Akron Radiology Inc. Technique Manual For MRI

Including Gadolinium Advisory Statement

Version 2022c

Summa Health System
CCOC
Western Reserve Hospital
Affiliated Imaging Centers: Green, Hudson, White Pond, Medina

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Gadolinium Advisory Statement – ARI

Gadolinium contrast material has been found to be associated with the condition Nonspecific Systemic Fibrosis (NSF). The following recommendations are suggested by Akron Radiology Inc. based on the American College of Radiology Guidelines:

Group II Agents (Gadavist, Multihance, Dotarem or Prohance)

As of 2017, when utilizing group II agents, based on the most recent scientific and clinical evidence the ACR Committee on Drugs and Contrast Media considers the risk of NSF among patients exposed to standard or lower than standard doses of group II GBCAs low or possibly nonexistent. Therefore, assessment of renal function with a questionnaire or laboratory testing is optional prior to intravenous administration. As in all instances, group II gadolinium agents should only be administered if they are deemed necessary by the supervising radiologist, and the lowest dose needed for diagnosis should be used as deemed necessary by the supervising radiologist.1

While the ACR Committee also states that the risk for NSF is extremely low regardless of renal function or dialysis status, in patients with end-stage renal failure on dialysis, we recommend avoiding the use of any gadolinium agent unless medically necessary. If gadolinium is given, then the agent should be administered just prior to dialysis.

Group I or III Agents (Magnevist, Optimark, Omniscan or Eovist)

When Group I or III agents MUST be used, patients over age 60 OR with risk factors for renal disease (i.e., dialysis, renal transplant, single kidney, kidney surgery, kidney cancer, diabetes or hypertension requiring medical therapy) are required to have their serum creatinine level measured before the contrast-enhanced MR examination.

GFR > 60: Acceptable to use Group I or III gadolinium agent.
GFR > 30: Acceptable to use Group I or III gadolinium agent if clinically necessary.
GFR <30: The usage of Group I or III gadolinium agent is considered contraindicated.

All deviations from the accepted guidelines are to be approved by the attending Radiologist.

References:
1. ACR Manual on Contrast Media. Version 10.3 May 2017
2. Incidence of Nephrogenic Systemic Fibrosis after Adoption of Restrictive Gadolinium-based
3. Contrast Agent Guidelines. Radiology July 2011 260:105-111.

Recommended Premedication for Contrast Allergy:

- **Routine prep (13hour):**
  Prednisone 50mg po at 13h, 7h and 1hr prior to contrast
  Benadryl 50mg po or IM 1hr before contrast

  Note: Hydrocortisone 200mg IV (at 13h, 7h and 1hr) can be substituted for Prednisone if patient cannot take po meds

- **Emergency prep (4 hour):**
  SoluMedrol 40mg IV or SoluCortef 200mg IV 4 hours prior
  Benadryl 50mg IV, IM or po 1hr prior

  Note: Decadron 7.5mg or Betamethasone 6mg can be substituted in patients with allergy to SoluMedrol or NSAIDS, especially if asthmatic

Reference: ACR Manual on Contrast Media v10.2

We have several vendors for MRI, please utilize the pdf below for consult.

Link to cross vendor terminology

MRI_Acronyms_18000000000016934.pdf

MRI Tips:

If fat saturation is not adequate on MSK sequences, utilize STIR sequences

Be judicious with your FOV and slice thickness; i.e. appropriate for the anatomy.

NEUROLOGIC IMAGING:

***Please note, T1 sequences noted for neuro protocols are SE or FSE unless otherwise noted. Please refrain from utilizing inversion recovery (IR) sequences for T1 weighted sequences.

BRAIN (ROUTINE) Note: Flow compensation is in use for precontrast T1

Sagittal	T1 SE/TSE
Axial	FLAIR
	T2 FSE
	Diffusion
	Susceptibility/BOLD/GRE
Coronal	T2 FSE

BRAIN (R/O TUMOR or known tumor including METS, Infection or Ordered with Contrast)

Axial	DWI
	T2
	FLAIR
	T2 GRE/SWI
	T1

Post Gad:
Volumetric 3D T1 (MPRAGE) obtained at 1 mm in the axial (or sagittal) plane and reconstructed in the other two remaining planes
T1 AX SE/FSE fat sat

BRAIN (MS or Demyelinating Disease)

Axial	DWI
	T2
	3D FLAIR (2D axial + sag when 3D unavailable)
	T2 GRE
	T1

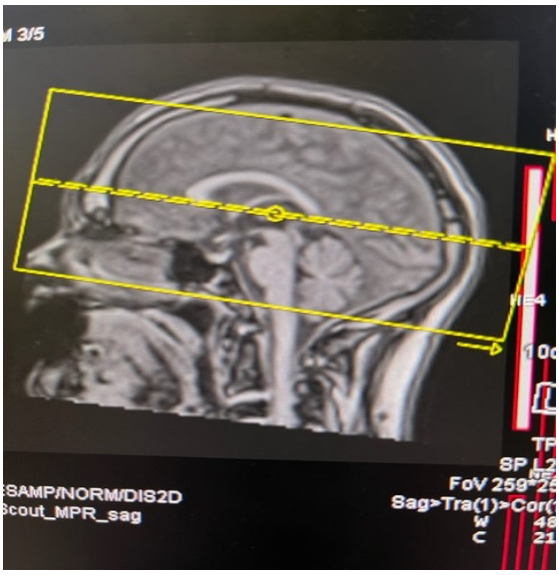
Post Gad: (5 minute delay)

Axial	3D T1 MPRAGE (axial and sagittal if 3D unavailable) T1 AX SE/FSE fat sat	

SEIZURE TREATMENT PLANNING (Dr. ROSSI)

Please verify order. Some patients for sz protocol are referred to Dr Rossi and associates and will need this protocol. Ideally this should be performed on 3T

Axial	GRE	
	FLAIR	
	T2 SPACE	- may not be available at offsites
	DWI	
Coronal	T1 MPRAGE pre	
	T2 SE	- Thin slices
	FLAIR	- thin slices
	T2 SPACE	- may not be available at offsites
Sagittal	FLAIR	
	T1 MPRAGE pre	- not needed at offsites
	T2 SPACE	- may not be available at offsites
Post-contrast	Coronal T1 MPRAGE post	
DTI when available		- may not be available at offsites. Make sure to include as much of brain as possible. See image below.



BRAIN (REFRACTORY SEIZURES <70 y.o.) – non-Rossi protocol

Sagittal	T1 SE
Axial	FLAIR
	T2 FSE
	GRE
	Diffusion
Coronal	T1 3D GE
	T2 FSE
	FLAIR

Post Gad: (Only if requested by referring physician):

Axial	T(1) SE
Coronal	T(1) SE

BRAIN (STROKE)

Routine Brain

Only if specified add:

- Intracranial MRA
- Neck MRA

Only if specified: Perfusion: Power inject 20cc of Gad w/ 2sec delay. Radiologist will choose level.

BRAIN (AVM)

Routine Brain
Intracranial MRA
Intracranial MRV

BRAIN (ANEURYSM)

Routine Brain
Intracranial MRA

BRAIN CSF Flow Study

Indications: NPH, Chiari malformation, aqueductal stenosis, posterior fossa mass/cyst, endoscopic 3rd ventriculostomy

Axial	DWI (sb1000)
	3D T1 MPRAGE
	T2
	FLAIR
Sag	T2 (2 mm slice thickness)
CSF Flow	2D FLASH (venc setting to 10 cm/sec, unless NPH then 20 cm/sec)

Brain for Traumatic brain injury

Indications: Subcuate traumatic brain injury with new or worsening symptoms or delayed recovery

Axial	DWI (sb1000)
	T2
	3D susceptibility weighted imaging (axial T2 GRE if SWI unavailable)
	3D FLAIR
	3D T1 MPRAGE

Internal Auditory Canals (Bell's Palsy (7th nerve), Trigeminal (5th nerve) Neuralgia)

Whole Brain:

Axial	T2 FSE
	FLAIR
	Diffusion

Pre Gad: (through area of interest)

Axial	T1 SE FatSat 3mm
	3D T2 GRE (CISS) 3mm

Post Gad: (through area of interest)

Axial	T1 SE FatSat 3mm
Coronal	T1 SE 3mm

Whole Brain:

Axial	T1 SE

Localize examination for area of concern:

IAC – Internal Auditory Canals
7th nerve – Slightly lower than for IAC
5th nerve - Brainstem

PITUITARY

Whole Brain:

Axial	T2 FSE

FLAIR

Pre Gad: (through pituitary)
Coronal thin T1 SE
Sagittal thin T1 SE

Post Gad: 90sec Coronal dynamic
Coronal thin T1 SE
Sagittal thin T1 SE

CERVICAL SPINE ROUTINE

FOV – Skull base through T1-2
Sagittal T1 SE
T2 FSE
STIR
Axial T2 Spoiled GE
T2 FSE

CERVICAL SPINE (SYRINX)

FOV – Skull base through T1-2
Sagittal T1 SE
T2 FSE
Axial T1 SE
T2 Spoiled GE

CERVICAL SPINE (Post Op)

Routine Cervical Spine <u>without Gad</u>

CERVICAL SPINE (Tumor, Infection or whenever Gad is requested)

FOV – Skull base through T1-2

Pre Gad:
Routine Cervical Spine
Sagittal Diffusion (add if possible if infection suspected)

Post Gad:
Axial Fat-saturated* T1 SE through entire spine
Sagittal Fat-saturated* T1 SE

* No fat-saturation for 1) Demyelinating disease / Multiple sclerosis or 2) If inadequate image quality from metallic hardware

THORACIC SPINE - Please place vitamin E marker at cervicothoracic junction

Sagittal T1 SE

T2 FSE
STIR

Axial T1 through entire spine
T2 FSE through entire spine

THORACIC SPINE (Tumor, Infection or whenever Gad is requested)- Please place vitamin E marker at cervicothoracic junction

Pre Gad:
Routine Thoracic Spine
Sagittal Diffusion (add if possible if infection suspected)

Post Gad:
Axial Fat-saturated* T1 SE
Sagittal Fat-saturated* T1 SE

* No fat-saturation for 1) Demyelinating disease / Multiple sclerosis or 2) If inadequate image quality from metallic hardware

LUMBAR SPINE

FOV -
Sagittal FOV: T11-12 through upper sacrum
T1 SE/FSE
T2 FSE
STIR

Axial FOV: T12-S1
T1 SE/FSE
T2 FSE – angled blocks through disc spaces (2-3 blocks only) see guide below
T2 FSE – straight- ONLY if entire canal was not included in angled blocks

If scoliosis present add:
Coronal T1 SE/FSE

LUMBAR SPINE (POST OP or whenever gadolinium contrast is requested)

FOV – T11-12 through upper sacrum
Post Op – Scan Pre & Post Gad T(1) Axials over entire spine

Pre-Gad:

Sagittal	T1 SE/FSE
Sagittal	T2 FSE
Sagittal	STIR
Sagittal	Diffusion (add if possible if infection suspected, can be done post gad)
Axial	T1 SE/FSE - angled blocks through spine (2-3 blocks only), stitched together
	T2 FSE - angled blocks through spine (2-3 blocks only), stitched together

Post Gad:

Axial	Fat-saturated* T1 SE/FSE, same positioning as pre gad
Sagittal	Fat-saturated* T1 SE/FSE

* No fat-saturation for 1) Demyelinating disease / Multiple sclerosis or 2) If inadequate image quality from metallic hardware

SPINE (CSF FLOW)

Use pulse gating

Axial: 2D Phase Contrast, flow compensation

Sagittal: 2D Phase Contrast, flow compensation

ABBREVIATED TOTAL SPINE SURVEY (CORD COMPRESSION, INFECTION, TUMOR, METS)

Case by case basis, discuss w/ radiologist

Perform in TWO SETS of Sagittal acquisitions (Use body coil if tall patient):

1. Total C spine and upper T spine
2. Lower T spine and total L spine

Sagittal	T1 SE/FSE
	T2 FSE
	STIR
Axial	T2 FSE

If ordered with Gad or if abnormal findings present:

Sagittal post T1 SE/FSE fat sat

Axial post T1 SE/FSE fat sat straight sequence only with angles to discs through area of interest

ORBITS

Brain: Whole Head

Axial	T2 FSE
	FLAIR
	Diffusion

Orbits: Cover entire orbit from brainstem forward.

Pre Gad:

Axial	T1 SE/FSE
Coronal	T1 SE/FSE FatSat
	T2 FSE FatSat
	STIR

Post Gad:

Coronal	T1 SE/FSE FatSat
Axial	T1 SE/FSE FatSat
Axial	T1 SE Whole brain No Fat Sat

NECK

Pre Gad:

Sagittal	T1 SE/FSE
Axial	T1 SE/FSE
Axial	T2 FSE Fat Sat
Coronal	T2 FSE Fat Sat, STIR if fat sat not sufficient

Post Gad:

Axial	T1 SE/FSE Fat Sat
Coronal	T1 SE/FSE Fat Sat

TMJ

Sagittal	T2 FSE (Bilateral, Closed position only)
	Proton Density Fat Sat (Bilateral, Open & Closed positions)
Coronal	T1 SE/FSE

If ordered with contrast, T1 Sag fat sat and T1 Cor fat sat

Musculoskeletal Imaging

KNEE

Sagittal	PD Fat Sat	(DO NOT ANGLE SAGITTAL IMAGES)
	PD	
	T2	
Axial	PD Fat Sat	
Coronal	PD Fat Sat	
	T1 SE/FSE	

If structural problem related to patella include:

Axial	T2 FSE

KNEE (ARTHROGRAM)

Post Injection:

Coronal	T1SE/FSE Fat Sat
	T2 FSE Fat Sat
Sagittal	T1 SE/FSE Fat Sat
	T2 FSE Fat/Sat

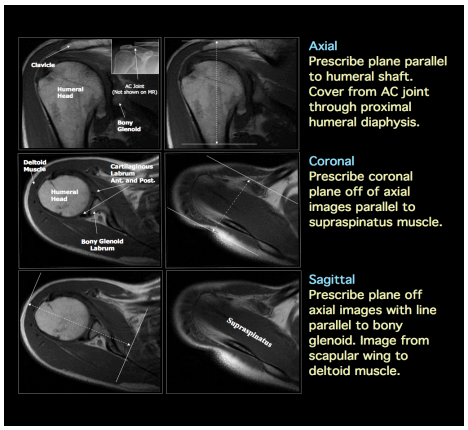
SHOULDER

Coronal	T1 FSE
	PD Fat Sat
	T2 FSE
Sagittal	T1 FSE
	T1 Fat Sat
Axial	PD Fat Sat

If r/o labral pathology include:

Axial	T1 SE/FSE

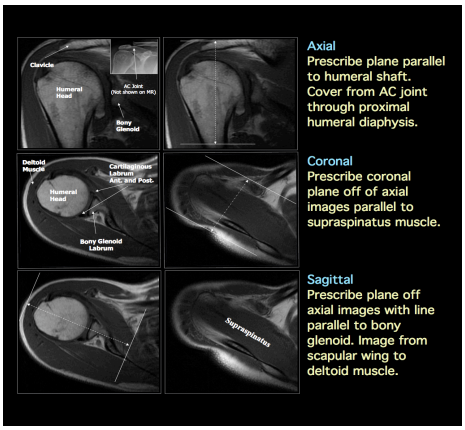
Set up coronal and sagittal off of axial at glenohumeral joint
Sagittal = parallel to joint
Coronal = perpendicular to joint



SHOULDER POST ARTHROGRAM

Post Injection:

Coronal	T1SE/FSE Fat Sat
	T2 Fat Sat
Coronal	T1SE/FSE Fat Sat with arm raised above head (ABER) see image below
Sagittal	T1SE/FSE Fat Sat
	T1 SE/FSE
Axial	T1SE/FSE Fat Sat



BRACHIAL PLEXUS

Large FOV bilateral:

Axial	T1 SE/FSE
Coronal	T1 SE/FSE
	T2 Fat Sat, STIR if fat sat not homogenous

Sagittal C-spine T1

Small FOV unilateral of affected side:

Axial	T2 Fat Sat
Sagittal	T2 Fat Sat

PECTORALIS MAJOR

Use shoulder coil low across chest/upper arm.

Small FOV (upper chest from humeral neck to mid shaft for pectoralis insertion):

Axial	STIR
	T1 SE/FSE

Moderate FOV (plane of pectoralis tendon as seen from axials):

Coronal	T1 SE/FSE
	PD Fat Sat

Moderate FOV (plane perpendicular to coronal):

Sagittal	T1 SE/FSE
	T2 Fat Sat

WRIST

Plain films needed for baseline

Coronal	PD Fat Sat
	T2 Fat Sat
	T1 SE
Axial	PD (through AOI and perpendicular to joint space)
	T2 Fat Sat
Sagittal	T2 Fat Sat (through AOI)

Patient is positioned head first with the fingers straight out.
Smallest FOV possible – Cover distal 2–3 cm of radius/ulna through CMC joints.

WRIST POST ARTHROGRAM

Post Injection:

Axial	T1 SE/FSE Fat Sat
Sagittal	T1 SE/FSE Fat Sat
Coronal	T1 SE/FSE
	T1 SE/FSE Fat Sat
	T2 Fat Sat

HAND

Coronal	T1 SE/FSE
	PD Fat Sat
	T2 Fat Sat
Sagittal	T2 Fat Sat

High Resolution:

Axial	PD (high resolution)
	T2 Fat Sat (high resolution)

HAND (ARTHRITIS)

Screening for inflammatory arthritis of both hands and wrists.
FOV to include distal radioulnar joint through MCPS of both hands.

Pre Gad:

Coronal	T1 SE/FSE
	PD Fat Sat
	T2 Fat Sat
Axial	PD
	T2 Fat Sat
Sagittal	T2 Fat Sat

Post Gad:

Axial	T1 SE/FSE Fat Sat
Coronal	T1 SE/FSE Fat Sat

DIGIT

Axial	PD
	T2 Fat Sat
Coronal	T1 SE/FSE
	T2 Fat Sat
Sagittal	PD (high resolution)
	T2 Fat Sat

*******When scanning thumb, planes need to be done in the plane of the thumb*******

HIPS

Need plain films for baseline
Except for Sagittals study is of **both** hips (body coil) regardless of what is requested.
Axials to include **entire** pelvis.

Bilateral:

Coronal	T1 SE/FSE
	STIR
Axial	T2 Fat Sat
	T1 SE/FSE

Unilateral:
(affected side only, small FOV, centered on joint space)

Sagittal	PD Fat Sat
Coronal	T2 Fat Sat
Axial Oblique	PD Fat Sat (angled to neck), figure 1
Cor Oblique	T2 2.5mm Fat Sat see image for positioning, figure 2

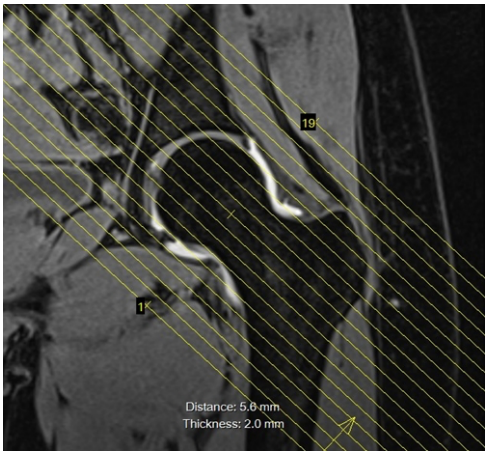


Figure 1 Axial oblique

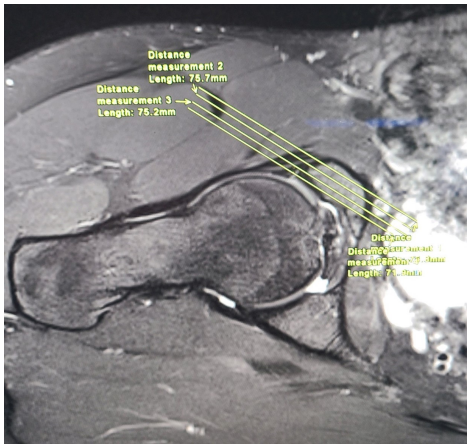


Figure 2 coronal oblique

HIP POST ARTHROGRAM

Post injection:

Axial	T1 SE/FSE Fat Sat (**axial oblique**)
	T2 Fat Sat
Coronal	T2 SE/FSE
	T1 SE/FSE Fat Sat
	T2 Fat Sat
Sagittal	T1 SE/FSE Fat Sat

Use flex coil on affected hip with small FOV.

PELVIS BONEY

Routine Hips (to cover entire pelvis through SI joints on coronals and through iliac bone on axials).

Sagittal PD Fat Sat

QUADRICEPS MUSCLE (THIGH)

Both sides with large FOV:
Coronal T1 SE/FSE
T2 Fat Sat
Axial T1 SE/FSE
T2 Fat Sat

Affected side only with small FOV:
Sagittal T2 Fat Sat

ADDUCTOR DETACHMENT (ATHLETIC HERNIA/PUBALGIA)

Large FOV of pelvis:
Coronal T1 SE/FSE
T2 Fat Sat
Axial T2 Fat Sat

Small FOV centered over pubic bone:
Axial Oblique – 90 degrees to long axis of symphysis as seen on sagittal.
Axial Oblique PD
T2 Fat Sat
Sagittal T2 Fat Sat (through symphysis)
Sagittal T2 Fat Sat (through affected hip)

SACROILIAC JOINTS (all with contrast unless contraindicated)

Plain films are desired for baseline
FOV centered on sacrum and SI joints
Coronal oblique (parallel to long axis of sacrum)
T1 SE/FSE
T2 Fat Sat
T2 Fat Sat

Axial oblique (perpendicular to coronal plane scan)
T1 SE/FSE

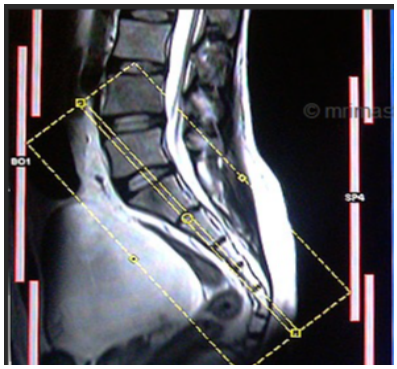


Figure 4 Oblique coronal

T2 Fat Sat
Post-Gad:
T1
FSE/SE Obl
AX/Cor Fat Sat

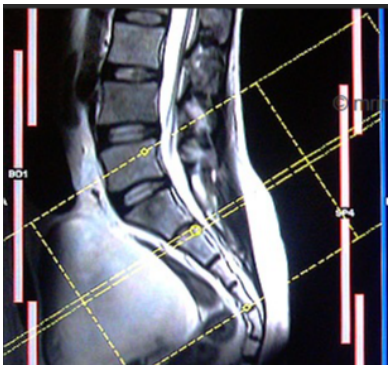


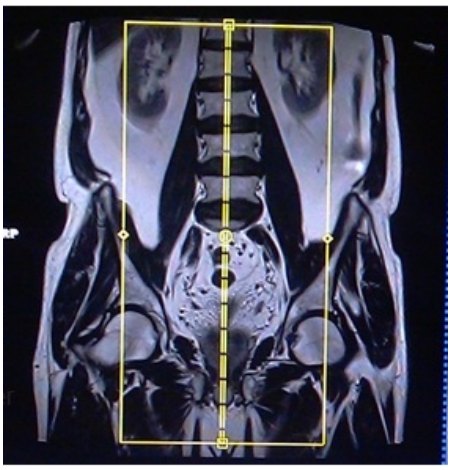
Figure 3 Oblique Axial

SACRUM see SI joints for positioning guide

Axial	T1 SE/FSE
	T2 FSE
Coronal	T1 SE/FSE
	T2 Fat Sat
Sagittal	T2 FSE

LUMBOSACRAL PLEXUS

Axial	T1 SE/FSE



	T2 FSE
Cor oblique	T1 Fat Sat
	STIR
Post-Gad	
Axial	T1 SE/FSE
Cor oblique	T1 SE/FSE Fat Sat

Figure 5 Sagittal *Figure 7 Coronal* *Figure 6 Axial*

EXTREMITY MASS

Required: conventional radiographs and skin marker on all cases.
Skin marker above & below lesion, not directly over lesion.
Inject Gad on all tumor cases regardless of region.

Pre Gad:

Axial	T2 FSE (obtain first - most important!)
	T1 SE/FSE
	T1 SE/FSE Fat Sat
	T2 FSE Fat Sat or STIR

In plane where the pathology is best seen

	T1 SE/FSE
	T2 Fat Sat

Post Gad:

Axial	T1 SE/FSE Fat Sat

Same 2nd plane as pre gad

	T1 SE/FSE Fat Sat

EXTREMITY INFECTION

Pre Gad

Axial	T1 SE/FSE
	T2 Fat Sat

In plane where pathology is best seen

	T1 SE
	T2 FSE Fat Sat

Remaining plane

	T1 SE/FSE (when imaging small joints)
	T2 FSE Fat Sat

Post Gad:

Axial	T1 SE/FSE Fat Sat

Same 2nd plane as pre gad

	T1 SE/FSE Fat Sat

THIGH (OTHER THAN FOR MASS)

Large FOV bilateral thighs

Coronal	T1 SE/FSE
Coronal	T2 FSE Fat Sat or STIR
Axial	T2 Fat Sat or STIR

Small FOV unilateral side of symptoms

Coronal	T1 SE/FSE
Coronal	T2 Fat Sat or STIR
Axial	T1 SE/FSE
Axial	T2 FSE Fat Sat or STIR
Sagittal	T2 FSE Fat Sat or STIR

LEG (OTHER THAN FOR MASS)

Large FOV bilateral legs

Coronal	T1 SE/FSE
Coronal	T2 FSE Fat Sat or STIR
Axial	T2FSE Fat Sat or STIR

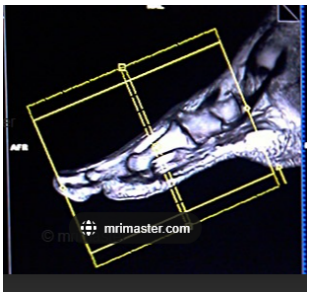
Small FOV unilateral side of symptoms

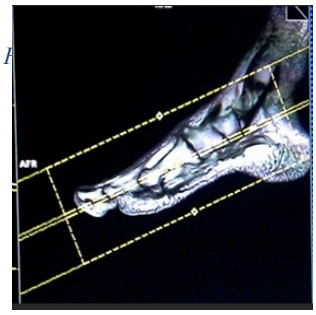
Coronal	T1 SE/FSE
Coronal	T2 FSE Fat Sat or STIR
Axial	T1 SE/FSE
Axial	T2 FSE Fat Sat or STIR
Sagittal	T2 FSE Fat Sat or STIR

ANKLE/FOOT

Plain films are required if exam is for bone abnormality.
Hindfoot is same as ankle, forefoot is midfoot forward.
Foot-axial is long axis, Ankle-axial is short axis.

Sagittal	T1 SE/FSE
	T2 FSE Fat Sat or STIR
Coronal	T1 SE/FSE
	PD
	T2 FSE Fat Sat or STIR
Axial	T2 FSE Fat Sat or STIR
	PD





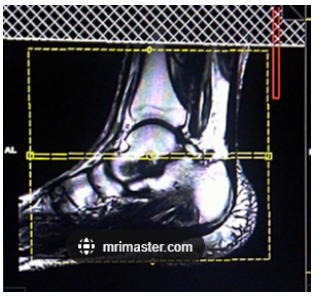
FOOT (NEUROMA)

Routine Ankle/Foot
Omit - Coronal PD
Add:
Pre Gad:

Coronal	T1 SE/FSE Fat Sat

Post Gad:

Coronal	T1 SE/FSE Fat Sat
Sagittal	T1 SE/FSE Fat Sat



FOOT (INFECTION)

Axial is long axis, Coronal is short axis

Sagittal	T1 SE/FSE
	T2 FSE Fat Sat or STIR
Coronal	T1 SE/FSE
	T2 FSE Fat Sat
Axial	T1 SE/FSE
	T2 FSE Fat Sat or STIR

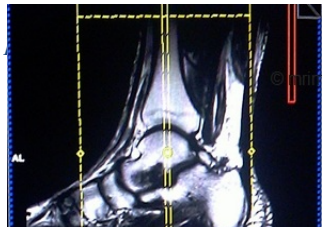


Figure 12 Coronal ankle

Post Gad:
Sagittal T1 SE/FSE Fat Sat
Coronal T1 SE/FSE Fat Sat

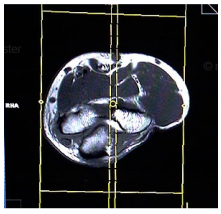


Figure 13 Coronal *Figure 14 Sagittal*

ELBOW

Axial PD FSE
T2 FSE Fat Sat or STIR
Sagittal T2 FSE Fat Sat or STIR
Coronal T1 SE/FSE
PD FSE Fat Sat
T2 FSE Fat Sat or STIR

Set coronals and sagittals off of axial acquisition. Use epicondyles to set slices. Always include bicipital (radial) tuberosity.

ELBOW (ARTHROGRAM)

Post Injection:
Axial T1 SE/FSE Fat Sat
Coronal T1 SE/FSE Fat Sat
T2 FSE Fat Sat
Sagittal T1 SE/FSE Fat Sat

ELBOW/ARM (BICEP RUPTURE)

Axial T1 SE/FSE
PD Fat Sat
Sagittal T1 SE/FSE larger FOV 200-250 cm
T2 FSE larger FOV 200-250 cm
Coronal T1 SE/FSE
STIR

FOREARM

Axial T1 SE/FSE
T2 FSE Fat Sat or STIR
Sagittal PD FSE Fat Sat
Coronal T1 SE/FSE
PD FSE Fat Sat

TOTAL BODY FOR MULTIPLE MYELOMA

Coronal T1 SE/FSE Use slice thickness as appropriate for patient size
STIR

Cover areas of interest in large field of view including as little as

1. Head/neck
2. Chest and upper abdomen/upper extremities and lower abdomen
3. Pelvis/lower extremities

Abdominal Imaging

LIVER (ROUTINE)

Axial T1 GE (all sequences are single breath hold)
T2 Ultrafast SE
IN / OUT
Diffusion b0-50 and 800-1000
Coronal T2 Single Shot
Post Gad:
Axial T1 GE
Coronal T1 GE
Dynamic study with power injection at 0sec (arterial), immediate (venous), 90sec, 3min, 5, 15 min

SPLEEN

- Same as Routine Liver including 15 minute post-contrast delay
- Change FOV to cover entire spleen

LIVER (HEPATOMA, CIRRHOSIS, METS) - EOVIST

Pre Eovist:
Axial T1 Ultrafast Spoiled GE
T2 Breath Hold
IN / OUT
Coronal T1 GRE
T2 Breath Hold

Post Eovist:
Axial T1 Ultrafast Spoiled GE
(Use bolus tracking over left ventricle)
Dynamic study with power injection at 0sec (arterial), immediate (venous), 90sec, 3min, 5min, 10min, & 20min.

Axial Diffusion b0-50 and 800-1000 (during delay)
Coronal T1 Ultrafast Spoiled GE 20 min

PANCREAS (ROUTINE)

Axial T1 GE (all sequences are single breath hold)
T2 Ultrafast SE
IN / OUT
Diffusion b0-50 and 800-1000
Coronal T2 Single Shot
SSFP
Multi rotation T2 Ultrafast SE thin slice breath hold (in best angle from thick slab)
Post processing MIPS & Source images

Post Gad:
Axial T1 GE
Coronal T1 GE
Dynamic study with power injection at 0sec (arterial), immediate (venous), 90sec, 3min, 5

BILIARY SYSTEM – MRCP

Biliary System:
Coronal T2 Ultrafast SE (single breath hold)
T2 Balanced GE
T2 Thick Slab
T2 3D restored 384 Triggered
Axial T2
T2 Fat Sat
In/Out phase GRE
Multi rotation T(2) Ultrafast SE thin slice breath hold (in best angle from thick slab)
Post processing MIPS & Source images

Liver:
Axial T1 FSE
T2 FSE
In/Out phase GRE
Diffusion b0-50 and 800-1000
Coronal T1 FSE

RENAL

Axial In/Out phase GRE
T2 FSE
T2 FSE Fat Sat
Coronal T1 GE single breath hold
T2 FSE
STIR

Post Gad:
Axial T1 GE single breath hold
Coronal T1 GE single breath hold
Send Axial Subtraction images to PACS (Axial T1 contrast minus Axial T1 pre)

Dynamic study with power injection at 0sec (arterial), immediate (venous), 90sec, 3min, & 5min.
Axial Diffusion b0-50 and 800-1000 (during delay)

MR UROGRAM

250 mL normal saline IV before
Axial In/Out
T2 FSE
T2 fat-sat

20 mg IV Lasix about 15 minutes before gad

Coronal T1 GE single breath
T2 FSE
STIR
T2 thick slab MRCP with MIP

Coronal 3d flash to cover kidneys ureters and bladder
Pre, 20, 100-120 sec
Axial vibe 3 minute
Coronal 5, 6, 7, 8, 9, 10 minutes
axial vibe 12
coronal 15 minutes

Make subtractions for all post-gad sequences

ADRENAL GLAND

Axial T1 FSE
T1 FSE Fat Sat
T2 FSE
In Phase / Out of Phase GE
Coronal T2 FSE
In Phase/ Out of Phase GE

ABDOMEN – NONSPECIFIC (ABDOMINAL PAIN, OTHER)

Field of view – diaphragm through iliac crests
Axial T1 GE
T2 fat sat
IN/OUT
Coronal T2

MRI ENTEROGRAPHY

Prep – 4-6hr NPO
Contrast – 3 x 450ml bottles of Volumen (or Breeza) one hour prior to imaging
Optional glucagon – 1 mg IM (contraindicated in glaucoma, known pheochromocytoma or insulinoma) (Note: Onset of action 8-10 min and duration of 12-27 min)
Field of view – Coronal performed with large FOV to include entire abd/pelv
Patient position - PRONE
Pre Gad:
Coronal T2 Fat Sat (Breath hold)
Steady State GE
Diffusion 0-50 and 800-1000
Axial T2 Abdomen (Breath hold)
T2 Pelvis (Breath hold)

Post Gad:
Coronal T1 GE Multiphase 0, 30, 70 sec

Axial	T1 GE Fat Sat Abdomen
	T1 GE Fat Sat Pelvis

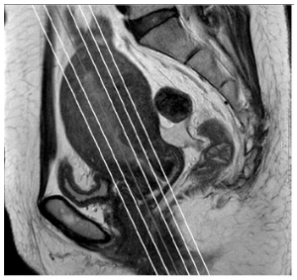
PELVIS (SOFT TISSUES OR BLADDER CA STAGING)

Axial	T1 FSE
	T2
	T2 Fat Sat
Axial	Diffusion b0-50 and 800-1000
Coronal	T2 Fat Sat
Sagittal	T2 FSE

Post Gad (Bladder CA staging or if requested):
T1 all planes with FatSat

PELVIS - Perianal fistula – NO rectal gel
Soft tissue protocol but angle to anal canal plus
Small FOV Axial T2
Small FOV Axial T2 FS

PELVIS – Congenital uterus
Indications: Mullerian duct anomaly, uterine agenesis, arcuate, unicornuate / bicornuate, didelphys, septate uterus
Soft tissue protocol plus
Angled T2 axial and coronal along plane of uterus, see below



Axial T1 FSE Fat Sat

Figure 16 Long Axis

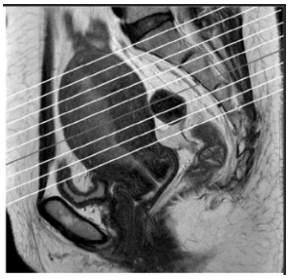


Figure 15 Short Axis

PELVIS (ENDOMETRIOSIS)

	T1 FSE no fat sat
	T2
	T2 Fat Sat
	T2*
Coronal	T2 Fat Sat
Sagittal	T2 FSE

PELVIS – Urethral diverticulum
Indications: Urethral diverticulum, vaginal cyst, Bartholin gland cyst, Skene gland cyst

Axial	T2 SSFSE
	T1
Coronal	T2 SSFSE
Sag	T2 SSFSE

Small FOV (20-24) for rest of study

Axial	T2
	T2 FS
	DWI
	SPACE with fat sat (if available)
Sagittal	T2 FS
Coronal	T2

Axial T1 pre, T1 fat sat post at 30-70sec, coronal and sag T1FS

PELVIS (UTERINE ARTERY EMBOLIZATION)

Pre Gad:

Axial	T1 Spoiled GE 2D Fat Sat
	T2 Fat Sat
	T2 FSE – angled parallel to long axis of uterus
Sagittal	T2 FSE
Coronal	T2 FSE - angled perpendicular to long axis of uterus

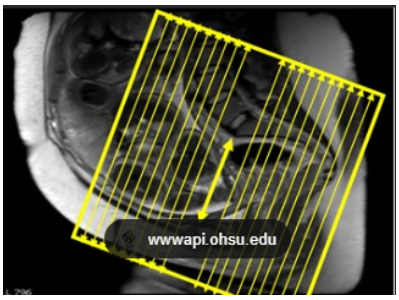


Figure 17 Oblique coronal for inlet

Post Gad:

Axial	T2 Spoiled GE 2D FatSat

PELVIS (PELVIMETRY)

Axial	T1 FSE
Sagittal	T1 FSE

Oblique (inlet) Coronal T1 FSE

PELVIS (PLACENTA)

Axial	T1 GE single breath hold
	T2 TSE (Breath hold)
Sagittal	T2 TSE (Breath hold)
Coronal	T2 TSE (Breath hold)

RECTAL OR CERVIX (STAGING FOR TUMOR)

3T unless s/p hip arthroplasty

Note: Please make attempt to get Colonoscopy/Sigmoidoscopy report for rectal CA cases and put in PACS

Insert 120ml of ultrasound gel into rectum for rectal cancer – try to get large air bubbles out

Field of view – lower pelvis only – small field of view
Axial oblique (perpendicular to long axis of rectum at level of tumor)
T1 (no fat sat or gad on any sequences)
T2 FSE no fat sat
Diffusion b0-50 and 800-1000

Sagittal T2 FSE
Coronal T2 FSE

If with contrast, add:
Axial T1 FS pre-contrast
Axial, coronal and sagittal with fat-sat

MR Defecography – COE and Barberton only
Insert 120 mL of ultrasound gel into rectum
Locations, MAP and SHIM
Axial T1 of the pelvis (FOV of the scans should cover pubic symphysis to inferior coccyx)
AX FASE
SAG FASE
COR T2
SAG SSFP CINE (20 phases, 2 seconds long)
Rest
Squeeze (Kegel): First couple images rest, then instruct patient to squeeze for 8 seconds, rest, repeat
Strain: Same as above but instruct to strain (Valsalva) instead of squeeze
Evacuate x3: Same as above but ask patient to push gel out.
If patient cannot evacuate, add 60 mL more gel and attempt again. If unsuccessful with this, have patient go to the bathroom and re-image after gel evacuated

PROSTATE
3T unless s/p hip arthroplasty or UroLift
Preference is to wait four weeks after prostate biopsy
Pre-Gad:
Axial T1 Whole pelvis
All remaining sequences small field of view
Axial T2 FSE
Sagittal T2 FSE
Coronal T2 FSE
Axial Diffusion b0-50 and 1400

Post-Gad:
Axial Multiphase T1 FAT SAT

SCROTUM

Use small flex coil
Pre Gad:

Axial	T1 FSE
	T2 FSE
Sagittal	T1 SE

Post Gad:

Axial	T1 FSE
Sagittal	T1 FSE

PENILE MRI position penis as sagittal as possible

Axial T2 FSE
T2 FS
T1 SE
In phase & out of phase
DWI
Coronal
T2 FSE
Sagittal
T2 TSE
T2 Fat-sat
If request with contrast
Axial T1 fat-sat pre-contrast
3plane post-gad with fat-sat

ABDOMEN/PELVIS (SUSPECTED APPENDICITIS IN PREGNANCY)

Axial	T1 GE breath hold
	T2 SSFSE breath hold with fat sat
	IN/OUT
Sagittal	T2 SSFSE breath hold
Coronal	T2 SSFSE breath hold with wide field of view to include kidneys/GB

ABDOMINAL WALL MASS

Scan only area of interest, palpable marker if applicable

Axial	T2
	T2FS
	SSFP
	T1
	In/out of phase
	DWI
Sag	T1

T2

Axial T1 FS pre + post axial, coronal and sagittal

CHEST

Perform in prone position when attention to anterior structures

Axial	T1 FSE
Coronal	T1 FSE
	T2 FSE

MRA Imaging

CIRCLE OF WILLIS (HEAD OR INTRACRANIAL)

Sagittal Scout
Axial: 3D TOF MRA, combined MOTSA

CAROTID (NECK OR EXTRACRANIAL)

Pre Gad:
Axial: 2D or 3D TOF MRA of entire carotid system

Post Gad:
Axial: 3D TOF MRA (from Aortic Arch to Circle of Willis)

CAROTID (NON-CONTRAST) (NECK OR EXTRACRANIAL)

Axial: 2D or 3D TOF MRA entire carotid system
Axial: 3D TOF MRA of carotid bifurcation only

MR VENOGRAM HEAD

Pre-Gad:
Sagittal: 2D TOF MRV
Coronal: 2D TOF MRV
Post Gad: 2D TOF MRV Wide FOV

RENAL ARTERIES

Coronal	T2 Balanced GE
Axial	T2 Balanced GE
	T2 FSE
	T1 Spoiled GE

Run coronal 3D subtraction & axial timing bolus sequences.

Post Gad: 3D-TOF MRA of renal arteries

RENAL ARTERIES (DONOR)

Axial	T1 Spoiled GE
Coronal	T1 FSE
	T2 FSE

Run breath hold no contrast mask & axial timing bolus sequences.

Post Gad:
3D-TOF MRA of renal arteries

Coronal	T1 FSE

RENAL VEINS

Axial:	T2 Balanced GE
Coronal:	T2 Balanced GE

Breath hold no contrast mask

Post Gad: Timing run w/ 10sec scan delay, 5cc test bolus just above renal arteries.
3D-TOF MRA breath hold

Add Renal Protocol post Gad if examination performed to evaluate tumor.

PORTAL VEIN

Axial	T2 Balanced GE
Coronal	T2 Balanced GE
Sagittal	2D TOF MRA with sat bands on one side through portal vein
	2D TOF MRA with sat band on <u>other</u> side through portal vein
	T1 SE Black Blood

Breath hold no contrast mask

Post Gad: Timing run w/ 30sec scan delay, 5ml test bolus
3D-MRA breath hold with double dose

INFERIOR VENA CAVA

Axial: T2 Balanced GE
Coronal: T2 Balanced GE

2-D axial MRA to cover IVC (5 slices/breath hold, MIP together)

Breath hold no contrast mask

Post Gad: Timing run w/ 30sec scan delay, 5cc test bolus
3D-MRA breath

THORACIC AORTA

Use Cardiac Table gating
Axial T1 FSE gated
Para Sagittal T1 FSE gated (Candy Cane)

Breath hold no contrast mask

Axial: Timing run in Aortic Arch, 2ml test bolus

Post Gad: Para Sagittal 3D MRA of Aorta

When doing para sagittals be sure to change orientation to coronal before angled

AORTIC ARCH & GREAT VESSELS

Axial: T2 Balanced GE to include ascending and descending aorta

Post Gad: Para Sagittal CareBolus

ABDOMINAL AORTA

Axial: T1 Steady State GE
Coronal T1 Steady State GE

Post Gad: Coronal 3D CareBolus

PERIPHERAL LOWER EXTREMITY RUNOFF

Localizer from renal to ankle

Do visual prep
OR
Do timing bolus

Post Gad: Coronal 2D TOF MRA
1st phase – 2.0cc/sec for 20cc through femurs
2nd phase – 1.0cc/sec for 30cc through ankle

do scan from renal to ankle then back up from ankle to renals

CARDIAC Only at COE and ACH Inpatient scanners. Cardiac manuals are on site.

BREAST IMAGING

BREAST (ROUTINE)

Axial	T1
	T2 Fat Sat
	T2 Fat Sat

Contrast: 10ml Gadavist with 20 sec delay

Post Gad:	Axial multiphase dynamic
Delayed:	Sag L and R Fat Sat

BREAST (IMPLANTS)

Axial	T2 TIRM
	T2 Fat Sat
	T2 Water Suppression
	T2 TIRM Fat Sat
Sagittal	T2 TIRM
	T2 Fat Sat
	T2 Water Suppression
	T2 TIRM Fat Sat

Ver 7.0 Revisions

Updated Routine Brain
- diffusions
- Sagittal sequences
- CSF flow

Updated Routine L/S with axial T(2)

Updated all MS
- Knee add pd fatsat
- Shoulder add t2 cor fatsat
- Ankle change t1 coronal to pd fatsat
- Elbow change t2 axial to fatsat
- Hip change t2 axial to fatsat
- Hip arthrogram no t2
- Revamp forearm

Abd
- added in/out phase as routine
- added t2 thick slab rotations to MRCP

MRA
- Peripheral lower extremity runoff

Cardiac

7.1 Revisions:

Tech update

IAC FatSat

Abd Ao

8.0 Revisions

Added Brain Bleed
- Sacrum
- Breast
- Extremity infection

Sagittal STIR spines

Arm raised shoulder arthrogram

Updated liver to dynamic
- renal with T(2) FatSat
- MRCP with trigger 3D, Ultrafast SE coronal, and Liver
- Dynamic pancreas

Added MRA Portal Vein

Version 9.0 Revisions
Gad Advisory Statement

Version 10.0 Revisions
New MSK protocols
- PDFS in place of T(2) on almost all sequences

Rtn use of Gad for infection

Version 11.0 Revisions
Neuro update from Sept meeting
- Rtn Post Gd brain in two planes
- Update orbits

New MSK protocols
- Quad muscle
- Adductor rupture (hernia)
- Forearm

Update MSK
- Elbow
- Ankle
- Extremity mass & infection add PD FatSat, best plane
- Hips

Abd update
- Uterine Ablation protocol
- Add pelvimetry

MRA carotid update

Version 11.1 Revisions
Neuro update from Sept meeting
- Add rtn BOLD
- Dynamic Sella
- Add GRE to T spine
- Update no gad for post op C spine
- Did not: add rtn brain coronal, pre T1 axial on post gad brains, seizure MPRAGE

MSK
- Update latest shoulder
- Hips with small FOV unilateral and axial oblique added
- New SI jnt post gad
- Foot/ankle orientation change and add Neuroma & infection
- Move brachial plexus to msk
- Add pectoralis major
- Add hand and digit
- Add bony pelvis
- Add calf

Version 11.3 Revisions

Neuro

- Rtn brain on IAC studies
- Sagittal post gad on initial pituitary
- Post op lumbar T(1) over surgical levels only
- Orbits to include rtn brain

MSK

- Revised Athletic Pubalgia

Abd

- Add Placenta
- Dynamic Renal
- Gad adrenals
- High T(2) liver hemangioma

Version 11.4 Rev

Neuro

- Add FLAIR axials to seizures
- Sella T(1) post dynamic coronal
- Post op lumbar entire spine – go figure

Abd

- EOVIST

Version 11.5 Rev

Change:

- HASTE – Ultrafast SE
- THRIVE – Ultrafast Spoiled GE
- TRUFI – Balanced GE
- FLASH – Spoiled GE
- FISP – Steady State GE

Abd

- Add coronal STIR to Renal

Version 11.5b Rev

Neuro

- Add Pre Gad T(1) axials to all brains
- Axial MPRAGE (3D IR) to seizures
- Add Cor T(2) FatSat to neck

MSK

- Change pelvis to T(2) FatSat

Abd

- Update dynamic timing in abd

Version 13 Rev (6/4/2013)

Neuro

All pituitary exams include dynamic post contrast imaging
Cervical spine axial FSE T(2) included on routine

Abd

Rectal MR for staging added
Liver Eovist limited to hepatoma, cirrhosis or mets
Liver Eovist – 20 min imaging includes coronal
Adrenal – post contrast imaging deleted
Add Susupected appendicitis in preganancy protocol

Gadolinium advisory updated

Version 2013b (9/2013)

Updated numbering scheme

MSK

Proton/Spin density sequence performed at TE of 60
Changed SI joint protocol
Thighs
Legs

Abd

Diffusion weighted imaging with b value 0-50 and 800-1000 added for most abdominal sequences
Pelvic for endometriosis – T1 is now with fat sat
Rectal – angle axial perpendicular to long axis of rectum at level of tumor
Prostate

MRA

Added optional post-gad MRV head

Version 2014

Neuro

Specified field of view for Cervical and Lumbar
Add Axial GRE to Brain for seizure
Limit Brain for seizure to patients <70 yo, otherwise perform routine Brain

MSK

For Infection - SE T(1) all three planes in small joints

Abd

Updated Pelvis for UAE

Version 2015

Neuro

Updated Entire Spine Survey

MSK

Updated Foot (Infection)

Version 2015b

Neuro

Seizure protocol only for refractory seizure or specific requests for protocol

IAC – coronal T1 post Gad now performed without fat sat (ACR accreditation requirements)

Orbits - Add Pre Gad axial T1 and T2 non-fat sat orbits and coronal STIR pre contrast (ACR)

MSK

Knee – add sagittal T(2) (ACR)

Ankle/Foot – add T(1) coronal (ACR)

SI joints use Gad for all

Shoulder – add coronal T(1)

Abd

Renal – change axial T(1) to In/Out phase GRE (ACR

Add MR Urogram

Pancreas – If cyst known or detected, then add thin slice MRCP sequence to determine if cyst communicates to pancreatic duct

MRCP now includes dynamic multiphase post Gad T(1) of liver

Enterography performed in prone position. Add optional IM glucagon

Rectal protocol changed to Rectal or Cervix for staging

Prostate – add axial T(1) whole pelvis (ACR)

Version 2015c

Neuro

Brain for seizures – remove axial 3D, add coronal T(1)

Orbits – Remove axial T(2)

Abd

MRCP back to non-contrast

Add Abdomen – nonspecific (abdominal pain, other)

Other

Updated Gadolinium advisory statement regarding patients at risk requiring creatinine determination

Version 2015d

Neuro – Brain with contrast - delete coronal T(1)

MSK

Add T(1)FatSat

MRA

MR Venogram Head – use gadolinium on all except when patient undergoing MRA during same exam

Added statement about Ablovar (blood pool agent)

Version 2016a
Neuro - L spine – axials done in blocks angled through discs, but straight can be included especially if entire canal was not included in angled blocks
Abd - Pelvis for soft tissues – post contrast sequence to be performed without fat suppression
Pelvis for rectal CA – tech please make attempt to get colonoscopy report
Breast -Updated sequences

Version 2016b
MRI Brain for seizure for patients with first seizure or 70 y.o.– perform routine brain without contrast or with/without contrast if requested

Version 2017
Add Total Body for Multiple Myeloma
Reverse policy regarding seizure as noted in 2016b

Version 2018
Updated abdomen/pelvis in pregnancy for suspected appendicitis

Version 2018b
Brain (routine) add Cor T(2)
Corrected typos in MRV Head
Brachial plexus – add cervical spine sag sequence
Add Lumbosacaral plexus protocol

Version 2018c
TMJ coil no longer available. Use head coil
Prostate T1 pre and post contrast use Fat Sat (large FOV T1 is without Fat Sat)
Updated Breast MRI
Update to Gadolinium advisory statement

Version 2019
Brain for seizure – coronal changed to 3D GE T(1)
Adrenal - added coronal in/out phase GE
MR Enterography – change axial T2 to no fat sat
Carotid MRA – noncontrast can be done 2D or 3D

Version 2019b
Brain for known tumor – Change post contrast to 3D volumetric (MPRAGE)

Version 2019c
Updated Brain protocols (deleted Cor T1 from routine and Cor T2 brain with contrast)
All protocols realigned in proper columns

Version 2020a – Jan 2020
Chest for endobronchial valve

Version 2020b – May 2020
Renal MRI – send subtraction images to PACS
Rectal MRI – optional ultrasound gel usage
Pelvis with contrast – indication includes bladder CA staging

Version 2020c – August 2020 with Oct update
Neck – change axial precontrast T1 to non-fat sat
Liver – post contrast – remove 15 min delay sequence
L spine post op – Angle Axial T2 through discs

Version 2021a – April 2021
Pancreas – post-contrast series to end after 5 minutes
Kidney – post-contrast series to end after 5 minutes
Rectal cancer – 120 cc rectal gel for rectal cancer
MR Defecography – added protocol for COE and Barberton
MR hand – reminder for MR thumb to perform in plane of thumb
Post-op Lumbar spine – reminder to perform T2 angled blocks through disc spaces
Brain –add 3D high resolution T2 in area of concern if indication is "encephalocele"
Pelvis (soft tissues or bladder CA staging) – add axial T2 no fat-sat, DWI
Pelvis (endometriosis) – add axial T1 no fat-sat, axial T2 no fat-sat, axial T2*
Adrenal – add axial T2

Version 2021b – October 2021
Pancreas and **Kidney** post-contrast series to end after 5 minutes, but all **livers** go out to 15 minutes
Pituitary changed from ½ dose gad to normal dose
New **Penile MRI** protocol
Cervical cancer: clarify there is an axial T2 without FS. For gad, add axial pre-contrast T1FS + 3 planes post *with fat-saturation*
New **seizure protocol** for Dr. Rossi patients; changes to previous seizure protocol (offsites may not have all sequences including SPACE, okay to omit these unless ordered by Rossi)

Version 2022a
Liver: remove coronal T1 and STIR, add Coronal T2 SSFSE
Pancreas: is now identical to liver but
1. Addition of coronal SSFP
2. Thick slab and 3d navigated MRCP on all patients
3. Post-gads only go to 5 minutes, not 15

Spine with contrast: do all post-gads with fat sat except
1. MS / demyelinating disease
2. If tech determines too much artifact to adequately perform T1FS

Please confirm all MRCP performed with in/out of phase

Version 2022b

Lumbar with contrast
- Change axials to be 2 or 3 angled blocks through whole spine to obtain complete coverage, stitch together blocks into 1 sequence

Hip arthrogram: Specify that Axial T1 is axial oblique
3T
- Rectal CA, cervical CA and prostate all should be on 3T
- Exception: Barberton and old COE scanner if s/p hip arthroplasty

Spleen: New protocol (same as routine liver)
MR Urogram: new protocol, includes Lasix (need nursing)
Change MS protocol
New CSF Flow and traumatic brain injury protocols

Version 2022c

Thoracic spine: Add vitamin E marker to cervicothoracic junction. Also changed axial T2 to FSE, not GRE
MRV: removed statement "do not use contrast if performing MRA during same exam"
Perianal fistula protocol
Congenital uterus protocol
Urethral diverticulum protocol
MRCP: Add in/out of phase
Abdominal wall mass protocol
Prostate: DWI do low b value and b1400. Urolifts to 1.5T only
Combined and altered brain with contrast for r/o mass + known mass
Abbreviated total spine (fat sat post)
Simplified liver protocols to routine and Eovist