Peripheral MR Angiography

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RUNOFF VESSELS

The noninvasive evaluation of the pelvic and lower extremity arteries is now routinely performed with MR angiography. Contrast-enhanced MR angiography has proven to be an accurate method to diagnose lower extremity peripheral vascular disease.

However, because of the large amount of anatomy, this task is particularly challenging for MR. Isolated iliac artery evaluations are easily and quickly (less than 15 min) performed by MRA, either with 2D TOF or 3D gadolinium-enhanced techniques.

Unlike other MRA exams, a comprehensive evaluation of the pelvis and runoff vessels requires multiple "stations" to be acquired during a single MR study. This can be acquired using a number of different techniques (see table on next page). Currently we favor a combination of a stepping-table gadolinium-enhanced MRA and an unenhanced 2d TOF MRA of the calf vessels and foot.

Above the knee gadolinium-enhanced 3D MRA is both reliable and rapid method of evaluating the arteries. Below the knee, in our experience the gadolinium-enhanced techniques are less accurate. We rely on 2D TOF below the knee because it has greater resolution than the contrast-enhanced techniques; but it does take a considerably longer period of time to acquire.

Peripheral MRA is best done after a thorough surgical and clinical history has been obtained. Direct communication with the referring surgeon or physician allows the radiologist to specifically tailor each exam so that the clinical concern is addressed and so that only the minimum amount of anatomic coverage required is examined. For instance, at many centers, patients with claudication are only imaged from the abdominal aorta to the popliteal arteries. This is a much more rapid exam than one that includes the calves and ankles.

TECHNIQUES

As stated above numerous techniques are currently available to perform peripheral MRA. These include all 2d TOF, multi-injection 3d Gad with or without 2d TOF, and stepping table 3d Gad MRA with or without 2d TOF. Peripheral vascular coils have recently been introduced, which we have found to be very helpful.

When trying to determine the approach that is best, local institutional factors come into play; is a PV coil available? Do the MR system have stepping-table software etc.

One "low-tech" approach that we have used successfully is to perform two or three separate gadolinium enhanced MR angiograms during a single examination. Using this technique, a gadolinium-enhanced 3D GRE MR angiogram is performed in the usual manner, although a relatively low dose of gadolinium is delivered. The patient is then moved 40-50 cm, and after scouting and prescribing another sequence, a second gadolinium bolus is infused and another 3D GRE MR angiogram is obtained. Together the two angiograms cover as many as 90 cm of anatomy. A third station can also be performed in the same manner as long as a total of 0.3 mmol/kg of gadolinium is not exceeded. Use of the subtraction technique is useful for these studies.

Another useful method involves the use of a stepping table. A dynamic step-table technique has been used routinely with conventional and digital subtraction angiography to increase the amount of anatomy imaged per contrast injection. With this method, the patient or x-ray tube is incrementally translated so that a bolus of contrast material is imaged as it flows through the arterial system.

MANUAL STEP-TABLE METHOD

A similar approach may be adapted for gadolinium-enhanced 3D GRE MR angiography. We devised a method to rapidly move the patient between 3D-GRE acquisitions without having to scout or to execute time-consuming pre-scan adjustments. After acquiring a gadolinium-enhanced 3D GRE MR angiogram of the abdominal aorta, this method allowed us to rapidly move the patient and initiate another 3D-GRE acquisition centered on the thighs within 5-10 seconds. With this technique, we have been able to rapidly acquire two contiguous contrast -enhanced 3D-GRE MR angiograms following a single gadolinium-DTPA infusion.

A reference mark is placed on the side of the gantry using a piece of tape, so that the table can be manually repositioned back to this point when necessary. The patient and table can now be moved back and forth between stations freely. To move the patient between "stations" the table is manually disconnected from the mechanical drive apparatus and both the patient and table is withdrawn 40-45 cm. This is only possible on some MR scanners. Check with the manufacturer representative to see if this is possible on your scanner.

Contrast is infused for a longer period of time than for other MRA exams. Many methods are in use, we use a biphasic injection of 1cc/sec for 20 sec followed by 0.5 cc/sec for 40 sec, all followed by 20cc saline flush at 1 cc/sec. This yields a 60 sec gadolinium "bolus", which keeps the arterial signal high for the duration of the stepping table acquisition.

AUTOMATED STEP-TABLE METHOD

Most MR system vendors have recently introduced new software programs which perform the stepping table exam automatically. This has made it significantly easier to perform the study and allows for more accurate table positioning. A single prolonged contrast infusion is used as described above.

One drawback of the technique is the relatively lower resolution as compared to other MRA techniques. Since the three (or four) stations need to be acquired before there is substantial venous return, the acquisition time of each station must be reduced, necessitating reduction in image matrix and therefore resolution. The use of peripheral vascular coils and newer pulse sequences, such as the ellipitical-centric phase ordered 3d sequence will hopefully aid in increasing resolution (Table 2).

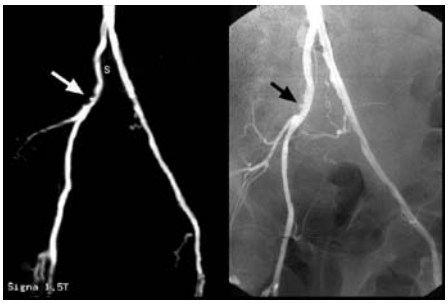

Fig 1. *A gadolinium-enhanced 3D MR angiogram of the pelvis depicts a large ulcerative right iliac plaque. Conventional angiography confirms the presence of the plaque (right).*

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Table 1. *Peer-reviewed studies comparing 3d-gad MRA of the lower extremity arteries to conventional angiography, sensitivity and specificity of MRA for detection of stenosis >50%.*

Author	Reference	Sens	Spec
Poon	AJR 97	100	100
Rofsky	Radiology 97	97	96
Visser	Radiology 00	97	96
Ruehm	AJR 1999	92	97
Sueyoshi	Radiology 99	97	99

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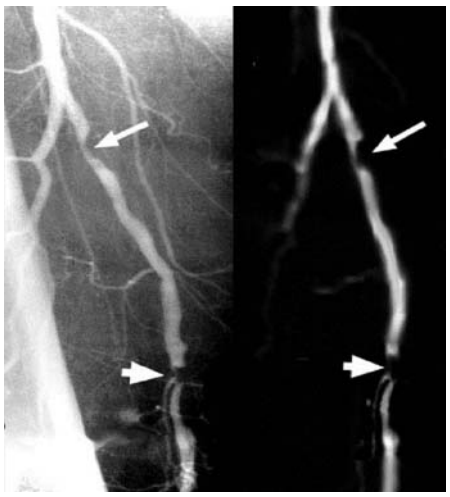

Fig 2. *Direct comparison of a conventional angiogram (left) and a 3d gadolinium-enhanced MR angiogram (right) of the superficial femoral artery. The two focal areas of stenosis (arrows) are accurately depicted on the MRA as compared with the conventional angiogram.*

Table 2. Automated stepping table paramaters for a GE LX system running 8.3 software. Note total acquisition time, including table motion, is less than 1 minute for the study.

	# slices Bandwidth	Parameters	Encoding	Acq time
Pelvis	28 62 kHz	256 x 160 TR 3.9 TE 1.0	Sequential 1 Nex	15
Thigh	28 125 kHz	256 x 160 TR 3.9 TE 1.0	Ellipitical 0.75 Nex	15
Calf	24 125 kHz	256 x 160 TR 3.9 TE 1.0	Ellipitical 0.75 Nex	12

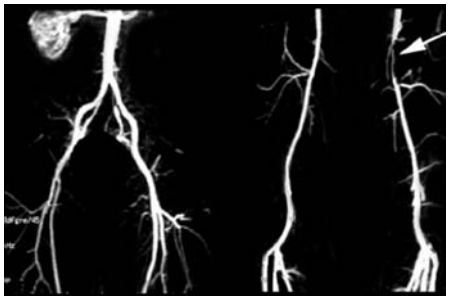

Fig 3. *A manual step-table exam depicts normal pelvic arteries, left, and a long segment high grade left superficial femoral artery stenosis (arrow), left.*

Fig 4. *A "stepping-table" gadolinium-enhanced 3D MR angiogram of the lower extremity depicts normal anatomy bilaterally.*

STEPPING TABLE RUNOFF

System GE LXi Software version 8.0

POSITION
Position: Supine
Patient Entry: Feet First
Coil: PV Array
Series: 3D Upper

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

SCAN TIMING
TE: Minimum
Flip Angle: 35
Bandwidth: 41.7

SCAN RANGE
FOV: 44
Slice Thickness: 3.2
Locs per slab: 32

ACQUISITION TIMING
Freq: 256
Phase: 160
NEX: 0.75
Phase FOV: 0.9
Freq Dir: S/I
Auto Cent: Water

ADDITIONAL PARAMETERS

User CV´s	**Multiphase**	**Sat Bands**
#Stations: 3		none

CONTRAST: 40 cc @ 2cc/sec for 10 sec the 0.5 cc/sec for 40 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: Use above for Pelvic and thigh station
For calf, turn Ellipitical Centric on (user CV), increase matrix to 256 x 224, reduce slice thickness to less than 2 mm
Use a low resolution 2d TOF first as a scout