

SHEDDING LIGHT ON THE SUBJECT

Appropriate Imaging Tests
Lead to Meaningful Results

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OBJECTIVES

- ▣ Summarize the advantages and limitations of specific imaging tests and why clinical information is so important to radiologists
- ▣ Generate an understanding of how to select the most appropriate test for a patient in a specific scenario.

Evidence Based Medicine

- ▣ The ACR Appropriateness Criteria are evidence-based guidelines to assist in making the most appropriate imaging or treatment decision for a specific clinical condition.
- ▣ Available online at ACR.org
- ▣ Enhance quality of care and contribute to the most efficacious use of radiology.
- ▣ At SMMC, we also take into account radiation dose to the patient and overall cost

Evidence Based Medicine

ACR Appropriateness Criteria®

Clinical Condition: Acute Abdominal Pain and Fever or Suspected Abdominal Abscess . Postoperative patient with fever.

Radiologic Procedure	Appropriateness Rating
CT abdomen and pelvis with contrast	8
CT abdomen and pelvis without contrast	7
US abdomen	6
MRI abdomen and pelvis with contrast	6
X-ray abdomen	5
MRI abdomen and pelvis without contrast	5
X-ray contrast enema	4
Ga-67 scan abdomen	4
X-ray upper GI series with small bowel	3
In-111 WBC scan abdomen and pelvis	3

Available Imaging Modalities

- ▣ X-ray
- ▣ Ultrasound
- ▣ Computed Tomography
- ▣ MRI
- ▣ Angiography and nuclear medicine
- ▣ PET
- ▣ Fluoroscopy

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Imaging Test Decision

- ▣ Which imaging modality to use?
- ▣ What is the clinical question to be answered?
- ▣ Do I need to ask for special imaging protocols, IV contrast or oral contrast?

Imaging test selection by Body Region

- ▣ Abdomen
- ▣ Chest
- ▣ Neuro/spine

Imaging test selection by Body Region

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Abdominal X-Ray Series

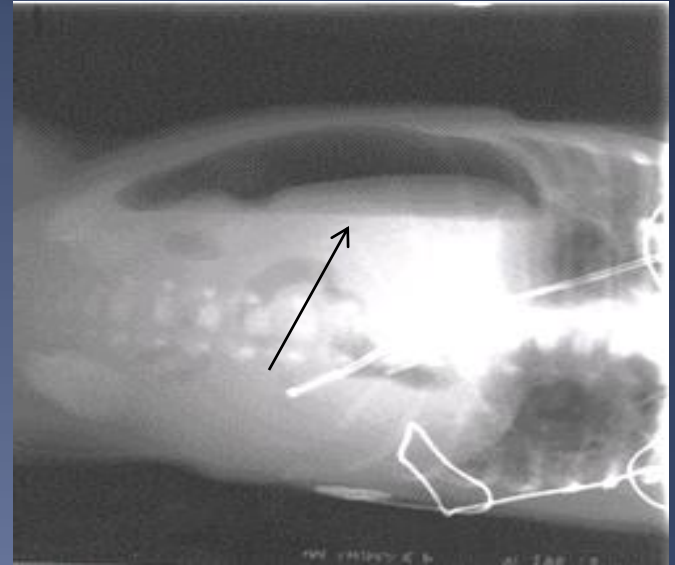
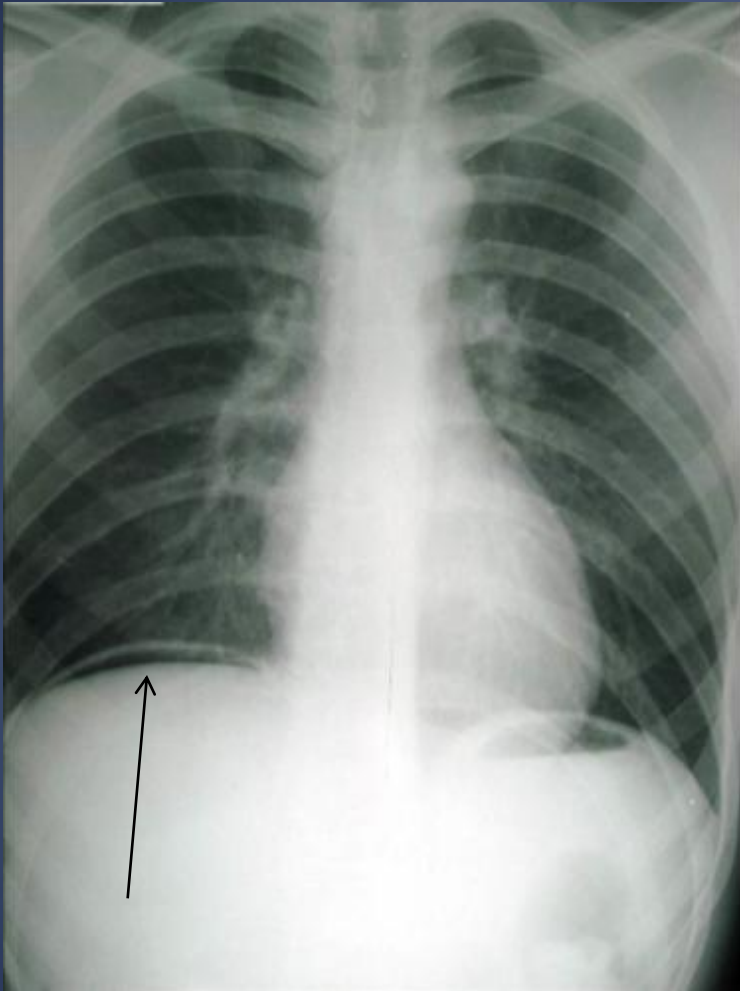
- ▣ Advantages
 - Rapid, generally easily available
 - inexpensive
 - Relatively low radiation dose

- ▣ Appropriate for:
 - Ingested foreign body
 - Suspected perforation
 - SBO

Foreign Bodies

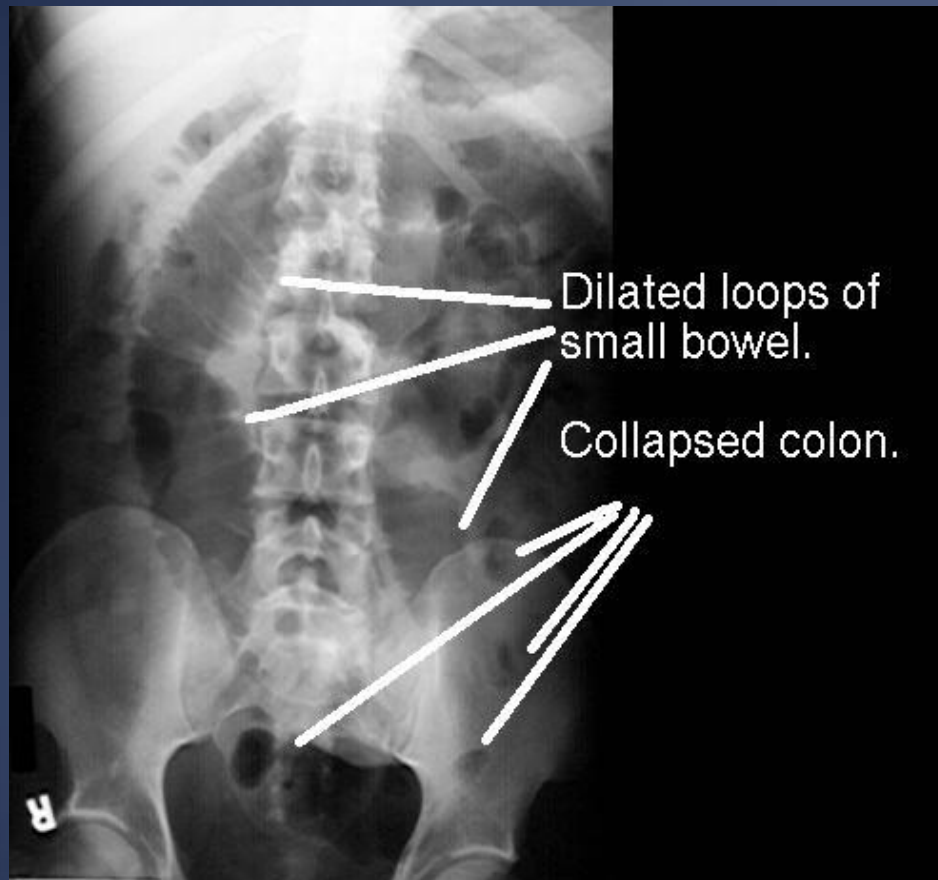


Free air



Small Bowel Obstruction

Supine positioning



Upright positioning



Limitations of Abdominal X-ray

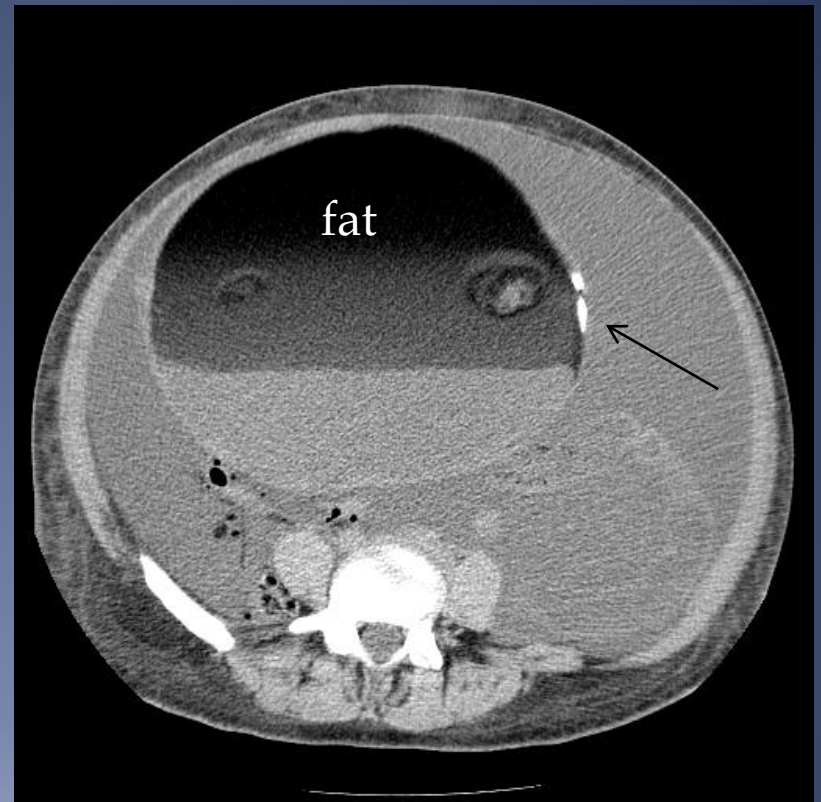
? constipation



Massive stomach distention
Secondary to Gastro paresis



Limitations of Abdominal X-ray



Tooth in a teratoma

Utility of Ultrasound and CT

▣ Ultrasound

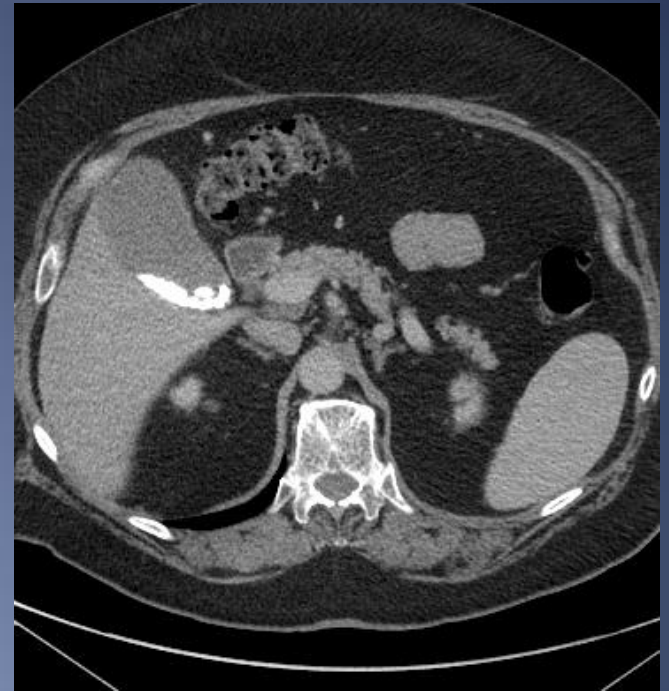
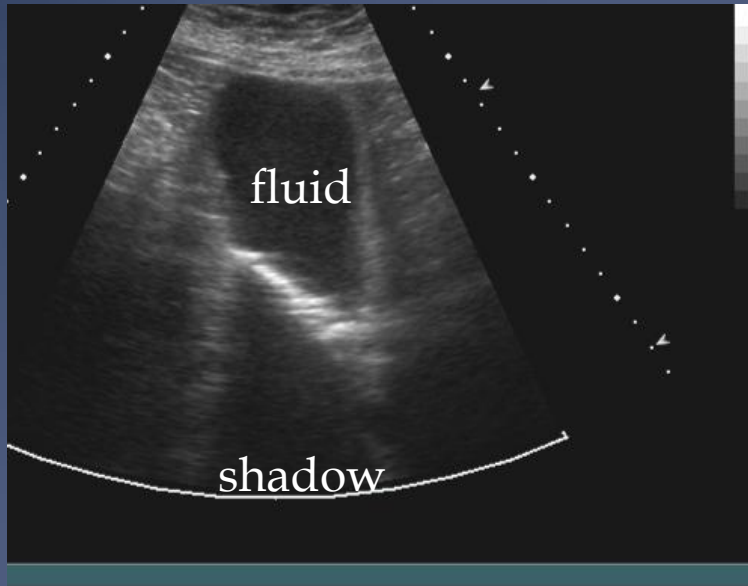
- No radiation exposure
- Good for biliary tract disease
- Abdominal organ survey
- Ascites

▣ Computed Tomography

- Bowel disease
- More complete view overall

Ultrasound of biliary tract

Skin surface

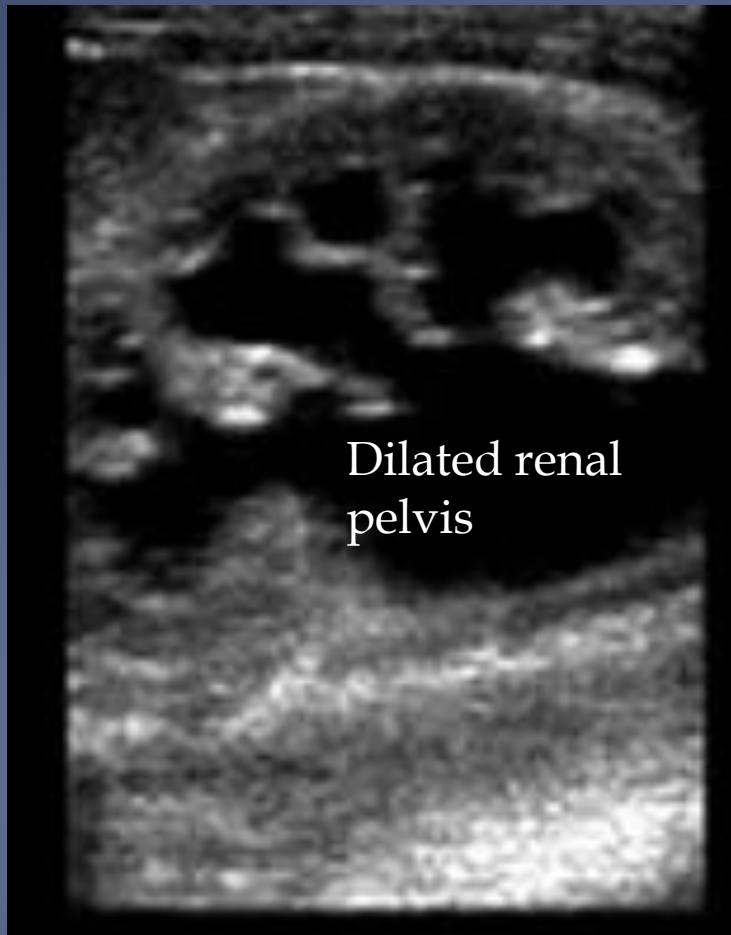


Ultrasound



Ultrasound

▣ hydronephrosis



Ultrasound

- ▣ Good for:
 - Fluid
 - ▣ Gallbladder, dilated collecting system, bladder
 - ▣ Ascites, pleural effusions
 - Superficial structures
 - ▣ Lymphadenopathy
 - ▣ seromas
 - ▣ Vascular imaging
 - Female pelvis

Ultrasound

- ▣ Limited for:
 - Masses of liver, spleen and kidneys
 - Characterization of superficial masses
 - Renal stones
- ▣ Not good for:
 - Gas obscured structures
 - ▣ Pancreas
 - ▣ Deep vasculature
 - Bowel
 - Fat

Typical Radiation Dose

- ▣ Limited for:

Computed Tomography

- ▣ Good for:
 - Fat obscured organs/large patients
 - Gas-obscured structures
 - Abdominal masses, deep or superficial
 - Renal stones
 - Bowel
- ▣ Not so good for:
 - Uterus/adnexal pathology
 - Gallstones/choledocolithiasis

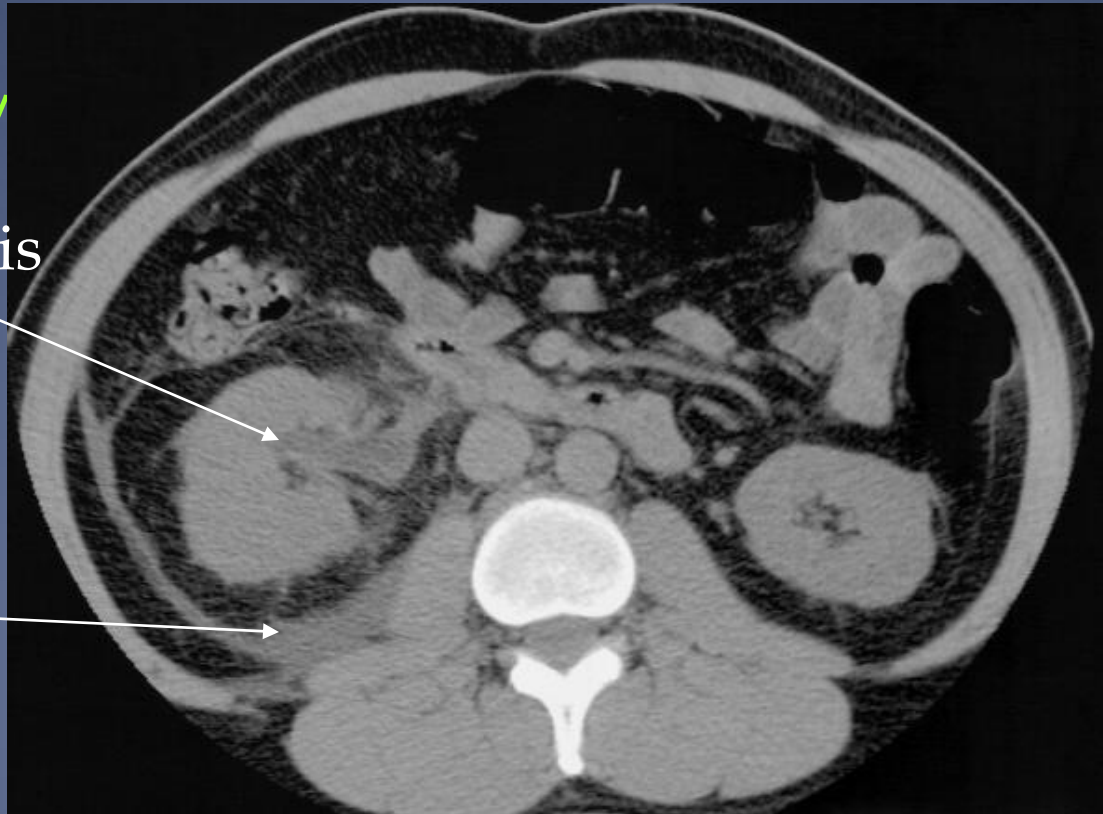
CT of the abdomen

- ▣ Fat is the friend of CT
 - In the acute setting, oral contrast is not generally required
 - IV contrast helpful, especially in the thin patient
- ▣ Studies have shown CT to be the most cost-effective imaging modality, >96% sensitive
 - Appendicitis
 - Diverticulitis
 - ischemia

Renal stones

1) 32 y/
hydronephrosis

stranding

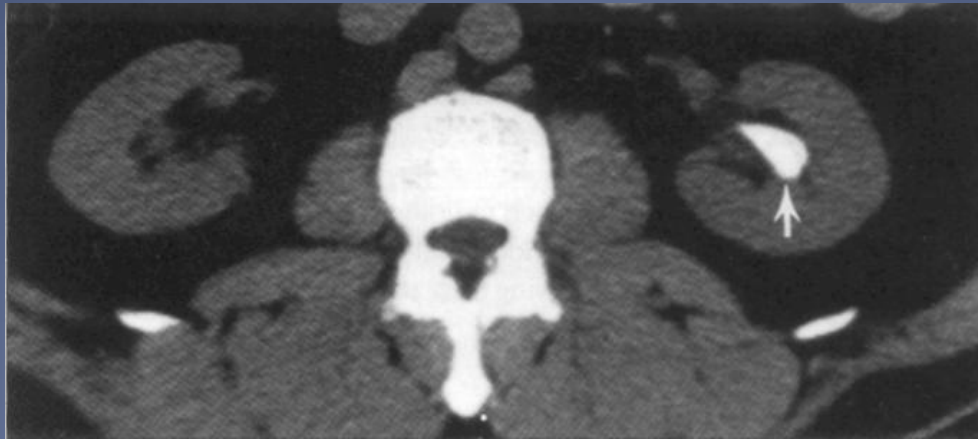


Renal stone



Renal Stones

Sensitivity



Uric acid stone

Abdominal Pain Study

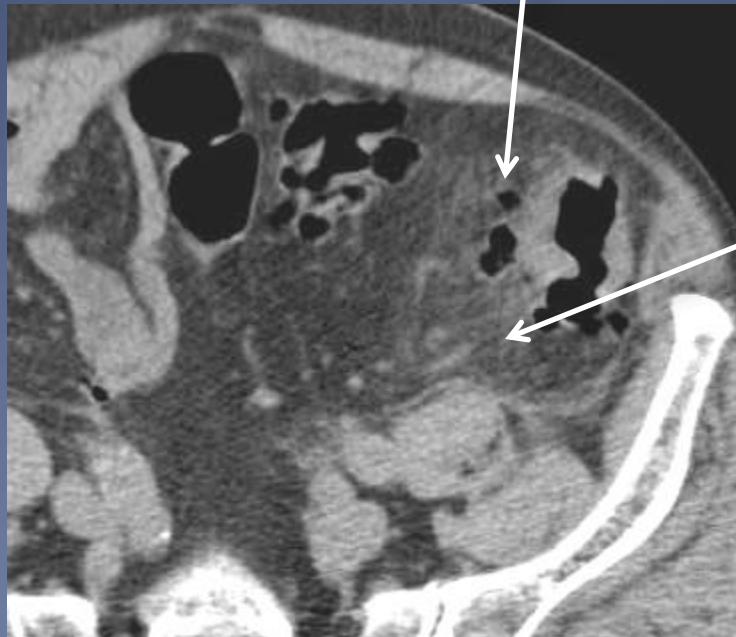
appendicitis

Inflamed
appendix



Diverticulitis

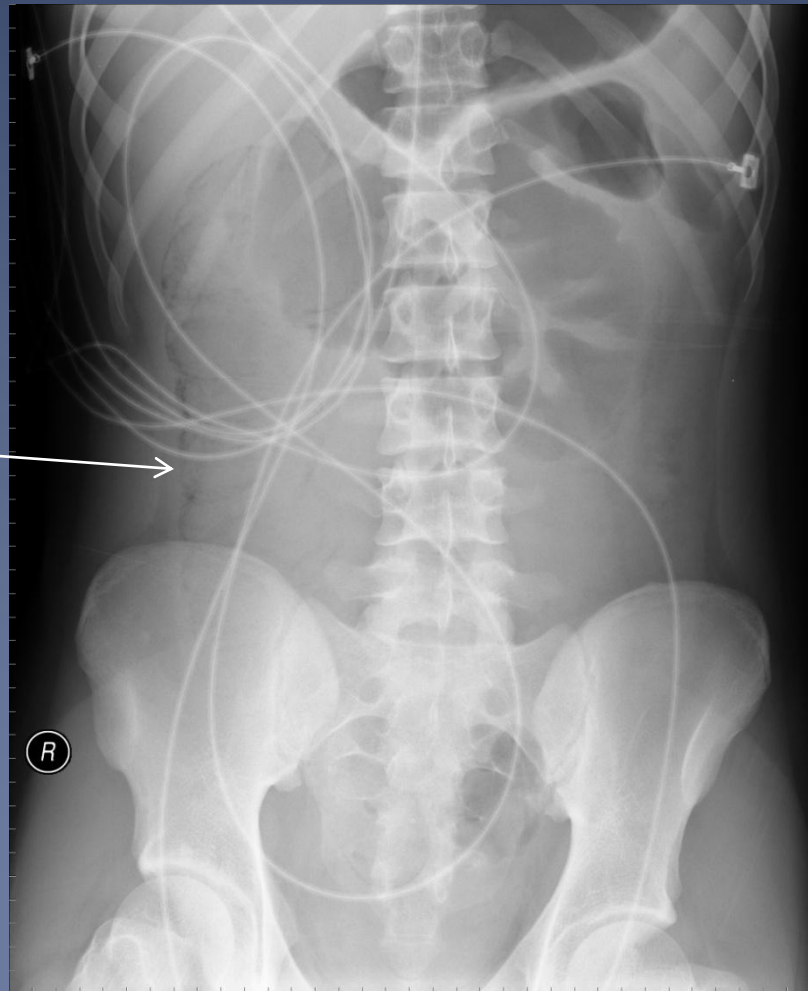
diverticula



Inflammation
of fat

CT detects gas

? stool



CT detects gas



CT detects gas

Portal venous gas



What is the Clinical Question to be Answered?

- ▣ What are you looking for?
- ▣ Interpretation of findings can be dependent upon type of patient, history of current situation, duration of symptoms, etc
- ▣ More information is better.

Free fluid

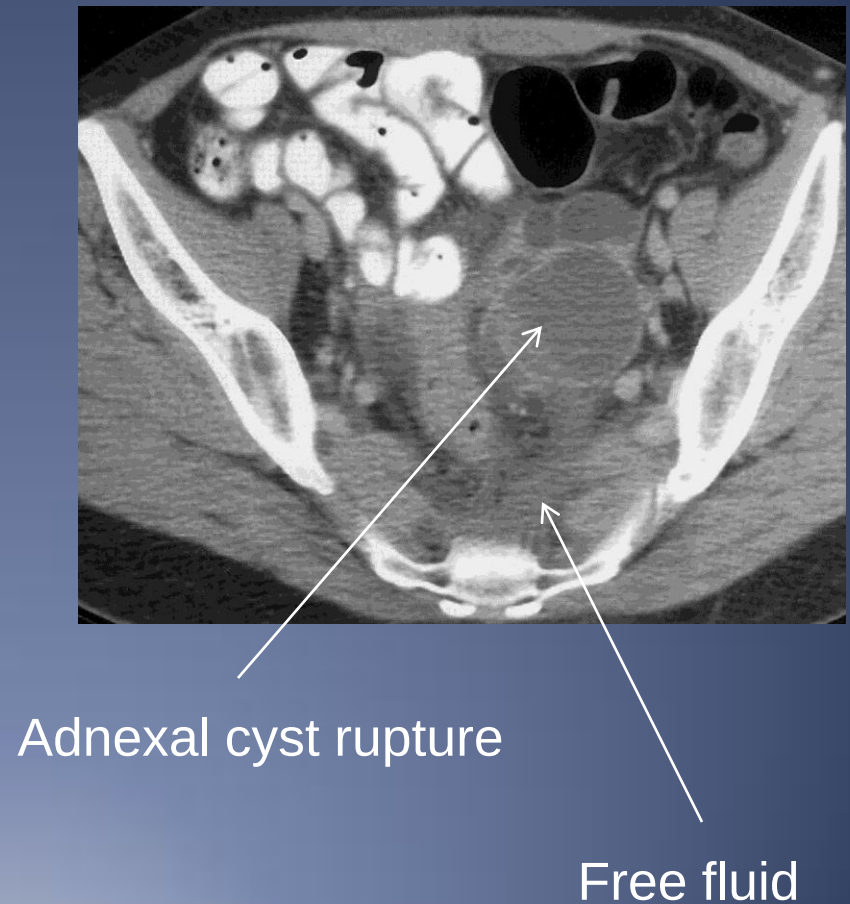
Normal or Abnormal?

Free fluid



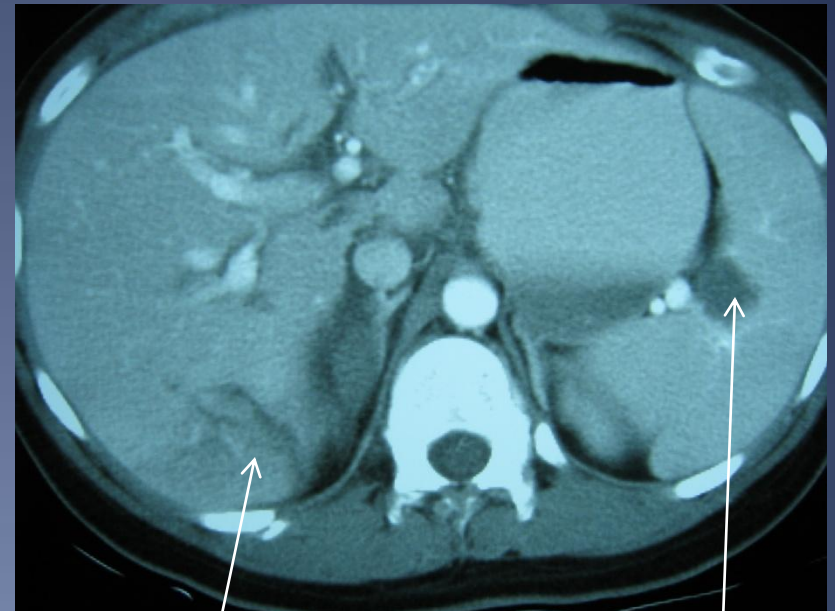
Free fluid

Normal or Abnormal?



Free fluid

Normal or Abnormal?



Free fluid

Normal or Abnormal?

Free fluid



carcinomatosis



Is IV contrast necessary?

- ▣ Fat is a natural contrast
 - Thin patients need IV contrast
- ▣ High suspicion for renal stones probably does NOT require IV contrast
- ▣ If unsure, the use of IV contrast helps in finding other diagnoses

Is IV contrast necessary?



Hydronephrosis
? stone

Is IV contrast necessary?



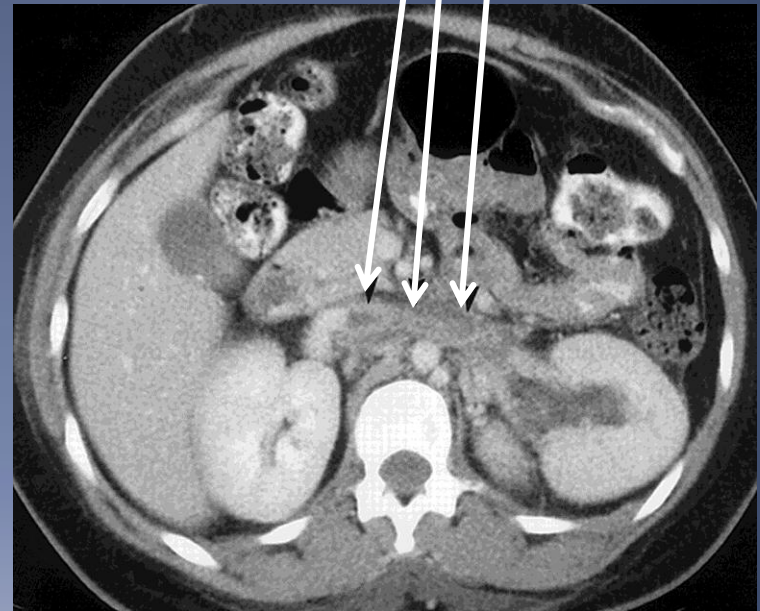
Pyelonephritis in
32 y/o woman with
fevers and UTI



Is IV contrast necessary?



Renal vein thrombosis in
27 y/o with SLE

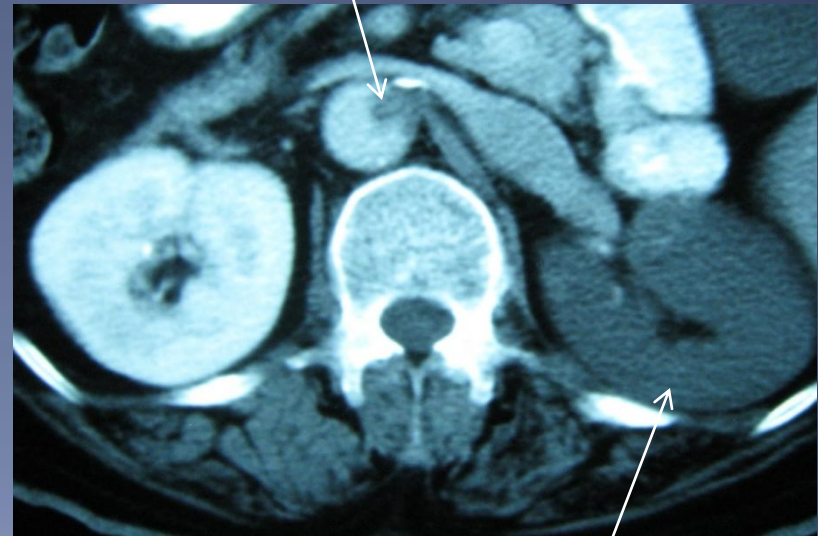


Is IV contrast necessary?



Hydronephrosis
? stone

Renal artery occlusion in
Patient with Atrial Fibrillation



Unenhanced kidney

Is IV contrast necessary?

Contraindications to iodinated contrast

Otherwise has relatively low risk

Will not obscure findings such as stones

Help elucidate disease process

Short Answer: probably will not hurt to use IV Contrast

Advanced CT Protocol

- ▣ Not all abdominal CT's are created equal
 - Rapid multiphase imaging possible
 - ▣ Pancreatic protocol
 - ▣ Liver protocol
 - ▣ CT angiography

Advanced CT Protocol

Pancreas Protocol

Hepatic artery

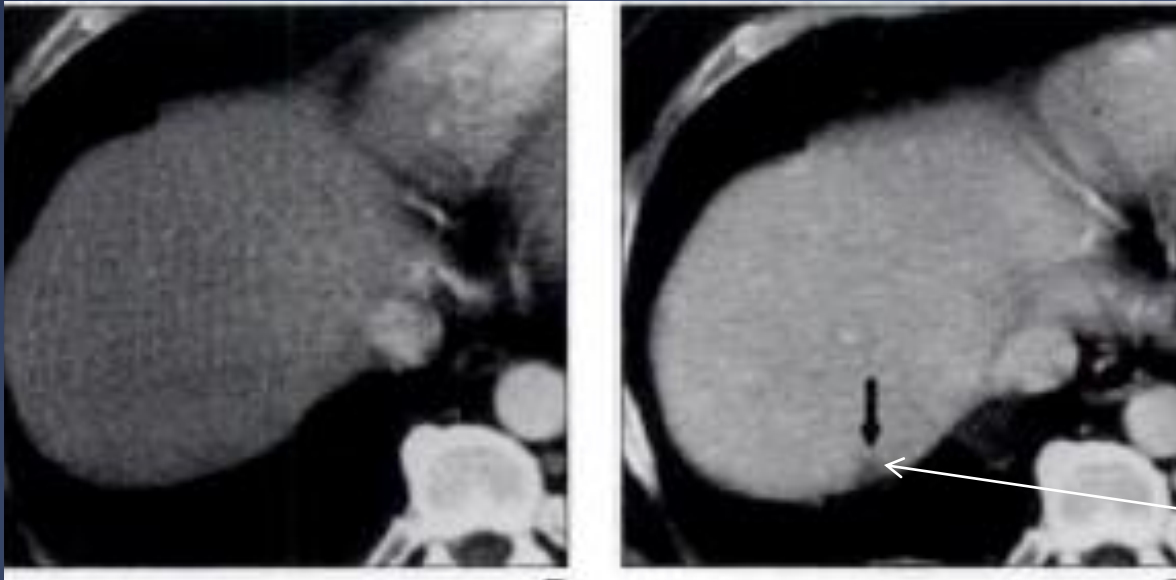
Pancreatic CA

Celiac axis



Advanced CT Protocol

Liver protocol

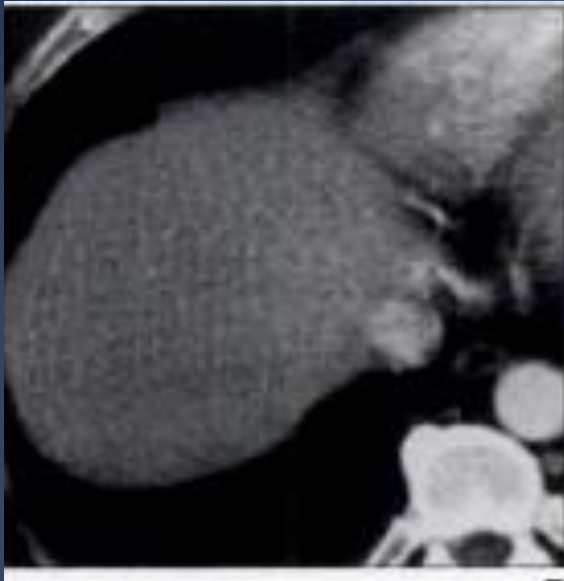


Question
lesion?

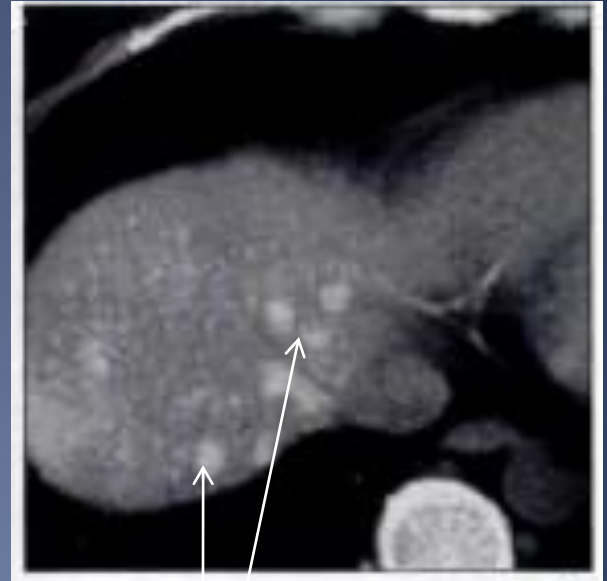
“Standard” CT abdomen

Advanced CT Protocol

Liver protocol



“Standard” CT abdomen

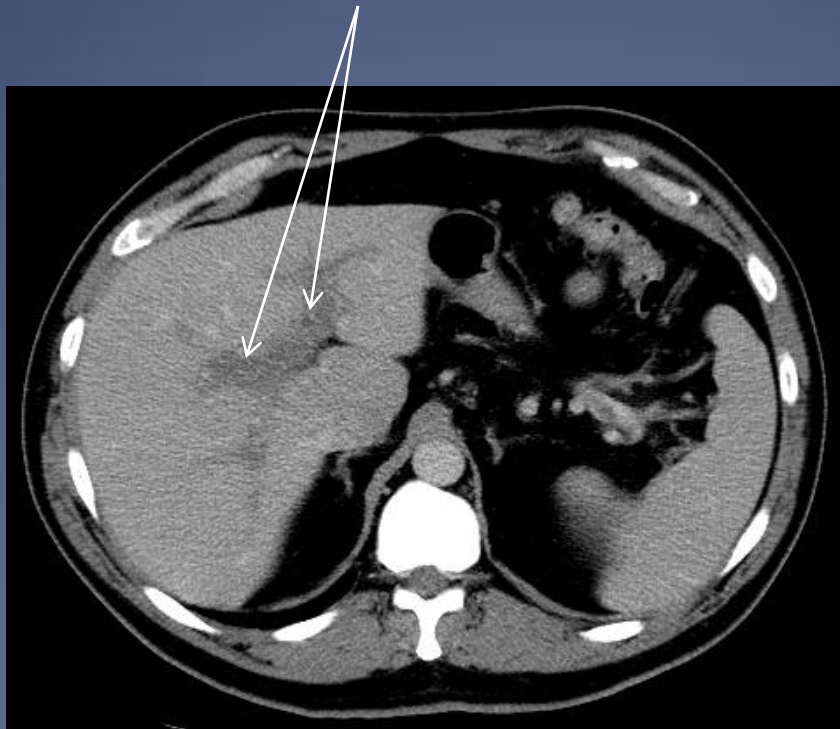


Arterial phase –
Hepatocellular CA

Advanced CT Protocol

Liver protocol -

Portal vein thrombosis

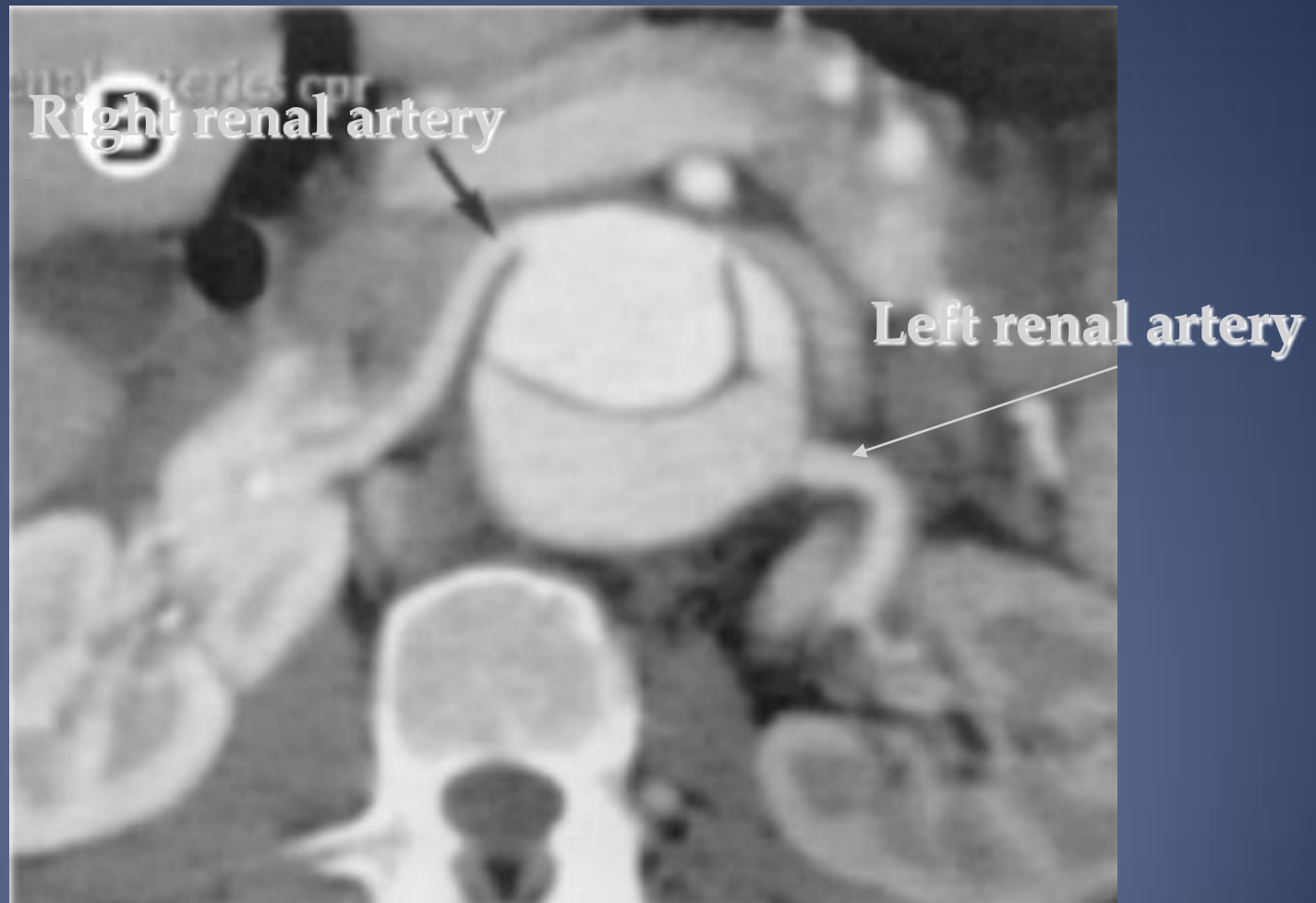


Advanced CTA Imaging

- ▣ AAA/PVD
- ▣ Renal artery stenosis
- ▣ Mesenteric artery stenosis
 - Sensitivity >95% (equal to conventional angiography)

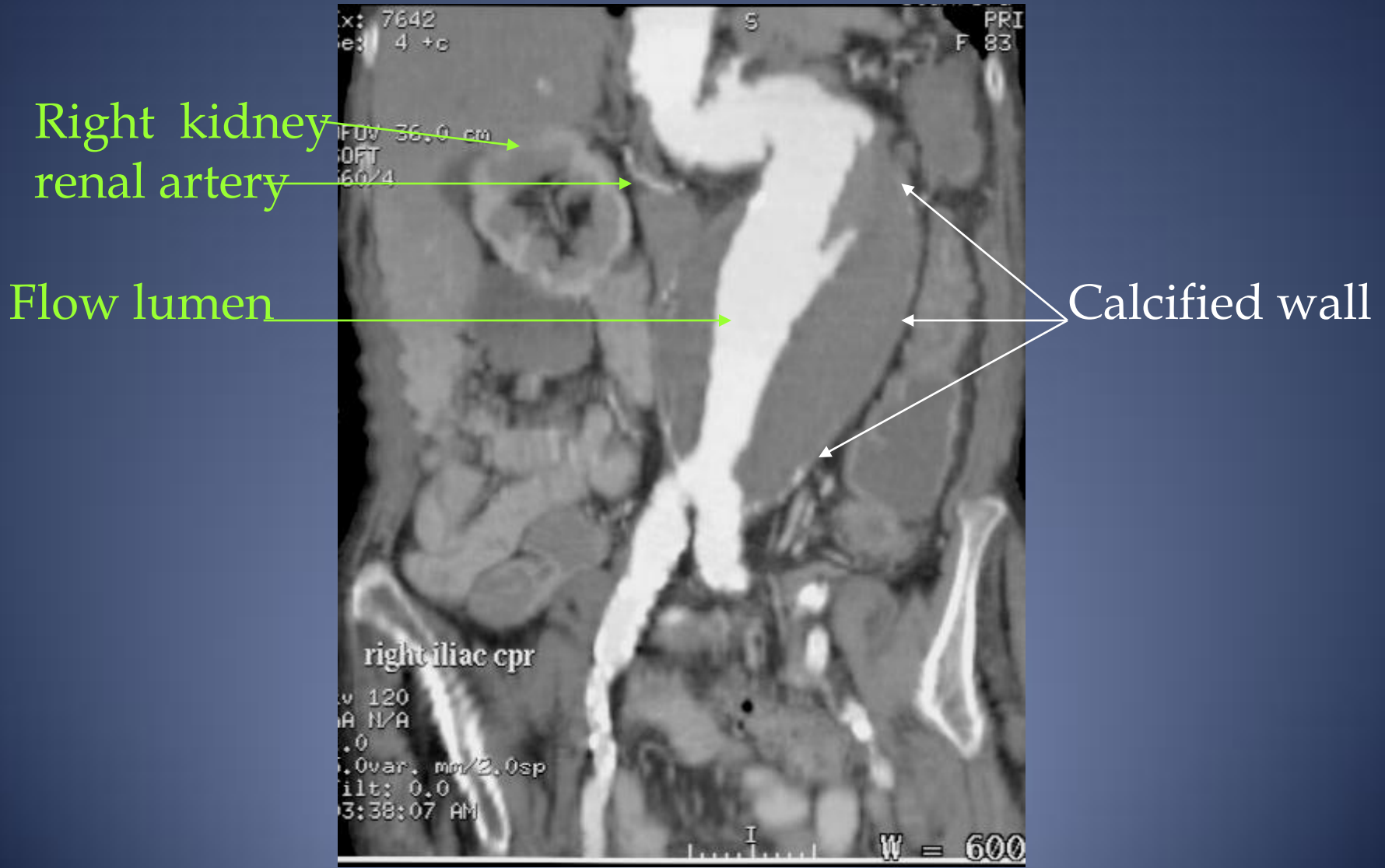
CT ANGIOGRAPHY

Aortic Dissection



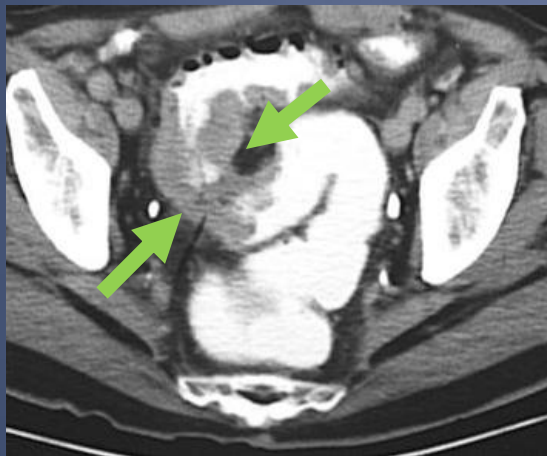
CT ANGIOGRAPHY

Abdominal Aortic Aneurysm

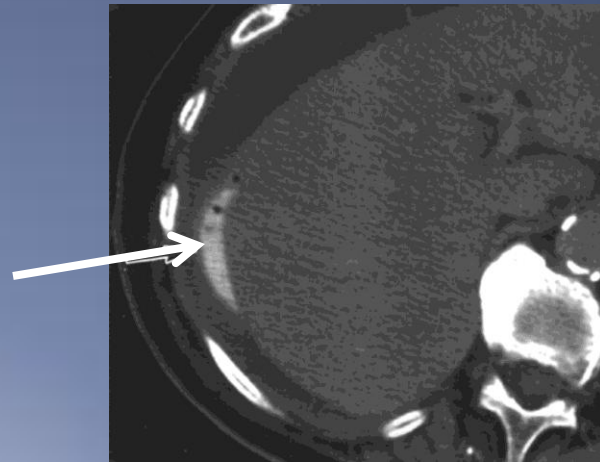


CT – is oral contrast necessary?

- ▣ Oral contrast is helpful for:
 - Chronic symptoms
 - Post operative patient in the evaluation for leak or abscess
 - Tumor staging



Sigmoid colon CA



Oral contrast leak

Advanced Abdominal Imaging

▣ MRI

- Generally not for acute abdominal complaints
 - ▣ ? Appendicitis in pregnant patients
- Good for:
 - ▣ Incidental adrenal mass workup
 - ▣ MRCP
 - ▣ Adnexal/uterine pathology
 - ▣ Certain tumors of liver and kidneys

MRCP



Summary of Abdominal Imaging Test Selection

- ▣ Abdominal x-ray series
 - SBO, free air, FB
 - Cheap, fast, but limited
- ▣ Ultrasound
 - Thin or young patients
 - Biliary disease, pelvic disease in women or children
- ▣ CT
 - Large body habitus. IV (not oral) in thinner patients and women
 - Bowel disease, deep organs, gas
 - Complete evaluation. Very sensitive

Patient selection

Ultrasound



Patient Selection

CT patient



Some large body habitus patients have relatively little peritoneal fat



Abdominal Workup Scenario

Decision Tree

- ▣ What are you looking for?
 - indication for exam?
- ▣ CT, US, XRAY or MRI
- ▣ If CT, with IV or Oral contrast?
- ▣ Special procedures
 - CTA, multiphase studies of liver or pancreas

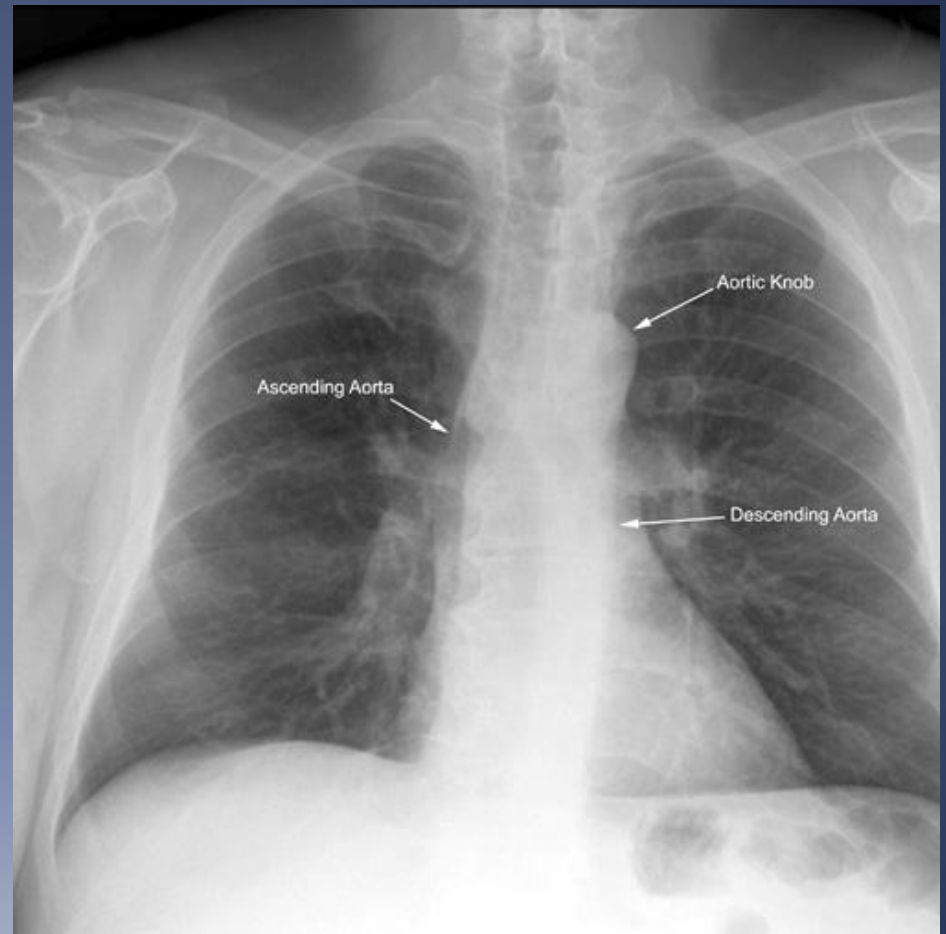
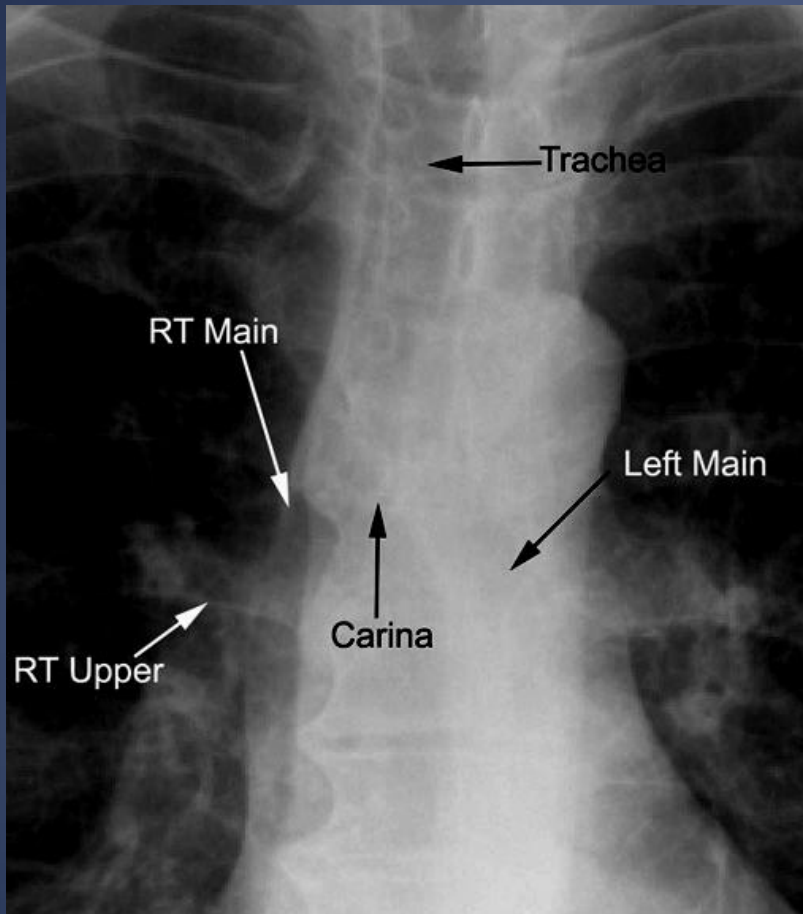
Chest Imaging

- ▣ CXR is still the most valuable player
 - Infiltrate and effusion
 - Pneumothorax
 - Detection of masses
- ▣ CT
 - Pulmonary embolism
 - Workup/follow-up of tumor
 - Vascular abnormalities
- ▣ Nuclear medicine
 - VQ scan

CXR interpretation



CXR interpretation

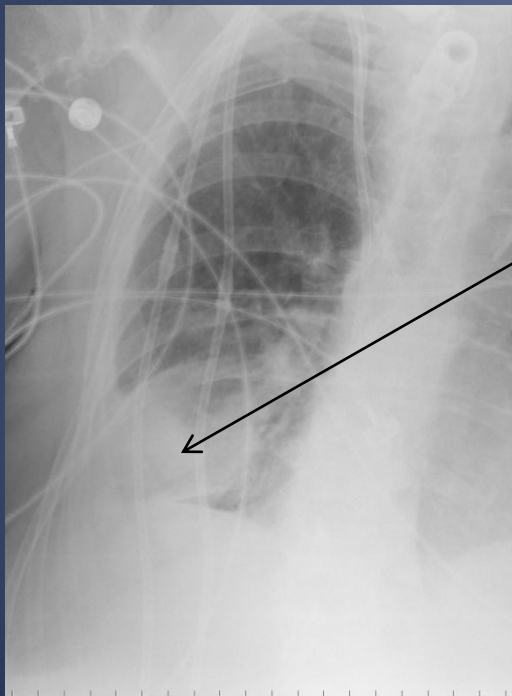


CXR interpretation

- ▣ Based on perception of density change
- ▣ Water, cells or debris in normally aerated structures
- ▣ Air in normally dense structures
- ▣ Configuration/mass effect
- ▣ Bones, lines, other

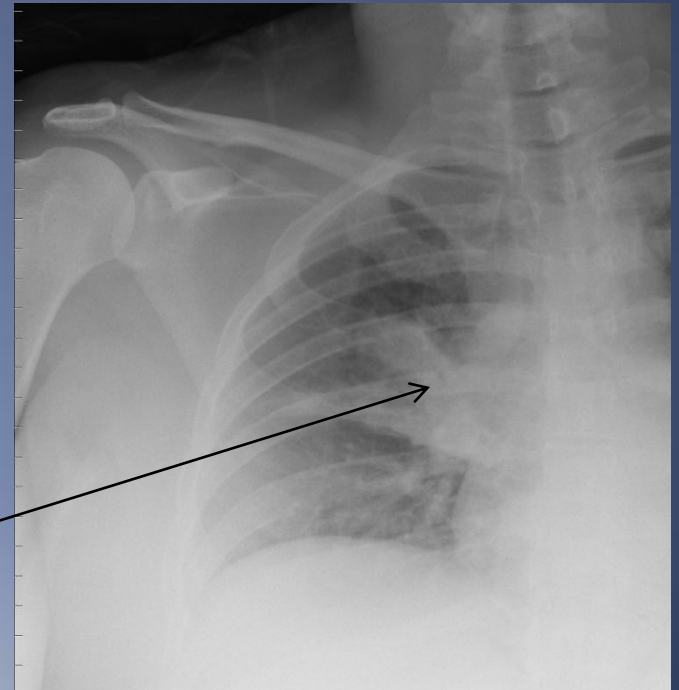
Infiltrates

- ▣ Normal lung silhouetted against the dense heart or diaphragm
- ▣ Infiltrate obscures the normal interface

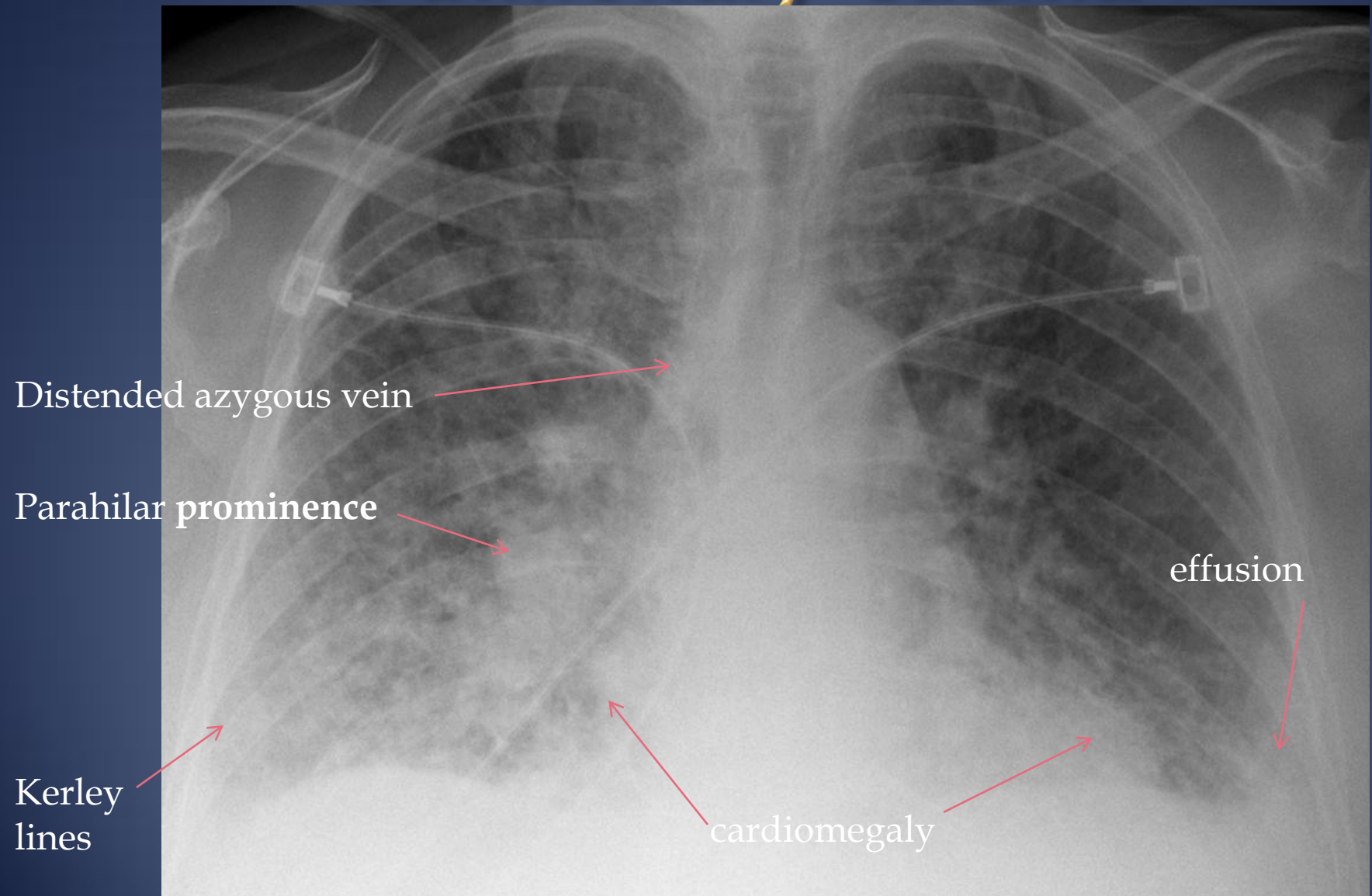


RLL infiltrate
obscures diaphragm

RUL infiltrate
obscures mediastinum



Pulmonary edema



Effusion

- ▣ Curves around lung
- ▣ Mass effect
- ▣ Decreased lung volume



Atelectasis

- ▣ Density within lung
- ▣ Volume loss

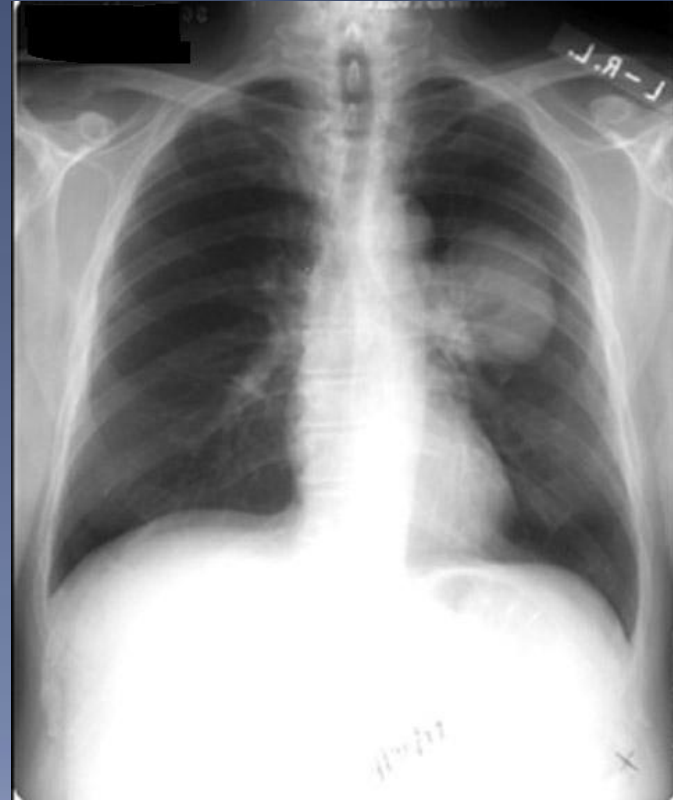
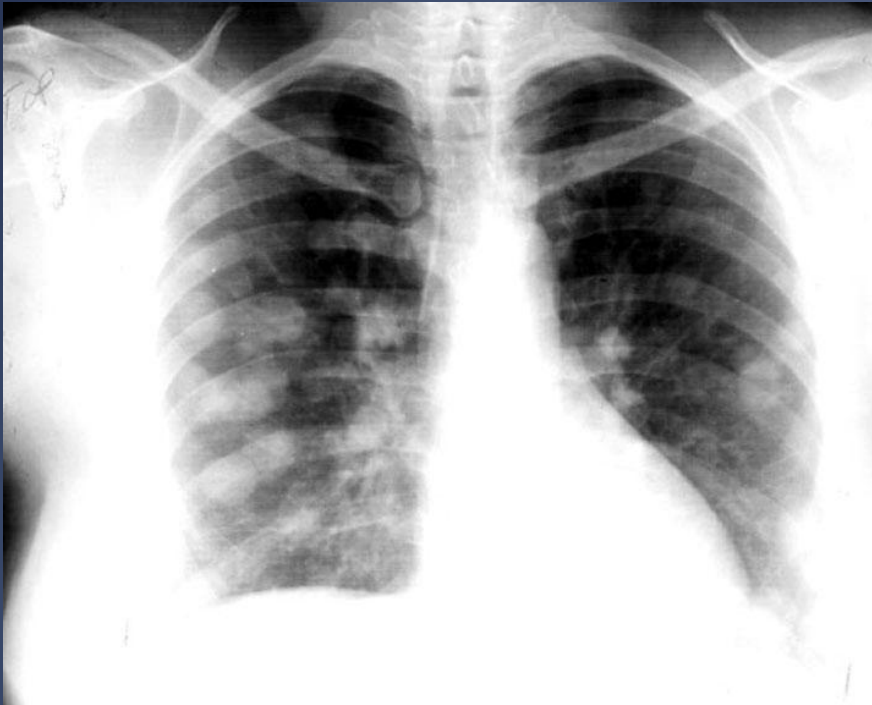


Pneumothorax

- ▣ See pleural line with aerated lung central and air in the pleural space peripherally



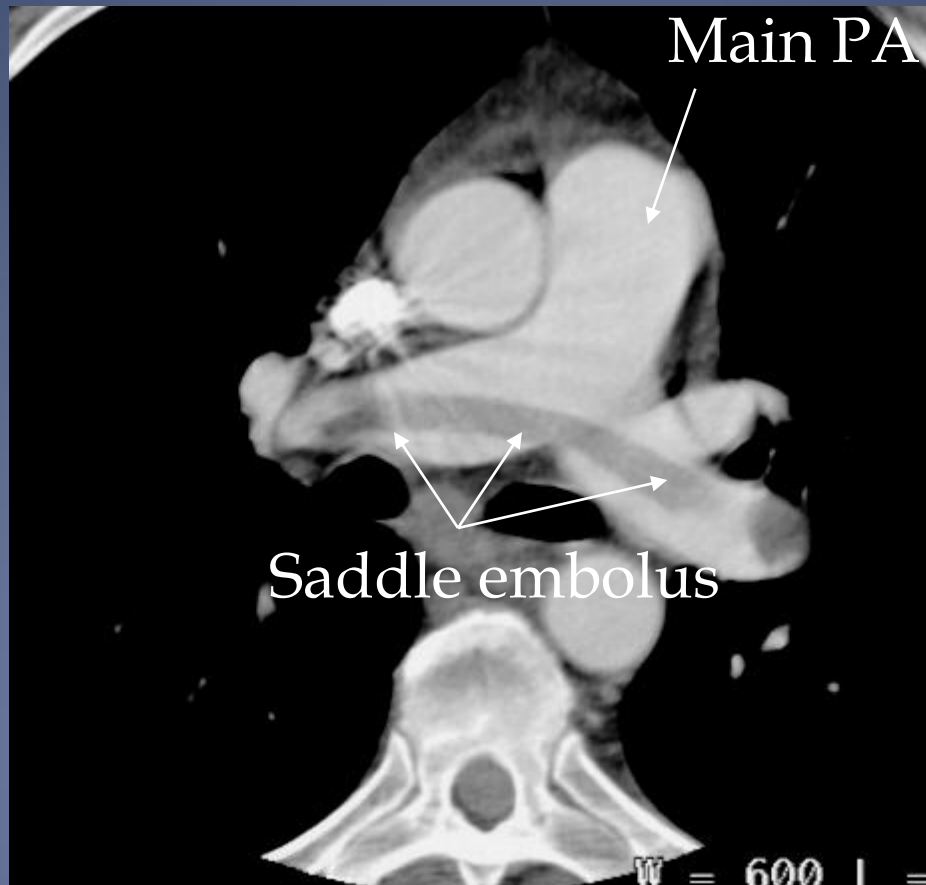
Masses



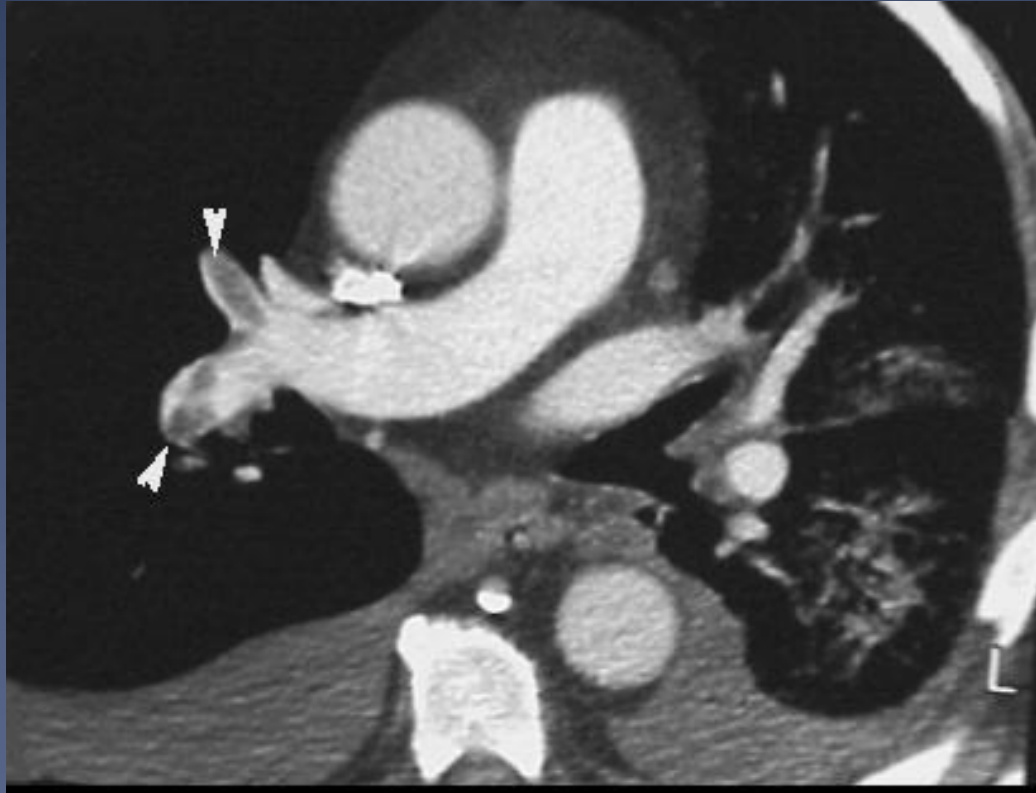
Pulmonary embolism

- ▣ Which to order? CT or VQ scan
 - VQ is slightly cheaper
 - VQ gives relative probability for PE
 - CT is very accurate.
 - ▣ nearly 100% positive predictive value
 - ▣ Very high negative predictive value for significant PE
 - CT slightly LESS radiation dose – best for pregnancy
 - VQ for elevated creatinine, unstable patient

PULMONARY CT ANGIOGRAPHY



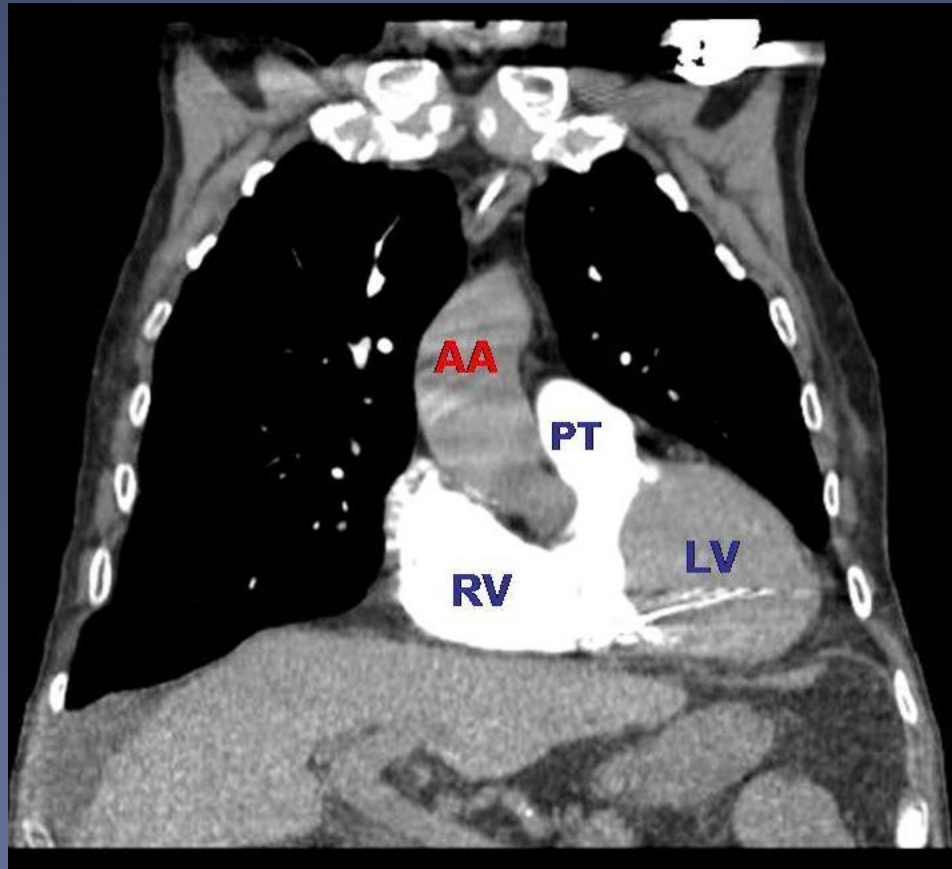
CT pulmonary angiogram



“target” appearance is 100% diagnostic of pulmonary embolism

CTangiogram

Timing is important



Summary for Chest Imaging

- ▣ CXR is king.
 - Great first step most of the time
 - Inexpensive and often diagnostic
 - Be sure to provide appropriate indication
 - ▣ No “rule out”.
 - ▣ Needs symptoms, signs or affecting history
- ▣ CT pulmonary angiogram vs VQ
 - CTPA more specific, accurate for PE and can find alternative diagnoses
 - VQ for contraindications to CTPA

Neuroradiology

- ▣ For the brain:

CT is the preferred imaging for:

- Trauma to skull or face. Sinus dz
- Acute, high clinical suspicion, headache
 - ▣ Worst headache of life. Thunderclap headache
- Acute stroke symptoms.
- CTA of intracranial and extracranial vasculature

- ▣ MRI probably best for all else.

More expensive, but no radiation. Often CT is “non-diagnostic” or an MRI is required for further workup anyway.

Head CT

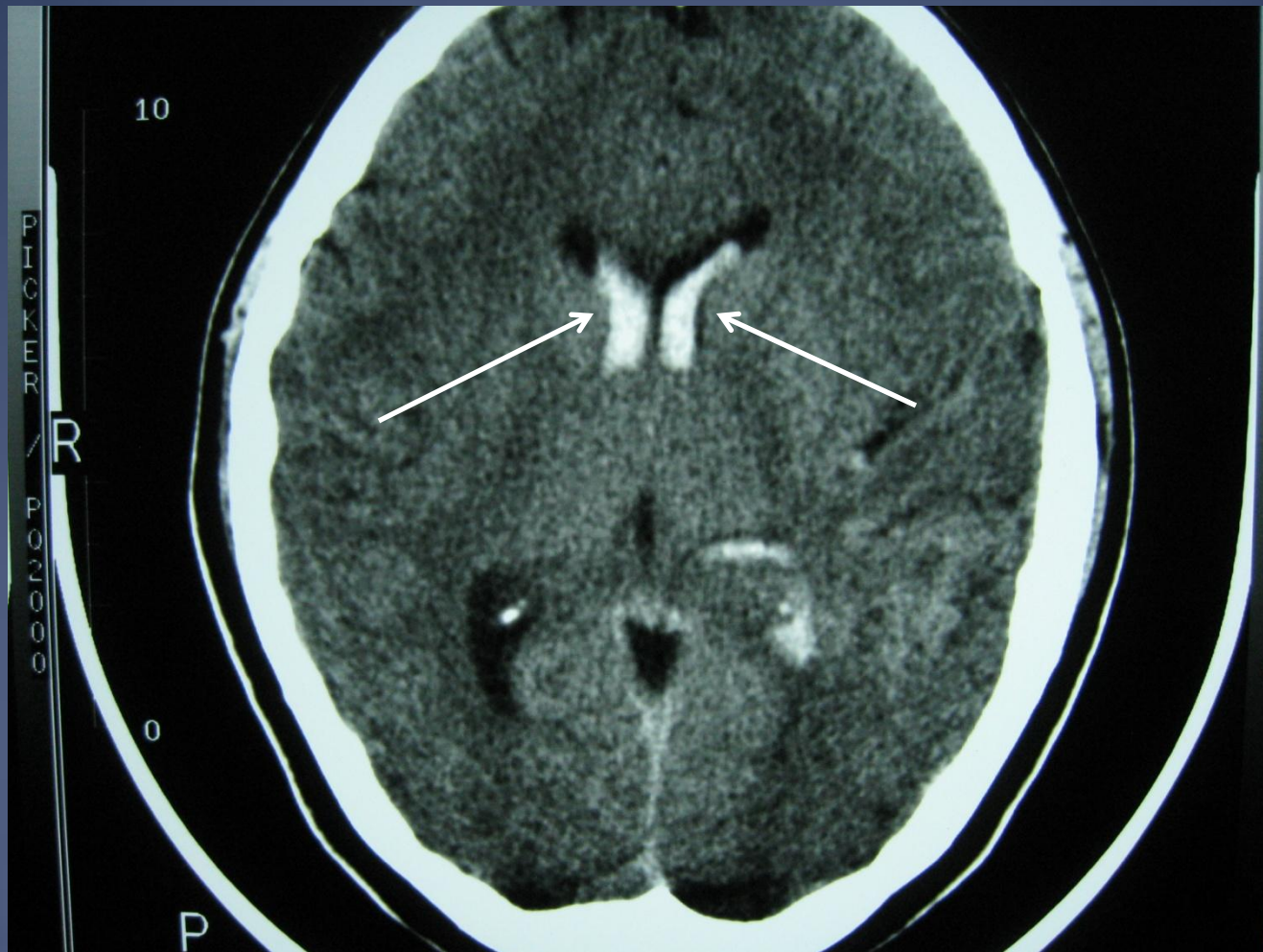
▣ trauma

Epidural
hematoma



Subdural
hematoma

Subarachnoid hemorrhage

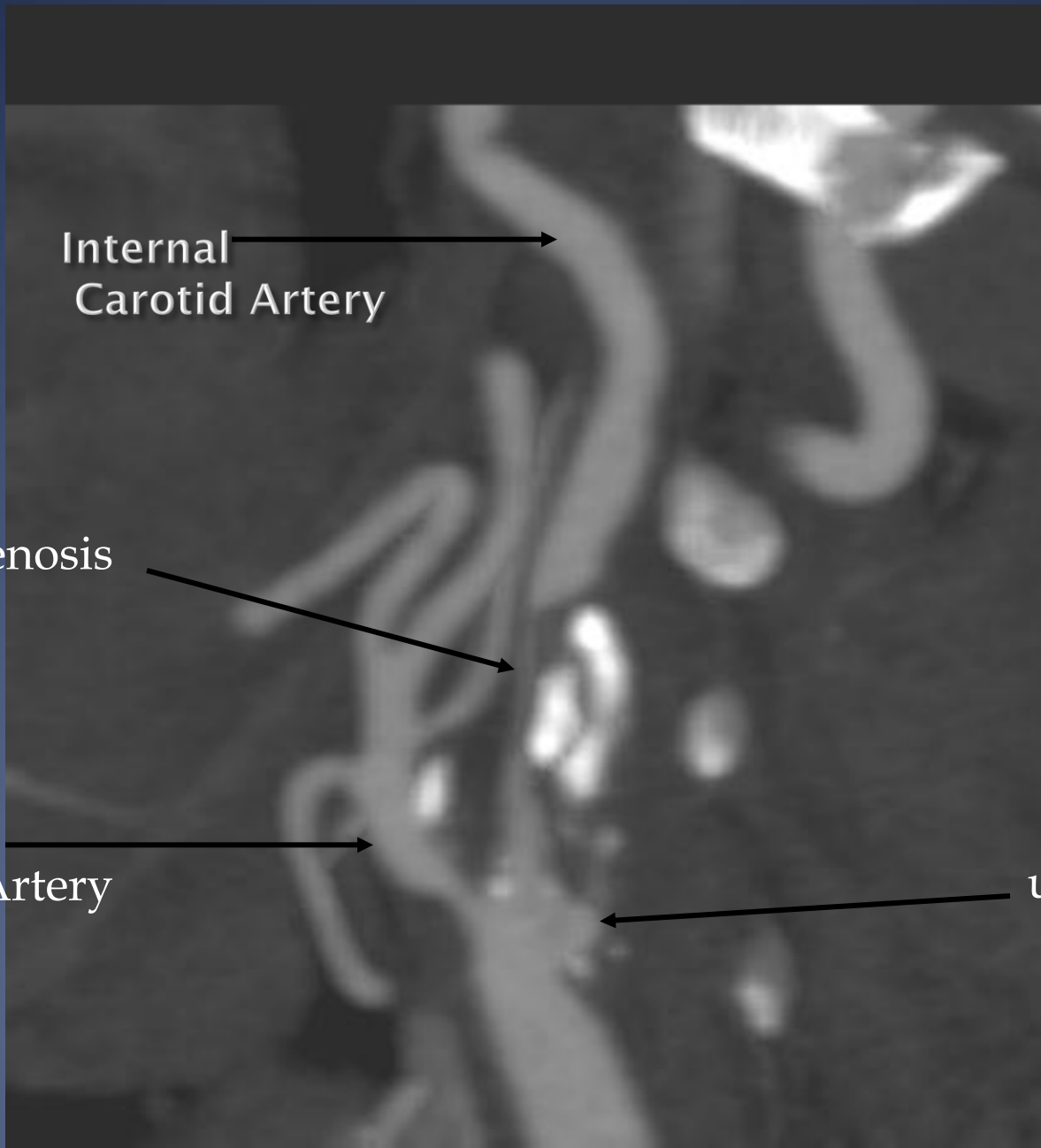


Internal
Carotid Artery

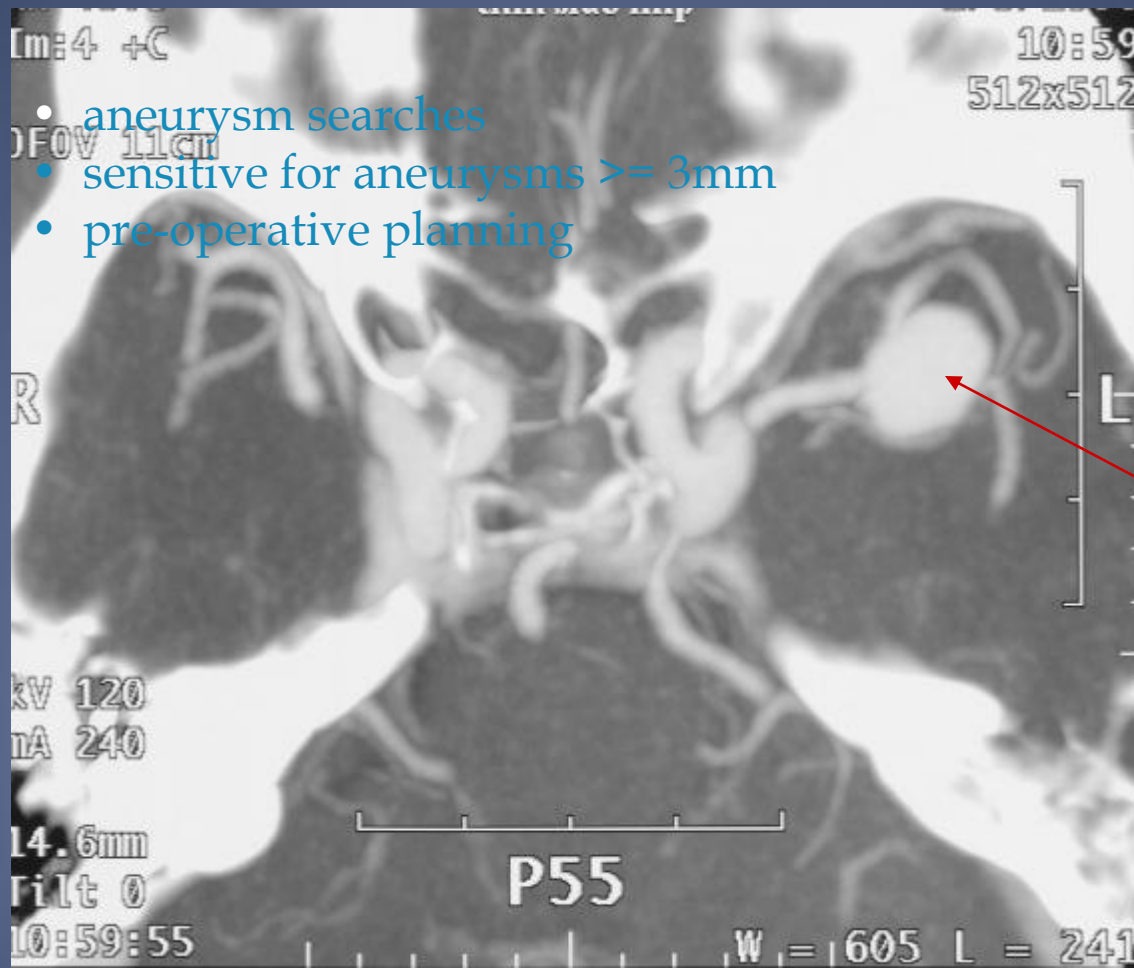
>90% stenosis

External
Carotid Artery

ulceration

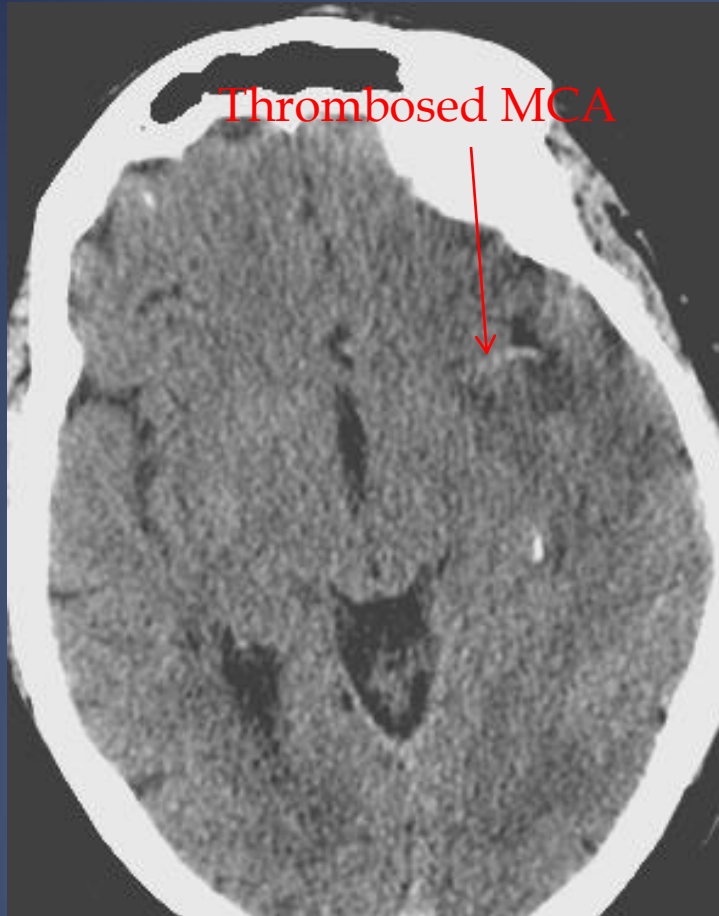


INTRACRANIAL CT ANGIOGRAPHY

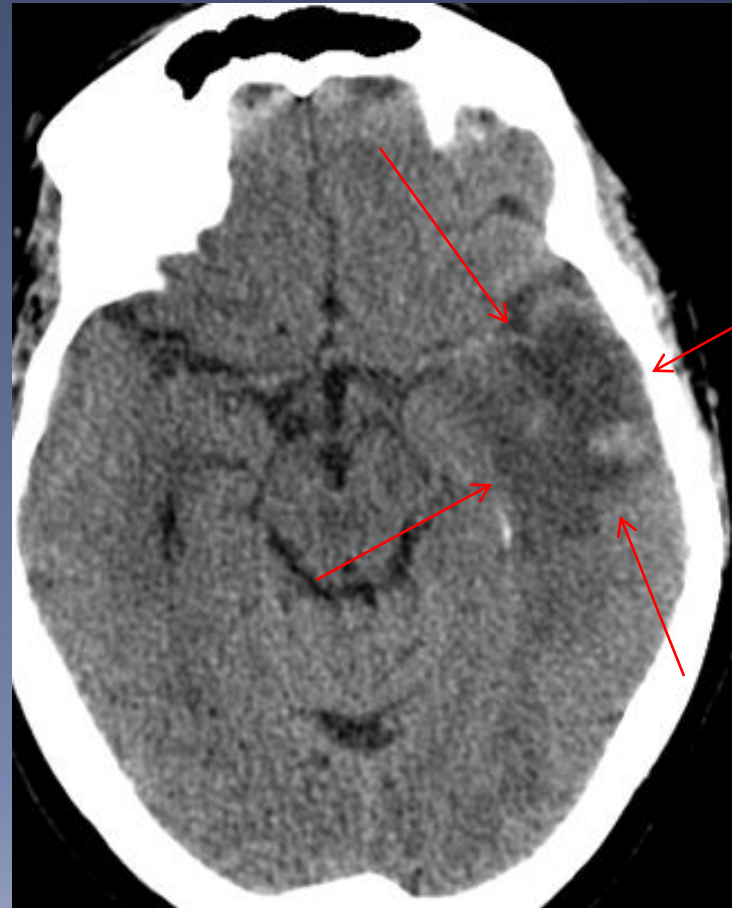


Left MCA
aneurysm

Head CT



Acute symptoms

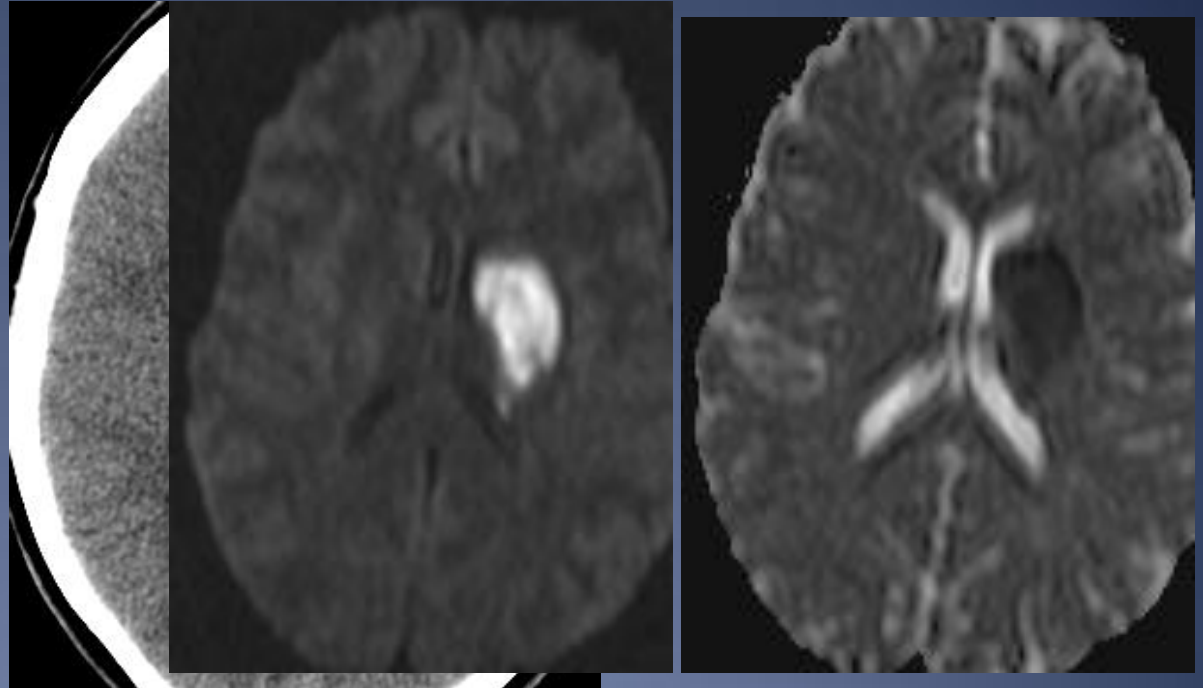


Repeat CT in 24 hours

CT vs MRI for stroke

- ▣ Really is CT plus MRI for stroke
- ▣ CT is for the acute presentation.
 - Excludes hemorrhage
 - Treatment stratification
 - Rapid test – code stroke
- ▣ MRI is very valuable in stroke imaging

MRI for stroke

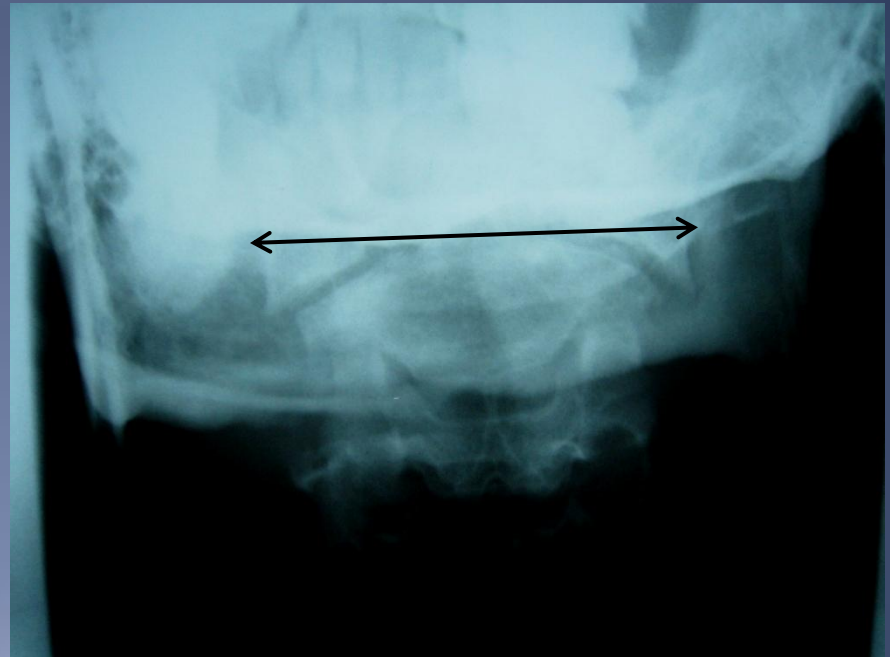
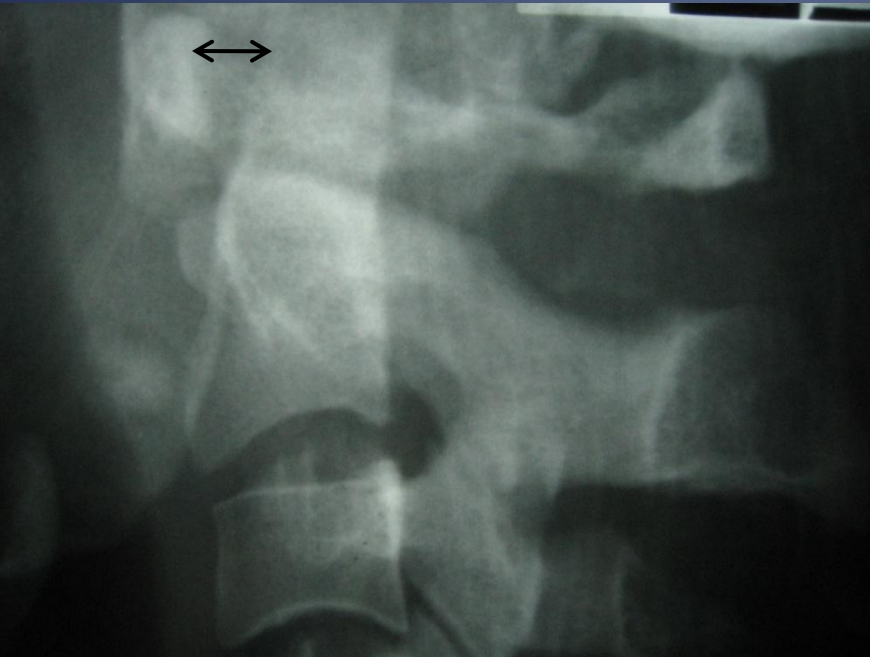


The acute spine

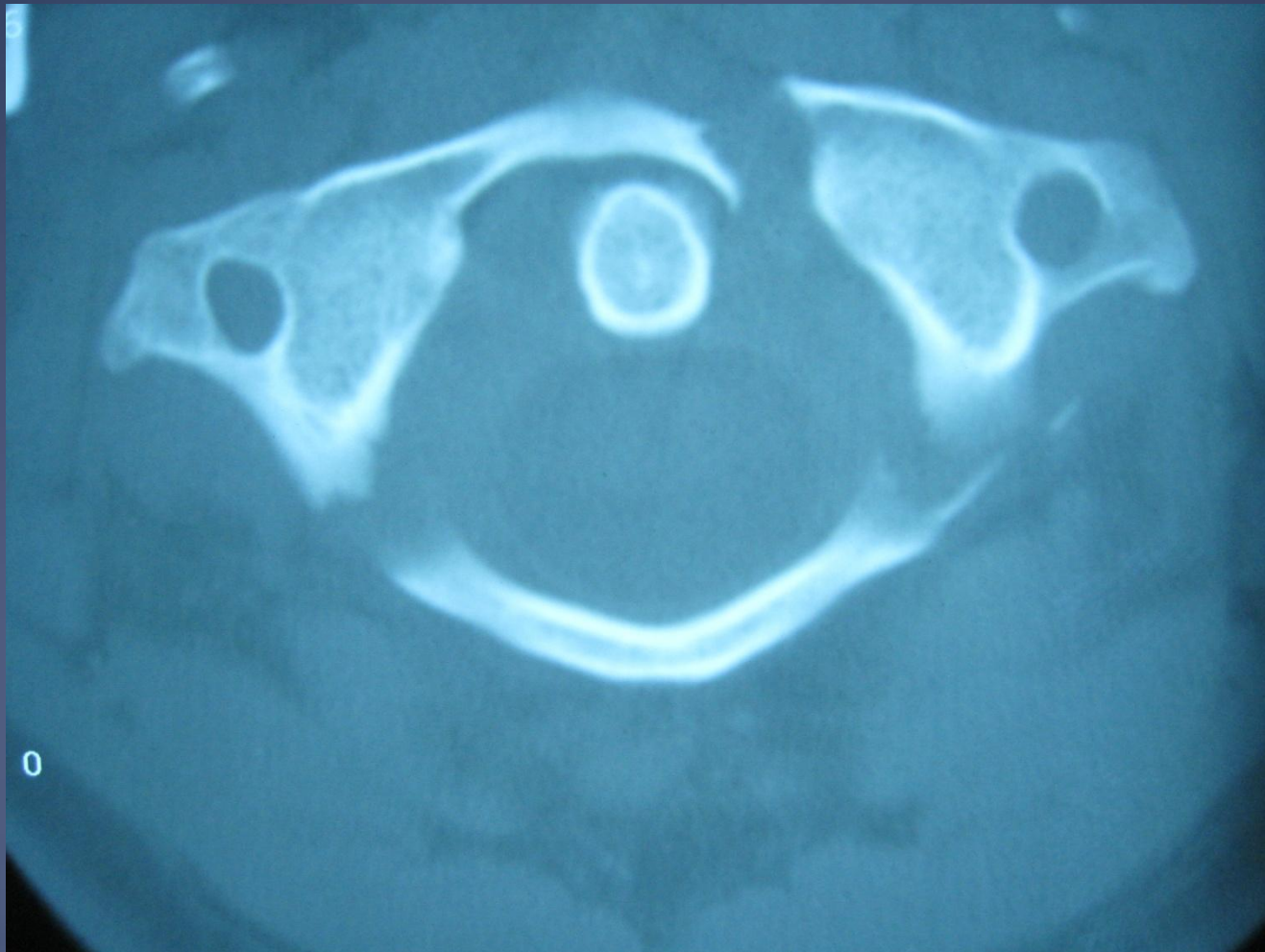
- ▣ Choice between X-ray and CT is clinically driven for C spine.
- ▣ If low/moderate suspicion, recommend X-ray
- ▣ If high suspicion recommend CT Cspine.
- ▣ If cannot see C1 thru T1, recommend CT
- ▣ LS spine, X-rays or MRI.
 - CT with high radiation exposure. Little information not seen on standard X-ray series

C spine trauma

Jefferson fracture

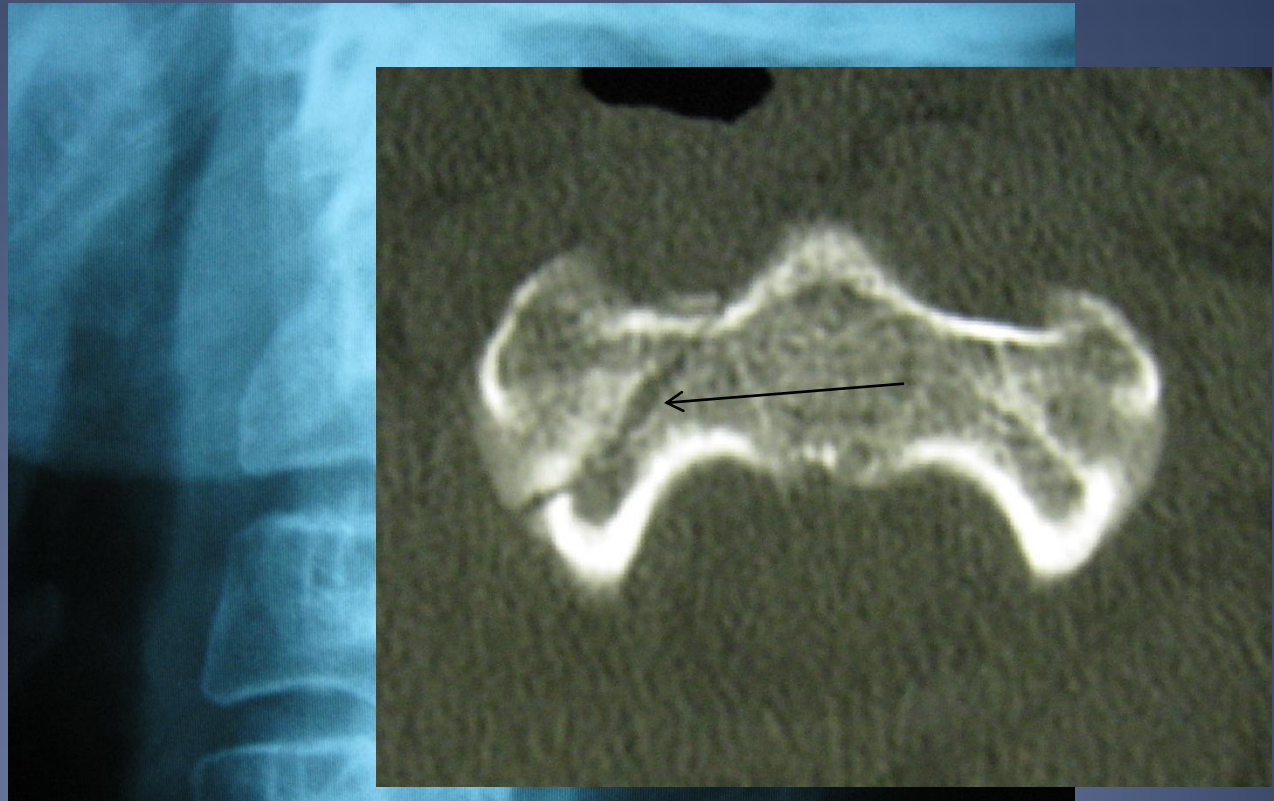


C1 burst fracture

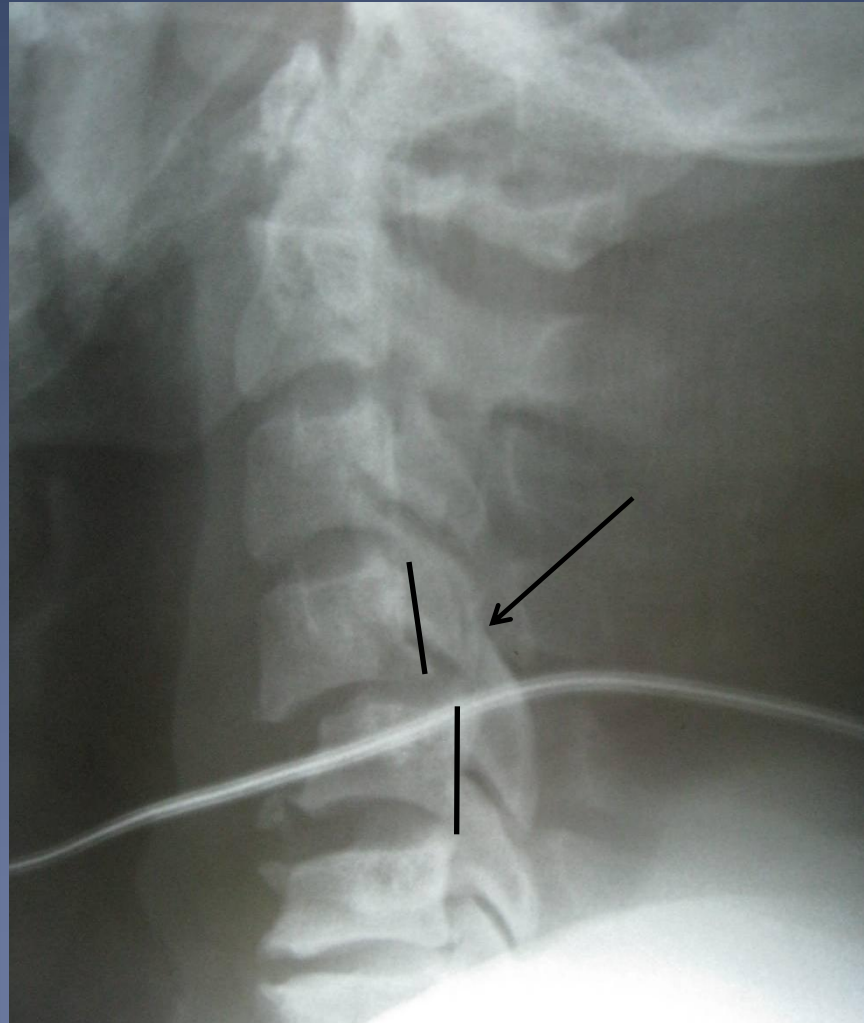


C spine trauma

C2, "Hangman's" type fracture



Bilateral locked facets



Summary for spine imaging

- ▣ X-rays important in the acute setting
- ▣ CT for high clinical suspicion C spine
- ▣ MRI for almost all others
 - Assess edema, acuity
 - Assess cord compromise
 - IV gadolinium if post operative

Musculoskeletal

- ▣ X-rays still are usually the best imaging modality in the acute setting
 - Inexpensive and often diagnostic
- ▣ MRI for orthopedic issues
 - Internal derangements of joints, soft tissue, muscle
 - AVN
- ▣ CT
 - Assess non-union
 - Orthopedic assessment of fractures
 - Occult fracture of hip

Musculoskeletal

- ▣ Most fractures visualized by x-ray and do not require further imaging with more expensive tests
- ▣ May require follow-up film in 10-14 days to look for the occult fracture.
- ▣ There are a few fractures which can be “tricky”

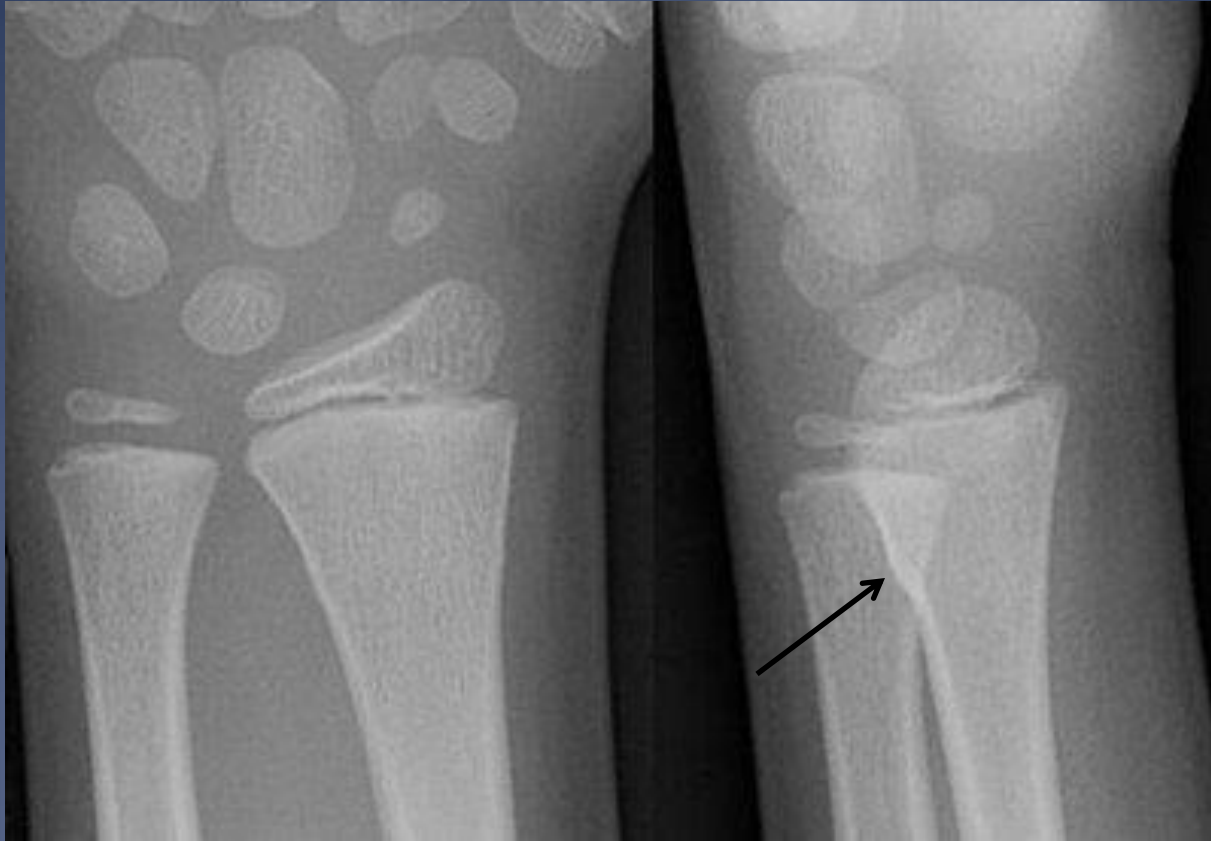
What to look for besides the fracture



What to look for besides the fracture



Complete series



Fractures often seen only on one view
Series should include 3 views of most body parts

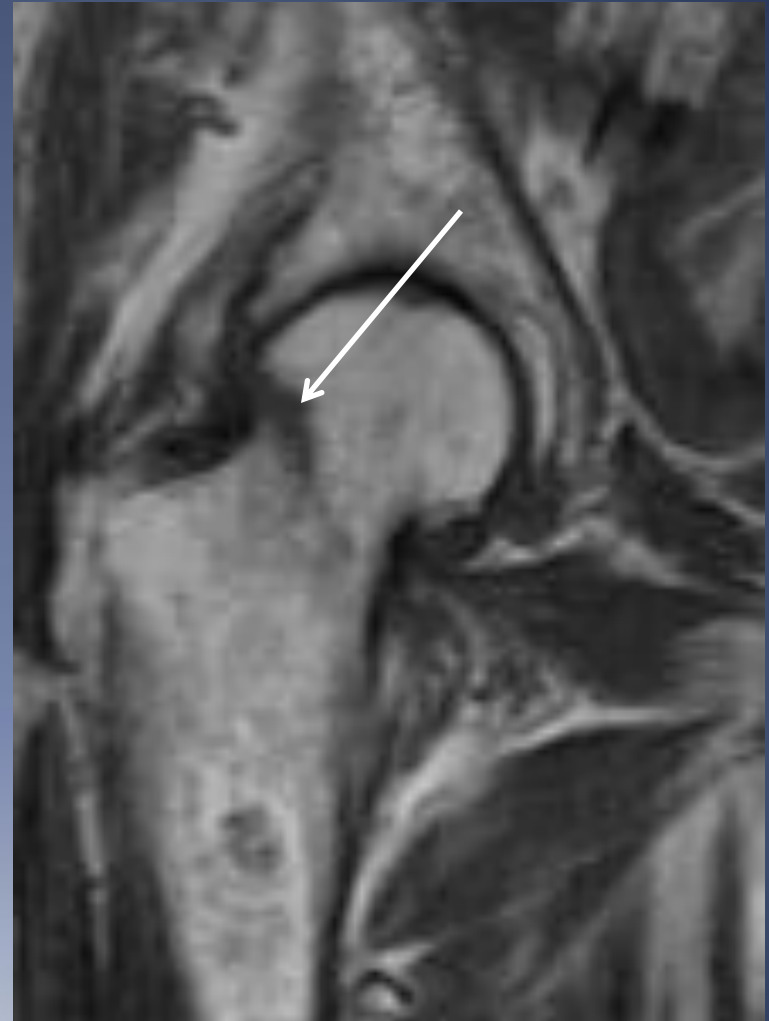
Hip trauma

- ▣ Depending on study, <90% fractures are visible on standard X-ray series
- ▣ CT>95% accurate, but not 100%
- ▣ MRI final determination
- ▣ Nuclear medicine lesser value as does not show details of fracture for surgical planning
 - Also has a false negative rate in acute fracture less than 3-4 days old

Hip trauma



Hip trauma CT and MRI



Musculoskeletal Summary

- ▣ X rays detect most fractures
- ▣ Prefer 3 views to 2 views as some fractures are only seen on one view of a series
- ▣ CT for facial fractures, occult hip fracture or orthopedic follow-up.
- ▣ MRI for orthopedic follow-up, workup of soft tissue or joint abnormalities.
- ▣ MRI for AVN or trauma sequelae.

Miscellaneous

- ▣ Osteomyelitis –prefer MRI,
 - If suspect abscess, perform with IV gadolinium
 - Bone scan cheaper, but not as accurate
- ▣ Hearing loss
 - Conductive or middle ear symptoms – CT
 - Sensor neural – MRI
- ▣ CT angiography
 - CTA for renal, carotid, aortic dissection, runoff
 - Circle of Willis – MR for screening, CT for detail
 - coronary

Conclusions

- ▣ Imaging test selection guidelines in radiology aim to:
 - determine the single best imaging test for specific symptomatology/diagnoses
 - Ultimately contribute to cost-effective strategies
 - Radiation dose reduction
 - Overall accuracy and timeliness to diagnosis
- ▣ Clinical information is invaluable to:
 - determine which imaging modality is best to use;
 - decide if IV or oral contrast or specific protocols are required;
 - improve the relevancy of interpretations.
- ▣ Do not hesitate to ask for help in choosing the best test