RIGHT IMAGE FOR THE RIGHT PATIENT

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Department of Radiology, UNC-CH
Abdominal Imaging Group
August 14, 2018
OVERVIEW

• Overutilization
• Review of general scan limitations
• Review of each modality, pros and cons, common indications
GROWTH OF IMAGING

- In the past decade, imaging services and their cost have grown at twice the rate of other technologies in the health care industry
  - Radiation dose!
  - $$$

GROWTH OF IMAGING: DOSE CONCERNS

• Dose to the public
  • 1980: Medical radiation made up <25% of average total radiation dose to US residents\(^1\)
  • 2010: Medical radiation made up >50% of average total radiation dose to US residents\(^1\)
  • “…we must ensure that patients undergoing CT receive the minimum radiation dose possible to produce a medical benefit”
  • LOWEST dose for any given patient

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  • “…we must ensure that patients undergoing CT receive the minimum radiation dose possible to produce a medical benefit”\(^2\)
  • LOWEST dose for any given patient
  • APPROPRIATE dose for any given patient

GROWTH OF IMAGING: DOSE CONCERNS

• Radiology is measured in effective dose (millisieverts: mSv)
  • Refers to radiation risk averaged over the entire body
• Background radiation (cosmic radiation, radon): 3 mSv/year
• Effective dose may be used to estimated risk of cancer/cancer related death
• Risk levels: Additional risk of fatal cancer from an examination
  • Negligible: less than 1 in 1,000,000
  • Minimal: 1 in 1,000,000 to 1 in 100,000
  • Very low: 1 in 100,000 to 1 in 10,000
  • Low: 1 in 10,000 to 1 in 1,000
  • Moderate: 1 in 1,000 to 1 in 500
  • These risk levels represent a very small addition to the 1 in 5 chance we all have of dying from cancer
# GROWTH OF IMAGING: DOSE CONCERNS

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Effective dose</th>
<th>Comparable for natural background radiation for:</th>
<th>Additional life risk of fatal cancer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra-oral XR</td>
<td>0.005 mSv</td>
<td>1 day</td>
<td>Negligible</td>
</tr>
<tr>
<td>Extremity XR</td>
<td>0.001 mSv</td>
<td>3 hours</td>
<td>Negligible</td>
</tr>
<tr>
<td>Chest XR</td>
<td>0.1 mSv</td>
<td>10 days</td>
<td>Minimal</td>
</tr>
<tr>
<td>Spine XR</td>
<td>1.5 mSv</td>
<td>6 months</td>
<td>Very low</td>
</tr>
<tr>
<td>Head CT</td>
<td>2-4 mSv</td>
<td>8-16 months</td>
<td>Low</td>
</tr>
<tr>
<td>Chest CT</td>
<td>1.5-7 mSv</td>
<td>6 months-2years</td>
<td>Very low to low</td>
</tr>
<tr>
<td>Abdominopelvic CT</td>
<td>10-20 mSv</td>
<td>3-7 years</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>PET-CT</td>
<td>25 mSv</td>
<td>8 years</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

- New software and dose reduction protocols are continually evolving
- Doses vary with scan technique and patient size
GROWTH OF IMAGING: COST OF EXAMS

- Conventional Radiography (X-ray): $149-$388
  - Two view chest x ray: $207
  - 4 views of the knee: $266
- Ultrasound: $386-1360
  - Breast ultrasound: $386
  - Abdominal ultrasound: $783
  - Carotid Doppler: $1360
- CT: $1072- $1832 per body part!
  - CT CAP w/wo contrast: $5322!
- MR: $1555 - $4547
  - Brain MR: $2189
  - Abdominal MRI w/wo contrast: $4547
GROWTH OF IMAGING: OVERUTILIZATION

- **Overutilization**: applications of imaging procedures where circumstances indicate that they are unlikely to improve patient outcome

- **Why does it happen?**
  - Self referral
  - Defensive medicine
  - Lack of comprehensive/accessible practice guidelines
  - Referring physicians
  - Radiologists
  - Patients

GROWTH OF IMAGING: OVERUTILIZATION

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• Why does it happen?
  • *Self referral*
  • *Defensive medicine*
  • Lack of comprehensive/accessible practice guidelines
  • Referring physicians
  • Radiologists
  • *Patients*
YOUR OPTIONS...

X ray  Ultrasound  CT  MR
YOUR OPTIONS...

X ray  Ultrasound  CT  MR

What views?
YOUR OPTIONS...

X ray  Ultrasound  CT  MR

Limitations?
YOUR OPTIONS...

X ray
Ultrasound
CT
MR

IV Contrast?
PO Contrast?
What type of CT?
YOUR OPTIONS...

X ray  Ultrasound  CT  MR

IV Contrast?
YOUR OPTIONS...

X ray  Ultrasound  CT  MR

IV Contrast?

NSF  Gadolinium deposition  Renal function
YOUR OPTIONS...

- X ray
  - Views?
- Ultrasound
  - Limitations?
- CT
  - IV?
  - PO?
  - Protocol?
- MR
  - IV Contrast?
  - NSF
  - Gadolinium deposition
  - Renal function
RESOURCES AT YOUR DISPOSAL

- ACR Appropriate Criteria
  - https://www.acr.org/Quality-Safety/Appropriateness-Criteria
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The ACR Appropriateness Criteria® (AC) are evidence-based guidelines to assist referring physicians and other providers in making the most appropriate imaging or treatment decision for a specific clinical condition. Employing these guidelines helps providers enhance quality of care and contribute to the most efficacious use of radiology. Learn More »
RESOURCES AT YOUR DISPOSAL

- ACR Appropriate Criteria

<table>
<thead>
<tr>
<th>Topic Name</th>
<th>Narrative &amp; Rating Table</th>
<th>Evidence Table</th>
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<tr>
<td>Acute (Nonlocalized) Abdominal Pain and Fever or Suspected Abdominal Abscess</td>
<td>Narrative &amp; Rating Table</td>
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<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
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<tbody>
<tr>
<td>US abdomen</td>
<td>8</td>
<td>Primarily to assess for gallstones.</td>
<td>O</td>
</tr>
<tr>
<td>CT abdomen with contrast</td>
<td>8</td>
<td>Best test to assess pancreatic parenchyma.</td>
<td></td>
</tr>
<tr>
<td>CT abdomen without contrast</td>
<td>6</td>
<td></td>
<td></td>
</tr>
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<td>6</td>
<td>“Without” should be performed with low dose technique. To detect presence of calcifications and/or calcified stones within pancreatic duct.</td>
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</tr>
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<td>MRI abdomen without contrast with MRCP</td>
<td>6</td>
<td></td>
<td>O</td>
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<tr>
<td>MRI abdomen without (including MRCP) and with contrast</td>
<td>6</td>
<td>Can also demonstrate pancreatic parenchyma as well as ducts and gallstones. May be somewhat limited in acutely ill patients related to procedure time. See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
</tr>
<tr>
<td>US abdomen endoscopic</td>
<td>4</td>
<td></td>
<td>O</td>
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**Clinical Condition:** Acute Pancreatitis

**Variant 1:** Etiology unknown, first episode of pancreatitis; abdominal pain, elevated amylase lipase; no fever or evidence of fluid loss at admission; clinical score pending.
RESOURCES AT YOUR DISPOSAL

- ACR Appropriate Criteria

### Variant 2:
Severe abdominal pain, elevated amylase lipase, 48 hours later assuming no improvement or degradation (assume no prior imaging).

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<td>8</td>
<td>Generally easier access to this modality.</td>
<td>☀ ☀ ☀</td>
</tr>
<tr>
<td>MRI abdomen without (including MRCP) and with contrast</td>
<td>8</td>
<td>Allows evaluation for choledocholithiasis. See statement regarding contrast in text under “Anticipated Exceptions.”</td>
<td>O</td>
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<tr>
<td>MRI abdomen without contrast with MRCP</td>
<td>7</td>
<td></td>
<td>O</td>
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<td>CT abdomen without contrast</td>
<td>6</td>
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<tr>
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<td>6</td>
<td></td>
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**Rating Scale:** 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

**RRL* Relative Radiation Level**
Clinical Decision Support

Starting January 1, 2020, the Protecting Access to Medicare Act (PAMA) will require referring providers to consult appropriate use criteria (AUC) prior to ordering advanced diagnostic imaging services (CT, MR, nuclear medicine exams and PET) for Medicare patients.

CareSelect Imaging™ / ACR Select®, a digital representation of the ACR Appropriateness Criteria® for diagnostic imaging, is a module contained within CareSelect Imaging. ACR Select can be integrated into most common electronic health records (EHRs). The National Decision Support Company (NDSC), which is now owned by Change Healthcare, is a CMS approved qualified Decision Support Mechanism (DSM).

Providers can access imaging AUC via stand-alone electronic clinical decision support (CDS) systems or CDS software embedded in a physician’s EHR. The ACR anticipates providers documenting that they consulted AUC with an “unique consultation identifier” in the exam order. However, claims processing instructions will be finalized by CMS in the upcoming Medicare Physician Fee Schedule rulemaking cycle.

No rendering provider — radiologist or otherwise — may receive Medicare payment for an advanced imaging exam if the referring provider does not verify that imaging AUC were consulted. Ordering physicians cannot shift the requirement to consult the guidelines to radiologists. Imaging providers cannot perform AUC administrative duties for referring providers. Imaging providers may refuse Medicare referrals lacking the “unique consultation identifier” and not be competitively disadvantaged.

Exams performed in the emergency department are included in the PAMA rule — except for the most emergent of cases. Inpatient exams are also exempted. HHS may make limited exceptions for rural providers with limited internet connectivity.
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RESOURCES AT YOUR DISPOSAL

- Your radiologist!!!!
RIGHT SCAN FOR THE RIGHT PATIENT

• Ultrasound
  • BODY HABITUS!
  • Will we be able to image the area in question?

• CT
  • Can the patient lie flat for several minutes on their back
  • Can the patient hold their breath for ~15 second

• MR
  • Is the patient able to lie in an enclosed space for up to one hour?
  • Can the patient lie on their back?
  • Can the patient hold their breath for 20 second?
  • Can the patient tolerate premedication (anxiety) and still follow breathing instructions?
  • Can the patient tolerate loud noises?
CONVENTIONAL RADIOGRAPH (X-RAY)

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheap</td>
<td>Limited sensitivity</td>
</tr>
<tr>
<td>Relatively low radiation dose</td>
<td>Possibly over utilized</td>
</tr>
<tr>
<td>Readily accessible</td>
<td>False positives</td>
</tr>
<tr>
<td>Clinician friendly</td>
<td>Unsatisfying reports!</td>
</tr>
</tbody>
</table>
CONVENTIONAL RADIOGRAPHS

- Unsatisfying reports
  - “Thin lucency in the proximal tibia, possibly non displaced fracture. Correlate for point tenderness”
  - “Left lower lobe consolidation may represent atelectasis, pneumonia or edema; cannot exclude underlying mass lesion”
  - “Further evaluation with CT of the ______ is recommended”
  - “Non specific finding. Clinical correlation recommended….”
Non specific lobulated left lower lobe mass, possibly loculated fluid, pleural based mass, neoplasm, infection….. Recommend correlation with CT of the chest.
Multiloculated collection in the pleural space consistent with empyema
CONVENTIONAL RADIOGRAPH

- Specific views and patient positioning may be helpful
  - Upright chest x ray: Pneumoperitoneum
  - Expiratory upright film: Pneumothorax
  - Decubitus films: Layering effusion
CONVENTIONAL RADIOGRAPH

- Specific views and patient positioning may be helpful
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  - Decubitus films: Layering effusion

Image courtesy of Saint Vincent’s University Hospital
CONVENTIONAL RADIOGRAPH

- Easily accessible
- Not always sensitive or specific
- Specific views may answer specific clinical questions
- You get what you pay for!
ULTRASOUND

Pros
- No radiation
- “Real time” imaging - blood flow, peristalsis, etc
- Cheap (relatively speaking)

Cons
- Operator dependent
- Patient dependent
  - Body habitus
  - Positioning
  - Breath hold
ULTRASOUND LIMITATIONS: BODY HABITUS

BMI 24

BMI 49
ULTRASOUND LIMITATIONS: BOWEL GAS
ULTRASOUND: LIMITATIONS

High Frequency ultrasound
- Good spatial resolution
- Superficial penetration

Superficial structures
- Thyroid
- Subcutaneous
- Breast
- Lymph nodes
- Superficial vessels

Low Frequency ultrasound
- Worse spatial resolution
- Deep penetration

Deeper structures
- Abdominal organs
ULTRASOUND: SUPERFICIAL STRUCTURES

THYROID NODULE

Cervical lymph nodes
ULTRASOUND: SUPERFICIAL STRUCTURES

THYROID NODULE

Cervical lymph nodes
ULTRASOUND: DYNAMIC IMAGING

Left inguinal hernia with Valsalva
ULTRASOUND: DYNAMIC IMAGING

Left inguinal hernia with Valsalva
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ULTRASOUND: DYNAMIC IMAGING

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ULTRASOUND: VASCULAR EVALUATION

- Cirrhotic patient: TIPS evaluation

Elevated velocities through TIPS indicative of stent malfunction
ULTRASOUND: BILIARY TREE

Intrahepatic biliary ductal dilatation

Normal caliber common bile duct
ULTRASOUND: BILIARY TREE

Intrahepatic biliary ductal dilatation

Normal caliber common bile duct
ULTRASOUND: GALLBLADDER/BILIARY TREE

- Incidental gallstone
ULTRASOUND: GU IMAGING

- First line modality:
  - Uterus
  - Ovaries
  - Testicles
  - Superficial structures

- Why?
  - Good soft tissue contrast
  - No radiation
ULTRASOUND: GU EVALUATION: UTERUS

- Post menopausal bleeding

I.II defined uterine mass, possibly leiomyoma although neoplasm cannot be excluded: Recommend ultrasound for further evaluation...
ULTRASOUND: GU EVALUATION: UTERUS

- Post menopausal bleeding

Ill defined uterine mass, possibly leiomyoma although neoplasm cannot be excluded: Recommend ultrasound for further evaluation...
FIGO grade II endometrial adenocarcinoma involving 81% of the myometrium
FIGO grade II endometrial adenocarcinoma involving 81% of the myometrium
ULTRASOUND: GU EVALUATION: TESTICLES

- 13 year old male with testicular pain
ULTRASOUND: GU EVALUATION: TESTICLES

- 13 year old male with testicular pain

Right sided testicular torsion
ULTRASOUND: GU EVALUATION: KIDNEYS

• Useful:
  • Stones (sometimes)
  • Hydronephrosis
  • Cysts (sometimes)

• Not useful:
  • Characterizing solid renal masses
  • Ureteral stones (sometimes)

• *Coming soon: Ultrasound contrast! Stay tuned!
ULTRASOUND: HYDRONEPHROSIS
ULTRASOUND: NEPHROLITHIASIS
ULTRASOUND: SOLID VERSUS CYSTIC

Characteristics of a cyst
1. Anechoic = “black”
2. Posterior acoustic enhancement = “bright shadow”
3. No blood flow
4. Nothing in it

Multiple simple renal cysts
ULTRASOUND: SOLID VERSUS CYSTIC

Characteristics of a cyst
1. Anechoic = “black”
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Multiple simple renal cysts

Simple cyst
ULTRASOUND: SOLID VERSUS CYSTIC

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Simple cyst  Mildly complex cysts
ULTRASOUND: SOLID VERSUS CYSTIC

Characteristics of a cyst
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Cyst!

Cyst???

Simple cyst  Mildly complex cysts
ULTRASOUND: GU: KIDNEYS

- 79 year old female with acute kidney injury

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Simple cyst
Mildly complex cysts
ULTRASOUND: GU: KIDNEYS

- 79 year old female with AKI

Renal cell carcinoma
ULTRASOUND: GU: EVALUATION OF KIDNEY

- 71 year old male with right upper quadrant pain
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Clear cell renal cell carcinoma: 5 cm
ULTRASOUND: GU EVALUATION: KIDNEYS

• **Uses**
  
  • **Hydronephrosis**: Very good
  
  • **Calculi**: Good (renal caluli, not necessarily ureteral calculi)
  
  • **Cysts**: Okay (simple cysts, non obese patient)
  
  • **Masses (detection and characterization)**: Poor
ULTRASOUND

• First line imaging modality
  • Vascular pathology
  • Dynamic "real time" imaging
  • Biliary pathology
  • Uterus, ovaries, testicle
  • Kidneys (sometimes)

• **NOT useful for**
  • Characterizing solid lesions
  • Detection of occult pathology outside of the probe’s range
  • Penetrating extensive fat/gas
RECENTLY ARRIVED!
CONTRAST ENHANCED ULTRASOUND!!!
WHAT IS IT?

Gas filled microbubble

Lipid shell

*Sulfur hexafluoride
WHAT IS IT?

Gas filled microbubble

Lipid shell

Same size as RBC

2-8 microns

6-8 microns
WHAT IS IT?

Gas filled microbubble

Lipid shell

Oscillates when in US field
WHY DO WE NEED IT?
WHY DO WE NEED IT?

- Metabolism: Gas is exhaled, lipids broken down in liver
WHY DO WE NEED IT?

• Metabolism
  • NO renal excretion!
WHY DO WE NEED IT?

• Metabolism
  • NO renal excretion!
  • Basically no hepatic excretion!
WHY DO WE NEED IT?

- Metabolism
  - NO renal excretion!
  - Basically no hepatic excretion!
- Repeated injection
WHY DO WE NEED IT?

• Metabolism
  • NO renal excretion!
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• Repeated injection
  • Dose is ~2 mL (or less)
  • Bubbles last 5-10 minutes
  • Can destroy bubbles using ultrasound to reinject if needed
WHY DO WE NEED IT?

• Metabolism
  • NO renal excretion!
  • Basically no hepatic excretion!

• Repeated injection
  • Dose is ~2 mL (or less)
  • Bubbles last 5-10 minutes
  • Can destroy bubbles using ultrasound to reinject if needed
  • Have given up to 161 mL without adverse effects!
WHY DO WE NEED IT?

• Renal impaired patients
• Patients who cannot tolerate MRI
• Patients with contrast allergies
HOW DOES IT LOOK?

- Real time enhancement of lesion
  - Pattern of enhancement: Central vs. peripheral
  - Washout
    - Presence or absence
    - Timing of washout
  - Opportunity for repeat injections if uncertain of pattern
HOW DOES IT LOOK?

- Hemangioma
HOW DOES IT LOOK?

- HCC
HOW ACCURATE IS IT?
HOW ACCURATE IS IT?

Fig. 4. Summary receiver operating characteristic (ROC) curve for contrast enhanced ultrasound (CEUS). The size of the data marker is proportional to the weight of the individual study. AUC = 0.9555, SE(AUC) = 0.0158, Q* = 0.8980, SE (Q*) = 0.0222.

Fig. 5. Summary receiver operating characteristic (ROC) curve for contrast enhanced computed tomography (CECT). The size of the data marker is proportional to the weight of the individual study. AUC = 0.9148, SE(AUC) = 0.0376, Q* = 0.8475, SE (Q*) = 0.0423.

Fig. 6. Summary receiver operating characteristic (ROC) curve for contrast enhanced magnetic resonance imaging (CEMRI). The size of the data marker is proportional to the weight of the individual study. AUC = 0.9362, SE(AUC) = 0.0223, Q* = 0.8727, SE (Q*) = 0.0277.

Contrast-enhanced ultrasound using SonoVue®

Conclusions: SonoVue CEUS could provide similar diagnostic performance to other imaging modalities (CECT and CEMRI) for the assessment of FLLs. Economic analyses indicated that CEUS was a cost-effective replacement for CEMRI. The use of CEUS instead of CECT was considered cost-effective in the surveillance of cirrhosis and the characterisation of incidentally detected FLLs, with similar costs and effects for the detection of liver metastases from CRC. Further research is needed to compare the effects of different imaging modalities (SonoVue CEUS, CECT, CEMRI) on therapeutic planning, treatment and clinical outcomes. Future test accuracy studies should provide standardised definitions of a positive imaging test, and compare all three imaging modalities in the same patient group.

cost-effectiveness analysis
Lots more research and meta-analysis saying the same thing: CEUS works!!!
HOW DOES IT WORK

- Lesion localized on US
HOW DOES IT WORK

• Lesion localized on US
• Contrast injected
HOW DOES IT WORK

• Lesion localized on US
• Contrast injected
• Lesion watched in real time
  • Cine clips
  • Intermittent observation for 5+ minutes
  • Radiologist in room (for now)
HOW DOES IT WORK

• Lesion localized on US
• Contrast injected
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• If lesion characterized, exam is done and patient can go
HOW DOES IT WORK

• Lesion localized on US
• Contrast injected
• Lesion watched in real time
  • Cine clips
  • Intermittent observation for 5+ minutes
  • Radiologist in room (for now)
• If lesion characterized, exam is done and patient can go
• If lesion is not characterized, can repeat injection
LIMITATIONS

- Lesion must be visualized on ultrasound
  - Patient size
  - Gas
  - Limited penetration of cirrhotic/steatotic livers
LIMITATIONS

• Lesion must be visualized on ultrasound
  • Patient size
  • Gas
  • Limited penetration of cirrhotic/steatotic livers
• Staffing
  • Attending in room
  • 1 hour for exam (procedure slot)
CONTRAINDICATIONS

• Prior allergic reaction to *ultrasound contrast* (1 in ~12,000)
• Unstable cardiac disease
WHERE TO GO FROM HERE?

- Be patient
- Role in interventions
- LOTS of possibilities!!!
QUESTIONS?
COMPUTED TOMOGRAPHY

Pros
- Quick
- Easily accessible
- “Screening test”

Cons
- Radiation: doses are 100-500x those of conventional radiograph
- IV contrast
CT CONTRAST AGENTS

- At risk patients: BUN/Creatinine recommended within 30 days of the exam IF...
  - > 60 year old
  - History of renal disease
    - Dialysis
    - Renal transplant
    - Single kidney
    - Renal cancer
    - Renal surgery
  - Hypertension requiring medical therapy
  - History of diabetes
  - Metformin use
- No universal cutoff - will vary with institution
  - Range of serum creatinine 1.5-2.0

CT CONTRAST AGENTS: WHEN TO AVOID IT

- Risk factors for contrast induced nephropathy…
  - Repeated doses (20 hours to clear contrast from system)
  - Acute renal injury
  - Dehydration
  - Radiologist is consulted to determine if contrast is needed or if situation can be optimized

- DIALYSIS
  - If the patient is on hemodialysis AND anuric, IV contrast can be given
  - If the patient is still making urine, proceed cautiously

- PREVENTION
  - Hydration: oral or IV, no ideal rate
  - Sodium bicarbonate and N acetylcysteine (mucormyst) not validated
  - *Acute renal failure is a contraindication to IV contrast*
CT CONTRAST AGENTS: PREMEDICATION

• Reactions to contrast agents

  • Mild (no treatment): 5-8% of patients (flushing, nausea, vomiting)
  • Moderate (require treatment): 1% of patients (severe nausea/vomiting, hives, swelling)
  • Severe (require treatment): 0.1% of patients (anaphylaxis)
    • Expected death rate of 1 in 75,000¹
  • “Pseudo-allergy”: No allergic antibody- IV contrast causes histamine release from mast cells

CT CONTRAST AGENTS: PREMEDICATION

• Contrast reaction: At risk patients
  • Prior reaction
  • Shellfish allergy does not necessitate premedication\(^1\)

• Premedication:
  • 13 hours prior: Prednisone 50 mg (IV or po)
  • 7 hours prior: Prednisone 50 mg (IV or po)
  • 1 hour prior: Prednisone 50 mg (IV or po) and Diphenhydramine (Benadryl) 50 mg po\(^2\)

• “Emergency” premedication
  • Q4 hours until injection: 40 mg Methylprednisoneosodium succinate (Solu-medrol) or 200 mg hydrocortison sodium succinate (Solu-Cortef)
  • 1 hour prior: 50 mg diphenhydramine (Benadryl)

**Steroid less effective when given less than 4-6 hours prior to exam**

CT CONTRAST: METFORMIN, BREASTFEEDING

- **Metformin**
  - Acute renal failure caused by IV contrast can lead to an accumulation of metformin, resulting in lactate accumulation/lactic acidosis
  - Hold metformin for 48 hours post injection

- **Breastfeeding**
  - >1% of the dose is excreted in breast milk
  - >1% of the contrast in breast milk is absorbed from the GI tract
  - 0.01% of dose ingested by infant
  - If the mother is concerned, she may abstain from breast feeding for 24 hours
CT: WHEN AND WHY OF CONTRAST AGENTS

- **Principle**: Increased attenuation (brightness) from the iodine atom in contrast = “enhancement”
  - Magnitude of enhancement is related to amount of contrast deposited in a target organ or in the intravascular blood pool
- **Variables in enhancement**
  - Rate of injection
  - Cardiac output of the patient
  - Organ perfusion (i.e. single versus dual blood supply)
  - Timing of imaging
- **When do we use it?**
  - Vascular imaging
  - Infectious/inflammatory processes
  - Neoplasm

Herman, S. Computed Tomography Contrast Enhancement Principles and the Use of High Concentration Contrast Media. J Comput Assist Tomogr 2004; 28: S7-S11
CT: WHEN AND WHY OF CONTRAST AGENTS

• Getting a diagnostic scan…
  • Appropriate *use* of IV contrast
  • Appropriate *timing* of IV contrast
• Based on clinical history, a scan protocol is chosen to optimize the diagnostic yield
  • Precontrast imaging?
  • Multiple phases of imaging?
CT CONTRAST AGENTS: TIMING IS EVERYTHING

Same patient: Two lesions

Precontrast

Late arterial

Portal venous

Equilibrium
CT CONTRAST AGENTS: TIMING IS EVERYTHING

Same patient: Two lesions

METASTATIC DISEASE

HEMANGIOMA
CT CONTRAST: VASCULAR IMAGING
CT CONTRAST: VASCULAR IMAGING

Filling defect = pulmonary emboli

Bowed interventricular septum = Right heart strain
CT CONTRAST: INFECTION/INFLAMMATION

- Inflammed small bowel: No contrast
CT CONTRAST: INFECTION/INFLAMMATION

- With contrast: Diverticulitis with intramural abscess
CT CONTRAST: NEOPLASM

- Pancreatic neuroendocrine tumor: Without and with contrast
CT: IV CONTRAST: WHEN DON’T WE WANT IT?

- What is bright on CT?
  - Blood
  - Calcium
  - Iron
  - Foreign bodies
CT: IV CONTRAST: WHEN DON’T WE WANT IT?

• What is bright on CT?
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  • Iron
  • Foreign bodies
CT: IV CONTRAST: WHEN DON’T WE WANT IT?

- What is bright on CT?
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  - Calcium
  - Iron
  - Foreign bodies

Retroperitoneal hematoma
CT: IV CONTRAST: WHEN DON’T WE WANT IT?

- What is bright on CT?
  - Blood
  - Calcium
  - Iron
  - Foreign bodies
CT: IV CONTRAST: WHEN DON’T WE WANT IT?

- What is bright on CT?
  - Blood
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CT: IV CONTRAST: WHEN DON’T WE WANT IT?

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  - Foreign bodies
CT: IV CONTRAST: WHEN DON’T WE WANT IT?

• What is bright on CT?
  • Blood
  • Calcium
  • Iron
  • Foreign bodies
CT: SUMMARY

- IV contrast useful...
  - Vascular imaging
  - Infection/inflammation
  - Neoplasm

- IV contrast not useful...
  - Calcium (renal stones)
  - Blood (RP hematoma)
  - Iron/Foreign body

- A specific clinical history aids with scan protocoling
MRI: PROS AND CONS

• Pros
  • No radiation
  • Highly diagnostic modality
  • Excellent soft tissue contrast
  • Histologic information: fat, water, iron, fibrosis
  • Functional information: perfusion, peristalsis, cardiac output
• Improvements
  • Decreasing scan times
  • Emergency medicine
  • New sequences
MRI: PROS AND CONS

- Limitations: Patient
  - Enclosed space for up to one hour?
  - Lying on their back
  - Loud noises

- Limitations: Radiologist and system
  - Subspecialized reading
  - Longer scan times
  - Limited availability/varying magnets

- Solutions
  - Stereovision
  - Gentle use of anxiolytics
  - More MR trained radiologist/subspecialized reads
MRI: CATEGORIES AND CONTRAST AGENTS

• Multiple types of MRI
  • Neurologic: Brain, neck and spine
  • Abdominopelvic
  • Musculoskeletal
  • Vascular imaging
  • Cardiac imaging
  • And more!

• Pelvic MRI: Be specific!
  • Prostate MRI?
  • Rectal MRI?
  • MSK MRI?
MRI: CATEGORIES AND CONTRAST AGENTS

- Multiple types of MRI
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  - And more!

- Pelvic MRI: Be specific!
  - Prostate MRI?
  - Rectal MRI?
  - MSK MRI?

All three are ordered as a pelvic MRI
MRI: CATEGORIES AND CONTRAST AGENTS

- Multiple types of MRI
  - Neurologic: Brain, neck and spine
  - Abdominopelvic
  - Musculoskeletal: Bones, joints, soft tissues, spine
  - Vascular imaging
  - Cardiac imaging
  - And more!

- Every MRI order is reviewed by a radiologist to protocol appropriately
  - Rigorously protocolled
  - Tailored to the patient and clinical question
MRI CONTRAST AGENTS: NEPHROGENIC SYSTEMIC FIBROSIS

• “Fibrosing disease, predominantly of the skin and subcutaneous tissue, but also other organs, which may develop and progress rapidly, possibly causing death”

• Occurs with ESRD in association with gadolinium based IV contrast materials
  • Amount of gadolinium given (per scan and accumulated dose)
  • eGFR <30 have a 1-7% chance of developing NSF

• Has developed in patients with AKI even if renal function returned to normal

• Declining incidence with use of macrocyclic contrast agents

• Controversial topic! Be alert for changing literature

MRI CONTRAST AGENTS: NSF

- When can we give contrast?
  - ESRD on chronic HD:
    - Is CT possible instead of MR?
    - If MR must be performed, we choose least offensive contrast agent and lower dose
    - Consider hemodialysis ASAP
  - ESRD (GFR <15), not on HD
    - Avoid both MR and CT contrast agents if at all possible
    - If must be given, lower dose, etc

MRI CONTRAST AGENTS: NSF

- **Screening requirements:** require BUN/Creatinine within 30 days of exam\(^1\)
  - Age >60 years
  - Hypertension
  - Renal disease

- **GFR Guidelines**
  - GFR <15: No IV contrast
  - GFR 15-30: Use a lower risk contrast agent (Doderone, Multihance)
  - GFR >30: No problem!

- **Certain contrast agents have few, if any reported cases of NSF**
  - Multihance
  - Dotarem
  - Gadavist
  - Prohance
MRI CONTRAST AGENTS: NSF

- **Screening requirements**: require BUN/Creatinine within 30 days of exam\(^1\)
  - Age >60 years
  - Hypertension
  - Renal disease

- **GFR Guidelines**
  - GFR <15: No IV contrast
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Used at UNC
GADOLINIUM DEPOSITIONAL DISORDER

- High signal in brain tissue in patients with normal renal function
  - Associated with repeated doses of gadolinium
  - No known adverse effects
- Certain contrast agents not associated with this
  - Dotarem (used at UNC)
  - Prohance
- However, as led to a more cautious use of gadolinium contrast agents

Deposition
- Dentate nucleus
- Globus pallidus

MRI CONTRAST AGENTS: PREGNANCY AND BREASTFEEDING

• Pregnancy:
  • “Present data has not conclusively document any deleterious effects of MR imaging on the developing fetus”\(^1\)
  • Avoid in first trimester (not evidence based)
  • IV contrast DOES cross the placenta and is not given at our institution in pregnancy

• Breastfeeding:
  • > 0.04% of the IV dose in breast milk \(^2\)
  • > 1% of the contrast in breast milk is absorbed across the GI tract\(^2\)
  • Expected dose to infant <0.0004% of IV dose\(^2\)
  • If the mother is concerned, she may abstain from breastfeeding for 24 hours

MRI CONTRAST AGENTS: WHEN AND WHICH ONE

• Varying contrast agents available
  • Dotarem
  • Multihance
  • Eovist

• Indications: similar to CT
  • Vascular imaging
  • Infection
  • Inflammation
  • Neoplasm
MR- BODY IMAGING

• Please keep in mind that this is *problem solving* modality, not a screening modality

• The more specific the clinical history, the better the exam will be!

• **Common indications**
  - *Because the radiologist told you needed one*
  - Characterization of a lesion
  - Evaluation of the biliary tree
  - Follow up of treated disease
  - GU: Female pelvis, prostate (NOT CT!)
  - Imaging the bowel (small bowel, rectum)

• **Emerging indications**
  - Tissue composition (iron, fat, fibrosis)
Indeterminate hepatic lesion
Focal steatosis
MRI: IMAGING THE BILIARY TREE

Pancreatic duct

Pancreatic divisum
MRI: IMAGING THE BILIARY TREE

Pancreatic duct

Pancreatic divisum
MRI: IMAGING THE BILIARY TREE

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MRI: IMAGING THE BILIARY TREE

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Pancreatic duct
MRI: IMAGING THE BILIARY TREE

Pancreatic duct

Pancreatic divisum
MRI: IMAGING THE BILIARY TREE

Pancreatic duct

Pancreatic divisum
Magnetic Resonance Imaging (MRI) of the Female Pelvis

Bicornuate Uterus
MRI: IMAGING THE MALE PELVIS

PROSTATE CANCER
MVP: IMAGING THE MALE PELVIS

PROSTATE CANCER
MRI IMAGING: TISSUE COMPOSITION

- Liver
  - Fat content
  - Iron content
  - Fibrosis

- Bowel
  - MR enterography
  - Rectal MR

- MRI is a rapidly expanding and changing field. If you want to know if we can do it—just ask!!!
YOUR RADIOLOGIST

- Clinician feedback
  - Reports
    - Relevant? Unclear?
  - Imaging problems
    - Patient complaints?
    - Didn’t give you an answer
  - Pathology and/or clinical follow up
    - Were we right or wrong?

- You are our target population with our imaging and reports - let us know how we can improve and make your life easier!
TAKE HOME POINTS

- Overutilization is a real but solvable problem if a partnership exists between the clinician and radiologist.
- There are many different imaging modalities at your disposal with varied resources to help advise you:
  - ACR appropriateness criteria
  - Radiologist
- Appropriate scan for each patient:
  - Appropriate radiation dose
  - Scan limitations
  - Patient limitations
- Clinician feedback is critical for imaging and service improvement.
THANK YOU!
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