Optimal Imaging Studies for Primary Care: Thorax

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

Radiologic Clinics of North America: Vol 48, Issue1 (1/2010), WB Saunders

STR Meeting, 3/2010

"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

Relative Radiation Level	Effective Dose Estimate Range	Exam
None	0	U/S, Echo, MRI
Minimal	< 0.1 mSv	CXR
Low	0.1 – 1 mSv	
Medium	1 - 10 mSv	CTPA, CT, V/Q
High	10 – 100 mSv	CTAcor, CTAchAbd PulmAngio

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

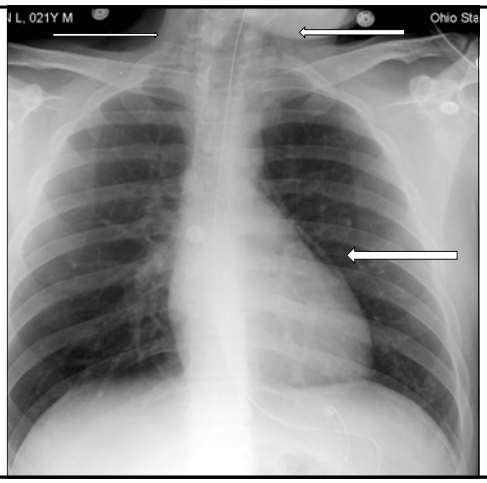
- **Acute adult respiratory illness**
- **Emergent viral infections**
- **Symptomatic immunocompromised patient**
- **Chronic dyspnea of suspected pulmonary origin**
- **Hemoptysis**
- **Rib fractures –PA only**

CXR for Cardiovascular Problems

- **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”**



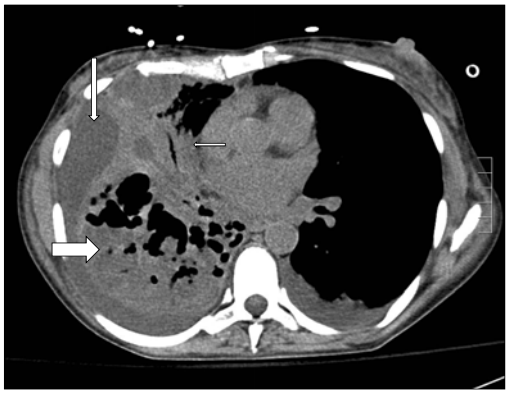
Moderate utility CXR

- **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

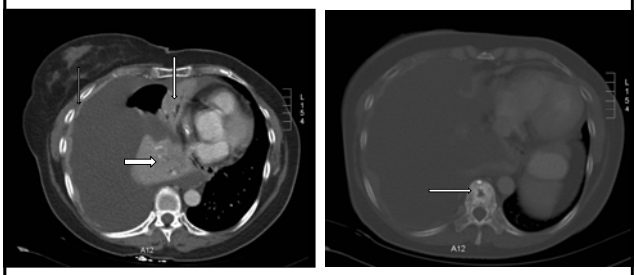
- **High probability of CAD: Catheter coronary angiography for therapy, *SPECT MPI, stress echocardiography, CTA coronary**
- **Low Probability of CAD: SPECT MPI, coronary CTA, cardiac MRI, echo**
- **Aortic Dissection, PE: CTA chest & abd, CTPA**
- **Chronic Chest Pain - evaluated in similar decision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

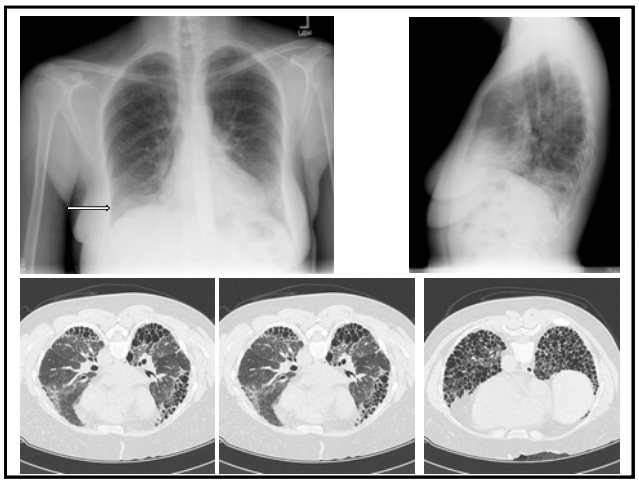


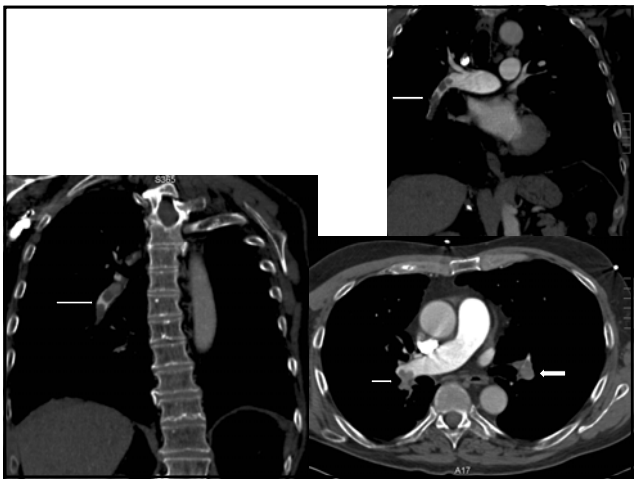
Chest CT Indications

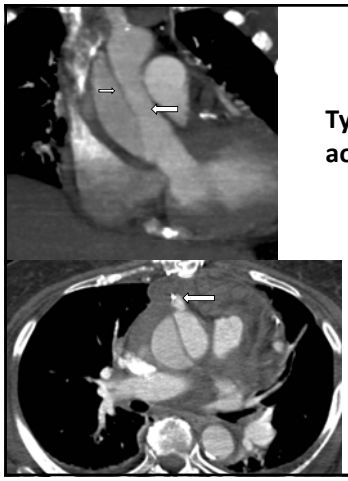
- **Failure of current therapy for chest problems**
- **Thoracic Malignancy (often detected on CXR)**
- **Staging, Metastatic w/u & surveillance**
- **Adult CHD, vascular evaluation, airway disease**
- **Trauma**
- **Chronic respiratory illness with negative CXR**

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

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*Radiologic Clinics of North America

PE

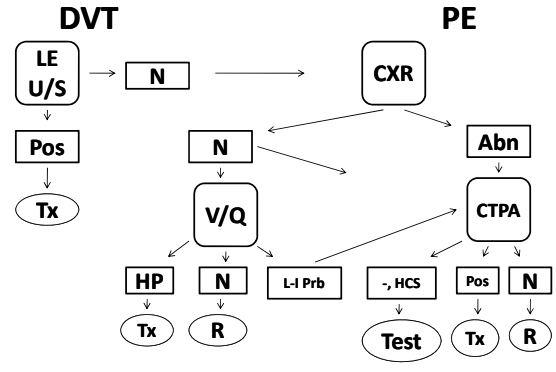
- CTPA (CT pulmonary angiography)- MDCT likely the new gold standard
- Availability, Utility of evaluating entire chest
- Sensitivity 83-100%, Specificity 89-97%
- Cost effective
- Radiation: young female, breast 20 mGy = 10-25 mam 2v or 100-400 CXR)

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

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

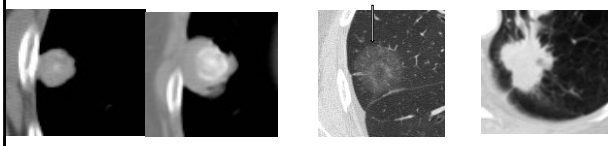
- In the low and intermediate probability population, negative D-dimer rules out PE.
- If + D-dimer, additional test needed.
- In high-risk patients, no need for D-dimer.
- CTPA, V/Q scan if CXR normal. If neg, LE U/S.
- Repeat CTPA, Q only, serial U/S, pulmonary angiography. (future: MR, C-AD, PIOPED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

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

- Fleischner Sociiety: 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
- Nonenhansed chest CT : calcification
- Enhansed chest CT: hilar node evaluation



Conclusion

- Chest Radiograph
- Acute Chest Pain
- PE management
- Solitary Pulmonary Nodule

Optimal Imaging Studies for Primary Care: Abdomen and Pelvis

Dr. Mitva Patel

American College of Radiology Appropriateness Criteria®

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.**

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

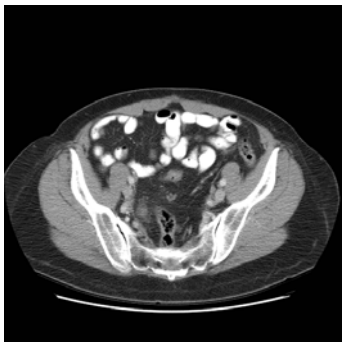
- **Clinical Scenario I:**
  - ✓ **Adult or adolescent with fever, leukocytosis and question of appendicitis.**
  - ✓ **Study of Choice: CT abdomen and pelvis with IV and oral contrast.**

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

- CT has been reported to show a non-appendicitis cause of pain in 20% of patients.



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

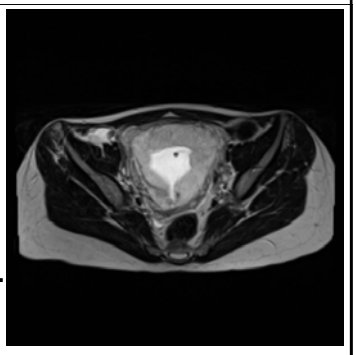
- Radiographs have a limited value in diagnosing acute appendicitis even in occasional circumstances when an appendicolith is identified (less than 5% of cases).
- Therefore radiographs are not recommended unless abdominal pain is generalized and other conditions are suspected.

Right Lower Quadrant Pain

- **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

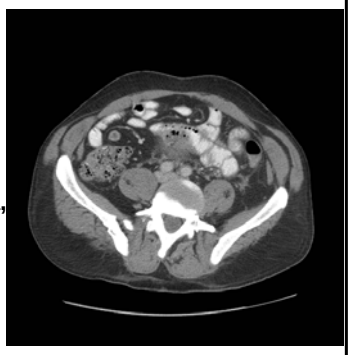
- **Most common cause of left lower quadrant pain in adults is acute sigmoid diverticulitis.**
- **Although patients with typical symptoms or history of diverticulitis may not need imaging for a diagnosis, imaging can detect complications that occur in 15-20% that may need surgery.**

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

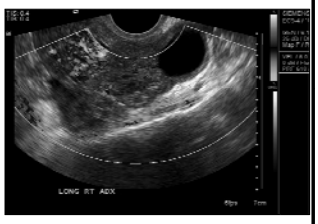
- **Clinical Scenario II:**
  - ✓ **Fever and Pain in a woman of childbearing age**
    - **In this setting, gynecological processes such as ectopic pregnancy and pelvic inflammatory disease are also important diagnostic considerations.**
  - ✓ **Initial test of choice: Ultrasound of the pelvis**

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.**

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.**

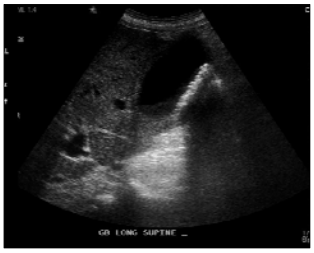


Right Upper Quadrant Pain

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

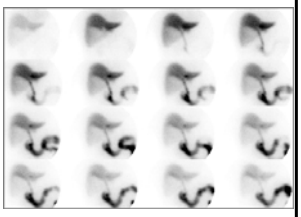
Right Upper Quadrant Pain

- **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.**



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

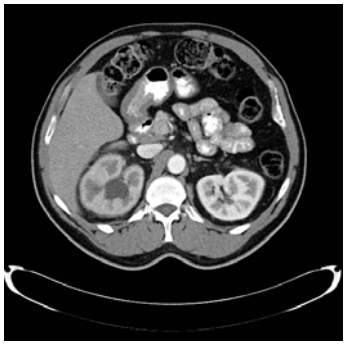
- If radiographs are negative and clinical suspicion persists, CT abdomen and pelvis with intravenous and oral contrast is recommended.
- CT may also identify site and cause of obstruction.

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.



Acute Pancreatitis

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

Acute Pancreatitis

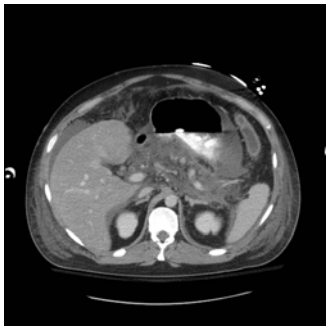
- Clinical Scenario I:
  - ✓ Etiology unknown, first episode of pancreatitis.
- Initial Study of Choice:
  - ✓ Ultrasound of the right upper quadrant.
- US targeted for evaluation of gallstones is recommended in every patient with acute pancreatitis.

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.**

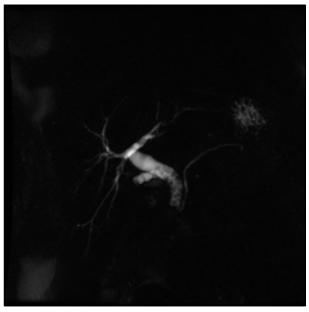


Crohn's Disease

- **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**

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

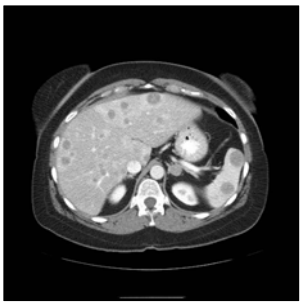
- **CT enterography**
  Allows evaluation of mucosal enhancement (indicator of active disease) which would have been obscured by positive contrast (barium).
- **Findings:**
  - ✓ **Mucosal Hyperenhancement**
  - ✓ **Bowel wall thickening**
  - ✓ **Mural stratification**
  - ✓ **Hyperemic vasa recta**

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

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

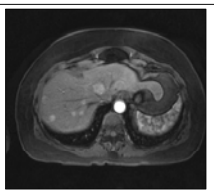


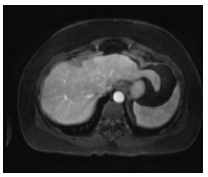
Suspected Liver Metastasis

- 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

- 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).**

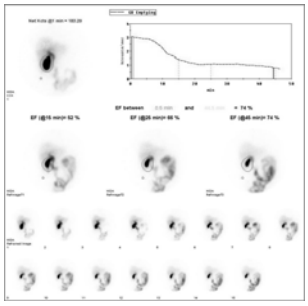
Acute Pancreatitis

Conclusion

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

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).**



Optimal Imaging Studies for Primary Care

Musculoskeletal Indications

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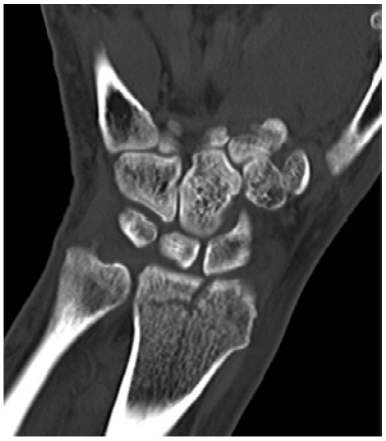
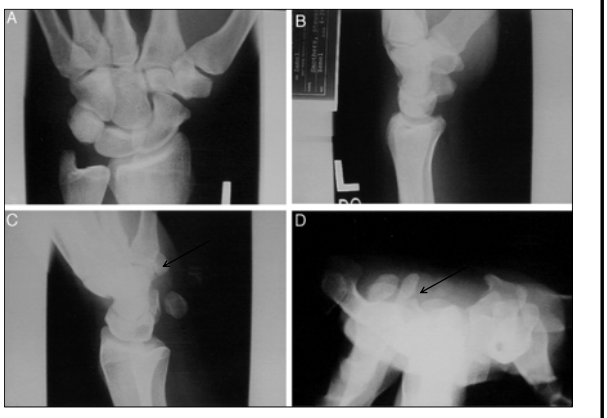
Acute Hand and Wrist Trauma

- **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.**



http://ajs.sagepub.com/content/31/1/106/F4.large.jpg

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.**

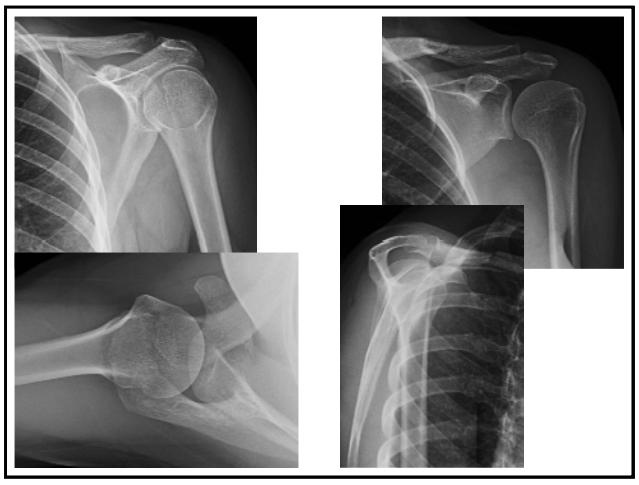
Wright, L. et al. Radiographics March 2004, 24, 467-479

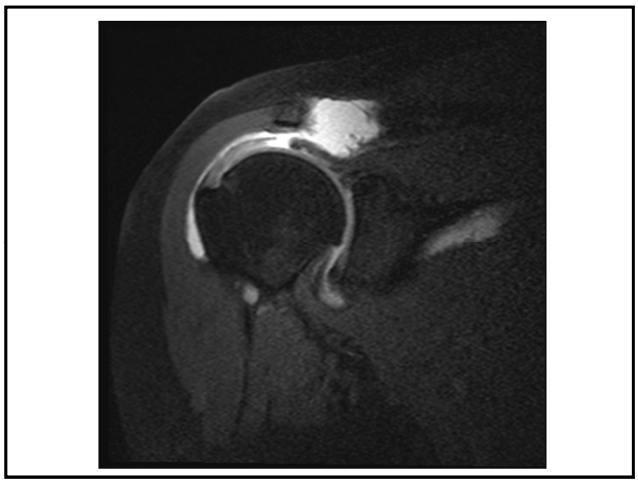

Non-acute or Non-traumatic Knee Pain

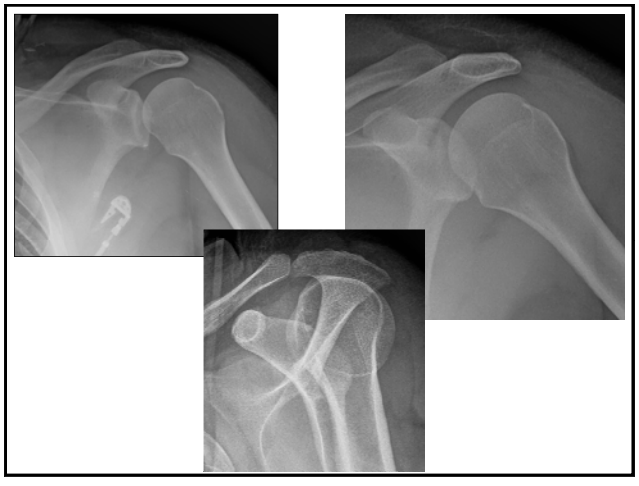
- **Initially radiographs. If nondiagnostic (normal or effusion) or w/ evidence of internal derangement => MRI.**
- **Child w/ radiographs demonstrating osteochondral injuries => MRI +/- arthrogram.**
- **Adult initial radiographs demonstrate inflammatory, crystalline or DJD – no further imaging needed.**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

- Hoffman JR, Mower WR, Wolfson AB, Todd KH, Zucker MI. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. National Emergency X-Radiography Utilization Study Group. *N Engl J Med 2000; 343(2):94-99.*
- Stiell IG, Wells GA, Vandemheen KL, et al. The Canadian C-spine rule for radiography in alert and stable trauma patients. *JAMA 2001; 286(15):1841-1848.*

Chronic Ankle and Foot Pain

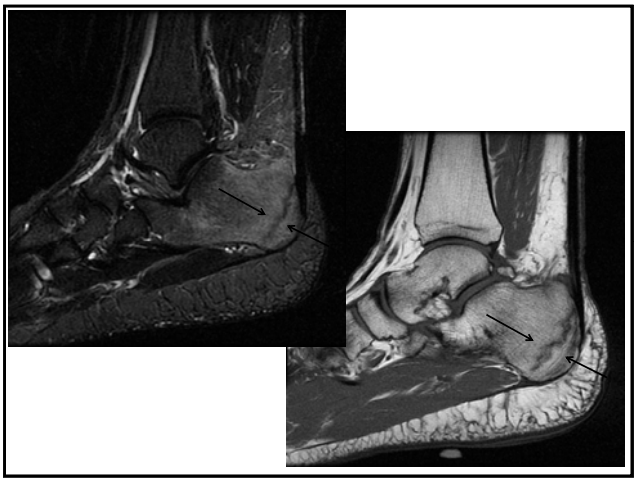
- Chronic ankle pain – radiographs best initial study.
- MRI if radiographs normal and suspected instability, osteochondral injury, impingement or tendonopathy. MRA or US.*

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 inflamm arthropathy, suspected Morton's neuroma => MRI WITH contrast.

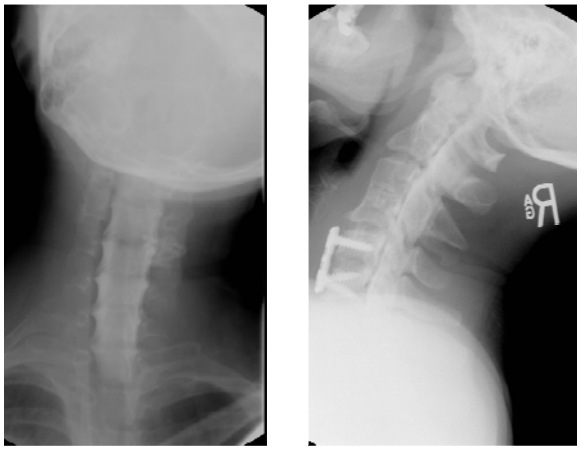


Chronic Neck Pain

- **Radiographs.**
- **After radiographs, if neurologic signs or symptoms => MRI. Myelography if MRI contraindicated.**

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.**



Diabetic Foot with Suspected Osteomyelitis

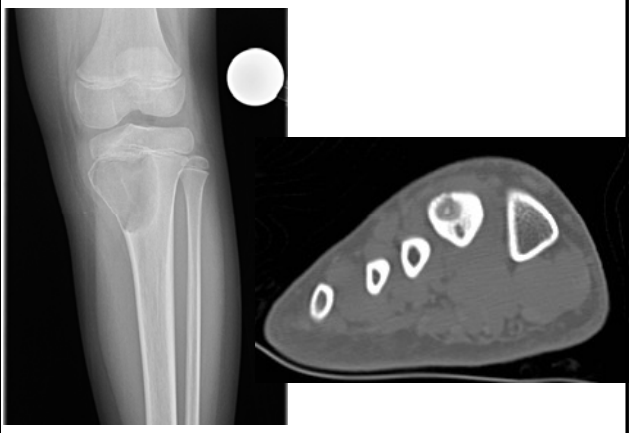
- Soft tissue swelling without ulcer or neuropathy: radiographs and MRI with contrast are complimentary and both indicated.
- In-111 WBC scan if MRI contraindicated.
- Neuropathy with ulcer +/- exposed bone: recommendations are same => x-ray and MRI complimentary.
- Neuropathy without ulcer: x-rays and 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

- **ACR Appropriateness Criteria: http://www.acr.org/secondarymainmenucategories/quality_safety/app_criteria.aspx**
- **All images from The Ohio State University Medical Center.**