Radiology for the Internist

Brandon Weatherly, MD
University of Mississippi Medical Center
Department of Radiology
Objectives

Describe the services that radiology provides.

Highlight possible misunderstandings relating to imaging.

Provide case examples of inappropriate imaging ordered and appropriate recommendations.

Identify tips for ordering both imaging studies.
Case 1

It’s a Saturday and our team is on call. We are trying to get in touch with MRI to see if there is any way to get a study done and read today. That is all that is keeping the patient in the hospital. We have called all the numbers we can find and even the hospital operator, but we cannot reach anyone. Do the radiologists even work on the weekends?!?
Who are we?

- Generalists as well as multiple subspecialty fellowships
  - Emergency
  - Neuro
  - Body (chest, abdomen/pelvis)
  - MSK
  - Pediatrics
  - Breast
  - Interventional
Interventional - a route of confusion

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Integrated IR Residency</th>
<th>Traditional Pathway</th>
<th>Independent IR Residency</th>
<th>Independent IR Residency with ESIR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 year of ACGME approved non-radiology clinical training (internship)</td>
<td>Diagnostic radiology residency</td>
<td>Diagnostic radiology residency</td>
<td>Diagnostic radiology residency with ESIR: Program requires completion of 12 IR or IR-related rotations and, at least, 500 image-guided procedures within the IR domain.</td>
</tr>
<tr>
<td>PGY-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PGY-2</td>
<td>Diagnostic radiology training + 3 IR rotations</td>
<td>Diagnostic radiology residency</td>
<td>Diagnostic radiology residency</td>
<td></td>
</tr>
<tr>
<td>PGY-3</td>
<td>2 years of IR training</td>
<td>1 year of IR fellowship training</td>
<td>2 years of IR residency training</td>
<td></td>
</tr>
<tr>
<td>PGY-4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PGY-5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PGY-6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PGY-7</td>
<td>N/A</td>
<td>N/A</td>
<td>2 years of IR residency training</td>
<td>N/A</td>
</tr>
<tr>
<td>Total years of training</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>
Services offered:

- Radiography
- CT
- MRI
- Mammo/Breast US
- Fluoroscopy (Diagnostic and Therapeutic)
- Ultrasound
- Nuclear Medicine/PET
- Biopsies
- Interventional
We read more than you know...

- In addition to covering all imaging done at UMC, we also cover:
  - Select Specialty Hospital
  - Grenada Lake
  - Noxubee General
  - Holmes County
  - Hudspeth
  - Methodist Rehab
  - Mississippi Sports Medicine
The future?

Radiology Consultation
Case 2

A 63yo female with HFrEF, COPD, and recent COVID infection presents with acute encephalopathy and acute hypoxic respiratory failure. She is too altered to provide a history. CXR findings reveal bilateral patchy opacities.” She is sent for a CT of her chest to further elucidate her pulmonary pathology. However, when the read returns, it says, “Bilateral patchy opacities which could represent atelectasis, pneumonia, or pulmonary edema. Metastatic disease and other less likely etiologies cannot be excluded.”

Is it possible for that read to be any less helpful?!?!
The Radiologist’s Rebuttal...

WHY CAN’T I GET A GOOD HISTORY!?!?! I’M NOT A CBC or CHEM PANEL!
I’M A DOCTOR!
THEY DON’T CALL IT AN “&P”!
THEY CALL IT AN “H&H”!
Multifocal Pneumonia
Diffuse alveolar hemorrhage
Pulmonary Edema
A CT will clear this up right? Maybe?

Multifocal Pneumonia

ARDS

Pulmonary Edema

Diffuse Alveolar Hemorrhage
We see the imaging manifestations of the disease, not the disease itself...

Main types of pulmonary disease are alveolar and interstitial.

All 4 manifest as alveolar in late disease.

Outside of that we rely on patterns:

- Pulmonary edema (batwing)
- DAH (crazy paving)
- Etc...

But typically the findings overlap, and are not text book
We can use disease prevalence to help be more specific...

2018 - nonspecific patchy peripheral opacities

2021 - COVID
So how do I get the radiologist to be more specific in their impression?

History, of course.
A CT will clear this up right?

- Multifocal Pneumonia
- ARDS
- Pulmonary Edema
- Diffuse Alveolar Hemorrhage
- Heart failure with new onset SOB
- New onset SOB w/ hemoptysis; hx of vasculitis

- Elevate WBC and cough
- Long ICU stay with resp failure
- New onset SOB w/ hemoptysis; hx of vasculitis
Case 2 continued

Well, since the read was so noncommittal, maybe we should just get a high resolution CT of the chest so they can get a better look at the parenchyma.

That seems like a good idea...
A brief aside… the High Res CT

**High resolution CT is NOT meant for:**
- Thinner slices
- Better resolution of tiny anatomic detail

**At our institution, a High res CT DOES mean:**
- Thin lung cuts with 2 cm of spacing using a spatial resolution kernel
- Both Prone AND Supine images obtained
- Both Inspiratory AND Expiratory images obtained
- Additional thin cut slices through the lungs (not unique!)
The confusion is in the history (and maybe our protocol)...

Historically, regular CT was thick cut slices (5 mm or greater) and High Resolution was used to obtain thin cut slices.

This was done using advanced techniques (aka not normal)

Now EVERY CT we do has thin cut slices (0.75-2.5 mm and 3 mm). Every CT we do meets the historical definition of “High Res”

Current High Resolution CT protocol is meant for the evaluation diffuse lung diseases, with emphasis on Interstitial Lung Disease… NOT when the patient has another acute process going on
Back to problems with provided history...
I know I know, you TRY to put good history most the time .......

But it’s not just you....

There is a flaw within....

THE SYSTEM ITSELF
<table>
<thead>
<tr>
<th>Patient</th>
<th>Exam</th>
<th>Ordered</th>
<th>MRN/Acc.</th>
<th>Techs/Rads</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>CHEST WO / ABDOMEN WO / PELVIS WO CONTRAST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT ABDOMEN WO CONTRAST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT CHEST W / ABDOMEN W / PELVIS W CONTRAST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT CTA CHEST PE PROTOCOL</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT ABDOMEN W / PELVIS W CONTRAST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT HEAD WO CONTRAST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT CHEST WO CONTRAST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT ABDOMEN W / PELVIS W CONTRAST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT CHEST WO CONTRAST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT CHEST WO CONTRAST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CT LUMBAR SPINE WO CONTRAST</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A total of 10 exams were returned by this worklist filter.
CT Chest W/IV Contrast

### Frequency
- Once - Routine
- Once - Routine
- Once - STAT
- Once - Expedited (4-6 hours)
- Once - Timed
- Once - Pending Discharge

### First Occurrence
- Today 0635

### Scheduled Times
- Hide Schedule
- 12/5/17 0635

### Reason for Exam

#### Common Indications for Exam
- [ ] Abd trauma, blunt, patient is stable
- [ ] Asthma, acute, PNE or PTX suspected
- [ ] COPD exacerbation, complicated
- [ ] COPD exacerbation, uncomplicated
- [ ] Dyspnea chronic, had xray
- [ ] Dyspnea, cardiac origin suspected
- [ ] Emphysema
- [ ] Esophageal reflux
- [ ] Pleural effusion
- [ ] Vocal cord paralysis
- [ ] Weight loss, unintended, non-localized abd pain

#### Oncological Indications for Exam

#### Other Indications for Exam

#### Other Reasons

### Specific Protocols
- Routine
- Trauma
- PE Protocol
- Radiologist recommendation
- Thoracic Surgery Only - Early Stage

### History

### Is the patient allergic to IV contrast media?
- [ ] Yes
- [x] No

### Anesthesia Required?
- [ ] For apps after hours/weekends/holidays, contact AIC at 601-929-3070. For pediatric procedures with anesthesia, call Bats OR: 85-4547. For Grenada apps contact Anesthesia. Intranet — Contact U/Grenada Surgical Services — On Call Now.
Thoracic Surgery Only - Early Stage
<table>
<thead>
<tr>
<th>Time</th>
<th>Status</th>
<th>Patient ID</th>
<th>Exam Description</th>
<th>Ordered By</th>
<th>MRN/Acc.</th>
<th>Techs/Rads</th>
</tr>
</thead>
<tbody>
<tr>
<td>D 07h</td>
<td></td>
<td>2100663</td>
<td>CT CHEST WO/ ABDOMEN WO/ PELVIS WO CONTRAST</td>
<td>ERK WEISS</td>
<td>2100663</td>
<td>6318245</td>
</tr>
<tr>
<td>D 08h</td>
<td>11:07PM</td>
<td>0662929</td>
<td>CT ABDOMEN WO CONTRAST</td>
<td>DMITRY KAZHNIRKO</td>
<td>0662929</td>
<td>6318176</td>
</tr>
<tr>
<td>D 08h</td>
<td>11:19PM</td>
<td>2232207</td>
<td>CT CHEST W/ ABDOMEN W/ PELVIS W CONTRAST</td>
<td>NILDA WITTY</td>
<td>2232207</td>
<td>6318262</td>
</tr>
<tr>
<td>D 08h</td>
<td></td>
<td>0621150</td>
<td>CT CTA CHEST PE PROTOCOL</td>
<td>NILDA WITTY</td>
<td>0621150</td>
<td>6318254</td>
</tr>
<tr>
<td>D 14h</td>
<td>9:53AM</td>
<td>0546304</td>
<td>CT ABDOMEN W/ PELVIS W CONTRAST</td>
<td>FOSTER, THOMAS K</td>
<td>0546304</td>
<td>6316835</td>
</tr>
<tr>
<td>D 14h</td>
<td>9:56AM</td>
<td>0795978</td>
<td>CT HEAD WO CONTRAST</td>
<td>By Unknown Tech</td>
<td>0795978</td>
<td>6318656</td>
</tr>
<tr>
<td>C 06h</td>
<td>05:47PM</td>
<td>5123050</td>
<td>CT CHEST WO CONTRAST</td>
<td>NILDA WITTY</td>
<td>5123050</td>
<td>6318267</td>
</tr>
<tr>
<td>C 06h</td>
<td>05:59PM</td>
<td>0769908</td>
<td>CT ABDOMEN W/ PELVIS W CONTRAST</td>
<td>DAVIS, REULLI H</td>
<td>0769908</td>
<td>6318278</td>
</tr>
<tr>
<td>D 07h</td>
<td>06:00PM</td>
<td>1270871</td>
<td>CT CHEST WO CONTRAST</td>
<td>DMITRY KAZHNIRKO</td>
<td>1270871</td>
<td>6318226</td>
</tr>
<tr>
<td>D 07h</td>
<td>06:26PM</td>
<td>2234050</td>
<td>CT LUMBAR SPINE WO CONTRAST</td>
<td>STRADER, CATHERINE T</td>
<td>2234050</td>
<td>6318321</td>
</tr>
</tbody>
</table>

A total of 10 exams were returned by this worklist filter.
# Radiology Outpatient Order Form

**Attn: Patient - You MUST bring this form with you to the hospital. If you do not have this form, your procedure will not be done.**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone Scan</td>
<td></td>
</tr>
<tr>
<td>CT Scan</td>
<td></td>
</tr>
<tr>
<td>MRI Scan</td>
<td></td>
</tr>
</tbody>
</table>

**Patient Information**

- **Name:** [Patient Name]
- **Date of Birth:** [Date]
- **Address:** [Address]
- **Phone:** [Phone Number]

**Medication Information**

- **Medication Name:** [Medication Name]
- **Dosage:** [Dosage]
- **Frequency:** [Frequency]
- **Route:** [Route]

**Procedure Information**

- **Location:** [Location]
- **Date:** [Date]
- **Time:** [Time]

**Remarks:**

- [Remarks]

**Financial Information**

- **Payment Method:** [Method]
- **Amount Due:** [Amount]

**Signature:** [Physician Signature]

**Orders:**

- [Orders]

**Other:**

- [Other]

---

**Special Instructions:**

- [Special Instructions]

---

**Additional Information:**

- [Additional Information]
Key Points

Imaging in isolation can be very nonspecific.

History or pertinent clinical findings can drastically narrow the imaging differential.

We’re doctors, not lab tests. But we can only operate with what we are given. The more pieces of the puzzle we have, the more critical thinking we can do and ultimately help benefit patients more.
Case 3

Mr. Jones is a 52yo man who presents with nausea, vomiting, and severe abdominal pain. LFTs concerning for obstructive hepatopathy. Bedside US in the ER revealed mildly dilated CBD but no stones.

Should we go ahead and get a CT abdomen? Should we get it with or without contrast? When should we go straight to an MRI with MRCP?
MRI vs CT vs Ultrasound

CT: The best for most. Essentially a 360 degree xray. USES RADIATION (big no no)

MRI: Incredible soft tissue resolution. Not as good for fractures/lungs. Best when looking for **FLUID**. NO RADIATION. USES MAGNETS

Ultrasound: Great soft tissue resolution. Great for looking at fluid. **VERY** operator dependent. Can be used in real time to assist in diagnosis/procedure as well as to assess blood flow. NO RADIATION. NO MAGNETS.
What should I order?

- In most cases, it’s always good to start with an X-ray.
- If this does not provide enough information, CT is typically the next line of choice.
- There are some classic examples where a study besides CT is preferred.
- If in doubt, ask the radiologist.
When should I order CT? (Chest example)

CT is good for masses, abscesses, loculated effusions, concerning for empyema.

Chest CT should be ordered anytime the CXR doesn’t give you enough detail.

In most instances, CT should be reserved for confirmation and better characterization of certain findings on CXR.

EXCEPTIONS:

If you think pulmonary edema clinically and the CXR matches, you don’t need a CT.

If you think pneumonia clinically and the CXR matches, no need for a CT.

If you think pneumonia clinically and the CXR is normal, no need to order a CT. Just treat the pneumonia. You can order it if the patient clinically doesn’t improve.
What should I order? (quick tips)

**CT vs MRI**

AMS/Code grey: ALWAYS CT first (exclude blood)

Pelvic problems: typically ultrasound first, then MRI (CT is terrible)

Cirrhosis/HCC: can do either, ultrasound is by the guidelines but in real life can be tough with a bad liver to look for masses (at the end of the day, insurance may govern this decision)

Fracture in osteoporosis: guidelines recommend MRI as CT can miss nondisplaced fractures in the setting of osteoporosis

When in doubt: CALL US
Radiographs “the truth according to me”
aka guidelines are not always perfect

Chest xray is always the first go to

Abdominal xray it almost always the first go to

Musculoskeletal xray is always the first go to

Spine radiographs are tricky. They SHOULD be the first go to but can be very limited due to positioning/patient body habitus. If there is high concern for fracture, CT should be pursued

Face/Sinus xray is very low yield
The initial radiograph is VERY important!

**Myositis Ossificans**

Benign form of heterotopic ossification typically due to muscular trauma/intramuscular hematoma

Early MO is made up of mesenchymal cells and fibroblasts undergoing numerous mitoses resulting in a pseudosarcomatous appearance on both MRI and histology

Radiograph has classic peripheral rim of calcification by 4-6 weeks
Classic examples: Acute cholecystitis
The flaw in ultrasound for CBD stones...
Classic examples: Pancreatitis
Contraindications to CT

- Pregnancy

Contraindications to MRI

- Metal of concern
- 1st trimester pregnancy (controversial)

Contraindications to US

- Not many
- Doppler typically avoided in pregnancy
MRI - why is metal bad

#1 - It causes artifact which makes the study worthless.

#2 -

#3 -
Metal Object Artifacts

Effect of Metal on FatSat

Effect of Small Letter “c” Tattoo on Upper Arm

www.rad.pulmonary.ubc.ca/spotstuff/MArtifacts.html
MRI - *why is metal bad*

#1 - It causes artifact which makes the study worthless.

#2 - It heats up due to the radiofrequency pulse.

#3 -
Some metal objects such as electrodes, medication patches, bullets, old IVC filters, old pacemakers, etc...
MRI - why is metal bad

#1 - It causes artifact which makes the study worthless.

#2 - It heats up due to the radiofrequency pulse.

#3 - Magnetic pull.
http://www.mrisafety.com/
My patient has a pacemaker...

INSTITUTION DEPENDENT

UMC is one of the leading institutions in moving forward with safe protocols to provide MR imaging for patients with pacemakers.

Recently presented our protocol and outcome data at the Society of Skeletal Radiology conference.
Pacemaker (UMC protocol)

**Outpatient** - standard scheduling, disclose that the patient has an ICD, device RN will schedule appointment

It is helpful to have make/model info in the EPIC system

We are scanning both conditional AND non-safe devices

**Inpatient** - same protocol during weekdays and working hours
Pacemaker (UMC protocol)

Emergent/Weekend MRI:

1) Requires radiology approval
2) Ordering team contacts Cardiology for per/post procedural management and approval
3) Radiologist obtains consent from patient (in the event that the patient can’t consent, the primary team must obtain consent from a responsible party)
4) Primary team (ACLS certified) must be present to monitor vitals during exam
5) Cardiology notified at the start of the procedure
6) Primary team ensures patient leaves with appropriate device followup/settings
Caveat

We do not perform MRI on patients with devices who are not alert, oriented, and compliant.

We do not perform MRI on sedated/anesthesia/intubated patients with conditional/non-safe devices.
Case 4

Mr. Smith is a 72yo man with HTN, DM, and a complicated abdominal surgical history who presents with nausea, vomiting, and severe abdominal distention. He has not passed gas or had a bowel movement in the past four days. You are concerned for obstructive pathology.

Should you obtain a CT abdomen with or without contrast? With IV or oral or both?
Let’s talk contrast!

*** Disclaimer, due to time constraints I will be speaking broadly. Nephrologists, feel free to get angry and argue with me after the talk.
CT Contrast

Iodine based.

- Water soluble - used in fluoroscopy as well as intravenously

Gives us insight into a world of pathology that we couldn’t see without.

Opacification of structures is based on physiology!!!
CT Contrast

- High Osmolality Contrast Media -
  - 5-8x serum osmolality
  - High incidence of adverse events

- Low Osmolality Contrast Media -
  - <3x serum osmolality
  - Allergic-like reactions are rare, accounting for 0.6% of cases with only 0.04% considered severe.

Patients who suffer from allergic reactions to shellfish or topical iodine are not at any higher risk of contrast allergy than patients with any other allergy or asthma, which is only slightly elevated.
Patients who suffer from allergic reactions to shellfish or topical iodine are not at any higher risk of contrast allergy than patients with any other allergy or asthma, which is only slightly elevated.
Contrast Allergy

History of prior contrast reaction may require pretreatment before the next imaging study.

Reaction broken down by both Physiologic vs Allergic-like as well as by severity (mild, moderate, severe).

Major pre-treatment dividing line is Mild to Moderate.
# Contrast Allergy

## Type of Reaction

**Mild**

<table>
<thead>
<tr>
<th>Allergic-like</th>
<th>Physiologic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited urticaria / pruritis</td>
<td>Limited nausea / vomiting</td>
</tr>
<tr>
<td>Limited cutaneous edema</td>
<td>Transient flushing / warmth / chills</td>
</tr>
<tr>
<td>Limited &quot;itchy&quot; / &quot;scratchy&quot; throat</td>
<td>Headache / dizziness / anxiety / altered taste</td>
</tr>
<tr>
<td>Nasal congestion</td>
<td>Mild hypertension</td>
</tr>
<tr>
<td>Sneezing / conjunctivitis / rhinorrhea</td>
<td>Vasovagal reaction that resolves spontaneously</td>
</tr>
</tbody>
</table>
## Contrast Allergy - Type of Reaction

### Moderate - Severe

<table>
<thead>
<tr>
<th>Allergic-like</th>
<th>Physiologic</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Diffuse urticaria / pruritis</td>
<td>- Protracted nausea / vomiting</td>
</tr>
<tr>
<td>- Diffuse erythema, stable vital signs</td>
<td>- Hypertensive urgency</td>
</tr>
<tr>
<td>- Facial edema without dyspnea</td>
<td>- Isolated chest pain</td>
</tr>
<tr>
<td>- Throat tightness or hoarseness without dyspnea</td>
<td>- Vasovagal reaction that requires and is responsive to treatment</td>
</tr>
<tr>
<td>- Wheezing / bronchospasm, mild or no hypoxia</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Allergic-like</th>
<th>Physiologic</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Diffuse edema, or facial edema with dyspnea</td>
<td>- Vasovagal reaction resistant to treatment</td>
</tr>
<tr>
<td>- Diffuse erythema with hypotension</td>
<td>- Arrhythmia</td>
</tr>
<tr>
<td>- Laryngeal edema with stridor and/or hypoxia</td>
<td>- Convulsions, seizures</td>
</tr>
<tr>
<td>- Wheezing / bronchospasm, significant hypoxia</td>
<td>- Hypertensive urgency</td>
</tr>
<tr>
<td>- Anaphylactic shock (hypotension + tachycardia)</td>
<td></td>
</tr>
</tbody>
</table>
### Prior Mild Contrast Reaction - Premedication Protocol

**Adult (or Pediatric > 50 kg)**
- No Premedication
  **OR**
- Premedication with antihistamine alone:
  - Cetirizine (Zyrtec®) 10 mg by mouth 1 hour prior to imaging study*

**Pediatric (< 50 kg)**
- No Premedication
  **OR**
- Premedication with antihistamine alone:
  - Children 6 years and above: Cetirizine 10 mg by mouth 1 hour prior to imaging study**
  - Children 2-5 years: Cetirizine 5 mg by mouth 1 hour prior to imaging study**
  - Children < 2 years: Do not use cetirizine**

### Prior Moderate, Severe, or Unknown Severity Contrast Reaction - Premedication Protocol

**Adult (or Pediatric > 50 kg)**
Premedication with corticosteroid and antihistamine
- Methylprednisolone (Solu-Medrol®) 32 mg by mouth 12 hours and 2 hours prior to imaging study ***
  **AND**
- Cetirizine (Zyrtec®) 10 mg by mouth 1 hour prior to imaging study*

**Pediatric (< 50 kg)**
Premedication with corticosteroid and antihistamine
- Methylprednisolone (Solu-Medrol®) 1 mg/kg (up to 32 mg) by mouth 12 hours and 2 hours prior to imaging study ***
  **AND**
- Children 6 years and above: Cetirizine 10 mg by mouth 1 hour prior to imaging study**
- Children 2-5 years: Cetirizine 5 mg by mouth 1 hour prior to imaging study**
- Children < 2 years: Do not use cetirizine**
MRI contrast

Nonspecific uptake (Every agent besides Eovist)

- For simplification purposes, this can be said to function similar to that of CT contrast for imaging studies
- We currently use either Dotarem or Multihance

Eovist

- Newer MRI contrast agent which is taken up by hepatocytes and biliary system
- Delineates normal liver from abnormal
- Can be used to assess biliary structures (bile leak)
MRI Contrast Allergy

Similar guidelines followed, though attempts are made to avoid use if possible by finding alternate imaging techniques.
When to use contrast

**IV**

Basically… always if clinically feasible

Exception would be looking just for urolithiasis.

If contraindicated, we can still see most acute findings without contrast, we just may not be as definitive

**Oral**

This is a little less clear

You technically don’t need oral contrast for most things, including bowel obstruction.

Fistulas and leaks—also can give rectal contrast

Negative contrast – good for inflammatory bowel disease
Case 4 continued

For the previous patient with the SBO, the admitting team was so concerned about his abdomen, they forget to examine his lower extremities. During rounds the following morning, the astute attending notices two severe wounds on the left foot and ankle with necrosis and foul smelling discharge. The team is concerned for osteomyelitis and possible abscess. However, he now has a new AKI.

Should the patient receive an MRI with or without contrast? What about his renal function?
Key point  - Osteomyelitis

Start with radiographs, then MRI... But does it need contrast?
So why do we still like contrast if concern for infection?
Imaging considerations for patients with kidney disease

Oh boy, here we go....
<table>
<thead>
<tr>
<th><strong>CT (iodinated)</strong></th>
<th><strong>MRI (gadolinium)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>CIN (contrast induced nephropathy)</td>
<td>Nephrogenic systemic fibrosis (NSF)</td>
</tr>
<tr>
<td>Is it real? Don’t ask me, ask the nephrologists</td>
<td>Inflammation, edema, fibrosis of basically you’re whole body</td>
</tr>
<tr>
<td>Do we treat it as real. <strong>YES</strong></td>
<td>Bad stuff.</td>
</tr>
<tr>
<td></td>
<td>New agents have VERY low (no?) risk</td>
</tr>
</tbody>
</table>
CA-AKI (Contrast associated acute kidney injury)- sudden deterioration of renal function after contrast administration. Correlative.

CI-AKI (Contrast induced acute kidney injury, aka CIN)- sudden deterioration of renal function caused by contrast administration. Causative.

*Nearly all papers published before 2006 and many afterwards considered all CA-AKI cases to be CI-AKI (CIN)*
There are NO randomized trials differentiating CA-AKI from CI-AKI

The data we typically refer to shows:

“the risk of CI-AKI has been estimated to be near 0% at eGFR greater than or equal to 45, 0%–2% at eGFR of 30–44, and 0%–17% at eGFR less than 30 mL/min/1.73 m².”
<table>
<thead>
<tr>
<th>ESTIMATED GFR (ml/min/1.73 m²)</th>
<th>Guidelines for Contrast Administration and Hydration</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥30</td>
<td>Low risk. At the current time, there is very little evidence that intravenous iodinated contrast material is an independent risk factor for AKI in patients with eGFR ≥ 30 mL / min/1.73m².</td>
</tr>
<tr>
<td>&lt;30</td>
<td>Higher risk. This cohort of patients appears to be at greatest risk for post-contrast acute kidney injury after administration of intravenous iodinated contrast. <strong>Contrast should not be administered</strong> unless the patient is on dialysis and anuric, or if contrast is considered diagnostically imperative and the benefits of contrast outweigh the risk of post-contrast acute kidney injury. If the patient meets these criteria, the referring attending physician should document the need for contrast and that the benefit of contrast outweighs the risk of post-contrast acute kidney injury in the patient's medical record. Pre-procedural prophylaxis again post-contrast acute kidney injury with intravenous volume expansion therapy should be utilized. The optimal IV volume expansion protocol is unknown and ideally should be tailored to the patient's volume status and medical conditions, which may necessitate discussion between the referring physician and the radiology team. Suggested protocols:</td>
</tr>
<tr>
<td></td>
<td>• Inpatients – 0.9% normal saline at 100 mL/hr IV beginning 6-12 hours prior to contrast administration and continuing 4-12 hours afterwards</td>
</tr>
<tr>
<td></td>
<td>• Outpatients – 0.9% normal saline 500 mL IV bolus prior to contrast administration. Additionally, post-exposure oral hydration (1 cup of water per hour for 8 hours) should be considered provided the patient is not under fluid restriction for medical reasons</td>
</tr>
</tbody>
</table>
MRI Contrast

Linear vs cyclic vs macrocyclic

Overwhelming majority of cases of NSF attributed to 3 agents (Omniscan, Optimark, Magnevist)

Dotarem - no unconfounded cases of NSF

Eovist - no known cases of NSF
MRI Contrast

Current UMC MRI Contrast protocol:

Dotarem and Multihance (Class II) - NO RESERVATIONS. No prior labs, can give in AKI and CKD, does not require post administration dialysis.

Eovist (Class III) requires workup to make sure that certain requirements are met.

<table>
<thead>
<tr>
<th>eGFR &gt; 30</th>
<th>eGFR &lt; 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group II GBCA (Gadavist®)</td>
<td>Single dose appropriate</td>
</tr>
<tr>
<td>Group III GBCA (Eovist®)</td>
<td>Single dose appropriate</td>
</tr>
</tbody>
</table>

UCSF:
She’s pregnant...

CT – we prefer not to CT pregnant women due to the radiation dose. However, in emergent situations or where imaging is NEEDED, we can.

Contrast is NOT contraindicated. If you are making the decision to scan a pregnant woman, do not go through the risk and not get the optimal images.

MRI – somewhat risk free (after 1st trimester). However, gadolinium contrast IS contraindicated in pregnancy.
Mrs. Cunningham is a 54yo female with HIV and prior DVT who presents with severe sepsis with acute hypoxic respiratory failure secondary to disseminated cryptococcus. She was recently admitted with a lung and liver abscess and treated with induction with ampho and flucytosine. She has not been adherent to her outpatient medications.

You are worried about a PE but also need to evaluate the prior abscesses for progression.

Can you get a CT PE protocol AND a CT abdomen and pelvis with contrast at the same time?
How contrast works and why it matters

Goes where blood goes!

Shows physiology of structures!

Has characteristic patterns in certain pathologies!
What is a multiphasic study?

We can acquire the images at any time after contrast administration.

- Routine CT is acquired at 70 seconds post contrast injection. This is typical for the portovenous phase of contrast.
- Arteries and structures with more arterial predominant supply are most enhanced earlier (20 seconds)
- Other structures may enhance or washout later (2 min, 5 min, 10 min, etc…)

- Examples: GI bleed protocol, Ischemia protocol, Adrenal mass protocol, Pancreatic mass protocol, Liver mass protocol
Pancreatic neuroendocrine tumor
SMA Thrombus
Indeterminate adrenal lesion

Absolute wash out = \frac{\text{Enhanced CT (HU)} - \text{Delayed CT (HU)}}{\text{Enhanced CT (HU)} - \text{Unenhanced CT (HU)}} \times 100\% = \frac{88 - 49}{88 - 25} = 62\%
A special focus… the PE protocol.

Images are not acquired by time, but using a brightness indicator placed on the main pulmonary artery.

The pulmonary arteries are opacified even earlier than arterial phase.

So this is essentially a noncontrast study for everything but the pulmonary arteries.
Questions?
References

- My own case log
- All of the internet:
  - UCSF Patient Safety website
  - Radiologyassistant.nl
  - Radiopaedia.org