Introduction

This guide has been prepared to assist physicians with understanding MRI and using this modality in their practice.

With the growing number of imaging options available to physicians, it is becoming increasingly difficult to know what to order, when.

No guide can address all concerns for every possible clinical situation, but it is hoped that the information presented here will help referring physicians to navigate through the often confusing landscape of diagnostic imaging.

In December of 2006, Quinte Health Care was given the go ahead to develop an MRI service for the Belleville and surrounding communities. The MRI unit being installed at the Belleville General Site is a Siemens Avanto 1.5T scanner.

This is a state of the art MR scanner that produces high quality scans with the latest technology the MR world has to offer.
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What is MRI?

MRI stands for Magnetic Resonance Imaging.

Unlike other radiology procedures that use X-rays, MRI uses magnetism, radio waves, and a computer to help produce the images of the body.

The patient lies on a long table and is moved into the magnetic field. The magnetic field causes the hydrogen protons in the body to align themselves with this magnetic field. A radio frequency is then transmitted through the body causing the hydrogen protons to move. When the radiofrequency is turned off, the protons relax. As this happens a signal is detected by an antenna surrounding the part of the body being scanned. This signal is measured by the computer and transformed into an image. Thousands of these signals are measured and processed during a single scan series.

MRI is a painless radiology procedure that has the advantage of not using any X-rays.

There are no known side affects of the scan.

What are the Risks of MRI?

Since the MRI scanner generates a very strong magnetic field, this can pose a risk to some patients. Anyone accompanying the patient into the magnet room is subject to the same risk. The most common contraindications for scanning are:

- Cardiac Pacemaker
- Implanted defibrillator
- Brain aneurysm clips
- Metal in the eyes
- Implanted devices, such as insulin pumps
- Certain types of ear implants

Most implants are not contraindications as long as they have been in place 6 weeks or more.

A safety screening form must be completed before starting a scan.

In some cases, the exam cannot be performed due to certain implants.

The technologists can answer any questions patients may have before the scan.

The MRI exam may require an injection of a contrast material called gadolinium. This basically does the same thing as the I.V. contrast used in C.T.

The reaction rate for this contrast agent is very low.

Please see the separate contrast consent form for additional information.
Is Preparation Required for MRI Scan?

The first step is to be certain that it is safe for the patient to have an MRI scan. There is no specific preparation required. Patients may take their medication as usual. There are no food and drink restrictions unless the patient is having an abdominal or pelvic scan.

The patient should be NPO for three hours prior to those exams.

All removable metallic objects will be left outside the scanning room. These include jewelry, keys, watches, coins, eyeglasses, removable hearing aids, dentures and prosthetic devices.

A secure locker will be provided for these items.

How Long Does a MRI Scan Take?

That depends on the part of the body being scanned and whether any special or extra scans are needed. Normally, the entire exam takes between 15-45 minutes.

What Happens During the Scan?

The patient will first be screened by the MRI technologist.

This screening ensures the completion of the scan is appropriate and safe for the patient.

The procedure will then be explained in detail to the patient by the technologist who will answer any questions the patient may have.

Depending on which part of the body is being scanned, the patient will lie on the table and be advanced into the scanner either head or feet first.

The patient, although alone in the room, is always within plain sight of the technologist via a large window. The patient and technologist may communicate between scans by use of an intercom system. The scanning process, although painless, can be quite loud. Therefore, earplugs are provided for all patients. While the images are being obtained, the patient needs to lie as still as possible and follow the technologist’s instructions.

Most MRI exams last about 30 minutes but complex cases may approach an hour in length.

What is MR Contrast Material?

During an MRI examination, there may be a need for contrast (or “dye”) to be administered to the patient. The material injected is the element Gadolinium.

In MRI, the Gadolinium changes the way tissue reacts to the magnetism and radio waves allowing certain diseases, surgical scars and anatomy to become more visible.

As with any prescribed medication, there is always the chance that a patient could possibly have some type of reaction but it is quite rare for patients to experience any reaction to MRI contrast.

Possible reactions/side affects include: reddening around the injection site, itching around the injection site, warm flushed feeling and nausea.
In the unlikely event of a more serious reaction, we are equipped to handle MR contrast reactions as with x-ray contrast.

In the last few years a new disorder has been identified termed Nephrogenic Systemic Fibrosis. NSF appears to be an extremely rare condition that has been linked to Gadolinium administration to patients with severe renal disease (often on dialysis).

The condition can lead to disability or death. It should be stressed that the condition is extremely rare and not yet completely understood.

Patients with renal disease, that require Gadolinium for their MRI, will require blood work to check creatinine levels within four weeks of their examination.

Our MRI staff is aware of the issues involving NSF and will comply with standard practices with regards to limiting the risk posed to renal failure patients.

Please see the separate contrast consent form for additional information.

**Can Claustrophobic Patients be Scanned?**

Many claustrophobic patients can tolerate an MRI examination without sedation as the technologist is aware of these patients concerns and can help them.

If the claustrophobic patient is having a scan of their knee or ankle they go into the unit feet first with their head outside the machine and rarely require sedation.

It is advisable to prescribe a mild sedative (i.e. Ativan) for all other claustrophobic patients so they have it in hand on the day of their exam in case they require it to tolerate the test.

QHC will not provide the sedation for these patients.

If a patient may be taking a sedative it is important they are escorted to the exam by a friend or family member in case the patient cannot safely drive home.

**Why do Patients Sometimes Need X-rays Prior to a MRI Procedure?**

Occasionally, x-rays may be necessary prior to the MRI to screen for metallic objects that might be in the body. By far, the most common x-ray required is to screen for metallic foreign bodies in the eyes. If the patient has ever had metal in their eyes, and has not previously been screened for an MRI, they will require the x-rays.

If the patient has worked with metal, such as grinding or welding, but has always worn safety glasses then they likely will not require the x-rays.

To avoid delays on the day of the MRI exam, it is advisable to have these x-rays done prior to the day of the MRI exam.

Ideally, a report of the x-rays would be forwarded at the same time as the MRI requisition. However, the patient can bring a copy of the report or the images themselves on the day of the exam.
**Out-Patients**

- You must submit requests for MRI using the Quinte Health Care MRI requisition form. An MRI request form from another facility is acceptable as long as it includes standard MRI safety screening questions. MRI requests on all other forms unfortunately cannot be accepted, as they could lead to cancelled appointments and the loss of valuable magnet time.

- It is imperative the MRI requisition be filled out completely and accurately. Each section of the requisition has been prepared to help ensure a safe and thorough examination. Please provide as much clinical information as possible and ensure the safety questions are answered. Incomplete requisitions will be returned, without appointments, without exception.

- Please send the completed requisition to the Diagnostic Imaging Department at the Belleville General site.

**In-Patients**

- The same system used for CT will be followed for MRI. Please ensure a complete requisition is sent to the Diagnostic Imaging Department and an appointment will be made.

- **Please Note:** MR examinations take considerably longer to complete than CT for technical reasons. MR facilities can only accommodate a limited number of inpatient requests in any given week (considerably fewer than CT). Please consider the need for an inpatient MRI exam carefully.

**MRI and the Pregnant Patient**

Can a Pregnant Patient Undergo MRI?

Present data has not conclusively documented any negative effects of MR imaging exposure on the developing fetus.

No special consideration is recommended for the first, versus any other, trimester in pregnancy.

It is felt to be prudent to screen women of reproductive age for pregnancy prior to permitting them access to MR imaging environments.
If pregnancy is established, consideration should be given to reassessing the potential risks versus benefits of the pending study in determining whether performance of the requested MR examination could safely wait until the end of the pregnancy.

Pregnant patients can be accepted to undergo MR scans at any stage of pregnancy if the risk-benefit ratio to the patient warrants that the study be performed if:

1. The information requested from the MR study cannot be acquired via other non ionizing means (i.e. ultrasound)
2. The study is needed to potentially affect the care of the patient or fetus during the pregnancy.
3. The referring physician does not feel it is prudent to wait until the patient is no longer pregnant to obtain the study.

**MR Contrast Material and the Pregnant Patient**

MR contrast agents should not be routinely provided to pregnant patients.

This decision is one that must be made on a case-by-case basis.

Studies have demonstrated that gadolinium-based MR contrast agents pass through the placental barrier and enter the fetal circulation. From there, they are filtered in the fetal kidneys and then excreted into the amniotic fluid where it may remain indefinitely.

The risk to the fetus with administration of gadolinium-based MR contrast agents remains unknown and may be harmful.

*It is the policy of Quinte Health Care not to administer a gadolinium-based contrast agent to a pregnant patient that is in her first trimester under any circumstances.*

The decision to administer gadolinium to pregnant patients in their second or third trimester should be based upon risk-benefit analysis.

This analysis should be able to defend a decision to administer the contrast agent based on overwhelming potential benefit to the patient or fetus out weighing the theoretic but potentially real risks of long term exposure of the fetus to free gadolinium ions.

*It is recommended that pregnant patients undergoing an MR examination provide written informed consent documenting that they understand the potential risks and benefits of the MR procedure to be performed, are aware of the alternative diagnostic options available to them (if any), and that they wish to proceed.*
How to Avoid Delays in Obtaining an MRI for your Patient

1. If your patient has had metal in their eyes before and hasn’t had a previous MRI, it would be best to have orbital x-rays for foreign body done prior to the MRI appointment date. If the images are done outside the hospital, the patient should bring the report or the images themselves to the MRI department on the day of their appointment. If it is difficult to have their eyes x-rayed before the day of their MRI appointment, the patient should arrive for their MR appointment 60 minutes early.

2. Remember to always use a MRI requisition when requesting an MRI and ensure it is filled out completely. Delays will occur if the exam requested and clinical information areas are not filled out in full. The MRI safety questions must always be answered as well.

   All incomplete requisitions will be returned without an appointment, without exception.

3. If your patient has renal disease and needs an MRI with contrast they will need to have blood work done to check Creatinine levels. If you are requesting any of the following:
   - Any abdominal MRI except MRCP
   - Any MRA
   - Any spine level for syringomyelia, nerve sheath tumour or cord tumour
   - Any MRI for metastatic disease

   If your patient is renal impaired it is safe to assume they will need contrast and will need their blood tested.

   Please forward these results with the requisition. It is possible your patient will need contrast even if their exam is not listed above. In this case we will request the blood work be done by faxing the requisition back and indicating this is the case.

   PLEASE HELP US PROVIDE THE BEST POSSIBLE SERVICE BY AVOIDING DELAYS AND NOT WASTING VALUABLE MAGNET TIME.
Arnold-Chiari Malformation (Cerebellar Tonsilar Ectopia)
- MR is the preferred imaging modality.

Dementia
- CT is an excellent screening exam in elderly patients with dementia. CT will identify atrophy, hydrocephalus, most mass lesions and advanced small vessel disease. MRI is more sensitive, but CT is generally adequate.

Dizziness
- MR is preferred if cerebellar or brain stem pathology is suspected. Some patients may have additional symptoms, which necessitate internal auditory canal MR examination as well (clinical evidence of a vestibular schwannoma (acoustic neuroma)).

Facial Pain Syndromes (Trigeminal Neuralgia) Cranial Nerve Symptoms
- MR is the preferred imaging modality.

Headache
- Low suspicion, no neurological findings-CT preferred.
- Moderate to high suspicion, neurological findings-MR preferred.
- Possible acute sub arachnoid bleed-CT preferred.
- (Please note that studies have shown a very low rate of findings using either CT or MR in cases of uncomplicated, chronic headache).

Infection/Encephalitis (Herpes etc.)
- MR is the preferred imaging modality if the patient can co-operate.

Leptomeningeal Disorders (metastatic disease, infection)
- MR is the preferred imaging modality if the patient can co-operate.

Multiple Sclerosis (suspected or follow up)
- MR is the preferred imaging modality.

Pituitary Assessment, Sella (hormonal disturbance)
- MRI is preferred to evaluate for a pituitary tumour, parasellar mass.
- CT is indicated only in patients who cannot have an MRI.
Seizure

- Patients with a known history of CVA in whom clinical MRI with contrast is recommended in young and middle-aged patients with new onset seizures.

  MRI is preferred to evaluate for mesial temporal sclerosis (Hx of possible temporal lobe seizures).

  MR is preferred for patients with chronic epilepsy but these patients generally do not require contrast.

Elderly patients with new unexplained seizures can be assessed with CT, initially. MR can be useful on an elective basis if there is no acute finding on CT.

CT without contrast is sufficient in most elderly suspicion for non-ischemic pathology is low.

- Patients presenting with seizures through ER will usually be assessed initially with an unenhanced CT to exclude a significant acute finding. MR can follow, if needed, on an elective outpatient basis.

Stroke

- Acute presentation- CT (MR more sensitive for acute stroke but often not practical).

- 12-24 hrs post CVA most moderate to large cortical infarcts well seen on unenhanced CT.

- MRI is useful if the initial/follow up CT is negative, especially if brain stem or cerebellar infarction is suspected.

- MRI is preferred in young patients with neurologic deficits, as non-ischemic etiologies must also be considered (i.e. MS)

Tinnitus/Hearing Loss

- CT and MRI are complimentary.

- CT is better in evaluation of the petrous bone for tumour and vascular anomaly and is recommended in cases in which a middle ear mass is visualized otoscopically. CT is preferred in cases of conductive hearing loss.

- MR is superior in screening for a posterior fossa vascular malformation or mass.

- MR is advised in patient’s neurosensory hearing loss.

- MR is preferred for clinical suspicion of a vestibular schwannoma (acoustic neuroma).

Tumour or Possible Brain Metastasis

- MRI is more sensitive and specific for the presence of tumour.
Vascular Disorders (AVM, aneurysm, vasculitis, venous thrombosis)

- MR is the preferred imaging modality for vascular malformations and venous sinus thrombosis. Both CT and MR can screen for aneurysms non-invasively.

Head & Neck

- CT and MR are complimentary in assessment of pathology in this region.
- CT is preferred for assessment of larynx, petrous bone structures, bony skull base for tumour invasion and mandible.
- MR is preferred for cancer staging of head & neck tumours including assessment for perineural intracranial extension.
- Lymphadenopathy can be assessed by either modality.

Sinuses

- For assessment of common sinus problems such as chronic sinusitis and OMU disease, CT is preferred.
- MR is preferred for the assessment and staging of sinus tumours.
Orbits

- MR is preferred for orbital masses, optic neuritis, vascular abnormalities, and sudden blindness.
- CT is preferred for trauma, foreign body, and thyroid related orbital disease.
- Both modalities can be used to evaluate for orbital pseudotumour, orbital cellulitis, or abscess.

TMJ

- MR is preferred for evaluation of the articular disc (internal derangement of the TMJ).
- Note that perforations of the disc are often not well demonstrated by MR.
- CT is preferred for evaluating the bony structures for degenerative changes although MR can also assess for this to some extent.

Heart

- The use of MR for assessment of cardiac disease is increasing.
  
  QHC will not be offering Cardiac MR upon initial startup.
  
  We hope to add this service in the future once our core MR services are established.

Lungs/Mediastinum

- CT is the preferred modality overall for assessment of thoracic pathology.
- MR has no practical application in the assessment of lung pathology.

MR does not generally offer any advantage over CT in lung cancer staging except perhaps in assessing for chest wall, spinal or brachial plexus invasion.

Mediastinal lymph node enlargement is seen equally well with either modality.

At present, neither can identify malignancy in normal sized nodes nor differentiate between benign and malignant nodal enlargement.

- The accuracy of either modality in cancer staging is limited at present.
Breast

- The MRI service will not offer breast MR initially but it is expected that this will be made available in the near future once our core MR services are established. The scope of the program that will be offered has yet to be determined. However, these details will be circulated once known.

Body (Abdomen)

Multi-slice CT is often the preferred initial modality for imaging of the abdomen.

MR often plays a supportive or complimentary role to CT in the evaluation of abdominal pathology. It is often used to help clarify the nature of equivocal findings found on CT.

As such, MR of the abdomen is best used in a targeting fashion to answer specific questions. You should avoid requesting MR to address vague problems such as “bloating nyd”, “abdominal pain nyd” etc.

MR is sometimes used as an alternative imaging modality in patients with impaired renal function who cannot safely receive CT contrast. This is possible, as MR contrast does not adversely affect renal function.

There are some growing concerns however about the association between MR contrast and a rare disorder termed Nephrogenic Systemic Fibrosis (NSF). As such, most centers are being more cautious in their use of gadolinium contrast in renal failure patients.

NSF is very rare, has been seen only in patients with severe renal impairment (generally on dialysis), and is still not completely understood.

MR will likely continue to be useful as an alternative modality for patients with impaired renal function though there will likely be more restricted use of contrast in these patients in the future as NSF guidelines evolve.
WHEN REQUESTING AN ABDOMINAL OR PELVIC MRI ON A PATIENT WITH RENAL DISEASE PLEASE INCLUDE RECENT BLOODWORK RESULTS WITH THE REQUISITION.
FAILURE TO DO SO WILL RESULT IN DELAYS.
AN APPOINTMENT WILL NOT BE MADE UNTIL THESE RESULTS ARE KNOWN.

Liver
- Enhancement characteristics of liver masses are similar for MR and CT.

  MR can sometimes clarify the nature of lesions such as FNH, fatty infiltration, iron deposition disorders and hemangioma when equivocal on CT.

  MR can detect more metastatic lesions than CT, although this is sometimes academic.

  MR can offer improved detection of HCC in cirrhotic livers.

  Atypical lesions on CT are often atypical on MR as well and as such defy specific diagnosing by any imaging.

Kidneys
- MR can help to clarify the nature of equivocal findings found on CT or US.

  MR findings are, however, non-specific and enhancing renal lesions on MR are generally considered malignant unless proven otherwise.

Adrenals
- MR can help to identify some equivocal adrenal nodules as adenomas but note that many atypical adrenal nodules cannot be characterized by either CT or MR.

  These require follow up or biopsy depending on the level of clinical suspicion.

Spleen
- Many lesions non specific on CT are similarly non specific on MR.

Pancreas
- MR can be used to help identify and characterize pancreatic masses though as with many other scenarios, is often used after CT if additional information might be gained.

  Pancreatitis is usually assessed with CT.

  MR is less sensitive to the presence of calcifications and ductal stones than CT in chronic pancreatitis.

Biliary System
- MRCP (Magnetic Resonance Cholangio Pancreatography) offers a non-invasive, accurate method to evaluate the biliary ductal system. It can be very useful in assessing for ductal stones and strictures.

  The gallbladder is best initially assessed with US.
Nodes

- MR and CT are equal in their ability to detect enlarged nodes.
  Neither can identify malignancy in normal sized nodes nor differentiate between malignant or benign enlarged nodes.
- MR more readily identifies peritoneal seeding of malignancy providing the exam is tailored to this.
- In general, CT and US are usually utilized as the initial abdominal imaging modalities with MR used selectively in cases where it may offer additional information.
- Discuss any clinical problems that may arise with the MR Radiologists.

Pelvis

Pelvis (Gyne)

- Ultrasound remains the preferred imaging modality for the initial evaluation of gynecological problems. It is quick, reasonably non invasive and readily available.
  CT is often of little use in assessing ovaries and uterus.
- MR offers significant advantages over CT for Gyne applications such as:
  - Fibroids (size, number, location)
  - Adenomyosis
  - Staging of endometrial and cervical carcinoma
  - Characterization of some adnexal masses
  - Differentiating ovarian vs. uterine origin of adnexal masses
  - Uterine morphology (septate, bicornuate etc.)
  - Endometriosis
Pelvis (other)

- MR can be useful in the staging of rectal carcinoma, prostatic carcinoma and bladder neoplasms.
- MR can help to identify the course of complex pelvic fistulas.

Cervical

- Trauma - CT and MR are complimentary.
  
  Bony injuries are better demonstrated by CT.
  
  Central canal contents including spinal cord are better examined by MR.
- Degenerative disease, radiculopathy - MR is the preferred modality.
- Neoplastic disease - CT can demonstrate bony metastases but overall MR provides a more comprehensive exam as epidural space and cord are also easily examined at the same sitting.
- Spinal Cord abnormalities (MS, tumours, infection, inflammation)-MR is the preferred imaging modality.

Thoracic

- The same guidelines apply as for cervical guide.
- MR is sometimes useful in helping to differentiate osteoporotic compression fractures from vertebral collapse due to metastatic disease.

Accuracy varies from case to case as MR assessment for this is only partially reliable.
Lumbar

- Degenerative disease (no prior surgery)
  - Either CT or MR can be used to evaluate for disc disease.
  - Either CT or MR can be used to evaluate for spinal stenosis, though this is sometimes over estimated by MR.
- Initially, most low back pain patients are still evaluated with CT.

Please note that there is often poor correlation between clinical findings and either CT or MR findings.

Overall, imaging of almost any type does not often significantly alter clinical management or outcomes for back pain patients.

- Previous Back Surgery - contrast enhanced MR is the preferred modality.

MR is far more accurate in the assessment of postoperative scar vs. recurrent disc.

- Cauda Equina Syndrome, suspected conus pathology - MR is the preferred imaging modality.

- Tumour, arachnoiditis - MR is the preferred imaging modality.

Miscellaneous

- Suspected cord compression in any region - MR is the preferred modality.

- Suspected spondylo-discitis/epidural infection in any region - MR is the preferred modality.

- Suspected congenital anomaly (i.e. split cord, low conus, tethered cord) in any region - MR is the preferred modality.

- Suspected syringomyelia in any region - MR is the preferred modality.
MR is the preferred imaging modality for MSK problems. This applies to all joints.

Tendon, ligament, muscle, cartilage, bone marrow and other MSK structures are well evaluated by MR for trauma, tumour, infection, degenerative changes etc.

Most studies do not require contrast injection. However, this is sometimes used depending upon the clinical problem.

**Some Practical Considerations**

**Shoulder**
Many rotator cuff tears of the shoulder are easily demonstrated by US.

Shoulder US is a reasonable non-invasive initial examination for patients with painful shoulders.

MR is the preferred modality if there is suspicion of shoulder instability due to labral pathology.

If US is negative and rotator cuff pathology is still suspected, MR might be considered as a complimentary second study.

**Knee**
US of the knee is a quick and non-invasive examination that can assess for joint fluid, periarticular fluid collections and ligament and tendon pathology.

Ultrasounds’ major disadvantage is its inability to assess the ACL, PCL and meniscal structures.

Problems of internal derangement require MR assessment.

**Hip**
Although US can be useful for this joint, MR is probably the preferred modality in most cases when looking for soft tissue injury, fluid collections etc.

US accuracy is variable depending upon how well patients scan.

AVN is most accurately assessed by MR.

**Ankle, Wrist**
US is variably useful depending upon the clinical problem.

Overall, MR offers a more comprehensive exam but for some problems (i.e. Achilles pathology, plantar fasciitis, tenosynovitis, presence of ganglion cysts)

US can provide a reasonably quick, accurate and easily obtainable initial exam.

AVN is most accurately assessed by MR.
**Soft Tissue Masses**
US and CT can be of use in determining if a mass is cystic or solid.
MR is complimentary to these and can sometimes narrow the diagnostic possibilities.
The extent of soft tissue and bone tumours is more accurately assessed by MR.
In some cases no imaging modality can correctly determine the nature of a mass as many have non specific imaging characteristics.
Ultimately, some require biopsy or follow up studies.

**Bone Pathology**
Bone itself is more accurately assessed by CT.
Bone tumours and infection are more accurately assessed by MR as the extent of tumour involvement is more clearly shown by MR and normal marrow virtually excludes osteomyelitis.
AVN is most accurately assessed by MR.
MR provides a complimentary study in assessing for occult or stress fractures (hip, calcaneous etc.).
Marrow pathology is best assessed by MR if required.
Although abnormal marrow findings on MR are generally non specific, an abnormal MR exam can help to confirm the presence of marrow pathology and guide the clinician to a region suitable for marrow biopsy.
Vascular System

MR Angiography (MRA)

CT and MR angiography (CTA, MRA) techniques are both able to produce high quality images of vascular structures in a non-invasive fashion.

Each has its advantages and disadvantages.

CTA Pros & Cons

- Short exam times compared to MRA. (PRO)
- Claustrophobia is not a problem. (PRO)
- Safety issues of MR are not a problem. (PRO)
- Uses iodinated contrast that can affect renal function. (CON)
- Radiation exposure (CON)

MRA Pros & Cons

- No radiation. (PRO)
- MR contrast safer than CT contrast. (PRO)
- Some exams do not require contrast. (PRO)
- Long exam times compared with CTA. (CON)
- Claustrophobia is a problem for some patients. (CON)
- MR safety issues. (CON)
- Artifacts that can affect interpretation of studies. (CON)

Applications for MRA/CTA Include:

- Circle of Willis studies for aneurysm screening.
- Peripheral circulation (run off) studies for PVD.
- Carotid stenosis, dissection.
- Renal artery stenosis studies; renal vein/IVC tumour invasion.
- Intestinal angina assessment.
- Aorta for aneurysm, dissection, occlusion (CTA)
- Cranial venous sinus thrombosis (MRA)
- Pulmonary arteries for PE (CTA)