Austin Radiological Association

MRI Vascular Protocols

1.5T & 3T Protocols

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1.5T – 3T Vascular Protocols

General Guidelines

<table>
<tr><th colspan="2">VASCULAR</th></tr>
<tr><td>General</td><td>

NEVER hesitate to reach out to a radiologist for guidance!
Vendor Terminology
<table>
<tr><th>SIEMENS</th><th>GE</th></tr>
<tr><td>True FISP</td><td>FIESTA</td></tr>
<tr><td>HASTE</td><td>SSFSE</td></tr>
<tr><td>VIBE</td><td>LAVA</td></tr>
<tr><td>FLASH</td><td>SPGR</td></tr>
</table>

iPAT – parallel imaging
BH / FB – breath hold / free breathing

Calculating pixel size: FOV/matrix x FOV/matrix

* Information in blue font is 3T specific
</td></tr>
<tr><td>Technique</td><td>

VIBE sequences are replaced with a Dixon on 3T

</td></tr>
<tr><td>Protocol</td><td>

Evaluate Angio3D Pre for acceptable image quality before gadolinium administration
MIPs are performed off subtractions except in abdomen and chest
Abdomen and chest subtractions may be incorrect if pre and post respirations are different
MRA & MRV head / neck may be done same day

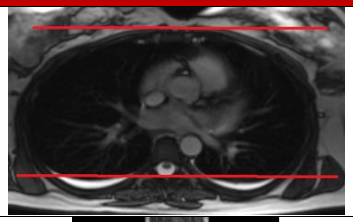
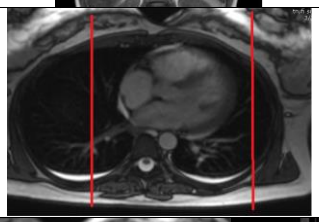
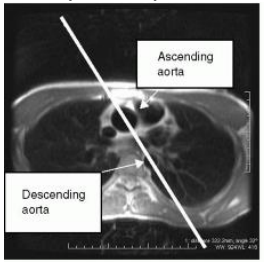
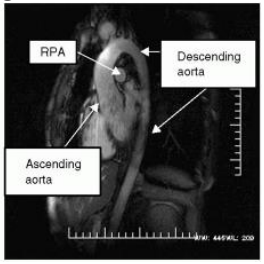
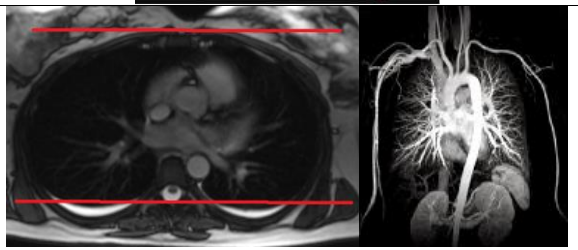
MRV neck pre
MRV head pre
MRA head (1ml Gad is not enough to contaminate the following sequences)
MRV neck post with 3 consecutive runs without delay between
MRV head post delayed, start immediately after MRV neck posts

</td></tr>
</table>

Contrast	• Twist / Angio 3D Cor Dynamic multi-measure
	  ○ Number of measurements can be altered to adjust scan time.
	  ○ Done as free breathing (FB). Use shallow breathing if used in chest, abdomen, or pelvis
	  ○ Total sequence scan time should be enough to obtain good arterial and venous phase
	  ○ Always send the Dynamic Cor and/or Sag MIPs to PACS
	  ○ Do not send the entire sequence. Send Dynamic MIP, pre, best arterial phase sub and best venous phase subtraction
	• Injection rates are 2ml / sec, unless stating differently in the protocol
	• X-ray / CT abdomen and pelvis imaging must be performed prior to MR contrast exams.
	•
	• DatScans must be performed prior to MR contrast exams.

Chest

MRA Thoracic Aorta

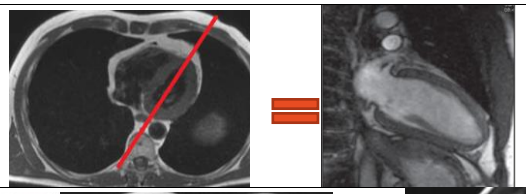
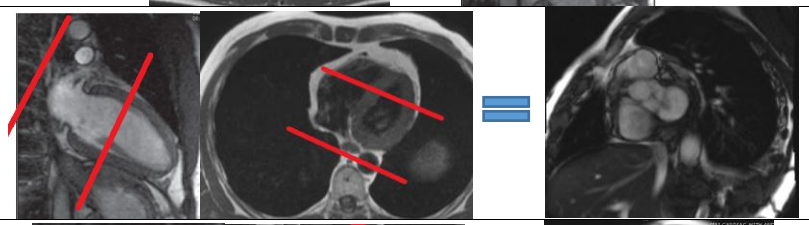
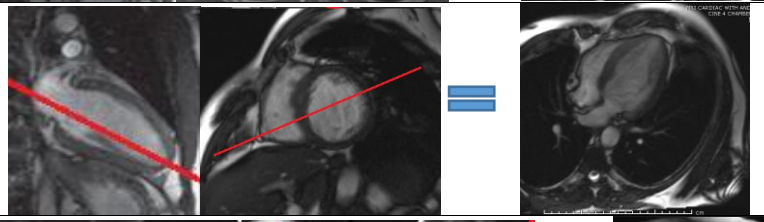
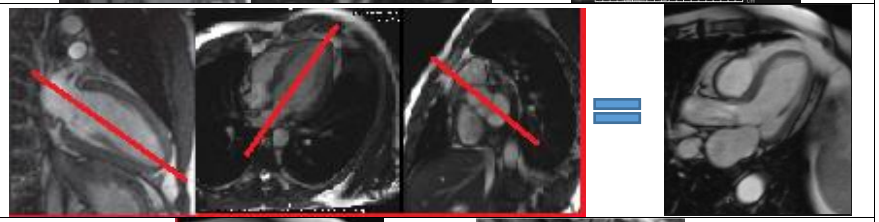
SEQUENCE	FOV (mm)	SLICE (mm)	TECHNIQUE	IMAGE
T1 Fl2D Cor BH	~340	7 x 2		
Trufi Ax BH T2 HASTE Fs Ax BH	~360	8 x 2		
Trufi Sag BH	~360	8 x 2		
Angio3D Cor Pre BH *Sag Candy Cane Care Bolus, 3ml/sec* Angio3D Cor Post BH TWIST	~360	1.5 x 0 1.3 x 0	Evaluate pre contrast images for any artifacts Candy Cane positioning  	

- Subtract post from pre
- MIP rotation and tumble of vessels from 3D volume post and not from subtractions
- Send to PACS: Fl2d Cor, Trufi Ax, T2 HASTE FS Ax, Trufi Sag, 3D Volume Pre and 3D Volume Post, subtraction, MIPs

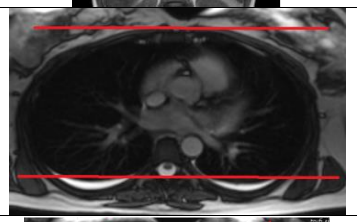
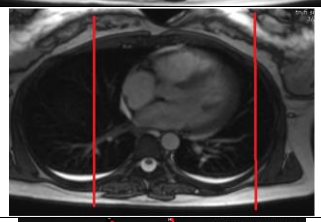
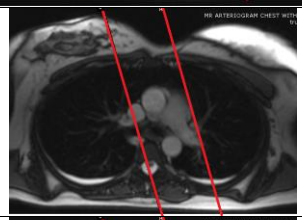
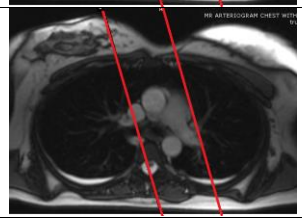
* 3T Specific

Thoracic Aorta Non-contrast

- This study is only done at the following locations: CIC, MID, QRY, CP MR1
- Cardiac gating using the ECG is used for scanning. Be sure to have the wireless ECG unit charged
- Capture cycle all scans except the chest localizer and cine scans

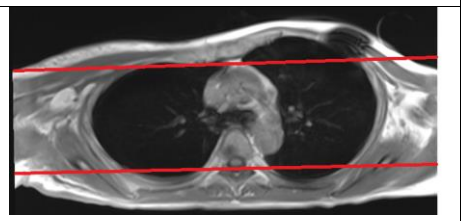
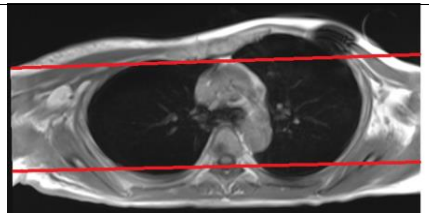
SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
Chest 3-Plane Loc	360			
Heart 3-Plane Loc Gated			Center slices on heart	
2 Chamber loc	320	8		
Short Axis loc -8 slices	320	8 x 1.5		
4 Chamber Loc	320	8		
3 Chamber Loc	320	8		
Cor Aortic Root Cine	340	6		

- continued on next page -

Ax trufi	340	8 x 2		
Cor trufi	340	8 x 2		
Sag trufi	340	8 x 2		
Sag Candy Cane trufi cine	340	10		
Sag Candy Cane 3D trufi	~360	3		
Reformat 3D Sag into Axial plane at 3mm and no gap Send to PACS: Cor Aortic root cine, Ax trufi, Cor trufi, Sag trufi, Sag Candy Cane trufi cine, Sag Candy Cane 3D trufi and Axial MPR				

Vascular Thoracic Outlet Syndrome

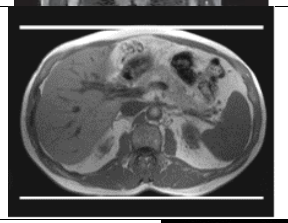
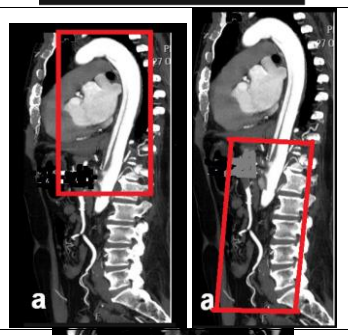
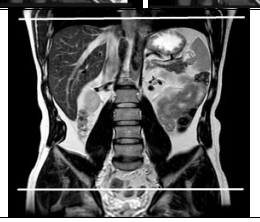
- Vascular Thoracic Outlet Syndrome happens when one or more of the veins (venous thoracic outlet syndrome) or arteries (arterial thoracic outlet syndrome) under the clavicle are compressed
- Weight appropriate dose of gadolinium is mixed with equal amount of saline. Half of the dose is injected during each bolus run. Each Injections are followed by 15 ml saline.
- Use torso coil on chest addition to anterior neck coil
- After the breath held arterial phase, have patient breath for about five second before doing the breath held venous phase. Explaining this step to patient before study will help.
- Inject in the unaffected side

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
Loc trufi 3-Plane with arms up	~340			
Angio3D Cor Pre BH Bolus Scan Cor Angio3D Cor Post BH Angio3D Cor Post delay BH	~360	1.4 x 0 1.1 x 0	Evaluate pre contrast images for any artifacts	
Loc trufi 3-Plane with arms down	~360	8 x 2		
Angio3D Cor Pre BH *Cor Care Bolus, 3ml/sec* Angio3D Cor Post BH Angio3D Cor Post delay BH	~360	1.4 x 0 1.1 x 0	Evaluate pre contrast images for any artifacts	

- Subtract post from pre
- MIP rotation and tumble of vessels from subtractions
- Send to PACS: Flash Cor, Trufi Ax, Trufi Sag, 3D Volume Pre and 3D Volume Post, subtraction, MIPS

Aortic Dissection / Chest-Bifurcation

- Accurate Sag loc allows for better positioning of 3D volume series.
- 3D Volume scans can be done in one shot in patients who are short in stature.
- On tall patients or when S-I FOV is limited, a multi-station MRA can be done as BH with proper respiratory coaching and short scan times. Having scan time of approximately 12 seconds or less for 3D volume should help patient hold breath for the duration of two scans.
- Inject gadolinium at rate of 1.5ml/second to ensure arterial enhancement in lower station

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 FL2D Ax T2 HASTE FS Ax T2 HASTE Ax	~340	7 x 2	• Above Arch through bifurcation • Scan in two or more sections with overlap	
T1 VIBE FS Ax	~340	3.4 x 0 3.0 x 0		
T1 FL2D Cor	~360	5 x 1	• Above Arch through bifurcation • Scan in two or more sections with overlap	
Angio3D Cor Pre Upper BH Angio 3D Cor Pre Lower BH *Cor Care Bolus, 3ml/sec* Angio3D Cor Post Upper BH Angio3D Cor Post Lower BH	~360	1.6 x 0 1.3 x 0	• Diaphragm though bifurcation • Evaluate pre contrast images for any artifacts • Breath-hold instructions are only given before the start of 3D Volume **upper** pre/post.	
T1 VIBE FS Ax Post	~340	3.4 x 0 3.0 x 0	Scan in two or more sections with overlap	

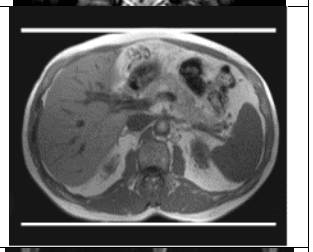
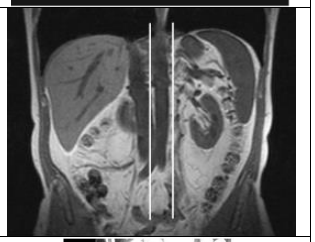
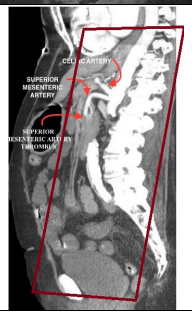
- Subtract post from pre
- MIP rotation and tumble of vessels from 3D volume post and not from subtractions
- Create Axial MPR 2x0mm

* 3T Specific

Abdominal

Aorta / Mesenteric Arteries

• Accurate Sag loc allows for better positioning of 3D volume series.

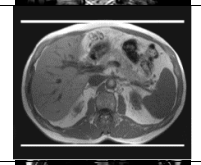
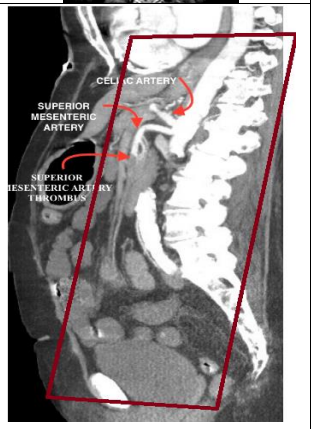
SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T2 FS HASTE Ax BH	~340	7 x 2 6 x 1	Diaphragm through bifurcation	
T1 FL2D Cor BH	~360	5 x 1	Diaphragm through bifurcation S-I	
T1 Sag Aorta localizer BH	~360	7 x 0	Running this scan as a T1 TSE will provide black-blood Sag loc	
Angio3D Cor Pre BH *Cor Care Bolus, 3ml/sec* Angio3D Cor Post BH Angio3D Cor Post Delay BH	~360	1.4 x 0 1.1 x 0	• Diaphragm though bifurcation • Evaluate pre contrast images for any artifacts • Contrast scans are repeated in case venous phase is needed. • Delays can be run 8 seconds apart to give patient just enough time to catch their breath	

• Subtract pre from post
• MIP rotation and tumble of vessels from 3D volume post and not from subtractions
• Create Axial MPR 2x0 mm, ~220 mm FOV

* 3T Specific

MRV Inferior Vena Cava

• Accurate Sag loc allows for better positioning of 3D volume series.

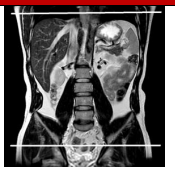
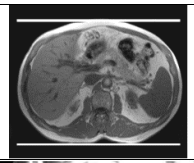
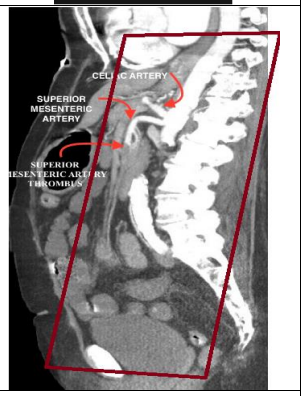
SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T2 FS HASTE Ax BH	~340	7 x 2 6 x 1	Diaphragm through bifurcation	
T1 FL2D Cor BH	~360	5 x 1	Diaphragm through bifurcation S-I	
2D TOF	~340	7 x -33%	With a superior sat band	
T1 FS VIBE Cor Pre BH	~360	3.4 x 0 3.0 x 0	• Diaphragm though bifurcation • Evaluate pre contrast images for any artifacts • Wait 8 seconds between each phase post contrast scans	
Angio3D Cor Pre BH *Cor Care Bolus, 3ml/sec* Angio3D Cor Post BH Angio3D Cor Post BH	~360	1.5 x 0		
T1 FS VIBE Cor Post BH T1 FS VIBE Cor Post BH T1 FS VIBE Cor Post BH	~360	3.4 x 0 3.0 x 0		

- Subtract pre 3D volume from best venous phase
- Subtract Immediate arterial phase from best venous phase
- MIP rotation and tumble of vessels from 3D volume post immediate and best venous phase, not from subtractions
- Create Axial MPR 2x0 mm from best venous phase

* 3T Specific

Median Arcuate Ligament Syndrome or Celiac Artery Compression Syndrome

- **Celiac artery compression syndrome** is characterized by chronic, recurrent abdominal pain related to compression of the celiac artery by the median arcuate ligament
- The compression worsens with expiration as the diaphragm moves caudally during expiration
- CE MRA is first done on expiration then repeated on inspiration
- Weight appropriate dose of gadolinium is mixed with equal amount of saline. The first half of the dose is injected during expiration and the remaining is injected during the inspiration portion. Both injections are followed by 10 ml saline.

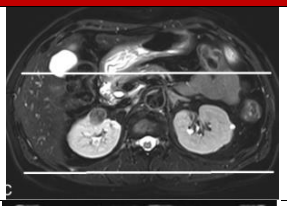
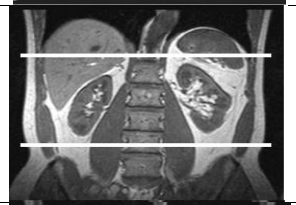
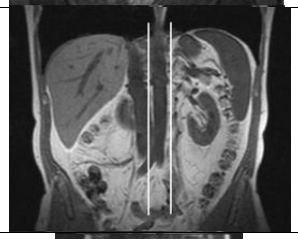
SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T2 HASTE FS Ax BH	~340	7 x 2 7 x 1	Diaphragm through bifurcation	
T2 Fl2D Cor BH	~360	5 x 1	Diaphragm through bifurcation S-I	
Angio3D Cor Pre BH Expiration *Cor Care Bolus, 3ml/sec* Angio3D Cor Post BH Expiration 5-minute delay Angio3D Cor Pre BH inspiration *Cor Care Bolus, 3ml/sec* Angio3D Cor post BH inspiration	~360	1.5 x 0 1.3 x 0	• Diaphragm though bifurcation • Evaluate pre contrast images for any artifacts • Start expiration instructions earlier to be on time for the contrast scan. • Expiration breath-hold instructions are better given manually on 3T	

- Send to PACS: HASTE Ax and Cor, 3D Volume Pre/Post, subtractions, MIP rotation and tumble, Axial and Sag MPRs
- Subtract pre from post
- MIP rotation and tumble of vessels from 3D volume post and not from subtractions
- Create Axial and Sag MPR 2x0 mm, ~220 mm FOV

* 3T Specific

MRA Renal

Note:
Pelvic renal transplants require both abdominal and pelvic imaging with the arterial phase focused on the pelvis.

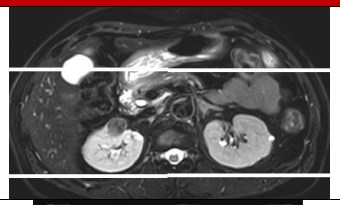
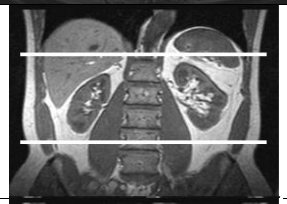
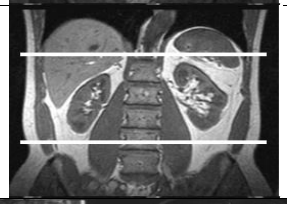
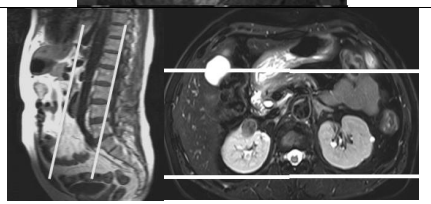
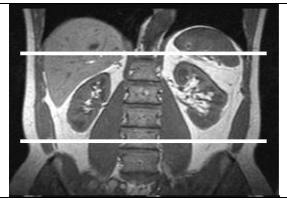
SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 2DFL Cor	~360	6 x 1 5 x 1		
T2 FS HASTE BH	~360	6 x 0		
T1 Sag Aorta localizer	~360	7 x 0	Running this scan as a T1 fast spin echo will give you a nice black-blood Sagittal localizer.	
Angio3D Cor Pre BH *Cor Care Bolus, 3ml/sec* Angio3D Cor Post BH Angio3D Cor Delay BH MIPs are as follows: Whole aorta and vessels rotation Renal arteries rotation Renal arteries tumble	~360	1.4 x 0 1 slab ~56 slices 1.1 x 0	• Evaluate pre contrast images for any artifacts • Include at least the anterior two-thirds of the kidneys on these scans. • Delays can be run 10 seconds apart to give patient just enough time to catch their breath	

- Sent to PACS: T2 FS Ax and T1 Cor, 3D Volume pre and posts, Subtractions, MIP Rotations and Tumble, Axial MPR
- Subtract pre from post
- MIP rotation and tumble of vessels from 3D volume post and not from subtractions, be sure to cut out the bright signals from fat
- Create Axial MPR 2x0 mm, ~220 mm FOV

* 3T Specific

MRA Renal Vein

Indications include Nutcracker phenomenon, renal vein compression, and renal vein thrombosis.

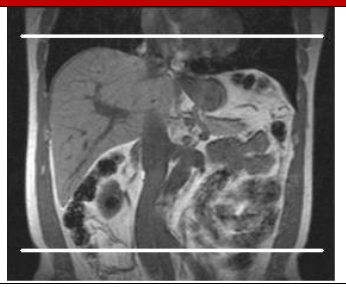
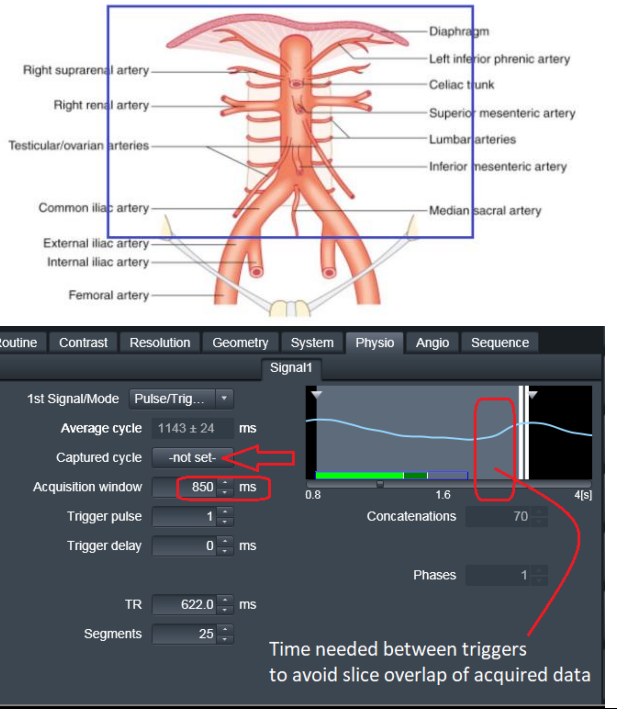
SEQUENCE	FOV (mm)	SLICE (mm)	TECHNIQUE	IMAGE
T1 2DFL Cor	~360	6 x 1 5 x 1		
T2 FS HASTE BH	~360	6 X 0		
T1 VIBE FS Ax Pre bh	~360	4 x 0 3 x 0		
Angio3D Cor Pre bh *Cor Care Bolus, 3ml/sec* Angio3D Cor Post bh Angio3D Cor Delay bh	~360	1.4 x 0 1 slab ~56 slices 1.1 x 0	• Evaluate pre contrast images for any artifacts • Include at least the anterior 2/3's of the kidneys on these scans. • Delays can be run 10 seconds apart to give patient just enough time to catch their breath	
T1 FS Vibe Ax Post bh T1 FS VIBE Ax Post bh	~360	4 x 0 3 x 0	Delays can be run 10 seconds apart to give patient just enough time to catch their breath	

- Subtract pre from posts
- MIP rotation whole aorta, rotation and tumble of vessels from 3D volume post and not from subtractions, be sure to cut out the bright signals from fat
- Create Axial MPR 2x0mm, ~220mm FOV from Angio3D Cor Delay BH

* 3T Specific

MRA/MRV Abdomen – Non-Contrast

• Pulse gated

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 FL2D Ax BH T2 FS HASTE Ax BH	~340	5 x 1		
2D TOF Ax	~340	5 x -33	• Above the diaphragm to below bifurcation • Arterial: tracking Foot sat band • Venous: tracking Head sat band • Reformat into Sag and Cor plane **Pulse trigger** • Capture Cycle • Subtract 250ms from Acquisition window, enter new ms & Apply sequence MIPs: • Cor	

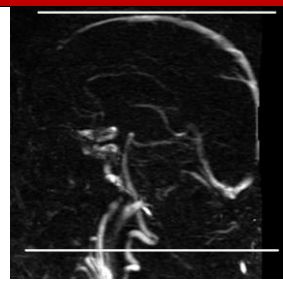
• Compose TOF for abdomen & pelvis exams.

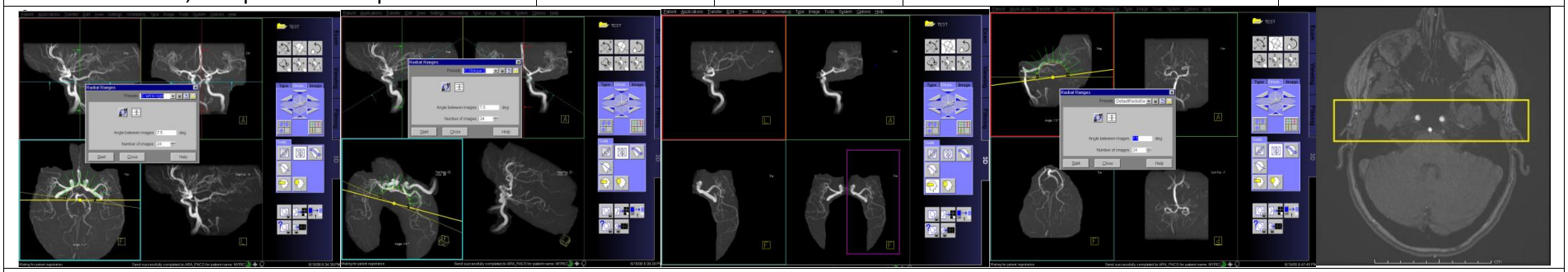
Head

MRA Intracranial - Circle of Willis (COW) With Contrast

(Updated 2/2/21)

- Unless specifically ordered without contrast, all MRA intracranial exams should be done with 1ml of gadolinium flushed with 10ml of saline
- No iPAT on 1.5T
- Consult with a Radiologist for metallic dental work causing significant artifact. The Radiologist may prefer a CTA. If a CTA is preferred, then the referring physician's office should be notified for a change of orders prior to the patient being scanned.

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
3D TOF Ax (optional TWIST, 3T) MIPs: • Uncut Rotation • Uncut Tumble • Anterior Rotation • Anterior Tumble • Anterior Oblique 1 • Anterior Oblique 2 • Anterior Right Rotation • Anterior Left Rotation • Posterior Rotation • Posterior Tumble MPRs: • Sag 1mm, whole brain • Cor 1mm, mid-pons to mid-sphenoid sinus	220 200	1.0 x -33.3% 0.7 x -21.8%	Optional TWIST technique for 3T: TWIST Sag, 256 FOV, 1mm slice	

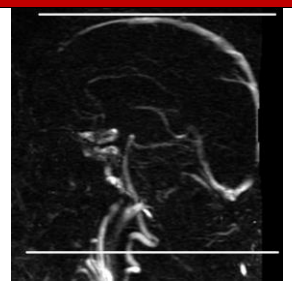
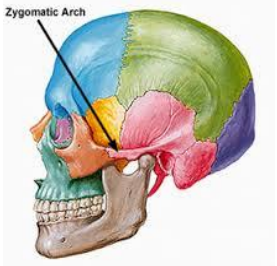
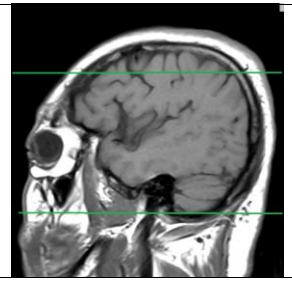


- Click for MIP Instructions
- Send to PACS: raw data & post processing

* 3T Specific

MRA Intracranial - COW Temporal Arteritis *3T Preferred

- Key words for this protocol are: Giant Cell, Cranial Arteritis, Horton's Disease
- This study evaluates temporal arteries (outside) of the skull while the vasculitis protocol evaluates vessels inside the brain for inflammation. Consult with rad if you have questions as this study can be ordered incorrectly.
- MRA intracranial exams should be done with 1ml of gadolinium flushed with 10ml of saline.
- Consult with a Radiologist for metallic dental work causing significant artifact. The Radiologist may prefer a CTA. If a CTA is preferred, then the referring physician's office should be notified of a change of order prior to the patient being scanned.
- Place skin marker at site of pain for MRA intracranial option only

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
3D TOF Ax MIPs: • Uncut Rotation • Uncut Tumble • Anterior Rotation • Anterior Tumble • Anterior Oblique 1 • Anterior Oblique 2 • Anterior Right Rotation • Anterior Left Rotation • Posterior Rotation • Posterior Tumble	220 200	1.0 x -33.3% 0.7 x -21.8%		
Contrast full dose and remove marker T1 SE FS Ax post (include 2/3 of brain from zygomatic arch(ear level) up)	230	3 x 0		

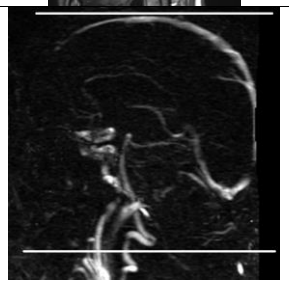
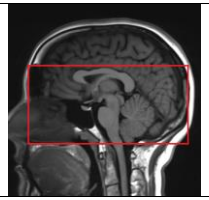
- Send to PACS: raw data & MIPs
- Rotations and tumble are 24 images 7.5° apart
- Anterior oblique 1 is 24 images from left to right around the anterior side of the patient from the Axial plane image that has been rotated 30° in both the coronal and sagittal directions
- Anterior oblique 2 is same as anterior oblique 1 with a 30° rotation in the opposite direction

* 3T Specific

MRA Intracranial - COW Vasculitis *3T preferred

(Updated 9/30/20)

- Intracranial MRA's should be done with 1ml of gadolinium flushed with 10ml of saline.
- This study evaluates blood vessels inside the skull for inflammation while the temporal arteritis protocol evaluates vessels outside the skull. Consult with a rad if order is unclear.
- TOF sequence should not use iPAT on 1.5T
- Consult with a Radiologist for metallic dental work causing significant artifact. The Radiologist may prefer a CTA.

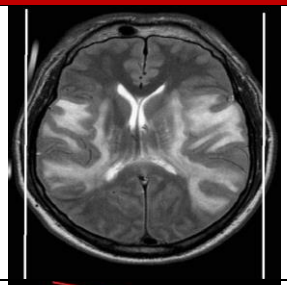
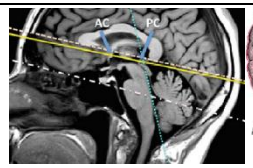
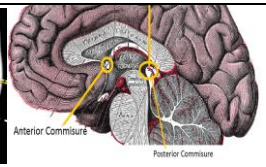
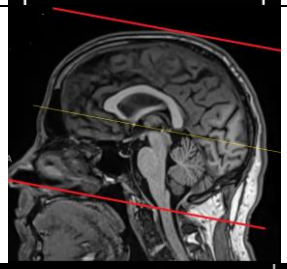
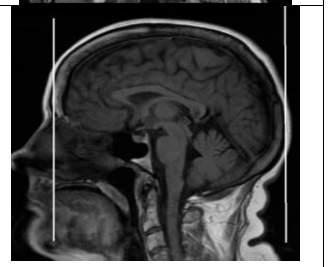
SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 SPACE spair-FS Ax Pre	230	1.0 x 0 0.7 x 0		
Contrast 1ml 3D TOF Ax	220 200	1.0 x -33.3% 0.7 x -21.8%	MIPs: • Uncut Rotation • Uncut Tumble • Anterior Rotation • Anterior Tumble • Anterior Oblique 1 • Anterior Oblique 2 • Anterior Right Rotation • Anterior Left Rotation • Posterior Rotation • Posterior Tumble	
Contrast Full dose T1 SPACE spair-FS Ax Post (Create thin MIPs)	230	1.0 x 0 0.7 x 0		

- Send to PACS: raw data & MIPs Rotations and tumble are 24 images 7.5° apart
- Anterior oblique 1 is 24 images from left to right around the anterior side of the patient from the axial plane image that has been rotated 30° in both the coronal and sagittal directions
- Anterior oblique 2 is same as anterior oblique 1 with a 30° rotation in the opposite direction
- Thin MIP instructions: Load T1 FL3D FS Ax Post into MIP, select Thin MIP under Type. Reformat into axials. Select 1.0 mm under image thickness and 1.0 mm for distance. Save new sequence as Ax Thin MIP

* 3T Specific

MRV Intracranial

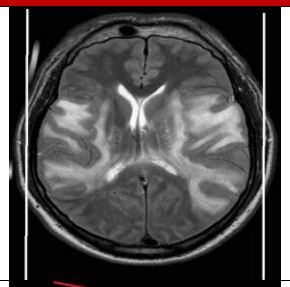
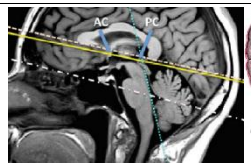
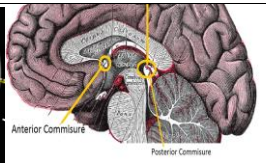
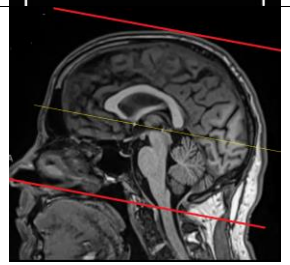
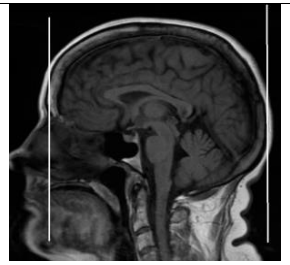
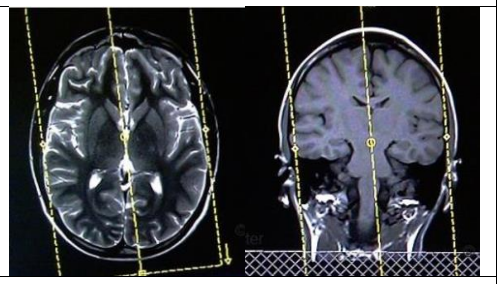
- Bolus Contrast: 10ml gadolinium, 2 ml/sec - 15ml normal saline flush
- Care-bolus done as an axial slice centered at skull base. Start post scans 5 seconds after observing contrast

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 Sag (full brain) if patient does not have a concurrent brain exam	230 220	5 x 2 4 x 1.2		
SWI Ax *(only send SWI & Phase series)* or GRE Cor **A40 SM, SW MR1, WLK, WMC, GE*	220 200	3 x 0 ~52 slices 5 x 1 ~28 slices	  Axials parallel to AC-PC line	
2D TOF Cor (full Brain)	250	3 x -1 2.5 x -0.8	Use inferior sat band to avoid arterial signal	
Angio3D Cor Pre *Ax Care Bolus, 2ml/sec* Angio3D Cor Post	230	1.4 x 0		

- Send to PACS: raw data, MIPs, and subtractions
- Subtract 3D volume pre/post & use subtraction for MIP rotation & tumble
- MIP 2D TOF Cor rotation & tumble
- Create 2x0 axial MPR from 3D Cor Volume post series

* 3T Specific

MRV Intracranial Without Contrast

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 Sag (full brain) if patient does not have a concurrent brain exam	230 220	5 x 2 4 x 1.2		
SWI Ax *(only send SWI & Phase series)* or GRE Cor **A40 SM, SW MR1, WLK, WMC, GE*	220 200	3 x 0 ~52 slices 5 x 1 ~28 slices	  Axials parallel to AC-PC line	
2D TOF Cor (full Brain)	250	3 x -1 2.5 x -0.8	The saturation band should be placed at the bottom to void the arterial signals	
2D TOF Obl Sag (full brain)	250	3 x -1 2.5 x -0.8	The 2D TOF OBL Sag is 10° oblique from the midline brain on the axial and coronal plane to reduce the in-plane saturation effects. The saturation band is placed at the bottom to void in flowing arterial signal.	

- Send to PACS: raw data, MIPs, and subtractions
- Subtract 3D volume pre/post & use subtraction for MIP rotation & tumble

* 3T Specific

Extremities

MRA Foot

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 Sag	~230	4 x 1		
T1 Ax	~230	4 x 1		
STIR Cor	~150	4 x 1		
Angio3D Sag Dyn Multi-measure TWIST	~270	1.2 x 0 0.7 x 0	• Inject immediately after first measurement during 5-second pause • Include entire foot and ¼ of the lower leg	

- Use best arterial only measurement subtractions for MIP rotation and tumble
- Send to PACS: anatomy scans, Sag Dyn-MIP, first measurement (pre), best arterial, best venous measurement and 2 respective subtractions

* 3T Specific

MRA Hand

- Inject in the unaffected side
- Two torso coils can be used on the 1.5T to “sandwich” and hand and the distal forearm

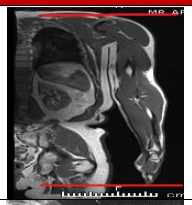
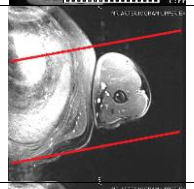
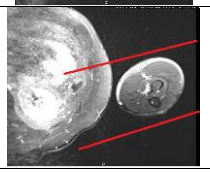
SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
STIR Ax	~140	4 x 1		
T1 COR	~230	3 x 1		
Angio3D Cor Dyn Multi-measure TWIST	260 220	1 x 0 0.7 X 0	• Inject immediately after first measurement, during 5-second pause • For venous images subtract arterial from delay	

- Use best arterial only measurement subtractions for MIP rotation and tumble
- Send to PACS, anatomy scans, first measurement (pre), Cor Dyn MIP, best arterial, best venous measurement and 2 respective subtractions

* 3T Specific

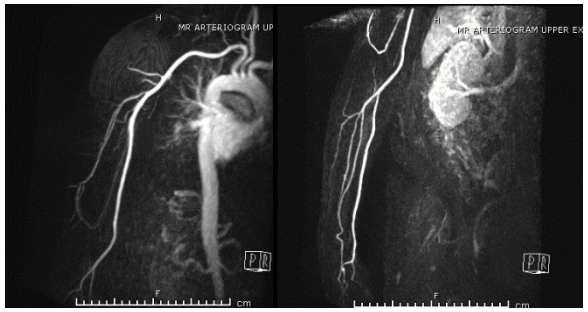
MRA / MRV Upper Extremity Run-Off

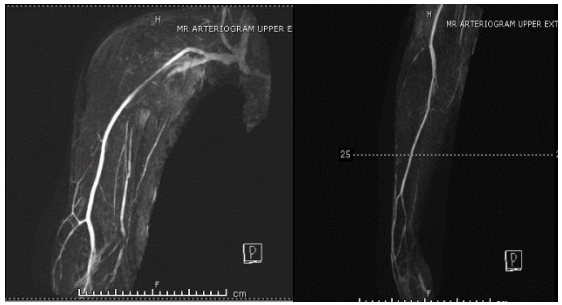
- Weight appropriate dose of gadolinium is mixed with equal amount of saline. The first half of the dose is injected during the proximal arm MRA and the second half is injected during the distal arm portion. Both injections are followed by 10 ml saline.
- Inject in the unaffected side
- Build-up arm so that the entire arm is in one plane
- 3-Stations might be needed for tall patients on Espree. Divide scans and gadolinium into three instead of two.
- A single station study can be done if the pathology is localized and specifically ordered
- If a venous phase is not needed, a multi-station run off can be performed

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T2 FS Ax	~260	6 x 1	Multiple stations to cover the entire arm	
T1 Cor	~340	4 x 1	Multiple stations to cover the entire arm	
Angio3D Cor Dyn Multi-measure Proximal	~340	1.3 x 0 0.8 x 0	• Delay after pause is 5 seconds. • Inject immediately after first phase, 3ml/sec	
Angio3D Cor Dyn Multi-measure Distal	~340	1.3 x 0 0.8 x 0	• Delay after pause is 5 seconds. • Inject immediately after first phase, 3ml/sec	

- Subtract post from pre for best arterial phase and best venous phase
- MIP rotation of vessels from subtractions

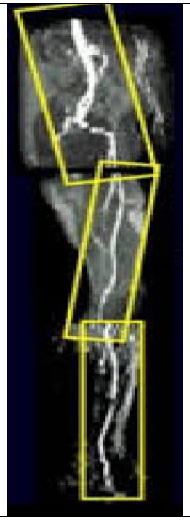
* 3T Specific





MRA / MRV Lower Extremity Run-Off

- The number of stations used in run-off depends on the scanner. Normally Espree uses 4-5, Skyra uses 4, and Avanto / Symphony uses 3 stations.
- 1.5T: CIC, CP MR1, GTN MR1, MPT MR2, MID, QRY, RCP MR2 or 3T: ACB, CP MR2, CP MR3, GTN MR2, MNR, MPT MR1

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
Vessel scout loc (repeat for all stations)	340 - 480	~10 x 0	• Reformatted into Sag • Having a good Sagittal vessel scout allows proper positioning of the scan	
Angio 3D Cor Pre multi-station pre *Cor Care Bolus Abdomen* Angio 3D Cor Post multi-station arterial Angio 3D Cor Post multi-station venous	340 - 480	1-1.5 x 0 .9-1.3 x 0	Multi-station injection rate • 1st station, 1.5ml/sec • 2nd & subsequent stations, 0.5ml/sec	

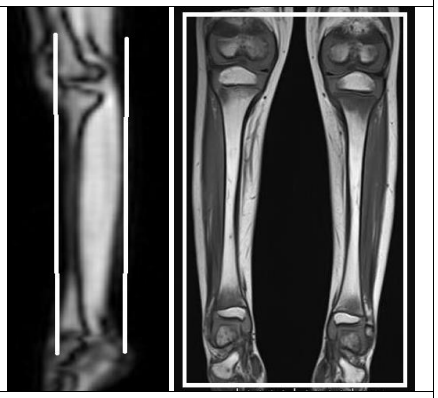
- Use subtractions for MIP rotation and tumble
- From the multi-measurement/twist sequence only send to PACS first measurement (pre), Cor Dyn MIP, best arterial, best venous measurement and 2 respective subtractions
- Send to PACS: all multi-station series and subtractions

* 3T Specific

MRA / MRV Lower Extremity

(Single Station)

- This study can be done for almost any body part
- Single station of lower legs, multi-measurement sequence with 3ml of gadolinium mixed with 5ml saline followed by 15 ml of saline can be performed before the multi-station MRA to ensure lower leg scans without venous contamination.

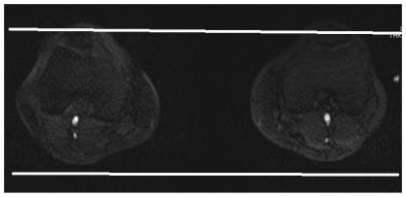
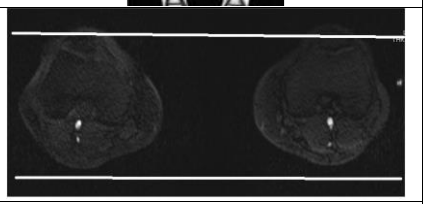
SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
Vessel scout loc	340 - 480	~10 x 0	• Reformatted into Sag • Having a good Sagittal vessel scout allows proper positioning of the scan	
Angio3D Cor Dyn Multi-measure TWIST	340 - 480	1.1 x 0 0.7 X 0	• Pause after measurement 1 is 10 seconds • Inject immediately after first measurement, 3ml/sec • Use best arterial and venous phase sub for MIPs • For venous images subtract arterial from delay	

- Use subtractions for MIP rotation and tumble
- Send to PACS: first measurement (pre), Cor Dyn MIP, best arterial, best venous measurement and 2 respective subtractions

* 3T Specific

Popliteal Artery Entrapment Syndrome

- Popliteal artery entrapment syndrome (PAES) is a developmental abnormality that results from an abnormal relationship between the popliteal artery and gastrocnemius muscle, popliteus muscle or a fibrous band causing compression of the popliteal artery.
- Weight appropriate dose of gadolinium is mixed with equal amount of saline. 1/3 of the dose is injected during each contrast enhanced dynamic run. Each injection is followed by 10 ml saline.
- Wait one minute between each dynamic sequence

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
STIR Ax Bilateral	~340	8 x 2 8 x 1 ~36 slices	Mid-thigh to mid-calf	
TOF Ax Bilateral **1.5T only*		3 x -0.2 ~55 slices		
Angio3D Cor Dyn Multi-measure Plantar Cor TWIST Plantar-flexion	~340	1.2 X 0 ~96 slices	• Position feet in appropriate flexion • Pause after measurement 1 is 10 sec. • Inject immediately after first measurement, 3ml/sec.	
Angio3D Cor Dyn Multi-measure Dorsi Cor TWIST Dorsi-flexion	~340	1.2 X 0		
Angio3D Cor Dyn Multi-measure Neutral Cor TWIST Neutral	~340	1.2 X 0		
T1 VIBE Ax HR Bilateral	~340	3 X 0 ~120 slices	• Mid-thigh to mid-calf • Non fat saturated • Out of phase TE is used, i.e. 4.4 - 4.7	
T1 VIBE Cor HR Bilateral	~340 mm	2.5 X 0 ~72 slices	• Mid-thigh to mid-calf • Non fat saturated • Out of phase TE is used, i.e. 4.4 - 4.7	

- Send to PACS: Anatomy scans, Cor Dyn MIPs (3), MIP rotation of the best phase of the affected position, axial reformat of the best phase of the affected position (2x0)
- MIP the best arterial phase subtractions from each scan for MIPS and reformat.

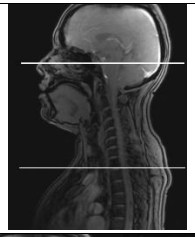
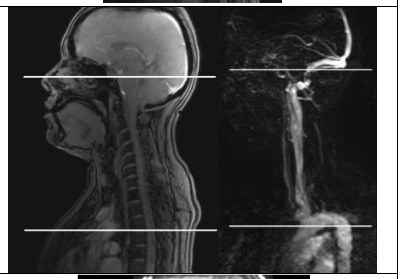
* 3T Specific

Neck

MRA Extracranial

(Updated 4/26/23)

- If done in conjunction with a MRA intracranial with contrast, the pre MRA extracranial must be done first

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
Vessel scout loc		10	• Should be reformatted into Sagittal plane • Having a good Sagittal vessel scout allows proper positioning of the scan	
T1 FS DIXON Ax black-blood	~240	5 x 1 4 x 1	• Include from lung apices (approx. T1/T2) to floor of sella	
2D TOF Ax	~240	6 x -33% 6 x -33% **no more than 40 slices/slab*	• Include from inferior border of arch to floor of sella	
Cor Care Bolus, 2ml/sec Angio3D Cor Post *No interpolation	300 – 320	≤1.5 x 0	Aortic arch through the Circle of Willis MIPs: • Uncut Rotation • Right Carotid Rotation • Left Carotid Rotation • Vertebral Bilateral Rotation MPR: • 1.5mm axial	

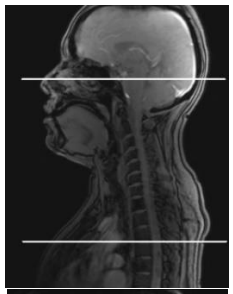
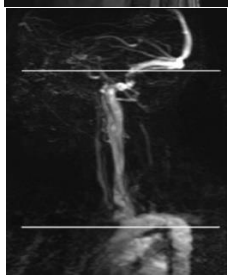
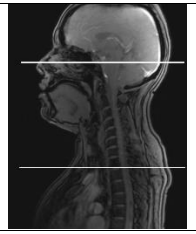
- Send to PACS 2D TOF, FS Ax Black-blood, Angio3D Cor Post, MIPs, and axial reformat
- Siemens: divide the slice thickness by the slice resolution % to determine actual slice thickness matrix. Maximum pixel size is 1 mm (frequency/read) x 2 mm (phase)

* 3T Specific |* ACR Requirements – Do not adjust parameters.

MRA Extracranial Non-contrast

(Updated 4/26/23)

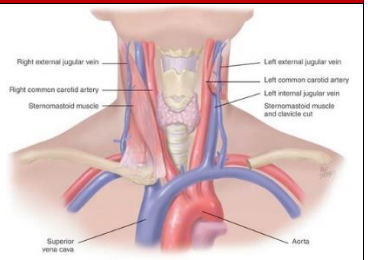
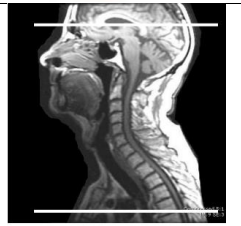
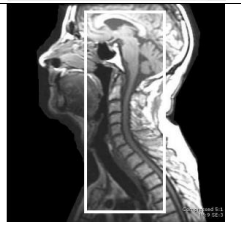
- If done in conjunction with an MRA intracranial with contrast, the 2D TOF and FS Ax black blood must be done prior to the administration of gadolinium
- Not performed on GE scanners
- Use an anterior torso coil over chest to get better signal over the arch

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
Vessel scout loc		10	• Should be reformatted into Sagittal plane • Having a good Sagittal vessel scout allows proper positioning of the scan	
2D TOF Ax	240	6 x -33% 6 x -33% **no more than 40 slices/slab*	• Include from inferior border of arch to floor of sella	
3D TOF Ax MIPs: • Uncut Rotation • Right Carotid Rotation • Left Carotid Rotation • Vertebral Bilateral Rotation	~240 200	1.2 x -20% 40 slices/slab, 6 slabs Phase A-P 100% PFOV 20% OS iPat 2 1.0 x -20.8% 24 slices/slab, 14 slabs	• Include from lung apices (approx. T1/T2) to floor of sella • For Symphony A40 increase slice thickness to 1.5 mm and reduce slabs to 5 • OS can be adjusted based on patient size • Adding an anterior coil on the chest will provide extra signal on the proximal vessels	
T1 FS DIXON Ax black-blood	240 220	5 x 1 4 x 1	• For Symphony A40 increase slice thickness to 1.5 mm and reduce slabs to 5 • Never increase slices/slab • OS can be adjusted based on patient size • Adding an anterior coil on the chest will provide extra signal on the proximal vessels	

- Send to PACS: 2D TOF, FS Ax Black-blood, 3D TOF Ax, MIPs

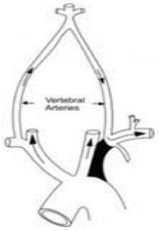
* 3T Specific

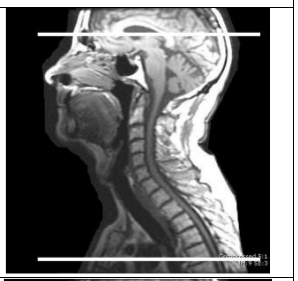
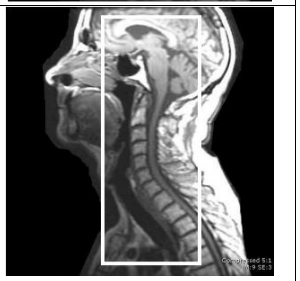
MRV Neck Jugular With or Without Contrast

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
2D TOF Trufi Ax Loc	280	6 x -33%	• Base of skull to IVC • Reformatted into Sag and Cor plane • Tracking F sat-band	
2D TOF Ax Venous	~240	3 x -33% ~110 slices		
Angio3D Cor Dynamic (10 measurements) MIPs are as follows: • Uncut Rotation • Right Int/Ext Jugular Rotation • Left Int/Ext Jugular Rotation	~340	1.2 x 0	• SVC through the Corpus callosum • Include both internal and external jugular veins • Pause after measurement 1 is 5 seconds • Inject immediately after first measurement	
• Subtract arterial from delay with best venous post & use resulting subtraction for MIP. • Create a set of Axial reformats from the best venous phase using a 2mm slice thickness.				

Subclavian Steal Syndrome

- If done in conjunction with a MRA intracranial with contrast, the 2D TOF Axial, & FS Ax black blood must be done prior to the administration of IV contrast.
- In the subclavian steal syndrome, due to stenosis of the subclavian artery, blood may be supplied to the arm via retrograde flow in the vertebral artery.



SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
Vessel scout loc			• Should be reformatted into Sagittal plane • Having a good Sagittal vessel scout allows proper positioning of the scan	
2D TOF Ax	~240	7 x -33% 4 x -33%	• Arch through Corpus callosum	
FS Ax black-blood	~240	5 x 1		
Angio3D Cor Dyn Multi-measure TWIST	~300	~1.5 x 0 1.2 x 0	Aortic arch through the Circle of Willis MIPs: • Uncut Rotation • Right carotid rotation • Left carotid rotation • Vertebral bilateral rotation MPR: • 2mm axial	

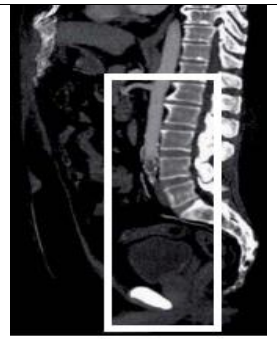
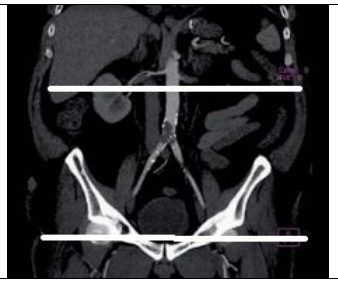
- Subtract pre/post & use resulting subtraction for MIP. Do not send subtractions to PACS.
- Send to PACS: 2D TOF, Ax FS Black-blood, Cor 3D Volume pre, Cor 3D Volume post, MIPs, Axial reformat, and Cor MIPs

* 3T Specific

Pelvis

MRV May-Thurner Syndrome

May-Thurner syndrome (MTS) is the pathologic compression of the left common iliac vein by the right common iliac artery, resulting in left lower extremity pain, swelling, or deep venous thrombosis

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
2D TOF Ax	~340	5 x -33% 4 x -33%	• Sat band is unused to visualize both arterial and venous flow • Create Sag and Cor MPRs • Having a good Sagittal vessel scout allows proper positioning of the CE angio scan	
T1 Fl2D Ax BH T2 FS HASTE Ax BH Trufi Ax BH	~340	6 x 1 5 x 1		
T1 VIBE FS BH	~340	3.5 x 0 3.2 x 0		
Angio3D Cor Dyn Multi-measure fb TWIST	340 - 480	1.5 x 0	• Inject immediately after first measurement during 5-second pause • Use best arterial only and venous phase sub for MIPs • Subtract arterial from delay to get just venous • Instruct patient to breath shallow during this scan	
T1 FS VIBE Post BH	~340	3.5 x 0 3.2 x 0		

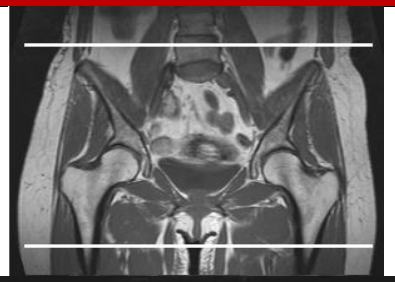
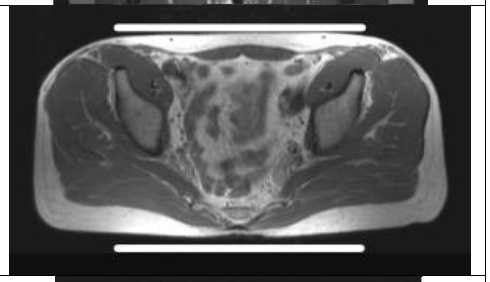
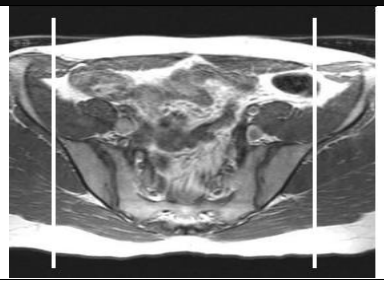
- Send to PACS, 2d TOF, anatomical scans, Cor dyn MIP, first measurement (pre), best arterial, best arterial and venous combo, subtraction of arterial from combo & Axial MPR of venous combo phase
- Use subtractions for MIP rotation and tumble
- Create Axial MPR of arterial venous combo phase

* 3T Specific

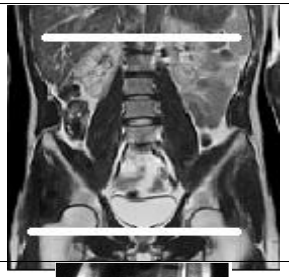
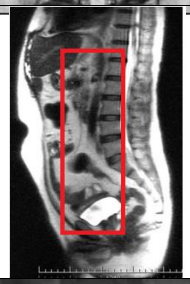
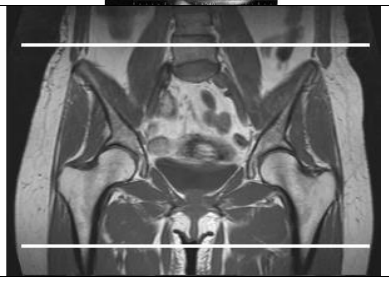
Pelvic Congestion Syndrome

Pelvic congestion syndrome is chronic pelvic pain caused by accumulation of blood in veins of the pelvis, which have dilated and become convoluted. The left gonadal vein (which empties into the renal vein) can have retrograde flow.

Pelvic congestion syndrome: axial contrast enhanced venous phase image (A) shows a dilated left gonadal vein, which is not showing flow related enhancement on axial TOF image (B). These findings suggest presence of retrograde flow/reflux within the left gonadal vein. It is further confirmed on arterial phase angiogram (C), which shows enhancement within the left gonadal vein before iliac veins; likely due to reflux from left renal vein on this coronal maximum intensity projection image. TOF, time of flight sequence.

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 Ax	~360	7 x 2		
T2 HASTE Ax T2 FS HASTE Ax	~240	7 x 2		
T1 FS VIBE Pre	~360	3.4 x 0 3 x 0		
T2 FS Cor	~240	5 x 1		
T2 HASTE Sag	~240	5 X 1		

- continued on next page -

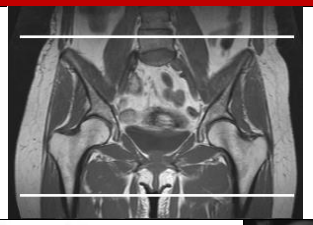
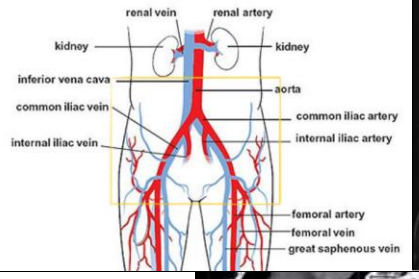
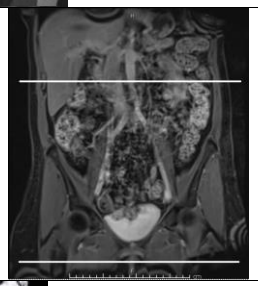
2D TOF Ax	~340	6 x -33%	• Tracking Head sat band	
Angio3D Cor Dyn Multi-measure TWIST	~350	1.5 x 0 1.1 x 0	• Instruct patient to breath shallow during this scan • Pause after measurement 1 is 10 seconds • Inject immediately after first measurement • Include from above renal veins to below gonads	
T1 FS VIBE Post	~360 mm	3.5 x 0 3.0 x 0		

- Be sure to include both right and left gonadal veins on the dynamic scan. The right gonadal vein generally empties into IVC while left empties into renal vein.
- Be sure to extent coverage to the gonads in male patients. Male patients should not be scanned on the Espree scanners.

* 3T Specific

MRA/MRV Pelvis

• Accurate Sag loc allows for better positioning of 3D volume series.

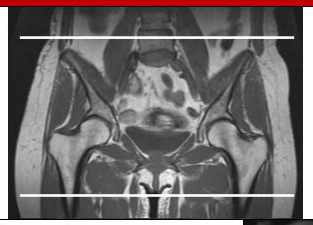
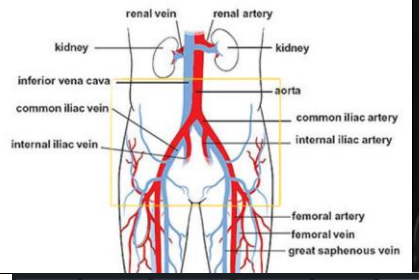
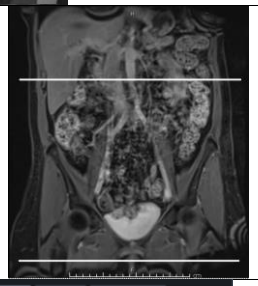
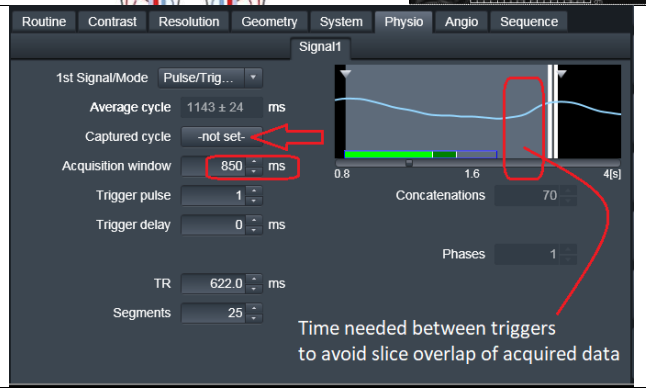
SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 FL2D Ax BH T2 FS HASTE Ax BH	~340	5 x 1		
2D TOF Ax	~340	5 x -33	• Above bifurcation to femoral heads to include internal & external iliac vessels • Arterial: tracking Foot sat band • Venous: tracking Head sat band • Reformat into Sag and Cor plane	 
T1 FS VIBE Cor Pre BH	340-400	3.4 x 0 3.0 x 0		
Angio3D Cor Pre BH *Cor Care Bolus, 3ml/sec* Angio3D Cor Post BH Angio3D Cor Post BH	340-400	1.4 x 0 1.1 x 0	• Evaluate pre contrast images for any artifacts • Wait 8 seconds between each phase post contrast scans	
T1 VIBE FS Cor Post BH T1 VIBE FS Cor Post BH	340-400	3.4 x 0 3.0 x 0		

• Subtract the arterial phase from the best venous phase.

* 3T Specific

MRA/MRV Pelvis – Non-Contrast

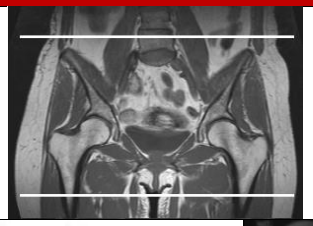
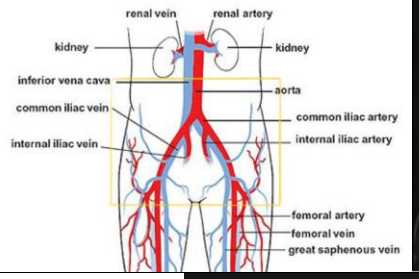
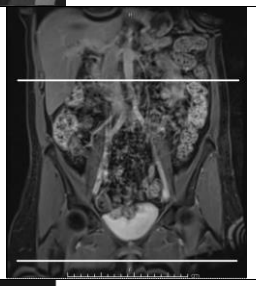
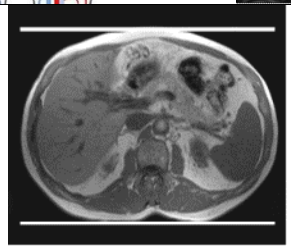
• Pulse gated

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 FL2D Ax BH T2 FS HASTE Ax BH	~340	5 x 1		
2D TOF Ax	~340	5 x -33	• Above bifurcation to femoral heads to include internal & external iliac vessels • Arterial: tracking Foot sat band • Venous: tracking Head sat band • Reformat into Sag and Cor plane **Pulse trigger** • Capture Cycle • Subtract 250ms from Acquisition window, enter new ms & Apply sequence MIPs: • Cor	  

• Compose TOF for abdomen & pelvis exams.

Perforator

- CT is the preferred modality.
-

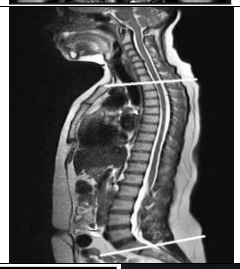
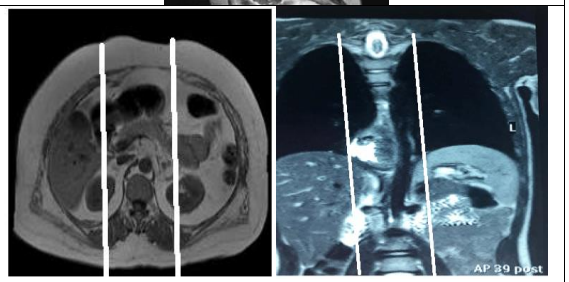
SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 FL2D Ax BH T2 FS HASTE Ax BH	~340	5 x 1		
2D TOF Ax	~340	5 x -33	• Above bifurcation to femoral heads to include internal & external iliac vessels • Arterial: tracking Foot sat band • Venous: tracking Head sat band • Reformat into Sag and Cor plane	 
T1 FS VIBE Cor Pre BH	340-400	3.4 x 0 3.0 x 0		
Angio3D Ax Pel Pre BH Angio3D Ax Abd Pre BH *Cor Care Bolus, 3ml/sec* Angio3D Ax Abd Post BH Angio3D Ax Pel Post BH	340-400	1.4 x 0 1.1 x 0	• Include skin to skin • Evaluate pre contrast images for any artifacts • Wait 8 seconds between each phase post contrast scans	
T1 VIBE FS Cor Post BH T1 VIBE FS Cor Post BH	340-400	3.4 x 0 3.0 x 0		

- Subtract the arterial phase from the best venous phase.

* 3T Specific

Spinal MRA

- FOV of the scans depends on the area of interest. If the full spine is of interest, study will have to be broken up into two visits. Consult with the Radiologist if unsure.
- For Vascular malformation of the spine, follow vascular anomalies protocol

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
Counting LOC Sag-full spine				
T2 Sag Spine	~340 – 440	3.5 x 1	Cover area of interest	
Trufi/fiesta Ax BH	~240	7 x 0	If a larger area is needed to be covered, axials may be broken into multiple scans	
Angio3D Sag Pre *Cor Care Bolus, 3ml/sec* Angio3D Sag Pos Angio3D Sag Post Second Angio3D Sag Post Delay TWIST	~360	1.4 x 0 1.2 x 0	• Evaluate pre contrast images for any artifacts • Arterial and phase 2 should be done in one breath-hold each phase should be less than 10 seconds • 6 second pause to have patient catch their breath • Single phase delay is high resolution and can be up to 20 seconds.	

- Subtract pre from post do MIPs from subtractions whenever possible
- Delay is not subtracted
- Create Cor MPR 1x0 mm, cover from mid-aorta through the spinous process

* 3T Specific

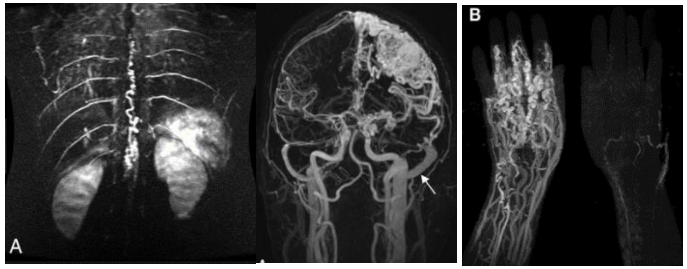
Vascular Anomalies / Malformations

- Parameters and location will vary depending on the lesion
- Consult a Radiologist with questions
- User BH scans if scan is of chest or abdomen

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
T1 Ax T2 FS Ax	~240	3.5 x 1		
T1 Cor T2 FS Cor	~240	3.5 x 1		
T2 FS Sag	~240	3.5 x 1		
2D TOF VENOUS	~240	2 – 3 x 0	Place Sat band between scan volume and heart	
T1 FS VIBE Ax Pre	~240	3 x 0		
Angio3D Cor Dyn Multi-measure TWIST	~240	1.3 – 2 x 0 0.8-1.5 x 0	Delay after pause is 5 seconds. Inject immediately after first phase	
T1 VIBE FS Ax Post	~240	3.5 x 0 3 x 0		
T1 FS Cor / Sag Post	~240	3.5 x 1 3 x 1	Pick best second plane	

- Subtract best phase post from the pre
- MIP rotation and tumble of vessels from 3D volume post and not from subtractions

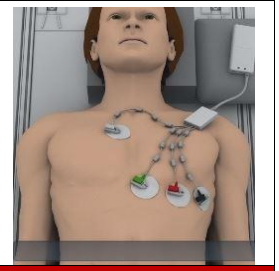
* 3T Specific

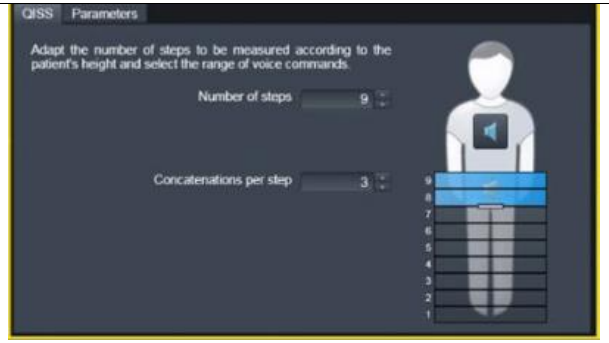


Non-Contrast Techniques, MPT 3T

QISS Lower Extremities Run-Off

- Position patient with Run-Off and Torso Coil with slightly overlap runoff coil due to Cord length.
- Shave off any excessive hair
- Place a small amount of gel on each lead and place PERU (ECG LEAD) as shown in picture.
- Localize patient at mid lower leg
- Instruct the patient there will be several breath-holds towards end of scan
- Chose best two ECG waves
- Check RR interval (acquisition window value) and choose above 800ms or Below 800ms, from decision

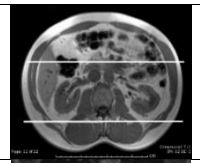
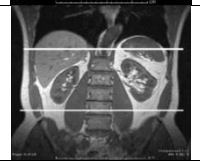


SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
Tim large loc			Localize at mid lower leg	
QISS trufi P2 Figure 1. Add or remove steps as needed for coverage. Any pelvic or abdominal steps should have breath-hold turned on (blue shade) Figure 2. Be sure to capture cycle on the physio > signal page			 	
• MIP Composed image, Rotation and Tumble				

Native – TrueFISP Renal MRA

- Set patient up with respiratory pillow secured with wide gray Velcro band. For best results observe where breathing motion is occurring; for example, if belly motion is seen place the respiratory pillow over that area
- Axial loc should have enough slices to cover the dome of the liver

Additional instructions available here

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
Loc Ax				
Loc Cor/Sag FB				
Loc T2 HASTE Cor FB	~340	3 x 0.3 ~26 slices	To determine exact position of renal arteries	
T2 HASTE Ax	~360	4 x 0 ~36 slices	Kidneys only	

Native Trufisp

Figure 1

Tip – position renal arteries in the upper portion of the FOV.

Figure 2 Set the upper border of the FOV very close to the origin of the vessel of interest. Do not include too much proximal aorta in the FOV.

Figure 3 Superior Inversion pulse top of grid should match top edge of FOV. The inferior inversion pulse top of grid should match bottom edge of superior inversion pulse.

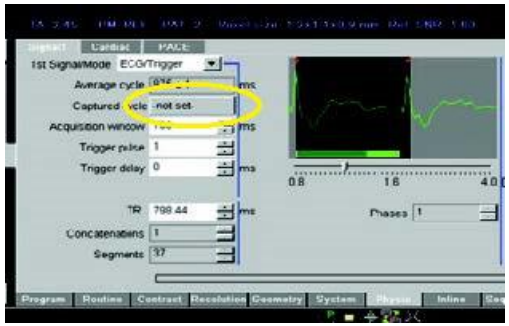
Geometry tab > Inversion (double inversion)

1. TI = 1350 @ 150mm
2. TI = 800 @ 100mm

Following is set in the protocol:
The superior edge of inversion pulse 1 should match the superior edge of the FOV. The superior edge of inversion pulse 2 should match the bottom edge of inversion pulse 1.

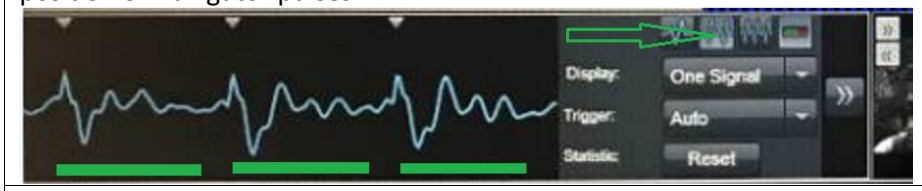
Physio tab > Captured Cycle
Set & Apply

Pro Tip – Acquisition Window MS will be a similar range of the TR. If more than 300ms difference Capture Cycle again.



Navigator information can be viewed in the Inline Display while scanning.

TIP – if using ECG view the 2nd option to slow the display. Confirm the data is collecting with the green bar. If red, stop sequence, Reset Statistics & verify position of Navigator pulses.



- MIP composed images to rotation and tumble

Native – Space Popliteal Artery Entrapment

- Feet first supine
- Peripheral Vascular coil
- ECG gating
- Center at mid lower leg

SEQUENCE	FOV (mm)	SLICE (mm)	COMMENTS	IMAGES
TrueFISP Loc				
Cine_TDScout				
NATIVE_SPACE_3D