Optimal Imaging Studies for Primary Care: Thorax

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ACR (American College of Radiology) Appropriateness Criteria (acr.org)


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“Then you will know the truth and the truth will set you free.”

Jesus, ~33 AD
John 8: 32

Chest Radiograph (CXR)

- Appropriate initial examination for most chest diseases and suspected cardiovascular problems (Ratings of 8 to 9)
- Minimal relative radiation level
- General assessment of severity of problems of the thorax
### Relative Radiation Level Designations

<table>
<thead>
<tr>
<th>Relative Radiation Level</th>
<th>Effective Dose Estimate Range</th>
<th>Exam</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>0</td>
<td>U/S, Echo, MRI</td>
</tr>
<tr>
<td>Minimal</td>
<td>&lt; 0.1 mSv</td>
<td>CXR</td>
</tr>
<tr>
<td>Low</td>
<td>0.1 – 1 mSv</td>
<td>CTPA, CT, V/Q</td>
</tr>
<tr>
<td>Medium</td>
<td>1 - 10 mSv</td>
<td>CTaor, CTaAbdPulmAngio</td>
</tr>
<tr>
<td>High</td>
<td>10 – 100 mSv</td>
<td></td>
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</tbody>
</table>

### Appropriate CXR

- Monitoring for tubes, lines, ICU patients, post operative patients
- Screening for pulmonary metastases – as baseline for sarcoma, melanoma, H&N Ca’s, renal cell Ca and testicular cancer
- Baseline for staging NSCLC and SCLC

### Appropriate CXR for Cardiovascular Problems

- Acute adult respiratory illness
- Emergent viral infections
- Symptomatic immunocompromised patient
- Chronic dyspnea of suspected pulmonary origin
- Hemoptysis
- Rib fractures – PA only

- Acute Chest Pain – low & high probability of CAD (coronary artery disease), suspected aortic dissection, PE (pulmonary embolism)
- New Congestive Heart Failure
- Chronic Chest Pain
- Dyspnea – suspected cardiac origin
- Bacterial Endocarditis
- Suspected congenital Heart Disease in Adult
“Inappropriate” CXR

- Routine CXR for mild, uncomplicated HTN
- Routine Admission or PreOp CXR in asymptomatic pt. with negative P-exam
- Daily routine portable CXR of stable inpatients, follow up “for tubes and lines”

Moderate utility CXR

- Acute Respiratory Illness in patients <40 yo with N Pexam, no Signs, Symptoms or risk
- Uncomplicated acute asthma
- Acute exacerbation of uncomplicated COPD
- Moderate – severe HTN, stable CHF
- Routine/preop CXR of elderly pt. with prior CXR within 6 months with chronic cardiopulmonary disease

- Adults over 40 years of age presenting with pneumonia should have a follow up CXR(s) to document clearing of the disease.
## Acute Chest Pain

- High probability of CAD: Catheter coronary angiography for therapy, SPECT MPI, stress echocardiography, CTA coronary
- Low probability of CAD: SPECT MPI, coronary CTA, cardiac MRI, echo
- Aortic Dissection, PE: CTA chest & abd, CTPA
- Chronic Chest Pain - evaluated in similar decision fashion (chronic PE)

## Chest CT Indications

- Failure of current therapy for chest problems
- Thoracic Malignancy (often detected on CXR)
- Staging, Metastatic w/u & surveillance
- Adult CHD, vascular evaluation, airway disease
- Trauma
- Chronic respiratory illness with negative CXR

## Breast cancer patient
Type A, (DeBakey II) aortic dissection

Pulmonary Embolism

- 3rd CV death cause in US: #1 IHD, #2 stroke
- Incidence: 300,000 to 600,000
- Difficult to diagnose
- Death in up to 90% unrecognized PE


*Radiologic Clinics of North America
**PE**

- CTPA (CT pulmonary angiography)- MDCT likely the new gold standard
- Availability, Utility of evaluating entire chest
- Sensitivity 83-100%, Specificity 89-97%
- Cost effective
- Radiation: young female, breast 20 mGy = 10-25 mam 2v or 100-400 CXR)

**PE in Pregnancy**

- LE U/S: + Treat; If (-) => CXR
- N CXR: V/Q scan: (+) Tx;
  - Low- Intermed => CTPA
- Abn. CXR: CTPA: (+) Tx,
- CTPA: (-) high clin. suspicion, do additional testing,
- [Neg D-dimer useful in low suspicion of PE]

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**PE in Pregnancy**

- Fleischner Society: LE doppler/US then CTPA
- 3rd Trimester Fetal Dose CTPA: <130 mGy
- V/Q scan Fetal dose: 100-370 mGy
- 9 month in utero background: 1000 mGy
- =20 mGy breast dose: 1/1200-1/3500 Ca risk
- (?Thyroid testing of fetus within One week)
Pre-Test Probability

- In the low and intermediate probability population, negative D-dimer rules out PE.
- If + D-dimer, additional test needed.
- In high-risk patients, no need for D-dimer.
- CTPA, V/Q scan if CXR normal. If neg, LE U/S.
- Repeat CTPA, Q only, serial U/S, pulmonary angiography. (future: MR, C-AD, PIOPED III)

Guidelines for Management of Small Pulmonary Nodules Detected on CT Scans: A Statement from the Fleischner Society; Radiology 2005; 237:395-400

- Fleischner Society: High vs Low Risk, 2 year follow up, average size 4mm or less
- No recommendation for ground glass nodules: BAC, AAH, longer follow up

Solitary pulmonary nodule

- True solitary pulmonary nodule
- 3 cm or less, small nodules 1 cm or less
- Nonenhanced chest CT: calcification
- Enhanced chest CT: hilar node evaluation

Conclusion

- Chest Radiograph
- Acute Chest Pain
- PE management
- Solitary Pulmonary Nodule
Common Indications: Abdomen and Pelvis

- Right Lower Quadrant Pain
- Left Lower Quadrant Pain
- Right Upper Quadrant Pain
- Suspected Small Bowel Obstruction
- Hematuria
- Acute Pancreatitis
- Crohn’s Disease
- Suspected Liver Metastasis

Right Lower Quadrant Pain

- Most common cause is acute appendicitis.
- At most institutions, patients with definitive examination findings of appendicitis will undergo operation without imaging.

Clinical Scenario I:
- Adult or adolescent with fever, leukocytosis and question of appendicitis.
- Study of Choice: CT abdomen and pelvis with IV and oral contrast.
Right Lower Quadrant Pain

- CT abdomen and pelvis with IV and oral contrast
  - Most accurate study for evaluating patients with acute appendicitis

Right Lower Quadrant Pain

- Radiographs have a limited value in diagnosing acute appendicitis even in occasional circumstances when an appendicolith is identified (less than 5% of cases).
- Therefore radiographs are not recommended unless abdominal pain is generalized and other conditions are suspected.

Right Lower Quadrant Pain

- Recently some ER physicians and surgeons have suggested eliminating IV and oral contrast to expedite evaluation.
- Non contrast study may not have the same accuracy as those with contrast.
- May be more useful in the future when radiologists develop more experience regarding the subtleties of interpretation.
### Right Lower Quadrant Pain

- **Clinical Scenario II:**
  - Pregnant patient with fever and leukocytosis.
  - Initial test of choice: Ultrasound of the right lower quadrant with graded compression.

### Right Lower Quadrant Pain

- Some institutions are offering MRI for evaluation of pregnant females with RLQ pain.
- Like ultrasound, also lacks radiation.

### Right Lower Quadrant Pain

- Ultrasound of the right lower quadrant
- Better in 1st and early 2nd trimester

### Left Lower Quadrant Pain

- Most common cause of left lower quadrant pain in adults is acute sigmoid diverticulitis.
- Although patients with typical symptoms or history of diverticulitis may not need imaging for a diagnosis, imaging can detect complications that occur in 15-20% that may need surgery.
Left Lower Quadrant Pain

- Radiographs:
  - Limited in value unless complications such as perforation or obstruction are suspected.
- Barium Enema:
  - Risk for colonic perforation and contamination of the peritoneal cavity.
  - Also lacks evaluation of pericolonic inflammation and abscess.
- CT abdomen and pelvis with IV and oral contrast:
  - Study of choice*

Left Lower Quadrant Pain

- CT can diagnose diverticulitis and potential complications such as abscesses, fistula, obstruction or perforation.

Left Lower Quadrant Pain

- Findings show:
  - Diverticula
  - Surrounding Fat stranding

Left Lower Quadrant Pain

- CT can aid in planning for potential CT guided abscess drainage.
**Left Lower Quadrant Pain**

- Clinical Scenario II:
  - ✓ Fever and Pain in a woman of childbearing age
    - In this setting, gynecological processes such as ectopic pregnancy and pelvic inflammatory disease are also important diagnostic considerations.
  - ✓ Initial test of choice: Ultrasound of the pelvis

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**Right Upper Quadrant Pain**

- Primary diagnosis to be made is acute cholecystitis.
- Both ultrasound and scintigraphy with HIDA (hepatobiliary iminodiacetic acid) demonstrate high sensitivity in diagnosing acute cholecystitis.
- Although HIDA is more specific, ultrasound is more readily available and can be performed quicker.

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**Left Lower Quadrant Pain**

- Ultrasound of the pelvis is more sensitive than CT for the detection of gynecologic abnormalities and also has added benefit of no radiation.

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**Right Upper Quadrant Pain**

- Clinical Scenario I:
  - ✓ Fever, elevated white blood cell count and positive Murphy's sign.
- Study of Choice:
  - ✓ Ultrasound of the right upper quadrant.
**Right Upper Quadrant Pain**

- Initial study of choice:
  - Ultrasound of the right upper quadrant
- US:
  - Gallstones
  - Gallbladder wall thickening
  - Pericholecystic Fluid
  - Positive sonographic Murphy's sign

**Right Upper Quadrant Pain**

- Gallbladder not observed by 60 min. → morphine administered → imaging continued for an additional 30 minutes.
- Nonvisualization of the gallbladder by 90 minutes (with morphine) = acute cholecystitis.

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**Right Upper Quadrant Pain**

- Clinical Scenario II:
  - Suspected acalculous cholecystitis.
- Study of Choice:
  - Scintigraphy with HIDA

**Suspected Small Bowel Obstruction**

- Radiographs have been the traditional starting point for imaging evaluation of suspected small bowel obstruction (SBO).
- However, studies testing the utility of radiographs have shown varying results with some investigators reporting 80-90% success and others yielding 20-40%.
### Suspected Small Bowel Obstruction

- Radiographs are a reasonable initial examination due to lower cost and radiation.

### Suspected Small Bowel Obstruction

- Barium enema-
  - Can exclude large bowel obstruction but is unreliable for diagnosis of SBO.
- Small bowel follow through-
  - Limited by non uniform small bowel filling, intermittent fluoroscopy and length of examination.

### Suspected Small Bowel Obstruction

- If radiographs are negative and clinical suspicion persists, CT abdomen and pelvis with intravenous and oral contrast is recommended.
- CT may also identify site and cause of obstruction.

### Hematuria

- Clinical Scenario: Hematuria with flank pain.
- CT abdomen and pelvis without IV or oral contrast.
**Hematuria**

- Clinical Scenario II:
  - Hematuria, older patient
- CT Urogram
  - Non-contrast through kidneys
  - Post contrast through abdomen and pelvis - Two phases.

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**Acute Pancreatitis**

- US is also effective in diagnosing biliary obstruction which when present, often prompts ERCP to relieve cause of obstruction.

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**Acute Pancreatitis**

- Clinical Scenario I:
  - Etiology unknown, first episode of pancreatitis.
- Initial Study of Choice:
  - Ultrasound of the right upper quadrant.
- US targeted for evaluation of gallstones is recommended in every patient with acute pancreatitis.

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**Acute Pancreatitis**

- Clinical Scenario II:
  - Severe abdominal pain, continued elevation of amylase and lipase for 48 hrs, no change in clinical status.
- Study of Choice:
  - CT abdomen and pelvis with IV and oral contrast.
### Acute Pancreatitis

- CT is an insensitive detector for biliary calculi but is good at delineating the pancreas and peri-pancreatic abnormalities.

### Crohn’s Disease

- **Clinical Scenario I:**
  - Adult, initial presentation (abdominal pain, fever or diarrhea), Crohn’s Disease suspected.
- **Study of Choice:**
  - CT enterography
- **CT enterography differs from standard abdominal CT**
  - Uses neutral enteric contrast to distend bowel
  - Narrower slice thickness and reconstructions

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### Acute Pancreatitis

- CT may not identify the cause of biliary obstruction.
- If further imaging is required this is usually accomplished with ERCP or MRCP.

### Crohn’s Disease

- **CT enterography**
  - Allows evaluation of mucosal enhancement (indicator of active disease) which would have been obscured by positive contrast (barium).
- **Findings:**
  - Mucosal Hyperenhancement
  - Bowel wall thickening
  - Mural stratification
  - Hyperemic vasa recta
Crohn’s Disease

- Clinical Scenario II:
  - Adult with known Crohn’s disease, fever, pain and leukocytosis.
- Study of Choice:
  - Routine CT
    - Used to evaluate extra-enteric complications of Crohn’s Disease such as bowel obstruction, abscess and fistula.
  - MRI
    - Preferred study for evaluating perianal complications of Crohn’s Disease.

Suspected Liver Metastasis

- Clinical Scenario:
  - Newly diagnosed primary cancer (rule out liver metastasis) or surveillance following treatment of primary tumor.
- Preferred examination:
  - CT abdomen and pelvis with IV and oral contrast*

Suspected Liver Metastasis

- Most hepatic metastasis are hypovascular when imaged with routine post contrast CT (portal venous phase).
- In general, imaging with routine CT is adequate to detect most hepatic lesions.

Suspected Liver Metastasis

- Hypervascular lesions are seen best in the arterial phase.
- Hypervascular Metastasis:
  - Renal cell carcinoma
  - Carcinoid
  - Islet cell carcinoma
  - Thyroid cancer
  - Melanoma
  - Neuroendocrine tumor
- Addition of arterial phase in these cases (dual phase CT)
**Suspected Liver Metastasis**

- MRI
  - More sensitive than contrast enhanced CT for detecting individual hepatic metastasis
- PET
  - Limited in demonstrating small liver metastasis (under 1cm).

**Conclusion**

- Discussed common clinical scenarios that may be encountered in primary care and the optimal imaging studies recommended by ACR for each scenario.

**Acute Pancreatitis**

- Right Upper Quadrant Pain
  - Gallbladder not observed by 60 min but is seen after morphine administration → abnormal gallbladder function.
  - Gallbladder is observed in a clinical setting of biliary pain or chronic calculous or acalculous cholecystitis → CCK is infused for the measurement of the ejection fraction. (EF under 35% = chronic cholecystitis).
Acute Hand and Wrist Trauma

- Radiographs first exam for wrist trauma, suspected fracture or dislocation.
- Confirmed distal radius fracture; surgical planning => CT.
- Initial radiographs negative, clinically suspect scaphoid or distal radius fracture: cast and repeat radiographs 10-14 days or MRI (w/o contrast)
- CT as alternative to MRI in contraindicated patients
**Acute Hand and Wrist Trauma**

- Suspected distal radial ulnar joint (DRUJ) subluxation: bilateral wrist CT with supinated and pronated views + radiographs of affected side.
- Suspected hamate fracture, initial radiographs normal or equivocal => special x-ray views (semisupinated or carpal tunnel view) or CT.
- Suspected game keepers thumb injury: thumb radiographs; stress views* or US*. MRI if radiographs negative.

**Acute Trauma to the Knee**

- Fall or twisting injury with one or more of: effusion, focal tenderness, inability to bear weight => first study => radiographs.
- MVA w/ suspected posterior knee dislocation => radiographs and MRI can be done initially, +/- MRA, CTA or conventional arteriography.
Non-acute or Non-traumatic Knee Pain

- Initially radiographs. If nondiagnostic (normal or effusion) or w/ evidence of internal derangement => MRI.
- Child w/ radiographs demonstrating osteochondral injuries => MRI +/- arthrogram.
- Adult initial radiographs demonstrate inflammatory, crystalline or DJD – no further imaging needed.
- Initial radiographs demonstrate AVN => MRI if needed for therapy.

Shoulder Trauma

- R/O fracture or dislocation (acute trauma) => Grashey views with internal/external rotation with scapular-Y and/or axillary view.
- Subacute pain, suspect RTC tear/impingement, over age 35, initial radiographs neg or with osteophytosis => MRI; US*.
- Under age 35: MR arthrogram (if available); high field MRI may be good alternative.
- MR Arthrography study of choice in suspected instability/labral tear.
Suspected Spine Trauma

• NEXUS and CCR studies determining clinical criteria for imaging in c-spine trauma.*
• Imaging indicated by above criteria: CT. MR can be done concurrently and can offer complimentary information.
• Myelography if MRI contraindicated.
• Radiographs only recommended as follow up in patient with no unstable injury initially, but kept in collar for pain – re-evaluation.
### Suspected Spine Trauma


### Chronic Ankle and Foot Pain

- Chronic ankle pain – radiographs best initial study.
- MRI if radiographs normal and suspected instability, osteochondral injury, impingement or tendonopathy. MRA or US.*

### Stress/Insufficiency Fracture

- Radiographs required first step.
- Not hip or sacrum - repeat in 10-14 days. Can do MRI if anxious patient or repeat radiographs negative.
- In hip/sacrum, rec bone scan with or after initial radiographs. If bone scan positive or equivocal, may get MRI for confirmation or further eval.
- Ddx stress fracture vs metastasis long bone, initial radiographs neg, bone scan not specific – MRI; in sacrum CT usually diagnostic for fracture.
- Osteoporotic patients => MRI after initial radiographs as bone scan may give false negative in this population.

### Chronic Ankle and Foot Pain

- Child with rigid, flat foot; r/o tarsal coalition => radiographs; CT secondary but complimentary.
- Reflex sympathetic dystrophy: Tc-99 bone scan if radiographs neg.
- Frieberg's infraction: radiographs.
- Suspected tendonopathy, athlete with pain over navicular, plantar fasciitis, tarsal tunnel syndrome => MRI w/o contrast.
- Evaluation of inflammar arthropathy, suspected Morton's neuroma => MRI WITH contrast.
### Chronic Hip Pain

- Radiographs – AP and frog leg lateral.
- X-rays neg => suspect OA, AVN or surrounding soft tissue abnl – MRI; suspect osteoid osteoma – CT.
- Suspect labral tear +/- femoroacetabular impingement symptoms => MR Arthrography.
- X-rays neg. Suspect referred pain but want to rule out hip – Differential injections with local anesthetic +/- corticosteroid.

### Chronic Neck Pain

- Radiographs.
- After radiographs, if neurologic signs or symptoms => MRI. Myelography if MRI contraindicated.
Diabetic Foot with Suspected Osteomyelitis

- Soft tissue swelling without ulcer or neuropathy: radiographs and MRI with contrast are complimentary and both indicated.
- In-111 WBC scan if MRI contraindicated.
- Neuropathy with ulcer +/- exposed bone: recommendations are same => x-ray and MRI complimentary.
- Neuropathy without ulcer: x-rays and MRI complimentary. CT if MRI contraindication. Tc-99m 3 phase bone scan may be helpful for pre-radiographic findings of disease or if MRI contraindicated.

Primary Bone Tumors

- Radiographs absolute requirement for suspected bone lesions.
- MRI if persistent symptoms but radiographs neg. Can do Tc-99m bone scan but MRI more sensitive and specific.
- Benign lesions – CT depending on size, location and type of lesion.
- Osteoid osteoma – CT. Bone scan helpful to localize if radiographically occult.
Primary Bone Tumors

- Aggressive features on radiographs => MRI.
- CT may be helpful to evaluate for areas of cortical breakthrough or pathologic fracture or if MRI unavailable.
- PET/CT +/- in initial work-up. Can be overlap in benign and malignant lesions. Sometimes useful for follow up to distinguish post surgical change from recurrence or metastases.

Soft Tissue Masses

- Radiographs should be done initially but often more advanced imaging still needed.
- For most lesions, MRI with contrast is study of choice.
- Chest or abdominal wall lesions may be better evaluated with CT.
- US may be useful, particularly in periarticular locations (poss synovial or Bakers cyst) or in the foot (Morton's neuroma).
References

- All images from The Ohio State University Medical Center.