



IMAGING OF PREGNANT AND LACTATING PATIENTS

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February 14, 2020

OBJECTIVES



- Discuss the effects of ionizing radiation on the fetus
- Evaluate specific risks of each imaging modality
- Discuss the use of contrast agents in CT and MR in pregnant and lactating patients
- Review current recommendations for the diagnostic work-up of common clinical scenarios encountered in pregnancy



INTRODUCTION

- Use of radiologic examinations in pregnant women has more than doubled in the past decade in the US (Kwan JAMA 2019)
- Most of what we know about radiation effects is based on atomic bomb survivors and radiation disasters
- Widespread confusion about the safety of imaging modalities in pregnancy amongst ordering providers and radiologists
- Results in the unnecessary avoidance of useful diagnostic tests or interruption in breastfeeding

FETAL RISK

- **Spontaneous abortion**

- Radiation exposure greater than 50-100 mGy before implantation may cause embryonic demise.
- If successful implantation, no consequence to fetus (all-or-none effect)

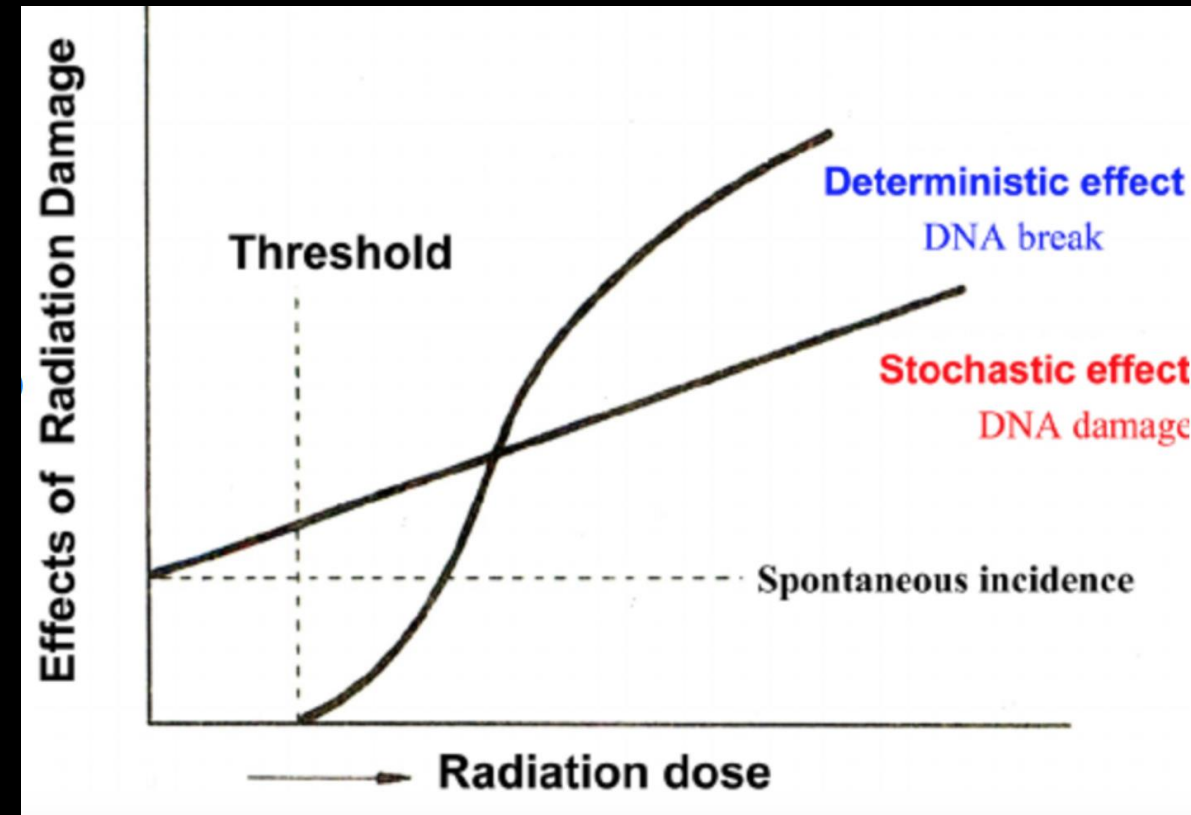
- **Teratogenesis**

- Fetal malformation, microcephaly, IUGR, decreased IQ
- Deterministic (nonstochastic) – threshold radiation must be crossed, around 100 mGy
- Highest risk from radiation between 8-15 weeks gestation due to rapid neuronal development and migration

FETAL RISKS CONTINUED

Carcinogenesis

- Stochastic (nondeterministic) – random DNA mutations, can occur at any radiation dose
- Linear no-threshold model – no minimum dose, with increased risk for higher radiation doses
- Difficult to predict cancer risk at radiation doses less than 100 mGy
- Relative risk of fatal cancer may be doubled after 50 mGy fetal exposure
 - Baseline risk is low – odds go from 1 in 2000 (baseline) to 2 in 2000



FETAL RISK

Table 1: Summary of Suspected In Utero Induced Deterministic Radiation Effects*[4,5]

Menstrual or Gestational age	Conception age	<50 mGy (<5 rad)	50–100 mGy (5–10 rad)	>100 mGy (>10 rad)
0–2 weeks (0–14 days)	Prior to conception	None	None	None
3rd and 4th weeks (15–28 days)	1st–2nd weeks (1–14 days)	None	Probably none	Possible spontaneous abortion.
5th–10th weeks (29–70 days)	3rd–8th weeks (15–56 days)	None	Potential effects are scientifically uncertain and probably too subtle to be clinically detectable.	Possible malformations increasing in likelihood as dose increases.
11th–17th weeks (71–119 days)	9th–15th weeks (57–105 days)	None	Potential effects are scientifically uncertain and probably too subtle to be clinically detectable.	Risk of diminished IQ or of mental retardation, increasing in frequency and severity with increasing dose.
18th–27th weeks (120–189 days)	16th–25th weeks (106–175 days)	None	None	IQ deficits not detectable at diagnostic doses.
>27 weeks (>189 days)	>25 weeks (>175 days)	None	None	None applicable to diagnostic medicine.



IMAGING MODALITIES USED IN PREGNANCY

ULTRASOUND

- Imaging technique of choice in pregnant patients
- No reports of adverse fetal effects
- Theoretical increase in temperature in fetus, up to 2 degrees Celsius, though unlikely to be sustained
- Risk of temperature elevation lowest in B-mode and M-mode, higher with color and spectral Doppler

MAGNETIC RESONANCE IMAGING

- Safe in pregnancy
- Theoretical concerns of acoustic damage, though no cases identified
- Gadolinium contrast – FDA category C drug
 - Water soluble, can cross placenta into fetal circulation and amniotic fluid
 - Administered in a chelated form as free gadolinium is toxic
 - One prospective study demonstrated no adverse neonatal outcomes among 26 women who received gadolinium in first trimester
 - If lactating woman receives gadolinium, breastfeeding should NOT be interrupted

RADIOGRAPHY, FLUOROSCOPY, AND INTERVENTIONAL RADIOLOGY

- If no direct fetal or abdominopelvic exposure, dose to fetus is negligible
- Pregnancy should not alter decision to perform examination

TABLE 3: Estimated Conceptus Doses from Radiographic and Fluoroscopic Examinations

Examination	Typical Conceptus Dose (mGy)
Cervical spine (anteroposterior, lateral)	< 0.001
Extremities	< 0.001
Chest (posteroanterior, lateral)	0.002
Thoracic spine (anteroposterior, lateral)	0.003
Abdomen (anteroposterior)	
21-cm patient thickness	1
33-cm patient thickness	3
Lumbar spine (anteroposterior, lateral)	1
Limited IV pyelogram ^a	6
Small-bowel study ^b	7
Double-contrast barium enema study ^c	7

Note—Reprinted with permission from [7].

^aLimited IV pyelogram is assumed to include four abdominopelvic images. A patient thickness of 21 cm is assumed.

^bA small-bowel study is assumed to include a 6-minute fluoroscopic examination with the acquisition of 20 digital spot images.

^cA double-contrast barium enema study is assumed to include a 4-minute fluoroscopic examination with the acquisition of 12 digital spot images.

COMPUTED TOMOGRAPHY (CT)

- Most commonly used in the setting of trauma or suspected pulmonary emboli
- Dose reduction techniques such as single phase contrast, increasing pitch, automated exposure control, and limiting image length should be used
- Abdominal shielding does not lead to dose reduction – most of fetal dose from internal scatter

TABLE 4: Estimated CT Conceptus Doses From Single Acquisition

Examination	Dose Level	Typical Conceptus Dose (mGy)
Extraabdominal		
Head CT	Standard	0
Chest CT	Standard	0
Routine	Standard	0.2
Pulmonary embolus	Standard	0.2
CT angiography of coronary arteries	Standard	0.1
Abdominal		
Abdomen, routine	Standard	4
Abdomen/pelvis, routine	Standard	25
CT angiography of aorta (chest through pelvis)	Standard	34
Abdomen-pelvis, stone protocol ^a	Reduced	10

Note—Reprinted with permission from [7].

^aAnatomic coverage is the same as for routine abdominopelvic CT, but the tube current is decreased and the pitch is increased because standard image quality is not necessary for detection of high-contrast stones.

CT CONTRAST AGENTS

- Oral contrast is safe during pregnancy and lactation
- Iodinated IV contrast is FDA category B – no risk in animal studies, no controlled studies in pregnant women
- Breastfeeding can be continued without interruption after iodinated contrast
 - <1% of administered dose excreted into breast milk, less than 1% of that absorbed by infant's GI tract.

NUCLEAR SCINTIGRAPHY

- Small amount of radioactive material is injected into patient to evaluate organ function and structure
- Ventilation/Perfusion study most commonly performed study
- Fetal exposure is from radioactivity accumulating in maternal organs and transport of radiopharmaceuticals across the placenta
- Treatment with sodium iodide 131 is contraindicated due to risk of permanent hypothyroidism in fetus
- Breastfeeding cessation suggested after use of gallium 67 and ^{131}I -NaI

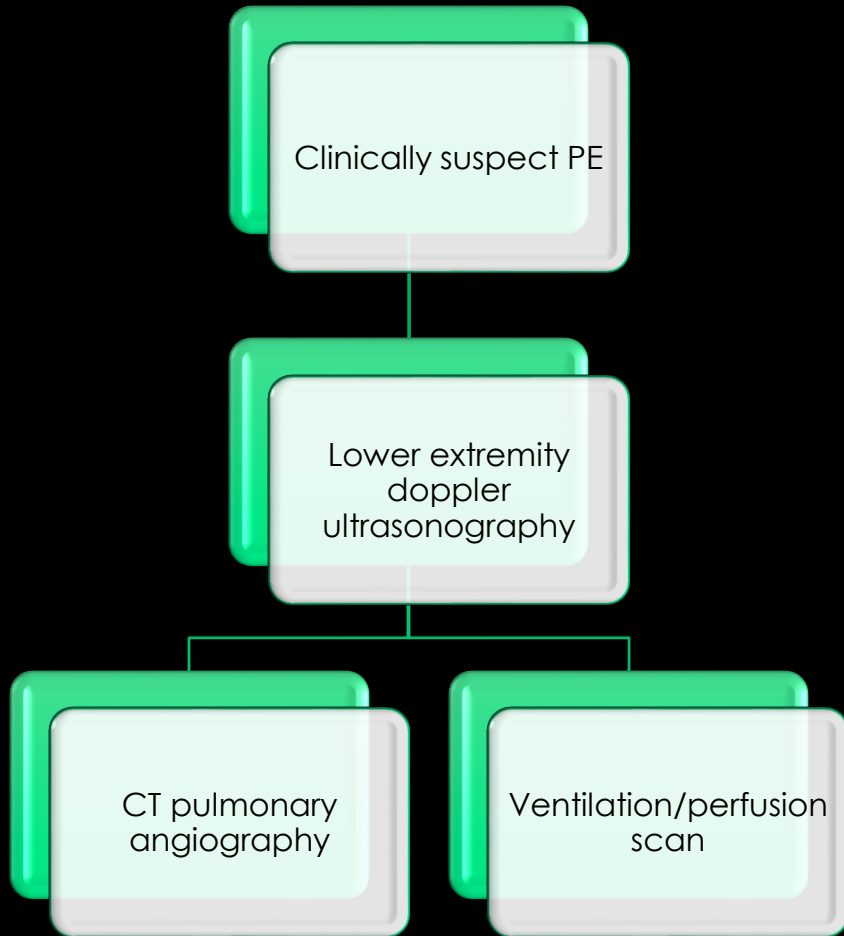


RECOMMENDATIONS FOR COMMON CLINICAL SCENARIOS

ACUTE PULMONARY EMBOLISM

- Increased risk of PE/DVT in pregnancy due to hypercoagulability and venous stasis
- Leading cause of maternal mortality in developed world – 15% mortality rate
- Isolated pelvic DVT more common (may present with abdominal pain)
- D-dimer less useful as often elevated during pregnancy

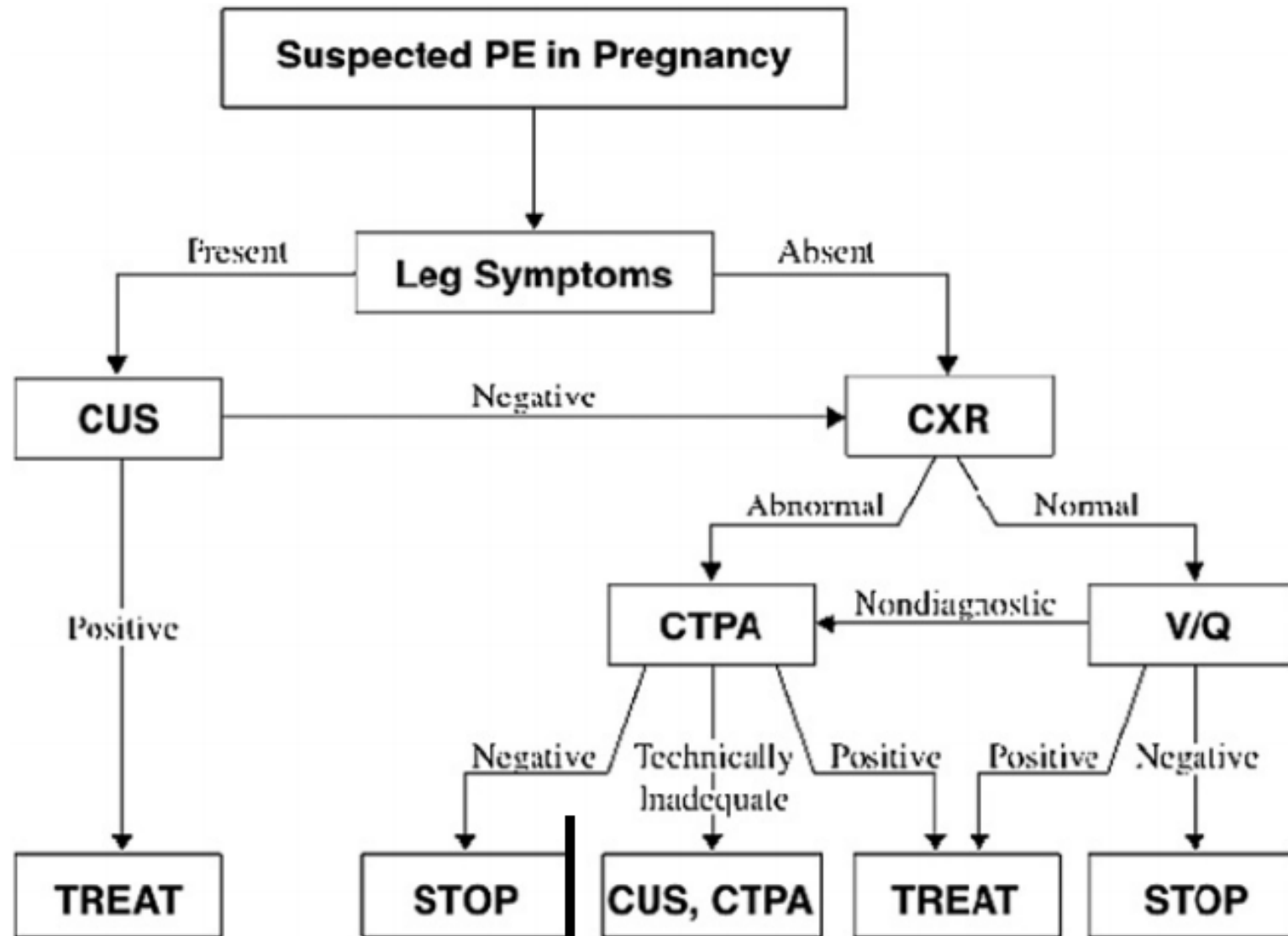
ACUTE PULMONARY EMBOLISM



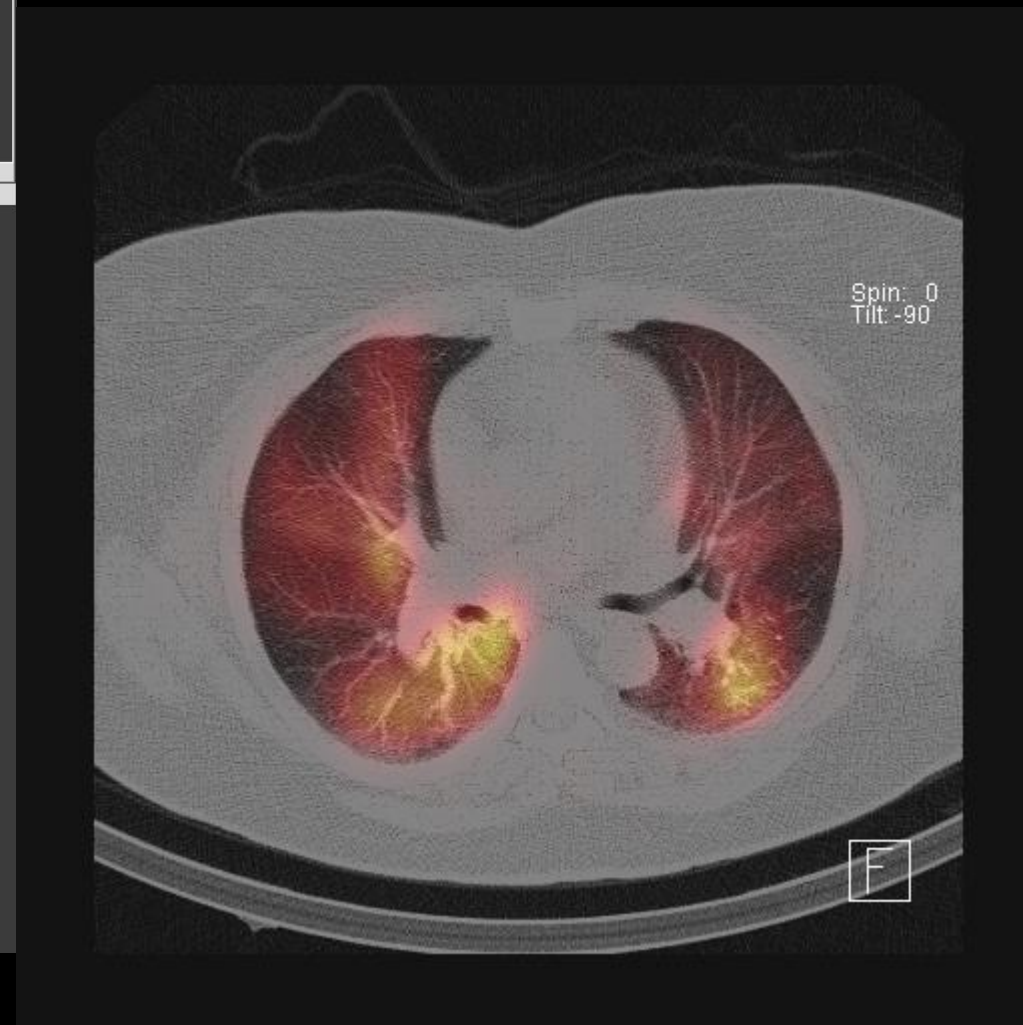
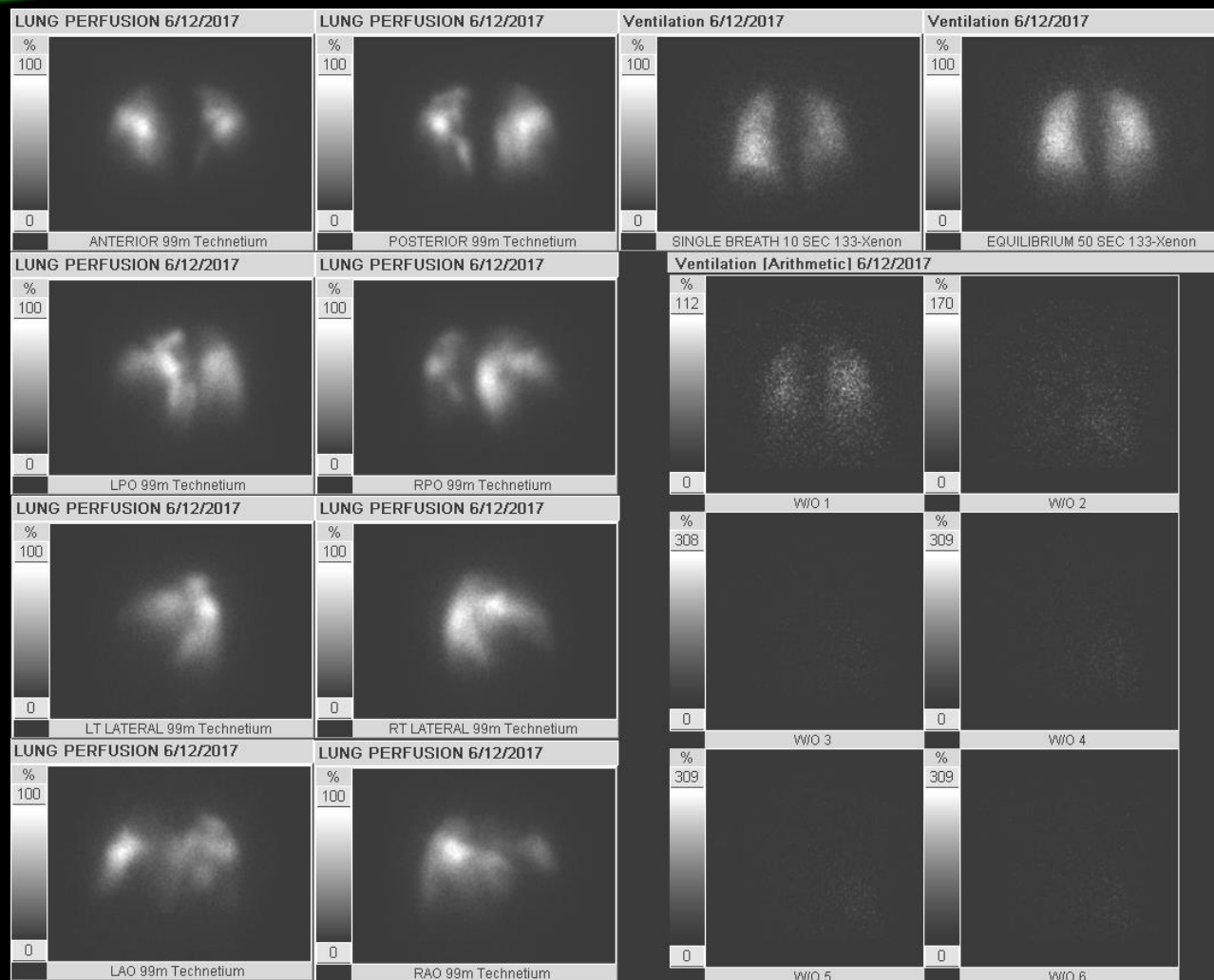
- Start evaluation with lower extremity doppler ultrasound if leg symptoms are present
 - If positive, further testing usually not necessary
- Choice between CT-PA and V/Q is still controversial
 - Fetal radiation dose for both studies is minimal (0.1-0.4 mGy)
 - In general, CT-PA is lower dose to fetus when fetus is small and further from field of view
 - Maternal breast dose is higher with CT-PA (10 mGy vs 0.25 mGy)

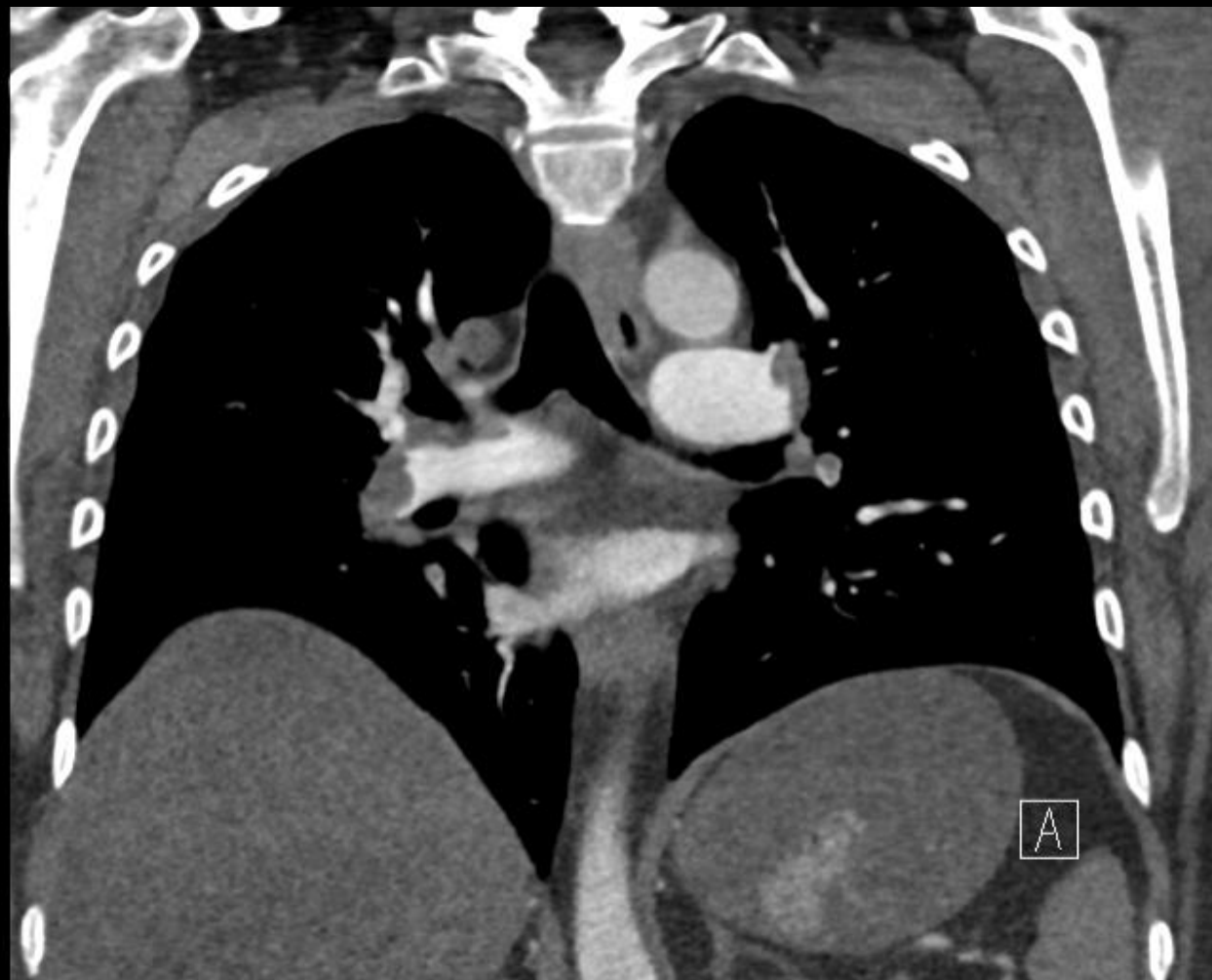
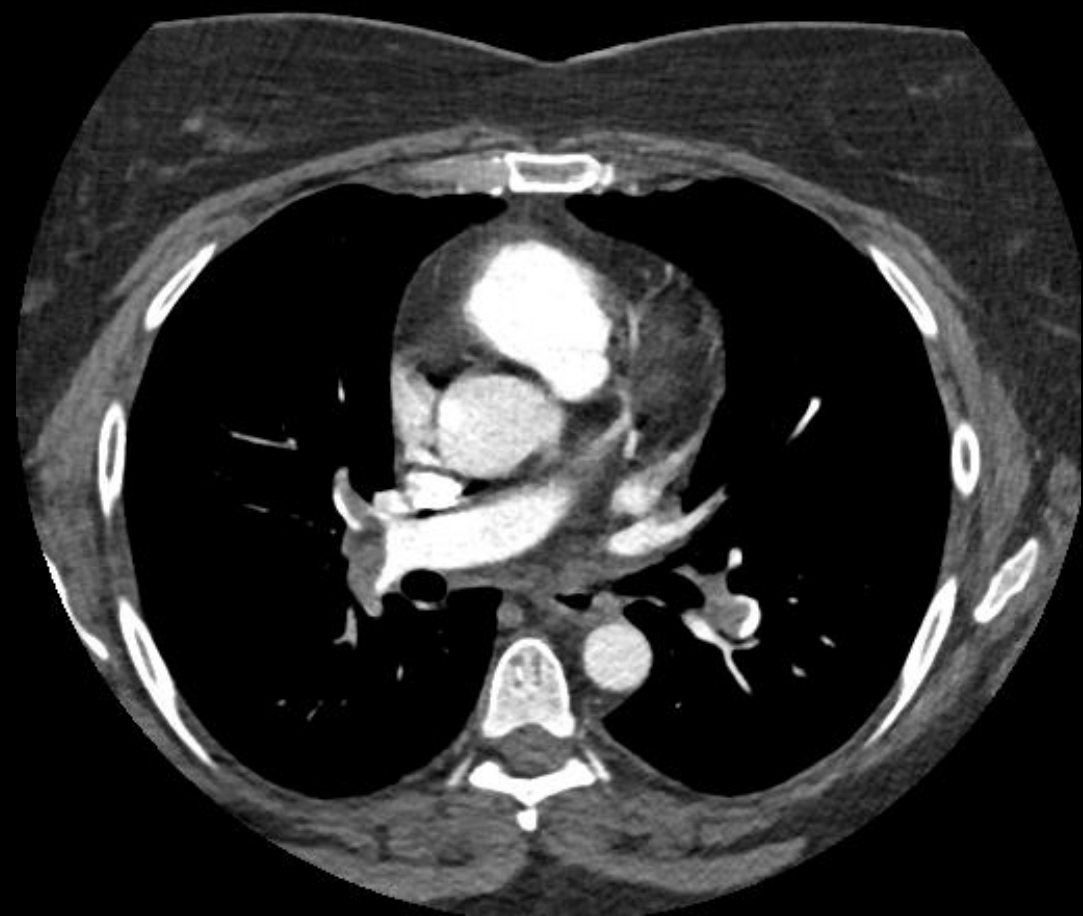
IMAGING OF PULMONARY EMBOLISM

- If V/Q performed, ventilation and SPECT/CT portions often omitted to reduce radiation
- CT-PA studies in pregnancy are more frequently of poor quality due to cardiac output directed toward fetus
- CT has the advantage of detection of other thoracic pathology
 - Pneumonia, aortic abnormality, pericardial disease
 - Tend to have less inter-reader variability
- ACOG, ACR, Fleischner Society, PLOPED, American Thoracic Society, and Society of Thoracic Radiologists all have statement paper
- Cochrane review in 2017 noted both CT-PA and V/Q are reasonable options, with low quality of evidence



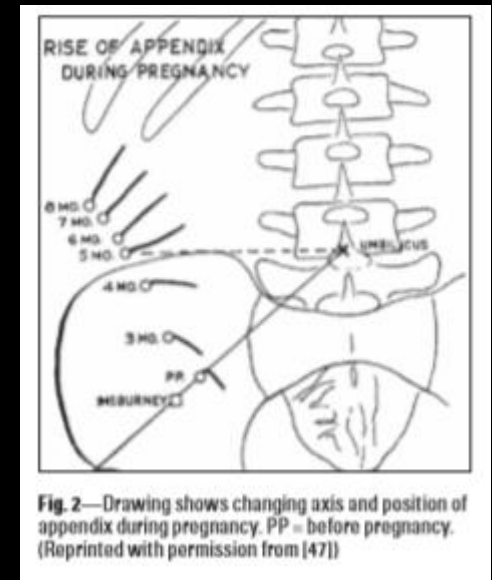
Proposed diagnostic algorithm from the American Thoracic Society Consensus Guidelines 2011





ACUTE APPENDICITIS

- Most common nonobstetric indication for surgery in pregnant patients
- Location of appendix changes during pregnancy as displaced by uterus
- Graded compression ultrasound often initial imaging modality
 - Initial studies demonstrate high sensitivity and specificity (85-100% sens and 92-96% spec), though more recent studies show much lower sensitivity (20-36%)
 - High rate of indeterminate studies
 - Utility of sonography decreases as pregnancy progresses



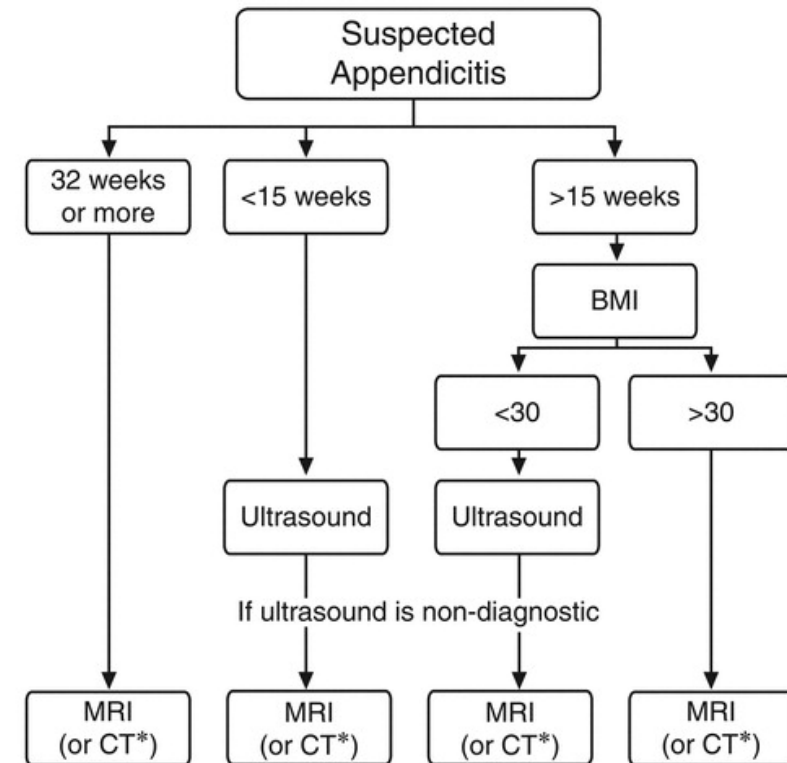
Baer et al. Appendicitis in pregnancy. JAMA 1932; 98:1359-1364

ACUTE APPENDICITIS

- MRI is preferred second line modality
 - NPV of 98-100%
- CT with contrast can be performed if MRI unavailable



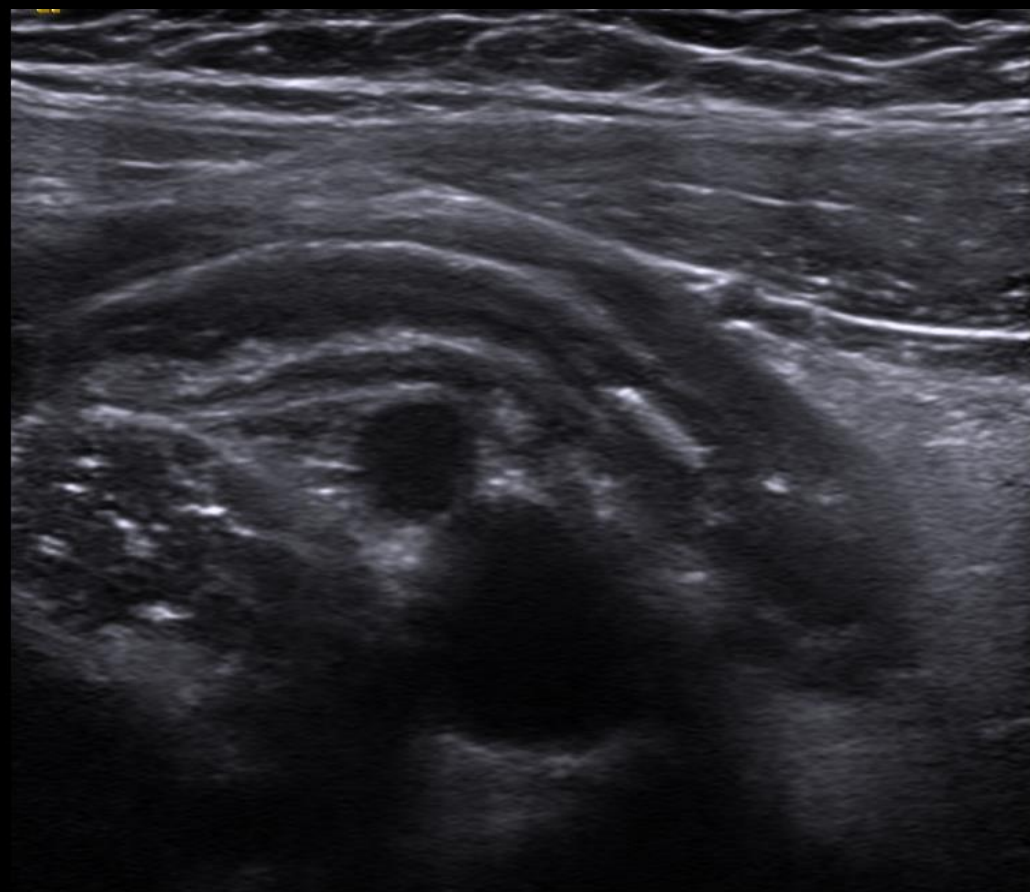
Spalluto et al. Radiographics 2012



Wieseler et al. Imaging in pregnant patients: Examination appropriateness. Radiographics 2010; 30(5)

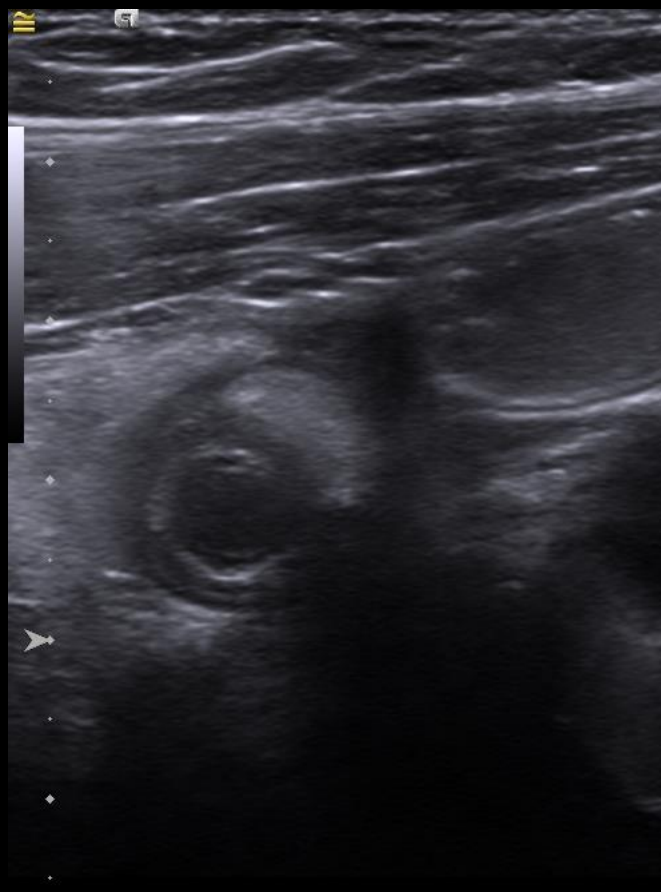
APPENDICITIS CASE

- 19 year old female 9 weeks pregnant presents with one week of right lower quadrant pain and elevated WBC count
- Pelvic Ultrasound ordered

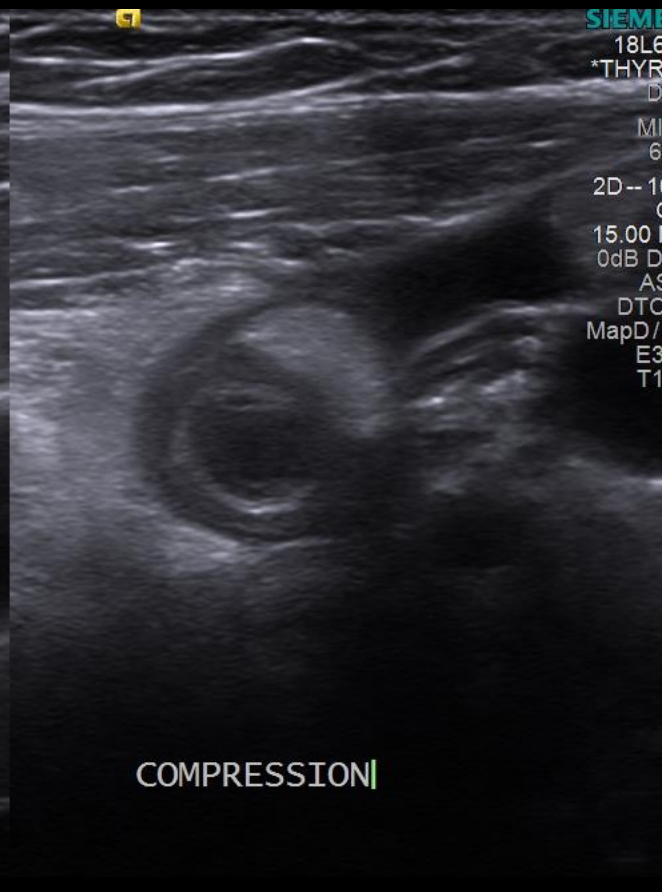


RLQ SAG

5cm



RLQ TRV



COMPRESSION

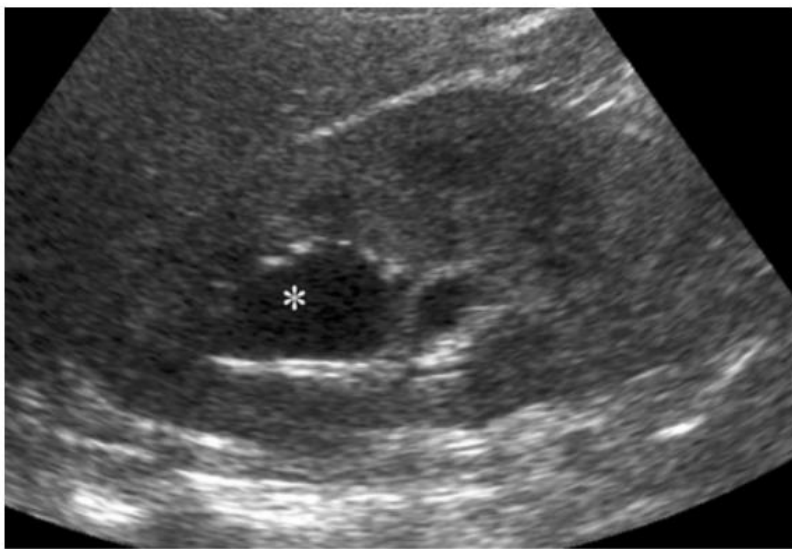
5.5cm

SIEMENS
18L6 HD
*THYROID
Detail
MI: 0.7
60fps
2D -- 100%
GEN
15.00 MHz
0dB DR65
ASC 5
DTCE M
MapD/ST2
E3/P3
T1/B0



UROLITHIASIS

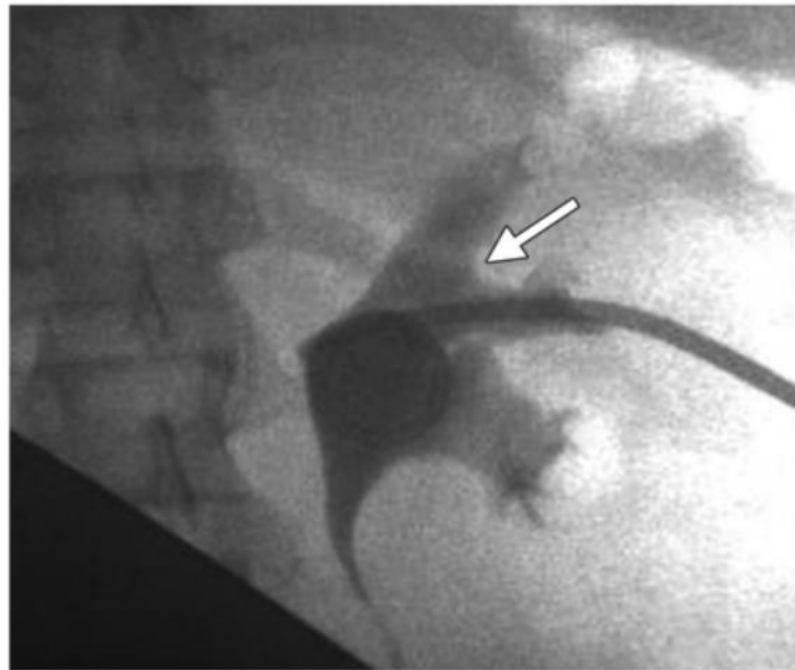
- Obstructive renal stones occur in 1 in 3300 pregnant patients
- Most (70-80%) pass spontaneously
- Renal ultrasound is preferred initial study
 - Limited by difficulty distinguishing pathologic hydronephrosis and physiologic dilation of the collection system
 - Occurs in 60-94% of pregnant patients, more common on right
- CT of the abdomen without contrast (CT KUB) or MR urography second line
- IV pyelogram not recommended – dose similar to CT with decreased sensitivity



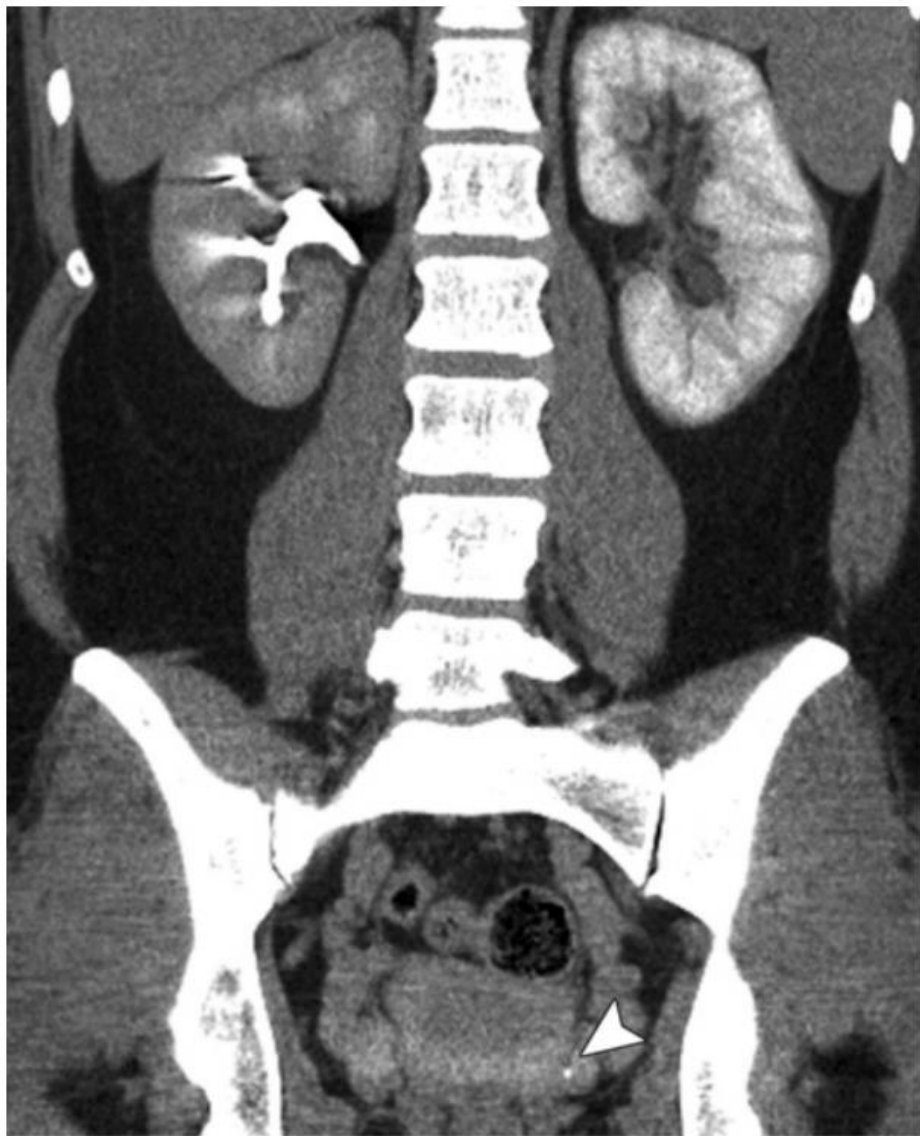
a.



c.



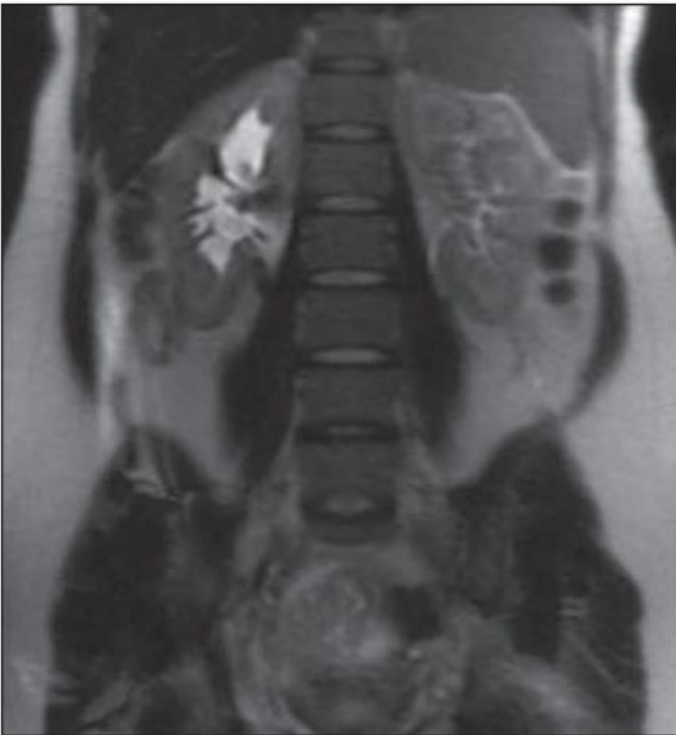
Wieseler et al. Imaging in pregnant patients: Examination appropriateness.
Radiographics 2010; 30(5)



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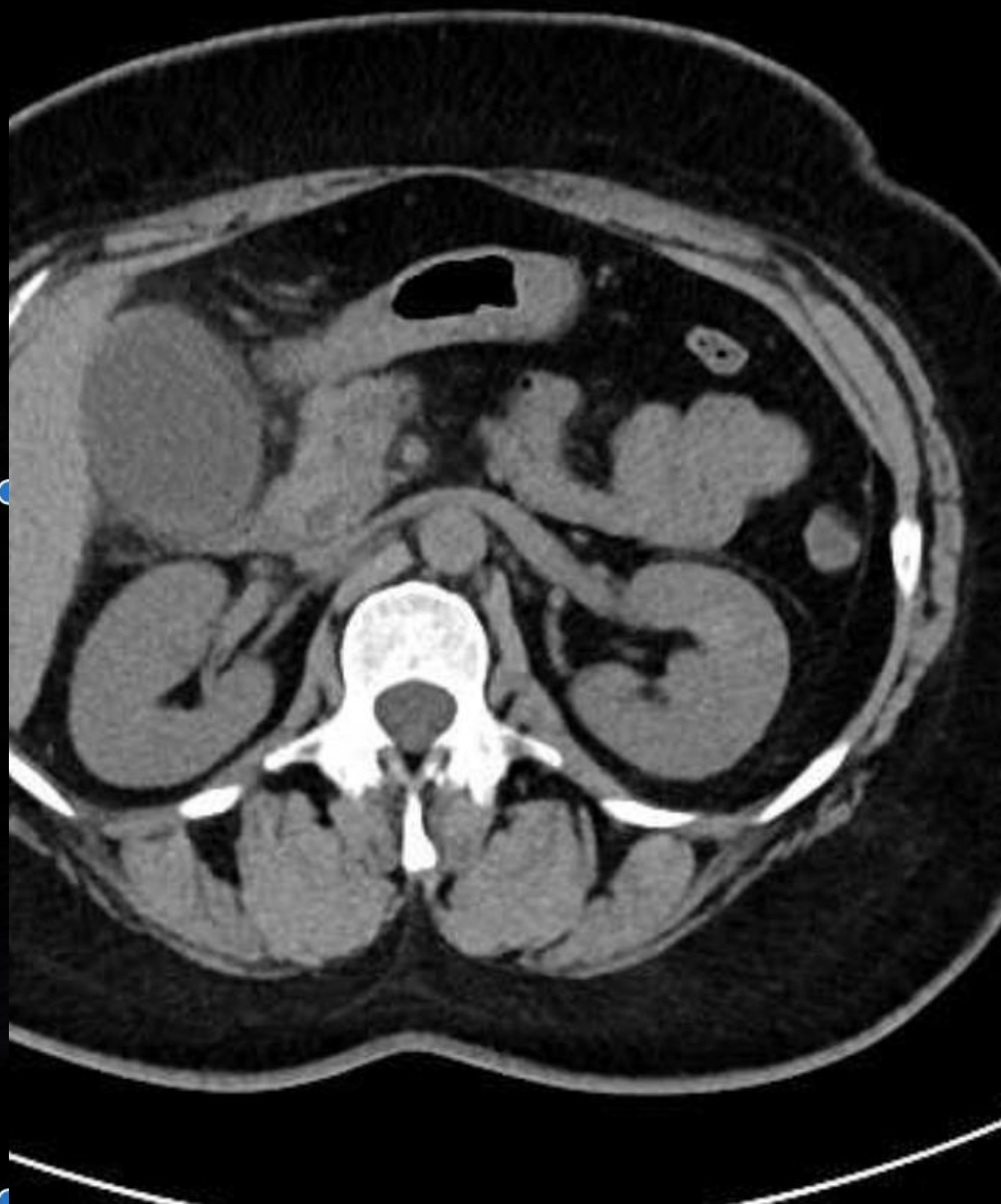
MR urography

- Uses heavily T2 weighted sequences to show collecting system
- Physiologic ureteral dilatation shows midureteral narrowing with gradual tapering of the ureter to sacral promontory
- Pathologic dilation – abrupt caliber change, perirenal edema, ureteral filling defects
- More sensitive for ureteral dilatation than CT, less sensitive for stones



ACUTE CHOLECYSTITIS

- Gallbladder disease is second most common nonobstetric indication for surgery during pregnancy
- Increased risk due to decreased gallbladder contractility, increased cholesterol synthesis, and increased bile stasis
- Dedicated right upper quadrant ultrasound is most appropriate imaging study
- MRI/MRCP – second line imaging study
 - Heavily T2 weighted sequence depicts biliary tree
 - Gadolinium contrast unnecessary
 - Sensitive for evaluation of choledocholithiasis
 - If negative, can generally forgo ERCP



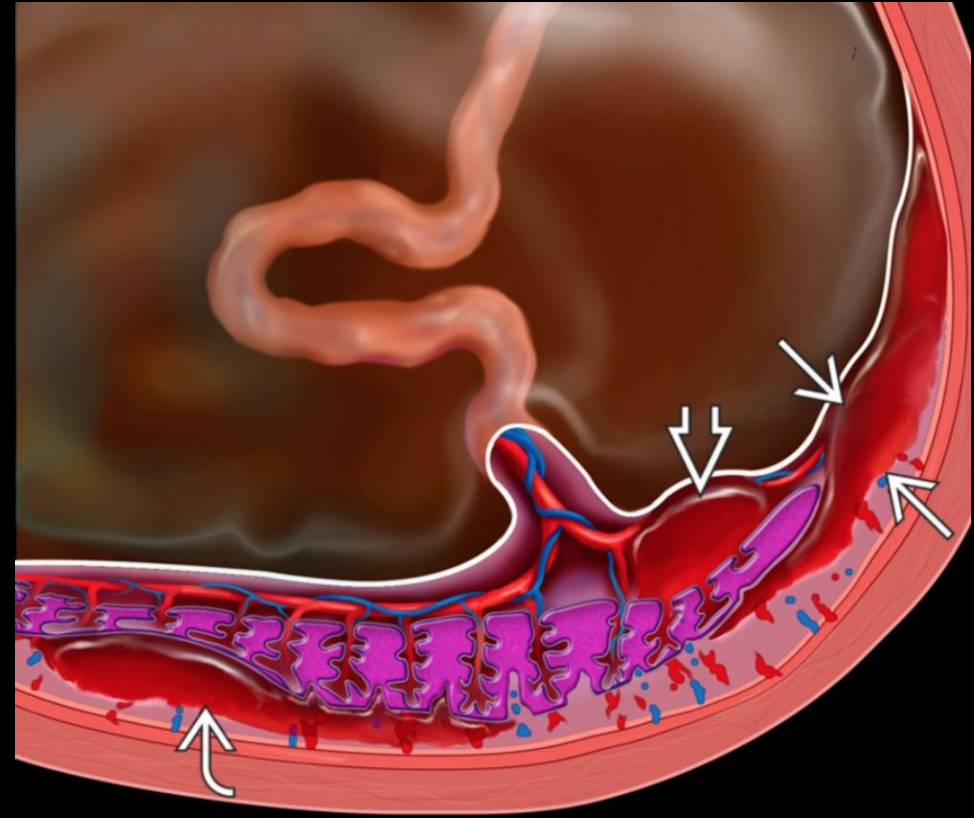


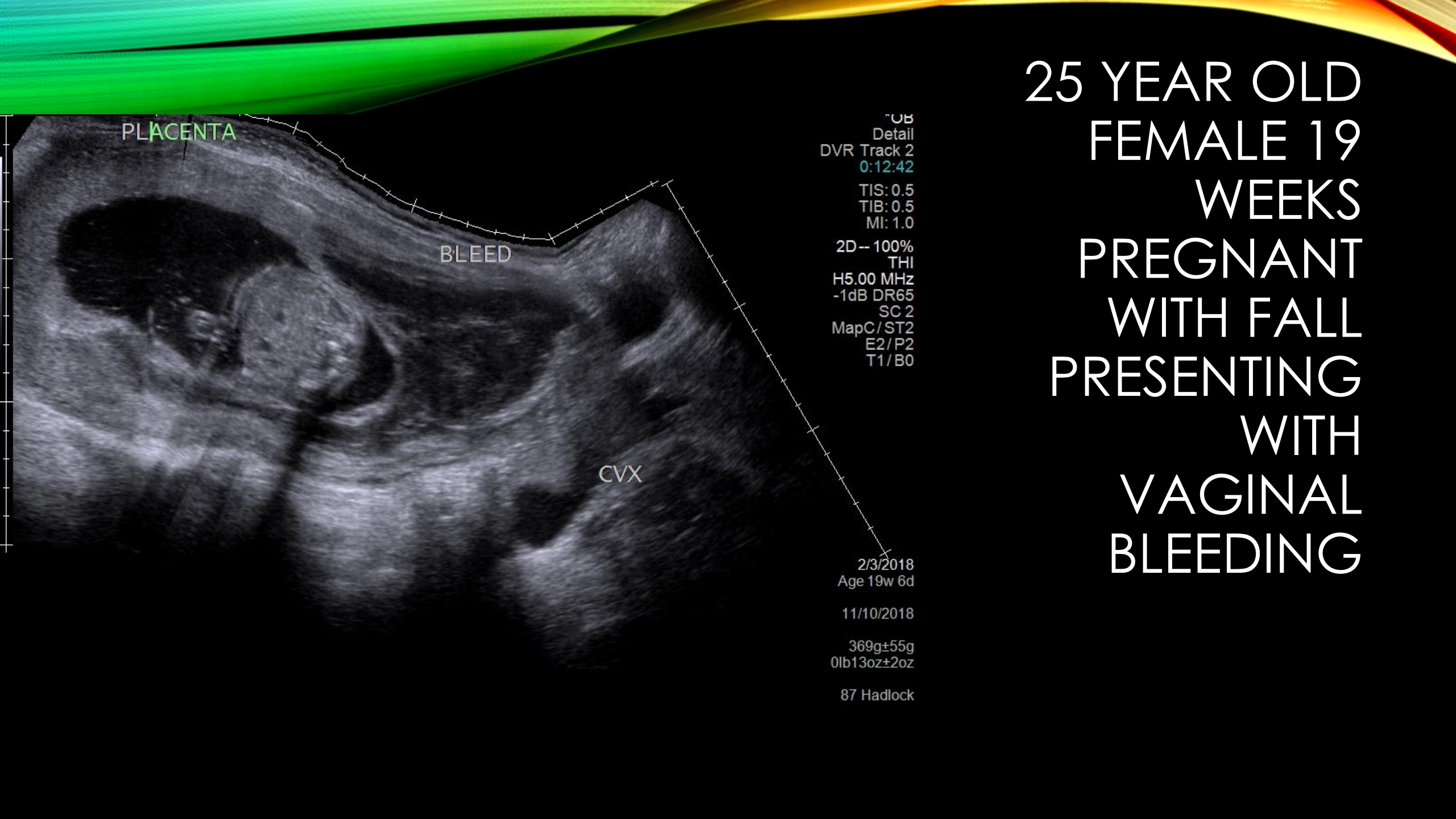
TRAUMA IN PREGNANCY

- Leading cause of non-obstetric maternal death
- Motor vehicle accidents most common form of trauma (66%)
- Study in Melbourne, Australia 2015 – only 19% of pregnant patients received recommended radiologic evaluation
- Priority is given to maternal survival – all imaging and procedural protocols for stabilization should be followed regardless of pregnancy status

IMAGING IN TRAUMA

- Focused abdominal sonography
 - Highly specific, but may have false negative in pregnancy
- CT should not be withheld due to pregnancy status
- IV Contrast SHOULD be given
- Placental abruption is most common uterine traumatic injury
 - 70-80% of abruptions are not seen on ultrasound
 - Marginal (most common), retroplacental, or preplacental (rare)
 - Appearance of hemorrhage depends on size and age of hematoma





25 YEAR OLD
FEMALE 19
WEEKS
PREGNANT
WITH FALL
PRESENTING
WITH
VAGINAL
BLEEDING

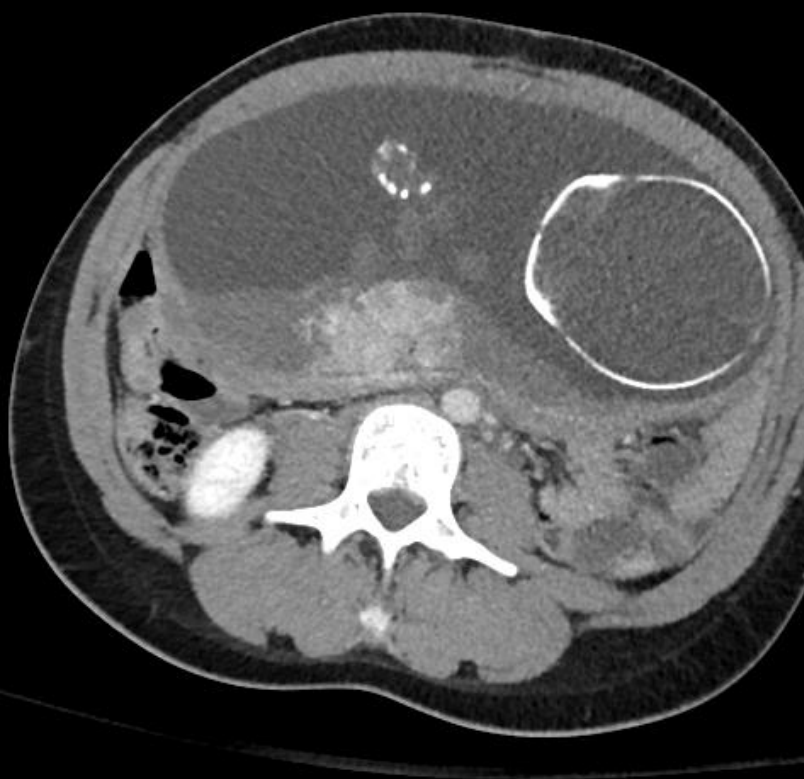
OB
Detail
DVR Track 2
0:12:42
TIS: 0.5
TIB: 0.5
MI: 1.0
2D-- 100%
THI
H5.00 MHz
-1dB DR65
SC 2
MapC/ST2
E2/P2
T1/B0

2/3/2018
Age 19w 6d

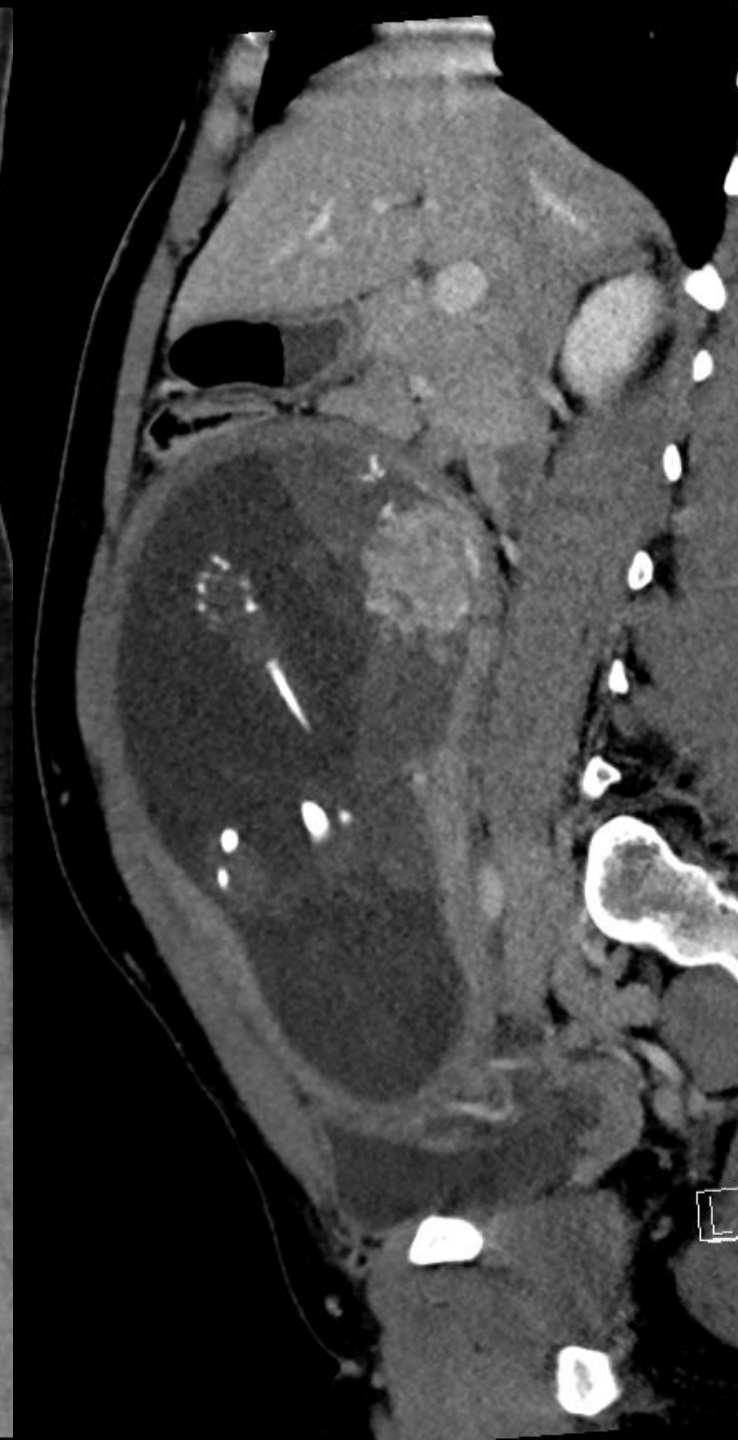
11/10/2018

369g±55g
0lb13oz±2oz

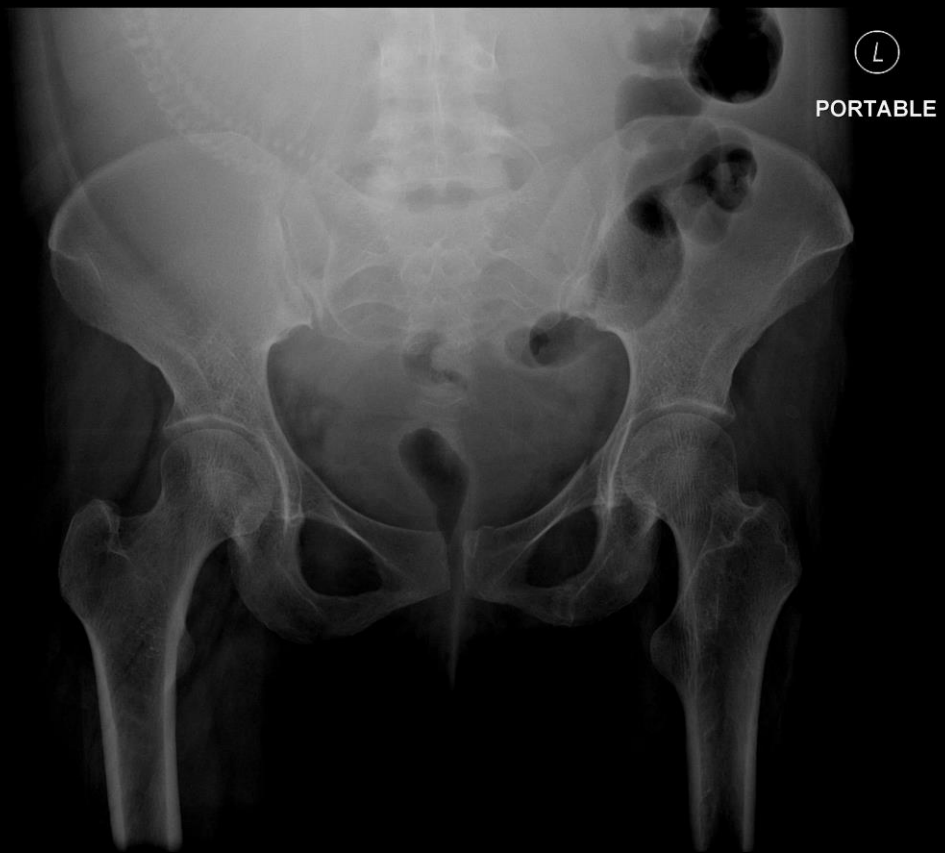
87 Hadlock

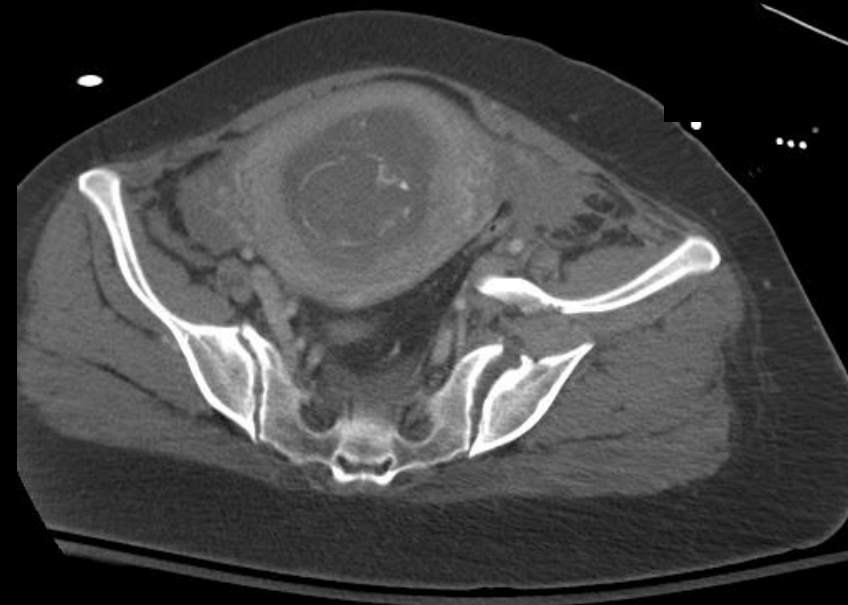


24 YEAR OLD FEMALE 26 WEEKS
PREGNANT WITH ABDOMINAL
PAIN AFTER MOTOR VEHICLE
ACCIDENT









TAKE HOME MESSAGE

'With few exceptions, radiation exposure through radiography, computed tomography (CT) scan, or nuclear medicine imaging techniques is at a dose much lower than the exposure associated with fetal harm. If these techniques are necessary in addition to ultrasonography or MRI or are more readily available for the diagnosis in question, they should not be withheld from a pregnant patient.'

-ACOG Committee Opinion Guidelines for Diagnostic Imaging in Pregnancy and Lactation



Please do not hesitate to come down
and talk to or call your friendly radiologist!



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