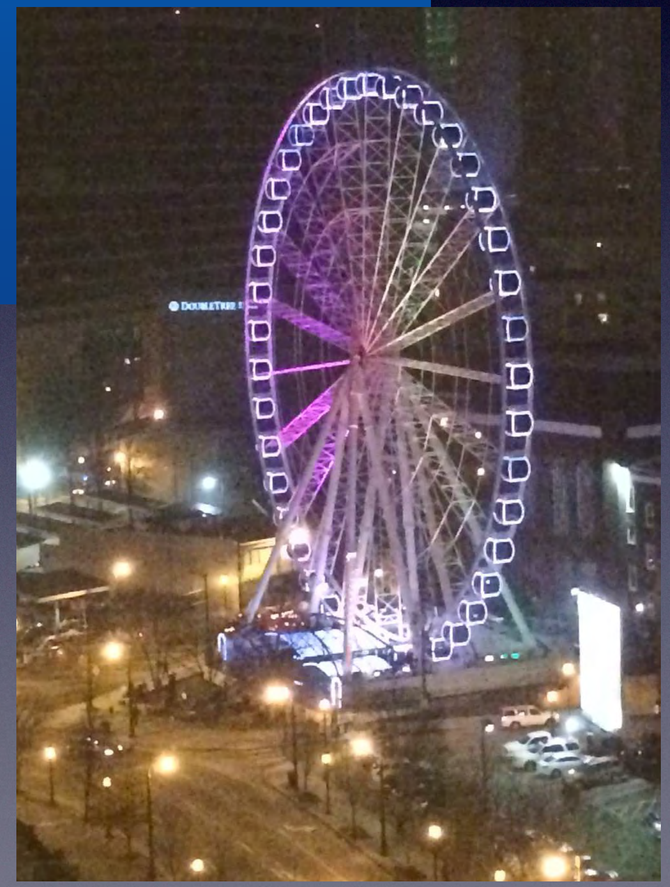
2015
ARIN Annual Convention

ATLANTA, GA



Arturo D. Gonzalez, MD, DABR, RPVI

Associate Professor of Radiology

LSU/School of Medicine, New Orleans

Head of Interventional Radiology

UHC/LGH, Lafayette, LA 70506

BASIC IMAGING PATHOPHYSIOLOGY AND VISUAL GUIDANCE IN IR PROCEDURES

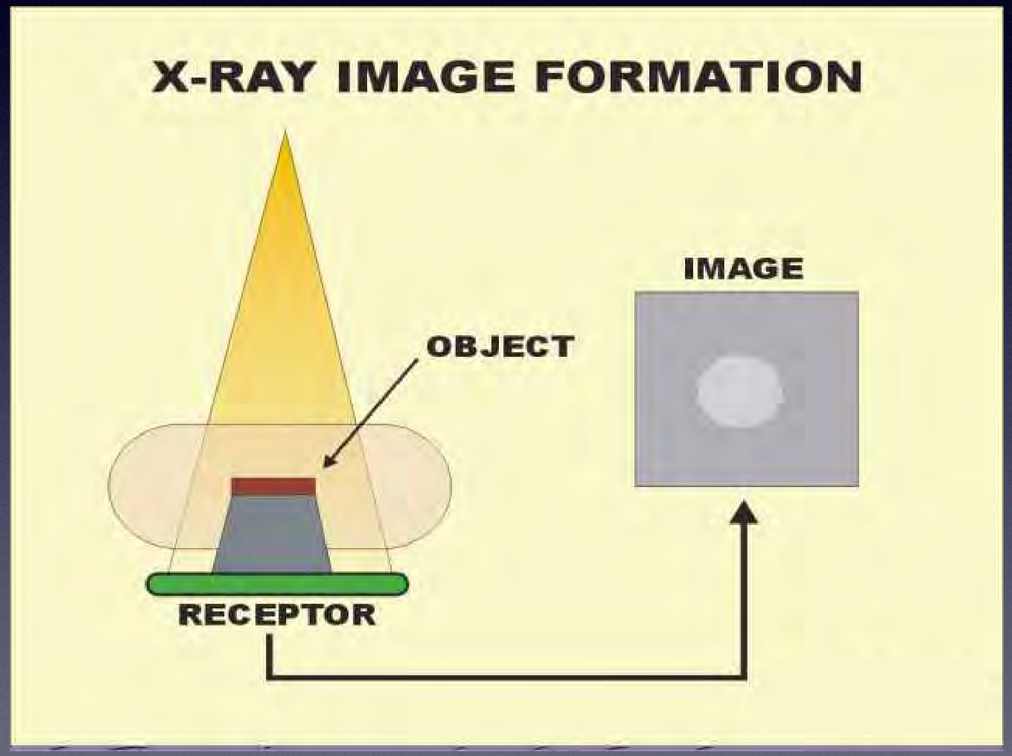
Image-guided Biopsies: Hot Topics Monday, March 2, 2015 at 1530

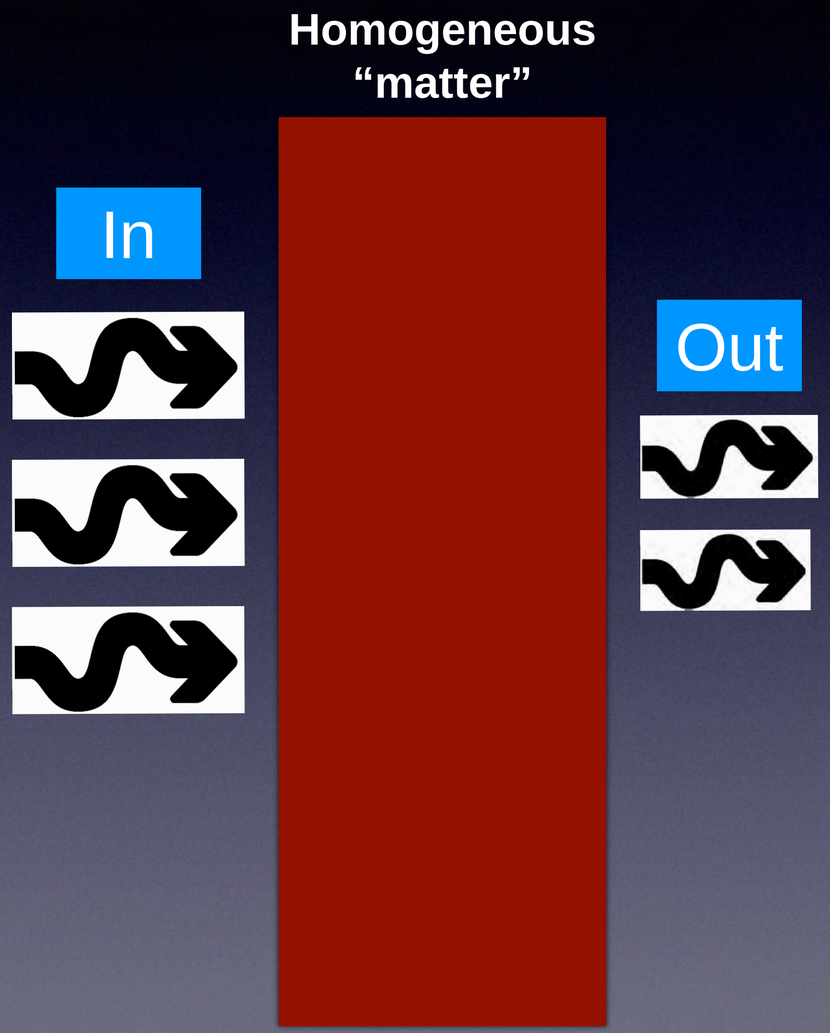
Educational Objectives

- Briefly analyze the image formation on conventional x-rays CT and ultrasound
- Describe the basic densities seen on conventional x-rays
- Explain what Houndsfield units are
- Discuss the advantages of ultrasound, fluoroscopy and CT for imaging guidance in IR procedures
- Enumerate the downside of same methods

PART 1,
BASIC IMAGING PATHOPHYSIOLOGY

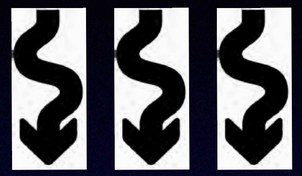
Conventional Radiology



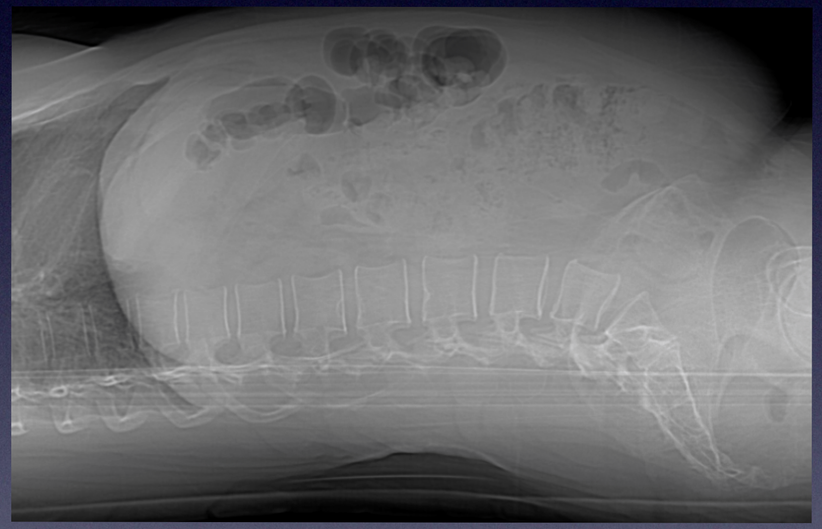


Conventional Radiology

In



Heterogeneous "matter"

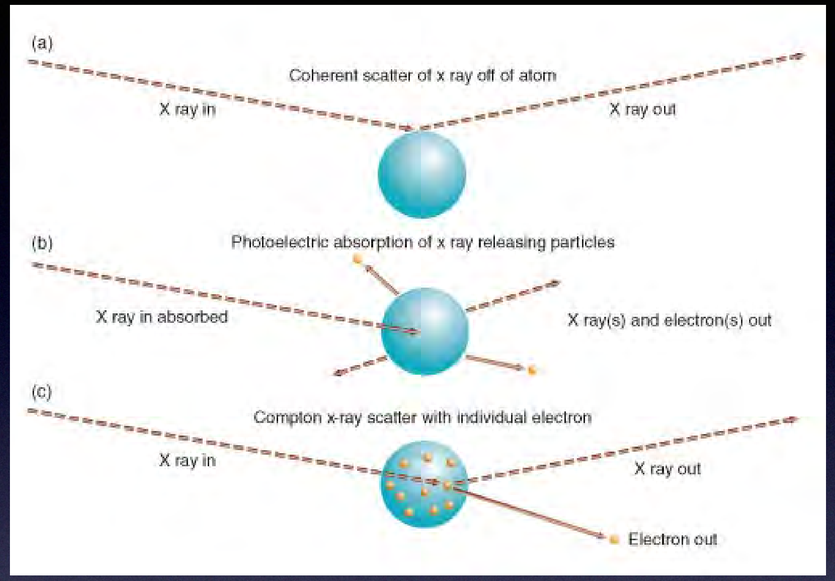


Out

X-ray beam attenuation: Reduction of intensity as it traverses matter (absorption/scattering)

- **Energy of beam entering matter**
- **Nature and thickness of matter being traversed**

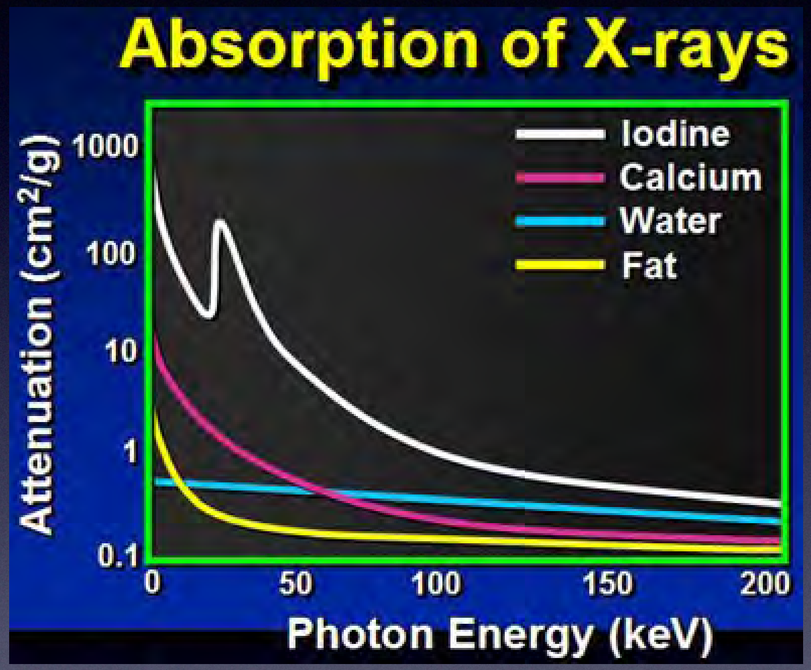
Conventional Radiology

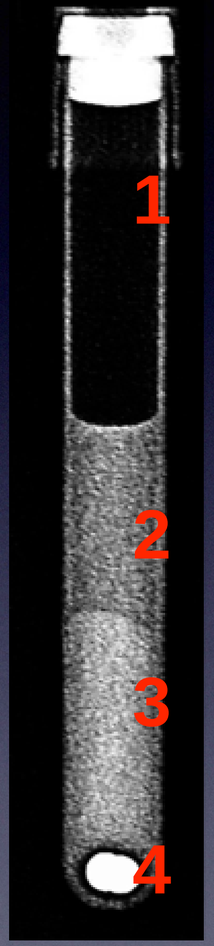


Physical Properties of Selected Materials

Material	Effective Atomic Number (Z)	Density (g/cm^3)	50 keV Linear Attenuation Coefficient (cm^{-1})
Water	7.4	1.0	0.214
Ice	7.4	0.917	0.196
Water vapor	7.4	0.000598	0.000128
Compact bone	13.8	1.85	0.573
Air	7.64	0.00129	0.00029
Fat	5.92	0.91	0.193

Densities On Conventional Plain Films





1: Air

2: Fat

3: Water

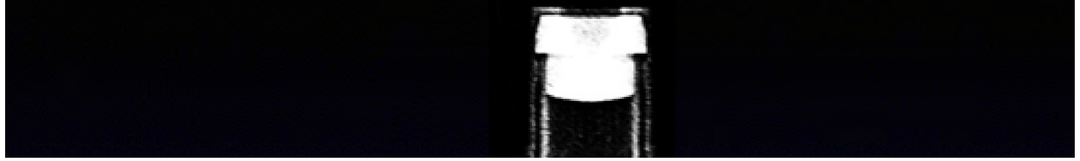
4: Metal or bone

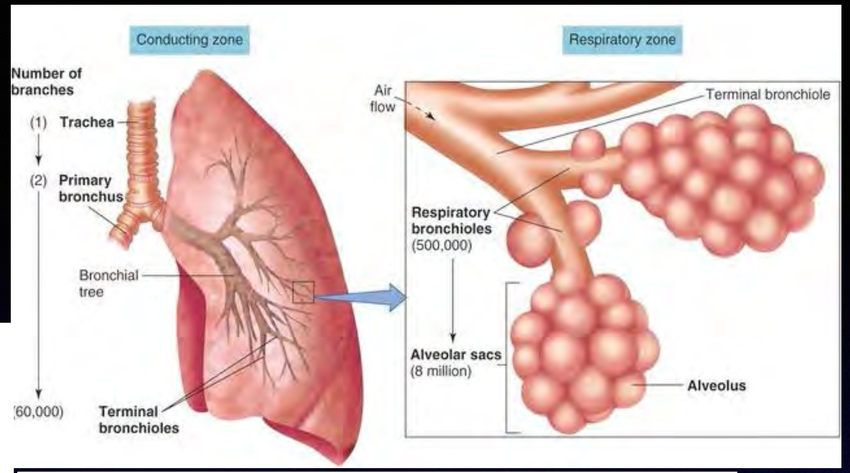
How they look?

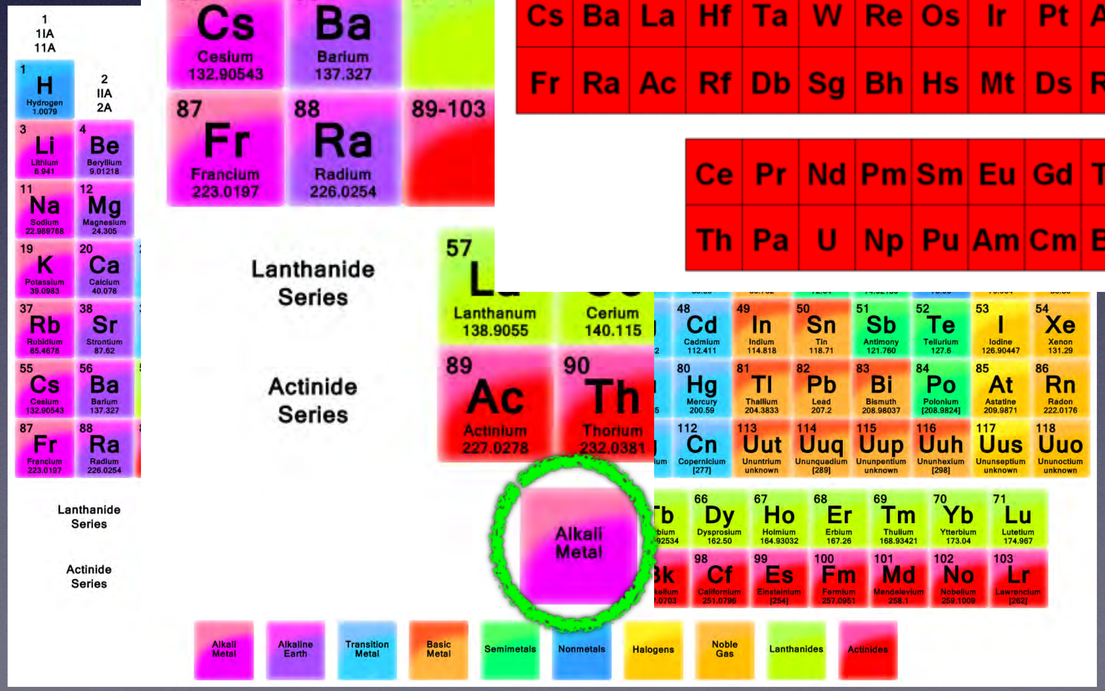
Dark (black): Air >> Fat

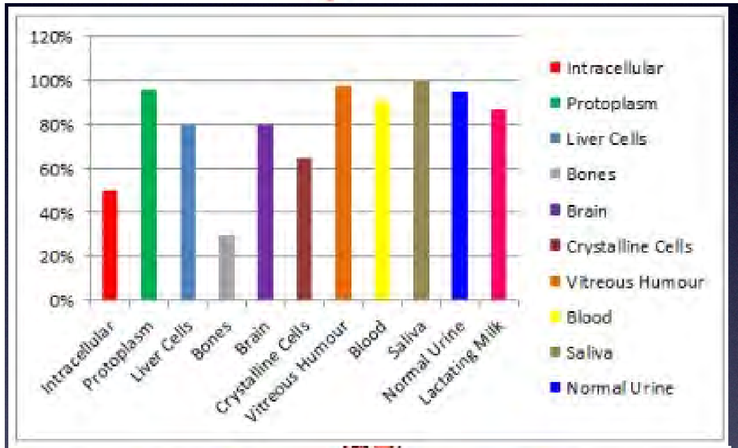
Bright (white): Water << Metal

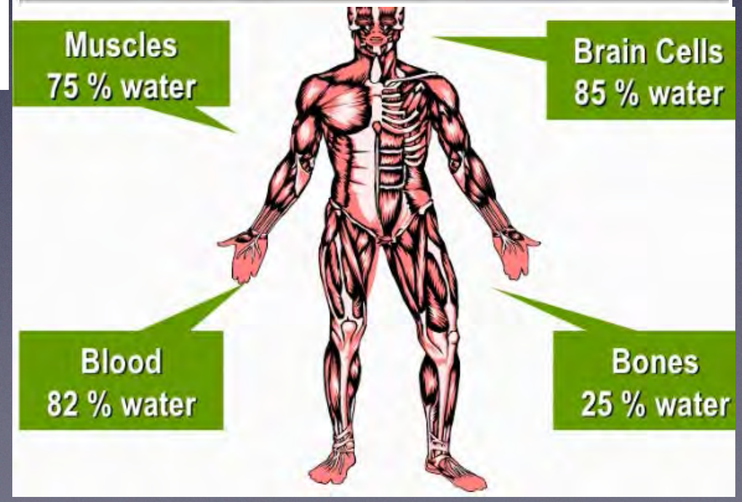
Densities On Conventional Plain Films





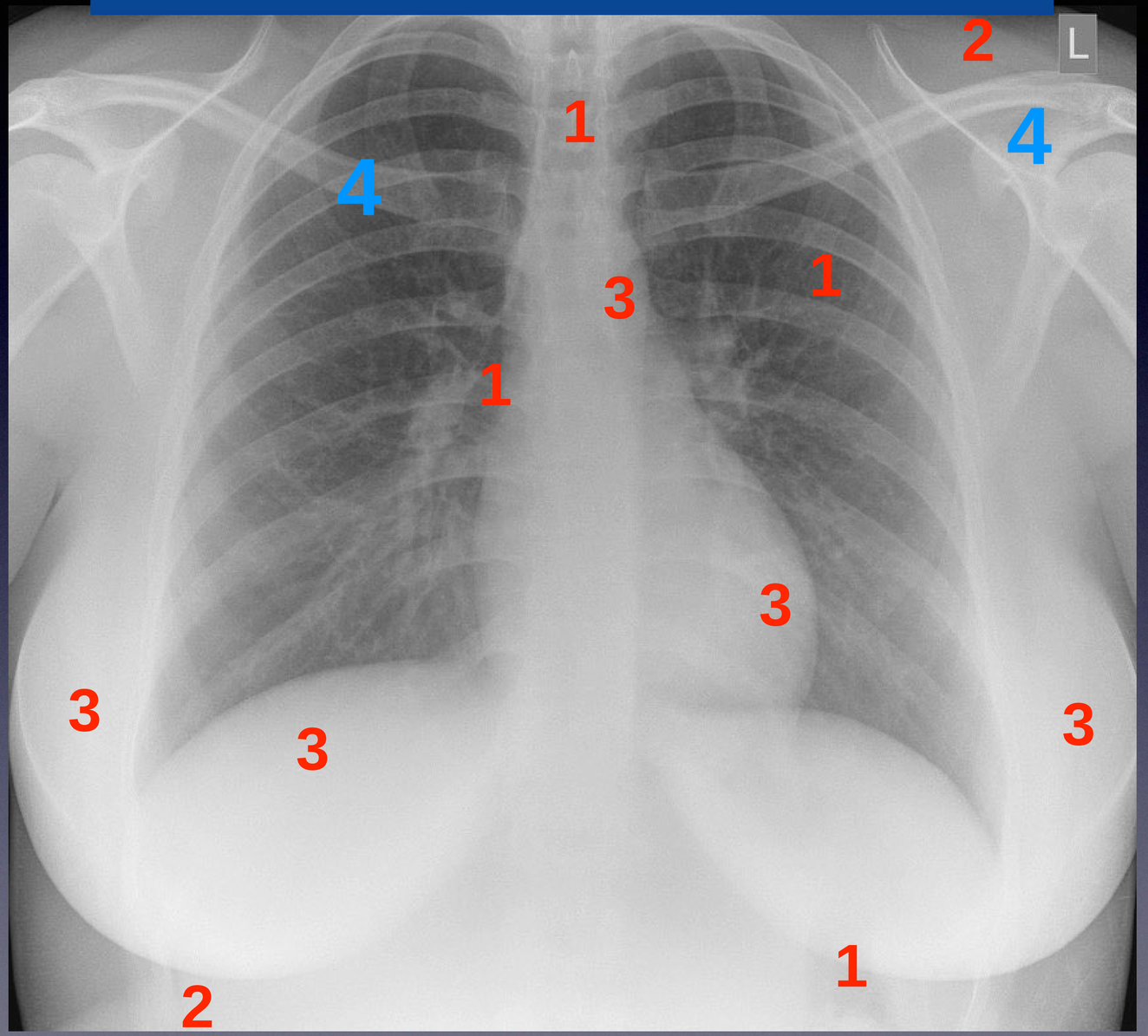






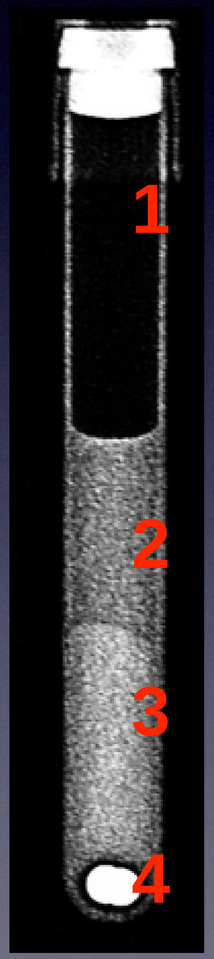
4: Bone or metal

Normal CXR



Densities On Conventional Plain Films

Two structures of same density, located in direct anatomic contact, *will* cancel each other out



Densities On Conventional Plain Films

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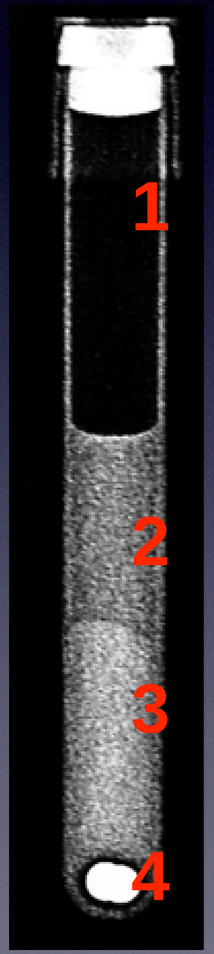
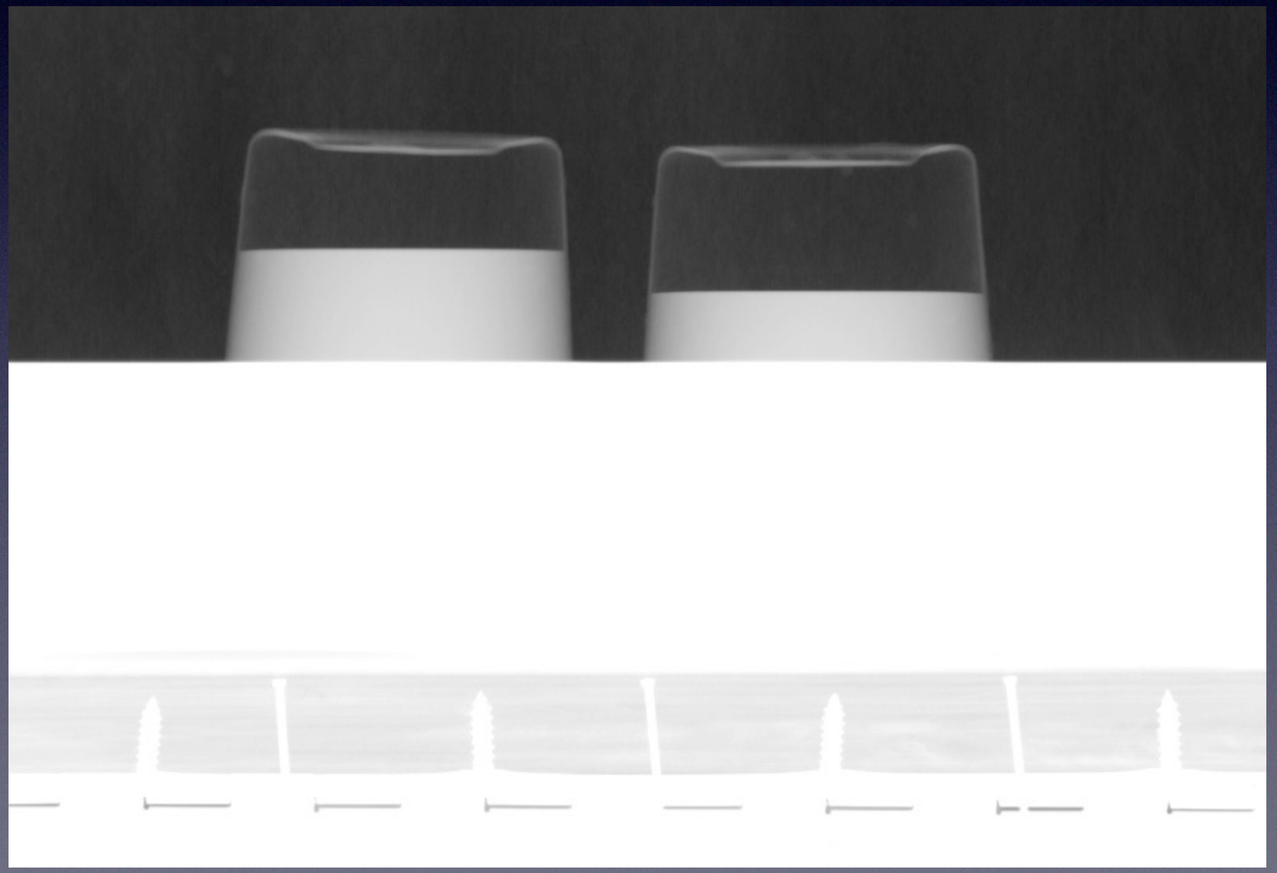
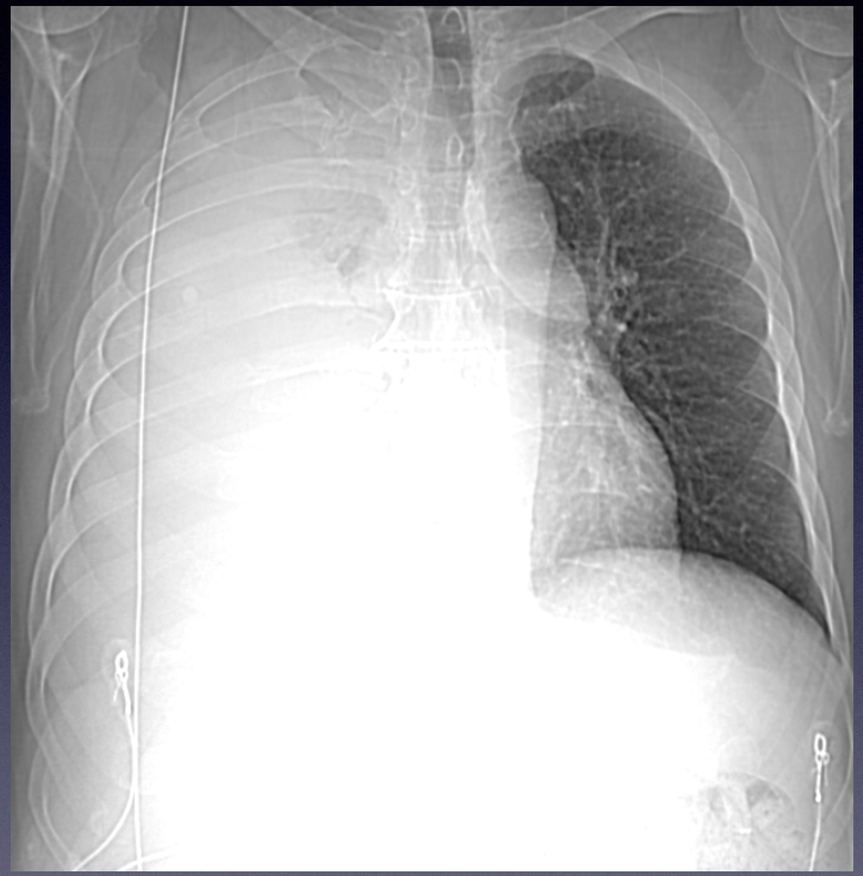
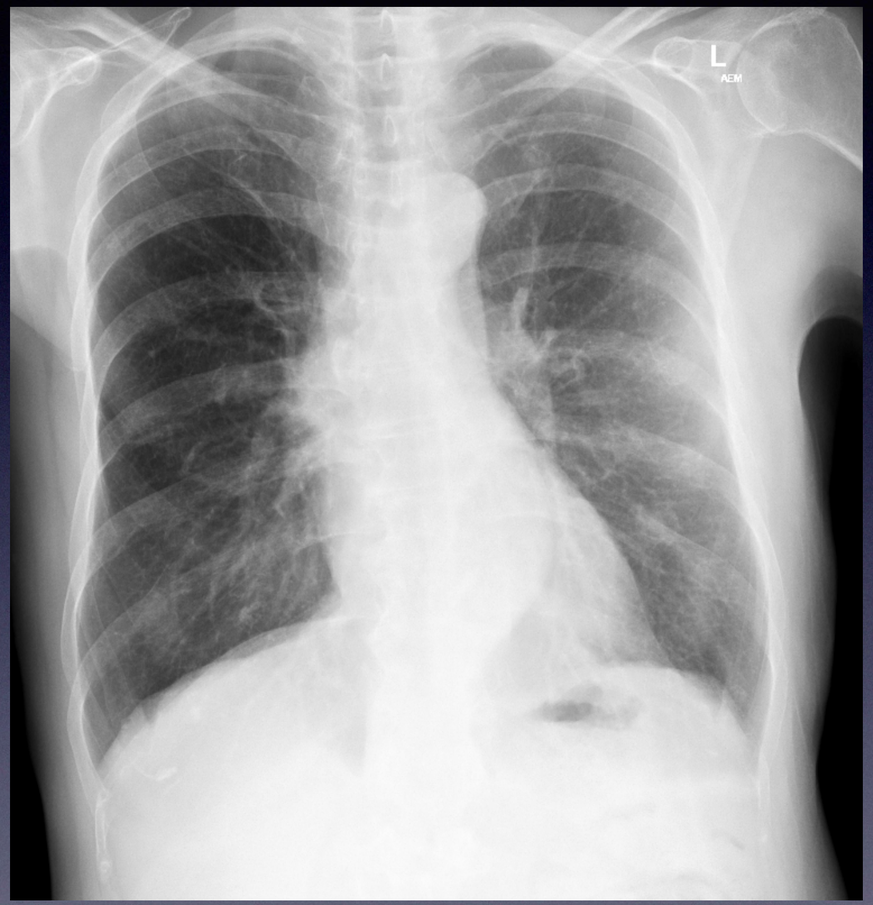




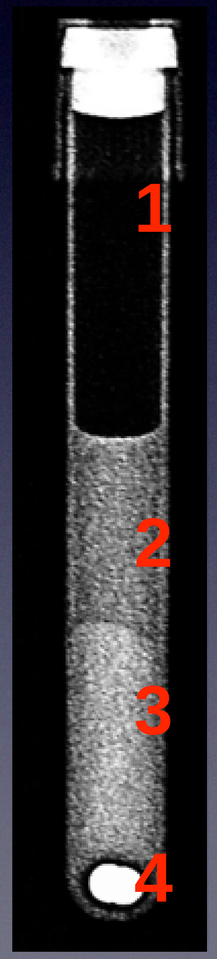
Similar Densities On Conventional Plain Films

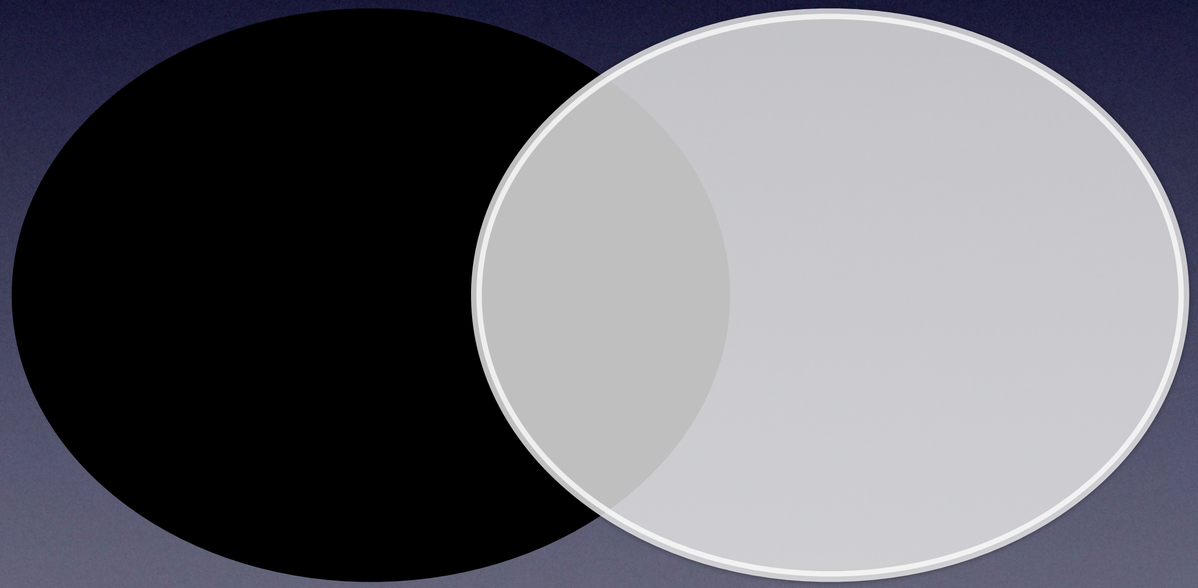


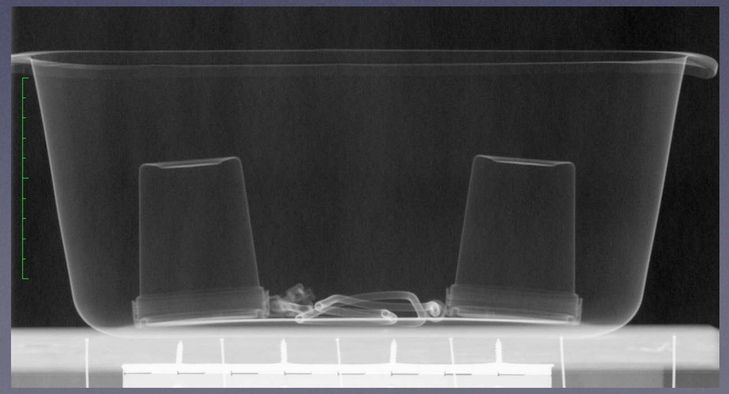


Densities On Conventional Plain Films

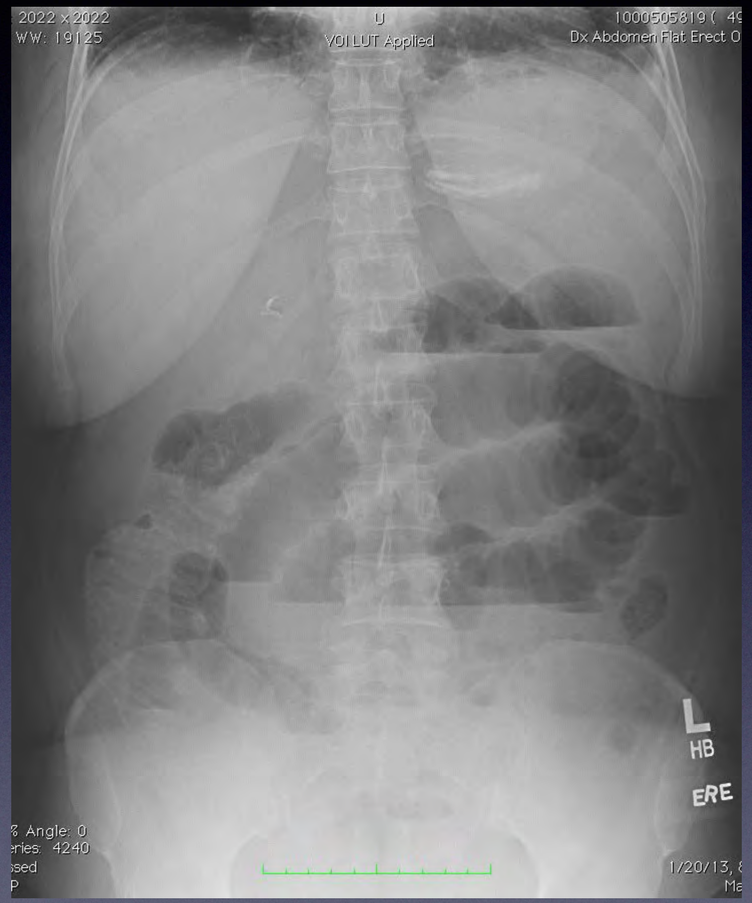
Two structures of opposed density *will not* cancel out each other, independently of their position

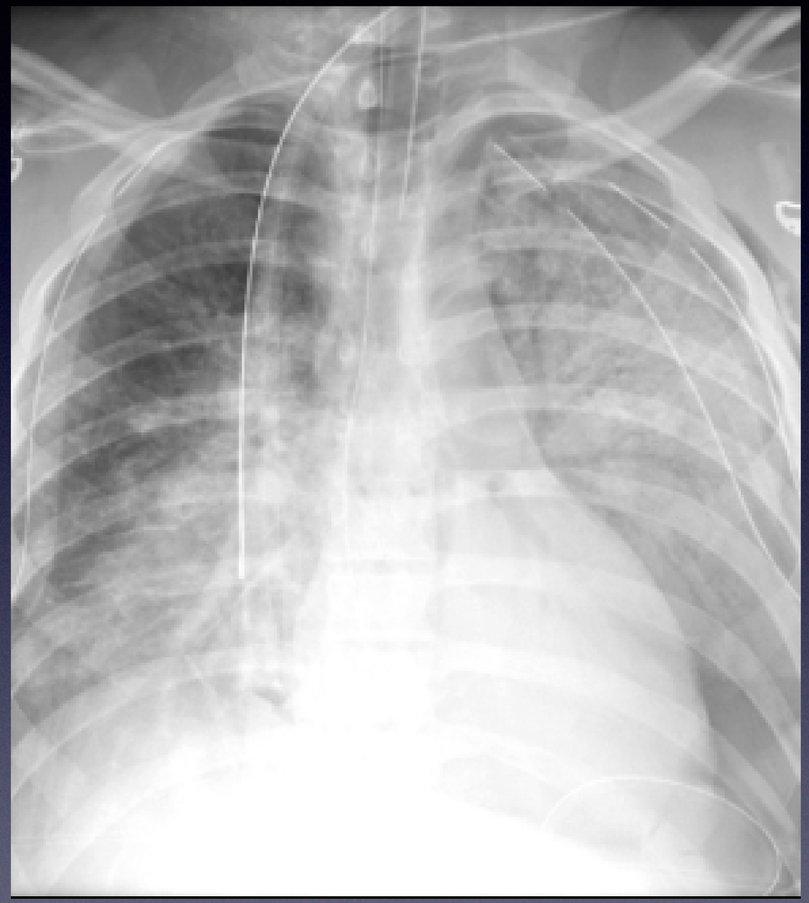






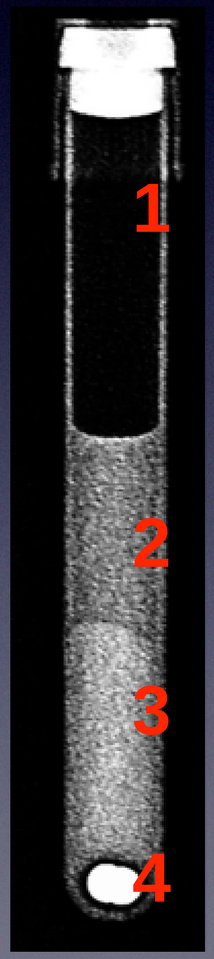
Opposed Densities On Conventional Plain Films

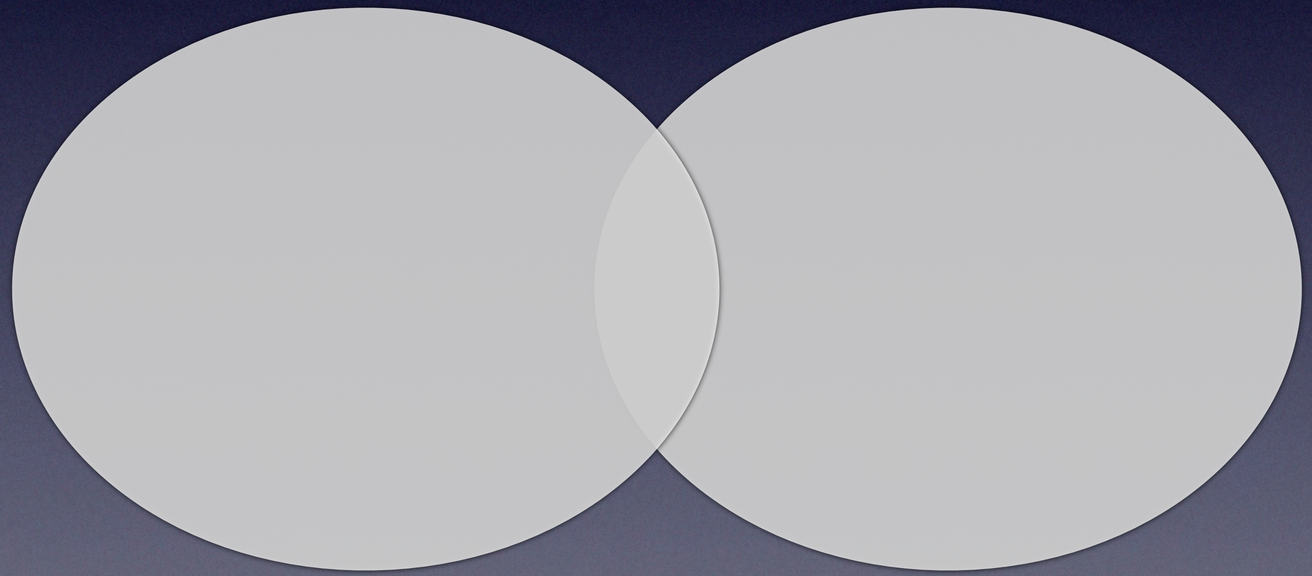


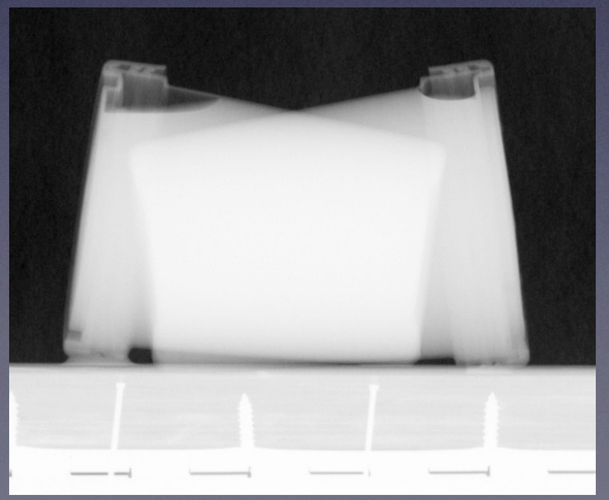


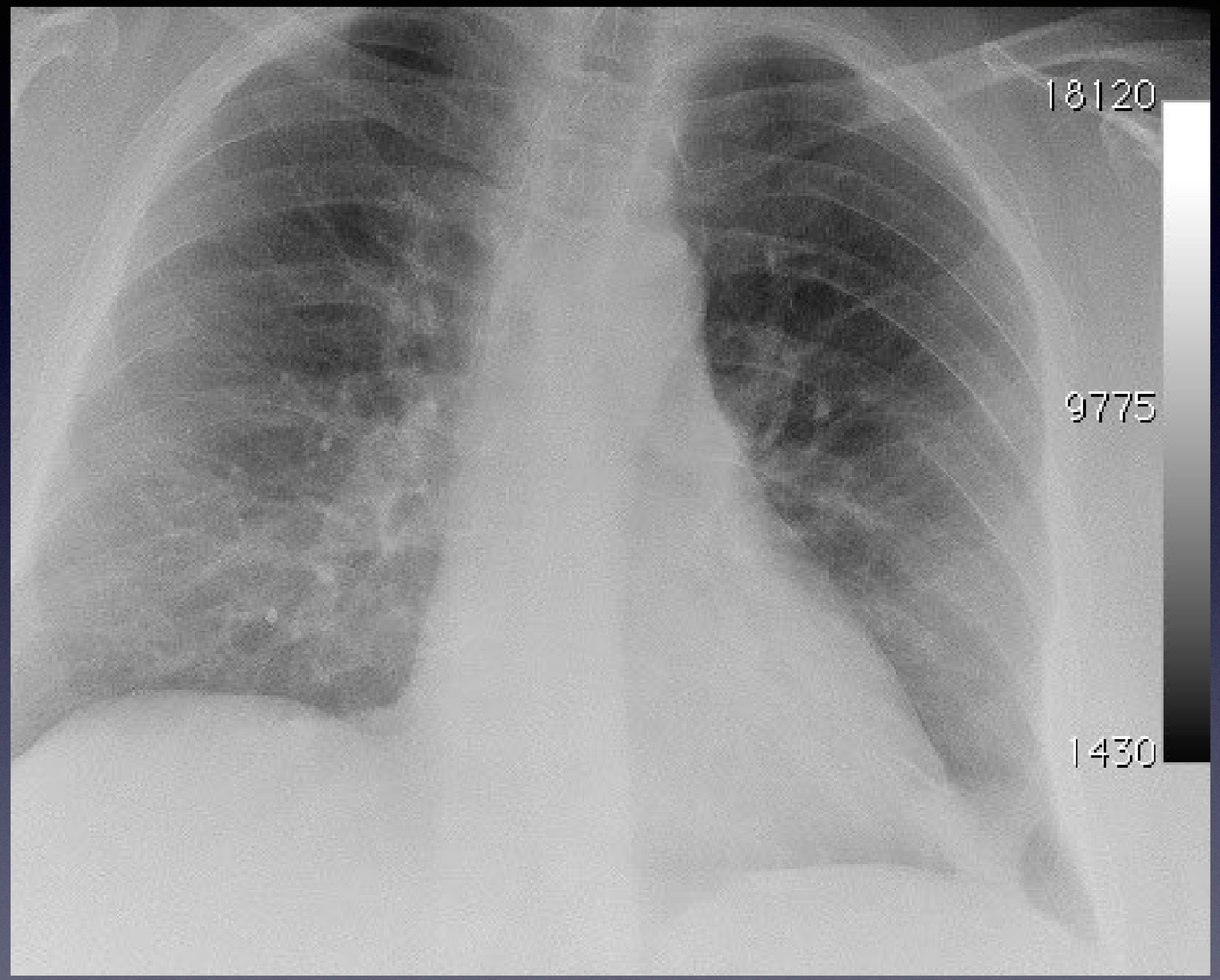
Densities On Conventional Plain Films

Two structures of same density, *not in direct anatomic* contact, *will not* cancel out each other





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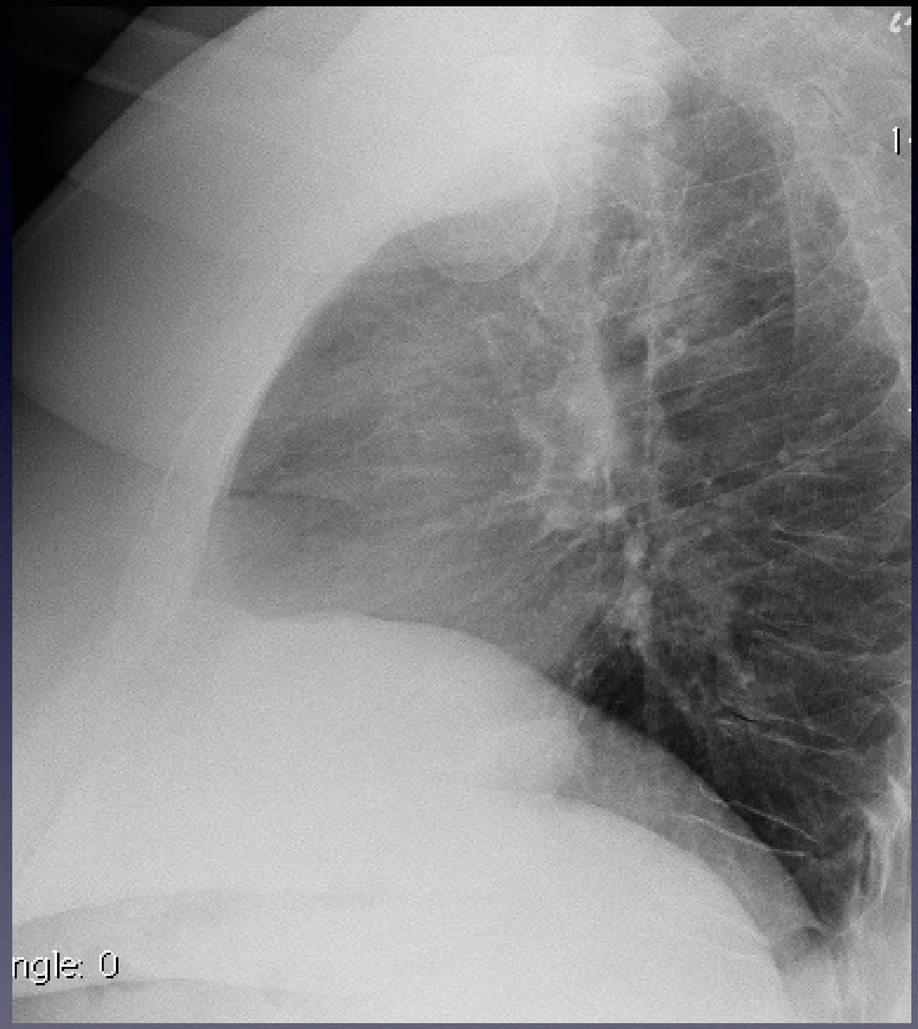
9775
1430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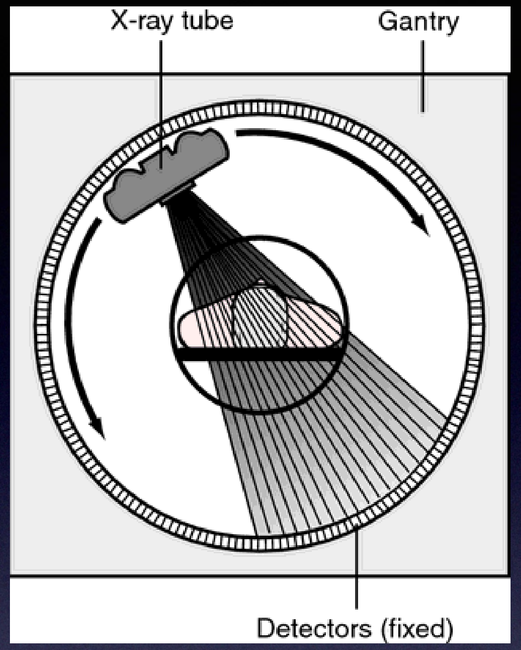
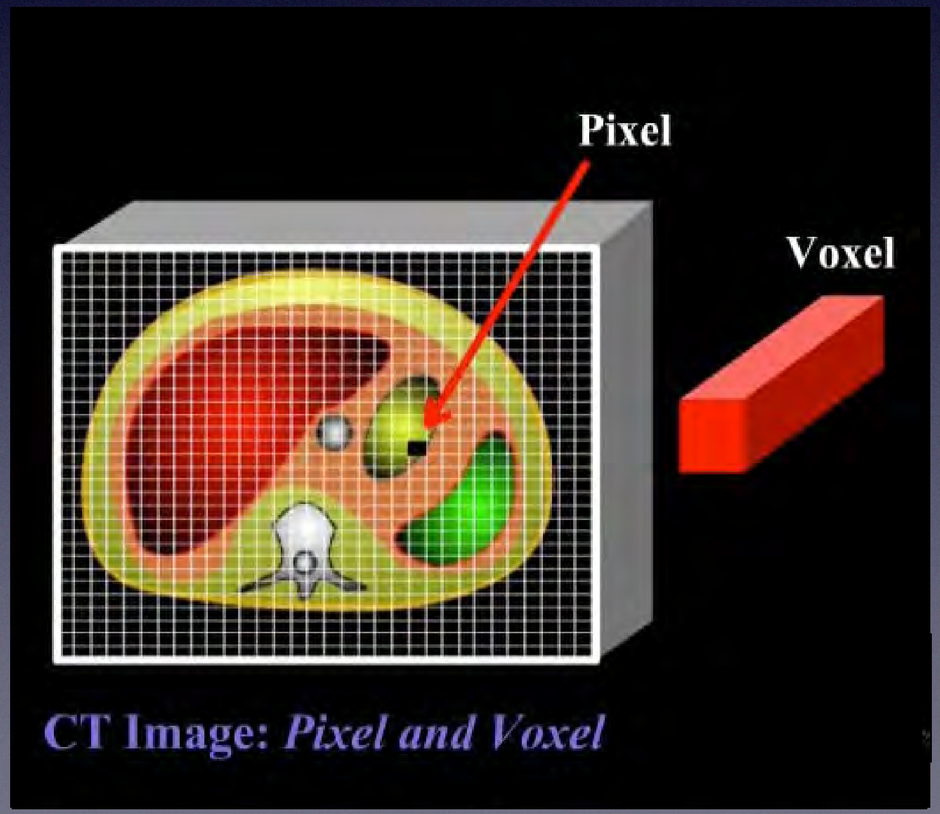
Computed Tomography CT



$$I = I_0 \cdot e^{-\mu x}$$

I= Intensity of X-ray beam passing through the thickness “X” of the studied material
I_0= Initial intensity of the X-ray beam
X= Thickness of the studied material
μ= Linear absorption coefficient of the studied material (cm-1)

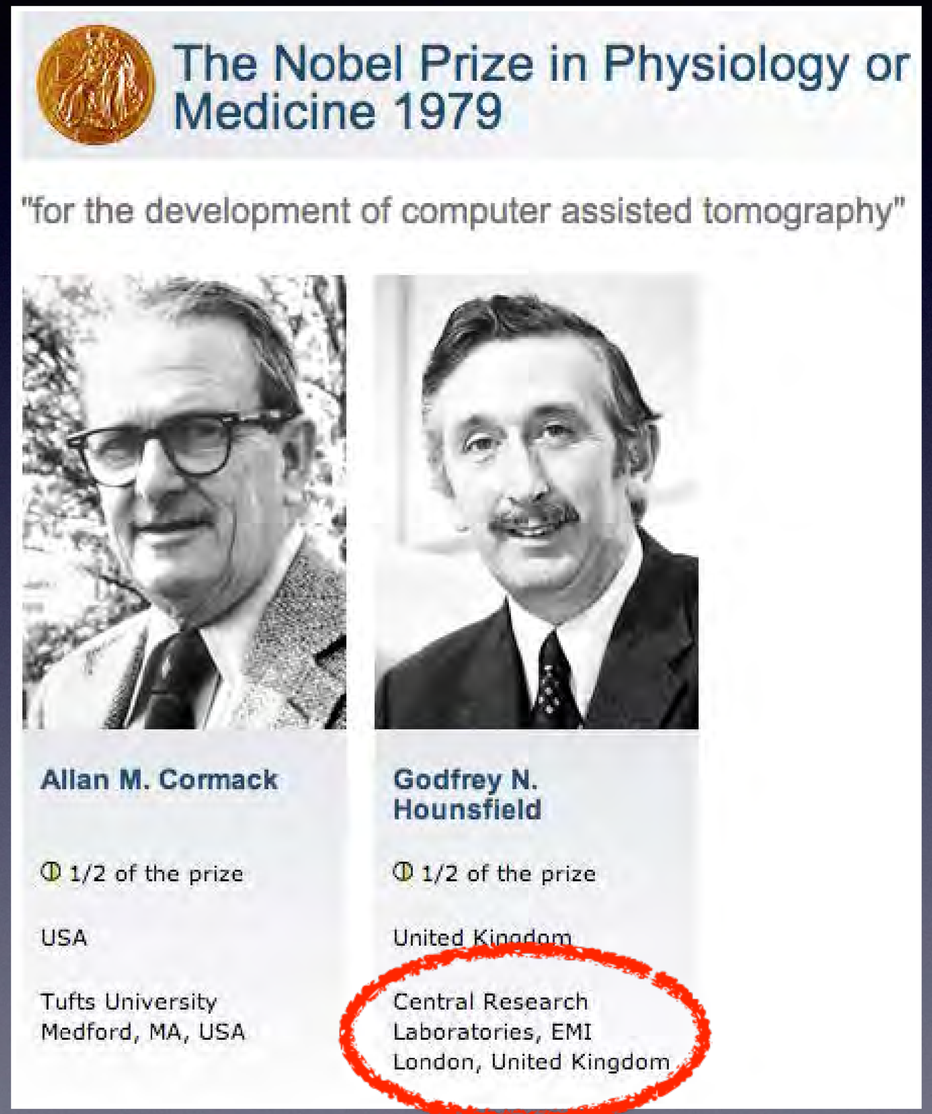


NON-CONTRAST ENHANCED CT (NECT)

STRUCTURE/TISSUE	HOUNSFIELD UNITS
Cortical bone	1,000
Liver	40-60
Gray Matter	46
White Matter	43
Blood*	40*
Muscle	10-40
Kidney	30
CSF	15
Water	0
Fat	-50 / -100
Air	-1,000

COMPUTED TOMOGRAPHY: BRIEF HISTORY

- Introduced into clinical practice in 1972
- Revolutionized imaging diagnosis by allowing analysis of cross section anatomic structures, without overlapping



COMPUTED TOMOGRAPHY: BRIEF HISTORY, 2

EMI Group, Ltd.

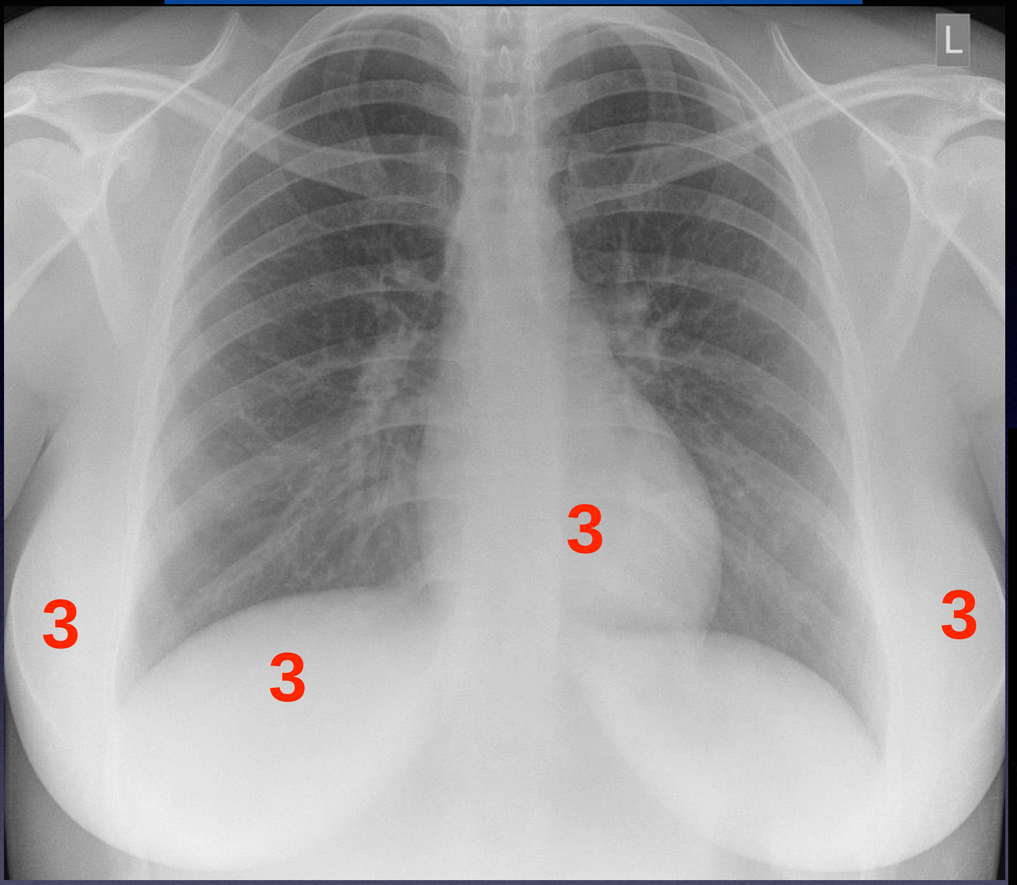
EMI

Type	Private
Founded	1931
Headquarters	London, England, UK
Key people	Guy Hands, Chairman
Industry	Music
Revenue	£1.46 billion (2008)
Net income	▼ £757 million (2007-2008)[1]
Employees	5,500 (January 2008)
Parent	Terra Firma Capital Partners
Website	EMI Group website

- Before and after WW-II, built radar and guided missiles
- Broadcasting equipment (1st TV transmitter in UK)
- First transistorized computer in UK
- Aircraft, calculators, electronic circuits
- Recording studios: The Beatles, The Beach Boys, the Hollies, the Rolling Stones, Cilla Black, Robbie Williams

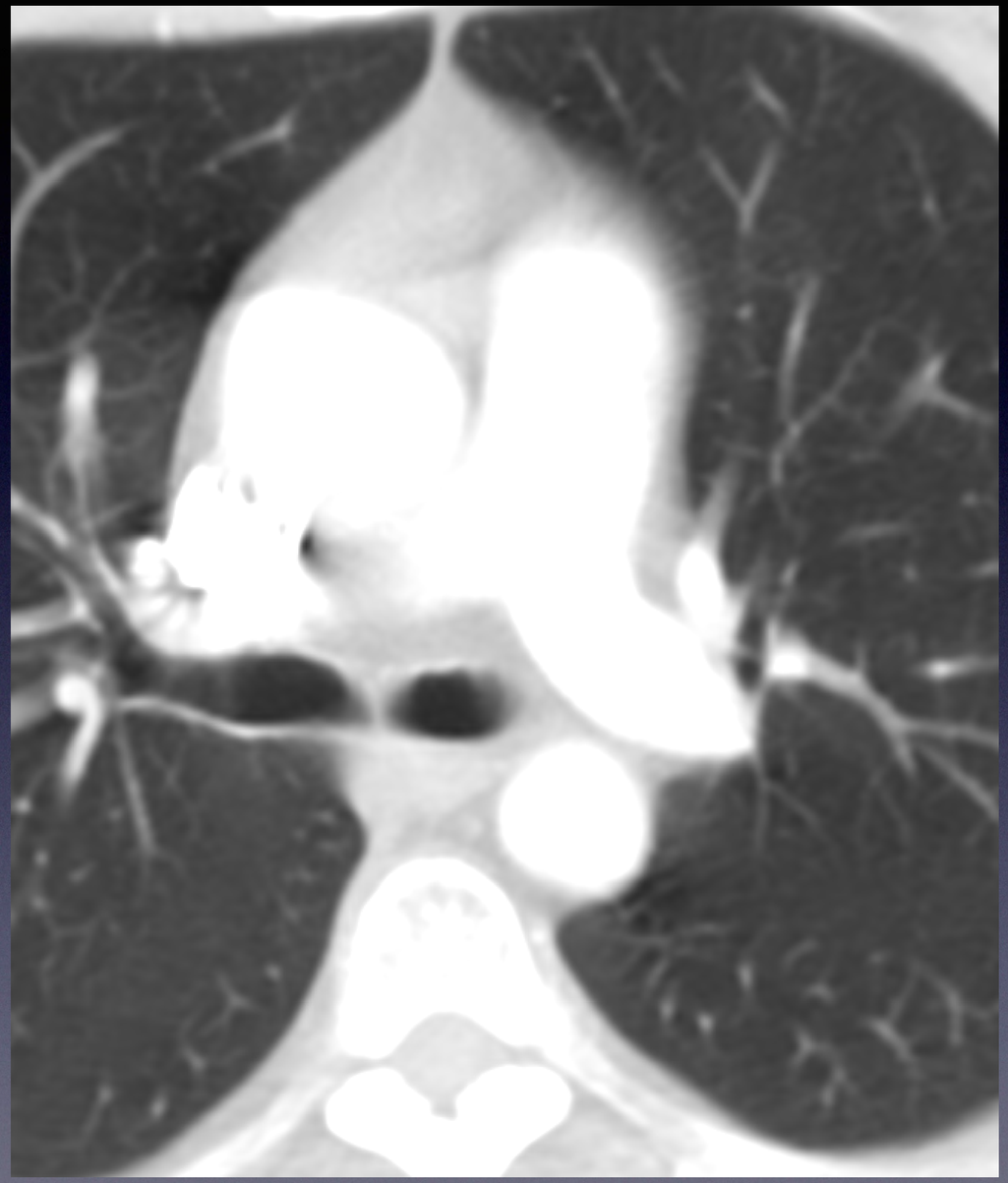
COMPUTED TOMOGRAPHY: BRIEF HISTORY, 3.....

Normal CXR

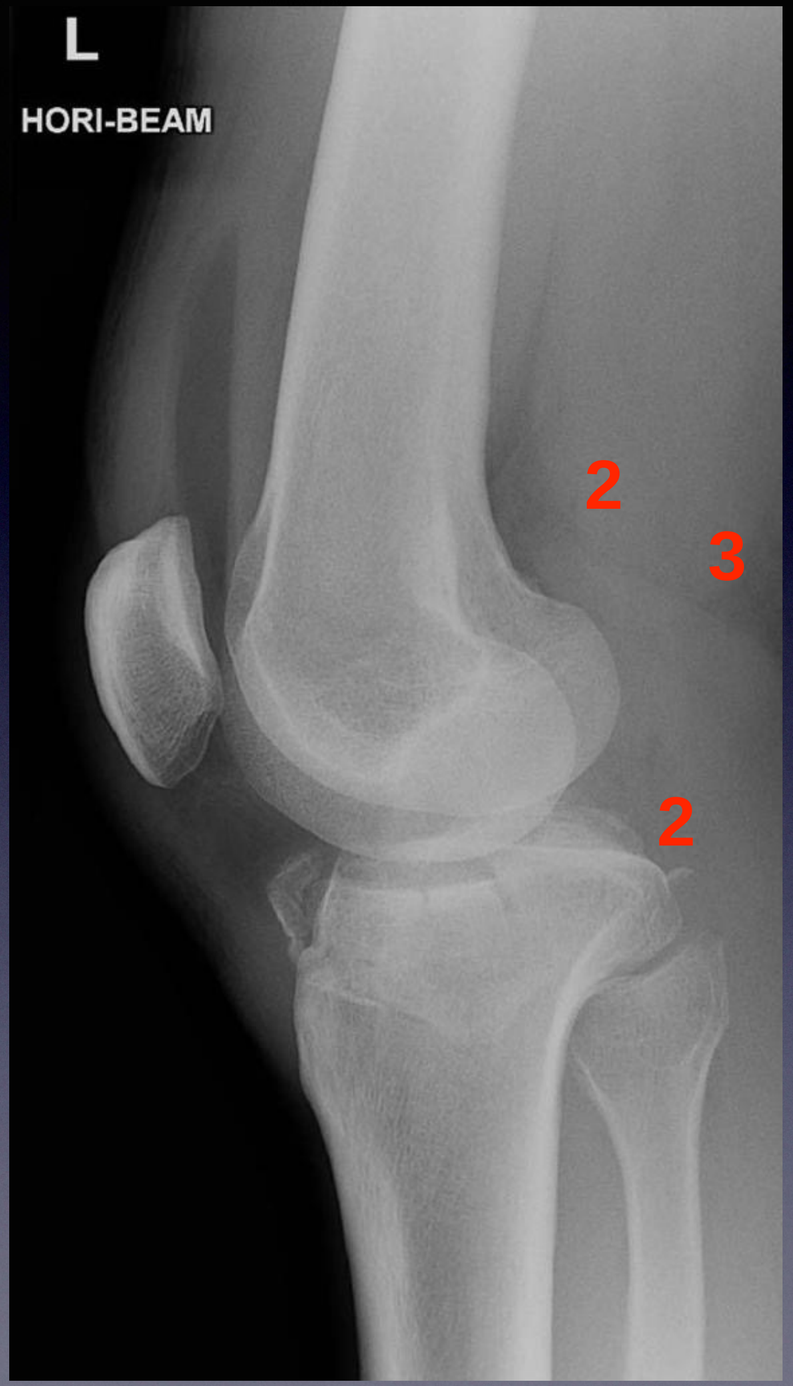


CT

Opposed Densities: Conventional Films & CT

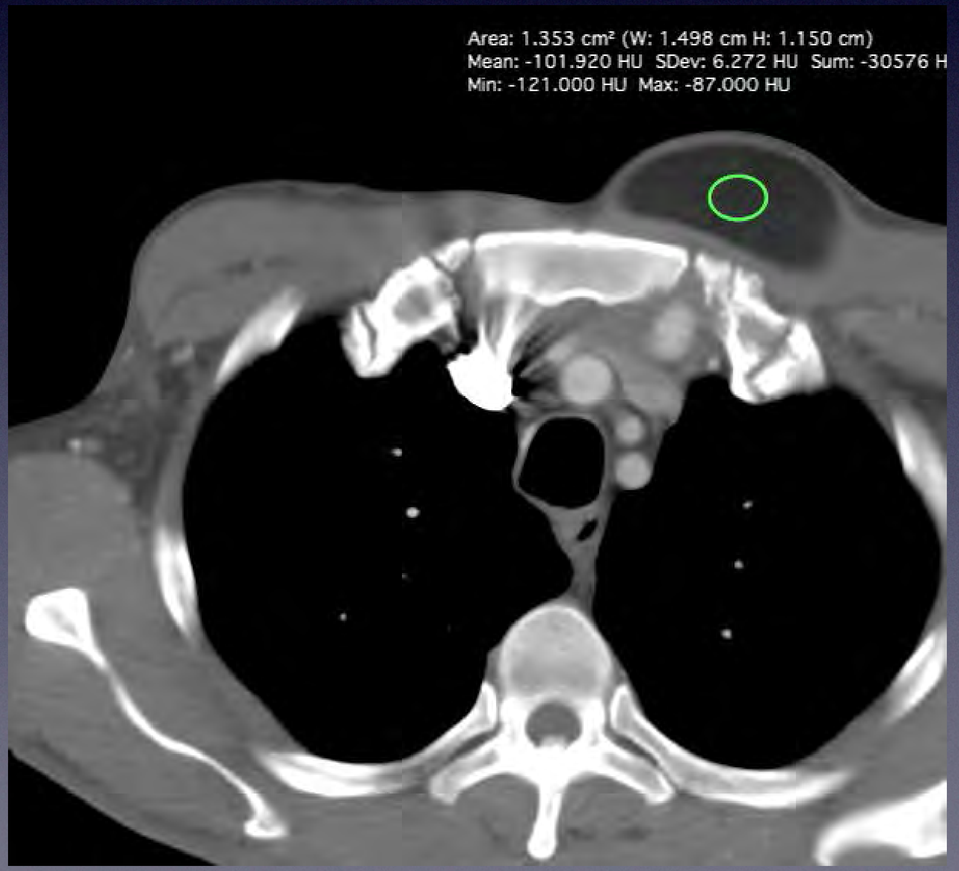


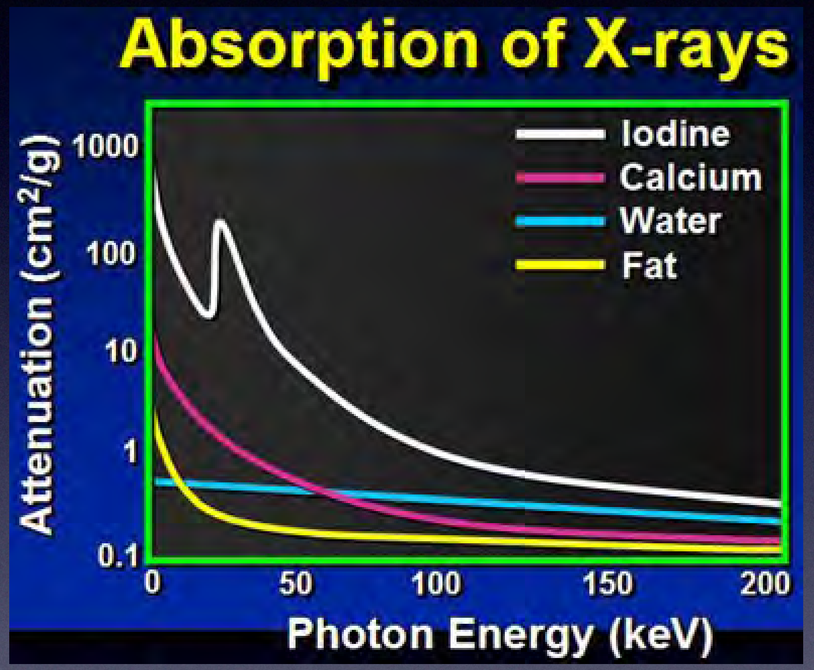
1


L
HORI-BEAM
2
3
2

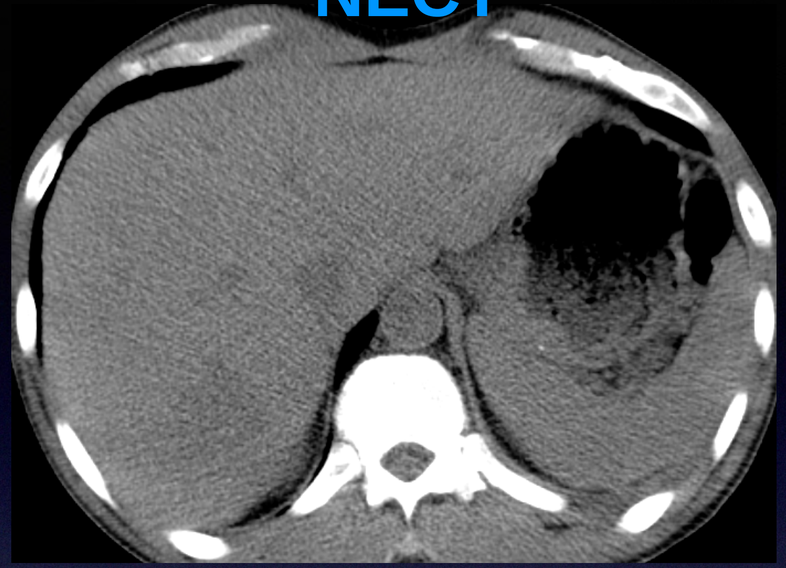
4

3

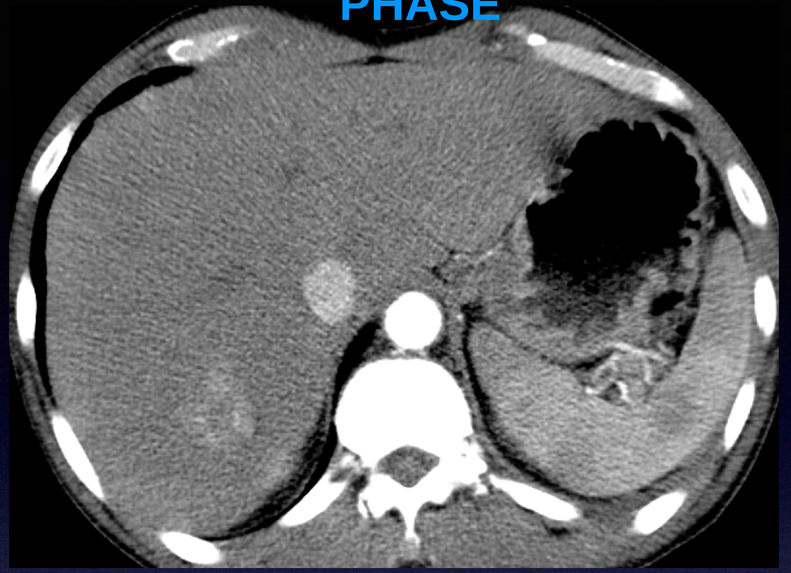

Area: 1.353 cm² (W: 1.498 cm H: 1.150 cm)
Mean: -101.920 HU SDev: 6.272 HU Sum: -30576 H
Min: -121.000 HU Max: -87.000 HU


Absorption of X-rays
Attenuation (cm²/g)
1000
100
10
1
0.1
0
50
100
150
200
Photon Energy (keV)
Iodine
Calcium
Water
Fat

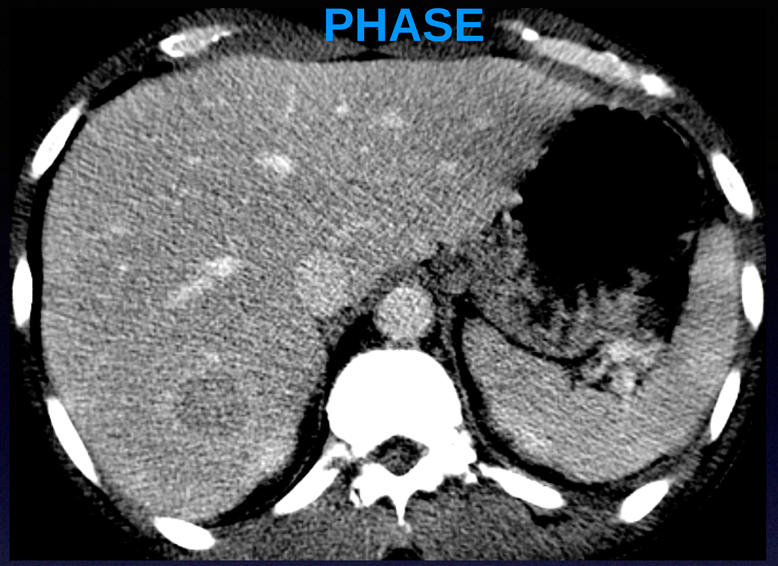
NECT

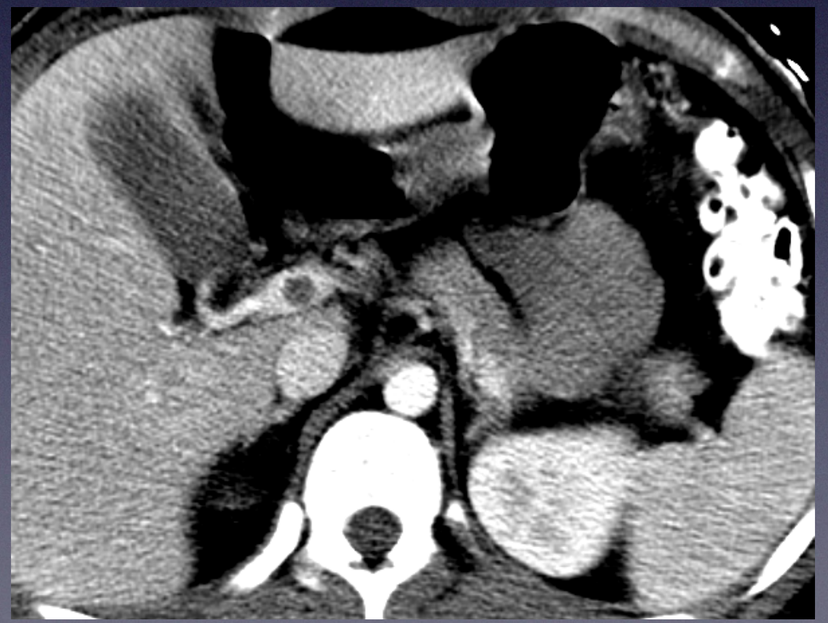


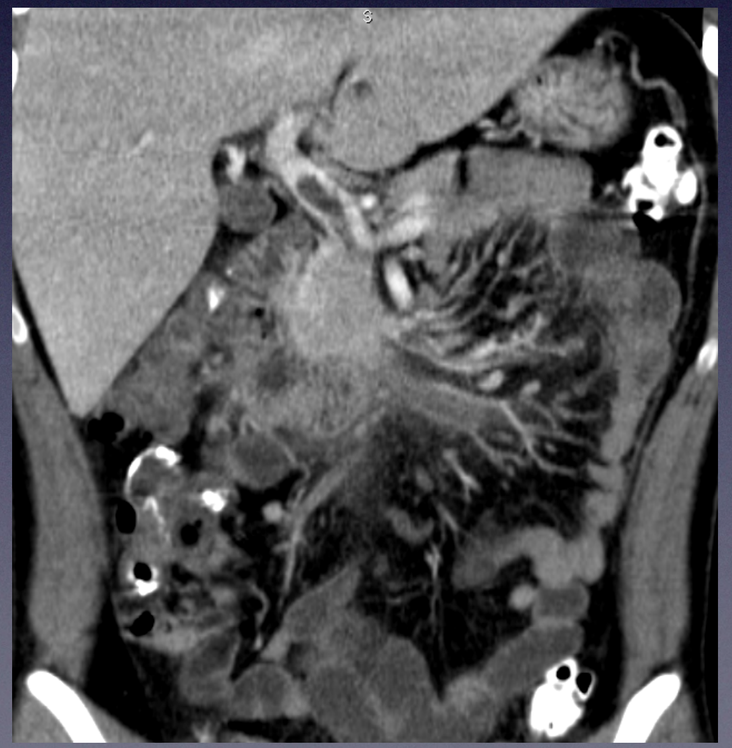
ARTERIAL PHASE



PORTAL PHASE







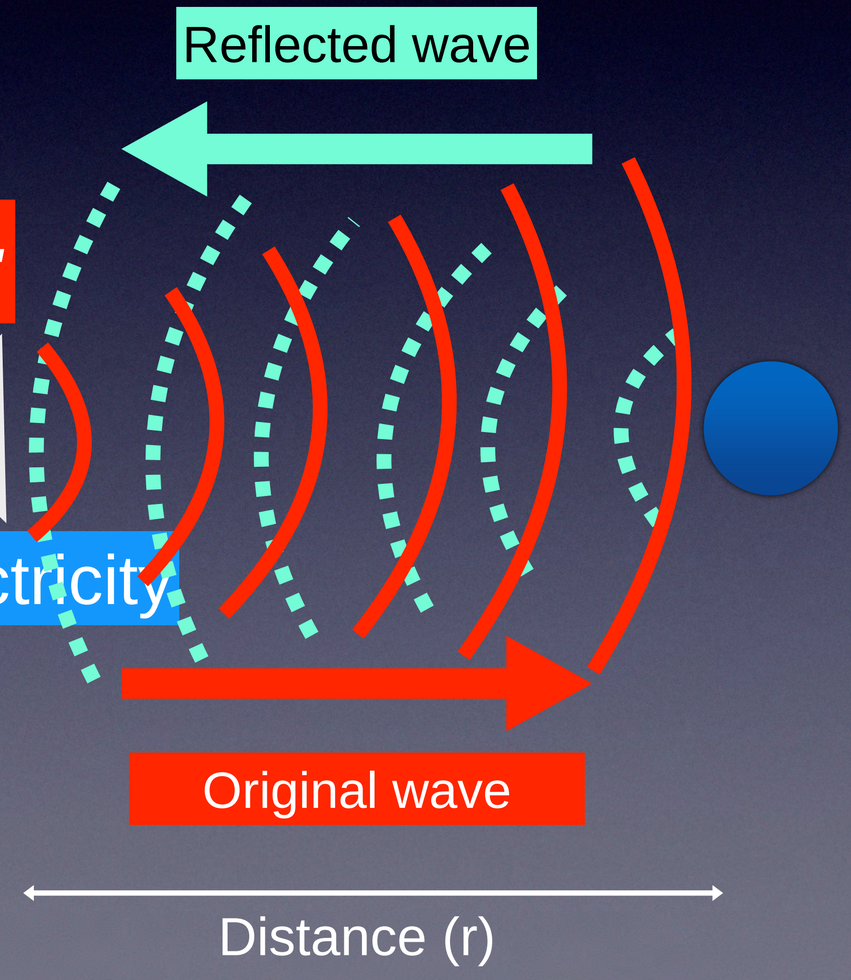
Ultrasound

Ultrasound

Piezoelectric effect:

Electricity will bend cry

Crystals are bent to generate electricity



Ultrasound

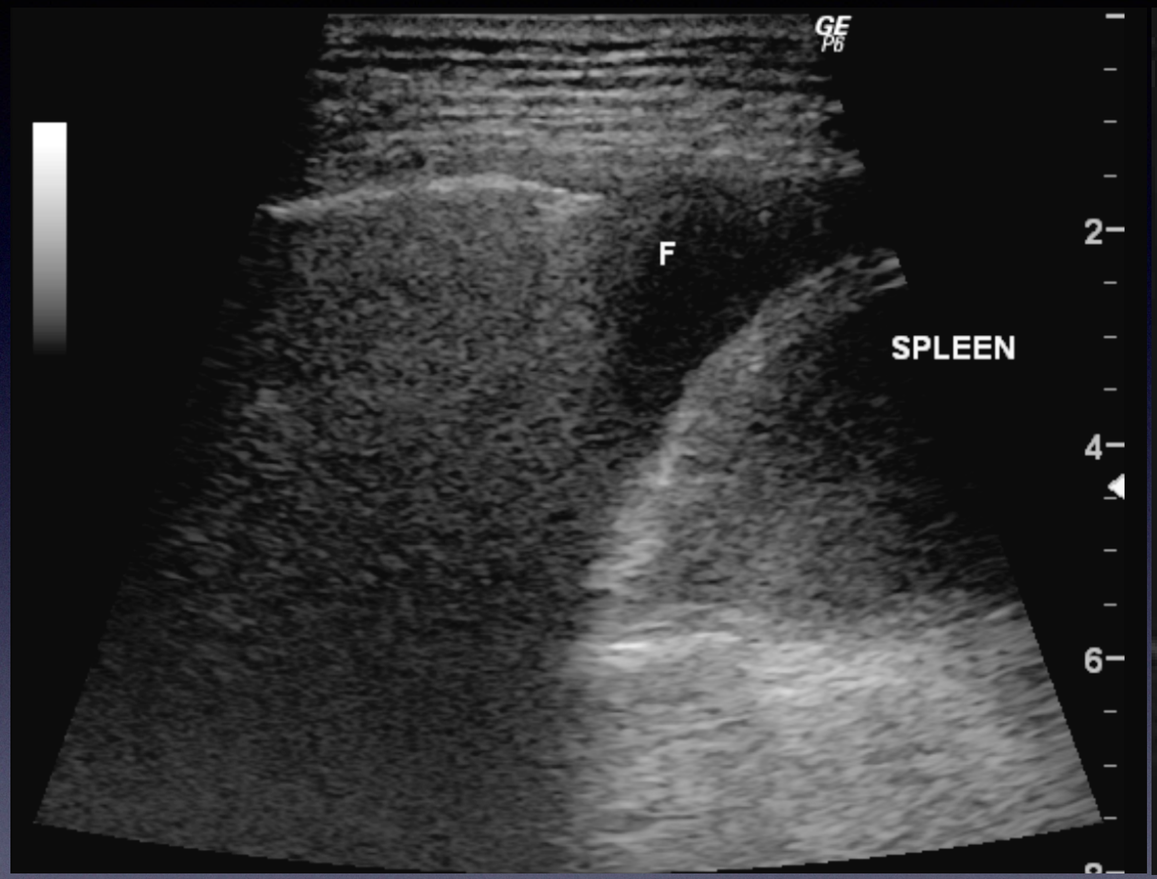
Material	Density (kgm^{-3})	Speed of sound (ms^{-1})	Acoustic impedance ($kgm^{-2}s^{-1}x10^{6}$
Air	1.3	330	0.000429
Water	1,000	1,450	1.50
Bone	1,500	4,000	6.00
Blood	1,060	1,570	1.59
Muscle	1,075	1,590	1.70
Soft tissue	1,050	1,500	1.58
Fat	925	1,450	1.38

Acoustic impedance

Ease of sound transmission between different materials

Acoustic impedance (z)= Density of material (p) x speed of sound in the material (v)

Ultrasound



PART 2,
VISUAL GUIDANCE IN IR PROCEDURES

Image Guidance

- Fluoroscopy
- Ultrasound
- Ultrasound/fluoroscopy
- Mammography or stereo
- CT

- CT/fluoroscopy
- Cone-beam CT
- MRI
- PET-CT
- Navigation techniques

Image Guidance

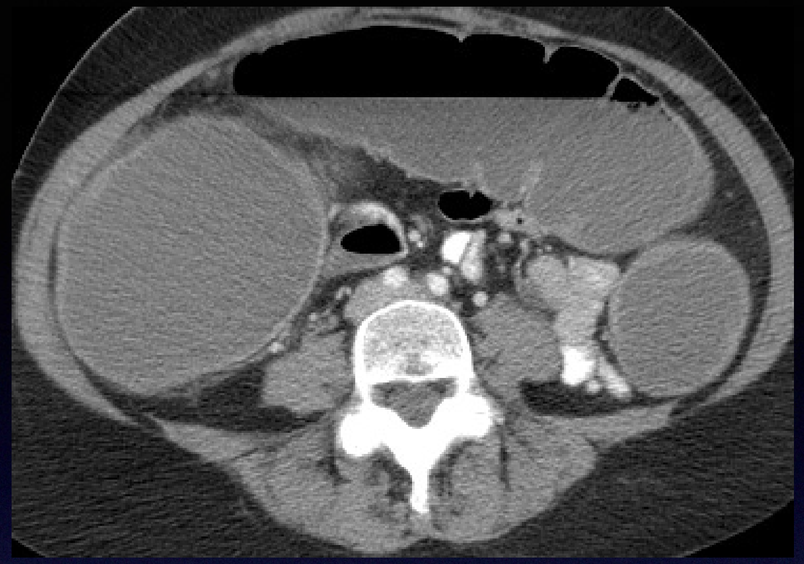
- Clear visualization of target
- Potential interposition of non-target organs
- Organs adjacent to target lesion
- Patient’s habitus and clinical status
- Access site and patient’s position
- Operator’s position in reference to the patient

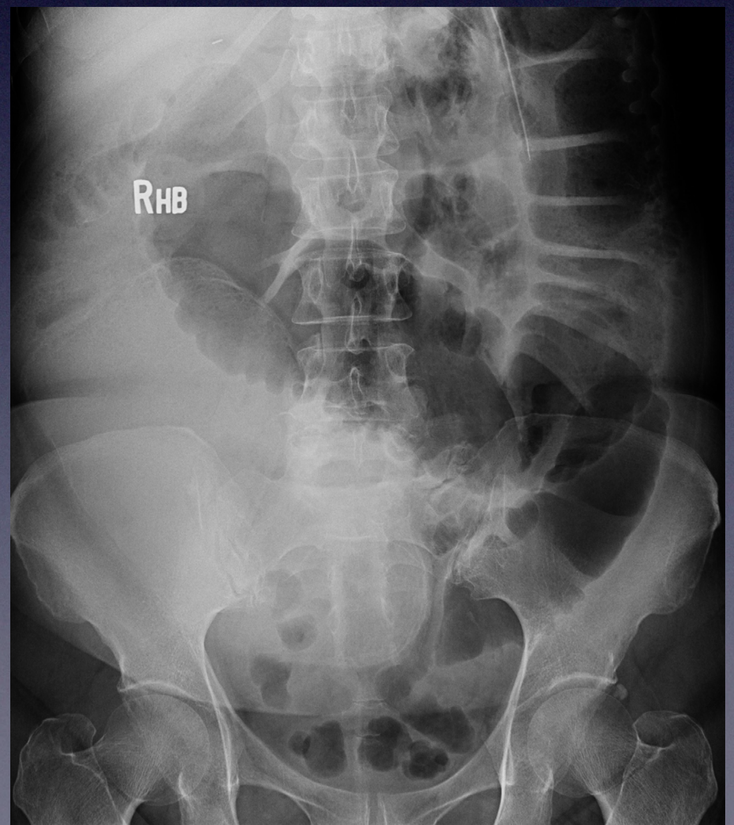
- Moderate sedation
- Monitoring by nurse
- Radiation exposure
- Operator’s preference and expertise
- Local available resources

Image Guidance

Fluoroscopy:

- Immediate access (IR suite)
- Immediate tools availability
- Quick method, easy to monitor patient
- Usually no contrast needed
- Wide working field
- Real-time availability
- Downside: Ionizing radiation, 2D study, poor depiction of anatomy, patient's habitus, gas interposition




RHB


PRONE


PRONE


PRONE

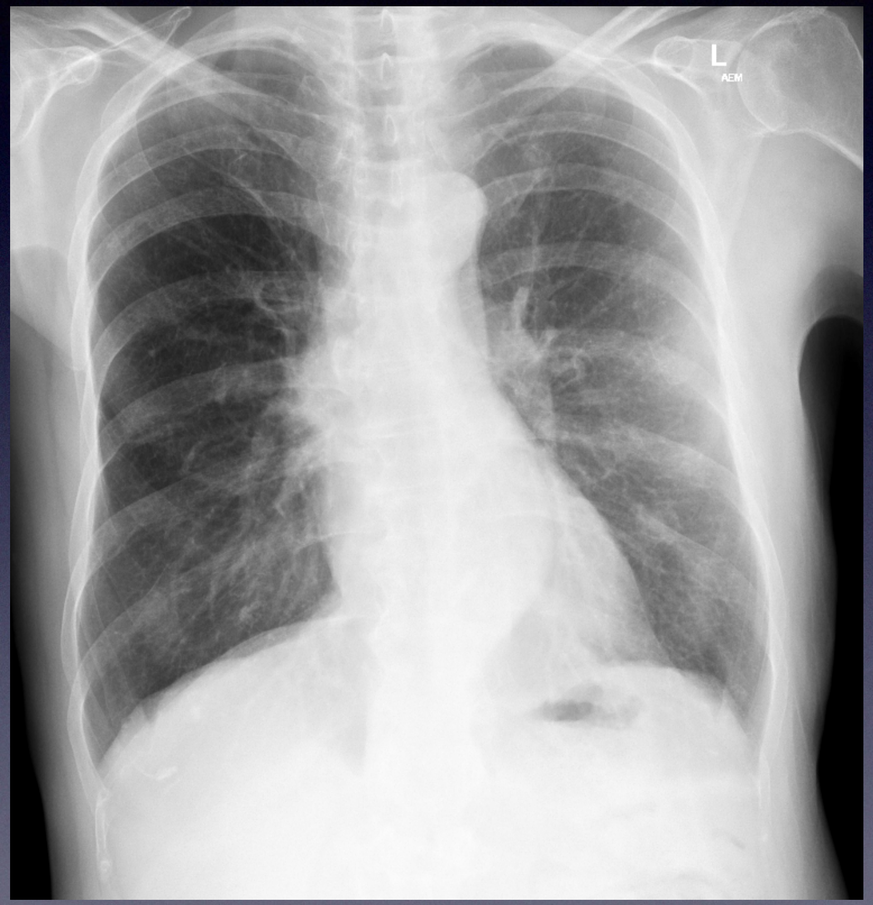

PRONE


SUPINE

Image Guidance

Ultrasound:

- Readily available (IR-dedicated equipment)
- Inexpensive, quick method, easy to monitor patient
- No ionizing radiation, no contrast needed
- 3D study, good depiction of anatomy, wide working field
- Multi-planar
- Real-time availability
- Needle guidance
- Downside: Patient’s habitus, gas interposition, bone interposition, operator dependent (physician doing procedure)


L
AEM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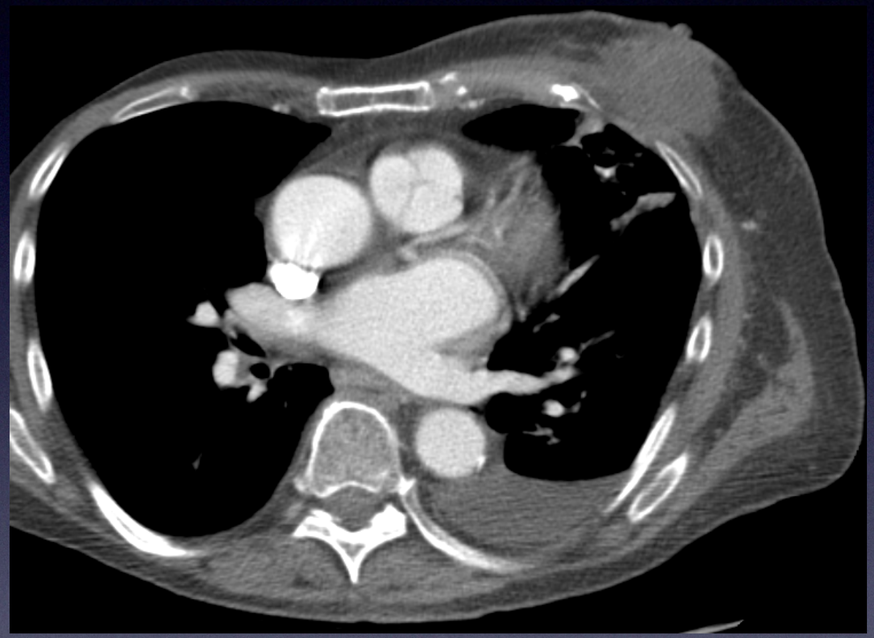

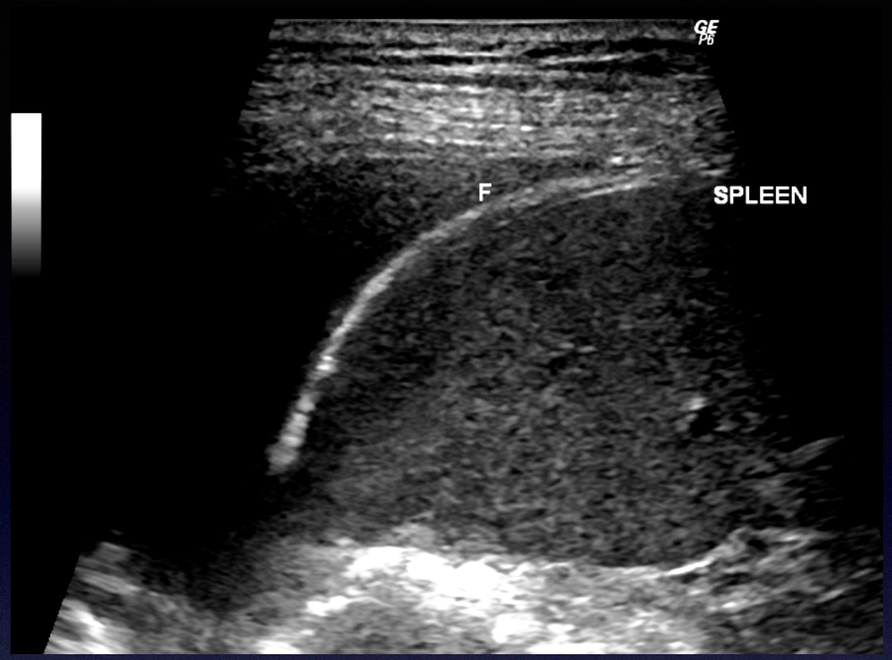
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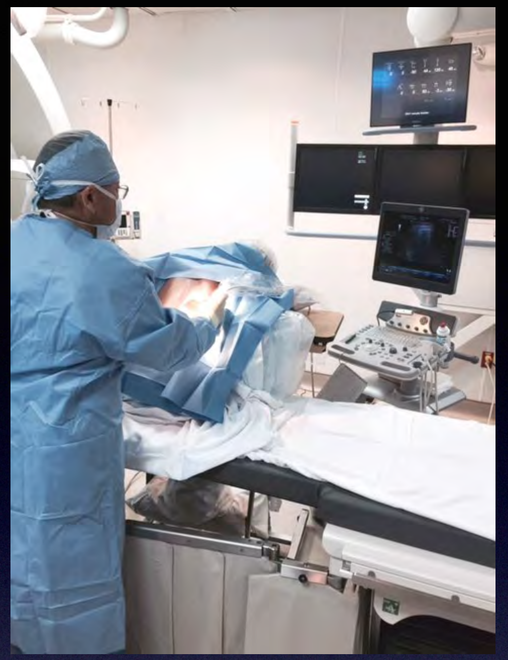


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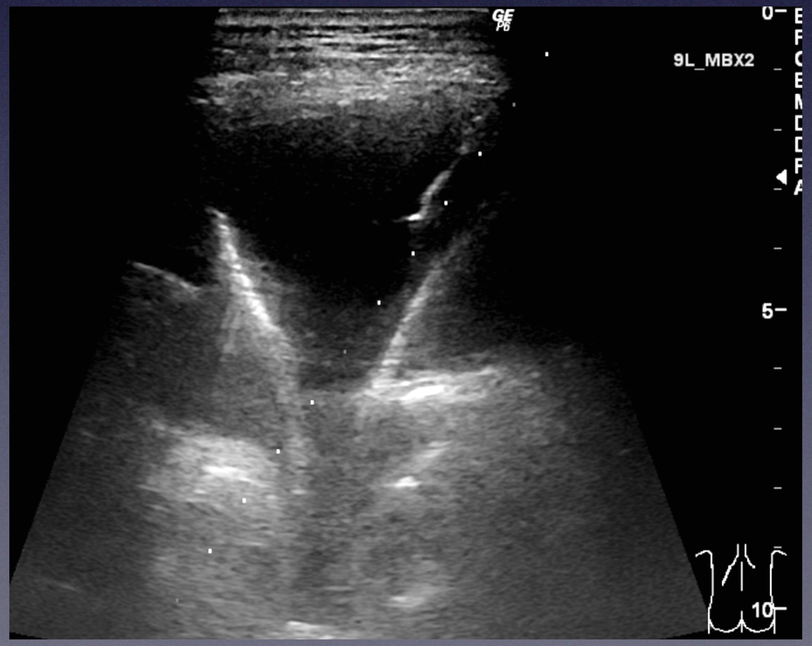
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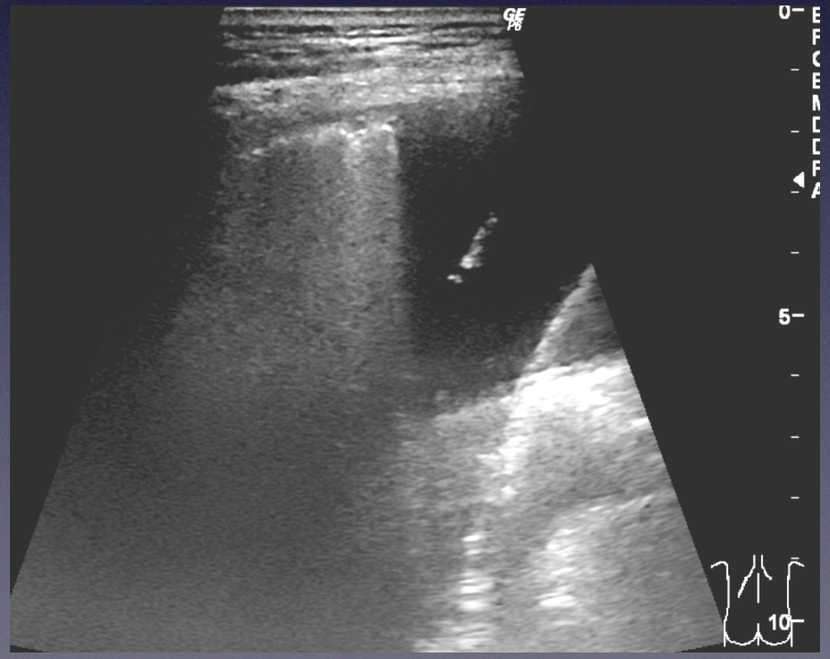
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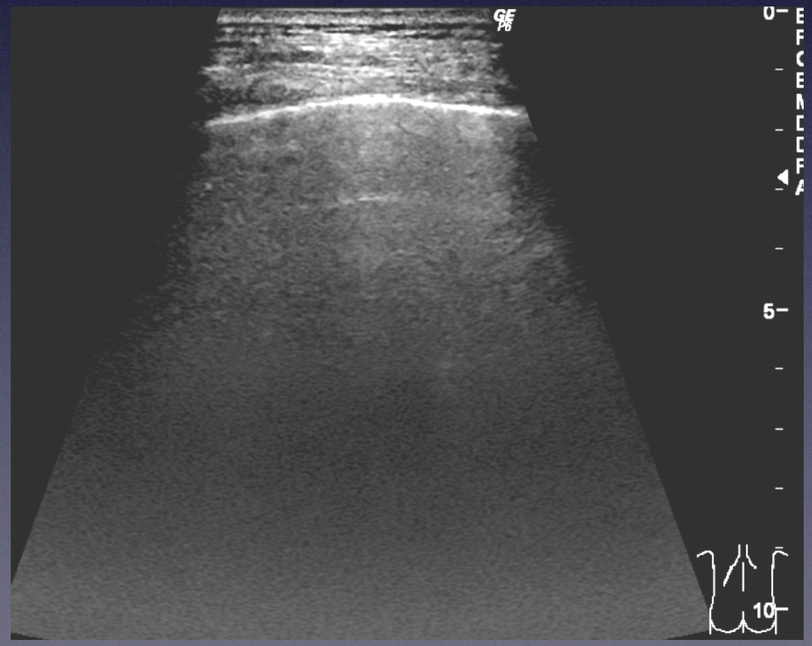
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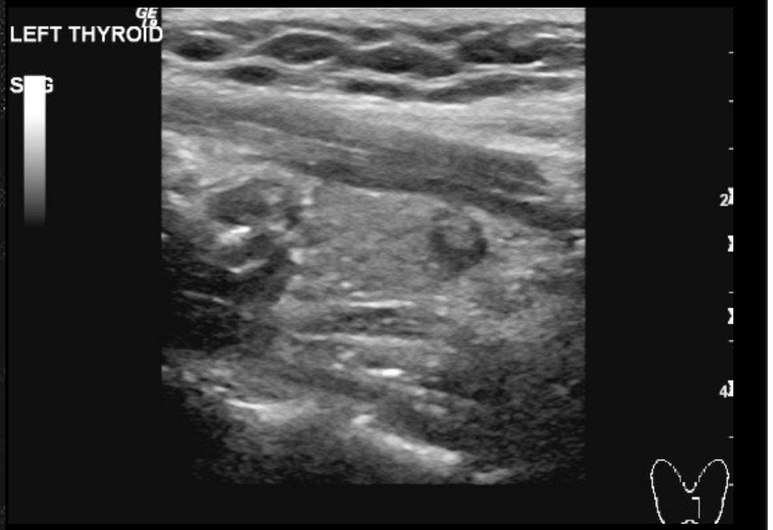
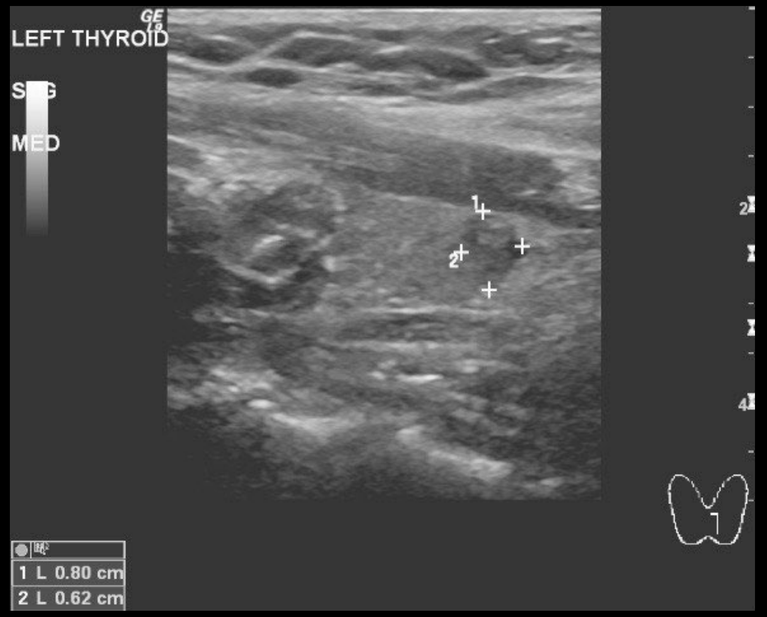




Clinical Diagnosis:
Left thyroid nodule

SPECIMEN ADEQUACY STATEMENT

Satisfactory for evaluation.

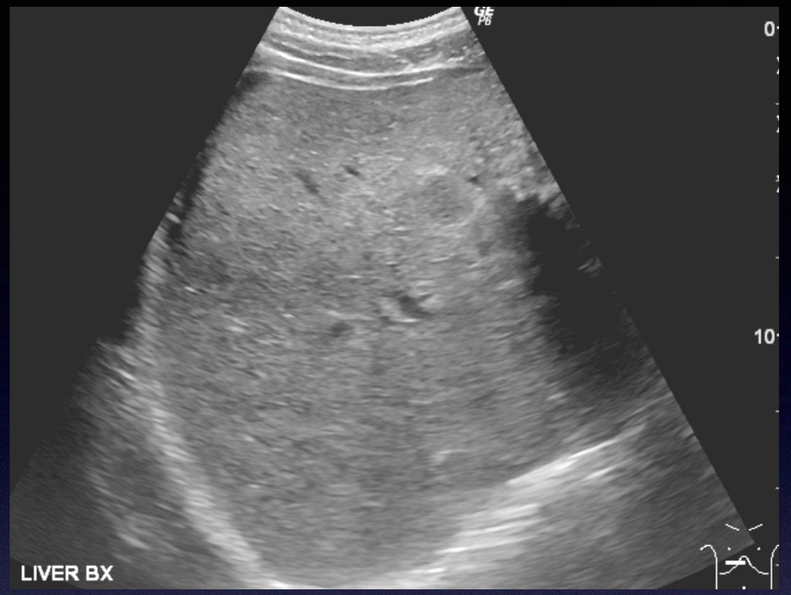
DESCRIPTIVE DIAGNOSIS

Ultrasound guided Fine needle aspiration of Left thyroid nodule:
-Cytomorphology of papillary thyroid carcinoma.

FINAL DIAGNOSIS
GROSS & MICROSCOPIC:

1. Left thyroid lobe, Lobectomy:
-Papillary thyroid carcinoma, follicular variant.
-Procedure: ---------- Total thyroidectomy.
-Specimen integrity: ---------- Intact, Right lobe 4 x 2 x 1 cm, Left lobe 3.5 x 2.4 x 0.7 cm.
-Tumor focality: ---------- Unifocal.
-Tumor laterality: ---------- Left lobe.
-Tumor size: ---------- 1.1 cm.
-Histologic type: ---------- Papillary carcinoma, classical and follicular features.
-Histologic grade: ---------- Grade I: Welldifferentiated
-Margins: ---------- Margins uninvolved by carcinoma.
-Distance of invasive carcinoma to closest margin: 0.2 mm (extremely close to inked margin and cauterized margin)
-Tumor capsule: ---------- Totally unencapsulated.
-Tumor capsular invasion: ---------- Cannot be assessed.
-Lymphovascular invasion: ---------- Not identified.
-Perineural invasion: ---------- Not identified.
-Extrathyroidal extension: ---------- Present: Minimal.
-Pathological staging: ---------- pT1b, pN0, pMna

2. Right thyroid lobe, Lobectomy:
-No evidence of malignancy.


LIVER BX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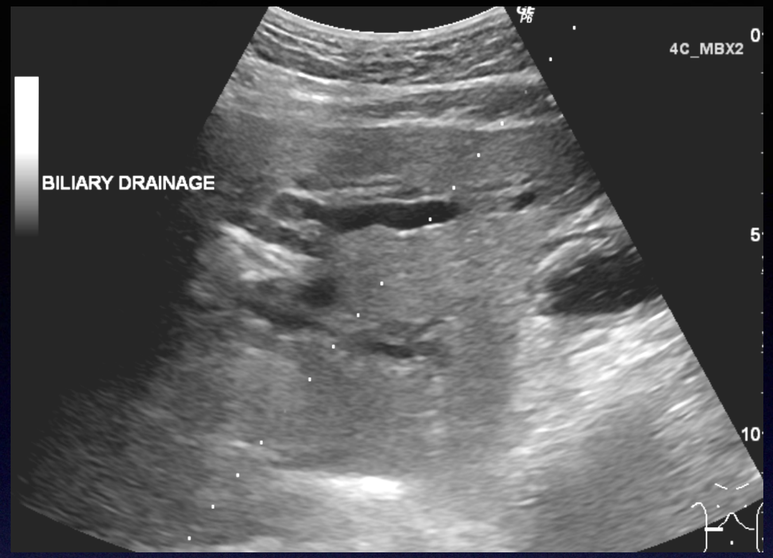
LIVER BX


LIVER BX


LIVER BX

Fluoroscopy & Ultrasound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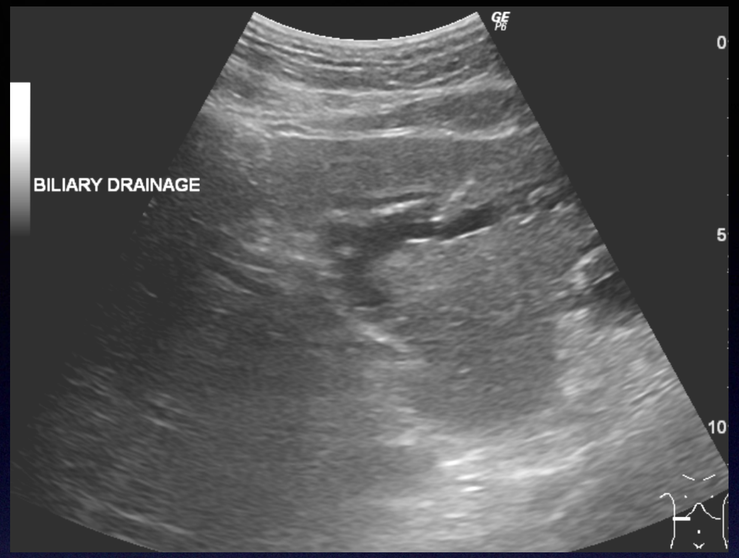
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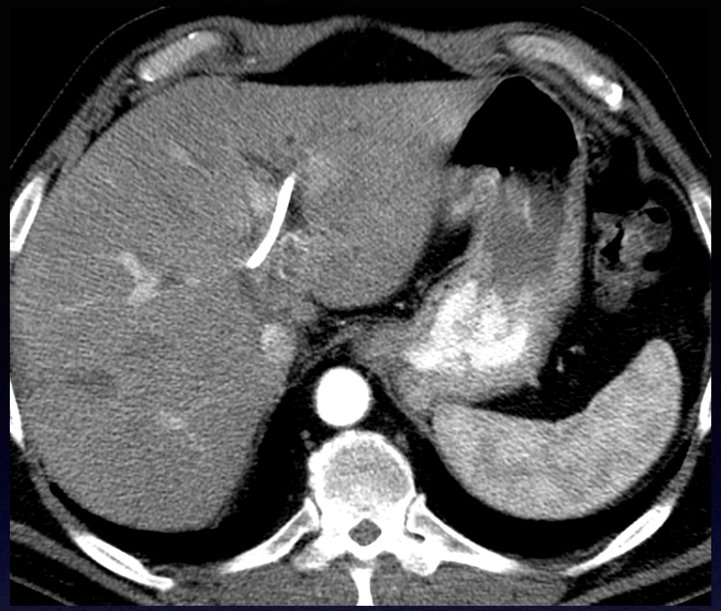

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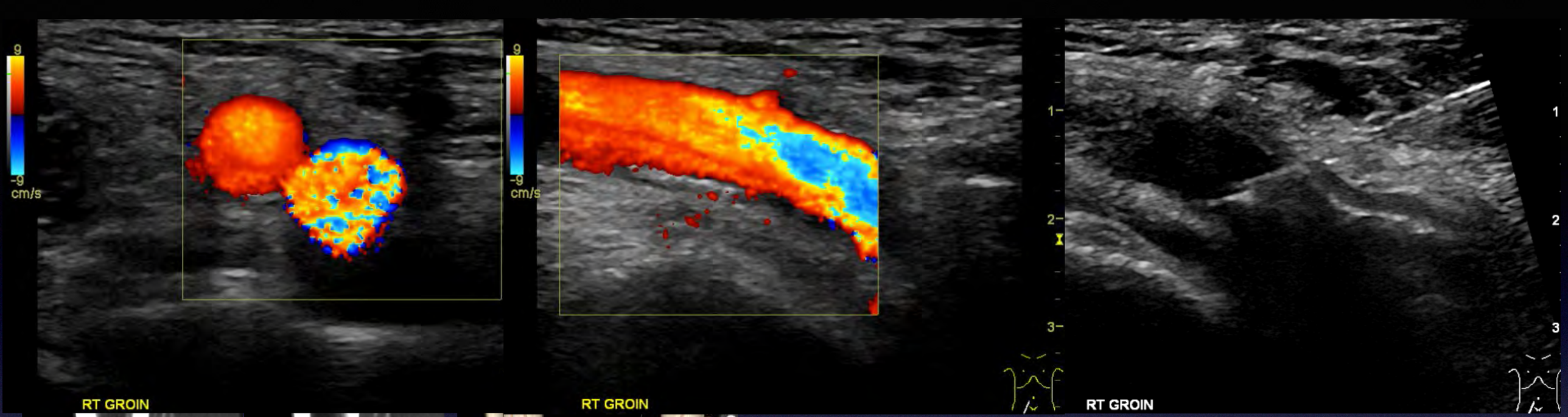
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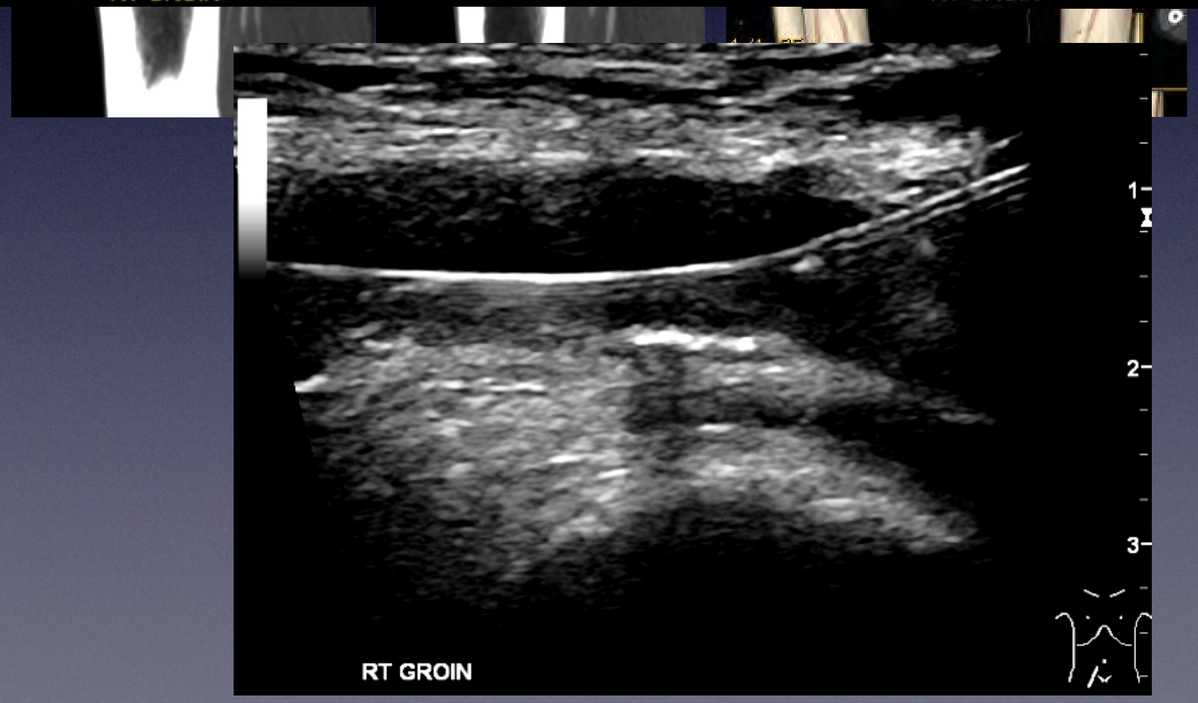
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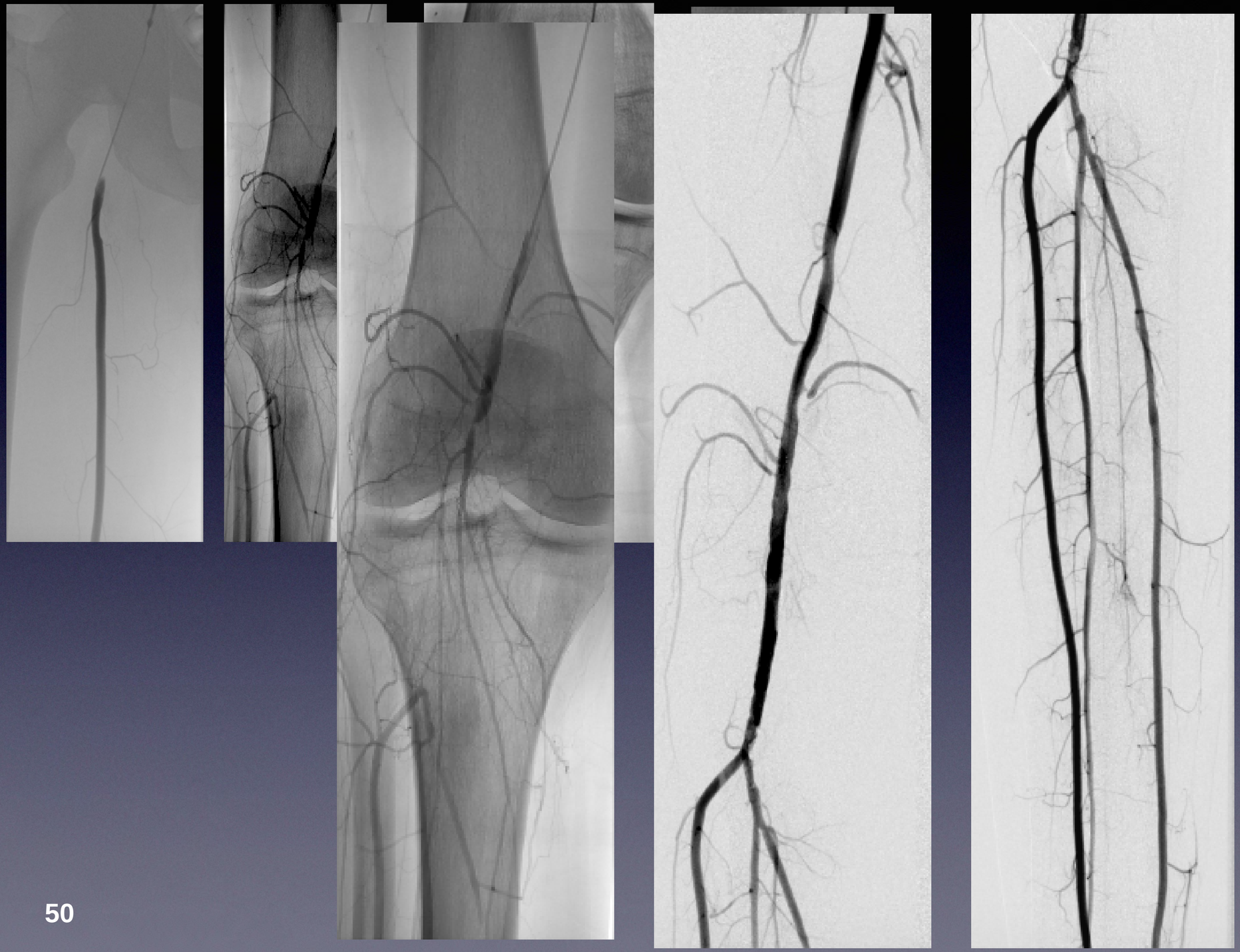
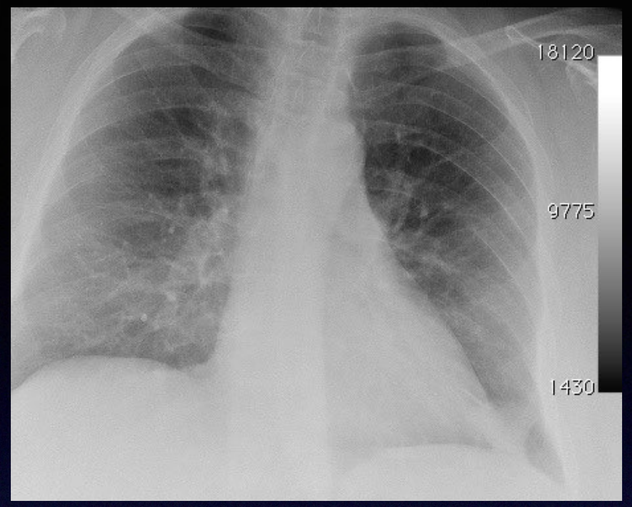


Image Guidance

CT:

- Rapid, but conditioned access (patient load, ER cases, # available techs)
- 3D study, better depiction of anatomy, tissue density characterization
- Downside: Ionizing radiation, contrast may be needed, more cumbersome (bring all your equipment, tools, monitor, etc.), crowded working area, expensive, limited working field (gantry), operator dependent (CT-tech)**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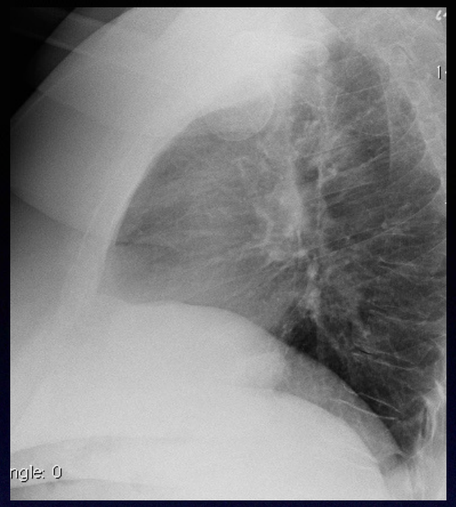

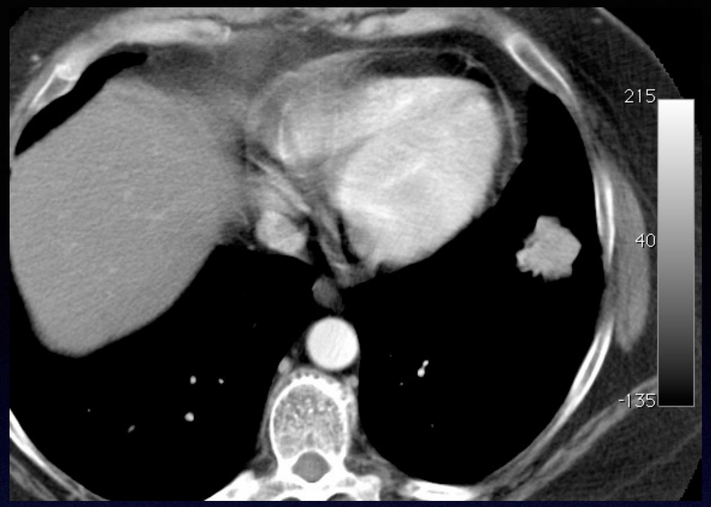
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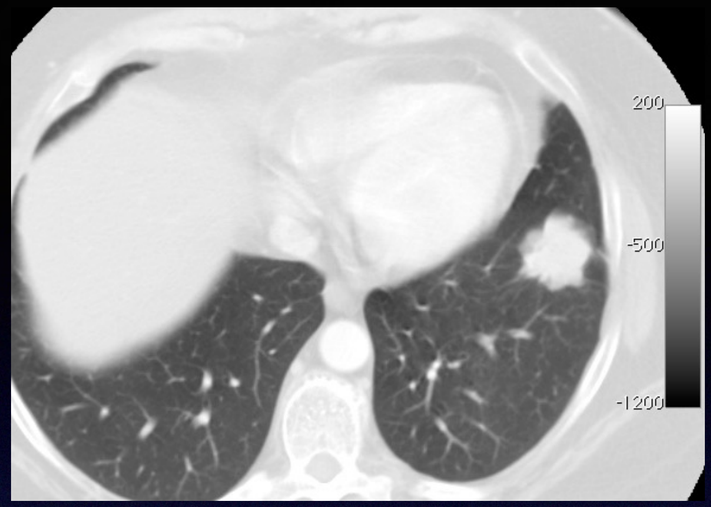
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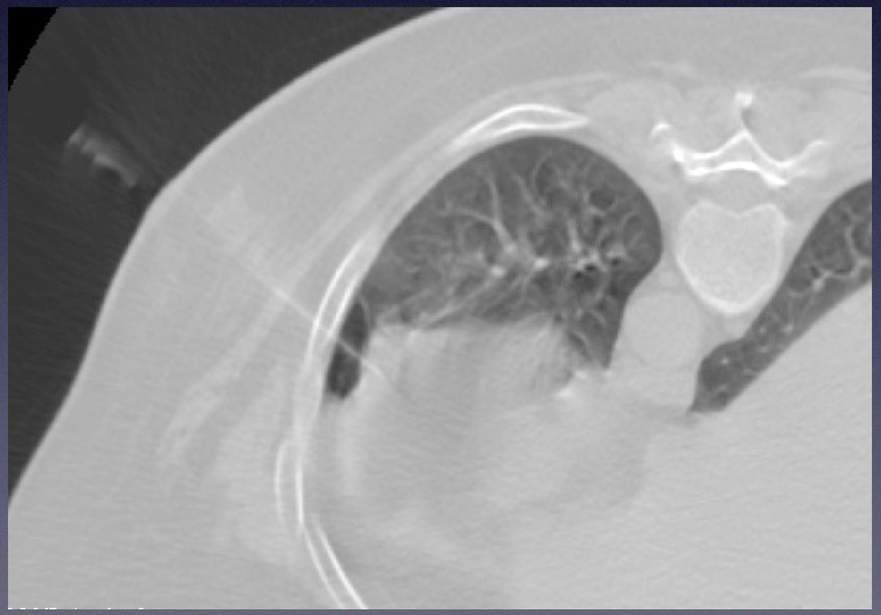
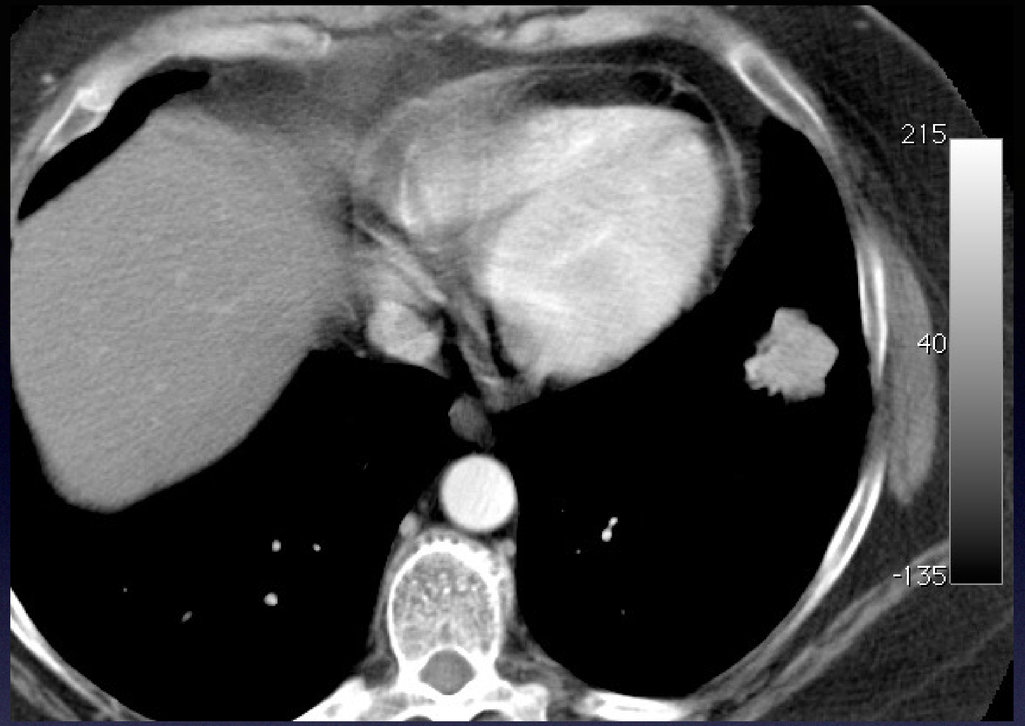
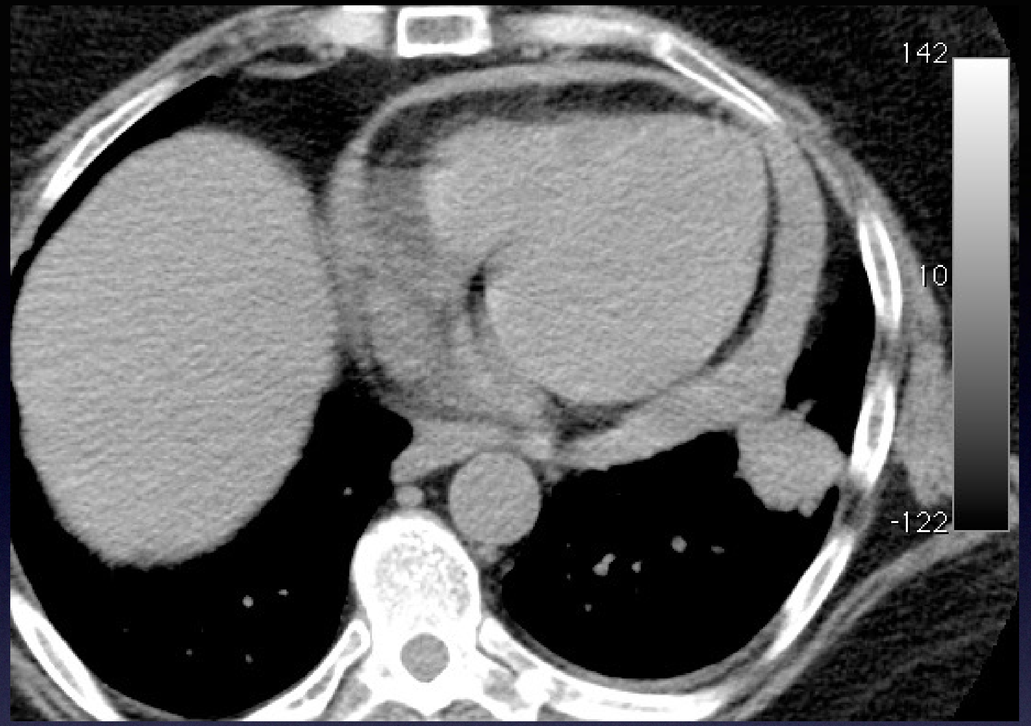






Source:
FNA-LLL lung mass

Specimen Description:
Cloudy cytology fixative submitted for cytospin and a blood clot submitted for cell block preparations.

Clinical Diagnosis:
LLL lung mass; History of lymphoma

SPECIMEN ADEQUACY STATEMENT
Satisfactory for evaluation, but limited by: Scant cellularity.

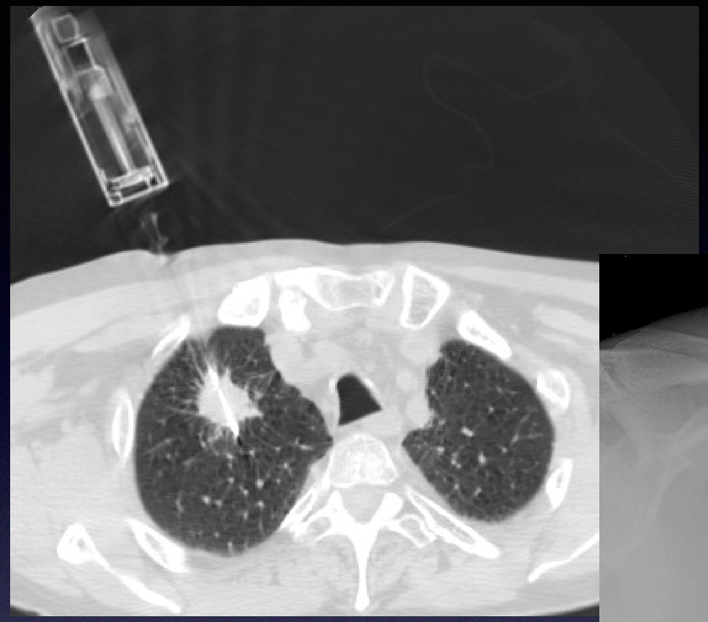
DESCRIPTIVE DIAGNOSIS

CT guided Fine needle aspiration of LLL Lung mass:
-A few cluster of atypical cells, indeterminate for malignancy.
Insufficient for further diagnostic evaluation.

FINAL DIAGNOSIS
GROSS & MICROSCOPIC:

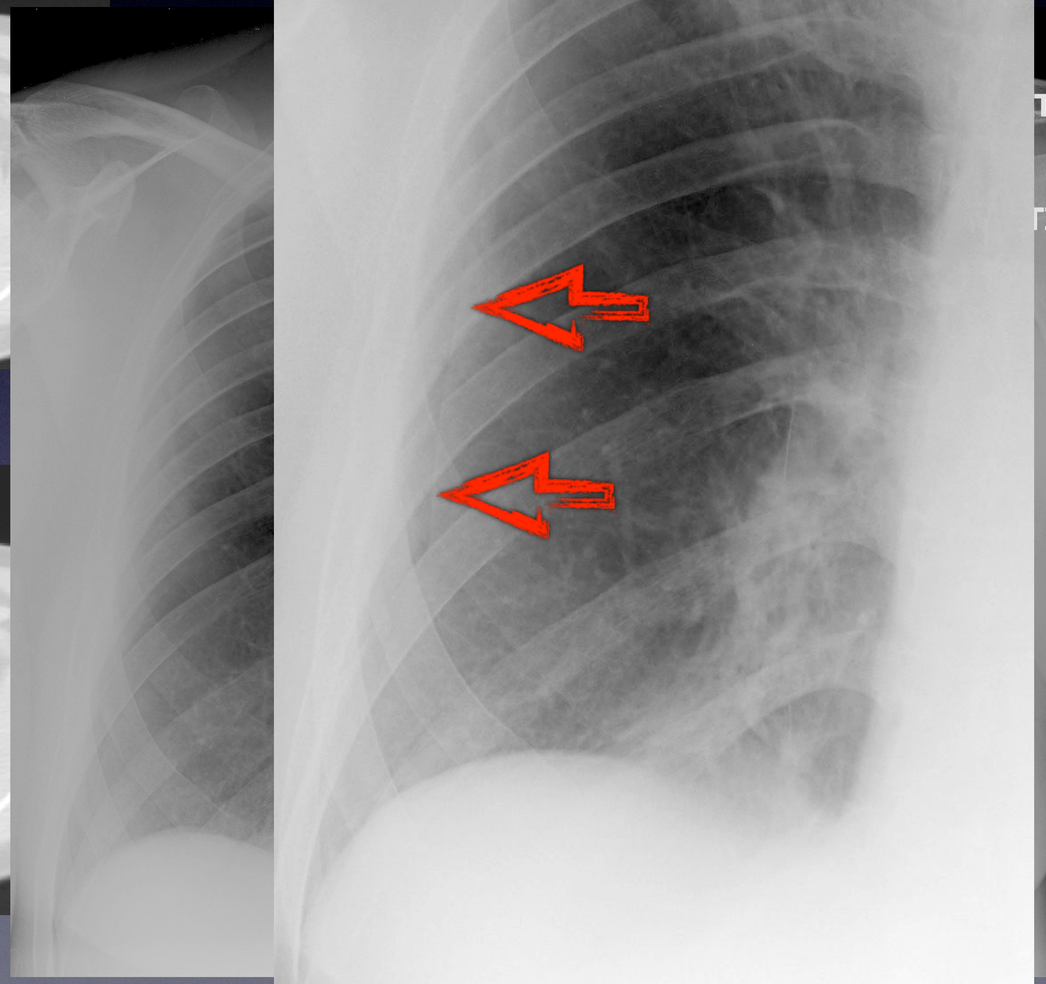
Left lung lesion, Wedge Resection:
Specimen integrity ---------- Disrupted focally, along the pleural surface
Specimen laterality---------- Left
Tumor site ---------- Not specified
Tumor size ---------- 3.1 cm
Tumor focality ---------- Unifocal
Histologic type ----------Papillary Adenocarcinoma. See comment.
Histologic grade ----------G2: Moderately differentiated
Visceral pleura invasion----------Not identified
Tumor extension----------Not identified
Parenchymal margin----------Uninvolved by invasive carcinoma
Distance of invasive carcinoma from closest margin: < 1 mm from the parenchymal margin
Treatment effect----------Not applicable
Lymph-vascular invasion----------Present

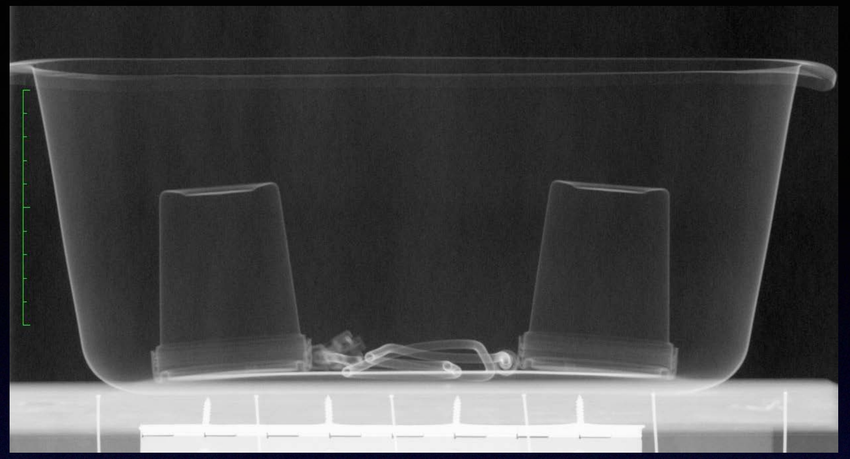
-Pathologic staging: pT2a, pNX

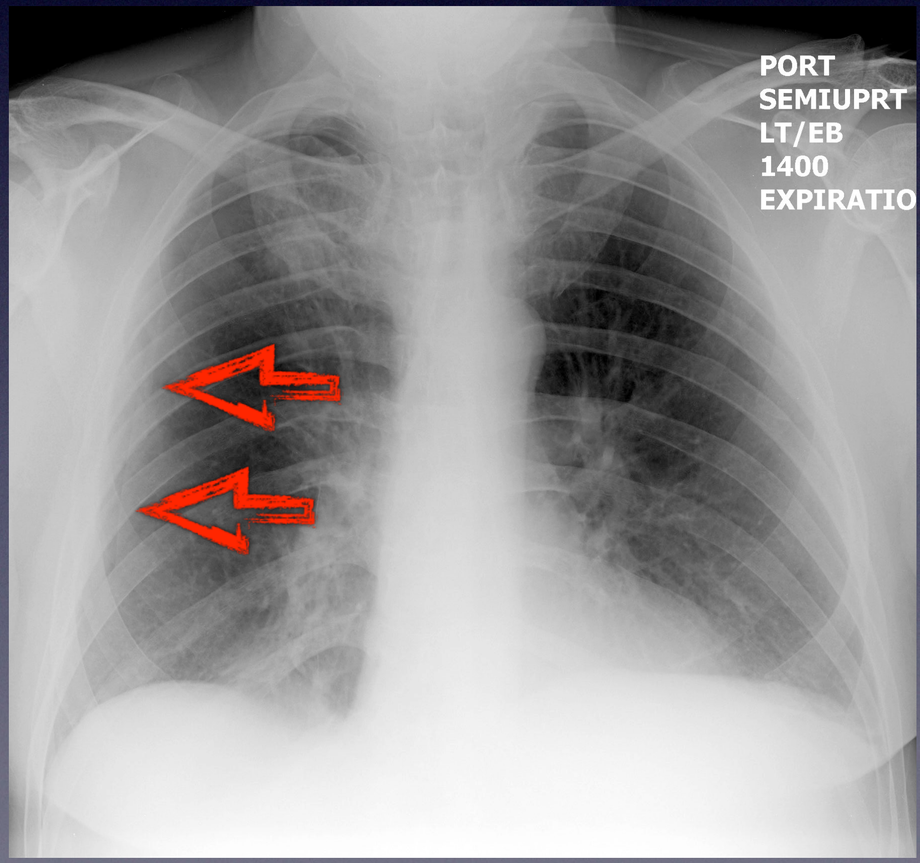


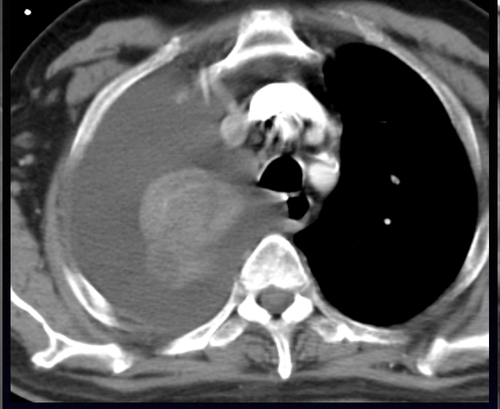
@ 0950 hours

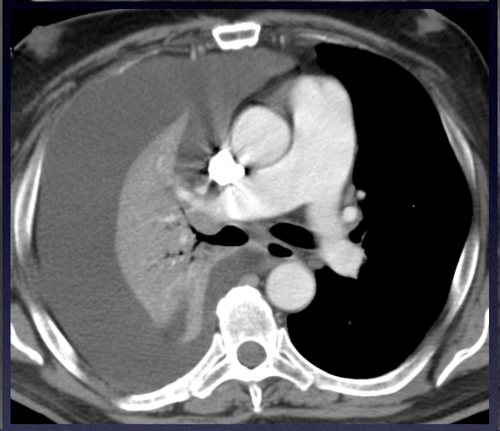
@ 0957 hours

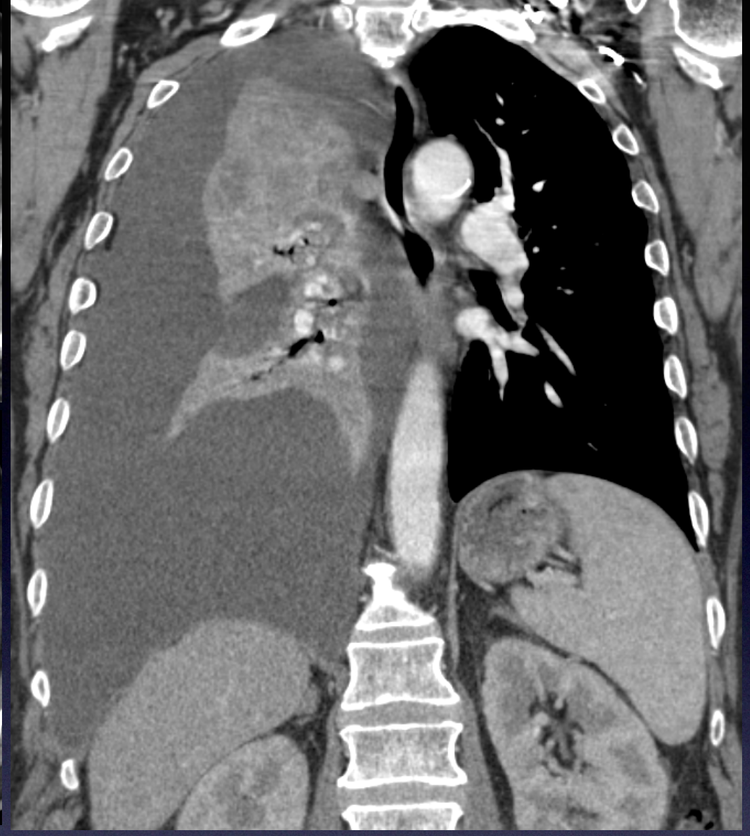


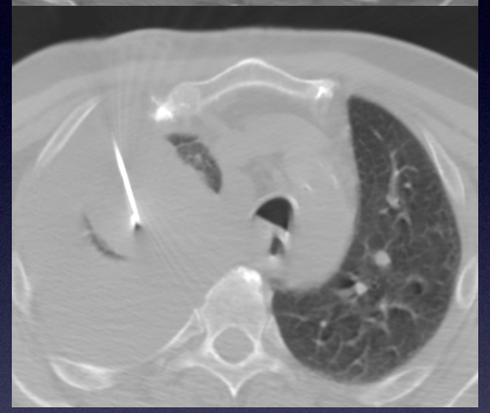


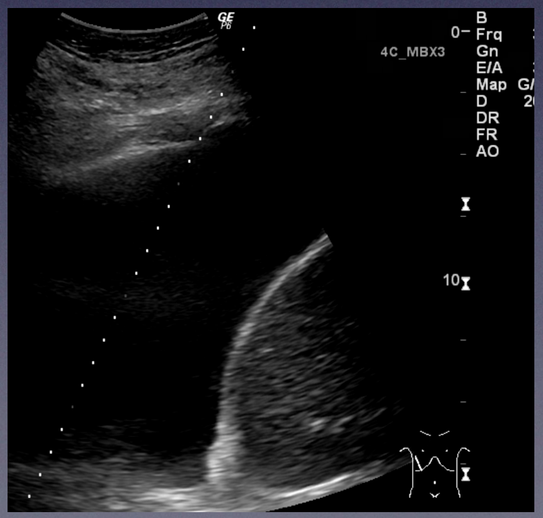








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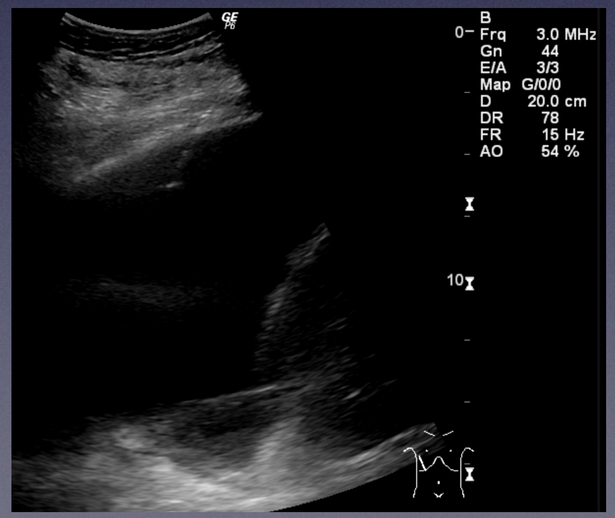
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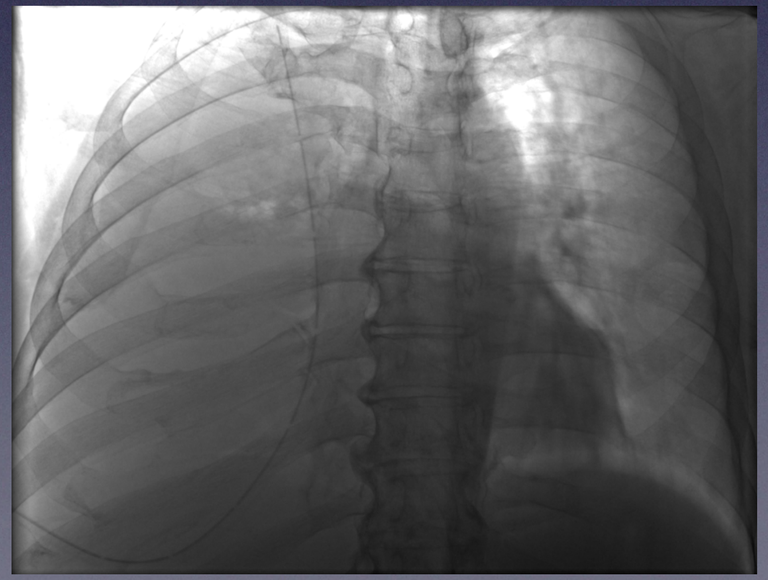
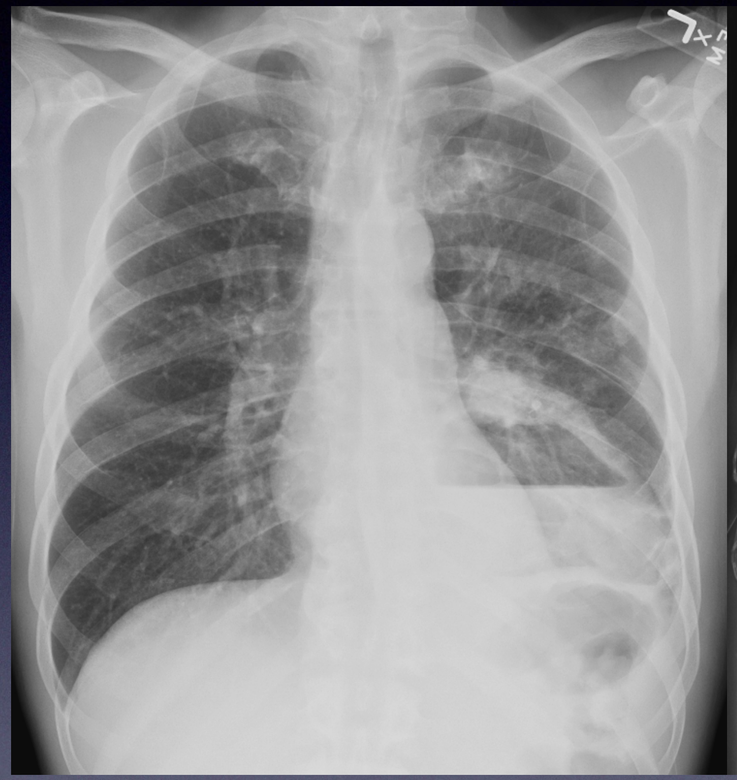
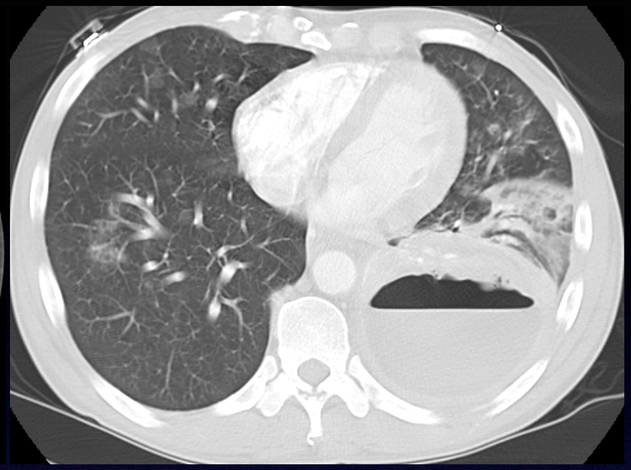
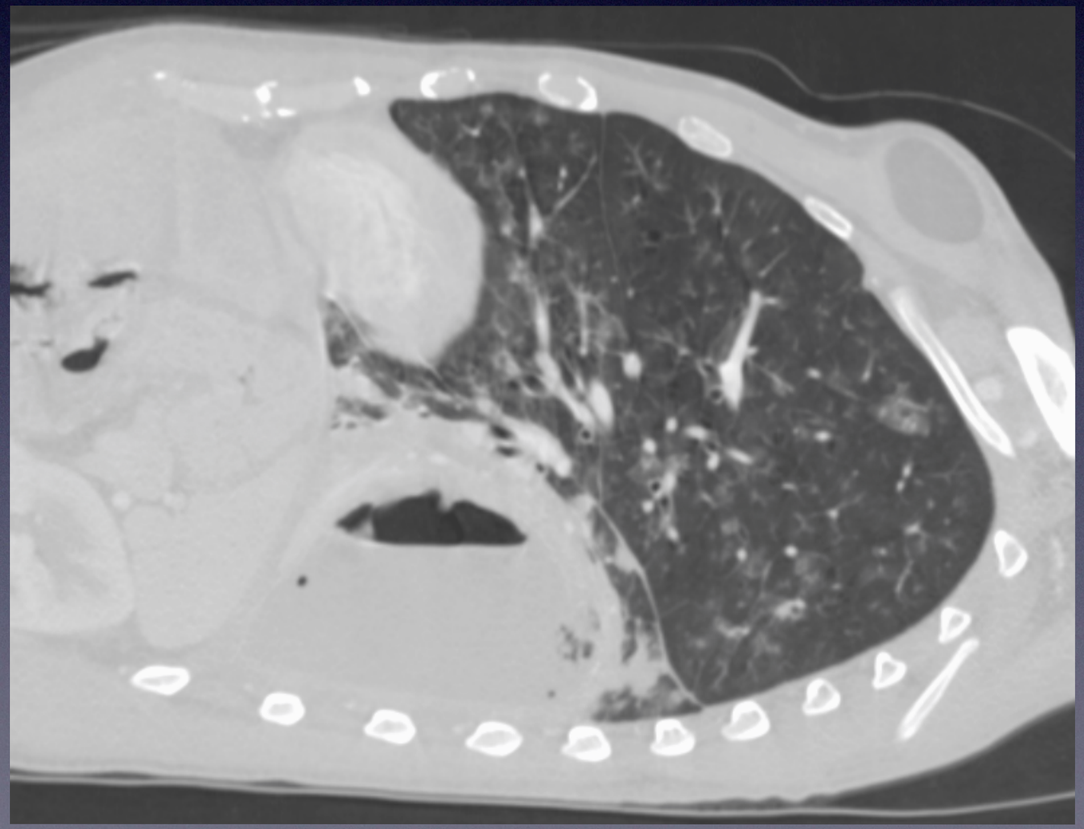
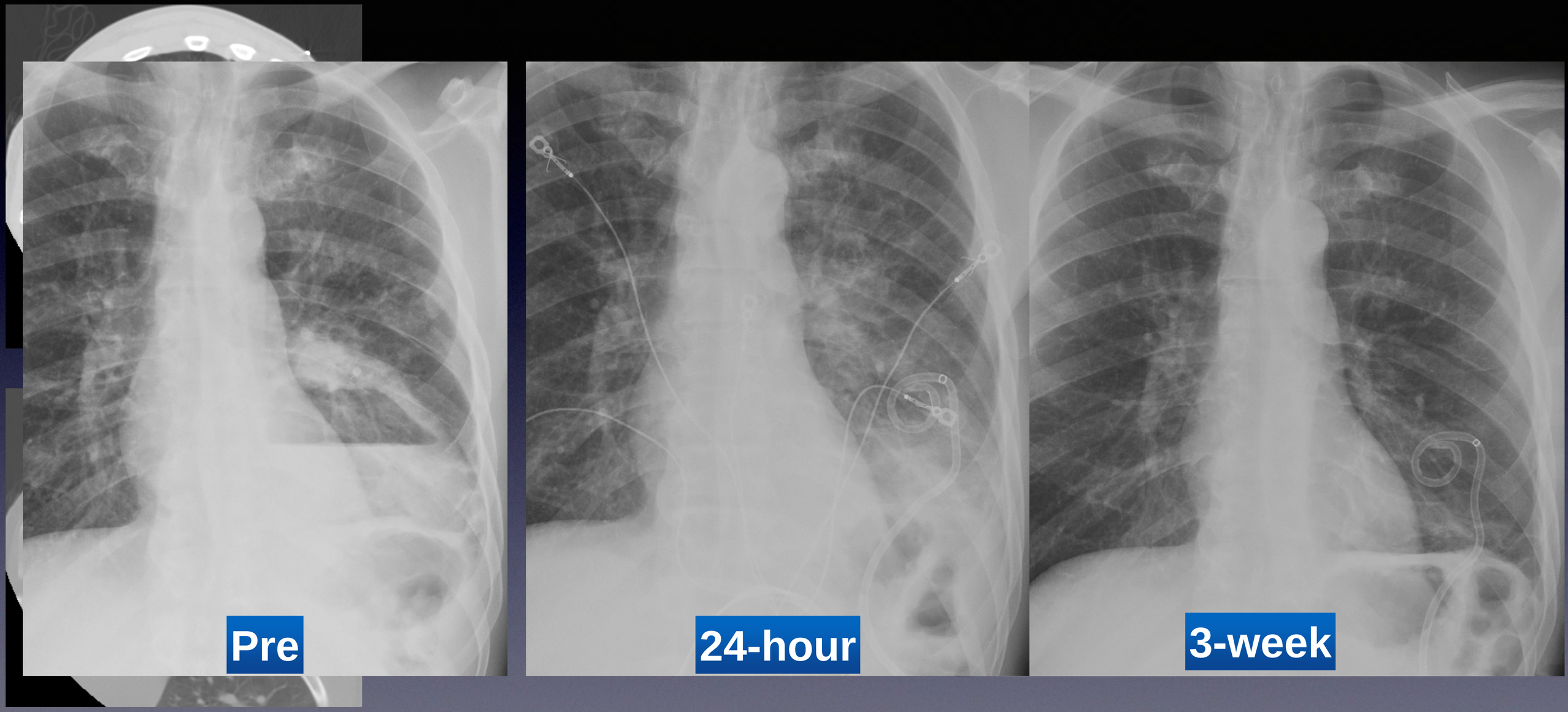


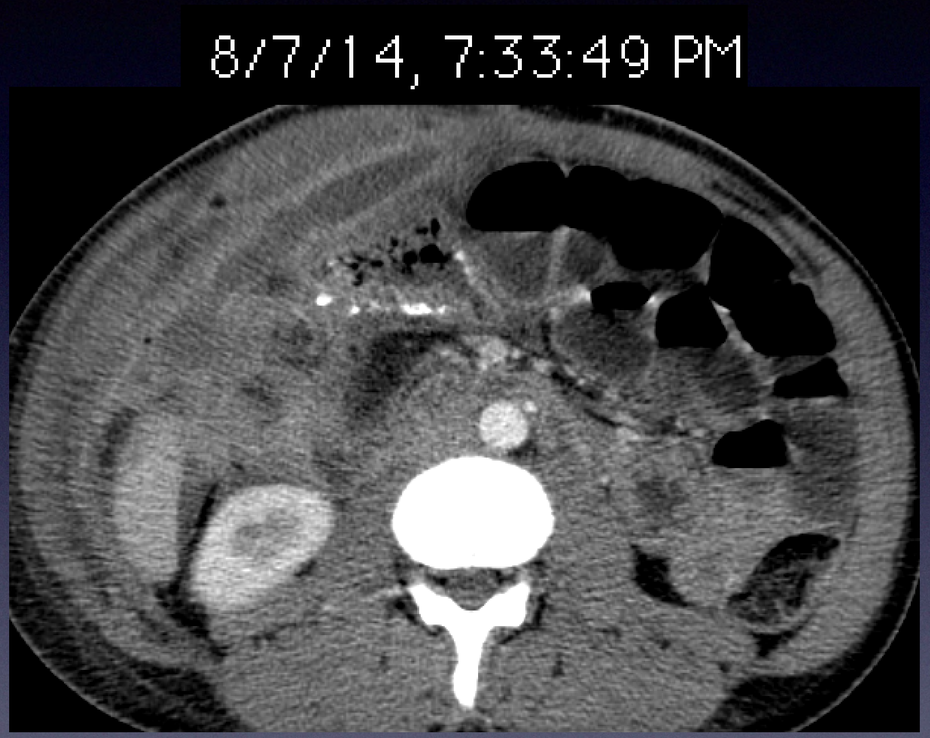







Pre
24-hour
3-week

CT & Ultrasound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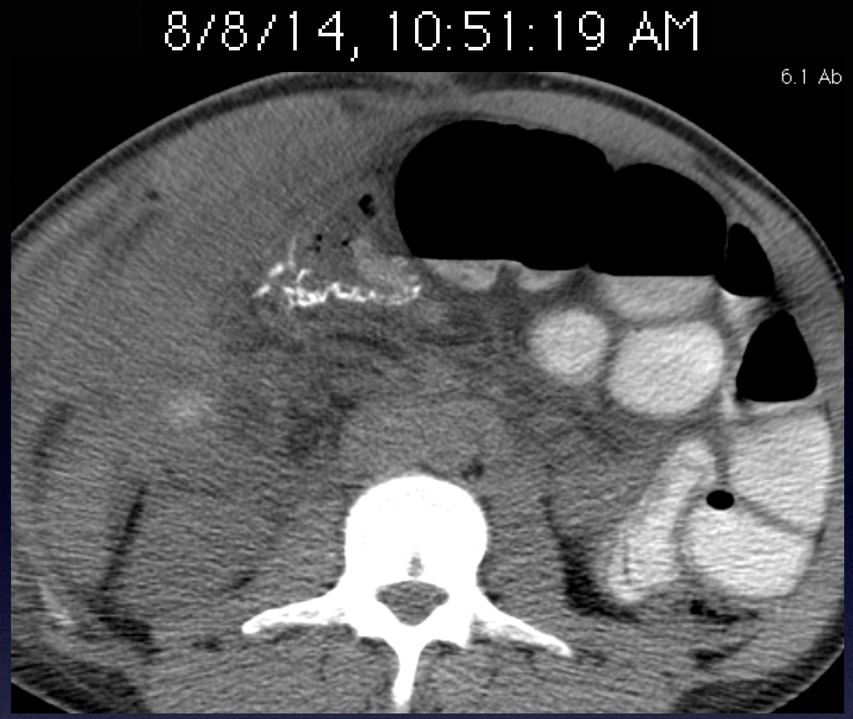
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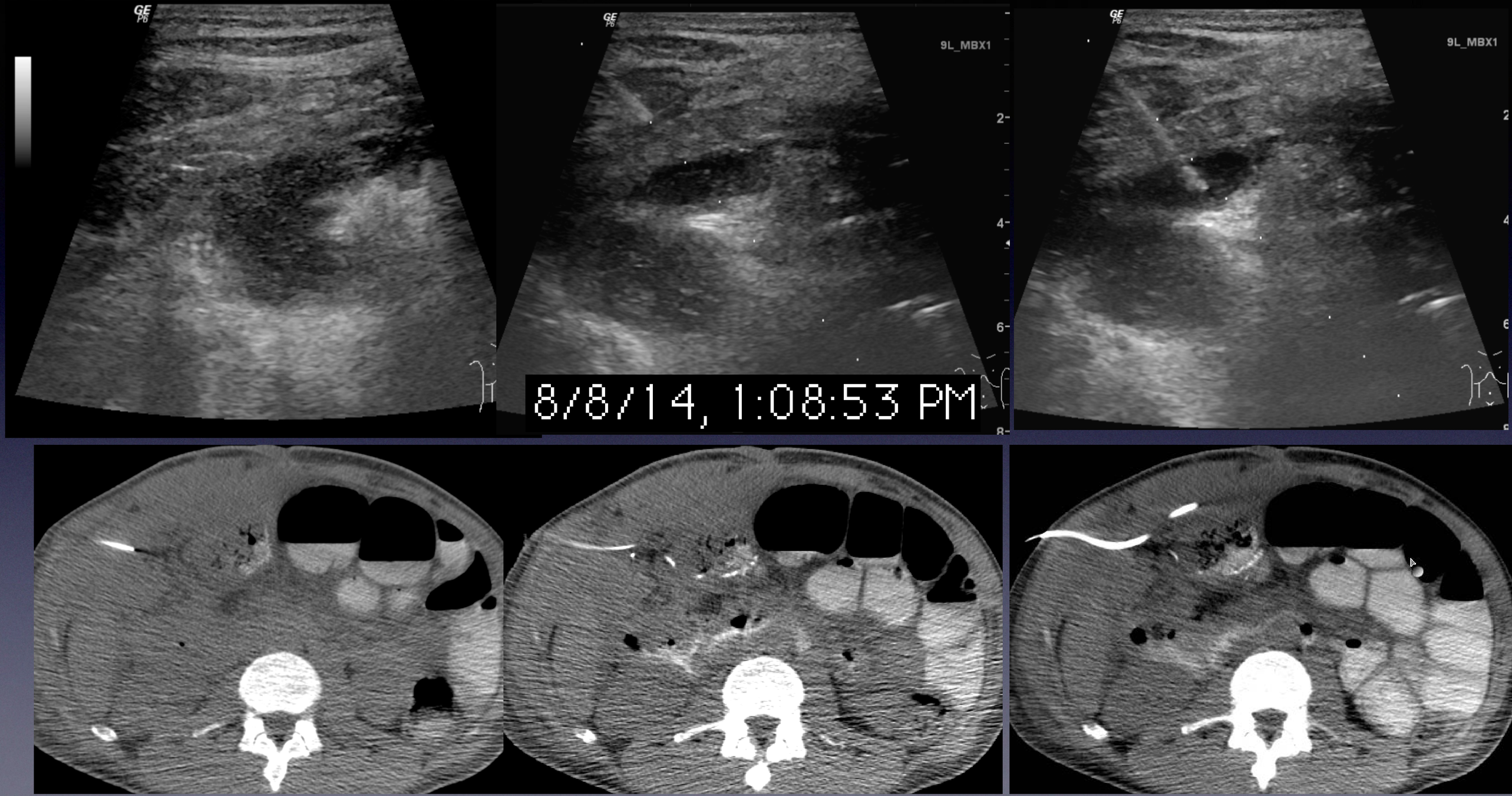
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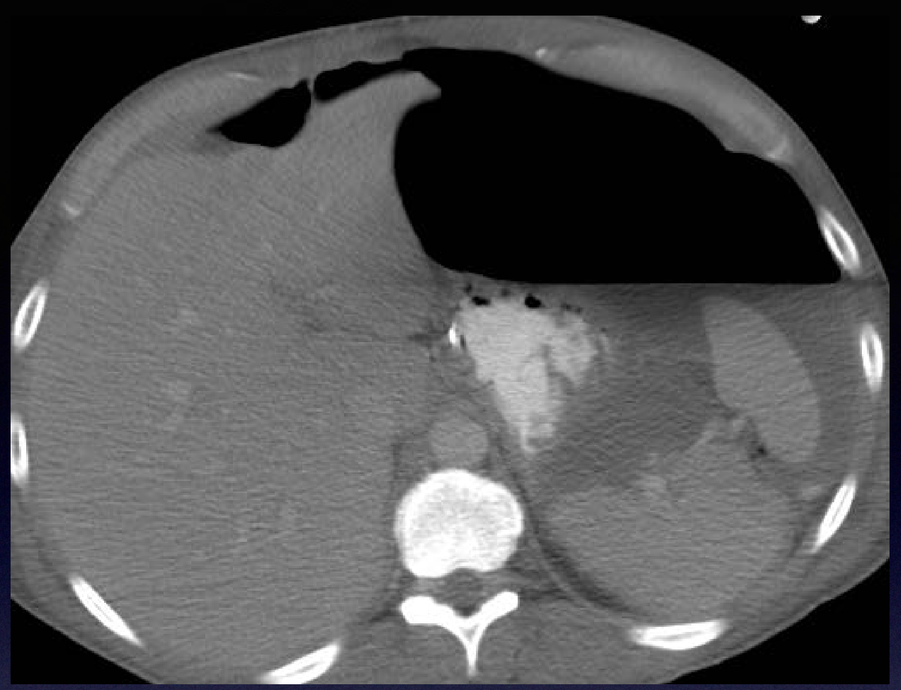

SUMMARY

- Nature, size and location of lesion will determine imaging guidance
- No perfect single imaging guidance, all have pros and cons
- Combination of methods is frequently needed
- Know planned operator’s position and patient’s habitus and position prior to the procedure
- Team approach is vital for patient safety

Thank you, ARIN,
and have a safe trip home