How and When to Order Imaging for the Primary Care Physician

Rajiv Tangri, D.O.

Diplomate American Board of Nuclear Medicine & Diplomate American Board of Radiology

Disclaimer

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Radiation Exposure from Medical Diagnostic Imaging Procedures
Health Physics Society http://hps.org/

Image Gently Website: http://www.imagegently.org

Questions that will be answered

- Do I need contrast for MRI?
- Do I need contrast for an MRA?
- Do I need contrast for CT?
- Do I need contrast for US?
- Do I need contrast for a bone scan?
- There are so many bone scans, which do I order?
- There are so many PET/CT scans, which do I order?
- What is Image Gently?
- How much radiation is used in an MRI?
- How much radiation is used in an US?
Modalities that don’t use radiation
- Radiology and Nuclear Medicine
- What is Contrast?
- CT scans
- X-Ray
- Ultrasound
- MRI
- Nuclear Medicine
  - PET/CT
  - Bone Scans

Modalities that **DO NOT** Use Radiation
- Ultrasound
  - Uses “sound waves” that are sent through the patient
- MRI
  - Magnetic Resonance Imaging uses strong magnets that temporarily magnetize atoms in water in the body
Radiology & Nuclear Medicine

● On a very general level:
  o Radiology images anatomy
    ▪ Generally, diagnostic radiology uses radiation or sound waves that pass through patients to locate structures
    ▪ Exception is MRI, which uses magnets
  o Nuclear medicine images physiology
    ▪ The patient is injected with a radio"tracer"- trace amounts, that should not elicit a physiologic response. These tracers go to the organ or system of interest by physiology.
    ▪ In nuclear medicine, radiation comes out of the patient and the location of the radiation source is imaged with a "fancy camera"
    ▪ Patients are radioactive for typically 24 hours after.
    ▪ Reactions in nuclear medicine are extremely rare and there is NO CONTRAST in any nuclear med procedure.

Radiology & Nuclear Medicine

● Gross example:
  o A CT scan shows what the inside of a body looks like by shining X-rays through the body.
  o A PET scan images the body by imaging where the radioactive glucose (sugar) went. The radiation comes out of the patient and we take "Scans" or pictures.
    ▪ You can fuse these images to get some beautiful pictures with a PET/CT
What is Contrast?

Verb (used with object)
1. To compare in order to show unlikeness or differences; note the opposite natures, purposes, etc.

Verb (used without object)
2. To exhibit unlikeness on comparison with something else; form a contrast.

Linguistics
3. To differ in a way that can serve to distinguish meanings: The sounds (p) and (b) contrast in the words “pin” and “bin.”

http://www.dictionary.com/browse/contrast
What is Contrast?

- In Radiology there are several types of contrast. Physical and image. First, we will talk about image contrast or the way we display images.

- Some of you may have heard of radiologists using the phrases, best seen in soft tissue, bone or lung windows. What does that really mean?

- Well we can adjust the brightness and contrast (rudimentary conversion of Window and Level) of the images to display different organs optimally. We call these windows to these structures...

Image Contrast

These images are all of the same non IV contrast enhanced CT scan

- Soft tissue & Lung windows

- Brain & bone windows
An X-Ray Machine


A CT Scanner

http://www.jnch.nic.in/CT-Scan.jpg
Oral contrast is utilized to show you where the stomach and intestines are so that other structures can be separated from them. Oral contrast helps in the evaluation of the bowel wall and see if there is an obstruction.
Oral Contrast

Mostly we use it to find masses within the lumens of these structures, such as this mass in the cecum.

A Barium Enema Image

https://www.asrt.org/content/ThePublic/AboutRadiologicProcedures/Barium_Enema_exam.aspx
Upper GI

http://smiswi.sasktelwebhosting.com/Images/Fluoro\%20gi\%20series.jpg

Oral Contrast

- This is what we tell patients that get barium or oral contrast for CT or X-Ray procedures:
- You should increase your water intake in the days following your examination. The barium may make your stools white for a few days. This is normal. If you experience constipation following the examination, tell your doctor. You may be advised to take a laxative.

https://www.asrt.org/content/ThePublic/AboutRadiologicProcedures/Upper_GI_Series.aspx
So, if oral contrast helps us see where the intestines are, intravenous contrast, helps us find where vascular structures are.

This helps us differentiate them from masses, lymph nodes and other lesions.

The added benefit of IV contrast is that within an organ we can see if there are vascular masses.

Nearly all malignancies cause angiogenesis to feed them. We can use this trait to help us find them upon a normal background of tissue enhancement.

Inflammation and infection also “enhance” relative to a non intravenous contrast study.
Without and With IV Contrast

Without and With IV Contrast
Without and With IV Contrast

Without and with IV Contrast
IV Contrast

So when don’t you want contrast?
So when don’t you want contrast?

- When you are looking for renal calculi
- For following lung nodules
- Bone lesions
- Looking at adrenal lesions you want non-contrast images to see if the lesion contains a lot of fat (Adenoma) before IV contrast administration.
- Otherwise, you should order IV and oral contrast

CT Contrast Allergies and Reactions

- IV Contrast: It is iodinated, so an iodine allergy is a contraindication.
  - If your patient has an allergy to contrast, safer for everybody to scan at the hospital.
  - Allergy to shellfish and seafood does not necessarily exclude a patient from IV contrast.
- DEHYDRATION is the most common cause of worsening renal insufficiency or renal failure.
  - We routinely will administer 125 cc of saline when we administer large doses of IV contrast
- Diabetic patients taking Metoformin, or products containing it, should wait 48 hours to restarting it to make sure renal function has returned to baseline.
Oral Contrast if IV Contrast Allergy?

- Policy for administering water soluble oral contrast to patients with a history of prior IV contrast reaction:
  - The oral contrast used for CT for in-patients and ER patients is dilute water soluble iodinated contrast (omnipaque). Approximately 1-2% of this is absorbed through the gut in normal patients. Therefore, there is a theoretic risk of a contrast reaction in a patient with a previous IV contrast allergy who gets oral omnipaque.

http://radiology.yale.edu/patientcare/policies/oralcontrast.aspx

Oral Contrast if IV Contrast Allergy?

- Policy for administering water soluble oral contrast to patients with a history of prior IV contrast reaction:
  - Patients with a history of previous moderate or severe reaction to IV contrast should receive barium Readicat or the scan can be done without oral contrast.
    - Moderate reactions are defined as: tachycardia, bradycardia, hypertension, generalized or diffuse erythema, dyspnea, bronchospasm, wheezing, laryngeal edema, mild hypotension.
    - Severe reactions are defined as: severe or rapidly progressing laryngeal edema, unresponsiveness, cardiopulmonary arrest, convulsions, profound hypotension, clinically manifest arrhythmias.

http://radiology.yale.edu/patientcare/policies/oralcontrast.aspx
Radiation doses for CT

Over the last 10 years or so CT has raised some concerns in the radiation it administers. Here are some helpful tips:

1. I don’t worry too much about CTs in a patient that has cancer. Reasoning: We need to see if it is getting better or worse, and we are unlikely to induce a cancer that would kill them before their primary.

2. I also don’t worry about radiation inducing cancer in patients that are over 40, because they will likely die of other causes before a cancer could be induced with a large number of CT scans.

3. That being said, we should be conscientious. Think about the cancers that are most common and try to avoid imaging those areas unnecessarily. Avoid unnecessary CTs of the chest and pelvis:
   a. Female pts develop lung, breast, and ovarian or uterine carcinomas most commonly.
   b. Male pts develop lung and prostate most commonly.

In the past, I have seen plenty of hospitals imaging kids daily. We all know those types of clinicians that want a STAT daily follow up CT to watch an abscess disappear.

Judicious use is all that is needed.

Think of CT as a life saving tool to confirm your diagnosis. CT is not a replacement for a thorough history and physical.

For more information on the doses of radiation associated with radiologic imaging tests, and how to minimize radiation doses to patients, please refer to this website:

http://www.imagegently.org/
Summary for CT Contrast

Non contrast CTs good for: Kidney stones, lung nodules, and osseous lesions

All other CTs should be just with oral and IV contrast, including oncology cases; Not with and without contrast, which doubles the radiation dose by scanning the body twice, once without and then with IV contrast.

An Ultrasound Machine

http://ultrasoundmachineguru.com/
Ultrasound Preparation and Contrast

- Contrast: Is not typically used. The machine can tell flow coming towards and away from the probe by the doppler effect.

- Sound waves are used to produce images.
  - The denser the object, the brighter the image.
  - Fasting for 6 hours is important. You don’t want food or pills to be mistaken for masses.
  - This also helps to decrease bowel gas which can really mess up images
An MRA Image

http://www.magnet.fsu.edu/education/tutorials/magnetacademy/mri/images/mri-scanner.jpg

An MRI Scanner

http://www.magnet.fsu.edu/education/tutorials/magnetacademy/mri/images/mri-scanner.jpg
An MRI Scanner

![An MRI Scanner](http://www.magnet.fsu.edu/education/tutorials/magnetacademy/mri/images/mri-scanner.jpg)

An open MRI Machine

![An open MRI Machine](http://www.health.com/health/static/hw/media/medical/hw/h9991392_002.jpg)
MRI Contrast and Preparation

- MRA (Magnetic Resonance Angiogram)- Does not need or use contrast, it detects the flow in vessels.
- Contrast: Only needed when looking for tumors, inflammation (MS) or infection around hardware
  - Maintain information on any implanted hardware, and particularly aneurysm brain clips in the patient’s medical record for easy access.
- MRI’s are loud- pts are provided with ear plugs.
- If the patient is claustrophobic, they should receive premedication and bring it to the examination.
  - They will need transportation home.

An MRA Image
T1 weighted FLAIR and T2 Axial

MRI T1 Image without and with Contrast
MRI FLAIR and T1 With Contrast

MRI Contrast

MRI Contrast VERY RARELY causes problems with patients.

Historically some agents have been shown to cause retroperitoneal fibrosis in patients on renal dialysis. Other than that, there are plenty of studies showing its safety.

CMS Indications for a dedicated PET scan

- Breast Cancer: Staging, re-staging, and response to therapy
- Colorectal Cancer: Diagnosis, staging and re-staging
- Esophageal Cancer: Diagnosis, staging and restaging
- Head & Neck Cancers (excluding CNS and thyroid): Diagnosis, staging and restaging
- Lung Cancer (Non-Small Cell): Diagnosis, staging and restaging
- Lymphoma: Diagnosis, staging and restaging
- Melanoma (Excludes evaluation of regional nodes): Diagnosis, staging and restaging
- Myocardial Viability: Covered for initial evaluation or following an inconclusive SPECT
- Refractory Seizures: Covered for pre-surgical evaluation
- Solitary Pulmonary Nodule (>90 days since prior PET scan)
- Indeterminate single pulmonary nodule
- Thyroid Cancer: Restaging
- More and more conditions are being approved, such as Alzheimer's
  - Amyvid Scan

PET/CTs are not indicated if you don’t have a diagnosis of cancer.
- Exemptions are a pulmonary nodule 8 mm or greater, cardiac studies looking for viable myocardium, and brain scans for dementia
- Not indicated for histories like:
  - The patient looks funny to me
  - There are markers suggesting an underlying malignancy
  - The gastrin level is high, the alk phos is elevated, the ...
  - Unknown abdominal masses, mediastinal adenopathy, paraneoplastic syndromes...
    - These are followed with CT or biopsied, then get PET/CT to stage them.
- Biopsy proven malignancies are what PET/CTs are designed to stage and follow
F-18 FDG is used for oncology

This is basically radioactive sugar (glucose)

PET Scan Preparation

- We are using radioactive sugar for imaging tumors, so the patient’s blood sugar must be under good control
  - <200 mg/dl when fasting

- This is why it is important to fast before the test
  - Some places (like SimonMed Inc.) request you eat a low carb diet the night prior
    - This is not critical.
  - Fasting 4-6 hours (no food, coffee, or juices. Water and medications are OK)
A Positron is Antimatter

Unstable parent nucleus

Proton decays to neutron in nucleus - positron and neutrino emitted

Positron combines with electron and annihilates

Two anti-parallel 511 keV photons produced

A Positron is Antimatter

Coincidence Processing Unit

Sinogram/Lastmode Data

Annihilation

Image Reconstruction
A CT Scanner

http://www.jnch.nic.in/CT-Scanner

A PET/CT Scanner

http://www.biij.org/2007/3/e49/fig2.jpg
PET – Breast Cancer

Types of PET/CT scans offered

- **Oncology:**
  - **FDG PET Scan**
    - Whole body from vertex of skull to toes
      - This is typically done for melanoma or myeloma
    - Eyes to Thighs
      - All the rest of the malignancies
        - Brain not included because of physiologic activity
        - Below thighs, unlikely osseous mets
Types of PET/CT scans offered

● Oncology:
  ● F-18 Bone Scan
    ○ State of the art bone scan looking typically for osseous mets. More sensitive than a nuclear whole body scan, but more expensive.
  ● Axumin PET/CT
    ○ Used in patients with prostate cancer and rising PSA

● Neurology:
  ● FDG PET/CT scan
    ○ Typically used to differentiate dementias
    ○ Can be used for oncology
  ● Amyvid and Vizamyl PET/CT scans
    ○ For Alzheimer’s evaluation
86 y.o. male with low uptake in the frontal and temporoparietal lobes consistent with Alzheimer’s Dementia

Amyvid PET Brain Scan
State of the art imaging for Alzheimers with Vizamyl Scan

A Gamma Camera

Types of nuclear bone scans offered

- Whole body bone scan - Used for oncology typically to evaluate for bone metastasis
- Triple phase bone scan - Used to look for osteomyelitis or occult fractures. We start imaging right after injection.
- Bone Scan with SPECT - Used to look at spine or pelvic lesions typically for fractures
- DEXA bone scan is for bone DENSITY

WBS

- Whole body bone scan
- Helps us find metastasis
Triple phase bone scan

Blood Flow images

Blood Pool images

Delayed Images

Pt has a Left talus contusion

SPECT/CT

- We can obtain bone scans in a similar way as we obtain a CT scan in 360 degrees. The images can be reprocessed in multiple planes.
- At SimonMed we are lucky enough to have several SPECT/CT scanners.
  - They can also do CT scans, much like a PET/CT so you can localize your abnormalities.
  - This is fantastic to find exactly where the uptake is.
Conclusion

- There is no radiation associated with MRI or US.
- US and Nuclear imaging does not use contrast.
- For CT, use oral and IV contrast unless you specifically don’t need it.
  - The times you don’t want contrast with CT are:
    - Bone lesions
    - Pulmonary nodules
    - Kidney stones
    - Adrenal
- For MRI contrast is only needed in a few cases
  - Tumor
  - Infection
  - Inflammation
- PET/CT should be used for Known tumors
- To learn about how to minimize radiation dose to patients, refer to www.imagegently.org.
- Thank you for staying awake! Enjoy the rest of the conference!