Phase FOV:** 0.9

### ADDITIONAL PARAMETERS

#### User CV's

**Turbo:** 1

#### Multiphase

**No Phases:** 3  
**Delay:** Minimum

#### 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 - (cc Gad/2) + (Acq time/2)

#### TIPS:

Arms above head or across abdomen to avoid wrap  
 FOV should be less than body width at level of renals  
 Do a second post gad run immediately after first, allowing for a quick 5 sec breathhold

#### Protocol:

Cor SSFSE Scout  
 Axial T1 FMPSPGR  
 Timing Run  
 3d Series, 1 pre and 2 post  
 Axial T1 FMPSPGR

## ABDOMINAL AORTA MRA

System GE LXi Software version 8.0

### POSITION

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

### IMAGING PARAMETERS

**Plane:** Coronal  
**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:** 28-36  
**Slice Thickness:** 1.6-2.4  
**Locs per slab:** 32-40

### ACQUISITION TIMING

**Freq:** 256      **Freq Dir:** S/I  
**Phase:** 160-192      **Auto Cent:** Water  
**NEX:** 0.5  
**Phase FOV:** 0.9

### ADDITIONAL PARAMETERS

#### User CV's

**Turbo:** 1

#### Multiphase

**No Phases:** 3  
**Delay:** Minimum

#### 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 - (cc Gad/2) + (Acq time/2)

#### TIPS:

Arms above head or across abdomen to avoid wrap  
 FOV should be less than body width at level of renals  
 Do a second post gad run immediately after first, allowing for a quick 5 sec breathhold

#### Protocol:

Cor SSFSE Scout  
 Axial T1 FMPSGR  
 Timing Run  
 3d Series, 1 pre and 2 post  
 Axial T1 FMPSGR