Imaging: What to order when

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Disclosures

No relevant financial relationships or conflicts of interest.

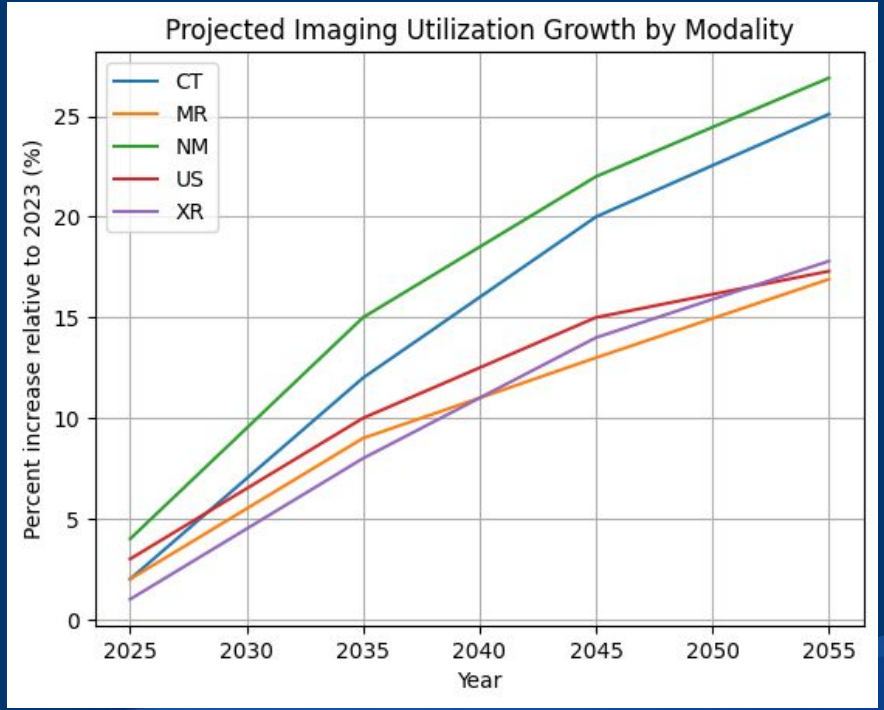
Learning Objectives

- Imaging trends, risk, cost and downstream effects of imaging.
- Differentiate the strengths and limitations of different modalities
- Review ACR Appropriateness Criteria
- Identify common and nuanced imaging misorders
- Recognize clinical scenarios that require specialized protocols and when contrast is needed

Imaging Trends

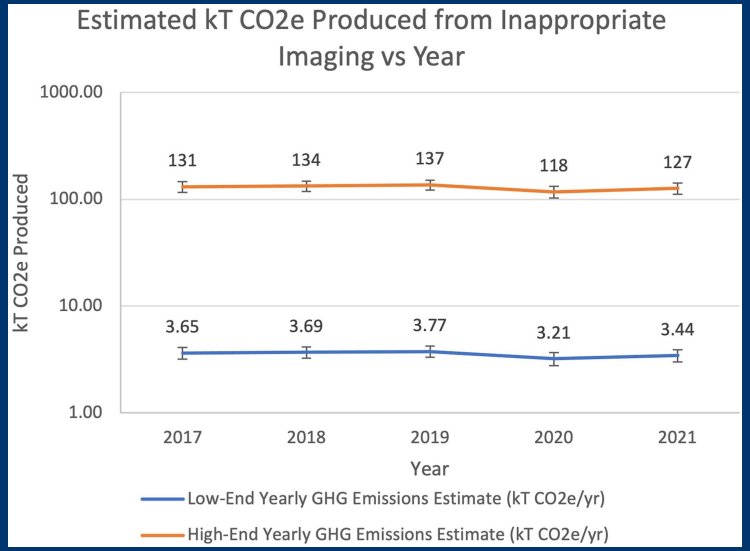
- Imaging utilization is projected to increase 16.9 - 26.9%
- CT utilization: projected to be 45% - 59% higher by 2055
- **Low-value or redundant imaging delays care, increases financial burden and strains systems on clinically meaningful studies**

Duszak et al. *J Am Coll Radiol*. 2025.



Why it matters

- Medical imaging costs the U. S. **$12 billion annually for “low value” imaging in the US**
- **20–50%** of examinations reported to be inappropriate or of “low value” or minimal to no benefit to patient care.
- 3.6 o 129 kilotons of excess carbon dioxide per year - electricity for up to 70,000 people for an entire year



Kjelle E et al. *Applied Health Economics and Health Policy*. 2024;22:485–501

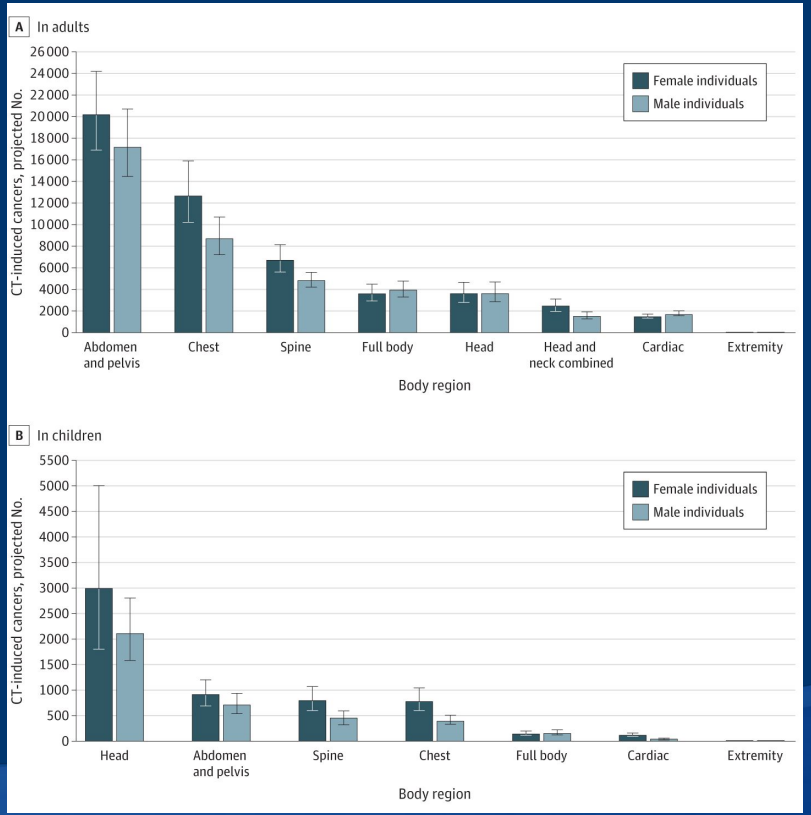
Why it matters

JAMA Internal Medicine | Original Investigation | LESS IS MORE

Projected Lifetime Cancer Risks From Current Computed Tomography Imaging

Rebecca Smith-Bindman, MD; Philip W. Chu, MS; Hana Azman Firdaus, MPH; Carly Stewart, MHA; Matthew Malekhedayat, BS; Susan Alber, PhD; Wesley E. Bolch, PhD; Malini Mahendra, MD; Amy Berrington de González, DPhil; Diana L. Miglioretti, PhD

Approximately 5% of annual cancer diagnoses were projected to result from CT utilization in 2023, comparable to alcohol (5%) and obesity (7-8%).

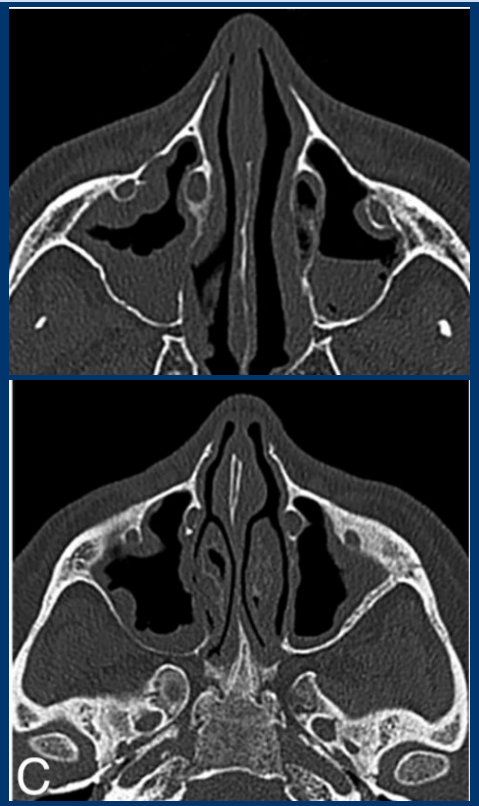


Always Ask

- What is my pretest probability?
- Will the result change management?
- Is this the right modality?
- Do I need contrast?
- Does this require a specialized protocol?

Will imaging help or change management?

- CT sinus not indicated for uncomplicated sinusitis
- 88% of sinus CTs were negative, 12% with features concerning for acute sinusitis
- 0 cases influenced antibiotic use
- **Top right (symptomatic), bottom right (asymptomatic)**



Hazhirkarzar et al. *Am J Neuroradiol.* 2025;46(10):2162–2167.

Choosing the right modality

Which of the following modalities have the highest spatial resolution?

a) Radiographs (X-ray)

b) Computed Tomography (CT)

c) Ultrasound

d) Magnetic resonance imaging (MRI)

Which of the following modalities have the highest contrast resolution?

a) Radiographs (X-ray)

b) Computed Tomography (CT)

c) Ultrasound

d) Magnetic resonance imaging (MRI)

Choosing the right modality

Modality	Best For	Strengths	Limitations
Radiograph	Bone, lungs, hardware	Fast • cheap • low radiation	Limited soft tissue detail
Ultrasound	Soft tissue, fluid, vascular, OB	No radiation • bedside • dynamic	Operator dependent • limited by body habitus/gas
CT	Acute pathology, trauma, lung, abdomen	Fast • comprehensive • high spatial detail	Radiation • contrast risk • incidental findings
MRI	Soft tissue, brain, spine, joints	Excellent contrast detail • no radiation	Slow • expensive • motion sensitive
Nuclear medicine	Function / physiology	Functional info • whole-body assessment	Lower resolution • radiation • slower

Putting in a good indication

- A total of 762 inpatient imaging requests were retrospectively reviewed for order completeness.
- >90% of inpatient imaging requests were considered incomplete
- Routine pre-op imaging: 2x higher odds of poor clinical indication

Parillo M et al. *Insights into Imaging*. 2024;15:268.

Putting in a good indication: Order A

Order: CT abdomen/pelvis

Indication: Fever

Findings: Small fluid collection near bowel. No rim enhancement. Scattered punctate foci of gas.

Impression: Small fluid collection near bowel. No rim enhancement. Trace adjacent postoperative pneumoperitoneum. No definitive abscess.

Putting in a good indication: Order B

Order: CT abdomen/pelvis

Indication: POD#7 right hemicolectomy. Fever, elevated WBC. Concern for anastomotic leak or abscess.

Findings: Gas tracking along the anastomosis. Faint rim hyperattenuating on reformatted imaging. Scattered punctate foci of gas.

Impression: Perianastomotic collection with adjacent gas, concerning for developing abscess related to anastomotic leak.

CT with or without contrast

CT: Iodinated Contrast

- Evaluating **infection** (appendicitis, diverticulitis, abscess)
- Assessing **solid organ pathology** (liver, pancreas, kidneys, spleen)
- Characterizing a **mass or malignancy** (with some caveats)
- Evaluating **vascular pathology** (PE, dissection, active bleed)
- **Most abdominal/pelvic pain** workups

CT with oral contrast

Oral contrast

- Post-operative anastomotic leak (ensure contrast reaches anastomosis)
- Bowel fistula (in limited cases)
- *Typically use iodine-based oral contrast, rarely barium due to risk of peritonitis in the setting of leak evaluation

DO NOT USE

- Acute GI bleed
- Intra-abdominal hemorrhage
- Acute mesenteric ischemia

MRI with or without contrast

IV contrast

- Suspected infection (e.g. abscess, postoperative infection, osteomyelitis*)
- Soft tissue or bone tumors
- Indeterminate lesion as follow-up from prior imaging

No contrast in pregnancy, and low GFR

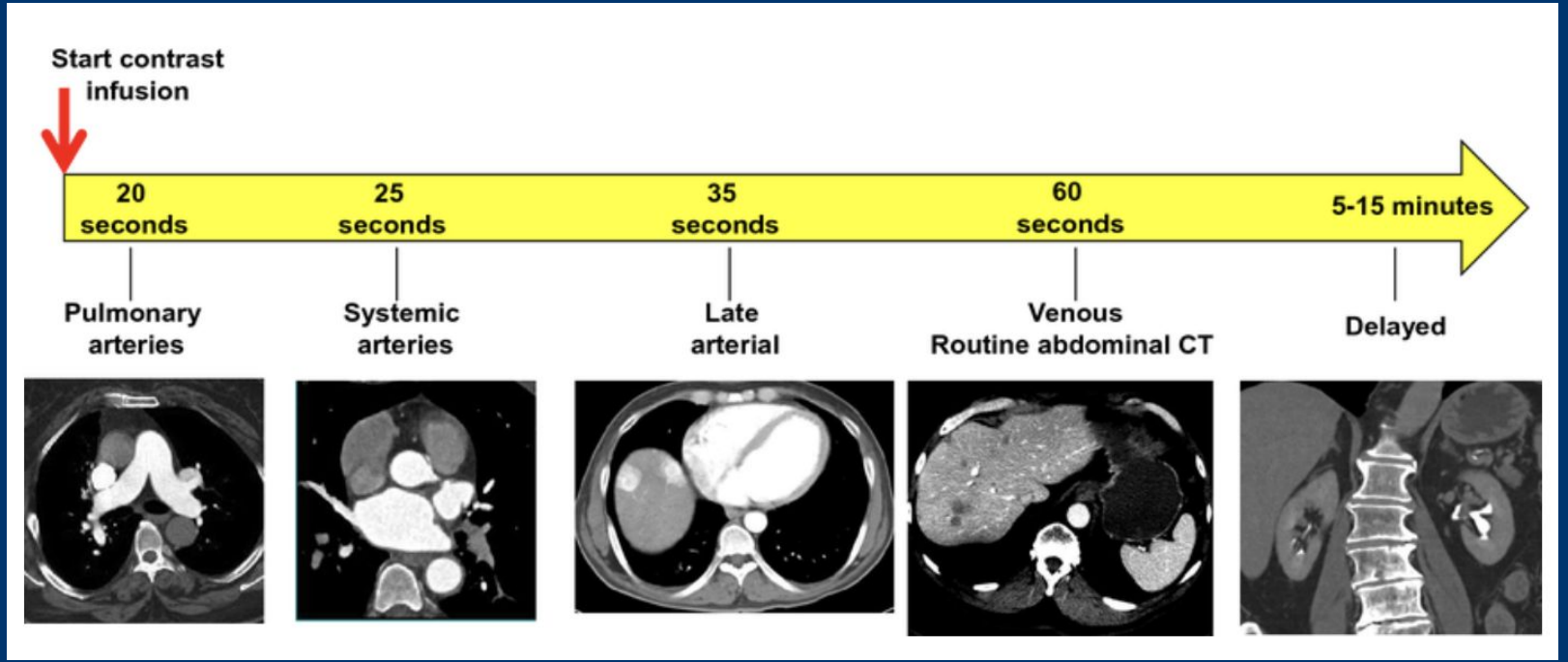
When contrast is not needed

- Acute stroke
- Degenerative spine disease
- Sports and age related pathologies (e.g. knee and shoulder)**

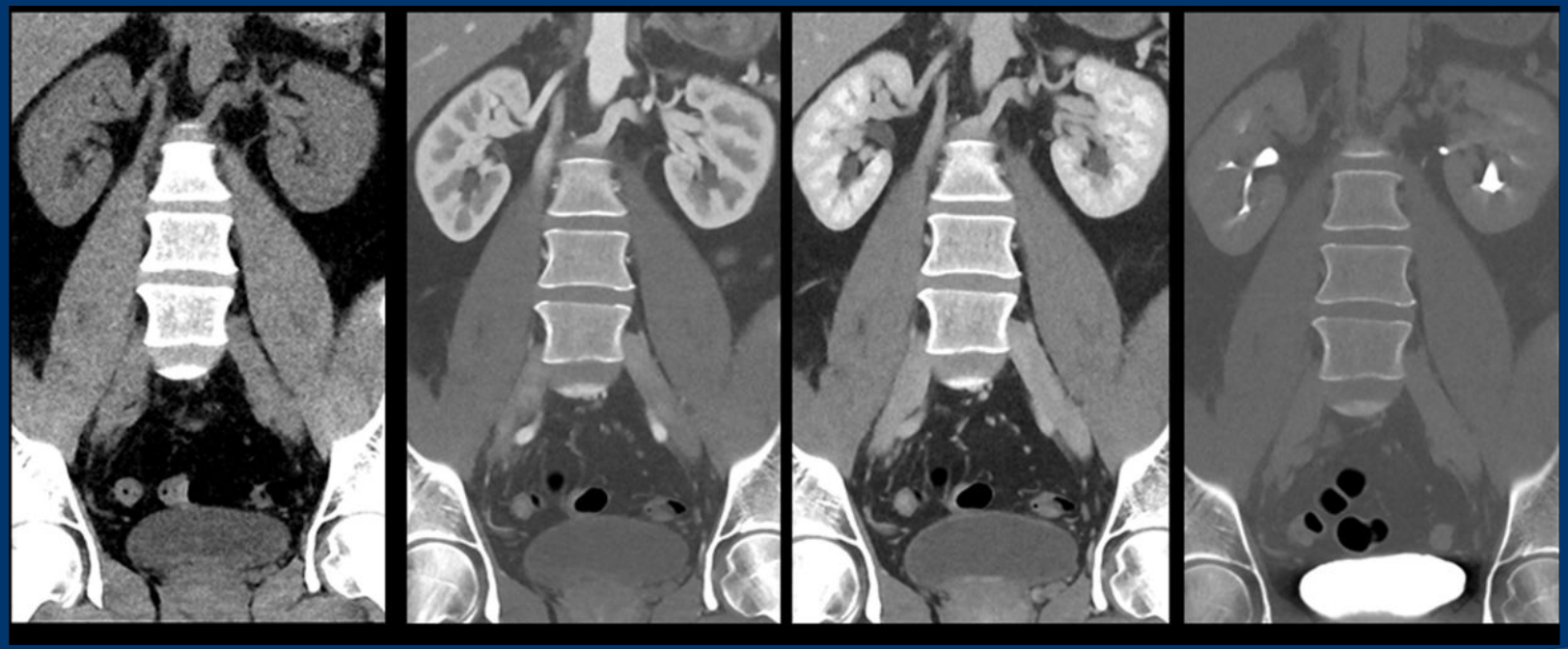
Arthrogram

- Shoulder or hip labral tear
- Femoroacetabular impingement

Why contrast matters



Why contrast *timing* matters



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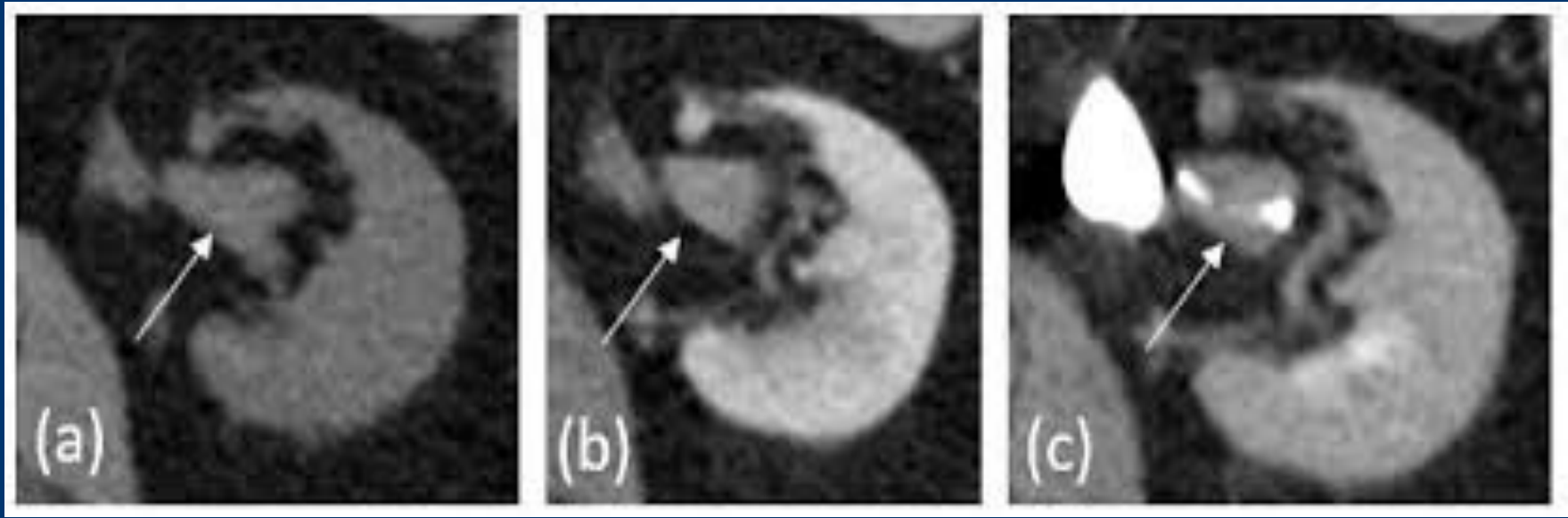

Tsikitas LA, Hopstone MD, Raman A, Duddalwar V. Imaging in Upper Tract Urothelial Carcinoma: A Review. *Cancers*. 2023; 15(20):5040.

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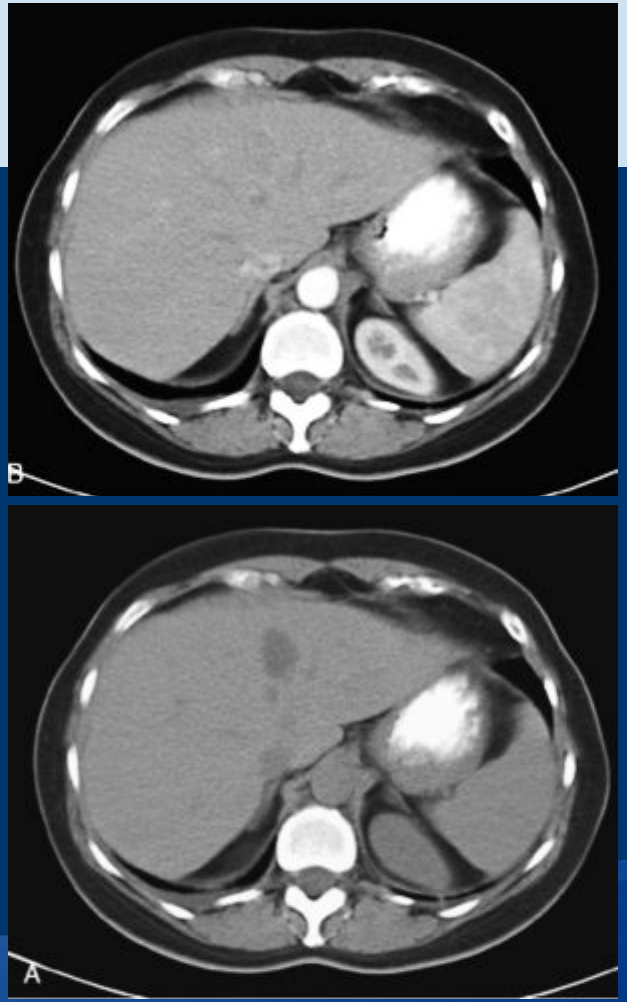
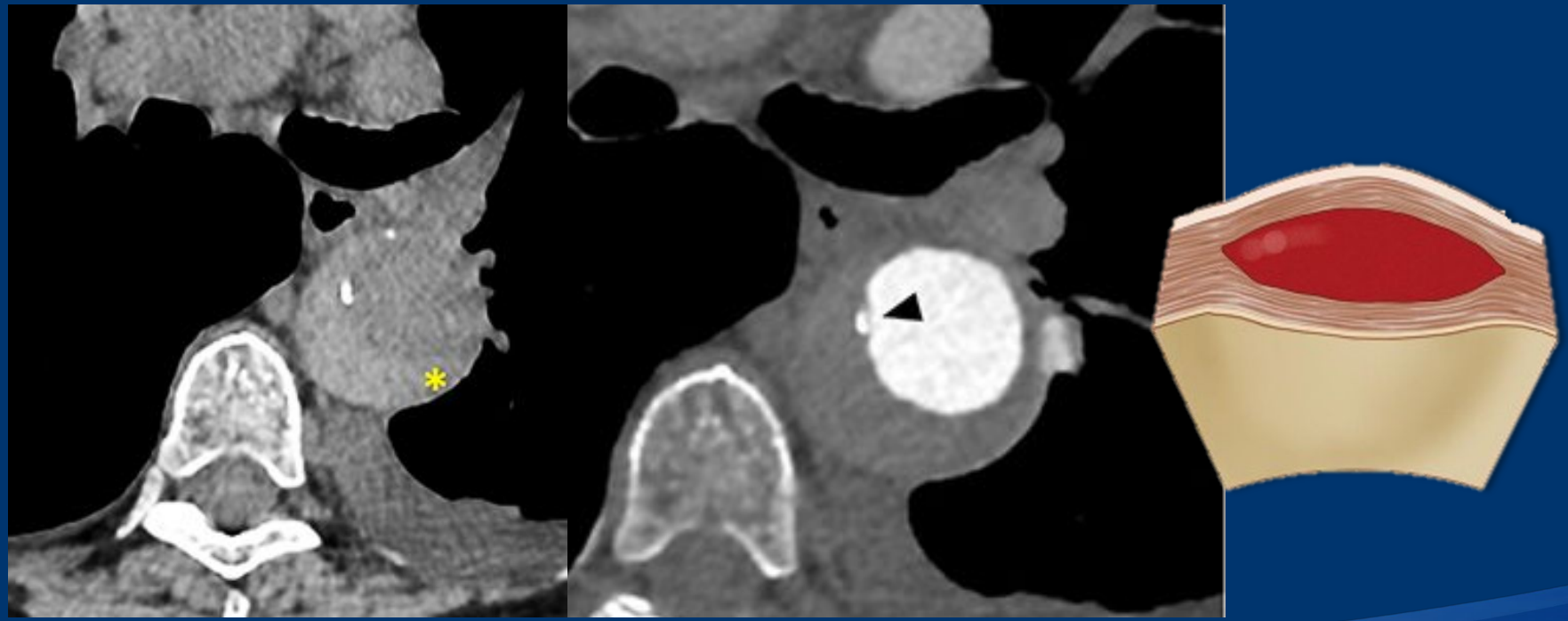
The importance of NONcontrast

Key Indications (differentiate high density material)

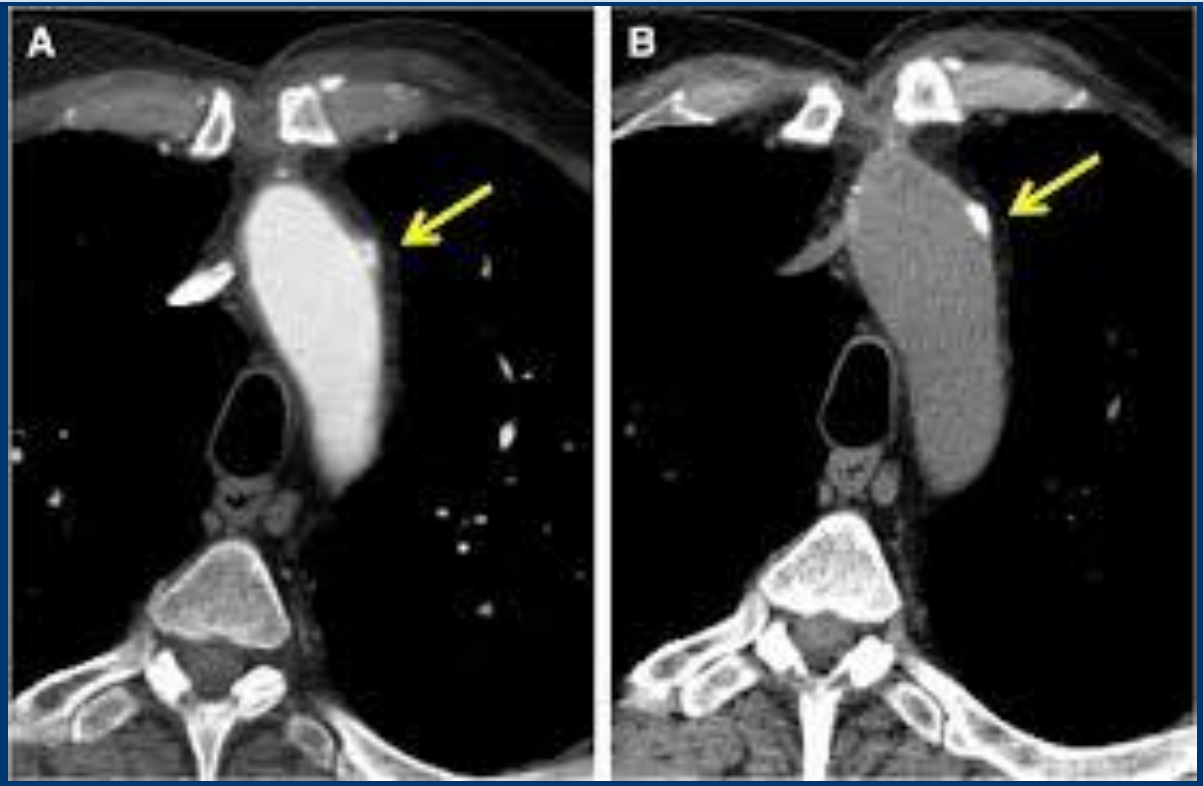
- Intracranial hemorrhage
- Renal stones
- Aortic intramural hematoma and cardiovascular repair
- Calcifications (coronary calcifications)
- Oncologic work-up (e.g. adrenal lesions, breast cancer with liver metastasis)



The importance of NONcontrast



The importance of NONcontrast



Preventza O et al Curr Radiol Rep. 2019;7(12):32.

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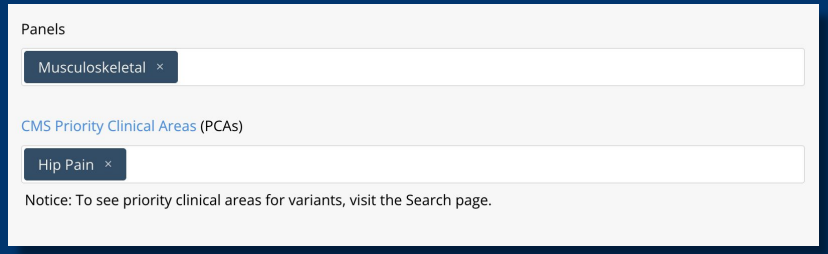
ACR appropriateness Criteria



Variant: 2 Adult. Acute hip pain, traumatic. Suspect fracture. Radiographs negative or indeterminate. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
MRI hip without IV contrast	Usually Appropriate	O
CT hip without IV contrast	Usually Appropriate	☢☢☢
US hip	Usually Not Appropriate	O
MRI hip without and with IV contrast	Usually Not Appropriate	O
Bone scan hip	Usually Not Appropriate	☢☢☢
CT hip with IV contrast	Usually Not Appropriate	☢☢☢
CT hip without and with IV contrast	Usually Not Appropriate	☢☢☢

270
Diagnostic Imaging and Interventional Radiology documents

4,000
clinical scenarios

1,300+
clinical variants

203
patient-friendly AC summaries

https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria

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ACR appropriateness Criteria Cont.

Clinical Scenario: Pediatric hematuria

Variant: 2 Child. Isolated microscopic hematuria (nonpainful, nontraumatic) with proteinuria. Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
US kidneys and bladder	Usually Appropriate	O
Arteriography kidneys	Usually Not Appropriate	☢☢☢☢
Voiding urosonography	Usually Not Appropriate	O
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢☢
Radiography abdomen and pelvis	Usually Not Appropriate	☢☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢

Variant: 4 Child. Painful hematuria (nontraumatic). Suspected urolithiasis. Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
US kidneys and bladder	Usually Appropriate	O
CT abdomen and pelvis without IV contrast	Usually Appropriate	☢☢☢☢
Radiography abdomen and pelvis	May Be Appropriate	☢☢☢
Arteriography kidneys	Usually Not Appropriate	☢☢☢☢
Voiding urosonography	Usually Not Appropriate	O
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢

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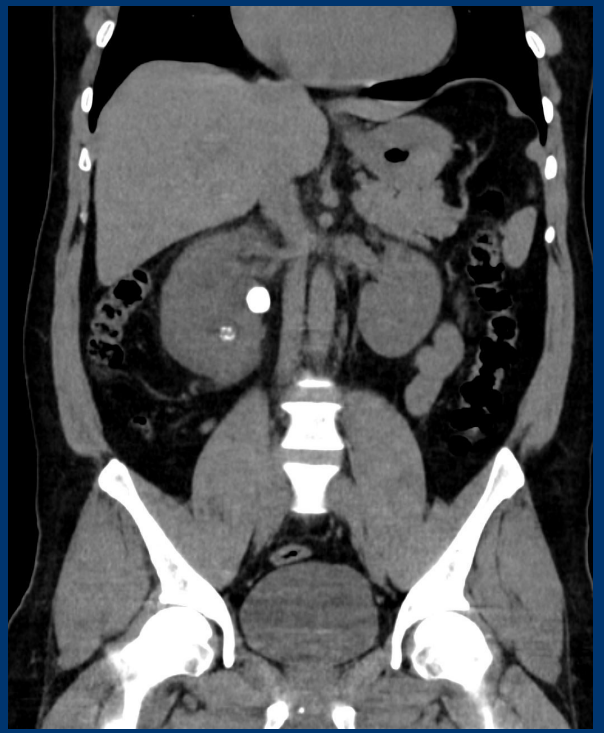
ACR appropriateness Criteria Cont.

Order: CTAP without contrast

Indication: Flank pain. Concern for renal stone.

Diagnosis: Right obstructive ureteropelvic urolithiasis



ACR appropriateness Criteria

- 59% appropriate per ACR Appropriateness Criteria
- Inappropriate orders: 59.4% (US), 29.1% (CT), 33.3% (MR
- Unnecessary: US 26%, CT 15%, MR 13%
- **Appropriate exams 3X more likely to yield findings that match clinical suspicion**

Francisco MZ et al. *Emerg Radiol*. 2024;31:367–372.

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System-Based Approach: High-Yield Imaging Applications

Women’s Imaging

The Palpable Breast Lump

Clinical Question: "I feel a mass, what do I click?"

- **Age < 30: Targeted Ultrasound** is the first-line study.
  - Younger tissue is dense; Mammo sensitivity is low.
  - Goal: Distinguish simple cyst vs. fibroadenoma vs. solid mass.
- **Age 30–39: Diagnostic Mammogram + Ultrasound.**
  - The "hybrid" age; clinical suspicion dictates the depth of the workup.
- **Age 40+: Diagnostic Mammogram.**
  - Standard of care. Most will receive a "reflex" Ultrasound if the Mammo is inconclusive or shows a mass.
- **Pro-Tip:** A "Normal" Mammogram report does **NOT** negate a palpable lump. If you feel it, it needs a Breast Ultrasound.

Women’s Imaging

Screening vs. Diagnostic (The Red Tape)

Why does the front desk keep calling my office?

- **Screening Mammogram:**
  - **Patient Status:** Asymptomatic. No lumps, no discharge, no pain.
  - **Process:** 2 views per breast. Read in "batch" by the radiologist. Results mailed in days.
- **Diagnostic Mammogram:**
  - **Patient Status:** Symptomatic (Lump, focal pain, skin dimpling) OR a "callback" from a screening.
  - **Process:** Extra views (Spot compression/Magnification). Read **real-time**. Patient gets results before leaving.
- **Key Coding Pearl:** If the patient tells you they feel a lump, you **must** order a Diagnostic study, or the facility will have to reschedule them.

Women’s Imaging

High-Risk Screening – The "Staggered" Strategy

Optimizing Surveillance for the High-Risk Patient.

- **The Goal:** Minimize the "interval cancer" window (cancers that appear between annual screens).
- **The Strategy:** Do not order the Screening Mammogram and Screening Ultrasound/MRI on the same day.
- **The 6-Month Alternation:**
    - **Month 0:** Annual Screening Mammogram (3D/Tomosynthesis).
    - **Month 6:** Screening Breast Ultrasound (for dense breasts) or Screening Breast MRI (for high-risk/BRCA).
- **The Benefit:** This provides a "look" at the breast tissue every 6 months rather than once a year. If a fast-growing tumor appears, you catch it in 6 months rather than 12.
- **Your Role:** You have to manage the calendar. Patients will often try to "bundle" them for convenience; explain that **frequency is more important than convenience** for high-risk detection.

Women’s Imaging

Imaging the Pregnant Patient

Myth-Busting: "We can’t scan her because she's pregnant."

- **The 50 mGy Rule:** Fetal risk (malformation or loss) is negligible below a cumulative dose of **50 mGy**.
  - **CT Chest (PE Protocol):** < 0.1 mGy fetal dose.
  - **CT Abd/Pelvis:** ~25 mGy fetal dose (Still 50% below the "danger" threshold).
- **The Priority:** Maternal health is fetal health. Do not withhold a life-saving CTA for suspected PE or Appendicitis.
- **Contrast Safety:**
  - **Iodinated (CT):** Category B. Crosses the placenta but no known teratogenic effects.
  - **Gadolinium (MRI):** Avoid unless absolutely critical. It lingers in amniotic fluid and is Category C.

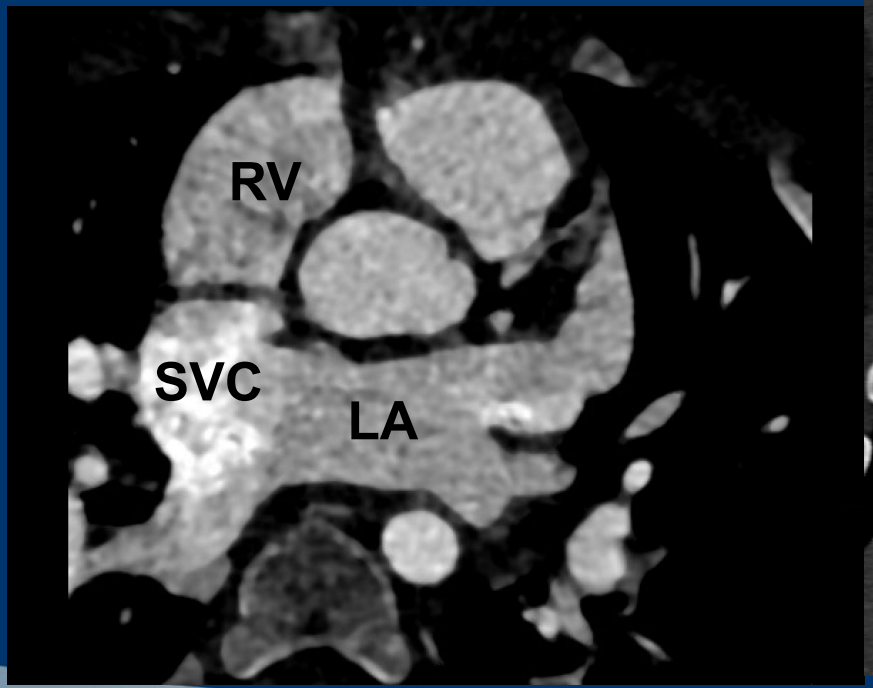
Women's Imaging

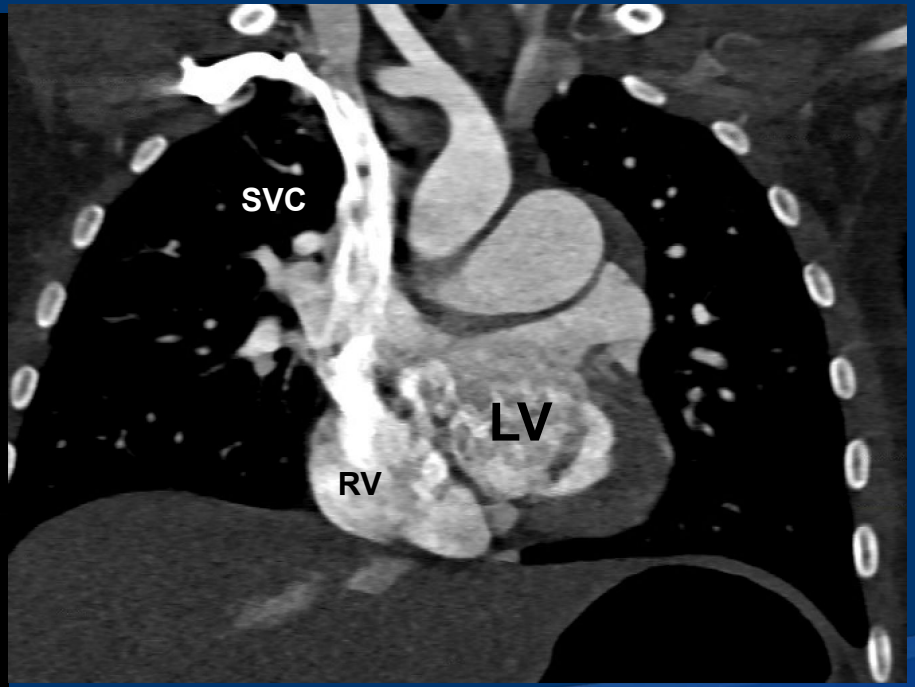
Acute Pelvic Pain - The "First Line"

When to put the CT probe down and call for Ultrasound.

- **Torsion, Ectopic, or PID: Transvaginal Ultrasound (TVUS)** is the Gold Standard.
  - Better spatial resolution for the adnexa than CT.
  - **Doppler** is required to assess blood flow (though normal flow doesn't 100% rule out torsion).
- **The Beta-hCG "Discriminatory Zone":**
  - If Beta is **> 2,000 mIU/mL**, you should see a gestational sac on TVUS.
  - If the uterus is empty and Beta is high = Ectopic until proven otherwise.
- **When to CT:** If the pain is non-localized or you suspect a bowel etiology (SBO, Appendicitis, Perforation).

Cardiothoracic Imaging





The Chest Radiograph

- ~830–840 million CXRs performed annually worldwide.
- CXRs account for ~40% of the 3.6 billion imaging studies/year
- Screening tool
- Good for:
  - Pneumothorax
  - Moderate to large pleural effusions
  - Pulmonary edema
  - Moderate to large consolidation
  - Lines and Tubes
  - Trauma
  - Assessing interval change (ICU)

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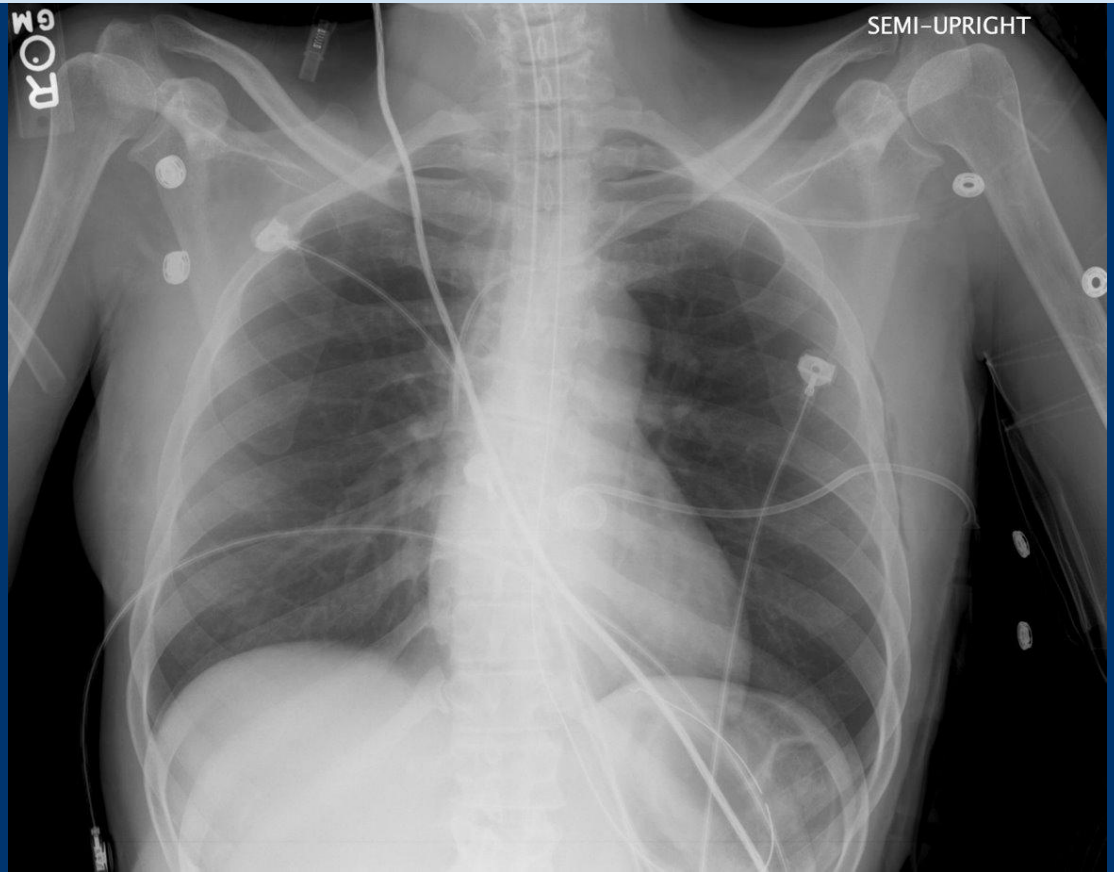
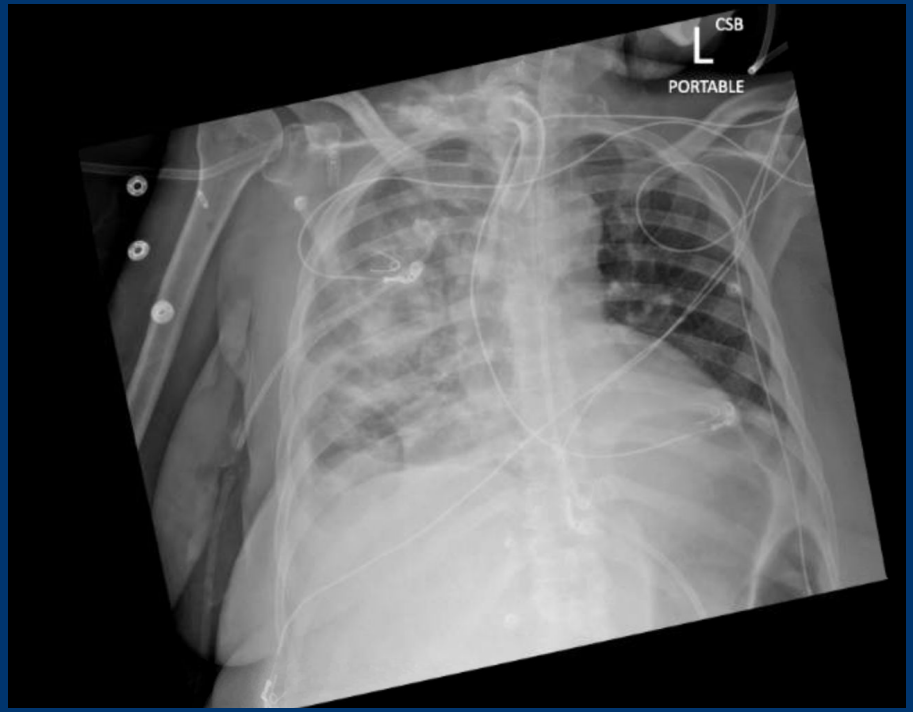
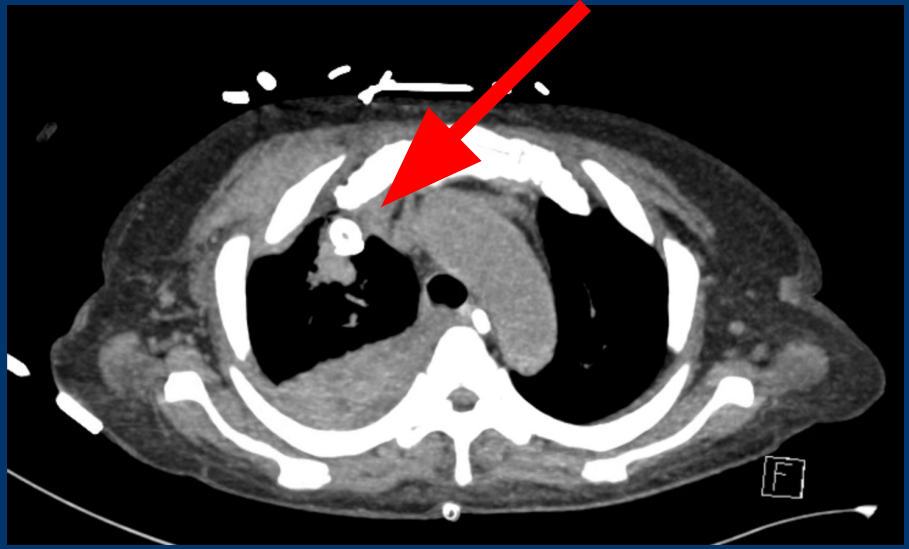
Daily ICU - Evaluating line and tubes

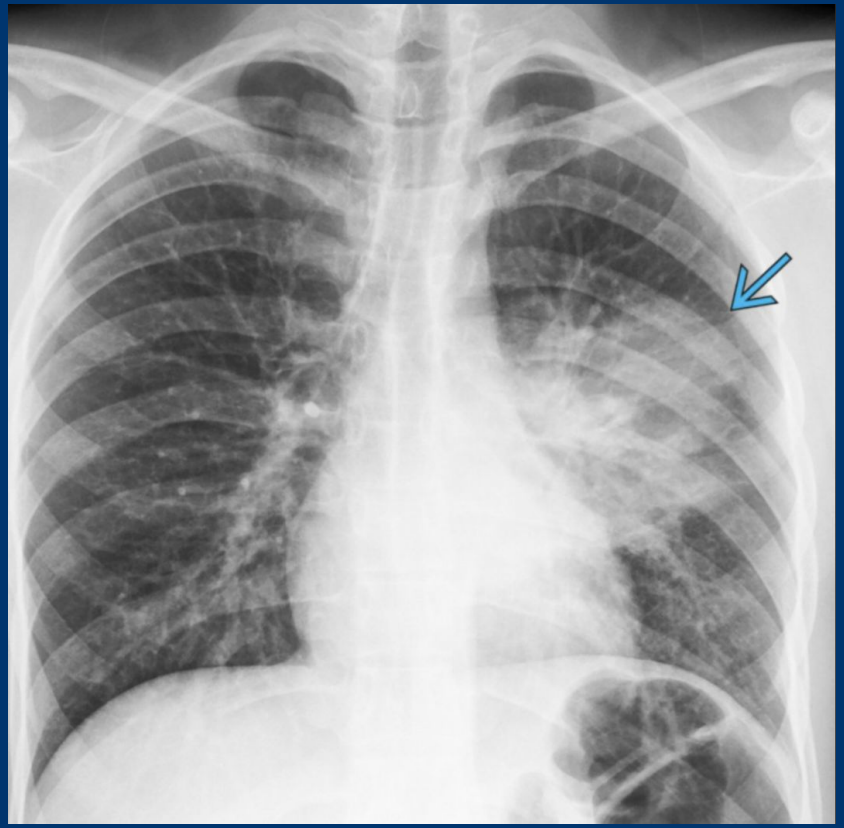


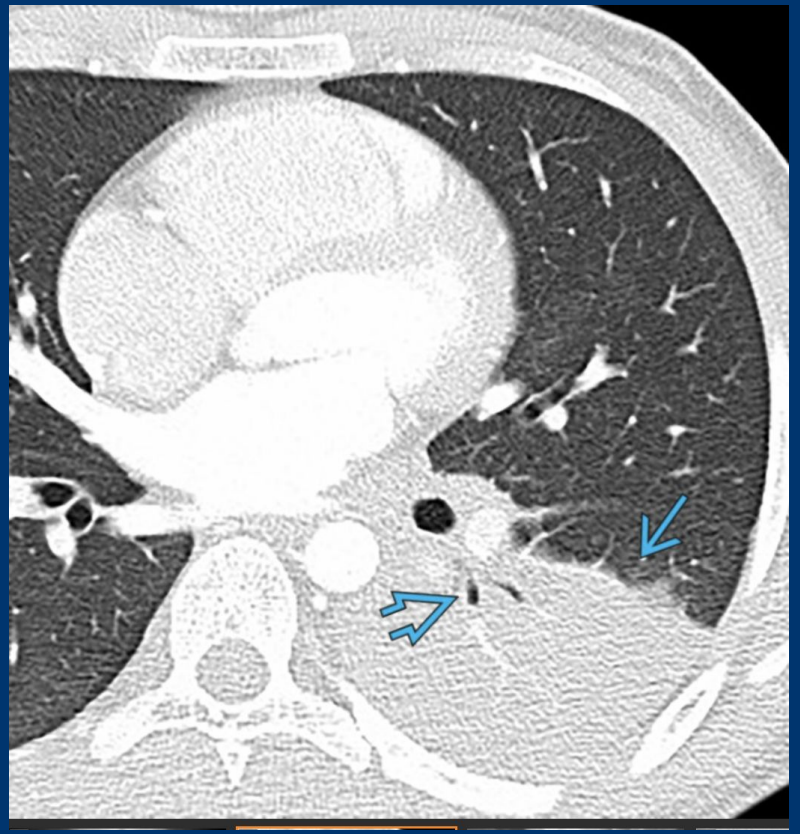
Daily ICU - Evaluating line and tubes



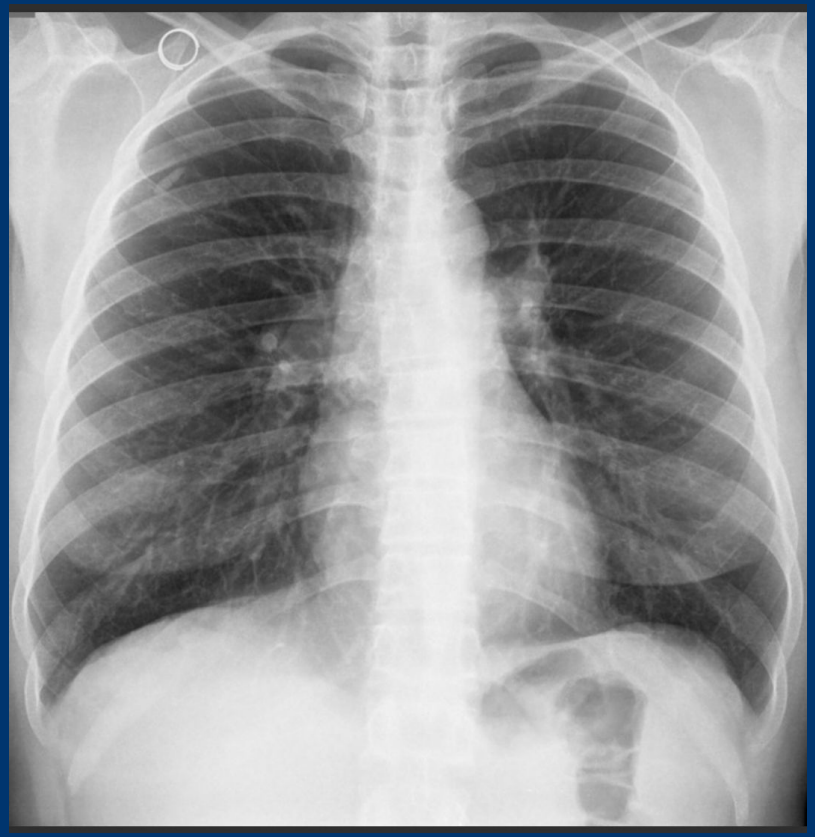


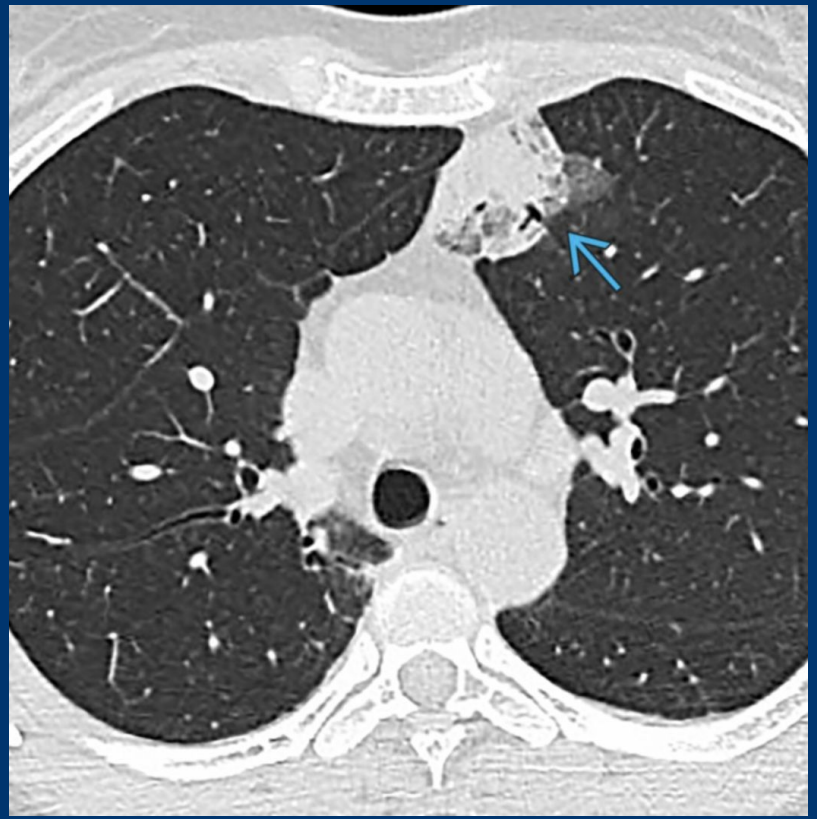
Chest Radiograph - Cough



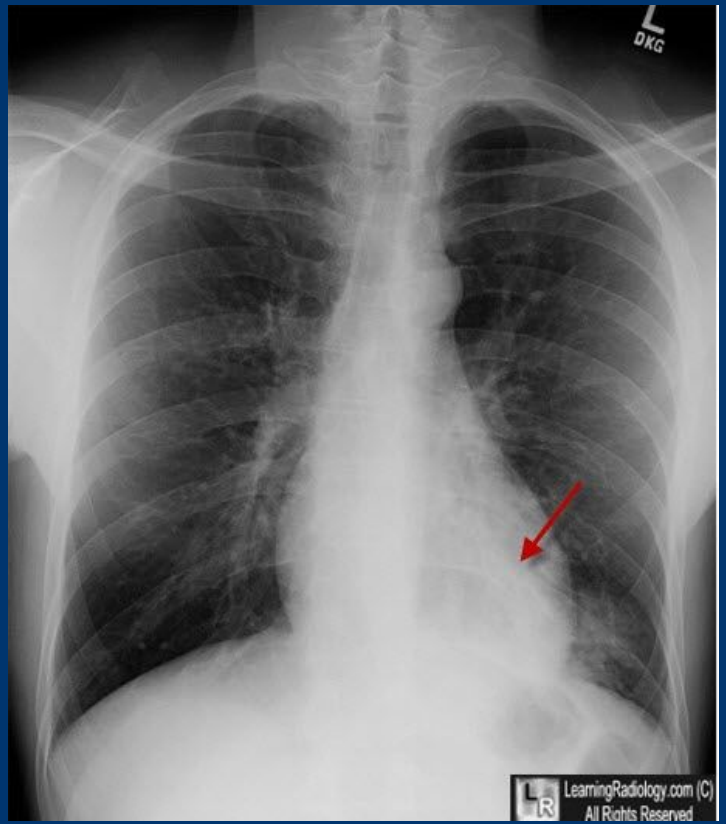


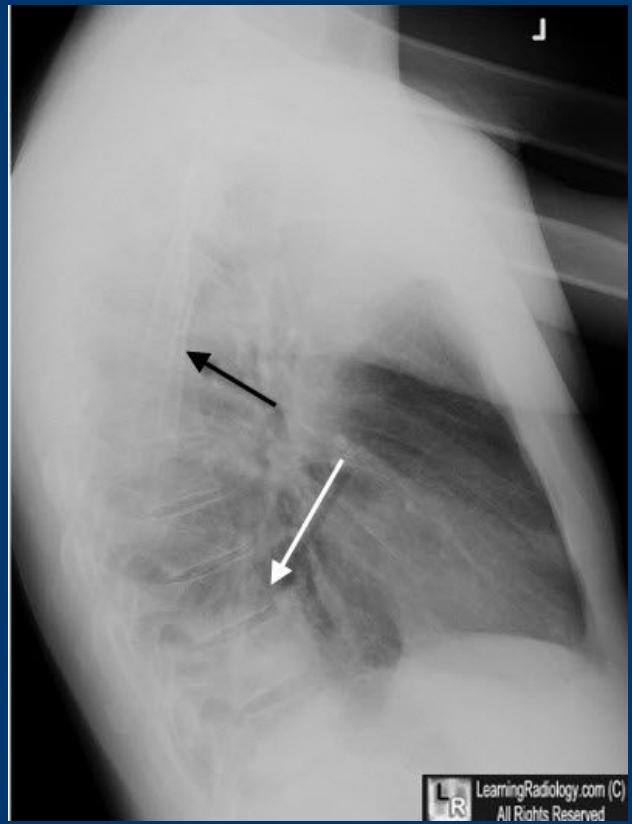
Does normal CXR = no pneumonia?



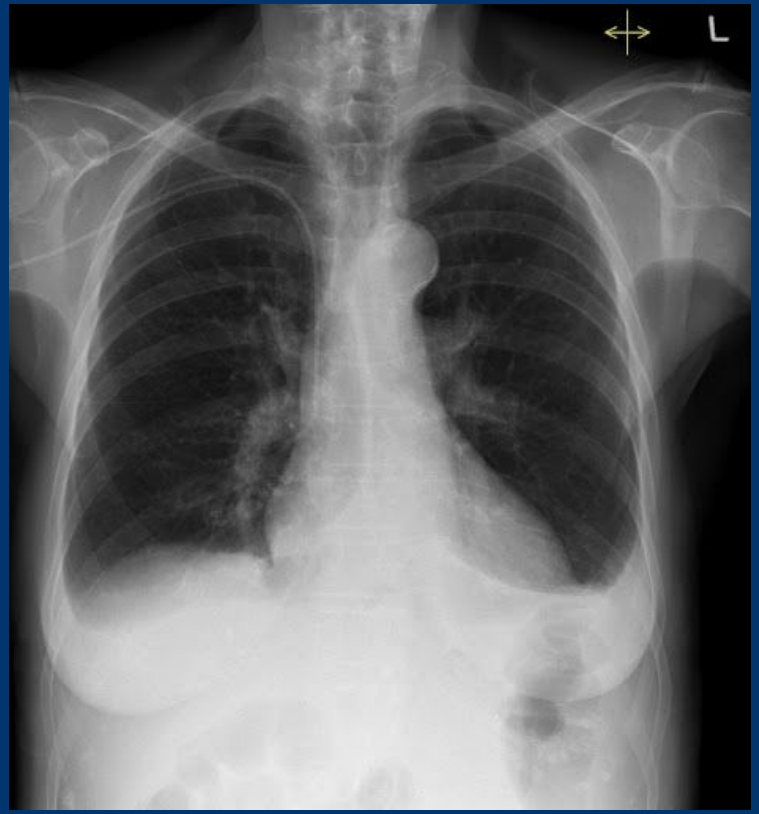


Don’t Forget - The lateral radiograph





Minimum pleural effusion volume that can be seen on single frontal view CXR?



a) 10 cc

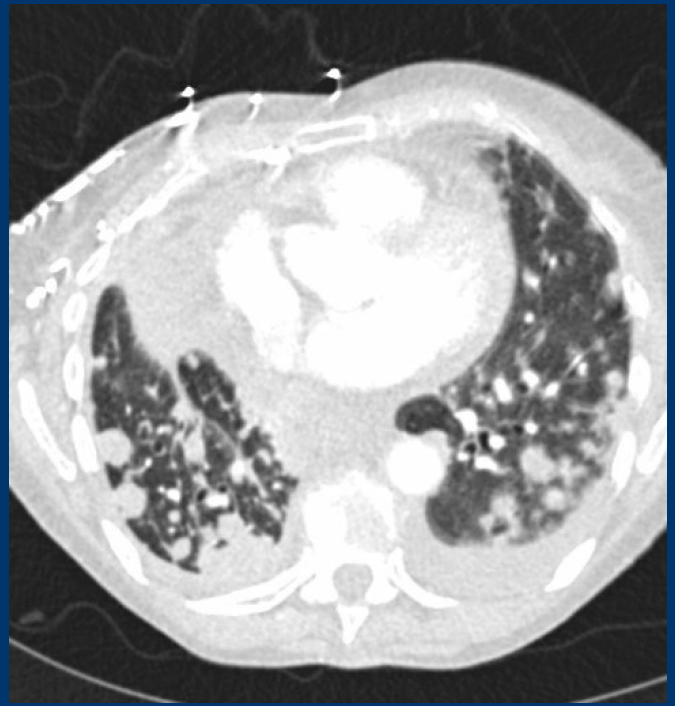
b) 100 cc

c) 200 cc

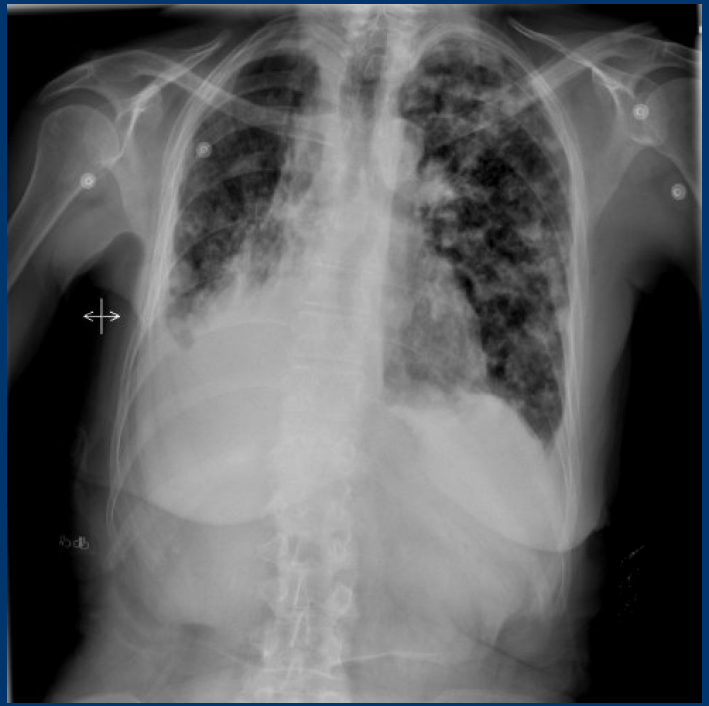
d) 500 cc

78 y/o female with a history of metastatic breast cancer
Indication: eval new lesions

Prior CT



Current exam



Acute Respiratory Illness

- **Viral SOB**
  - Dry cough < 6 weeks
  - Gradual improvement
  - Normal vitals, lung exam

→ No Imaging

- **Imaging may be indicated**
  - Persistent fever (>3-5 days after initial improvement)
  - Worsening persistent cough (> 6 weeks)
  - Hypoxia, Tachycardia
  - Hemoptysis
  - Immunocompromised state
  - Focal lung sounds

Acute Respiratory Illness

- However! In this French primary care study, antibiotics were initiated in 99.3% of patients with positive CXR and 68.7% with negative CXR.

- Take away: If you're going to treat regardless of the result, don't order the test.
    - Order CXR when it will change a decision:
        - rule in/out pneumonia when the diagnosis is uncertain
        - assess for complications (effusion/empyema)
        - high-risk/immunocompromised
        - severe presentation / hypoxia / admission threshold

Pinot *et al.* (2024), *Ann Fam Med* — chest X-ray influenced antibiotic decisions in suspected CAP.

Chronic respiratory illness - ACR

3 Chronic cough lasting more than 8 weeks. Persistent symptoms despite initial clinical evaluation and empiric treatment. Initial imaging. 12

Name	Category	Adult RRL	Peds RRL
Radiography chest	Usually appropriate	☢ <0.1 mSv	☢ <0.03 mSv [ped]
CT chest with IV contrast	Usually appropriate	☢☢☢ 1-10 mSv	☢☢☢☢ 3-10 mSv [ped]
CT chest without IV contrast	Usually appropriate	☢☢☢ 1-10 mSv	☢☢☢☢ 3-10 mSv [ped]

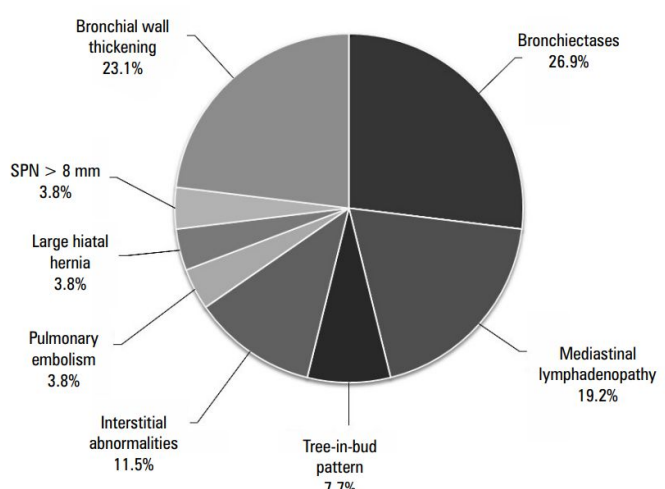
Chronic respiratory illness

Table 2. Comparison of demographics of patients with true negative CXR and false negative CXR

	True negative CXR	False negative CXR	p value
Number of patients	38	21	
Age [yrs]	61 (24–78)	63 (31–74)	ns
Sex [F/M]	30/8	14/7	ns
Duration of cough [months]	84 (5–192)	25 (3–240)	0.025
Smoking status [NS/ES]	23/15	10/11	ns
Smoking history [pack-years]	19.5 (5–30)	12.5 (5–45)	ns

Data are given as median and ranges or number of patients. Both groups were compared using Chi-squared test for categorical variables and Mann Whitney U test for continuous variables; F: female; M: male; NS: never smoker; ES: ex-smoker

64 % Negative predictive value



Negative CXR does not necessarily mean no disease.

Truba O, et al. Adv Respir Med. 2018;86:113-120.

Chest pain

- Acute chest pain drives >8 million ED visits/year
- Chest pain often triggers **multiple imaging exams** during a single encounter
- 10–15% of chest pain cases ultimately represent ACS

Hoffmann U, Bamberg F. Is Computed Tomography Coronary Angiography the Most Accurate and Effective Noninvasive Imaging Tool to Evaluate Patients With Acute Chest Pain in the Emergency Department? Circulation: Cardiovascular Imaging. 2009;2:251–263

Chest pain

A 34-year-old woman presents to the ED with sudden onset shortness of breath and pleuritic chest pain that started 2 hours ago. She recently returned from a 6-hour flight. She denies hemoptysis. No prior history of DVT or PE. No leg swelling. Vitals: HR 96, BP 118/72, RR 18, SpO_2 98% on room air. She is anxious but speaking in full sentences. Physical exam is otherwise normal.

Question:

What is the most appropriate next step in management?

A. Order CT pulmonary angiography
B. Order chest X-ray
C. Apply Wells criteria and obtain D-dimer if low/moderate risk
D. Start anticoagulation empirically
E. Order lower extremity Doppler ultrasound

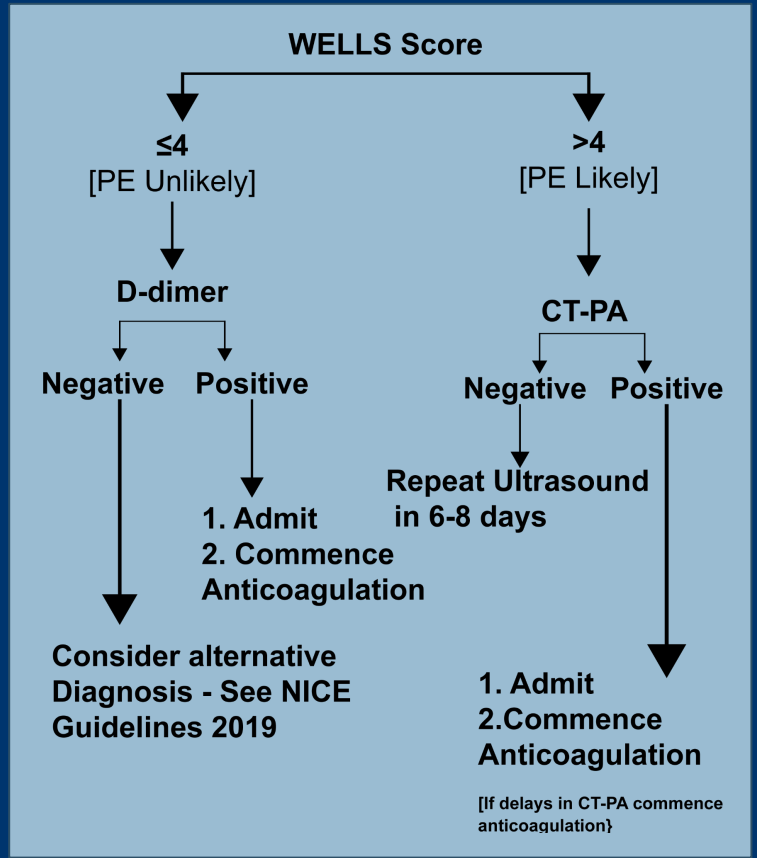
Pulmonary Embolism

Wells score

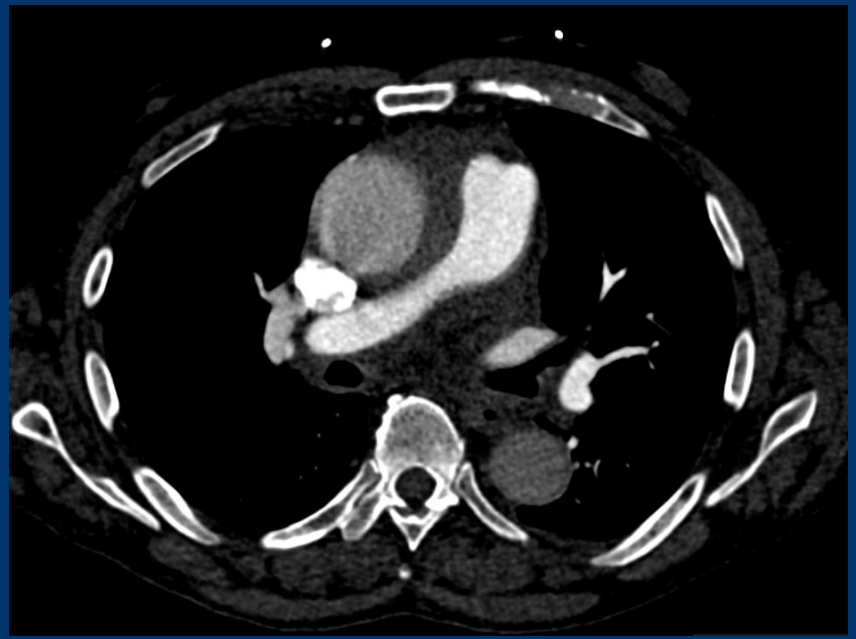
Criteria	Points
Clinical signs/symptoms of DVT	3
PE is most likely diagnosis	3
Tachycardia (>100 bpm)	1.5
Immobilization/surgery in previous 4 weeks	1.5
Prior DVT/PE	1.5
Hemoptysis	1
Active malignancy (trt w/in 6 month)	1

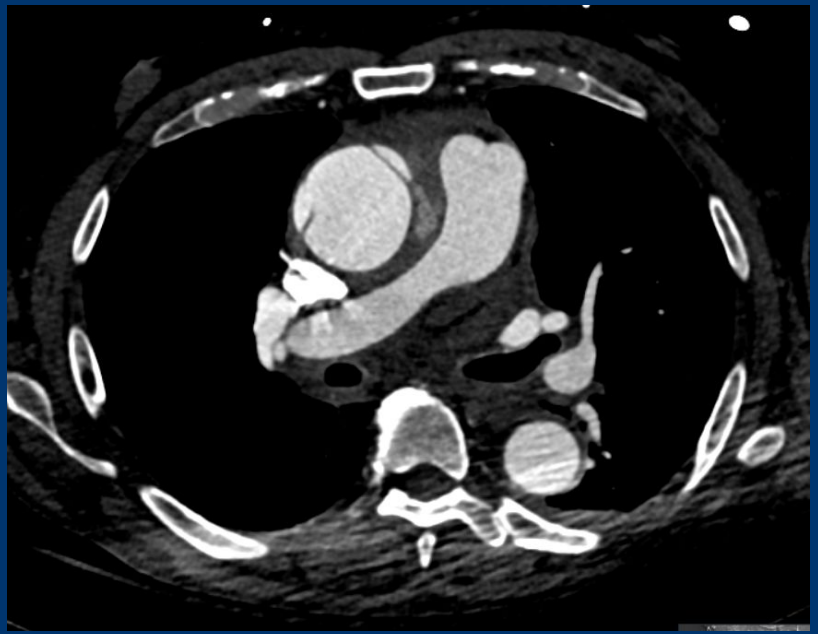
Low Risk	Intermediate risk	High risk
< 2 points	2-6 points	>6 points

PE unlikely	PE Likely
0-4 points	>4 points



Chest pain - Contrast and contrast timing





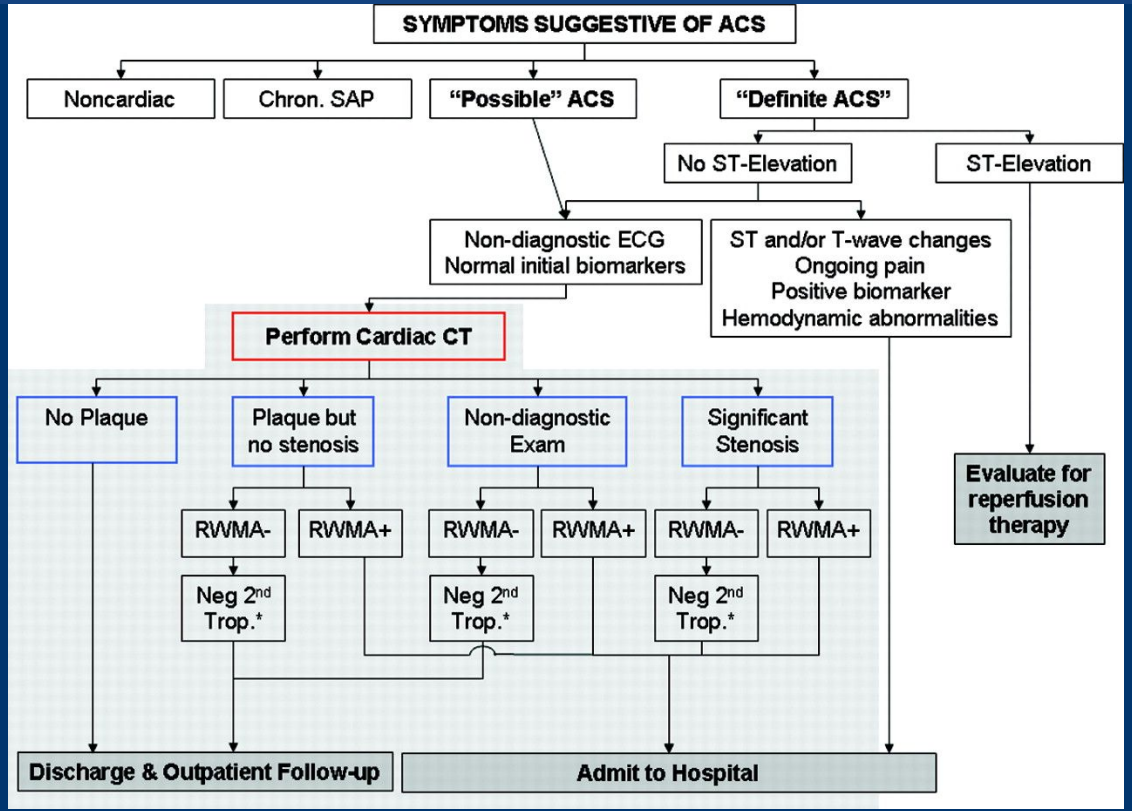
Woops - Aortic dissection

Triple Rule Out ? Useful Tool or Overkill

- A single contrast-enhanced ECG-gated CT designed to evaluate:
  - coronary arteries (ACS), pulmonary arteries (PE), thoracic aorta (dissection)
- Worse optimization for each individual target
- Higher radiation, more contrast, longer acquisition,...
- Studies show TRO rarely changes management compared to targeted CTA

If your clinical reasoning is good, you shouldn’t need a triple rule-out.

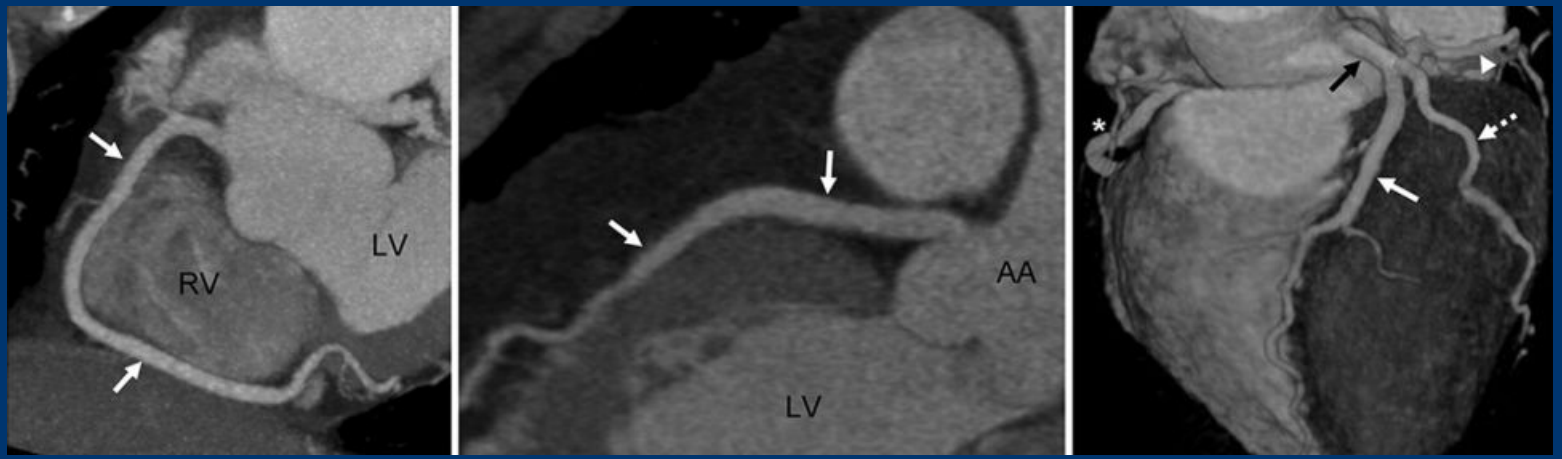
ACS - Where does imaging fit?



CTA is most useful in low–intermediate risk ACS with negative troponins

ACS? Where does CTA fit?

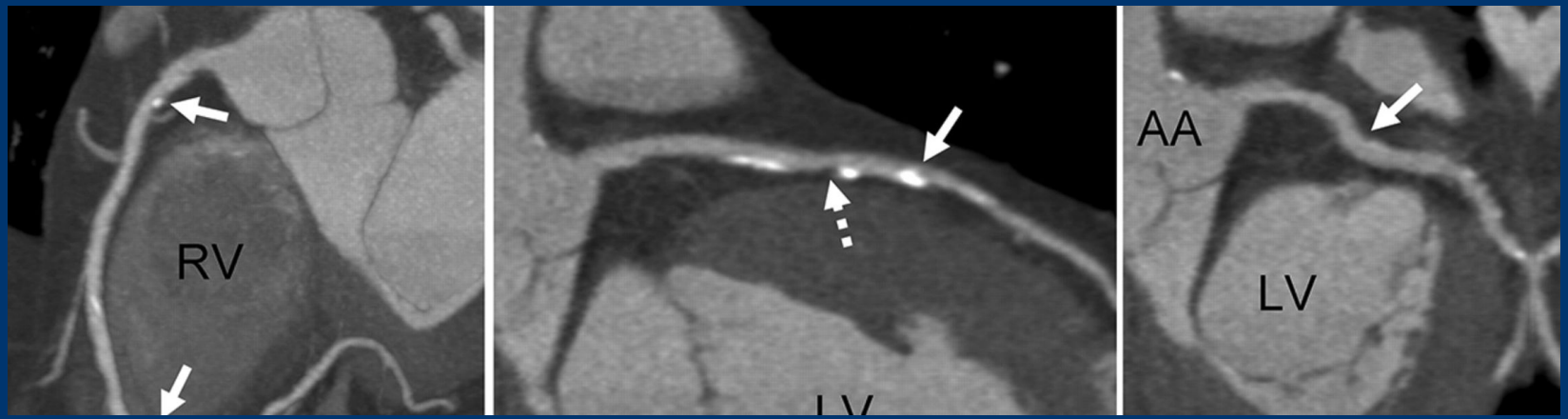
48-year-old woman presented with atypical acute chest pain



Hoffmann et al. Circulation: Cardiovascular Imaging. 2009;2:251–263

ACS? Where does CTA fit?

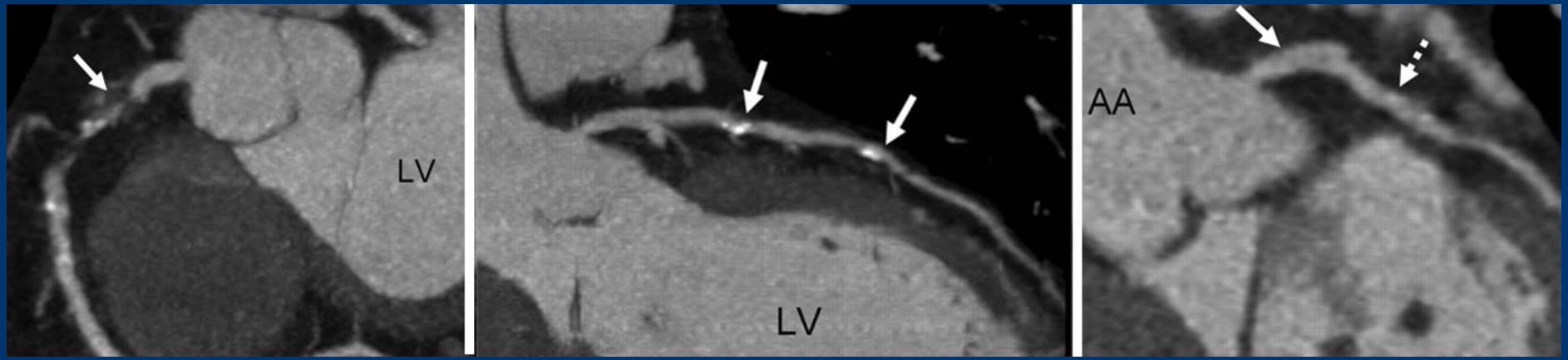
56-year-old man with multiple cardiovascular risk factors presented to the ED with substernal chest pain



Hoffmann et al. Circulation: Cardiovascular Imaging. 2009;2:251–263

ACS? Where does CTA fit?

67-year-old man presented to ED with repeated episodes of increasing stabbing chest pain but inconclusive initial ED evaluation



Hoffmann et al. Circulation: Cardiovascular Imaging. 2009;2:251–263

Coronary Artery Disease - Outpatient

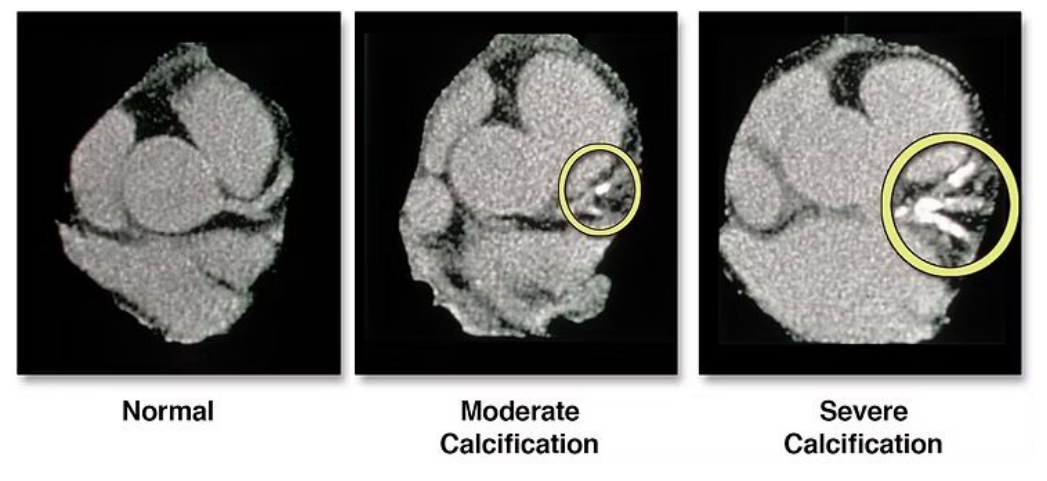
A 52-year-old man presents for routine cardiovascular risk assessment. He has no chest pain or cardiac symptoms. His blood pressure is 128/78 mmHg. Total cholesterol is 210 mg/dL and LDL is 135 mg/dL. He does not smoke and has no history of diabetes. His 10-year ASCVD risk is calculated at 8%. He is unsure whether he wants to start statin therapy and asks if additional testing could help guide the decision.

Which of the following is the most appropriate next step?

A. Order a coronary CT angiogram
B. Order a coronary artery calcium (CAC) score
C. Start high-intensity statin therapy immediately
D. Perform an exercise stress test
E. No further testing is indicated

Coronary Artery Calcium Score

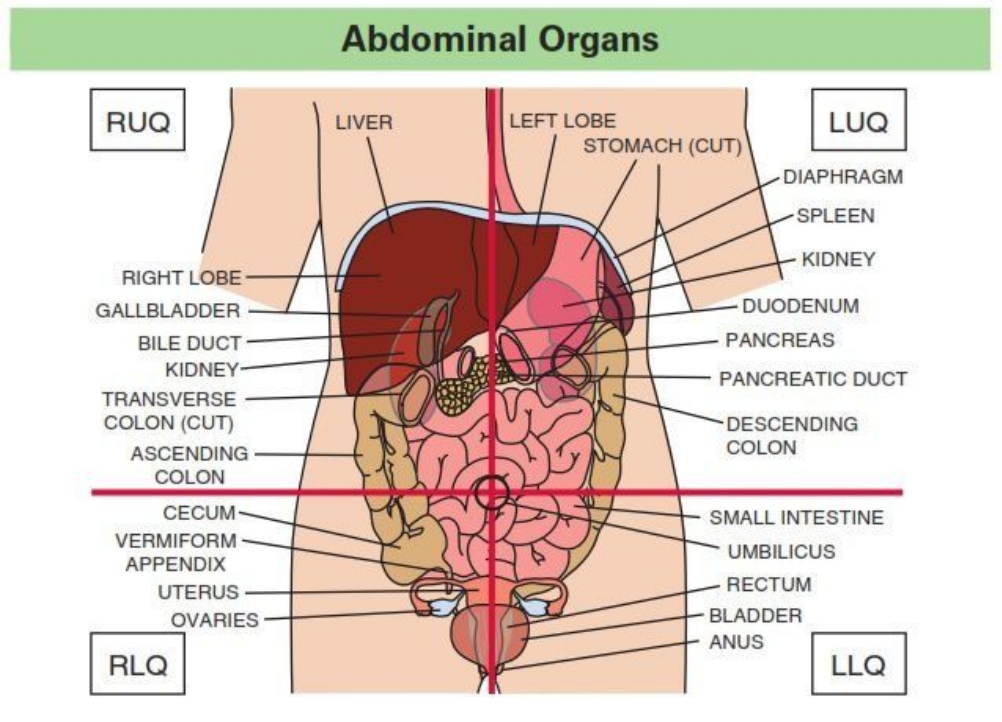
- CAC scoring is appropriate in:
  - asymptomatic patients
  - intermediate ASCVD risk (5–20%)
  - when statin decision is uncertain
- It predicts long-term risk, it does not diagnose acute disease.
- Do not use in patients with known CAD



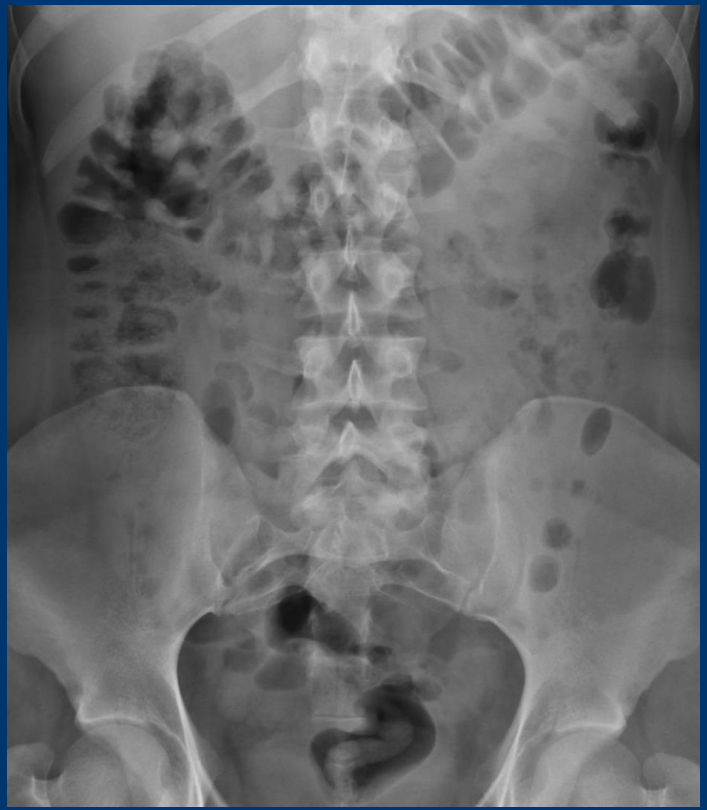
Cardiothoracic Imaging

Chest Radiograph	Chest / Cardiac CT	Chest / Cardiac MRI
Pneumonia (moderate/large) Pleural effusion Pneumothorax Pulmonary edema Line / tube position Acute trauma screening Interval changes	Pneumonia (complicated) Interstitial lung disease Lung nodules Malignancy Staging Mediastinal pathology Trauma PE Coronary artery disease	Cardiac structure and function (viability) Cardiac masses Pericardial disease Chest wall tumors Mediastinal masses

Abdominal Pain



Abdominal Radiographs



What can a supine abdominal radiograph diagnose? (pick all that apply)

a) Rule out small bowel obstruction

b) Detect free air

c) Stool burden or constipation

d) Kidney stones

e) None

Will imaging help or change management?

- 1,142 emergency department patients with chief complaint of constipation
- **<u>42% received abdominal X-ray</u>**

Driver et al. *Am J Emerg Med*. 2020.

Will imaging help or change management?

46% had moderate or large stool burden on X-ray

- 42% received no constipation treatment

Among those with normal or minimal stool burden:

- 55% were still diagnosed with constipation
- 45% still received constipation treatment

Abdomen and Pelvis (Abdominal Radiographs)

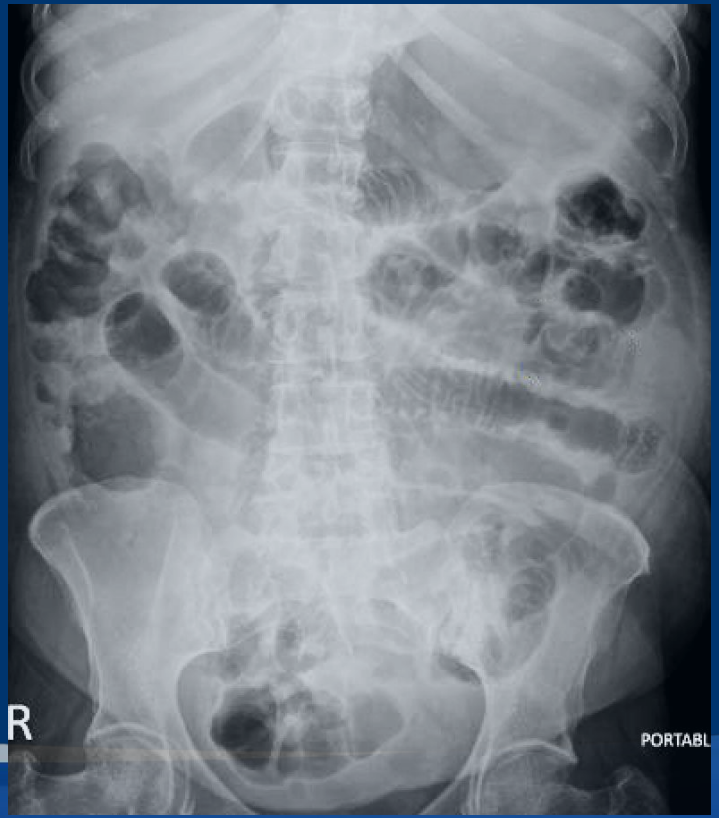
a) Ruling in bowel obstruction

b) Follow-up known bowel obstruction

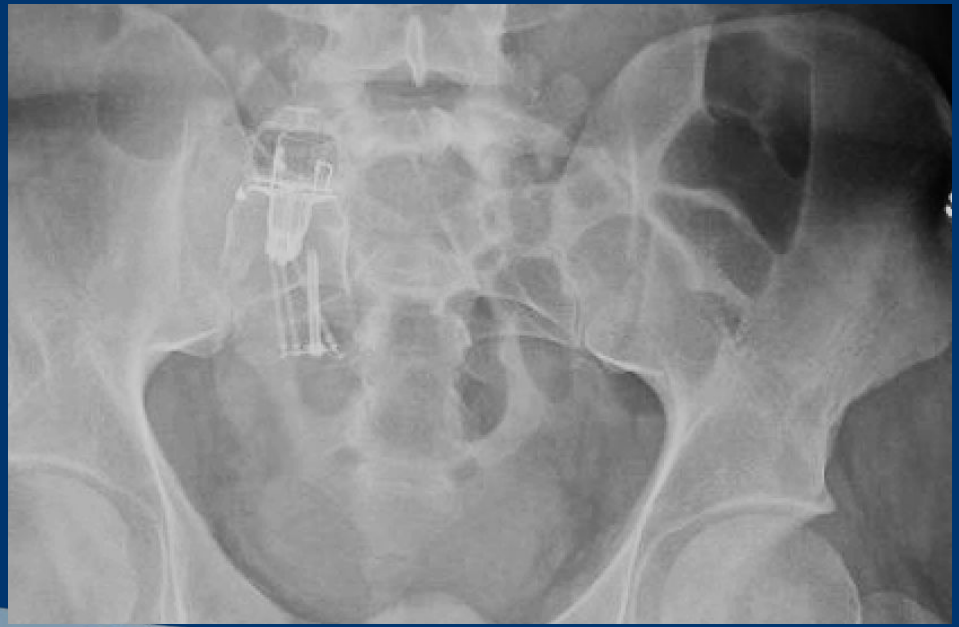
c) Large volume pneumoperitoneum (if upright)

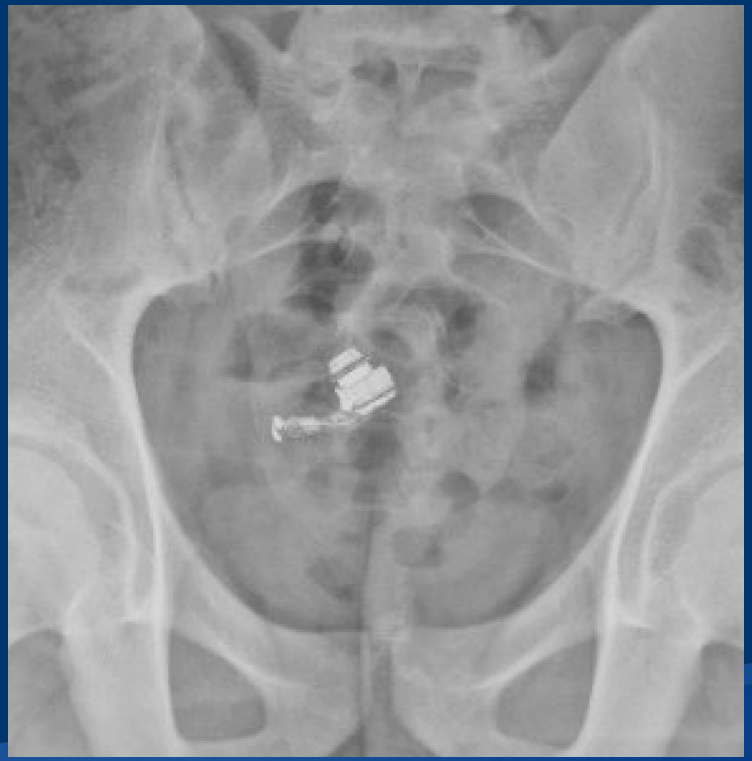
d) Radiopaque foreign bodies

Diagnosis? POD#4 sp ex lap



Foreign bodies





Patient has acute RUQ pain - what imaging test should I order?

a) Radiographs (KUB X-ray)

b) CT with contrast

c) CT without contrast

d) RUQ Ultrasound

e) Magnetic resonance imaging (MRI)

f) Need more information

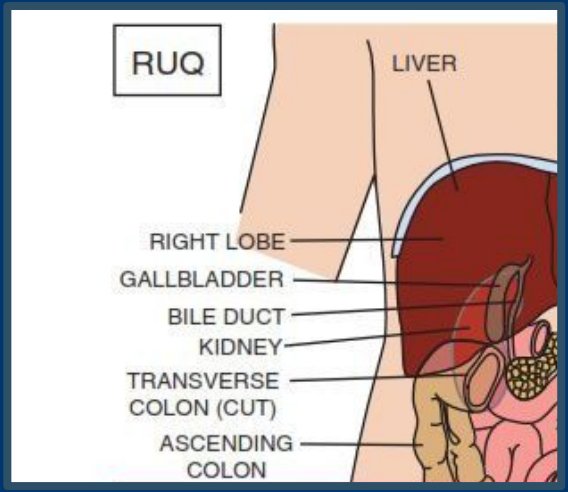
RUQ

Clinically

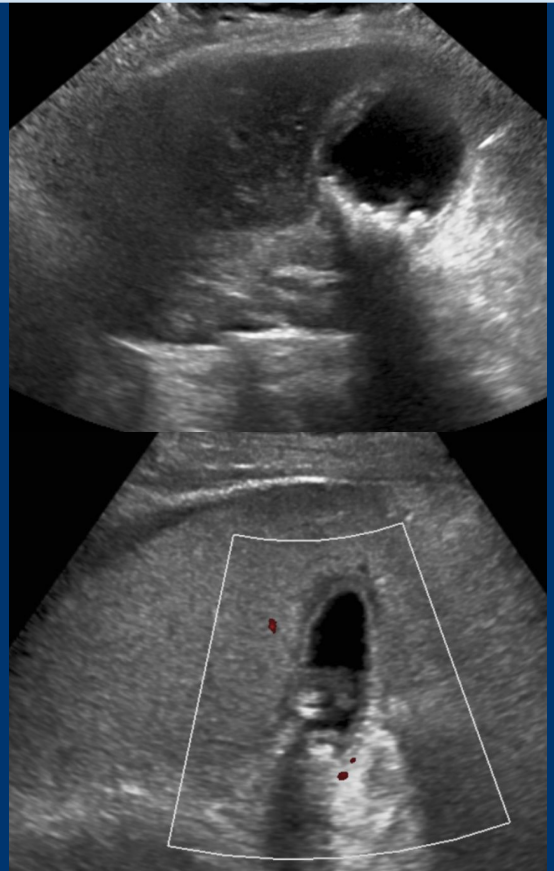
- RUQ Pain - Hepatobiliary zone
  - Differentials: Gallstones, cholecystitis, hepatitis, cholangitis
- Elevated AST/ALT, Alk Phos, Bilirubin, Lipase

Radiologically

- Best first test: **Ultrasound**



Acute Cholecystitis



HIDA

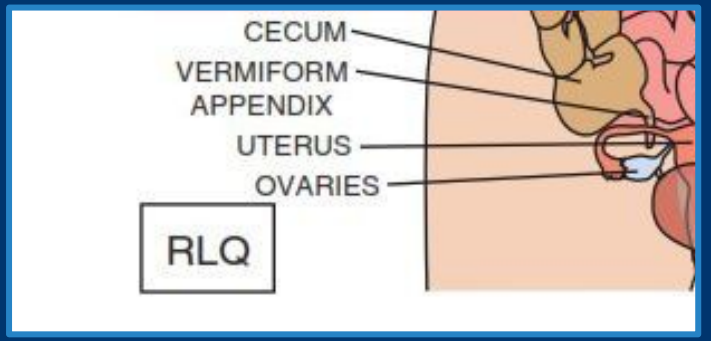
RLQ

Clinically

- RLQ pain
  - Differentials: Appendicitis, Ovarian pathology, Crohns, Kidney stone, Inguinal hernia
- Supporting labs: WBC, UA, pregnancy test

Radiologically

- Flank pain radiating to groin, blood in UA
  - **CT abdomen without contrast**
- GU
  - **Ultrasound**
- GI (IBD, appendicitis, diverticulitis)
  - Adults: **CT abdomen with IV contrast**
  - Pediatrics: **Ultrasound**

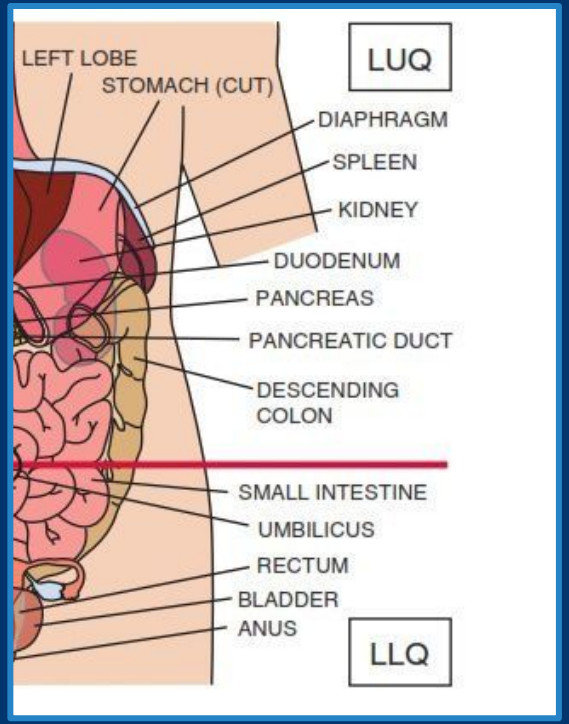


Abdominal Pain - LUQ & LLQ

Clinically

- LUQ pain
  - Differentials: Gastritis, dyspepsia, pancreatitis, splenomegaly
- LLQ pain
  - Differentials: Diverticulitis, Kidney stone

- LUQ
  - Gastritis/dyspepsia → **no imaging**
  - Pancreatitis
    - First Line: Ultrasound
    - CT is used only for diagnosing complications (>2-3 days)
- LLQ
  - Diverticulitis → CT with contrast
  - Kidney stone → non contrast CT



What is the most common ultrasound feature for pyelonephritis imaging

a) Patchy hypo and hyperechogenicity of renal parenchyma

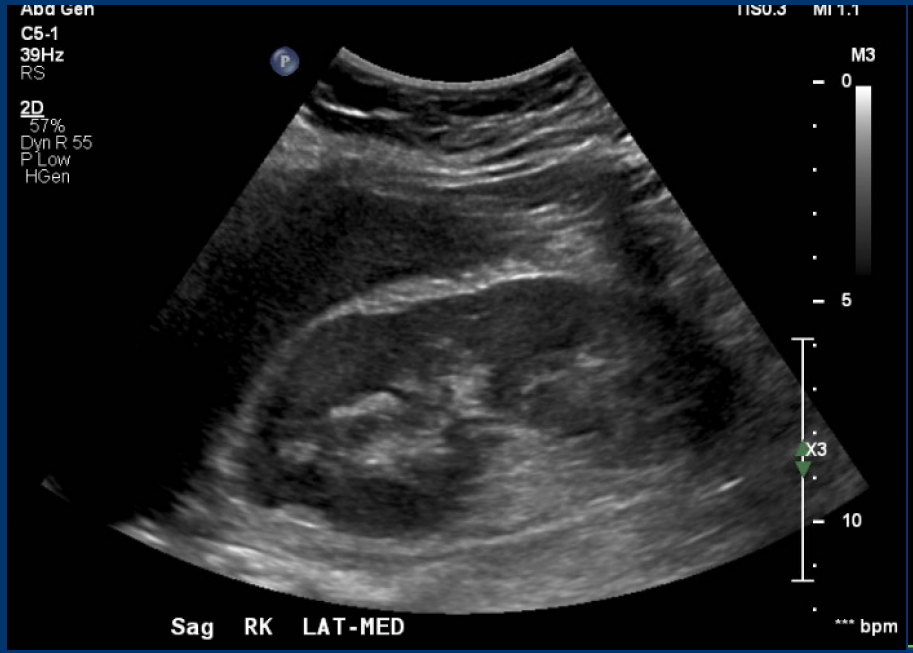
b) Diffuse hypoechogenicity of the kidney

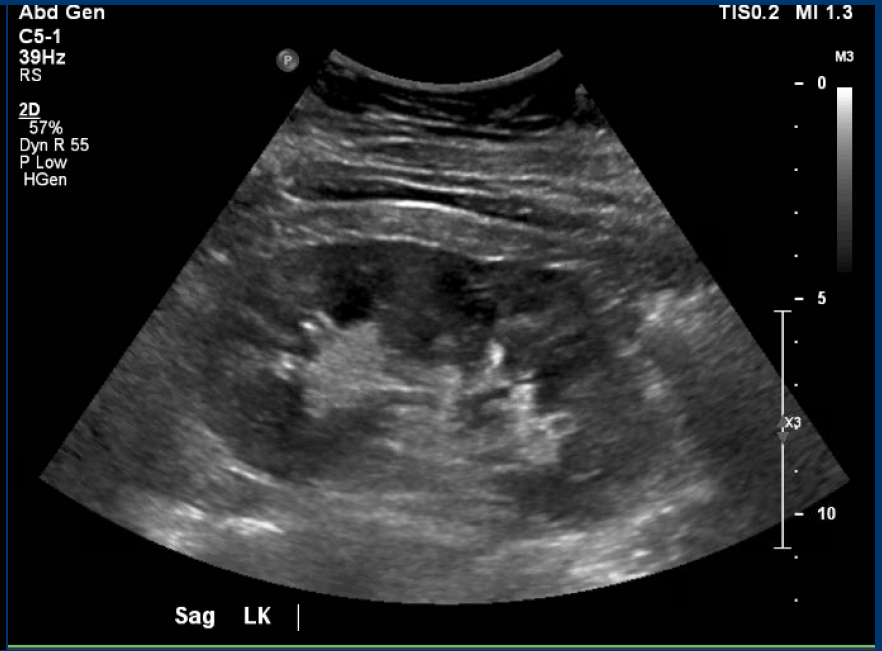
c) Multiple echogenic renal calculi with posterior acoustic shadowing

d) Diffuse hyperechogenicity of the kidney

e) Normal renal ultrasound

45 year old female with flank pain and abnormal urinalysis





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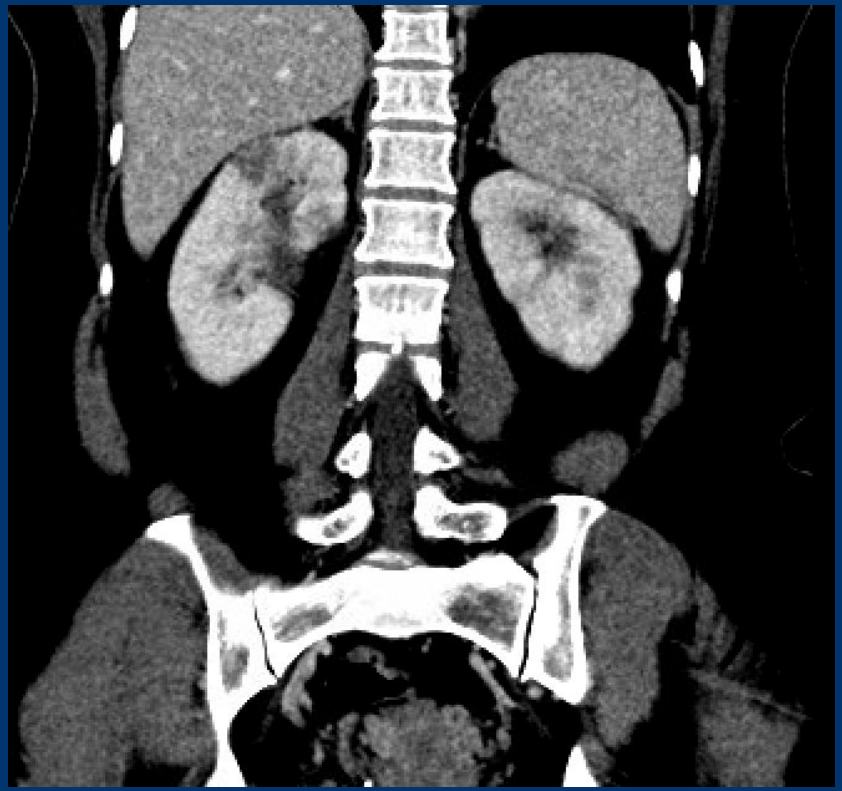
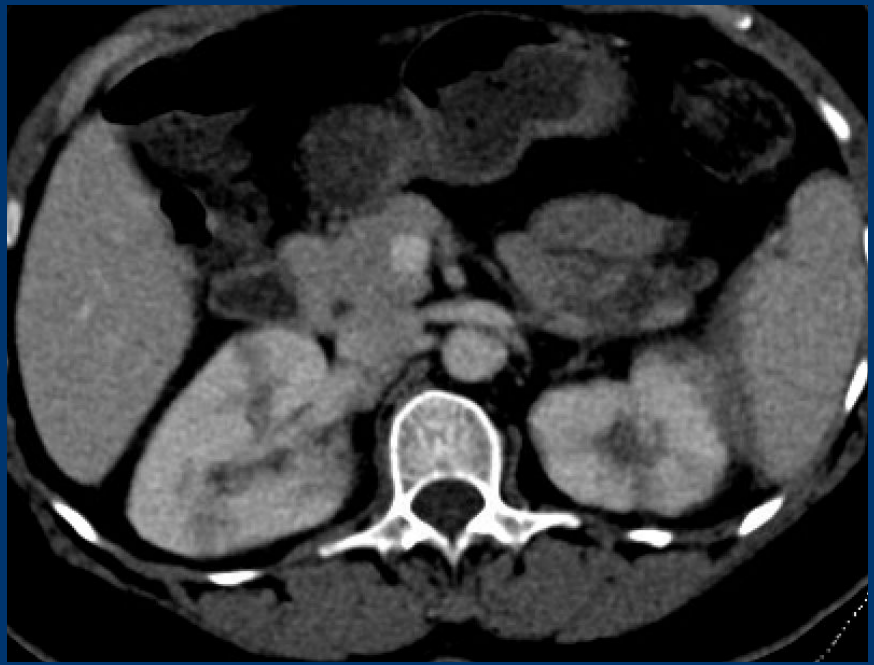
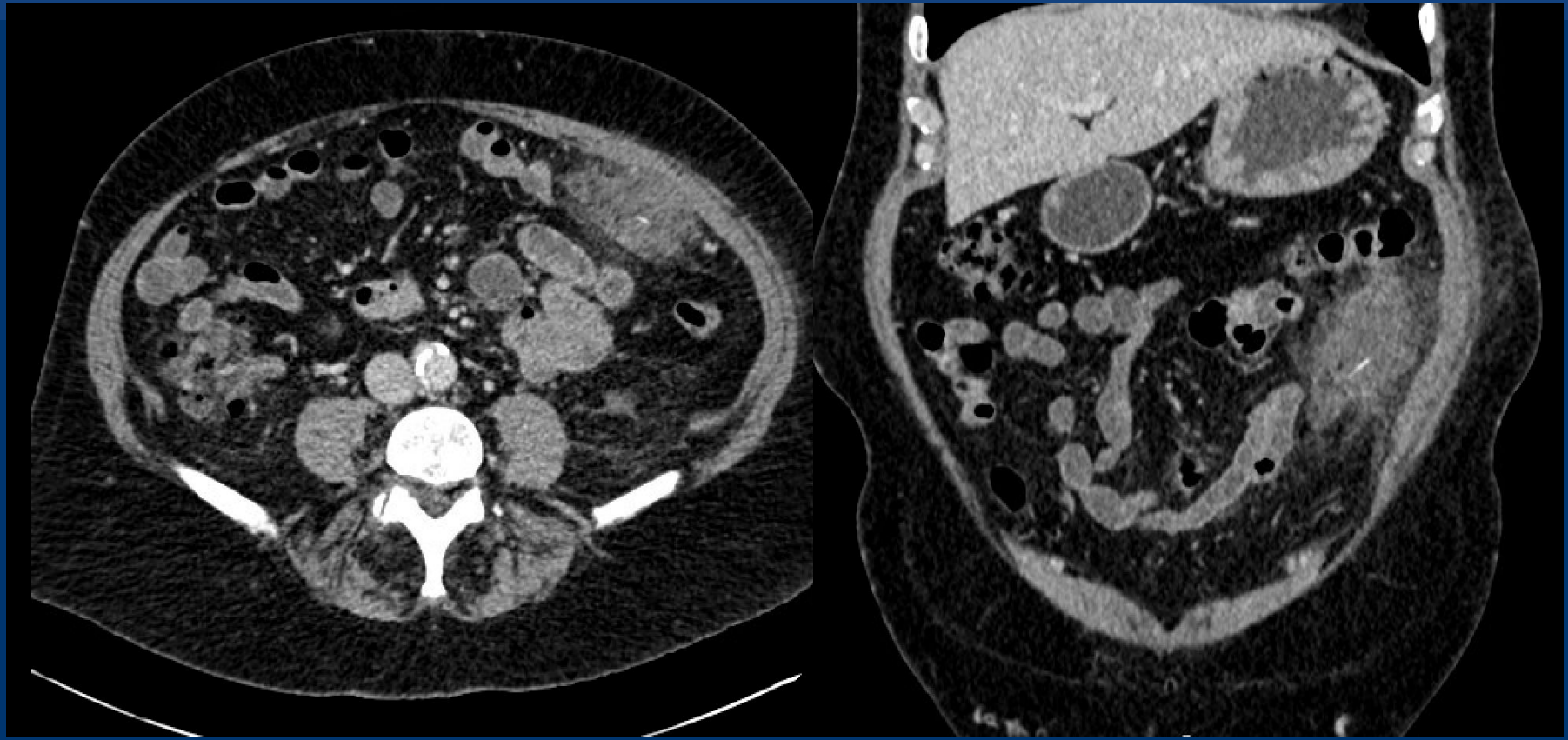
45 year old female with flank pain and abnormal urinalysis





56 y/o with worsening abdominal pain



35-year-old woman, intermittent RLQ pain x 8 months. No significant past medical history. Normal labs. Normal exam.

a) Radiographs (KUB X-ray)

b) CT with contrast

c) CT without contrast

d) RUQ Ultrasound

e) Magnetic resonance imaging (MRI)

f) No imaging is indicated

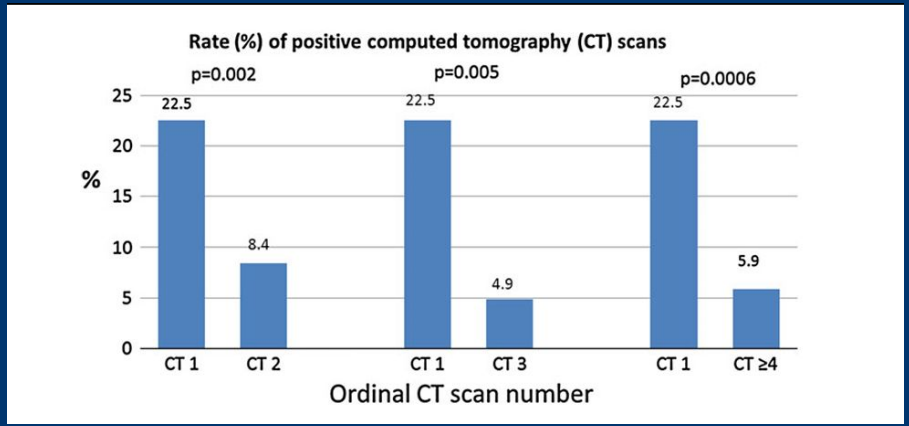
Abdominal Pain Red Flags

•Chronic and/or diffuse abdominal pain ⇒ Imaging often low yield without red flag symptoms.

- 1.2% of patients without warning features had positive CT findings in the outpatient primary care setting

- **Red flags that justify imaging** : Weight loss, GI bleeding, Anemia, Fever, persistent vomiting, cancer history, post-surgical complications

- Repeat imaging:



Master SS, Longstreth GF, Liu AL. Fam Pract. 2005;22(5):474-7. Nojkov B, et al. Diseases and Sciences. 2013;58(4):1074-83.

What is the next study?

66-year-old male with severe abdominal pain, A-fib, lactate 2.8, and soft abdomen.

a) CT abdomen with and without pelvis with excretory phase

b) RUQ ultrasound

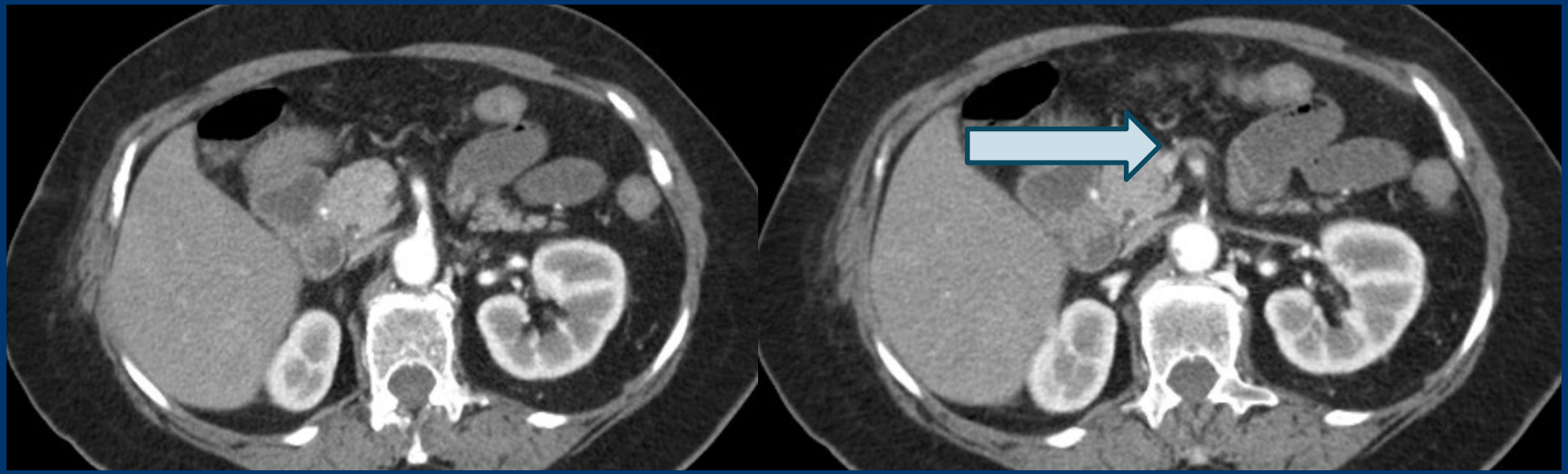
c) CTA abdomen and pelvis

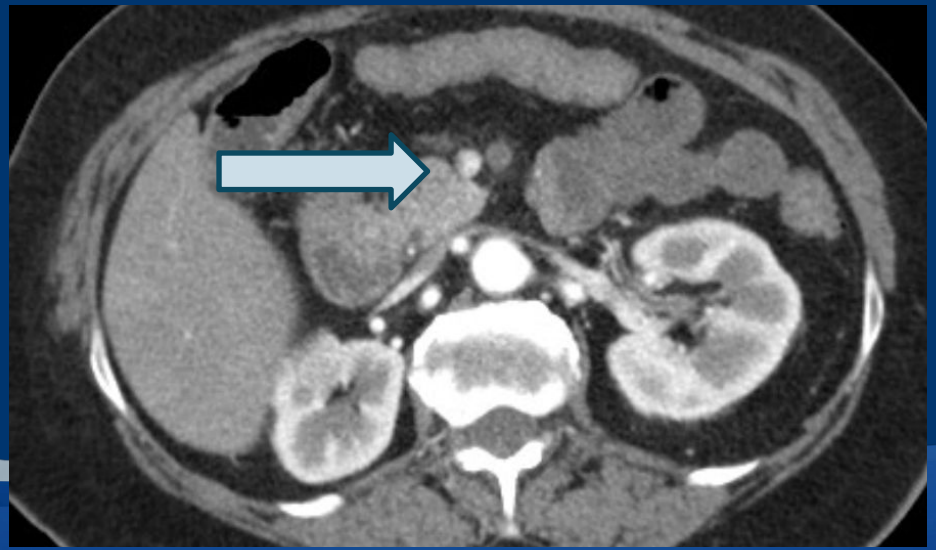
d) MRA abdomen and pelvis

What is the next study?

Variant: 1 Suspected acute mesenteric ischemia. Initial imaging.

Procedure	Appropriateness Category
CTA abdomen and pelvis with IV contrast	Usually Appropriate
US duplex Doppler abdomen	May Be Appropriate
Radiography abdomen	May Be Appropriate
Arteriography abdomen	May Be Appropriate (Disagreement)
MRA abdomen and pelvis without and with IV contrast	May Be Appropriate (Disagreement)
CT abdomen and pelvis with IV contrast	May Be Appropriate
MRA abdomen and pelvis without IV contrast	Usually Not Appropriate
CT abdomen and pelvis without IV contrast	Usually Not Appropriate
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate



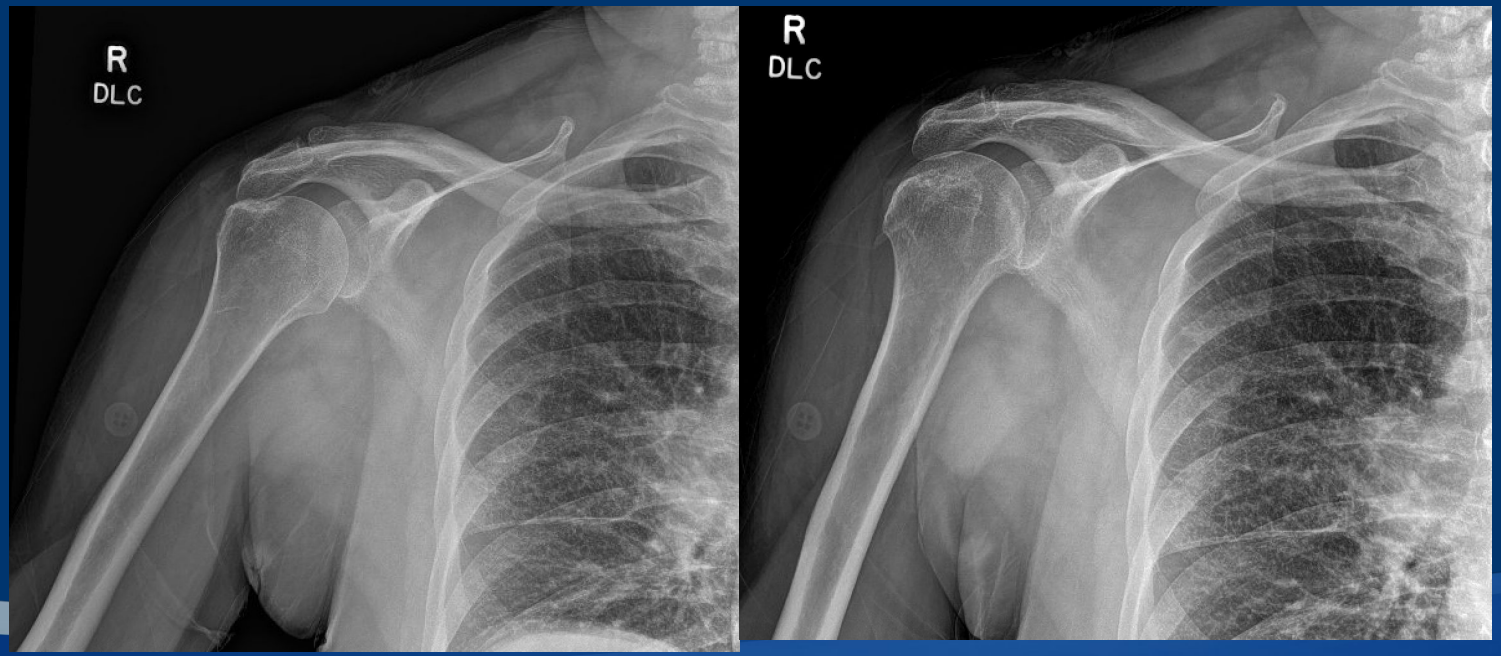


If you look, you'll find something

- Renal masses
  - Simple cysts: Benign, no follow up recommended. Extremely common, no cancer risk.
  - Other (complex cyst, etc) : sometimes might require more imaging for definitive diagnosis
- Liver lesions
  - Cysts: Benign
  - Other: Almost always benign without history of cirrhosis or cancer. Likely need an MRI for definitive diagnosis. Often hemangioma, FNH, adenoma, ….
- Adrenal lesions
  - Most adrenal nodules are benign and non-functional
  - Check hormones / refer to endocrine or if > 4cm.
- Ovarian lesions
  - Premenopausal: Normal ovulatory process < 5cm.
  - Postmenopausal: follow with ultrasound

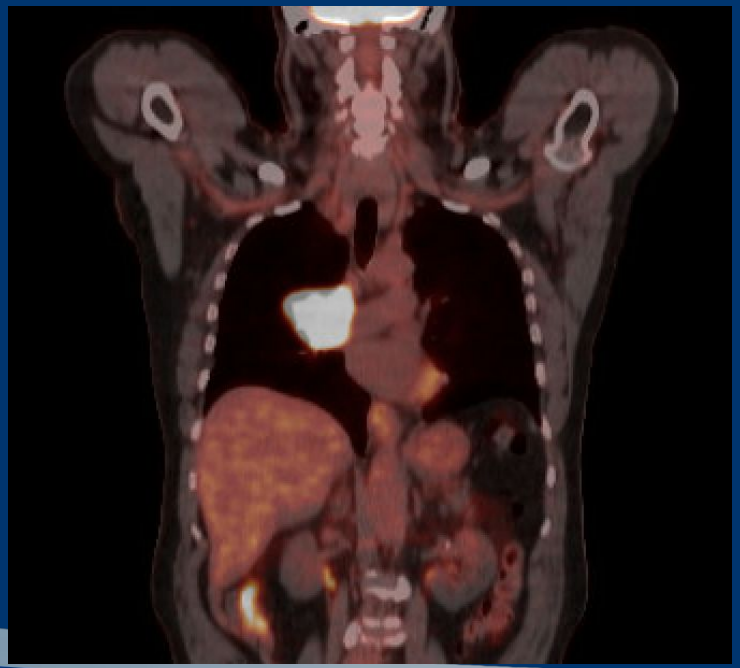
Unless you don’t look

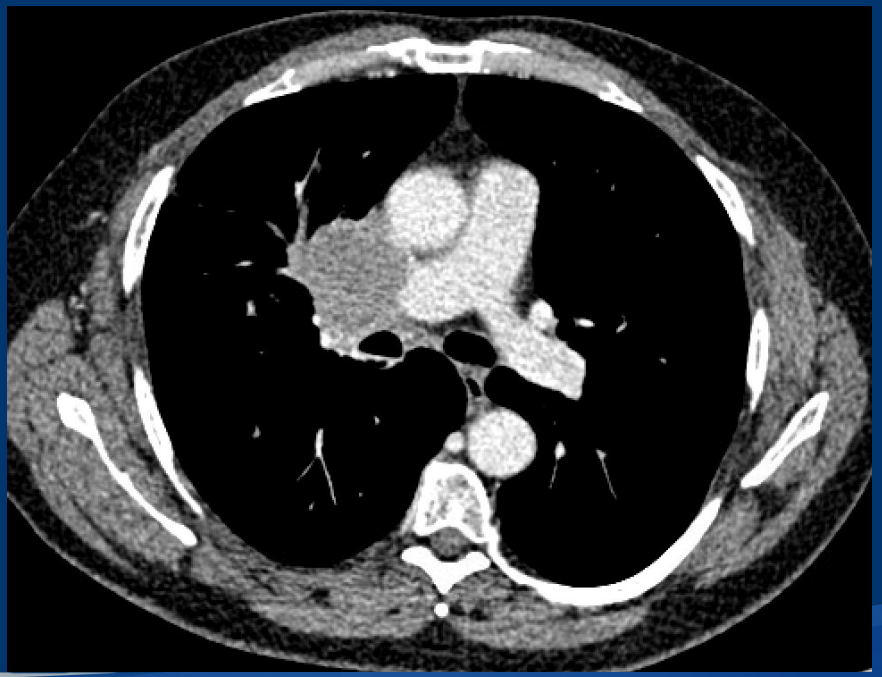
68-year-old male with right shoulder pain



Unless you don’t look

68-year-old male with right shoulder pain





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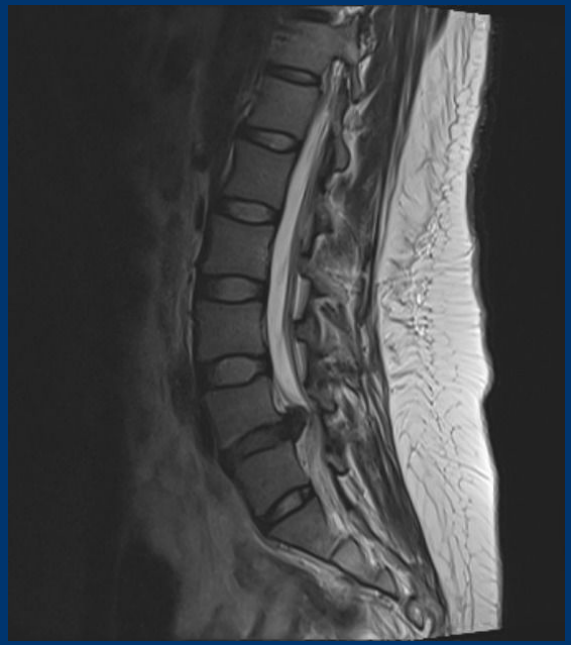
Musculoskeletal - Low Back Pain

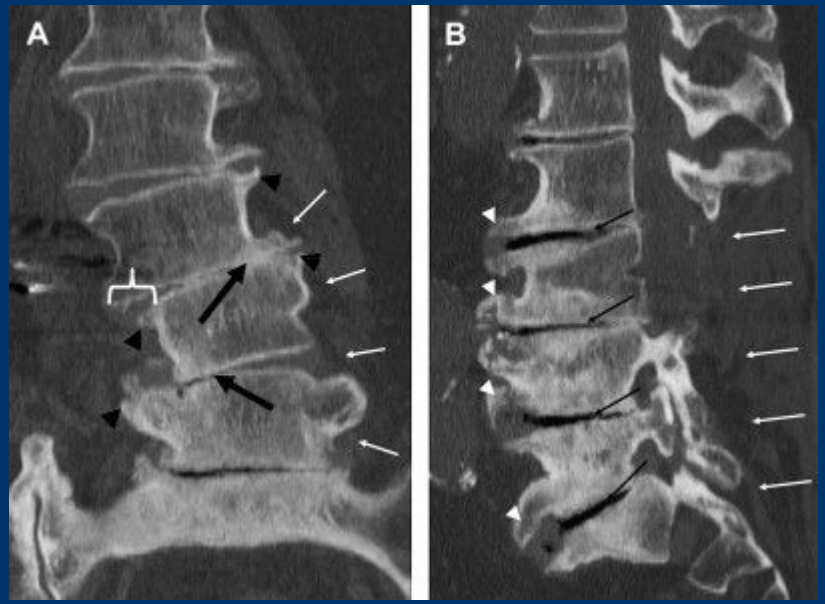
Expectations



Skalski M, Knipe H, Rodríguez G, et al. Degenerated disc. Reference article, Radiopaedia.org (Accessed on 15 Feb 2026) https://doi.org/10.53347/rID-42153

Musculoskeletal - Low Back Pain

Reality



Malfair D et al MRI Clinics of N. Am. 2007;15(2):221-238.

Musculoskeletal - Low Back Pain

Interpretation

Lumbar imaging for low-back pain without indications of serious underlying conditions does not improve clinical outcomes. Therefore, clinicians should refrain from routine, immediate lumbar imaging in patients with acute or subacute low-back pain and without features suggesting a serious underlying condition.

CONCLUSIONS:

Imaging findings of spine degeneration are present in high proportions of asymptomatic individuals, increasing with age. Many imaging-based degenerative features are likely part of normal aging and unassociated with pain. These imaging findings must be interpreted in the context of the patient's clinical condition.

Brinjikji W et al. **AJNR Am J Neuroradiol.** 2015;36(4):811-816. ; Chou R, et al. **Lancet.** 2009;373(9662):463-472.

Low back pain - ACR appropriateness

Variant: 1 Acute low back pain with or without radiculopathy. No red flags. No prior management. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography lumbar spine	Usually Not Appropriate	☢☢☢
MRI lumbar spine with IV contrast	Usually Not Appropriate	O
MRI lumbar spine without and with IV contrast	Usually Not Appropriate	O
MRI lumbar spine without IV contrast	Usually Not Appropriate	O
Bone scan whole body with SPECT or SPECT/CT complete spine	Usually Not Appropriate	☢☢☢
CT lumbar spine with IV contrast	Usually Not Appropriate	☢☢☢
CT lumbar spine without IV contrast	Usually Not Appropriate	☢☢☢
Discography and post-discography CT lumbar spine	Usually Not Appropriate	☢☢☢
CT lumbar spine without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT myelography lumbar spine	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

Variant: 2 Subacute or chronic low back pain with or without radiculopathy. No red flags. No prior management. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography lumbar spine	Usually Not Appropriate	☢☢☢
MRI lumbar spine with IV contrast	Usually Not Appropriate	O
MRI lumbar spine without and with IV contrast	Usually Not Appropriate	O
MRI lumbar spine without IV contrast	Usually Not Appropriate	O
Bone scan whole body with SPECT or SPECT/CT complete spine	Usually Not Appropriate	☢☢☢
CT lumbar spine with IV contrast	Usually Not Appropriate	☢☢☢
CT lumbar spine without IV contrast	Usually Not Appropriate	☢☢☢
Discography and post-discography CT lumbar spine	Usually Not Appropriate	☢☢☢
CT lumbar spine without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT myelography lumbar spine	Usually Not Appropriate	☢☢☢☢
FDG-PET/CT whole body	Usually Not Appropriate	☢☢☢☢

Low Back Pain - Red Flags

- Severe or progressive neuro deficits
- Fever, immunosuppression, IV drug use
- Cancer history / unexplained weight loss
- Chronic steroid use / significant osteoporosis
- Trauma
- Cauda equina symptoms (urinary retention, incontinence, saddle anesthesia,..)

Low back Pain – When Imaging is appropriate

Variant: 4 Low back pain with suspected cauda equina syndrome. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI lumbar spine without and with IV contrast	Usually Appropriate	O
MRI lumbar spine without IV contrast	Usually Appropriate	O

→ Emergency Department

Variant: 6 Low back pain with or without radiculopathy. One or more of the following: low-velocity trauma, osteoporosis, elderly individual, or chronic steroid use. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography lumbar spine	Usually Appropriate	☢☢☢
MRI lumbar spine without IV contrast	Usually Appropriate	O
CT lumbar spine without IV contrast	Usually Appropriate	☢☢☢

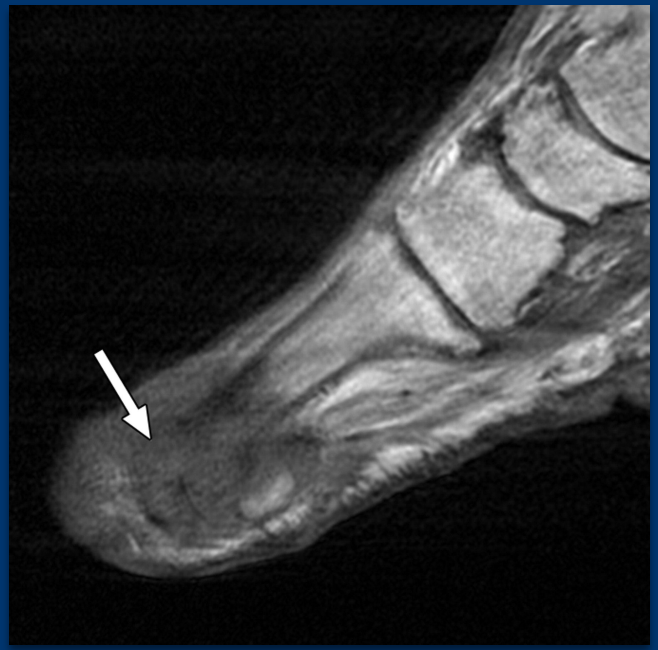
→ Concern for fracture

Osteomyelitis

- **Radiographs have low sensitivity for osteomyelitis ~62 %**
- Likely even lower in early course of disease
- Radiographs do not function for rule out osteomyelitis but to instead to establish baseline or alternative diagnosis

Procedure	Appropriateness Category
Radiography area of interest	Usually Appropriate
US area of interest	Usually Not Appropriate
MRI area of interest without and with IV contrast	Usually Not Appropriate
MRI area of interest without IV contrast	Usually Not Appropriate

Osteomyelitis workup after initial radiograph

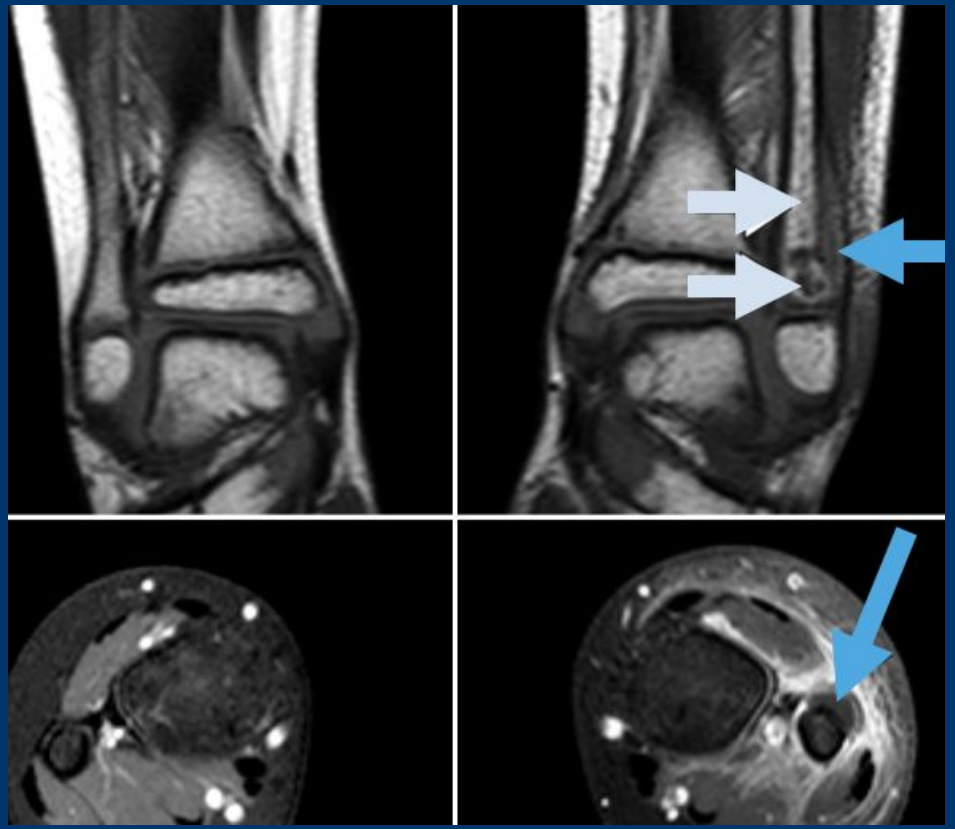


- MRI: sensitivity: ~95–97%
- Near-100% negative predictive value.

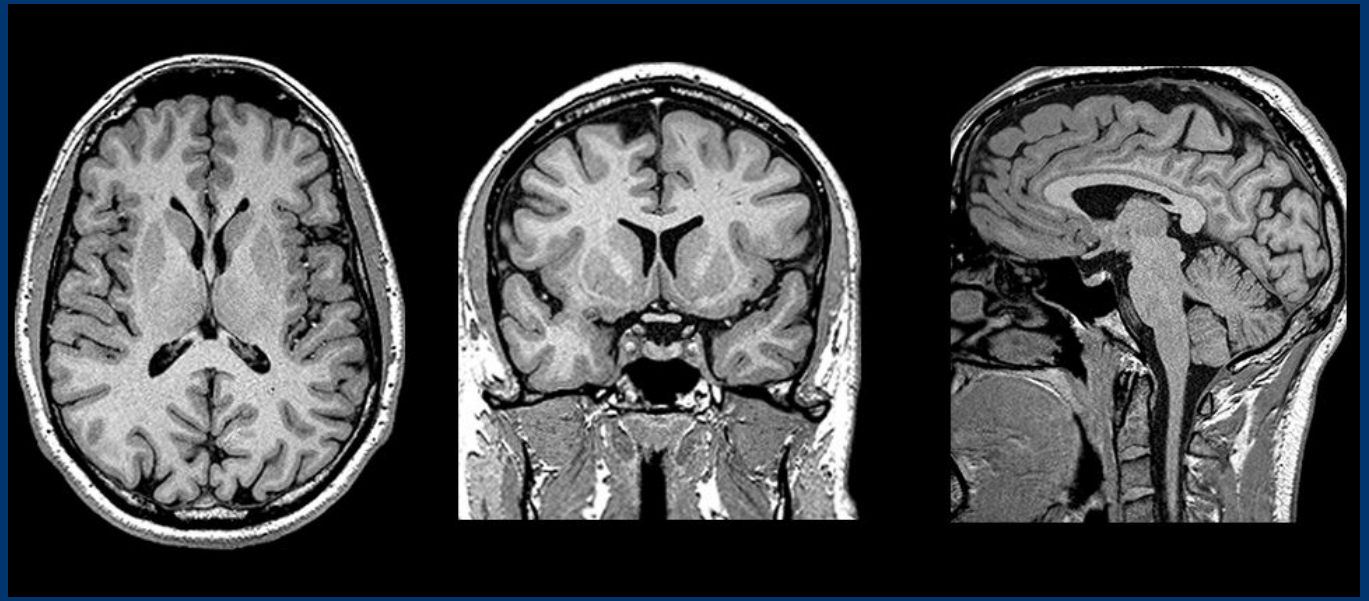
Variant: 3 Suspected osteomyelitis. Initial radiographs normal or with findings suggestive of osteomyelitis.

Procedure	Appropriateness Category
MRI area of interest without and with IV contrast	Usually Appropriate
MRI area of interest without IV contrast	Usually Appropriate
3-phase bone scan area of interest	May Be Appropriate
3-phase bone scan and WBC scan and sulfur colloid scan area of interest	May Be Appropriate
3-phase bone scan and WBC scan area of interest	May Be Appropriate
FDG-PET/CT area of interest	May Be Appropriate
WBC scan and sulfur colloid scan area of interest	May Be Appropriate
CT area of interest with IV contrast	May Be Appropriate
CT area of interest without IV contrast	May Be Appropriate

Osteomyelitis



Neuroimaging



Neuroimaging - headaches

- Headache is the **fourth leading cause of emergency department visits** in the United States
- **American Headache Society** guidance: *no neuroimaging is necessary* for headaches consistent with migraine with **normal neuro exam** and **no atypical features/red flags**.
- **0.2% prevalence of significant intracranial abnormality** among patients with migraine headache who had a normal neurologic examination

Variant 6: **Chronic headache. No new features. No neurologic deficit. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
CT head without IV contrast	Usually Not Appropriate	☢☢☢
MRI head without and with IV contrast	Usually Not Appropriate	O
MRI head without IV contrast	Usually Not Appropriate	O
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢
CTA head with IV contrast	Usually Not Appropriate	☢☢☢
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV head without IV contrast	Usually Not Appropriate	O
MRA head without and with IV contrast	Usually Not Appropriate	O
MRA head without IV contrast	Usually Not Appropriate	O

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Variant 4: **New headache. Classic migraine or tension-type primary headache. Normal neurologic examination. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Arteriography cervicocerebral	Usually Not Appropriate	☢☢☢
CT head with IV contrast	Usually Not Appropriate	☢☢☢
CT head without and with IV contrast	Usually Not Appropriate	☢☢☢
CT head without IV contrast	Usually Not Appropriate	☢☢☢
CTV head with IV contrast	Usually Not Appropriate	☢☢☢
CTA head with IV contrast	Usually Not Appropriate	☢☢☢
MRV head without and with IV contrast	Usually Not Appropriate	O
MRV head without IV contrast	Usually Not Appropriate	O
MRA head without and with IV contrast	Usually Not Appropriate	O
MRA head without IV contrast	Usually Not Appropriate	O
MRI head without and with IV contrast	Usually Not Appropriate	O
MRI head without IV contrast	Usually Not Appropriate	O

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Headache: Red Flags

Red flags increase the likelihood of detecting serious pathology.

Most neuroimaging studies in headache patients are normal.

Some red flags lack strong prospective evidence; likely requires even further refinement

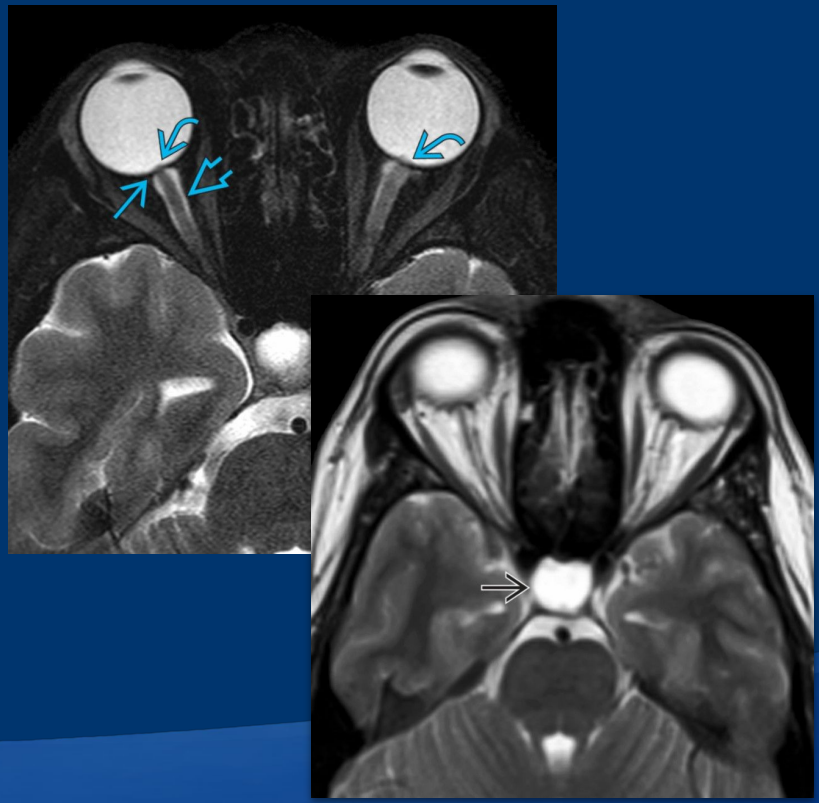
Do TP et al. *Neurology*. 2019;92:134–144.

MUSC
Medical University of South Carolina

26-year-old woman with presents with progressively worsening daily headaches over 3 months.

On physical exam:

- Visual acuity mildly reduced
- Bilateral optic disc edema on fundoscopic exam



Variant: 4 Headache with features of intracranial hypertension (eg, papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva). Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRI head without and with IV contrast	Usually Appropriate	O
MRI head without IV contrast	Usually Appropriate	O
CT head without IV contrast	Usually Appropriate	☢☢☢
MRV head with IV contrast	May Be Appropriate	O
MRV head without and with IV contrast	May Be Appropriate	O

Summary - Good Clinical Reasoning = Good Imaging

- **What is the clinical question?**
  Clear indication → better study → better interpretation
- **Will imaging change management?**
  If the result won't alter care, reconsider ordering
- **Choose the right modality**
  Use ACR Appropriateness Criteria as a guide
- **Start simple when appropriate**
  CXR / US before CT when clinically reasonable
- **Avoid reflex imaging**
  Chronic, diffuse, or low-risk symptoms rarely benefit
- **Think risk vs benefit**
  Radiation • contrast • incidentalomas • cost
- **Communicate with radiology**

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“The best study is the one that answers the clinical question with the least harm.”

Thank you!

MUSC

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