RAFV NEURO MRI PROTOCOLS

General guidelines/updates:

1. Please check to make sure all sequences have sent to PACS server before populating study in worklist
2. When in doubt, contact radiologist or neuroradiologist prior to/during scan if complex protocol
3. Monitor all pediatric sedated neuroradiology cases (brain and spine)
4. Monitor all MR spectroscopy cases with a neuroradiologist prior to pt getting off table
5. In certain cases, it is fine to deviate from established protocols (ie. If neurosurgeon requests limited MR cervical flex/ex or limited MR cervical spine sagittal views, that is fine)
6. Changes to prior protocols are highlighted in boldface
7. Do not add FIESTA through IACs unless IAC protocol is specifically requested
8. If newly detected intracranial tumor, run Axial T1 post as a STEALTH 1.5 mm sections straight away
9. Ax T2* GRE on all MR brain examinations
10. Separate protocols are listed for Theda Clark West (labeled TC West) and Neuroscience Group (labeled NSG) . These are in a separate document to avoid confusion.

ROUTINE BRAIN

5 mm thick sections

Sag  T1
Ax   T2 FRFSE Fat Sat
Ax   FLAIR
Ax   DWI/ADC
Ax   GRE T2* (Please acquire on all patients)

If post contrast, add:  If surgical lesion or metastases add:
Ax  T1 pre   Ax  T1 pre
Ax  T1 post  Ax  T1 post
Cor T1 post  Cor T1 post
Sag T1 post

If newly detected tumor or following up abnormal areas of enhancement concerning for tumor recurrence versus radiation necrosis, then also add:
Ax perfusion*

Generate rBCV (negative enhancement integral), MTT maps

** If newly detected intracranial tumor, run Ax T1 post as a STEALTH 1.5 mm sections

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For seizures, add:

Cor obl FLAIR through temporal lobes (2 mm)

Cor obl T2 FSE through temporal lobes high resolution (3 mm)

For the above two sequences, scan plane should be perpendicular to hippocampi and the FOV should be decreased to focus on bilateral temporal lobes

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For *Multiple Sclerosis*, add:

Sag FLAIR

** Cor postcontrast (optimal detection optic neuritis)**

Ax T1 pre/post

If Noncontrast MR Brain ordered for multiple sclerosis and renal function is fine, contact radiologist to get order changed to MR brain with and without contrast

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For memory loss, dementia, add:

Cor obl FLAIR through temporal lobes (3 mm)

Do not forget Axial T2* GRE

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For IAC, 7th/8th nerves (hearing loss, tinnitus, etc), add:

Through IAC, thin **(1-2 mm sections)**:

Ax T1 pre midbrain through skullbase

Ax T1 post midbrain through skullbase

Cor T1 post with fat sat orbital apex to 4th ventricle

Very thin sections (1 mm) (FIESTA)

Ax T2 mid brain through skull base

Ax T1 post through entire brain
For pulsatile tinnitus, add MRA COW 3dTOF

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**For pituitary gland, PRE-OP:**

Thin section (3 mm) covering pituitary gland

- Sag  T1 pre
- Cor  T1 pre
- Cor  FSE T1 dynamic at 45 sec intervals x 4
- Cor  T1 post
- Sag  T1 post

Through entire brain:

- Ax  T1 post

Do not need Axial FLAIR portion of study

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**For pituitary gland, POST-OP (NEW):**

- Sag  T1
- Cor  T1
- Cor  T2
- Sag  T1 Postcontrast Fat Sat
- Cor  T1 Postcontrast Fat Sat

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**For Circle of Willis MRA:**

- Ax  3dTOF from skull base to lateral ventricles

**ORBITS (Modified):**

<table>
<thead>
<tr>
<th></th>
<th>Ax T1</th>
<th>Cor T1</th>
<th>Ax T2 FS</th>
<th>Cor STIR</th>
<th>Ax T1 Post FS</th>
<th>Cor T1 Post FS</th>
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***Chiasm through orbits for Cor T1, Cor STIR, Cor T1 POST FS

**For MRV (dural venous thrombus), add:**

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<tr>
<th>Plane</th>
<th>Sequence Details</th>
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<tbody>
<tr>
<td>Cor</td>
<td>2dTOF SPGR</td>
</tr>
<tr>
<td>Sag</td>
<td>T2 Phase Contrast GRE venc 20</td>
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<tr>
<td>Cor</td>
<td>T2 Phase Contrast FRE venc 20</td>
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<tr>
<td>Ax</td>
<td>T2 Phase Contrast GRE venc 20</td>
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<tr>
<td>Sag</td>
<td>T1 3dTOF SPGR after contrast (reformat this into coronal and axial planes)</td>
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**Infant head (0-24 months) (congenital/migrational/myelination abnormality)**

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<th>Plane</th>
<th>Sequence Details</th>
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<tr>
<td>Sag</td>
<td>T1 (3 mm)</td>
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<tr>
<td>Ax</td>
<td>T1 (3 mm)</td>
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<tr>
<td>Ax</td>
<td>PD/T2 SE (age 0-1 TR, TE 3000, 60/120, age 1-2 TR, TE 2500 30/80)</td>
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<tr>
<td>Cor</td>
<td>1.5 mm SPGR</td>
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</table>

**If for hypoxia/ischemia, add:**

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<tr>
<td>Ax</td>
<td>DWI/ADC (2D TOF MRA through neck and 3D TOF MRA through circle of Willis if DWI positive)</td>
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**If for hydrocephalus, add:**

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<tr>
<td>Sag</td>
<td>T2 FRFSE (3 mm)</td>
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**Monitor with radiologist to see whether sagittal cine phase contrast images needed**

**If a mass is present:**

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<td>Sag</td>
<td>T1 post</td>
</tr>
<tr>
<td>Cor</td>
<td>T1 post</td>
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</tbody>
</table>

**If history complex partial seizures, add**

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<th>Sequence Details</th>
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<tr>
<td>Cor obl</td>
<td>FLAIR through temporal lobes (2mm)</td>
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<tr>
<td>Cor obl</td>
<td>T2 FSE through temporal lobes high resolution (3mm)</td>
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</tbody>
</table>
For the above two sequences, the scan plane should be perpendicular to the hippocampi, and the FOV should be decreased to focus on bilateral temporal lobes.

***Monitor all sedated pediatric scans

**For Peds head (24 months- 5 years)**

Sag  T1 (4mm)
Ax T1 (4mm)
Ax FLAIR (4mm)
Ax FSE T2 (4 mm)
Cor 1.5 mm SPGR
Ax DWI/ADC

**If there is a mass, add:**

Ax T1 post
Sag T1 post
Cor T1 post

If history of complex partial seizures, add:

Cor obl FLAIR through temporal lobes (2mm)
Cor obl T2 FSE through temporal lobes high resolution (3mm)

For the above two sequences, the scan plane should be perpendicular to the hippocampi and the FOV should be decreased to focus on bilateral temporal lobes.

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**MR Quick Brain** (This is to avoid sedation in chronic patients such as VP shunt follow-ups regardless of age or for screening examination such as with increasing head circumference)

Triplanar localizer

Sag  T2 SSFSE
Ax  T2 SSFSE
Coronal T2 SSFSE

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**Acute stroke (Limited)**

Triplanar localizer

Ax  T2*GRE
Ax Flair
Ax DWI/ADC
Ax Perfusion (CBV/MTT)

**MR Stroke Deluxe (very rare- routinely do CT/CTA/CT perfusion for acute stroke triage)**

Above protocol +
Ax T2
Ax 3D TOF through circle of willis
Ax 2dTOF through neck vasculature/+ postcontrast 3dTOF through neck vasculature

**Stroke follow-up**

Routine brain with contrast. Add head and neck MRA only if requested. Do not forget Ax T2* GRE

**SPINE**

**C-spine routine**

Sag T1
Sag T2 FSE
Ax T2* GRE
Ax T2 FSE

If history of trauma or loss of vertebral body height noted on initial sequences, add:

Sag STIR
Cor T2 FSE

If mets:

Sag STIR

**Acquire triplanar localizer through entire spine (cervical, thoracic, lumbar spine to determine whether there is critical cord compression elsewhere secondary to metastatic disease. If there is cord compression elsewhere in spine, hold patient and contact radiologist)**

If tumor is intracanalicular/foraminal, add:

Sag T1 post with fat sat

**For C spine flexion and extension, add:**

Sag T2 FSE on flexion (label as flexion)
T-spine routine

Sag T2 FSE extension (label as extension)

Sag T2 cervical spine localizer

Sag T1

Sag T2 FSE

Ax T1 (through regions of concern)

Ax T2 FSE (through each disk level)

If history of trauma or loss of vertebral body height noted on initial sequences, add:

Sag STIR

For post-contrast (tumor/mets, AVM, MS, syrinx, epidural abscess, diskitis, post-op), add:

Sag T1 post

Ax T1 post (through regions of concern)

If tumor is intracanalicular/foraminal, add:

Sag T1 post with fat sat

L spine routine:

Sag T1

Sag T2 FSE

Sag STIR

Ax T1

Ax T2 FSE

(Axials include L1/L2 through L5-S1 levels angled parallel to discs)

For post-contrast (tumors/mets, syrinx, etc.), add:

Ax T1 through regions of concern

Sag T1 post with fat sat

**If lumbar spinal hardware, no fat sat on Sag T1 post**

Screening T/L or C/T/L studies (? Compression fracture)

At all stations:
For thoracic spine acquisitions:

Sag T2 FSE through cervical spine (as localizer)

Sag T1
Sag T2
Sag STIR

At levels of concern perform

Ax T1
Ax T2

If contrast indicated:

Sag T1 post
Ax T1 post

If question tumor (bony, intracanalicular or foraminal) add

Sag T1 post with fat sat

Pediatric Spine Protocol for tethered cord or sinus tract

Sag T1, Sag T2 FSE, Sag STIR through whole spine
Ax T1/Ax FSE T2 through lumbar spine

**Extend scans through coccyx

If mass seen, add:

Sag T1 post, ax T1 post through region of interest

HEAD AND NECK

For nasopharynx/face (nasopharyngeal CA and sinus masses) OR for skullbase masses:

Sag T1

Ax T1 pre (4 mm) from top of frontal sinus through mandible
Ax T2 FSE (4 mm) with fat sat from top of frontal sinus through mandible
Cor T1 post (3 mm) with fat sat to include all sinuses through 4th ventricle

For glomus tumor, cover down to carotid bifurcation
Neck routine:
Ax  T1
Ax  T2 FSE with fat sat
Cor  STIR
Sag  T1

If contrast indicated, add:
Ax  T1 with fat sat
Cor  T1 with fat sat

Carotids routine:
Ax  2D TOF SPGR pre
Cor  FSPGR MRA post contrast

If ? dissection or Horner’s syndrome, add:
Ax  T1 with fat sat

TMJ routine:
Sag obl  T1 both sides closed mouth
Sag obl  PD both sides open and closed mouth

Brachial plexus:
Bilateral coverage on Ax and Cor
Superior coverage from C3 through T3
Sag on symptomatic side mid humeral head through midline spinal canal
Cor  T1
Cor  STIR
Sag  T1 FSE
Sag  STIR
Ax  T1 pre
<table>
<thead>
<tr>
<th>Sag</th>
<th>T1 post</th>
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<tr>
<td>Ax</td>
<td>T1 post</td>
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<tr>
<td>Cor</td>
<td>T1 post</td>
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<tr>
<td>Cor</td>
<td>T1 post with fat sat</td>
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</table>
RAFV NEURO TCWEST and NSG PROTOCOLS

1. New upgrade allows for less scan time, but there is more reformatting.

2. In order to expedite the study onto the worklist, please start reformatting of pre and post T1 BRAVO and FLAIR CUBE while scanning. In other words, do not wait until all sequences are acquired to begin reformatting. This will delay the interpretation by the radiologist and many of these patients have clinic appointments shortly following the MR scan.

3. Limited protocols are listed below. As a general rule, we have eliminated axial FLAIR acquisition. Instead of axial FLAIR acquisition, we have substituted CUBE FLAIR. This is acquired sagittally in 1 mm thin sections and may reformatted into all three planes (coronal, axial, sagittal).

4. For Multiple Sclerosis patients, we have eliminated the proton density scan in favor of the CUBE FLAIR. The CUBE FLAIR has superior spatial resolution and can be reformatted into all three planes.

5. Add IDEAL postcontrast T1 sequence for any spine with hardware. Do not send the fat and water separation images. Only send the composite IDEAL postcontrast image. The same goes for the brain (child with braces, etc)- please acquire post contrast IDEAL T1 image whenever significant metallic artifact is present.

ROUTINE BRAIN (TC West and NSG)

Sag  T1 “BRAVO” (Fast IR SPGR)- Acquired at 1 mm thin sections and MIP’d up to 3 mm sections. These are subsequently reformatted into coronal and axial planes, such that all three planes are generated from single Sagittal T1 BRAVO acquisition.

Ax  T2 FRFSE Fat Sat

Sag  CUBE (XETA) FLAIR- Acquired at 1 mm thin sections and MIP’d up to 3 mm sections. These are subsequently reformatted into coronal and axial planes.

Ax  DWI/ADC

Ax  GRE T2* ( Please acquire on all patients). If the patient has a history of cavernoma, Amyloid, trauma, AVM, vasculitis, SUBSTITUTE THE SWI SEQUENCE (“SWAN”) INSTEAD OF THE GRE

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If post contrast, add:

Sag  Postcontrast T1 “BRAVO” (Fast IR SPGR)- Acquired at 1 mm thin sections and MIP’d up to 3 mm sections. These are subsequently reformatted into coronal and axial planes, such that all three planes are generated from single postcontrast sagittal T1 BRAVO acquisition.

*** If giving contrast for scan, do CUBE FLAIR sequences POSTCONTRAST
***If significant metallic artifact (child with braces) call radiologist. Run ax T2 IDEAL and postcontrast ax T1 IDEAL through the brain. Do not send separate fat and water separation images - just send composite IDEAL image

If newly detected tumor or following up abnormal areas of enhancement concerning for tumor recurrence versus radiation necrosis, then also add:

1. Customary MR perfusion with contrast
   Generate rBCV (negative enhancement integral), MTT maps

2. Noncontrast ASL perfusion - we are currently doing a pilot study comparing noncontrast ASL perfusion to customary MR perfusion with contrast for tumors.

For seizures, add:
- Can eliminate the coronal oblique FLAIR through the temporal lobes, since we get this information for free from the CUBE FLAIR reformations.
- Can eliminate the coronal T1 SPGR since we get this information for free from the precontrast T1 BRAVO reformations

Cor obl T2 FSE through temporal lobes high resolution (3 mm)

For Multiple Sclerosis, add:
- Can eliminate the sagittal FLAIR since we get this information from the CUBE FLAIR reformats
- Can eliminate the proton density sequence

- Postcontrast T1 SPGR BRAVO and do the FLAIR CUBE postcontrast

If Noncontrast MR Brain ordered for multiple sclerosis and renal function is fine, contact radiologist to get order changed to MR brain with and without contrast

For memory loss, dementia, add:
- SWAN sequence (The enhanced susceptibility weighted sequence)

For IAC, 7th/8th nerves (hearing loss, tinnitus, etc), add:
Through IAC, thin (1-2 mm sections):
Ax T1 pre midbrain through skullbase
- Instead of reacquiring thin sections through skullbase, just send 1 mm thin axial and coronal postcontrast T1 BRAVO images through skullbase

Very thin sections (1 mm) (FIESTA)

Ax T2 mid brain through skull base

**For pulsatile tinnitus, add MRA COW 3dTOF**

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**For pituitary gland, PRE-OP:**

- Do not need to acquire special thin section images through pituitary gland since have 1 mm pre/post T1 BRAVO sequences through brain. Just reformat a smaller FOV through pituitary in all three planes based on pre/post T1 BRAVO weighted sequences

Cor FSE T1 dynamic at 45 sec intervals x 4

Through entire brain:

Ax T1 post

Do not need Axial FLAIR portion of study

**C-SPINE:**

Triplane localizer

Sag T2

Sag T1

Sag STIR

Ax T2

Ax 2D MERGE

**Sag T2 IDEAL for hardware**
Exam: HEAD w/o & w/ contrast (Brain Tumor)

Coil: HNS Head
Position: Head First/Supine
Landmark: Nasion

<table>
<thead>
<tr>
<th>Pulse Sequence</th>
<th>Options</th>
<th>TR</th>
<th>TE Ti</th>
<th>ETL</th>
<th>FA</th>
<th>VBW</th>
<th>FOV</th>
<th>Thick/Gap</th>
<th>Sat</th>
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3 Plane Loc

Calibration

Axial Diffusion

T1 3D BRAVO: scanned in Sagittal plane, reformat in all 3 planes at 22 FOV 3x3 mm

T2 Axial Fat/Sat Propeller

Axial Gradient if needed

Axial 3D ASL non contrast perfusion

Axial Perfusion 20ml Multihance

FLAIR 3D CUBE: scanned in Sagittal plane, reformat in all 3 planes at 22FOV 3x3mm;

T1 3D BRAVO: scanned in Sagittal plane, reformat in all 3 planes at 22 FOV 3x3mm
### WEST MR Protocols

**Exam:** HEAD/ PITUITARY  
**Coil:** HNS Head  
**Position:** Head First/Supine  
**Landmark:** Nasion

<table>
<thead>
<tr>
<th>Pulse Sequence</th>
<th>Options</th>
<th>TR</th>
<th>TE</th>
<th>TI</th>
<th>ETL</th>
<th>FA</th>
<th>VBW</th>
<th>FOV</th>
<th>Thick/Gap</th>
<th>Sat</th>
<th>Matrix</th>
<th>NEX</th>
<th>Freq Dir</th>
<th>Time</th>
<th>Instructions</th>
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<tbody>
<tr>
<td>3-Plane LOC</td>
<td>Seq, Fast, SS</td>
<td>Min</td>
<td>50</td>
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<td></td>
<td>26</td>
<td>5</td>
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<td>CAL Scan</td>
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<tr>
<td>AXIAL EPI</td>
<td>EPI, DIFF, Asset</td>
<td>Min</td>
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<td>:40 Phase FOV.060 Diffusion direction: TETRA</td>
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<td>50</td>
<td>22</td>
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<td>4:19 Acquire Sagittal projection</td>
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<td>160</td>
<td>1mm</td>
<td>160 locs per slab</td>
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<td></td>
<td></td>
<td>Reformat all 3 planes &amp; thin Cor/Sag Pituitary</td>
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</tr>
</tbody>
</table>

**Prep time:** 450  
**Acquire Sagittal projection**  
**Reformat all 3 planes & thin Cor/Sag Pituitary**
<table>
<thead>
<tr>
<th>propellar</th>
<th>COR Dynamic</th>
<th>EDR, TRF, Fast, ZIP512, MPH</th>
<th>400 Min</th>
<th>Full 20</th>
<th>22.78 20</th>
<th>3/0</th>
<th>224x160</th>
<th>2</th>
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<tbody>
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<td>140</td>
<td>22.73 24</td>
<td>1.4</td>
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<td>5:00</td>
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<td>S/I</td>
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<td>Acquire Sagittal projection Reformat all 3 planes &amp; thin Cor/Sag Pituitary</td>
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</tbody>
</table>

3 Plane Loc
Calibration
Axial Diffusion

T1 3D BRAVO: scanned in Sagittal plane, reformat in all 3 planes at 22 FOV 3x3 mm; THIN Cor and Sag thru pituitary 18 FOV 2x2mm

T2 Axial Fat/Sat Propeller

Dynamic Pituitary: will scan a pre, then inject; start scan after contrast and saline are complete

FLAIR 3D CUBE: scanned in Sagittal plane, reformat in all 3 planes at 22FOV 3x3mm;
T1 3D BRAVO: scanned in Sagittal plane, reformat in all 3 planes at 22 FOV 3x3mm; THIN Cor and Sag thru pituitary 18 FOV 2x2mm

Weight based contrast-20ml maximum, power inject at 2ml per second

10/12