Radiology Update: Cost Effective Radiology
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Objective

All slides and answers can be found at:
http://cebi.partners.org  (presentations tab)

I. Discuss factors that may contribute to the inappropriate use of radiological studies
II. Discuss the imaging workup of some commonly encountered clinical problems
III. Recommend methods to reduce inappropriate use of imaging studies
Background

• Excessive number of tests with ? Impact on patients’ outcome
  – Increasing concern of radiation risk
  – Increasing concern of costs

• Steady growth of imaging costs
  – Pre-authorization programs by payers

• Proper selection of imaging tests
  – Clinical problem, test characteristics, local expertise
  – Increasing complexity of imaging technology
  – Use of contrast-e.g. gadolinium induced NSF

Impossible to present “all” guidelines
I. Main causes of inappropriate use of imaging studies

- Test results are unlikely to affect patient management
- “short” interval follow-up studies
- Repeating studies which have already been performed (including elsewhere)
- Patient demand
- Not requesting the best test
  - Access to technology
- Inadequate clinical information provided on the requisition
II. Imaging Guidelines

- American College of Radiology (ACR)

- The British royal College of Radiologists (BRCR):
  - “Making the best use of a department of clinical radiology: guidelines for doctors”; 1995
II. Imaging Guidelines

- 80-90% of recommendations based on consensus opinion
- Take a long time to develop
- These are not algorithms:
  - do not account of local expertise
  - do not account for patient to patient variations
- Role of a Radiology Consultation Service?
Imaging Modalities

• Ultrasound:
  - adv: ionizing radiation, relatively cheap and accessible. Exam of choice in OB, excellent in the female pelvis
  - disadv: operator dependent, interference from bone, air, fat, difficult in the very obese
Imaging Modalities

• Computed Tomography (CT):
  – adv: no interference from bone, air or fat, easy in the obese, non-operator dependent, rapid exam, easily accessible at most sites
  – disadv: more expensive than US, ionizing radiation, intravenous contrasts with associated costs and risks
Imaging Modalities

• Magnetic Resonance Imaging (MRI):
  – adv. No ionizing radiation, exquisite soft tissue contrast (similar spatial resolution to CT), multiplanar imaging
  – disadv: more expensive than CT, less accessible than US/CT, rapidly changing technology, length of exam longer than CT, patient contraindications
Clinical Problem: Imaging Strategy

- Neuroradiology:
  - acute and chronic headache, low back pain
- Thoracic Radiology:
  - pulmonary embolism
- Abdominal Radiology:
  - bowel obstruction, appendicitis, renal colic, hematuria, common incidental lesions
- Musculoskeletal radiology
  - hip fracture
Case 1

• 40 year old female with acute onset of severe headache and loss of consciousness

• Best study to do first:

• If the first study is normal, the next test:
Best study to do first: CT
Next imaging study: cerebral arteriogram
Head and Neck
Clinical Problem: headache

- **Acute, severe:**
  - CT excellent for intracranial hemorrhage,

- **Chronic**
  - imaging not routinely indicated in the absence of focal signs or symptoms, unless evidence of raised intracranial pressure, posterior fossa signs

- **MRI is superior to CT in the posterior fossa, sellar and juxta-sellar regions**
Case 6

- 24 year old male with 6 wk history of low back pain not improving despite conservative treatment, right S-I radiculopathy

- Best study to do first:

- If first study is normal, the next test:
Best study to do first: MRI
Spine - Clinical Problem: low back pain

- 4-6 weeks of conservative treatment if no ‘red flag’
  - E.g. Malignancy, infection, bladder/bowel symptoms
- Remember that normal patients can have abnormal MRIs
- Need to continue to develop better decision rules and guidelines-
  - ACP October 2007, ACR
  - Embed as decision support in order entry systems
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<tr>
<th>Pain severity (Specify)</th>
<th>Leg weakness left (Specify)</th>
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<tr>
<td>Specify</td>
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<tr>
<td></td>
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<tr>
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<table>
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<td>Acute (&lt;4 weeks)</td>
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<td>Subacute (&gt;4 weeks - &lt;3 months)</td>
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<table>
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<tr>
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<tr>
<td></td>
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<tr>
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<td>Pharmacological therapy</td>
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<table>
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<td>Trauma: chronicity (Specify)</td>
<td>Fracture</td>
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<td></td>
<td>Demyelinating disease</td>
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| IV conscious sedation/anesthesia required                     |                 |
|                                                               |                 |

Ramin Khorasani, MD, MPH, 2011
Patient Name: Oteest, Carol
Birth Date: February 2, 1974
Age: 34 years
Ordering Provider: Khorasani, Ramin, M.D.
Exam: MRI L-Spine
Signs and Symptoms: Pain severity (Specify: mild), Pain duration (Specify: Acute (<4 weeks))
Relevant History: Course of conservative treatment during this episode (Specify: None)
Created By: N/A
Ordering Site: Primary Care Assoc of Norwood

Decision Support
Based on published evidence MRI is not recommended in the absence of clinical "red flags". If symptoms are disabling, consider consultation with the comprehensive spine center at 617-732-6860.

Clinical guidelines from the American College of Physicians and American Pain Society: Clinicians should perform diagnostic imaging and testing for patients with low back pain when severe or progressive neurologic deficits are present or when serious underlying conditions are suspected on the basis of history and physical examination (strong recommendation, moderate-quality evidence).

Please note that the information is presented to assist you in providing care to your patients. We do not provide advice regarding the appropriateness of coding, billing or claims processing. We make no representations regarding the payment or reimbursement for services rendered.

Add Indications  Ignore  Cancel
Comments:

Advise,

**Source 1:** Diagnosis and Treatment of Low Back Pain: A Joint Clinical Practice Guideline from the American College of Physicians and the American Pain Society

- **Recommendation 3:** Clinicians should perform diagnostic imaging and testing for patients with low back pain when severe or progressive neurologic deficits are present or when serious underlying conditions are suspected on the basis of history and physical examination (strong recommendation, moderate-quality evidence).

- **Recommendation 5:** Clinicians should provide patients with evidence-based information on low back pain with regard to their expected course, advise patients to remain active, and provide information about effective self-care options (strong recommendation, moderate-quality evidence).

- **Recommendation 6:** For patients with low back pain, clinicians should consider the use of medications with proven benefits in conjunction with back care information and self-care. Clinicians should assess severity of baseline pain and functional deficits, potential benefits, risks, and relative lack of long-term efficacy and safety data before initiating therapy (strong recommendation, moderate-quality evidence). For most patients, first-line medication options are acetaminophen or nonsteroidal anti-inflammatory drugs.


**Source 2:** American College of Radiology

**ACR Appropriateness Criteria** [American College of Radiology Appropriateness Criteria pdf](http://www.acr.org/Portals/0/PDF/cr/Accuracy/ACR_Claims_Accuracy.pdf)

**Indications of a more complicated status, often termed**

"red flags," include the following:

- Recent significant trauma, or milder trauma, age > 50
### Decision Support

A peer-to-peer consultation is required in order to submit an order.

Peer-to-peer consultation is available Monday - Friday 8 am - 6 pm. Please page Percipio Support at pager #38409 during off hours.

For a faster response, please be sure to enter a direct call back number in the space provided below.

Click the "SEND PAGE" button for peer-to-peer consultation.

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<th>Name</th>
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Enter the peer-to-peer consultation number here: 

Please note: If you have not received a callback within 15 minutes of clicking the "SEND PAGE" button, please page Percipio Support at pager #38409.
Case 8

- 73 F, with acute SOB, pleuritic chest pain, moderate clinical suspicion for acute PE

- Best study to do first:

- If the study is normal, the next test:
<table>
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<tr>
<th>Decision Support</th>
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<td>To accurately assess the probability of pulmonary embolism in this patient based on Well's Criteria you MUST check all that apply below.</td>
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<tr>
<td>□ Clinical Signs and Symptoms of DVT</td>
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<tr>
<td>□ PE is #1 Diagnosis, or Equally Likely</td>
</tr>
<tr>
<td>□ Heart Rate &gt;100</td>
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<tr>
<td>□ Immobilization at least 3 days, or Surgery in the Previous 4 weeks</td>
</tr>
<tr>
<td>□ Previous, objectively diagnosed PE or DVT</td>
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<td>□ Hemothysis</td>
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<tr>
<td>□ Malignancy with Treatment within 6 months, or palliative</td>
</tr>
<tr>
<td>□ None of the Above</td>
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</tbody>
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Please see "More Info" for references.

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Case 9

- 32 Y.O. Female with Braca1 gene mutation. Need to screen for breast cancer.

- Best study to do first:

- If the first study is normal, the next test:
42 y/o  BRCA 1  
ER/PR  Her2/Neu Negative  
High Grade Invasive Ductal Carcinoma (IDC)  
No Ductal Carcinoma In situ (DCIS)

MR post contrast shows round rim enhancing mass  
Axial delayed MR shows washout delayed kinetics  
Ultrasound shows an oval mass with irregular margins
56 y/o, Strong Family History; BRCA Negative
ER/PR Her2/neu Negative
High Grade IDC
High grade DCIS

Contrast enhanced MRI shows an oval mass with irregular margins and rim enhancement. Around the mass is non-masslike enhancement worrisome for DCIS
57 y/o BRCA 2
ER/PR Her2/Neu Negative
Intermediate Grade IDC
No DCIS

Oval mass with irregular margins
Heterogeneous internal enhancement

US shows irregular mass
Angular margins
33 year old BRCA 1
ER/PR Her2/Neu Negative
Grade III IDC

Large round mass with rim enhancement
Breast MRI and breast cancer

- Established yearly screening tool adjunct to mammography in high risk population—e.g. Braca1 gene mutation
- It is being used [with large variation in practice] in staging of newly diagnosed breast cancer primarily to look for multi-centric disease
  - Need to develop evidence on use of MRI in this context to improve patient outcomes
- Other screening use not supported by current evidence
Case 10

• 42 F with acute onset lower abdominal pain, N/V, no fever, normal WBC, no prior surgical history, you are worried about an acute small bowel obstruction

• Best study to do first:

If the first study is normal, the next test:
Abdomen
utility of “KUB”

• Excellent for suspected perforation (supine abdomen, erect CXR),
• If suspected bowel obstruction with history of prior obstruction (supine and upright)
• In most other instances not very helpful as negative or positive result usually leads to another imaging test such as CT or US
Abdomen-Clinical Problem: Small bowel obstruction

- "KUB" good first test if:
  - prior surgery, obstruction;
  - may be normal rarely in acute obstruction
- Acute SBO:
  - if further imaging, CT better than small bowel follow through (barium study) to diagnose obstruction and its etiology
- Chronic or recurrent SBO:
  - CT enterography
- CT to look for other etiologies for pain
mucosal hyperenhancement: segmental attenuation greater than adjacent jejunum or ileum (+/- wall thickening [> 3mm])
Case 11

• 24 F, with 2 day history of RLQ pain, anorexia, fever, no prior surgical history, peritoneal signs in the RLQ, WBC = 12k, negative BHCG

• Best study to do first

If first study is normal, the next test:
Case 12

• 24 M diabetic with 2 day history of RLQ pain, fever, WBC = 6k, elevated blood sugars, could be acute appendicitis

• Best study to do first:

• If first study is normal, the next test:
Case 12 variant

• RLQ pain x2days, 16 wks pregnant

• Best study to do first:

• If first study is normal, the next test:
Abdomen-Clinical Problem: appendicitis

• Clinical diagnosis, imaging not routinely indicated
• If equivocal clinical diagnosis: CT is test of choice in this scenario with sensitivity and specificity > 95%
• In pregnancy, ultrasound in expert hands, MRI best test
• NEJM
  – 1/98: CT on all patients with RLQ pain-not standard of care
  – 2008- CT decreased negative appendectomy rate to <2%
• BWH
  – NAR 30% in females, 12% in males in 1990
  – NAR 1.5% females, 1.8% males in 2007
  – >95% of appendectomies had preoperative CT
  – 14.6% of CT for appendicitis went to OR
  – Estimate 20 CT per 1 less appendectomy-need further studies
Case 13

• 25 M, acute onset of right renal colic, hematuria

• Best study to do first:

• If the first study is normal, the next test:
Abdomen
Clinical Problem: renal colic

• Most common imaging strategy used to be “KUB” followed by IVP or US if necessary. IVP had been considered the gold standard.

• Spiral CT without oral or IV contrast is now the examination of choice replacing “KUB” and IVP
  – similar radiation dose
  – 5 – 10 minute study, no IV contrast
  – Can see all stones
Case 13-variant

- 45 M, with unexplained hematuria

- Best study to do first:

- If the first study is normal, the next test:
CT Urography-
volumetric imaging

- Non-contrast 3 mm axial reconstruction
  - ? renal stones,
- IV-contrast-nephrographic phase imaging (100 seconds)
  - ? Enhancing mass (?renal cell carcinoma)
- IV saline, 10 mg lasix- axial, coronal reconstruction-pyelographic phase (15 min)
  - ? Urothelial lesion-upper tracts, bladder
How about harm from radiation exposure?

- ‘Substantial’ concern for harm from radiation exposure from Medical Imaging, esp CT-
  - Real but overblown in the media
- 1-2% potential (many assumptions) incrementally increased risk of malignancy over baseline of approximately 40% lifetime cancer risk in US
How about harm from CT radiation exposure?

- If CT is clinically appropriate and superior to other imaging modalities, its benefits substantially exceed the potential harm.
- We do need better science to more accurately assess risk.
Case 14

- 45 F with an incidental 2.5 cm right adrenal mass found on CT, performed to elevate an incidental liver lesion on RUQ US looking for gallstones!

- Best study to do first:

If the first study is normal, the next test:
In-Phase

Out of Phase
A: Unenhanced CT HU= 29
B: Enhanced            HU= 73
C: 15 min.           HU= 44

Absolute enhancement washout= 
\[(73-44)/(73-29)\times100= 66\%\]

“Lipid-poor” Delayed Washout
Case 14a

- 56 F with a right lung mass, ipsilateral mediastinal nodes on CT with 2 cm right adrenal mass, Adrenal metastasis?

- Best study to do first:

- If the first study is normal, the next test:
Abdomen-Clinical Problem: adrenal lesion

• Adrenal imaging predominantly anatomic, diagnosis of functional adrenal tumors requires biochemistry

• In patients with an incidental adrenal lesion or those with a primary malignancy, a non-contrast CT, limited adrenal MR, washout CT, or occasionally PET CT may obviate the need for follow up or biopsy
Case 15

- 45 M, medical malpractice lawyer, found to have an incidental 6 cm simple right renal cyst on abdominal ultrasound

- Best study to do first:

- If first study is normal, the next test:
Case 16

- 73 F, who has a 2 cm echogenic mass in the liver found incidentally on ultrasound, no prior medical history

- Best study to do first:

- If first study is normal, the next test:
CT with Contrast

T2 Weighted MRI
Dynamic MRI sequence with Gadolinium: FNH
Incidental Liver lesions

- Great majority are benign cysts, hemangiomas - diagnosis can be made on ultrasound, CT, MRI
- If no prior malignancy, indeterminate solitary <15 mm hepatic lesion is highly likely to be benign (>98%), options:
  - Do nothing
  - Re-image in 6-12 months - show stability - then stop
  - Make benign diagnosis with MRI then stop
Incidental Liver lesions

• Modality of choice for characterization is MRI
Case 17

• 52 M physician, s/p fall with right hip pain, unable to move right hip

• Best study to do first:

• If the first study is normal, the next test:
Best study to do first: Plain films
Next imaging study?:

- MRI
Musculoskeletal Clinical Problem: ? Hip fracture

- Plain films are the first choice
- Normal plain films, high clinical suspicion: MRI is the study of choice to exclude occult fracture
Case 18

- 52 M, with Rheumatoid arthritis, diabetes and chronic renal insufficiency, with new 3 cm brain lesion on CT done for headache

- Best study to do first:

- If the first study is normal, the next test:
Nephrogenic Systemic Fibrosis (NSF) is a rare disease that has been described in patients with renal insufficiency receiving intravenous MRI contrast material (gadolinium). In rare cases NSF has resulted in lung or heart failure and patient death.

Patients with the following conditions may be at increased risk for severe renal insufficiency (eGFR <30) and therefore at increased risk for NSF:

- Personal or family history of kidney failure
- Diabetes Mellitus treated with oral hypoglycemic and/or insulin
- Multiple Myeloma or other paraproteinemia syndromes or diseases
- Lupus or other collagen vascular diseases

Other conditions that have been associated with NSF include:

- Current dialysis treatment
- Acute renal failure
- Hepatorenal syndrome
- Awaiting or 6 weeks status post liver transplantation
- End stage liver disease

1) Do any of the above conditions apply?
   - Yes
   - No

2) Is the patient currently taking Cox-1 or Cox-2 inhibitors nonsteroidal anti-inflammatory drugs (e.g., naproxen, celecoxib, ibuprofen)?
   - Yes
   - No

This information is presented to assist you in providing care to your patients. It is your responsibility to exercise your independent medical knowledge and judgment in providing what you consider to be in the best interest of the patient.
Policy:

1. Guidelines for patients who are not on dialysis

When contrast-enhanced MR imaging is requested for a patient with renal insufficiency who is not on dialysis, the decision to administer gadolinium will depend on the severity of the renal insufficiency as follows:

- **eGFR > 60 (normal renal function):** The regular dose of gadolinium will be calculated using a weight-based FDA approved formula: 0.1 mmol/kg body weight [0.2ml/kg] with a maximum dose of 20 ml/patient. In some clinical situations, high dose injection will be used. Regardless of the dose used, no informed consent is necessary in these patients with eGFR above 60.

- **eGFR between 30-60 (mild to moderate renal failure):** Gadolinium will be administered using a weight-based FDA approved formula: 0.1 mmol/kg body weight [0.2ml/kg] with a maximum dose of 20 ml/patient. High dose injection should only be used when absolutely necessary (e.g. cardiovascular MRI exams, brain perfusion studies). Regardless of the dose used, no informed consent is necessary in these patients with eGFR between 30 and 60.

- When contrast-enhanced MR imaging is requested for a patient with severe renal insufficiency, (eGFR <30) alternative imaging, if possible, should be considered, to avoid use of gadolinium-based contrast agents. The decision to administer gadolinium should be made after consultation by a radiologist with the referring service. If the use of a gadolinium-based contrast agent is considered to be a medical necessity in these patients, the referring physician and the patient will be informed of the potential risks of developing NSF. An informed consent must be obtained from the patient prior to the administration of gadolinium using a consent form specifically developed for the administration of gadolinium in patients with severe renal impairment. The radiologist covering the MRI section protocolling the MRI study is responsible for obtaining the consent.

**NOTE:** Patients with severe renal failure and the inability to obtain informed consent must be referred to the nephrology service for decision making.
Case 19

• 52 M, no risk factors for colon cancer, has never been screened

• Best study to do first:

• If the first study is normal, the next test:
Case 23

- 25 y.o F with presentation suggestive of appendicitis. There is a 30% chance in your estimation that she has appendicitis. We have a test with 95% sensitivity, 95% specificity. The test is positive. What is the chance that she has appendicitis?
  
  <30%  30-75%  75-90%  >90%
Case 24

- 25 y.o F with presentation unlikely of appendicitis. There is a 2% chance in your estimation that she has appendicitis. We have a test with 95% sensitivity, 95% specificity. The test is positive. What is the chance that she has appendicitis?

<30%  30-75%  75-90%  >90%
Prevalence 30%

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## Prevalence 2%

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“Health” Imaging: screening programs

- Breast cancer: Mammography/digital mammography, breast MRI
- Lung cancer-screening NLST trial 2011
- Coronary calcium scoring-broad screening not validated yet, role of Cardiac PET, multi-slice CT in development
- Colon cancer screening—excellent data on efficacy, currently not reimbursed for general screening
- Whole body screening—not indicated

NEED MANAGEMENT GUIDELINES BEFORE IMPLEMENTING!
III. Recommendations

• Think of how the result of an imaging test may change the management of your patient BEFORE you request an examination

• Give as much clinical information as reasonable on the requisition
  – history more helpful than “rule out”s!!
  – blank requisition may result in a radiologist missing a subtle but important finding
III. Recommendations

• Use your radiologist as a consultant, this is her/his Job!!

• Slides at http://cebi.partners.org