OVERVIEW

• Ordering imaging
  — US vs CT vs MRI
  — Cost comparison

• Contrast material
  — Intravenous contrast
  — Enteric contrast
  — Contrast induced nephropathy
  — Nephrogenic systemic sclerosis

• ACR appropriateness criteria
  — Modality, protocol, radiation exposure

• Top ten tips
ULTRASOUND

- No radiation, not magnetic
- Readily and widely available
- Operator dependent
- Ideally used for:
  - Thin adults
  - Superficial structures
    - Thyroid, breast, testes, lumps & bumps
  - Female pelvis (transabdominal and transvaginal)
  - Biopsies
- Visualization may be limited due to:
  - Body habitus – obesity, high diaphragm, dense tissues, fatty liver
  - Bones – ribs
  - Air – lungs, bowel gas
COMPUTED TOMOGRAPHY

- Ionizing radiation
- Not magnetic
  - Implantable devices not a danger but may produce artifact
- Short exam time
  - Seconds
- Short ring
- Iodinated IV contrast
  - Larger volume
- Ideal for:
  - Big picture (pain, fever)
  - High resolution imaging (lungs, arteries)
  - Critically ill or uncooperative patient, elderly
MAGNETIC RESONANCE IMAGING

- No radiation
- Strong magnet
  - Pacemakers, certain implants, clips etc.
  - Screening sheet
- Long exam time
  - >30 minutes
- Very loud, long tube
  - Claustrophobia (Valium 5mg PO)
- Gadolinium IV contrast
  - Small volume
- Ideal for:
  - Focused exam
  - Better soft tissue contrast
  - Tissue characterization
MRI SAFETY SCREENING SHEET

- Concerns with ferromagnetic material
  - Heating, movement, missile effect
- Hardware, stents, clips, coils, implantable devices
  - Need manufacturer name, device name
  - Patient may have a card, operative note, year placed
- Shrapnel, bullet fragments
  - Depends on location (bone, lung, orbit) and chronicity
  - Can pull with over 200 times the force of gravity
MRI – PACEMAKER/ICD PROTOCOL

- Radiologist approval
- Cardiology device team evaluation
  - Degree of dependence on device (frequency of shocks etc)
  - Lead integrity
  - Device in place at least 4-6 weeks
- Pacer team present during MRI to program and interrogate device before and after scan
- MD/NP/PA will monitor patient during MRI
- Consequences
  - 99% have no issues
  - Rarely may malfunction requiring replacement
EXAM TIME – CT vs MRI

Abdomen/Pelvis CT
- <12 seconds acquisition (0.6mm)
- Scanner will reconstruct coronal and sagittal

Abdomen MRI
- 40 minutes of image acquisition (if cooperative patient and no need to repeat)
- >12 sequences, at least 10 require breathholds
- 20-30 images per sequence
COST – CHEST

• Portable CXR
  — $253 (tech: 232 prof: 21)
• PA and lateral CXR
  — $275 (tech: 249 prof: 26)
• Chest CT without IV
  — $1670 (tech: 1494 prof: 176)
• Chest CT(A) with IV
  — $2236 (tech: 1924 prof: 213)

Average reimbursement is 43%
COST – ABDOMEN/PELVIS

• KUB (2 views)
  — $245 (tech: 225 prof: 20)
• Ultrasound
  — Abdomen: $624 (tech: 539 prof: 85)
  — Renal: $571 (tech: 485 prof: 86)
  — Pelvis: $508 (tech: 427 prof: 81)
• Abdomen & Pelvic CT without IV
  — $2448 (tech: 2137 prof: 311)
• Abdomen & Pelvis CT with IV
  — $3377 (tech: 3051 prof: 326)
• Abdomen MRI without and with IV
  — $3268 (tech: 2832 prof: 436)

Average reimbursement is 43%
CT – INTRAVENOUS CONTRAST

- Iodine based extracellular agent
- Excreted by the kidney
- Volume of about 100-140 mL
- Low osmolality
CT IV CONTRAST – ADVERSE EVENTS

• Mild
  — Cough, flushing, itching, hives
  — 1-2 in 1000
  — Subsequently need premedication
    • 50 mg prednisone PO 13 hrs, 7 hrs, 1 hr prior to contrast and 50 mg diphenhydramine 1 hr prior

• Severe
  — Laryngeal edema or cardiopulmonary arrest
  — 1-2 in 10 000
  — No future IV contrast

• No relationship to allergies to seafood or iodine containing topical antiseptics
• Historically studies of the risk of contrast induced nephropathy have been technically flawed and far overestimate the risk

• Risk of CIN exists
  — Affects <5% of all patients undergoing CECT
  — Extraordinarily low risk even in chronic renal failure as long as baseline eGFR >30
  — CIN is most concerning in patients with...
    • Acute renal failure or chronic dysfunction with eGFR <30
    • Intermittent dialysis or with residual renal function

• Ultimately the decision to give IV contrast is based on clinical urgency and risk/benefit analysis
CT IV CONTRAST – NEPHROTOXICITY

• Who gets screened before their CT?
  – All inpatients, all ER patients, outpatients >60 yo
  – History of renal disease or kidney surgery
  – Hypertension, diabetes, collagen vascular dz, chronic or high dose NSAIDs

• Prevention
  – Hydration is best
    • Oral: 500 ml during 6 hrs before and 2400 ml during 24 hrs after
    • IV: NS 100 ml/hr for 6-12 hrs before and 4-12 hrs after
  – Conflicting data for bicarbonate

• Dialysis patients
  – Contrast is cleared, no need for urgent dialysis unless needed for volume/osmotic load
CT IV CONTRAST

• Metformin
  – Risk of lactic acidosis if patient has underlying renal dysfunction
  – In patients with history of renal dysfunction, discontinue at time of CT and resume after 48 hours once renal function confirmed to be normal

• Pregnancy
  – Assuming CT is appropriate, IV contrast material can be given during pregnancy
  – IV contrast is OK while breast feeding (<1% excreted in breast milk)
CT ENTERIC CONTRAST

• Types
  – Barium is standard, helpful for interloop collections, differentiating bowel from masses, mesenteric adenopathy
  – Water-soluble when concerned about bowel perforation
  – Neutral oral contrast (CTE) for bowel wall assessment

• Routes of administration
  – Oral, rectal, via tube (NG, FT, drain)
MRI IV CONTRAST

- Gadolinium-based
  - Rare earth metal
  - Toxic in its free form
  - Chelated for use as contrast
- Extracellular agent
- Cleared by renal excretion
- Not routinely given in pregnancy
- Breast feeding
  - No adverse effects reported
  - 0.04% excreted in breast milk
MRI IV CONTRAST – ADVERSE EFFECTS

- Mild
  - Nausea, vomiting, headache
  - 0.07-2.4%
- Allergy
  - Hives, rash or very rarely bronchospasm
  - 0.004-0.7%
- Subsequent reactions are worse, patients should be pre-medicated if history of prior reaction
NEPHROGENIC SYSTEMIC FIBROSIS

- Fibrosis of soft tissues and internal organs, rarely fatal
- Developed in <5% of patients with severe renal failure undergoing CE MRI
- Etiology unknown, thought to be due to free gadolinium, no known cure
- Screening
  - History of renal disease, HTN, DM
- GFR
  - <30 or on dialysis → no gadolinium depending risk/benefit ratio
  - 30-60 → ½ dose
- Gadolinium is not nephrotoxic in clinical doses
- Hemodialysis reduces the risk of NSF
  - Need immediate dialysis
  - Peritoneal dialysis not shown to be protective
ACR APPROPRIATENESS CRITERIA

• Evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging decision
• Hopes to promote the most efficacious use of radiology
• Developed by expert panels which include leaders in radiology and other specialties
• 176 topics with over 883 clinical variants
• http://www.acr.org/ac
# ACR Appropriateness Criteria

**Example: Crohn Disease**

<table>
<thead>
<tr>
<th>Gastrointestinal</th>
<th>Narrative &amp; Rating Table</th>
<th>Evidence Table</th>
<th>Lit Search</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute (Nonlocalized) Abdominal Pain and Fever or Suspected Abdominal Abscess</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
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<td>Acute Pancreatitis</td>
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<td>Blunt Abdominal Trauma</td>
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<td>Chronic Liver Disease</td>
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<td>Colorectal Cancer Screening</td>
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<td>Imaging of Mesenteric Ischemia</td>
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CT enterography/enteroclysis versus standard abdomen/pelvis CT

Computed tomography (CT) enterography/enteroclysis represents a CT examination with a specialized protocol in order to optimize the detection of more subtle pathology in the small bowel. Neutral contrast (by mouth for enterography and by nasoduodenal tube for enteroclysis) is given in large amounts to promote optimal distention of the small bowel [15-19]. Combined with other modifications including thin collimation, multiplanar reconstruction, and intravenous (IV) contrast, this protocol maximizes technique to depict inflammatory changes in the small bowel related to CD [16,18-22]. Most institutions and practices utilize CT enterography, whereas relatively few undertake CT enteroclysis due to the technical demands of the procedure related to placement of a nasoduodenal tube. Bowel distention of the jejunum is typically less at enterography than with enteroclysis but is considered acceptable with good technique [23,24].

It is difficult to precisely determine the test characteristics in CD exactly due to the lack of true reference standard as discussed in the previous section. However, the overall diagnostic performance for CT enterography/enteroclysis is excellent. When an endoscopic standard is utilized, sensitivity for CD ranges from 75% to 90%, with a specificity of >90% [25-29]. Compared against other imaging modalities, CT enterography/enteroclysis represents an optimal option in most patients [17,28,30-34]. The diagnosis of acute inflammation is made through visualization of thickened small bowel with mural stratification as well as extraenteric processes including engorged vasa recti/vascular, and surrounding inflammatory stranding [19,25,27,35-40]. Because CT enterography/enteroclysis is a cross-sectional imaging modality, assessment for

ACR Appropriateness Criteria® 9 Crohn Disease
TOP TEN TIPS

#1 – Ultrasound is best for gallstones.

Why not CT?

US has >98% sensitivity for gallstones
65-75% seen on CT, remainder isodense to bile
TOP TEN TIPS

#2 – CT is best for kidney stones.
#3 – Hydronephrosis is visible on all modalities.
TOP TEN TIPS

#4 – MSK needs x-rays within 3-6 months of an MRI.
TOP TEN TIPS

#5 – Barium for fluoroscopy is different than barium for CT.
TOP TEN TIPS

#6 – Breast density is coming to a report near you.

• Utah legislature is currently in the process of passing breast density reporting law
  — Patient driven advocacy groups
• 4 categories of breast density
• Indicator of the sensitivity of the mammogram in the detection of breast cancer
• ~50% of women in the screening population have “dense breasts” on mammography
• More info on breast density on UpToDate
WHAT TO DO?

• What can you do? Inform patients.
  – Dense breasts are not abnormal
  – Breast density is a subjective assessment, may vary year to year
  – No perfect screening test
  – No agreement on supplementary screening in dense breasts
  – Screening US is not recommended (high false positive rate)

• What are we doing?
  – Using breast tomosynthesis (3D) as a primary screening modality (not supplemental)
  – Decreases call back rate in dense breasts (decreases false positives)
  – Increases cancer detection rate by 2/1000 (6/1000 → 8/1000)
TOP TEN TIPS

#7 – Abdomen OR Pelvis MRI

- Problem solving modality
  - Tailored to answer a specific question
  - Focused on an organ or lesion
  - History (and often prior imaging) is extremely important

- Exam time

- Cost
  - Abdomen MRI – $3269
  - Pelvis MRI – $3303
  - Total - $6572!!!!
TOP TEN TIPS

#8 – Sinusitis is best imaged with CT in the non-acute setting.
TOP TEN TIPS

#9 – Female pelvis – skip the CT.

- Ultrasound is first-line imaging
- CT does not depict uterine zonal anatomy or characterize adnexal masses
FEMALE PELVIS – MRI FOR PROBLEM SOLVING
TOP TEN TIPS

#10 – We would love to hear from you! The more information you give us, the better we can help you.