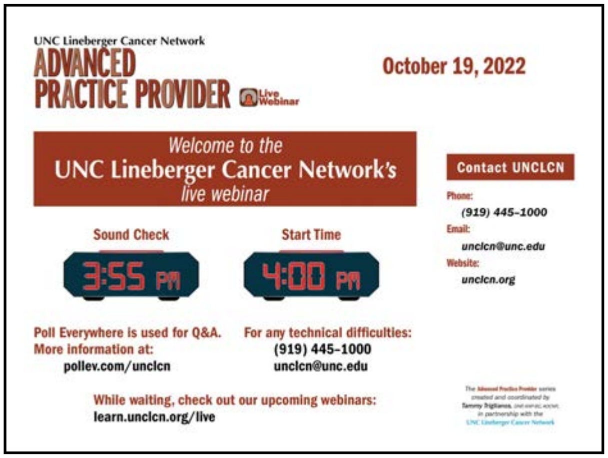
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October 19, 2022
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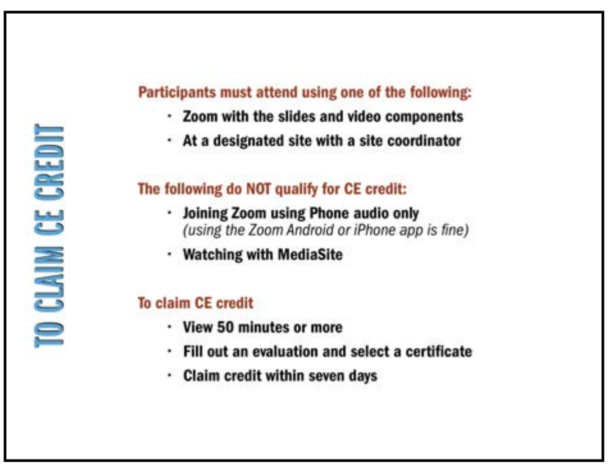
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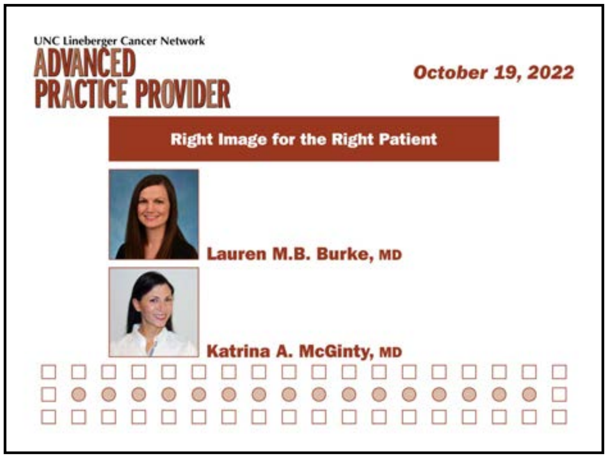
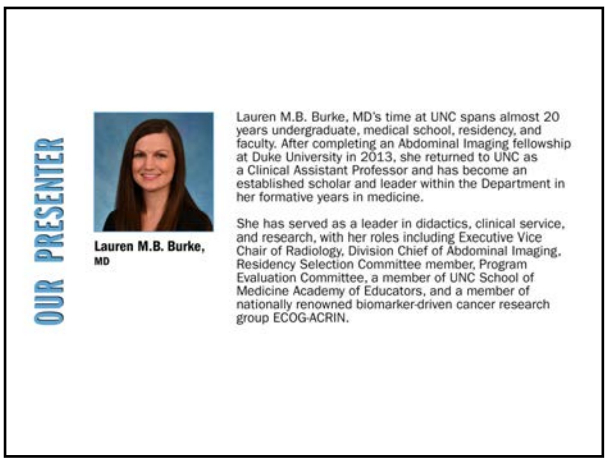
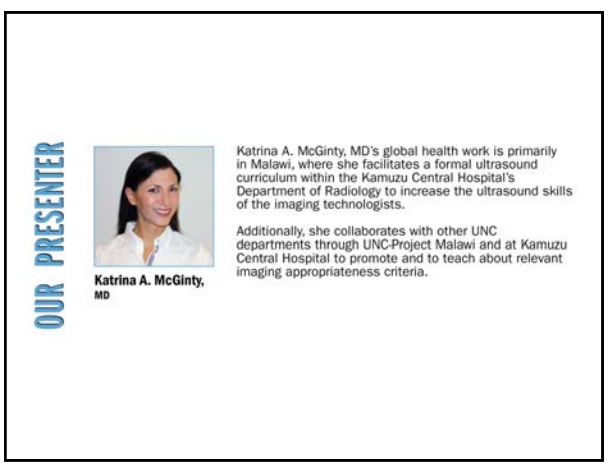

UNC Lineberger Cancer Network
ADVANCED PRACTICE PROVIDER
October 19, 2022
Right Image for the Right Patient
Lauren M.B. Burke, MD
Katrina A. McGinty, MD

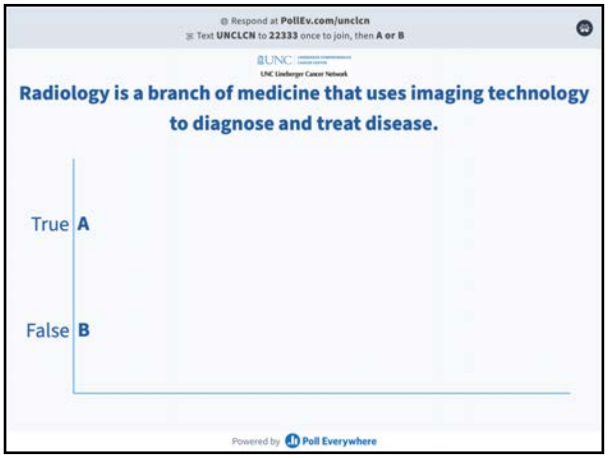
7


OUR PRESENTER
Lauren M.B. Burke, MD
Lauren M.B. Burke, MD's time at UNC spans almost 20 years undergraduate, medical school, residency, and faculty. After completing an Abdominal Imaging fellowship at Duke University in 2013, she returned to UNC as a Clinical Assistant Professor and has become an established scholar and leader within the Department in her formative years in medicine.
She has served as a leader in didactics, clinical service, and research, with her roles including Executive Vice Chair of Radiology, Division Chief of Abdominal Imaging, Residency Selection Committee member, Program Evaluation Committee, a member of UNC School of Medicine Academy of Educators, and a member of nationally renowned biomarker-driven cancer research group ECOG-ACRIN.

8


OUR PRESENTER
Katrina A. McGinty, MD
Katrina A. McGinty, MD's global health work is primarily in Malawi, where she facilitates a formal ultrasound curriculum within the Kamuzu Central Hospital's Department of Radiology to increase the ultrasound skills of the imaging technologists.
Additionally, she collaborates with other UNC departments through UNC-Project Malawi and at Kamuzu Central Hospital to promote and to teach about relevant imaging appropriateness criteria.

9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Radiology is a branch of medicine that uses imaging technology to diagnose and treat disease.
True A
False B
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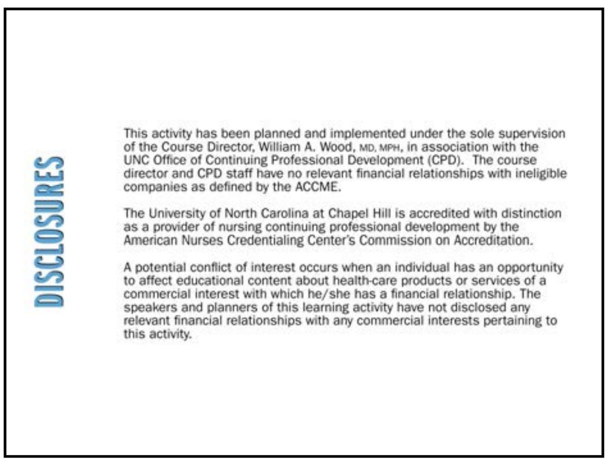
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RIGHT IMAGE FOR THE RIGHT PATIENT

Katrina McGinty MD and Lauren MB Burke MD
Department of Radiology, UNC-CH
Abdominal Imaging Group
October 19, 2022

13

OVERVIEW

- Overutilization
- Review of general scan limitations
- Review of each modality, pros and cons, common indications

14

GROWTH OF IMAGING

- In the past decade, imaging services and their cost have grown at twice the rate of other technologies in the health care industry
  - Radiation dose!
  - $$$

Hendee, W. et al. Addressing Overutilization in Medical Imaging. Radiology. August 2010.

15

GROWTH OF IMAGING: DOSE CONCERNS

- Dose to the public
  - 1980: Medical radiation made up <25% of average total radiation dose to US residents[1]
  - 2021: Medical radiation makes up nearly 50% of average total radiation dose to US residents[2]
- "...we must ensure that patients undergoing CT receive the minimum radiation dose possible *to produce a medical benefit*"
- *LOWEST* dose for any given patient

1. Smith-Bindman, Rebecca. Is Computed Tomography Safe? N Engl J Med; 363:1-4
2. EPA. Radiation source and doses.

16

GROWTH OF IMAGING: DOSE CONCERNS

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- "...we must ensure that patients undergoing CT receive the minimum radiation dose possible *to produce a medical benefit*"[2]
- ~~*LOWEST* dose for any given patient~~
- *APPROPRIATE* dose for any given patient

1. Smith-Bindman, Rebecca. Is Computed Tomography Safe? N Engl J Med; 363:1-4
2. EPA. Radiation source and doses

17

GROWTH OF IMAGING: DOSE CONCERNS

- Radiation is measured in effective dose (millisieverts: mSv)
  - Refers to radiation risk averaged over the entire body
- Background radiation (cosmic radiation, radon): 3 mSv/year
- Effective dose may be used to estimated risk of cancer/cancer related death
- Risk levels: Additional risk of fatal cancer from an examination
  - Negligible: less than 1 in 1,000,000
  - Minimal: 1 in 1,000,000 to 1 in 100,000
  - Very low: 1 in 100,000 to 1 in 10,000
  - Low: 1 in 10,000 to 1 in 1,000
  - Moderate: 1 in 1,000 to 1 in 500
  - These risk levels represent a very small addition to the 1 in 5 chance we all have of dying from cancer

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GROWTH OF IMAGING: DOSE CONCERNS

Procedure	Effective dose	Comparable for natural background radiation for:	Additional life risk of fatal cancer
Intra-oral XR	0.005 mSv	1 day	Negligible
Extremity XR	0.001 mSv	3 hours	Negligible
Chest XR	0.1 mSv	10 days	Minimal
Spine XR	1.5 mSv	6 months	Very low
Head CT	2-4 mSv	8-16 months	Low
Chest CT	1.5-7 mSv	6 months-2years	Very low to low
Abdominopelvic CT	10-20 mSv	3-7 years	Low to moderate
PET-CT	25 mSv	8 years	Moderate

- New software and dose reduction protocols are continually evolving
- Doses vary with scan technique and patient size

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GROWTH OF IMAGING: COST OF EXAMS

- Conventional Radiography (X-ray):
  - Two view chest x ray: $344
  - Pelvis and hips: $314
- Ultrasound:
  - Single Breast ultrasound: $453
  - Abdominal ultrasound: $1051
  - Echocardiogram: $2050
- CT: $1600-5000 per body part
- MR:
  - Lumbar spine MRI: $5018
  - Abdominal MRI w/wo contrast: $4815

"You see, Ms. Jenkins, by doubling up on patients in the MRI, we're able to cut costs in half, thereby passing the savings on to you."

20

GROWTH OF IMAGING: OVERUTILIZATION

- **Overutilization**: applications of imaging procedures where circumstances indicate that they are unlikely to improve patient outcome
- Why does it happen?
  - Self referral
  - Defensive medicine
  - Lack of comprehensive/accessible practice guidelines
  - Referring physicians
  - Radiologists
  - Patients

Hendee, W. et al. Addressing Overutilization in Medical Imaging. Radiology. August 2010.

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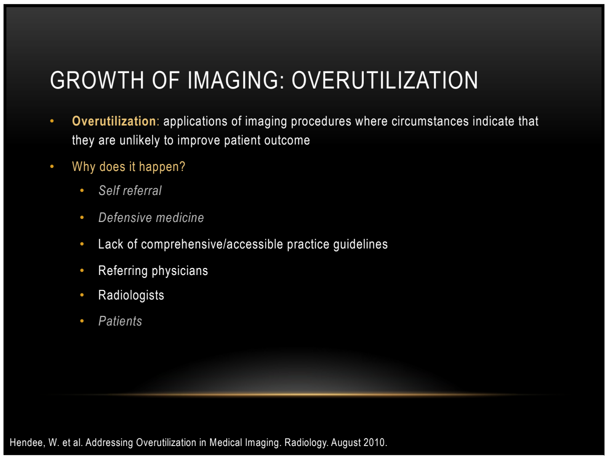
GROWTH OF IMAGING: OVERUTILIZATION
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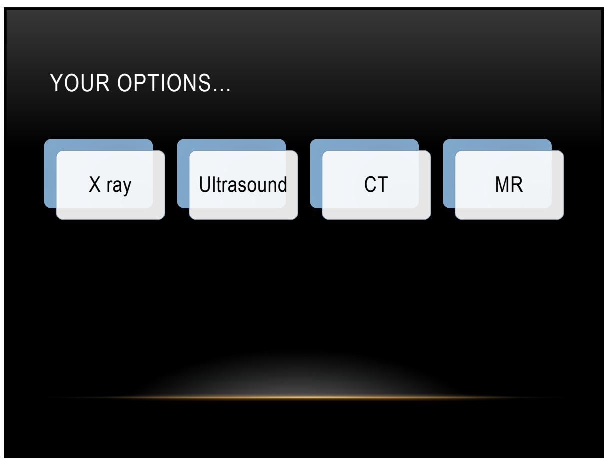
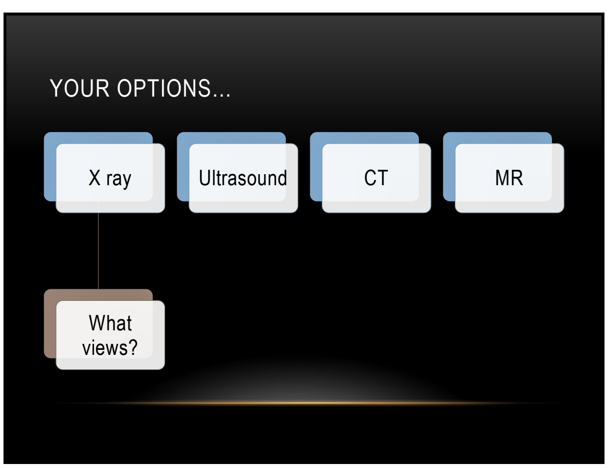
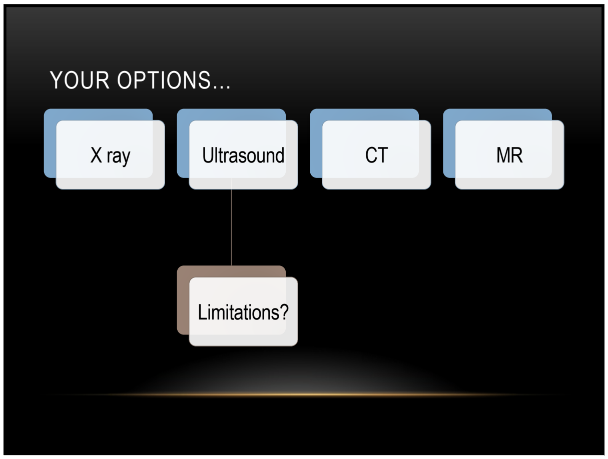

YOUR OPTIONS…
X ray
Ultrasound
CT
MR

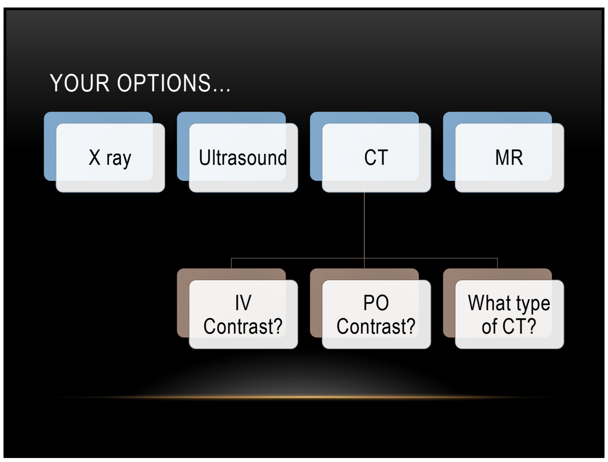
23


YOUR OPTIONS…
X ray
Ultrasound
CT
MR
What views?

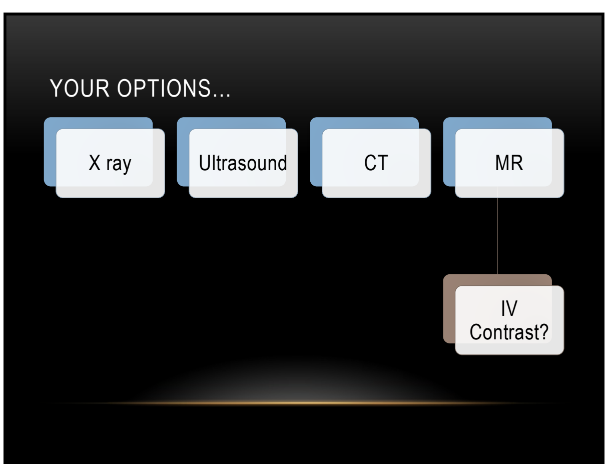
24


YOUR OPTIONS…
X ray
Ultrasound
CT
MR
Limitations?

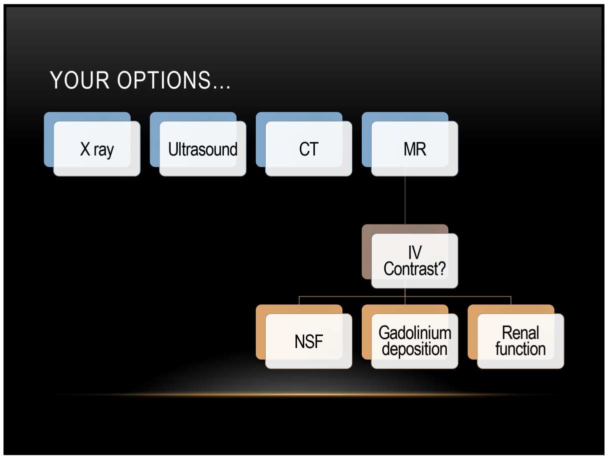
25


YOUR OPTIONS…
X ray
Ultrasound
CT
MR
IV Contrast?
PO Contrast?
What type of CT?

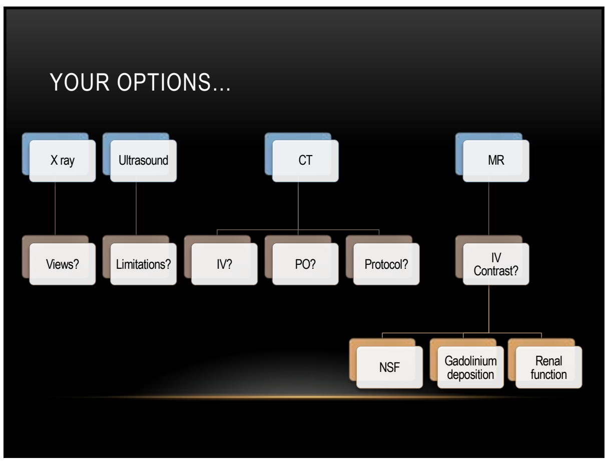
26


YOUR OPTIONS…
X ray
Ultrasound
CT
MR
IV Contrast?

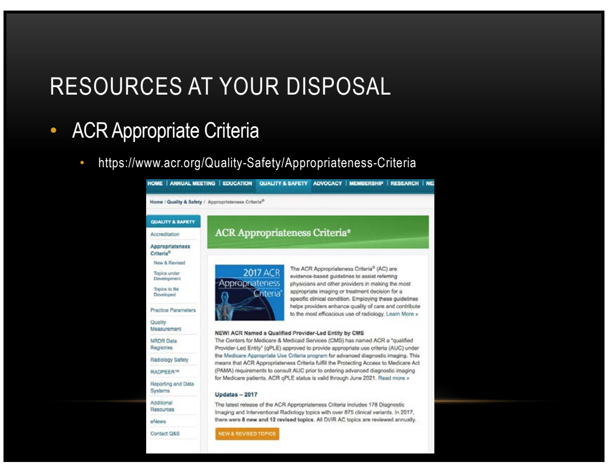
27


YOUR OPTIONS…
X ray
Ultrasound
CT
MR
IV Contrast?
NSF
Gadolinium deposition
Renal function

28


YOUR OPTIONS…
X ray
Ultrasound
CT
MR
Views?
Limitations?
IV?
PO?
Protocol?
IV Contrast?
NSF
Gadolinium deposition
Renal function

29


RESOURCES AT YOUR DISPOSAL
ACR Appropriate Criteria
https://www.acr.org/Quality-Safety/Appropriateness-Criteria
ACR Appropriateness Criteria®
2017 ACR Appropriateness Criteria

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RESOURCES AT YOUR DISPOSAL

- ACR Appropriate Criteria
  - https://www.acr.org/Quality-Safety/Appropriateness-Criteria

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RESOURCES AT YOUR DISPOSAL

- ACR Appropriate Criteria

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RESOURCES AT YOUR DISPOSAL

- ACR Appropriate Criteria

33

RESOURCES AT YOUR DISPOSAL

- ACR Appropriate Criteria

Clinical Condition: Acute Pancreatitis

Variant 1: Etiology unknown, first episode of pancreatitis; abdominal pain, elevated amylase lipase; no fever or evidence of fluid loss at admission; clinical score pending.

Radiologic Procedure	Rating	Comments	RRL*
US abdomen	8	Primarily to assess for gallstones.	O
CT abdomen with contrast	8	Best test to assess pancreatic parenchyma.	☢☢☢
CT abdomen without contrast	6		☢☢☢
CT abdomen without and with contrast	6	"Without" should be performed with low dose technique. To detect presence of pancreatic calcifications and/or calcified stones within pancreatic duct.	☢☢☢☢
MRI abdomen without contrast with MRCP	6		O
MRI abdomen without (including MRCP) and with contrast	6	Can also demonstrate pancreatic parenchyma as well as ducts and gallstones. May be somewhat limited in acutely ill patients related to procedure time. See statement regarding contrast in text under "Anticipated Exceptions."	O
US abdomen endoscopic	4		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

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RESOURCES AT YOUR DISPOSAL

- ACR Appropriate Criteria

Variant 2: Severe abdominal pain, elevated amylase lipase, 48 hours later assuming no improvement or degradation (assume no prior imaging).

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen with contrast	8	Generally easier access to this modality.	☢☢☢
MRI abdomen without (including MRCP) and with contrast	8	Allows evaluation for choledocholithiasis. See statement regarding contrast in text under "Anticipated Exceptions."	O
MRI abdomen without contrast with MRCP	7		O
CT abdomen without contrast	6		☢☢☢
CT abdomen without and with contrast	6	"Without" should be performed with low dose technique. To detect presence of pancreatic calcifications and/or calcified stones within pancreatic duct.	☢☢☢☢
US abdomen	6		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

35

DECISION MAKING SOFTWARE

Clinical Decision Support

Starting January 1, 2020, the Protecting Access to Medicare Act (PAMA) will require referring providers to consult appropriate use criteria (AUC) prior to ordering advanced diagnostic imaging services (CT, MR, nuclear medicine exams and PET) for Medicare patients.

CareSelect Imaging™ / ACR Select®, a digital representation of the ACR Appropriateness Criteria® for diagnostic imaging, is a module contained within CareSelect Imaging. ACR Select can be integrated into most common electronic health records (EHRs). The National Decision Support Company (NDSC), which is now owned by Change Healthcare, is a CMS approved qualified Decision Support Mechanism (DSM).

Providers can access imaging AUC via stand-alone electronic clinical decision support (CDS) systems or CDS software embedded in a physician's EHR. The ACR anticipates providers documenting that they consulted AUC with an "unique consultation identifier" in the exam order. However, claims processing instructions will b finalized by CMS in the upcoming Medicare Physician Fee Schedule rulemaking cycle.

No rendering provider — radiologist or otherwise — may receive Medicare payment for an advanced imaging exam if the referring provider does not verify that imagin AUC were consulted. Ordering physicians cannot shift the requirement to consult the guidelines to radiologists. Imaging providers cannot perform AUC administrative duties for referring providers. Imaging providers may refuse Medicare referrals lacking the "unique consultation identifier" and not be competitively disadvantaged.

Exams performed in the emergency department are included in the PAMA rule — except for the most emergent of cases. Inpatient exams are also exempted. HHS may make limited exceptions for rural providers with limited internet connectivity.

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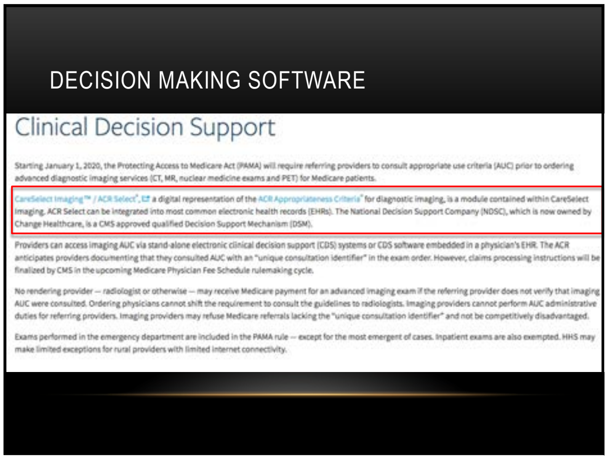
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RESOURCES AT YOUR DISPOSAL
Your radiologist!!!!
I ♥ MY
RADIOLOGIST

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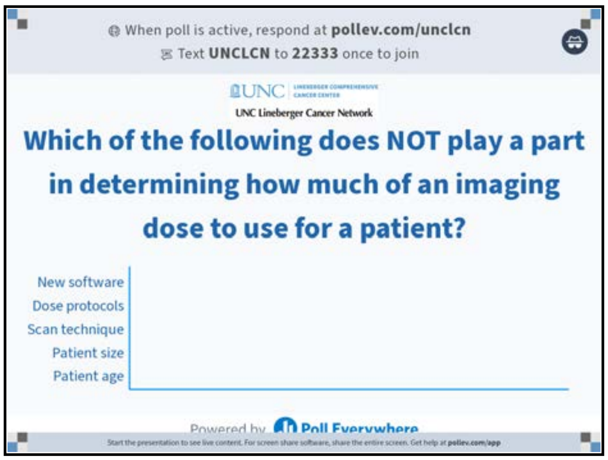
When poll is active, respond at pollev.com/unclcn
Text UNCLCN to 22333 once to join
UNC Lineberger Cancer Network
Which of the following does NOT play a part in determining how much of an imaging dose to use for a patient?
New software
Dose protocols
Scan technique
Patient size
Patient age
Powered by Poll Everywhere

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RIGHT SCAN FOR THE RIGHT PATIENT

- Ultrasound
  - Patient factors: body habitus, mobility, bandaging
  - Will we be able to image the area in question?

40

RIGHT SCAN FOR THE RIGHT PATIENT

- Ultrasound
  - Patient factors: body habitus, mobility, bandaging
  - Will we be able to image the area in question?
- CT
  - Can the patient lie flat for several minutes on their back
  - Can the patient hold their breath for ~15 second

41

RIGHT SCAN FOR THE RIGHT PATIENT

- Ultrasound
  - Patient factors: body habitus, mobility, bandaging
  - Will we be able to image the area in question?
- CT
  - Can the patient lie flat for several minutes on their back
  - Can the patient hold their breath for ~15 second
- MR
  - Is the patient able to lie in an enclosed space for up to one hour?
  - Can the patient lie on their back?
  - Can the patient hold their breath for 20 second?
  - Can the patient tolerate premedication (anxiety) and still follow breathing instructions?
  - Can the patient tolerate loud noises?

42

CONVENTIONAL RADIOGRAPH (X-RAY)

Pros

- Cheap
- Relatively low radiation dose
- Readily accessible
- Clinician friendly

Cons

- Limited sensitivity
- Possibly over utilized
- False positives
- Unsatisfying reports!

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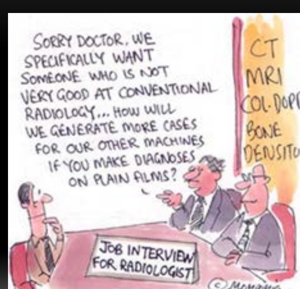
CONVENTIONAL RADIOGRAPHS

- Unsatisfying reports
  - "Thin lucency in the proximal tibia, possibly non displaced fracture. Correlate for point tenderness"
  - "Left lower lobe consolidation may represent atelectasis, pneumonia or edema; cannot exclude underlying mass lesion"
  - "Further evaluation with CT of the ______ is recommended"
  - "Non specific finding. Clinical correlation recommended…."



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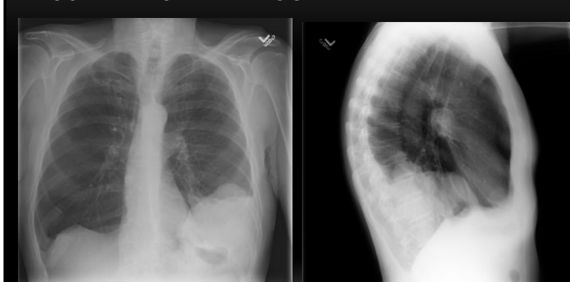
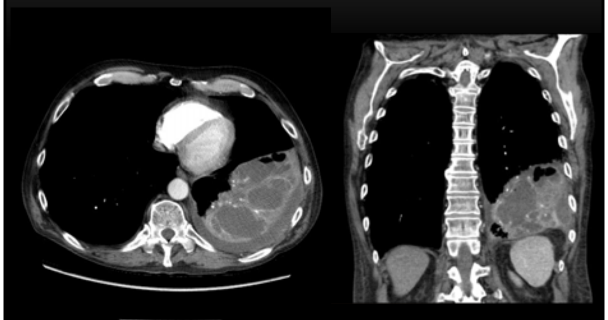
CONVENTIONAL RADIOGRAPH



Non-specific lobulated left lower lobe mass, possibly loculated fluid, pleural based mass, neoplasm, infection….. Recommend correlation with CT of the chest.

45

CONVENTIONAL RADIOGRAPH

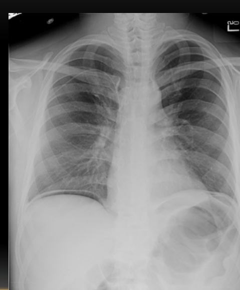


Multiloculated collection in the pleural space consistent necrotizing pneumonia and empyema

46

CONVENTIONAL RADIOGRAPH

- Specific views and patient positioning may be helpful
  - Upright chest x ray: Pneumoperitoneum
  - Expiratory upright film: Pneumothorax
  - Decubitus films: Layering effusion



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CONVENTIONAL RADIOGRAPH

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  - Upright chest x ray: Pneumoperitoneum
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  - Decubitus films: Layering effusion

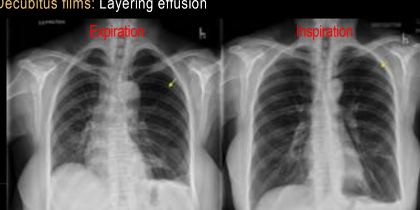

Image courtesy of Saint Vincent's University Hospital

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CONVENTIONAL RADIOGRAPH

- Easily accessible
- Not always sensitive or specific
- Specific views may answer specific clinical questions
- You get what you pay for!

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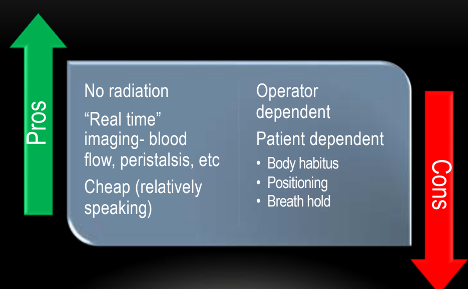
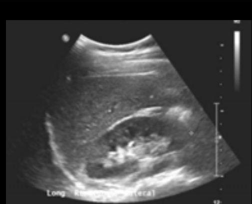
ULTRASOUND



50

ULTRASOUND LIMITATIONS: BODY HABITUS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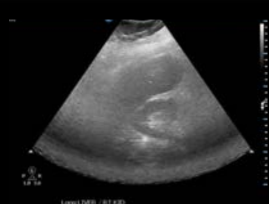
BMI 49

51

ULTRASOUND LIMITATIONS: GAS

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ULTRASOUND: LIMITATIONS

High Frequency ultrasound

- Good spatial resolution
- Superficial penetration

Superficial structures

- Thyroid
- Subcutaneous
- Breast
- Lymph nodes
- Superficial vessels

Low Frequency ultrasound

- Worse spatial resolution
- Deep penetration
- Deeper structures
  - Abdominal organs

53

ULTRASOUND: SUPERFICIAL VERSUS DEEP

THYROID NODULE

GALLSTONE

54

ULTRASOUND: SUPERFICIAL VERSUS DEEP

THYROID NODULE

GALLSTONE

55

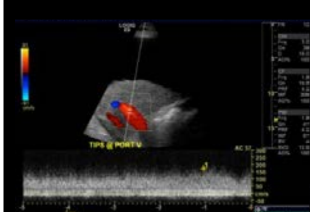
ULTRASOUND: DYNAMIC IMAGING

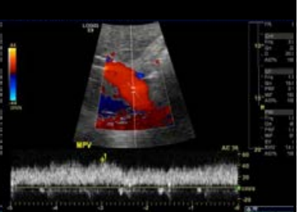
Right inguinal hernia with Valsalva

56

ULTRASOUND: VASCULAR EVALUATION

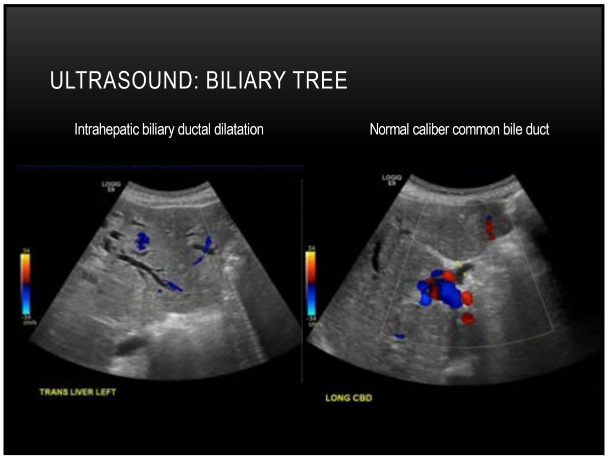
- Cirrhotic patient: TIPS evaluation



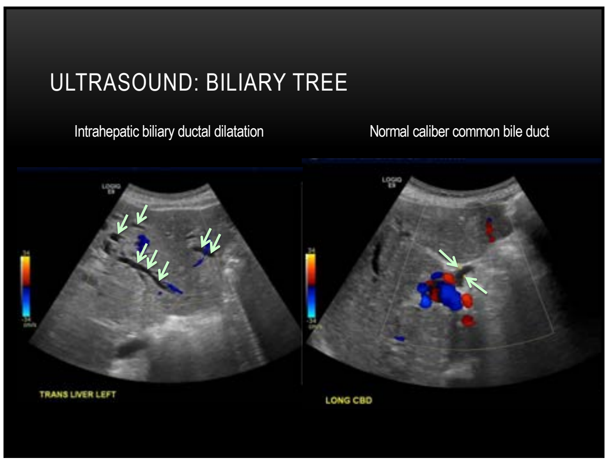


Elevated velocities through TIPS indicative of stent malfunction

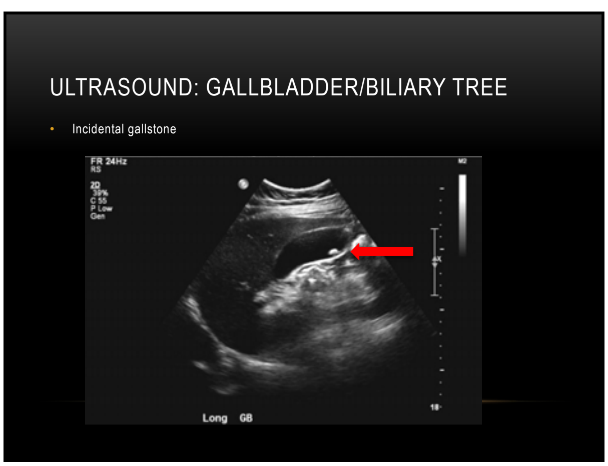
57


ULTRASOUND: BILIARY TREE
Intrahepatic biliary ductal dilatation
Normal caliber common bile duct
TRANS LIVER LEFT
LONG CBD

58


ULTRASOUND: BILIARY TREE
Intrahepatic biliary ductal dilatation
Normal caliber common bile duct
TRANS LIVER LEFT
LONG CBD

59


ULTRASOUND: GALLBLADDER/BILIARY TREE
Incidental gallstone
FR 24Hz
Long GB

60

ULTRASOUND: GU IMAGING

- First line modality:
  - Uterus
  - Ovaries
  - Testicles
  - Superficial structures
- Why?
  - Good soft tissue contrast
  - No radiation

61

ULTRASOUND: GU EVALUATION: UTERUS

- Post menopausal bleeding

Ill defined uterine mass, possibly leiyomyoma although neoplasm cannot be excluded: Recommend ultrasound for further evaluation…

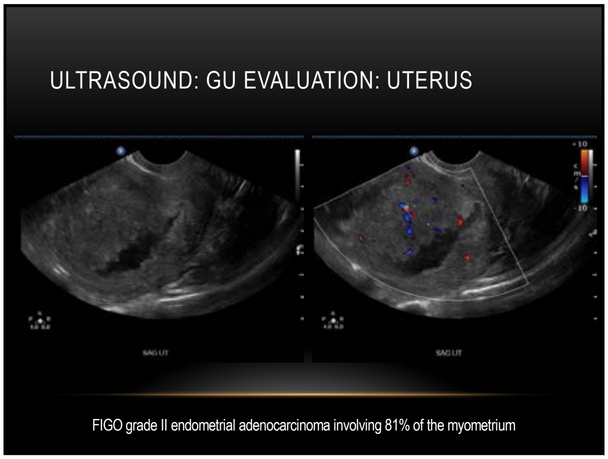
62

ULTRASOUND: GU EVALUATION: UTERUS

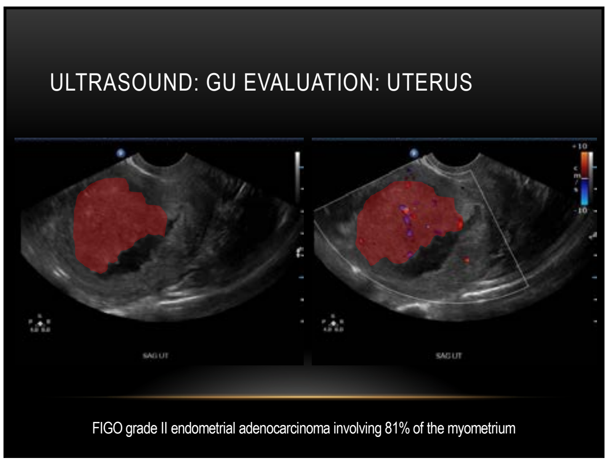
- Post menopausal bleeding

Ill defined uterine mass, possibly leiyomyoma although neoplasm cannot be excluded: Recommend ultrasound for further evaluation…

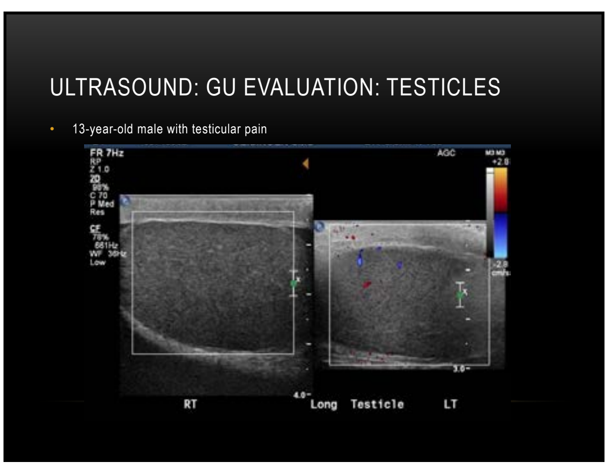
63


ULTRASOUND: GU EVALUATION: UTERUS
SAG UT
SAG UT
FIGO grade II endometrial adenocarcinoma involving 81% of the myometrium

64


ULTRASOUND: GU EVALUATION: UTERUS
SAG UT
SAG UT
FIGO grade II endometrial adenocarcinoma involving 81% of the myometrium

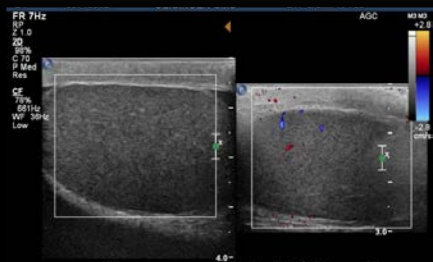
65


ULTRASOUND: GU EVALUATION: TESTICLES
13-year-old male with testicular pain
FR 7Hz
AGC
RT
Long Testicle
LT

66

ULTRASOUND: GU EVALUATION: TESTICLES

- 13-year-old male with testicular pain

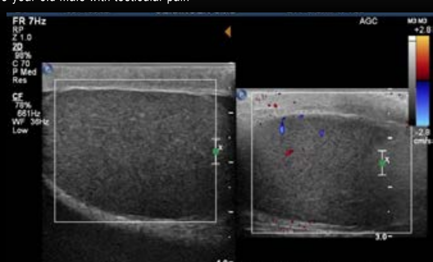


Absent flow in the right testicle

67

ULTRASOUND: GU EVALUATION: TESTICLES

- 13-year-old male with testicular pain



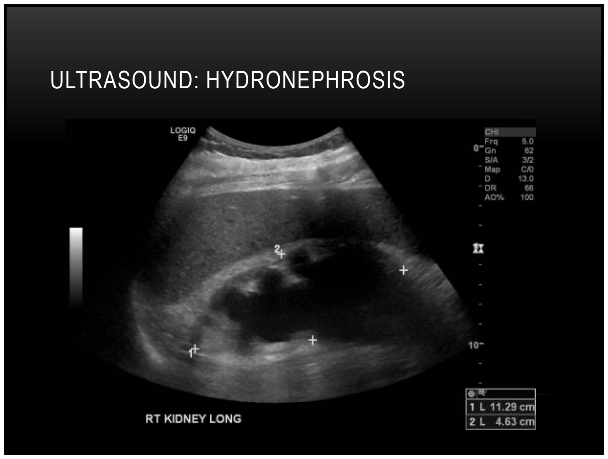
Absent flow in the right testicle
Testicular torsion

68

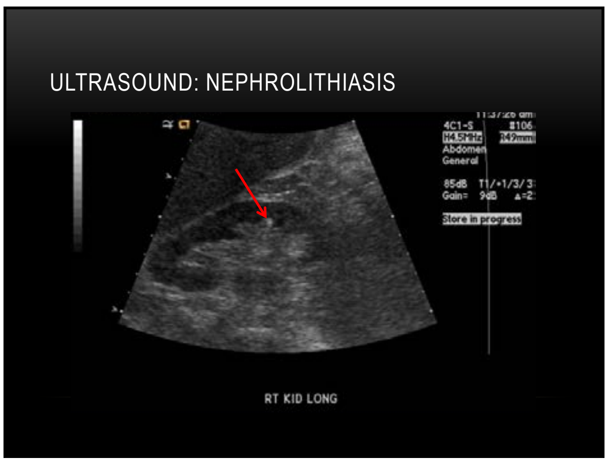
ULTRASOUND: GU EVALUATION: KIDNEYS

- Useful:
  - Stones (sometimes)
  - Hydronephrosis
  - Cysts (sometimes)
- Not useful:
  - Characterizing solid renal masses
  - Ureteral stones (sometimes)

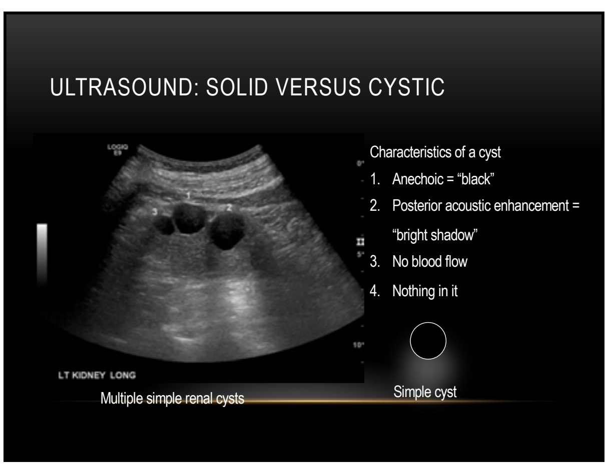
69


ULTRASOUND: HYDRONEPHROSIS
RT KIDNEY LONG
1 L 11.29 cm
2 L 4.63 cm

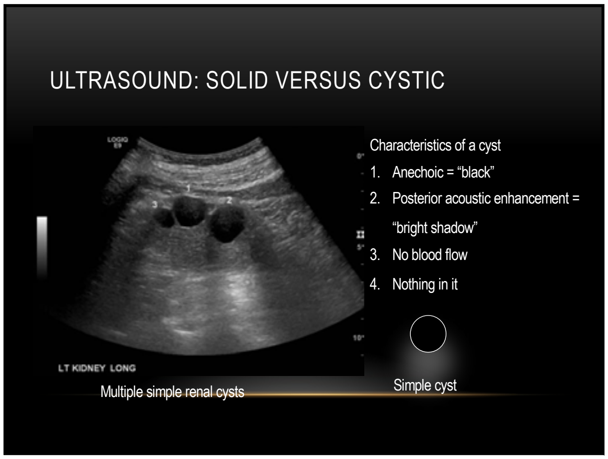
70


ULTRASOUND: NEPHROLITHIASIS
Store in progress
RT KID LONG

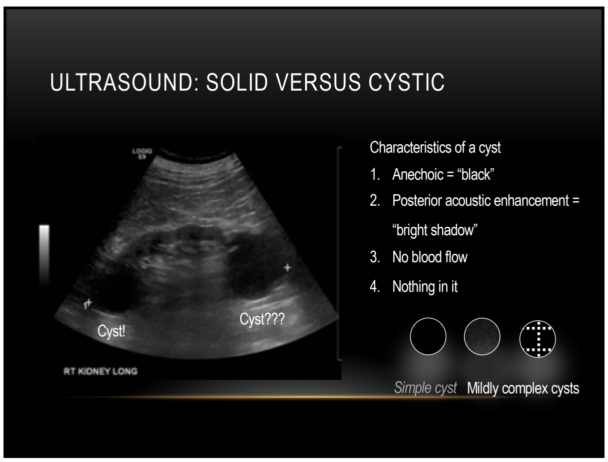
71


ULTRASOUND: SOLID VERSUS CYSTIC
Characteristics of a cyst
1. Anechoic = "black"
2. Posterior acoustic enhancement = "bright shadow"
3. No blood flow
4. Nothing in it
LT KIDNEY LONG
Multiple simple renal cysts
Simple cyst

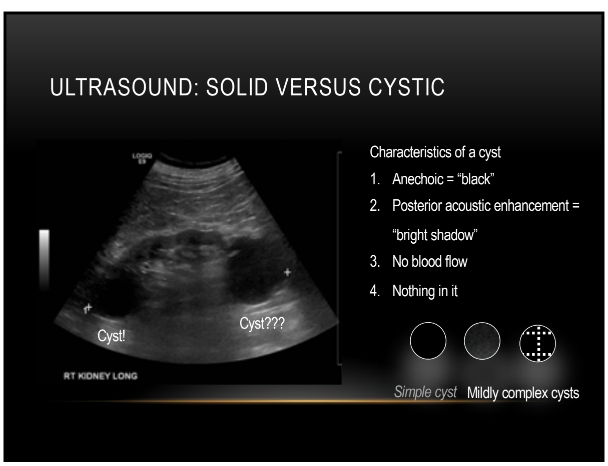
72


ULTRASOUND: SOLID VERSUS CYSTIC
LT KIDNEY LONG
Multiple simple renal cysts
Characteristics of a cyst
1. Anechoic = "black"
2. Posterior acoustic enhancement = "bright shadow"
3. No blood flow
4. Nothing in it
Simple cyst

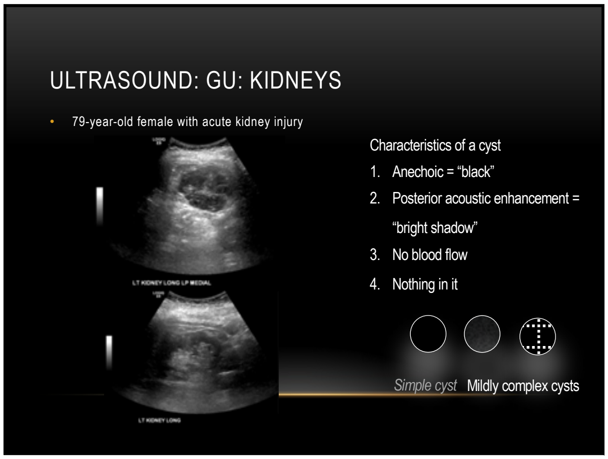
73


ULTRASOUND: SOLID VERSUS CYSTIC
Cyst!
Cyst???
RT KIDNEY LONG
Characteristics of a cyst
1. Anechoic = "black"
2. Posterior acoustic enhancement = "bright shadow"
3. No blood flow
4. Nothing in it
Simple cyst
Mildly complex cysts

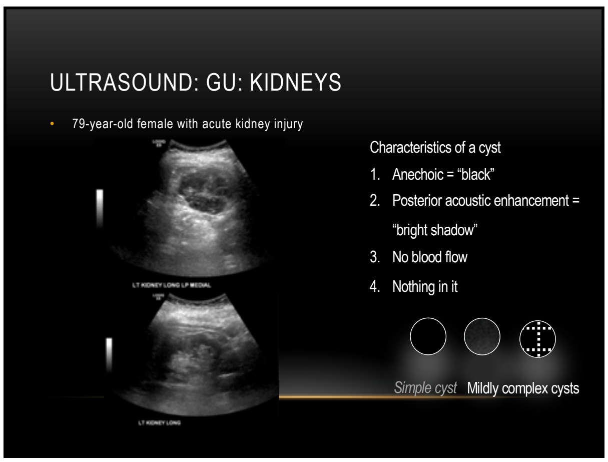
74


ULTRASOUND: SOLID VERSUS CYSTIC
Cyst!
Cyst???
RT KIDNEY LONG
Characteristics of a cyst
1. Anechoic = "black"
2. Posterior acoustic enhancement = "bright shadow"
3. No blood flow
4. Nothing in it
Simple cyst
Mildly complex cysts

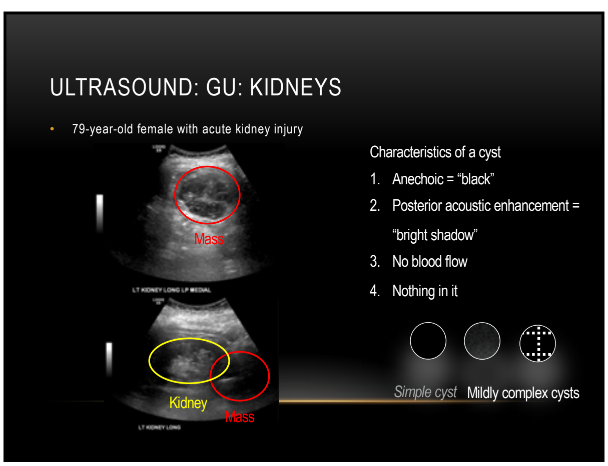
75


ULTRASOUND: GU: KIDNEYS
• 79-year-old female with acute kidney injury
Characteristics of a cyst
1. Anechoic = "black"
2. Posterior acoustic enhancement = "bright shadow"
3. No blood flow
4. Nothing in it
Simple cyst
Mildly complex cysts

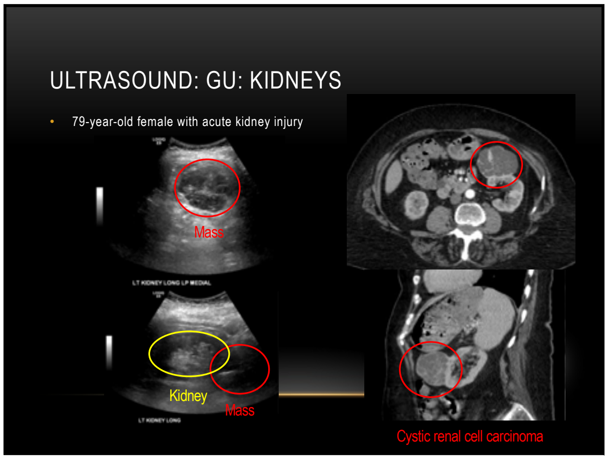
76


ULTRASOUND: GU: KIDNEYS
• 79-year-old female with acute kidney injury
Characteristics of a cyst
1. Anechoic = "black"
2. Posterior acoustic enhancement = "bright shadow"
3. No blood flow
4. Nothing in it
Simple cyst
Mildly complex cysts

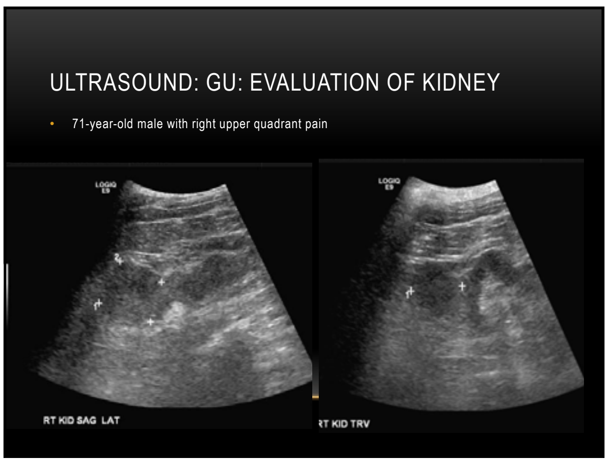
77


ULTRASOUND: GU: KIDNEYS
• 79-year-old female with acute kidney injury
Mass
Kidney
Mass
Characteristics of a cyst
1. Anechoic = "black"
2. Posterior acoustic enhancement = "bright shadow"
3. No blood flow
4. Nothing in it
Simple cyst
Mildly complex cysts

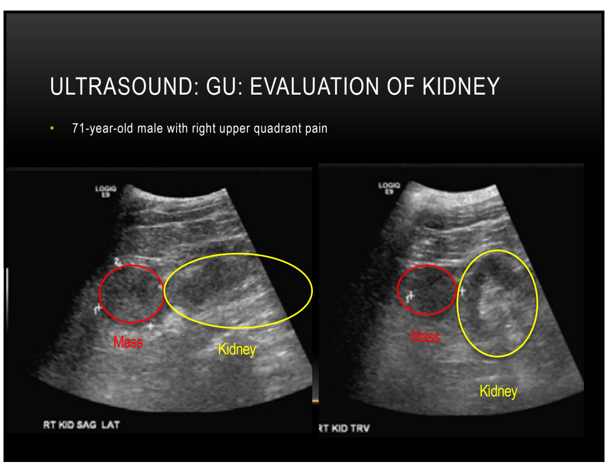
78


ULTRASOUND: GU: KIDNEYS
79-year-old female with acute kidney injury
Mass
Kidney
Mass
Cystic renal cell carcinoma

79


ULTRASOUND: GU: EVALUATION OF KIDNEY
71-year-old male with right upper quadrant pain
RT KID SAG LAT

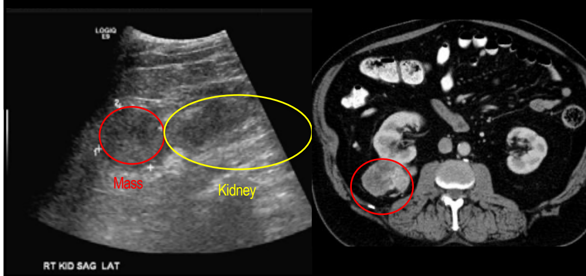
80


ULTRASOUND: GU: EVALUATION OF KIDNEY
71-year-old male with right upper quadrant pain
Mass
Kidney
Mass
Kidney
RT KID SAG LAT

81

ULTRASOUND: GU: EVALUATION OF KIDNEY

- 71-year-old male with right upper quadrant pain



82

ULTRASOUND: GU EVALUATION: KIDNEYS

- Uses
  - Hydronephrosis: Very good
  - Calculi: Good (renal calculi, not necessarily ureteral calculi)
  - Cysts: Okay (simple cysts, optimal patient)
  - Masses (detection and characterization): Poor

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ULTRASOUND

- First line imaging modality
  - Vascular pathology
  - Dynamic "real time" imaging
  - Biliary pathology
  - Uterus, ovaries, testicle
  - Kidneys (sometimes)

84

ULTRASOUND

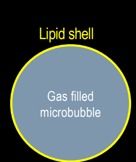
- First line imaging modality
  - Vascular pathology
  - Dynamic "real time" imaging
  - Biliary pathology
  - Uterus, ovaries, testicle
  - Kidneys (sometimes)
- NOT useful for
  - Characterizing solid lesions
  - Detection of occult pathology outside of the probe's range
  - Penetrating extensive fat/gas

85

RECENTLY ARRIVED! CONTRAST ENHANCED ULTRASOUND!!!

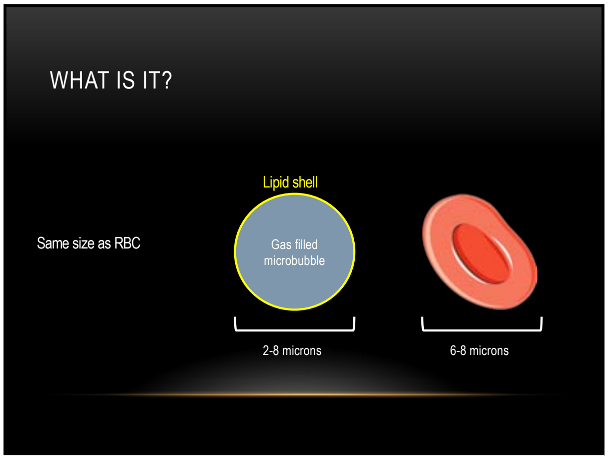
86

WHAT IS IT?

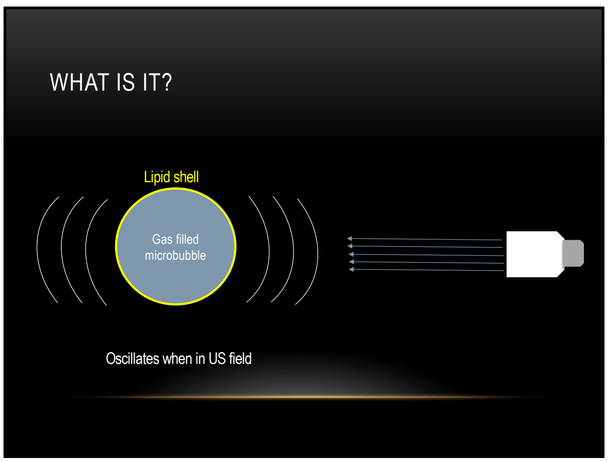


*Sulfur hexaflouride

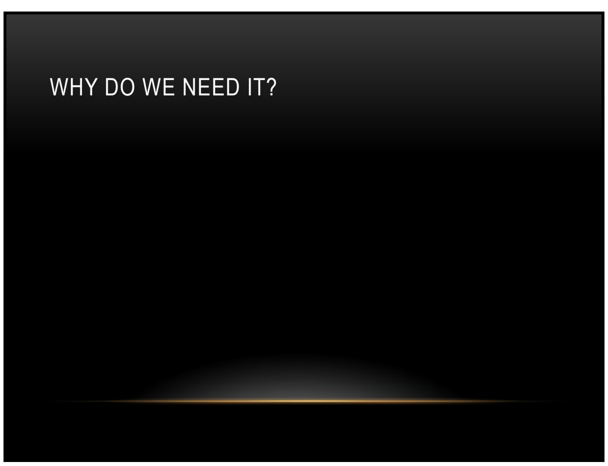
87


WHAT IS IT?
Lipid shell
Same size as RBC
Gas filled microbubble
2-8 microns
6-8 microns

88


WHAT IS IT?
Lipid shell
Gas filled microbubble
Oscillates when in US field

89


WHY DO WE NEED IT?

90

WHY DO WE NEED IT?

- Metabolism: Gas is exhaled, lipids broken down in liver

91

WHY DO WE NEED IT?

- Metabolism
  - NO renal excretion!

92

WHY DO WE NEED IT?

- Metabolism
  - NO renal excretion!
  - Basically no hepatic excretion!

93

WHY DO WE NEED IT?

- Metabolism
  - NO renal excretion!
  - Basically no hepatic excretion!
- Repeated injection

94

WHY DO WE NEED IT?

- Metabolism
  - NO renal excretion!
  - Basically no hepatic excretion!
- Repeated injection
  - Dose is ~1-2 mL
  - Bubbles last 5-10 minutes
  - Can destroy bubbles using ultrasound to reinject if needed

95

WHY DO WE NEED IT?

- Metabolism
  - NO renal excretion!
  - Basically no hepatic excretion!
- Repeated injection
  - Dose is ~1-2 mL
  - Bubbles last 5-10 minutes
  - Can destroy bubbles using ultrasound to reinject if needed
  - Have given up to 161 mL without adverse effects!

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WHY DO WE NEED IT?

- Renal impaired patients
- Patients who cannot tolerate MRI
- Patients with contrast allergies

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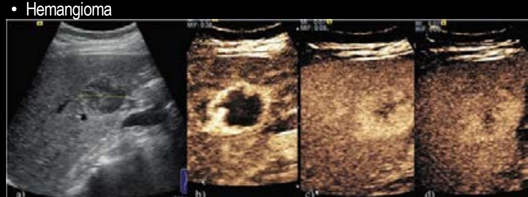
HOW DOES IT LOOK?

- Real time enhancement of lesion
  - Pattern of enhancement: Central vs. peripheral
  - Washout
    - Presence or absence
    - Timing of washout
  - Opportunity for repeat injections if uncertain of pattern

98

HOW DOES IT LOOK?

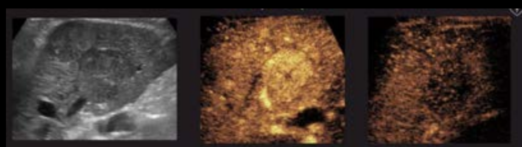
- Hemangioma



99

HOW DOES IT LOOK?

- HCC



100

HOW ACCURATE IS IT?

101

HOW ACCURATE IS IT?

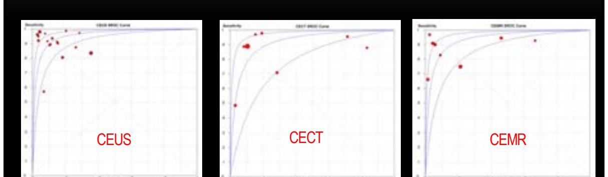


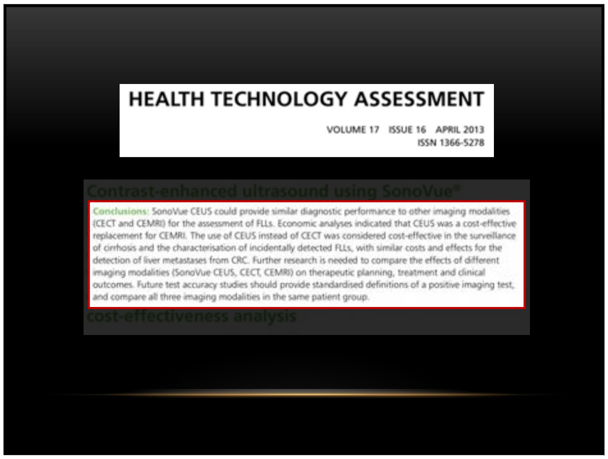
Fig. 4. Summary receiver operating characteristic (ROC) curve for contrast enhanced ultrasound (CEUS). The size of the data marker is proportional to the weight of the individual study. AUC = 0.9535, SE(AUC) = 0.0158, Q* = 0.8980, SE (Q*) = 0.0222.

Fig. 5. Summary receiver operating characteristic (ROC) curve for contrast enhanced computed tomography (CECT). The size of the data marker is proportional to the weight of the individual study. AUC = 0.9148, SE(AUC) = 0.0376, Q* = 0.8475, SE (Q*) = 0.0423.

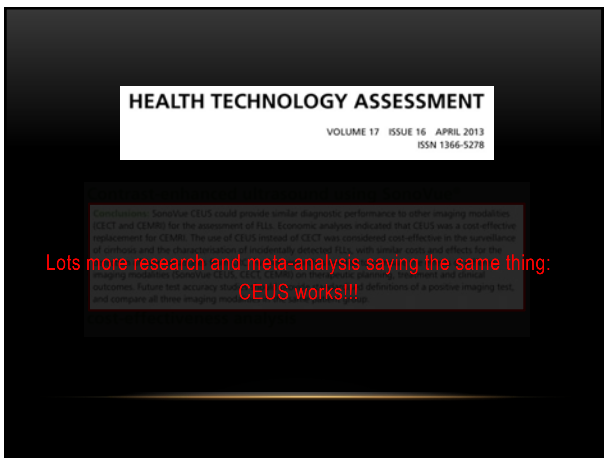
Fig. 6. Summary receiver operating characteristic (ROC) curve for contrast enhanced magnetic resonance imaging (CEMRI). The size of the data marker is proportional to the weight of the individual study. AUC = 0.9362, SE(AUC) = 0.0223, Q* = 0.8727, SE (Q*) = 0.0277.

Ultrasound in Med. & Biol., Vol. 37, No. 6, pp. 854–861, 2011

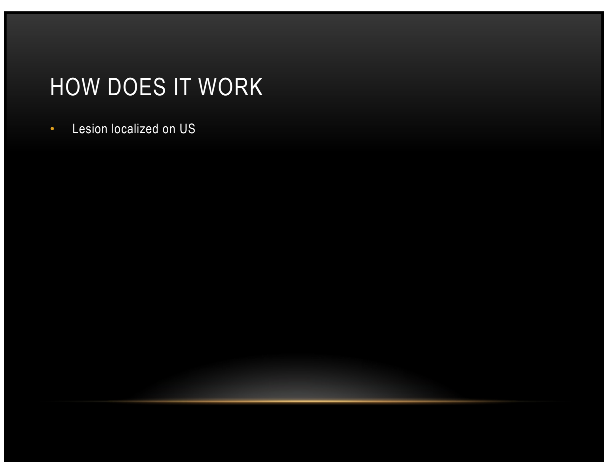
102


HEALTH TECHNOLOGY ASSESSMENT
VOLUME 17 ISSUE 16 APRIL 2013
ISSN 1366-5278
Contrast-enhanced ultrasound using SonoVue®
Conclusions: SonoVue CEUS could provide similar diagnostic performance to other imaging modalities (CECT and CEMRI) for the assessment of FLLs. Economic analyses indicated that CEUS was a cost-effective replacement for CEMRI. The use of CEUS instead of CECT was considered cost-effective in the surveillance of cirrhosis and the characterisation of incidentally detected FLLs, with similar costs and effects for the detection of liver metastases from CRC. Further research is needed to compare the effects of different imaging modalities (SonoVue CEUS, CECT, CEMRI) on therapeutic planning, treatment and clinical outcomes. Future test accuracy studies should provide standardised definitions of a positive imaging test, and compare all three imaging modalities in the same patient group.
cost-effectiveness analysis

103


HEALTH TECHNOLOGY ASSESSMENT
VOLUME 17 ISSUE 16 APRIL 2013
ISSN 1366-5278
Lots more research and meta-analysis saying the same thing:
CEUS works!!!

104


HOW DOES IT WORK
Lesion localized on US

105

HOW DOES IT WORK

- Lesion localized on US
- Contrast injected

106

HOW DOES IT WORK

- Lesion localized on US
- Contrast injected
- Lesion watched in real time by radiologist
  - Cine clips
  - Intermittent observation for 5+ minutes

107

HOW DOES IT WORK

- Lesion localized on US
- Contrast injected
- Lesion watched in real time by radiologist
  - Cine clips
  - Intermittent observation for 5+ minutes
- If lesion characterized, exam is done and patient can go

108

HOW DOES IT WORK

- Lesion localized on US
- Contrast injected
- Lesion watched in real time by radiologist
  - Cine clips
  - Intermittent observation for 5+ minutes
- If lesion characterized, exam is done and patient can go
- If lesion is not characterized, can repeat injection

109

LIMITATIONS

- Lesion must be visualized on ultrasound
  - Patient size
  - Gas
  - Limited penetration of cirrhotic/fatty livers

110

LIMITATIONS

- Lesion must be visualized on ultrasound
  - Patient size
  - Gas
  - Limited penetration of cirrhotic/fatty livers
- Staffing
  - 1 hour for exam (procedure slot)

111

CONTRAINDICATIONS

- Prior allergic reaction to *ultrasound contrast* (1 in ~12,000)
- Unstable cardiac disease

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WHERE TO GO FROM HERE?

- These are specialized and labor-intensive studies
- MR and CT are still your first line imaging modality for most indications
- CEUS *may* be indicated as a problem-solving tool in select patient

113

WHERE TO GO FROM HERE?

- These are specialized and labor-intensive studies
- MR and CT are still your first line imaging modality for most indications
- CEUS *may* be indicated as a problem-solving tool in select patient
- Short version: If you are thinking that your patient might be a candidate for CEUS, please do not just place the order- have a discussion with the radiologist first

114

WHERE TO GO FROM HERE?

- These are specialized and labor-intensive studies
- MR and CT are still your first line imaging modality for most indications
- CEUS *may* be indicated as a problem-solving tool in select patient

- Short version: If you are thinking that your patient might be a candidate for CEUS, please do not just place the order- have a discussion with the radiologist first
  - EPIC or email works as well, if you can't get one of us on the phone
  - These are only being scheduled at UNC as outpatients, so they are *never* emergent at UNC

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When poll is active, respond at **pollev.com/unclcn**
Text **UNCLCN** to **22333** once to join

UNC Lineberger Cancer Network

Which of the following is a benefit of a conventional radiograph?

- Good soft tissue contrast
- Specific vews may answer specific clinical questions
- Useful for characterizing solid lesions
- Penetrates fat/gas

Powered by Poll Everywhere

Start the presentation to see live content. For screen share software, share the entire screen. Get help at pollev.com/app

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QUESTIONS?

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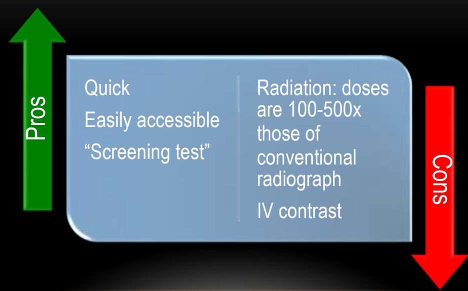
COMPUTED TOMOGRAPHY



118

CT: WHEN AND WHY OF CONTRAST AGENTS

- Principle: Increased attenuation (brightness) from the iodine atom in contrast = "enhancement"
  - Magnitude of enhancement is related to amount of contrast deposited in a target organ or in the intravascular blood pool
- Variables in enhancement
  - Rate of injection
  - Cardiac output of the patient
  - Organ perfusion (i.e. single versus dual blood supply)
  - Timing of imaging
- When do we use it?
  - Vascular imaging
  - Infectious/inflammatory processes
  - Neoplasm

Herman, S. Computed Tomography Contrast Enhancement Principles and the Use of High Concentration Contrast Media. J Comput Assist Tomogr 2004; 28: S7-S11

119

CT: WHEN AND WHY OF CONTRAST AGENTS

- We protocol every CT ordered…
  - Appropriate *use* of IV contrast
  - Appropriate *timing* of IV contrast
- Based on clinical history, a scan protocol is chosen to optimize the diagnostic yield
  - Precontrast imaging?
  - Multiple phases of imaging?

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CT CONTRAST AGENTS

- At risk patients: GFR/Creatinine recommended within *30 days* of the exam IF…
  - > 60 year old
  - History of renal disease
    - Dialysis
    - Renal transplant
    - Single kidney
    - Renal cancer
    - Renal surgery
  - Hypertension requiring medical therapy
  - History of diabetes
  - Metformin use
- No universal cutoff- will vary with institution
  - @UNC, GFR >30 can receive iodinated contrast

ACR Manual on Contrast Media, 2022

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CT CONTRAST AGENTS: WHEN TO AVOID IT

- Risk factors for contrast induced nephropathy…
  - Repeated doses (20 hours to clear contrast from system)
  - Acute renal injury
  - Dehydration
  - Radiologist is consulted to determine if contrast is needed or if situation can be optimized
- DIALYSIS
  - If the patient is on hemodialysis AND anuiric, IV contrast can be given
  - If the patient is still making urine, proceed cautiously
- PREVENTION
  - Hydration: oral or IV, no ideal rate
  - Sodium bicarbonate and N acetylecysteine (mucormyst) not validated
- *Acute renal failure is a contraindication to IV contrast*

ACR Manual on Contrast Media, 2022

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CT CONTRAST AGENTS: PREMEDICATION

- Reactions to contrast agents
  - Mild (no treatment): 5-8% of patients (flushing, nausea, vomiting)
  - Moderate (require treatment): 1% of patients (severe nausea/vomiting, hives, swelling)
  - Severe (require treatment): 0.1% of patients (anaphylaxis)
    - Expected death rate of 1 in 75,000[1]
- "Pseudo-allergy": No allergic antibody- IV contrast causes histamine release from mast cells

ACR Manual on Contrast Media, 2022
M. Saijoughlan. Intravenous Radiocontrast Media: A review of Allergic Reactions. US Pharm. 2012;37 (5): HS-14-HS-16

123

CT CONTRAST AGENTS: PREMEDICATION

- Contrast reaction: At risk patients
  - Prior reaction
  - Shellfish allergy does not necessitate premedication[1]
- Premedication:
  - 13 hours prior: Prednisone 50 mg (IV or po)
  - 7 hours prior: Prednisone 50 mg (IV or po)
  - 1 hour prior: Prednisone 50 mg (IV or po) and Diphenhydramine (Benadryl) 50 mg po[2]
- "Emergency" premedication
  - Q4 hours until injection: 40 mg Methylprednisonedosium succinate (Solu-medrol) or 200 mg hydrocortison sodium succinate (Solu-Cortef)
  - 1 hour prior: 50 mg diphenhydramine (Benadryl)
  - **Steroid less effective when given less than 4-6 hours prior to exam**

1. M. Saijoughlan. Intravenous Radiocontrast Media: A review of Allergic Reactions. US Pharm. 2012;37 (5): HS-14-HS-16
2. ACR Manual on Contrast Media, 2022

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CT CONTRAST: METFORMIN, BREASTFEEDING

- Metformin
  - No need to hold Metformin when GFR > 30
- Breastfeeding
  - >1% of the dose is excreted in breast milk
  - >1% of the contrast in breast milk is absorbed from the GI tract
  - 0.01% of dose ingested by infant
  - If the mother is concerned, she may abstain from breast feeding for 12-24 hours

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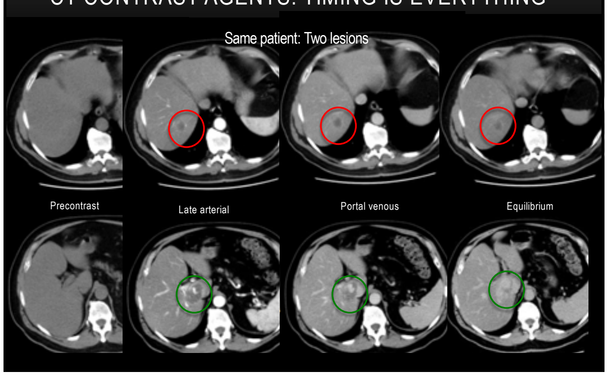
CT CONTRAST AGENTS: TIMING IS EVERYTHING



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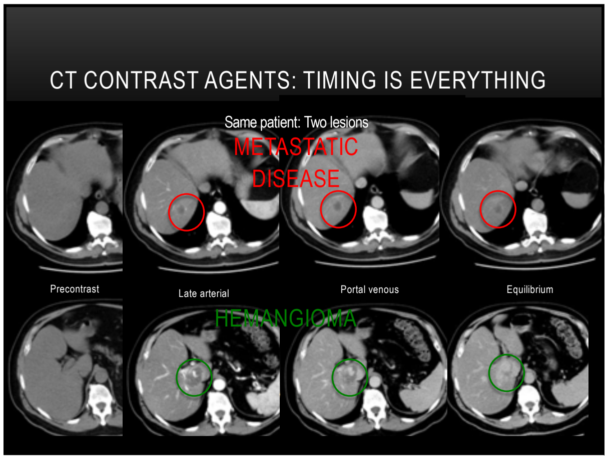
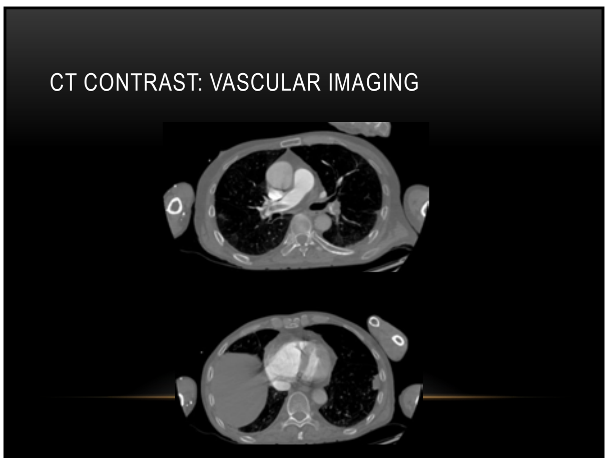
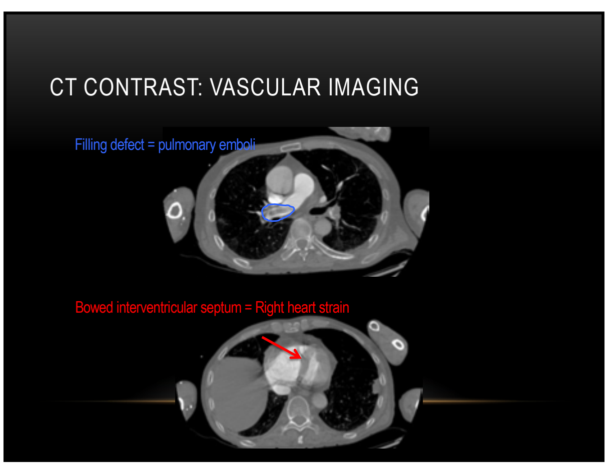

CT CONTRAST AGENTS: TIMING IS EVERYTHING
Same patient: Two lesions
METASTATIC DISEASE
Precontrast
Late arterial
Portal venous
Equilibrium
HEMANGIOMA

127


CT CONTRAST: VASCULAR IMAGING

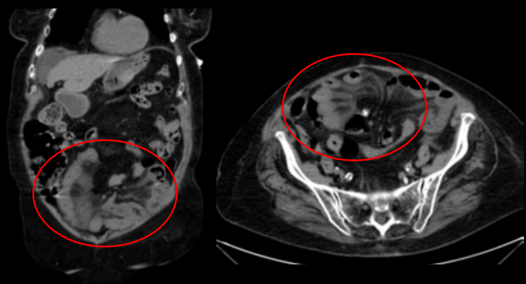
128


CT CONTRAST: VASCULAR IMAGING
Filling defect = pulmonary emboli
Bowed interventricular septum = Right heart strain

129

CT CONTRAST: INFECTION/INFLAMMATION

- Inflamed small bowel: No contrast



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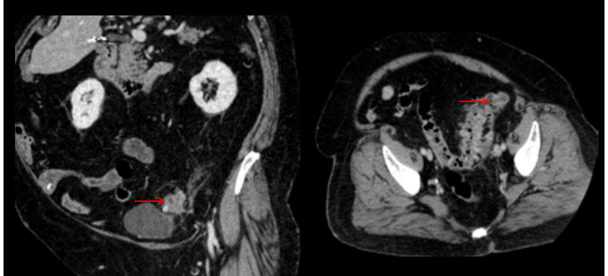
CT CONTRAST: INFECTION/INFLAMMATION

- With contrast: Diverticulitis with intramural abscess



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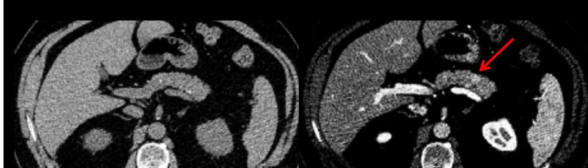
CT CONTRAST: NEOPLASM

- Pancreatic neuroendocrine tumor: Without and with contrast



No contrast: No tumor!

Pancreatic protocol CT: TUMOR

132

CT: IV CONTRAST: WHEN DON'T WE WANT IT?

- What is bright on CT?
  - Blood
  - Calcium
  - Iron
  - Foreign bodies

133

CT: IV CONTRAST: WHEN DON'T WE WANT IT?

- What is bright on CT?
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134

CT: IV CONTRAST: WHEN DON'T WE WANT IT?

- What is bright on CT?
  - Blood
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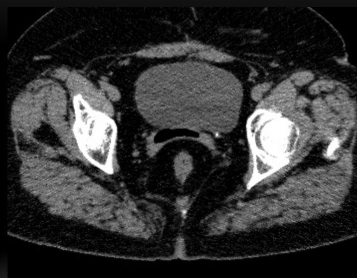
  - Iron
  - Foreign bodies

Retroperitoneal hematoma

135

CT: IV CONTRAST: WHEN DON'T WE WANT IT?

- What is bright on CT?
  - Blood
  - Calcium
  - Iron
  - Foreign bodies



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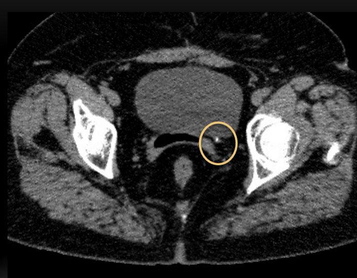
CT: IV CONTRAST: WHEN DON'T WE WANT IT?

- What is bright on CT?
  - Blood
  - Calcium
  - Iron
  - Foreign bodies



Left UVJ stone

137

CT: IV CONTRAST: WHEN DON'T WE WANT IT?

- What is bright on CT?
  - Blood
  - Calcium
  - Iron
  - Foreign bodies

138

CT: IV CONTRAST: WHEN DON'T WE WANT IT?

- What is bright on CT?
  - Blood
  - Calcium
  - Iron
  - Foreign bodies

139

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Text **UNCLCN** to **22333** once to join

UNC Lineberger Cancer Network

Which one of the following is an advantage for CT?

- Imaging of infection, neoplasm, and inflammation
- CT is contraindicated in breast feeding
- Good for patients with dehydration or acute renal failure
- Appropriate imaging for patients with diabetic nephropathy

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CT: SUMMARY

- IV contrast useful…
  - Vascular imaging
  - Infection/inflammation
  - Neoplasm
- IV contrast not useful…
  - Calcium (renal stones)
  - Blood (RP hematoma)
  - Iron/Foreign body
- A specific clinical history aids with scan protocolling

141

MRI: PROS AND CONS

- Pros
  - No radiation
  - Highly diagnostic modality
  - Excellent soft tissue contrast
  - Histologic information: fat, water, iron, fibrosis
  - Functional information: perfusion, peristalsis, cardiac output
  - Improvements
    - Decreasing scan times
    - Emergency medicine
    - New sequences

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MRI: PROS AND CONS

- Limitations: Patient
  - Enclosed space for up to one hour?
  - Lying on their back
  - Loud noises
- Limitations: Radiologist and system
  - Subspecialized reading
  - Longer scan times
  - Limited availability/varying magnets
- Solutions
  - Stereovision
  - Gentle use of anxiolytics
  - More MR trained radiologist/subspecialized reads

143

MRI: CATEGORIES AND CONTRAST AGENTS

- Multiple types of MRI
  - Neurologic: Brain, neck and spine
  - Abdominopelvic
  - Musculoskeletal
  - Vascular imaging
  - Cardiac imaging
  - And more!
- Pelvic MRI: Be specific!
  - Prostate MRI?
  - Rectal MRI?
  - MSK MRI?

144

MRI: CATEGORIES AND CONTRAST AGENTS

- Multiple types of MRI
  - Neurologic: Brain, neck and spine
  - Abdominopelvic
  - Musculoskeletal
  - Vascular imaging
  - Cardiac imaging
  - And more!
- Pelvic MRI: Be specific!
  - Prostate MRI?
  - Rectal MRI?
  - MSK MRI?

All three are ordered as a pelvic MRI

145

MRI: CATEGORIES AND CONTRAST AGENTS

- Multiple types of MRI
  - Neurologic: Brain, neck and spine
  - Abdominopelvic
  - Musculoskeletal: Bones, joints, soft tissues, spine
  - Vascular imaging
  - Cardiac imaging
  - And more!
- Every MRI order is reviewed by a radiologist to protocol appropriately
  - Rigorously protocolled
  - Tailored to the patient and clinical question

146

MRI CONTRAST AGENTS: NEPHROGENIC SYSTEMIC FIBROSIS

- "Fibrosing disease, predominantly of the skin and subcutaneous tissue, but also other organs, which may develop and progress rapidly, possibly causing death"
- Occurs with ESRD in association with gadolinium based IV contrast materials
  - *Amount of gadolinium* given (per scan and accumulated dose)
  - eGFR <30 have a 1-7% chance of developing NSF with group 1 GBCA agents
- Has developed in patients with AKI even if renal function returned to normal
- **Declining** incidence with use of macrocyclic contrast agents

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MRI CONTRAST AGENTS: NSF

- Screening requirements: require BUN/Creatinine within 30 days of exam[1]
  - Age >60 years
  - Hypertension
  - Renal disease

148

MRI CONTRAST AGENTS: NSF

- When can we give contrast?
  - GFR >30:
    - No problem!
  - ESRD (GFR <30), not on HD
    - Must be a group II GBCA (at UNC, we use Dotarem)
  - ESRD, on HD
    - Risk of NSF is low
    - Must be a group II GBCA and plan the MRI before regularly scheduled dialysis to help the clearance of the GBCA
    - Risk/benefit

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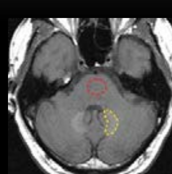
GADOLINIUM DEPOSITIONAL DISORDER

- High signal in brain tissue in patients with normal renal function
  - Associated w repeated doses of gadolinium
  - No known adverse effects
- Certain contrast agents not associated with this
  - Dotarem (used at UNC)
  - Prohance
- However, as led to a more cautious use of gadolinium contrast agents



Deposition
- Dentate nucleus
- Globus pallidus

Semelka R et al. Gadolinium in Humans: A Family of Disorders. AJR 207, August 2016 229-233

150

MRI CONTRAST AGENTS: PREGNANCY AND BREASTFEEDING

- Pregnancy:
  - "Present data has not conclusively document any deleterious effects of MR imaging on the developing fetus"[1]
  - Avoid in first trimester (not evidence based)
  - IV contrast DOES cross the placenta and is not given at our institution in pregnancy
- Breastfeeding:
  - > 0.04% of the IV dose in breast milk [2]
  - > 1% of the contrast in breast milk is absorbed across the GI tract[2]
  - Expected dose to infant <0.0004% of IV dose[2]
  - If the mother is concerned, she may abstain from breastfeeding for 12-24 hours

1. Kanal et al. ACR Guidance Document on MR Safe Practices: 2013. JMRI 37: 501-530 (2013)
2. ACR Manual on Contrast Media. 2022

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MR- BODY IMAGING

- Please keep in mind that this is primarily a *problem solving* modality
- The more specific the clinical history, the better the exam will be!
- Common indications
  - *Because the radiologist told you needed one*
  - Characterization of a lesion
  - Evaluation of the biliary tree
  - Follow up of treated disease
  - GU: Female pelvis, prostate (NOT CT!)
  - Imaging the bowel (small bowel, rectum)
- Emerging indications
  - Tissue composition (iron, fat, fibrosis)

152

MRI: LESION CHARACTERIZATION

Indeterminate hepatic lesion

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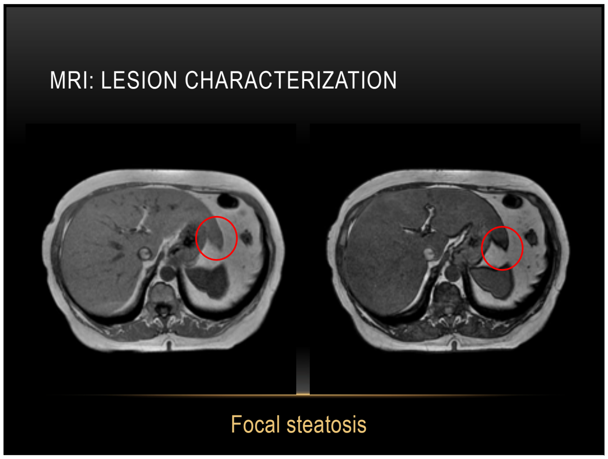
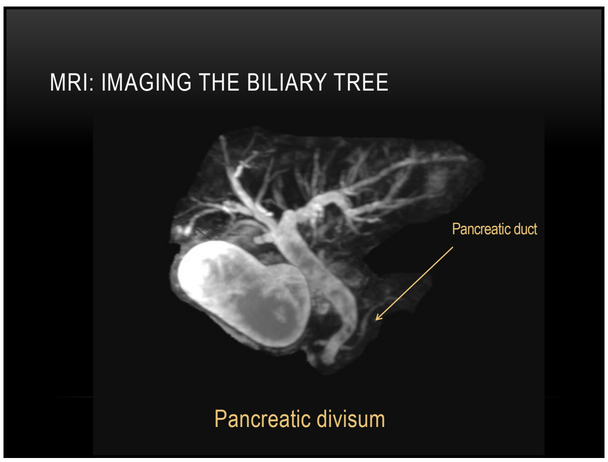
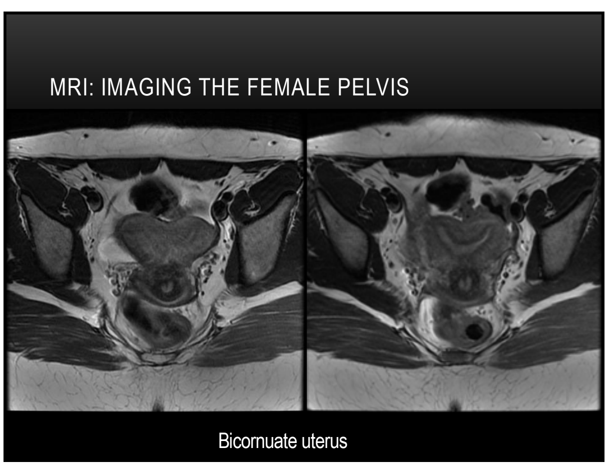

MRI: LESION CHARACTERIZATION
Focal steatosis

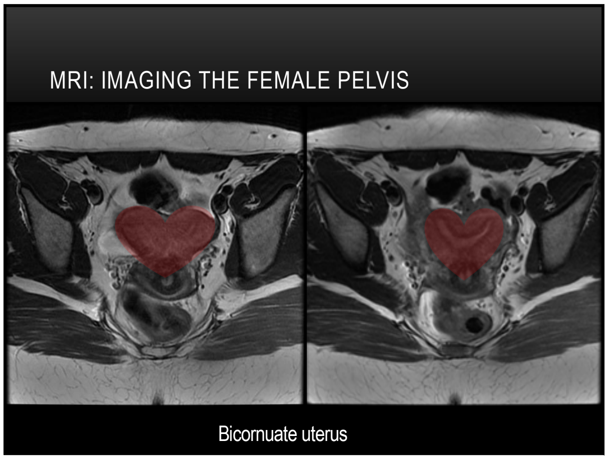
154


MRI: IMAGING THE BILIARY TREE
Pancreatic duct
Pancreatic divisum

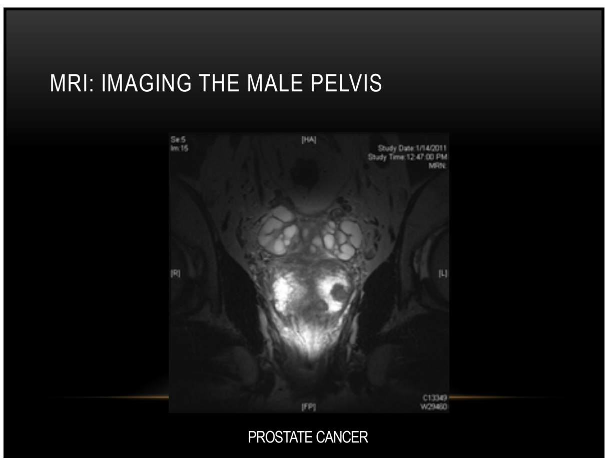
155


MRI: IMAGING THE FEMALE PELVIS
Bicornuate uterus

156


MRI: IMAGING THE FEMALE PELVIS
Bicornuate uterus

157


MRI: IMAGING THE MALE PELVIS
PROSTATE CANCER

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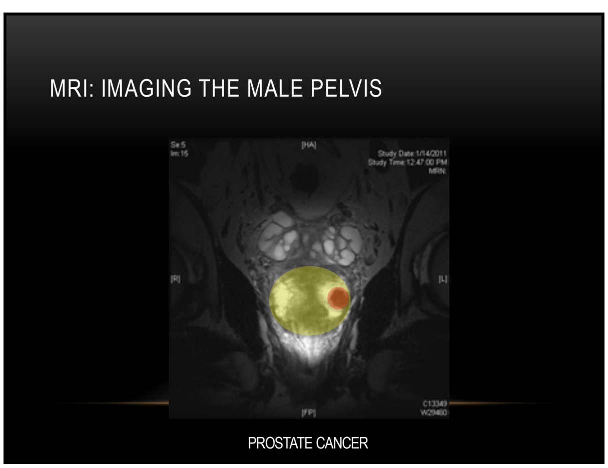
MRI: IMAGING THE MALE PELVIS
PROSTATE CANCER

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MRI IMAGING: TISSUE COMPOSITION

- Liver
  - Fat content
  - Iron content
  - Fibrosis
- Bowel
  - MR enterography
  - Rectal MR
- MRI is a rapidly expanding and changing field. If you want to know if we can do it- *just ask!!!*

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YOUR RADIOLOGIST

- Clinician feedback
  - Reports
    - Relevant? Unclear?
  - Imaging problems
    - Patient complaints?
    - Didn't give you an answer
  - Pathology and/or clinical follow up
    - Were we right or wrong?
- You are our target population with our imaging and reports- let us know how we can improve and make your life easier!

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TAKE HOME POINTS

- Overutilization is a real but solvable problem if a partnership exists between the clinician and radiologist
- There are many different imaging modalities at your disposal with varied resources to help advise you
  - ACR appropriateness criteria
  - Radiologist
- Appropriate scan for each patient
  - Appropriate radiation dose
  - Scan limitations
  - Patient limitations
- Clinician feedback is critical for imaging and service improvement.

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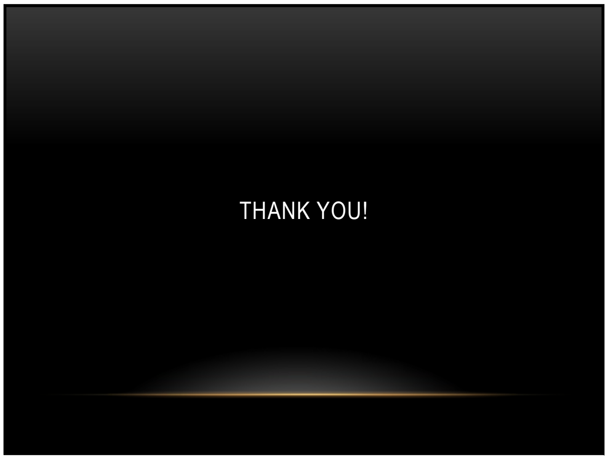

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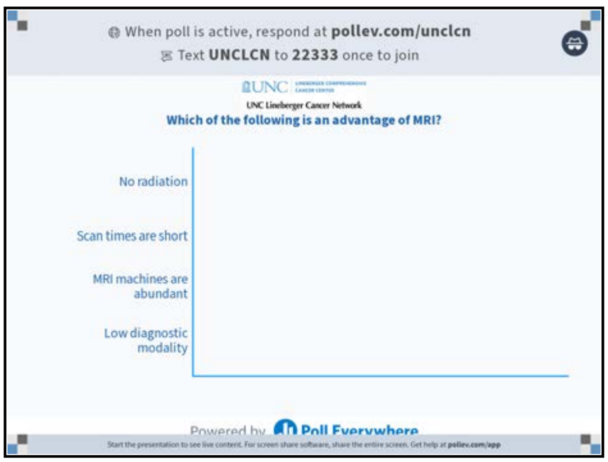

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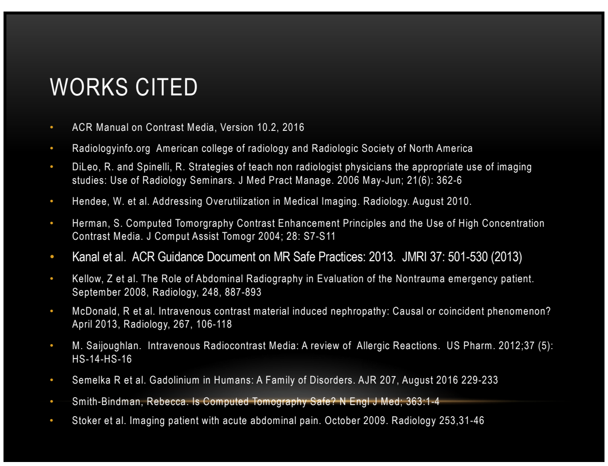

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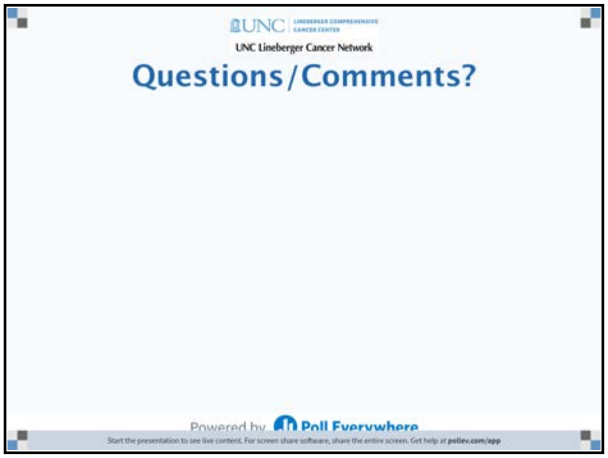
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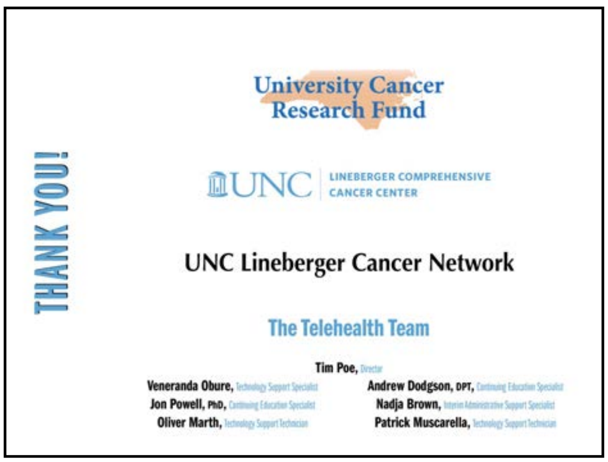
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Live Webinar
October 26
12:00 PM
Cardiovascular Toxicities of Cancer Therapies
Brian Colwell Jensen, MD
PATIENT CENTERED CARE
Live Webinar
November 2
12:00 PM
Providing LGBTQ Friendly Care in Oncology
Patricia Morfeld, RN, BSN, OCN
ADVANCED PRACTICE PROVIDER
Live Webinar
November 9
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Acute Radiation Side Effects
Lara Novak, PA-C
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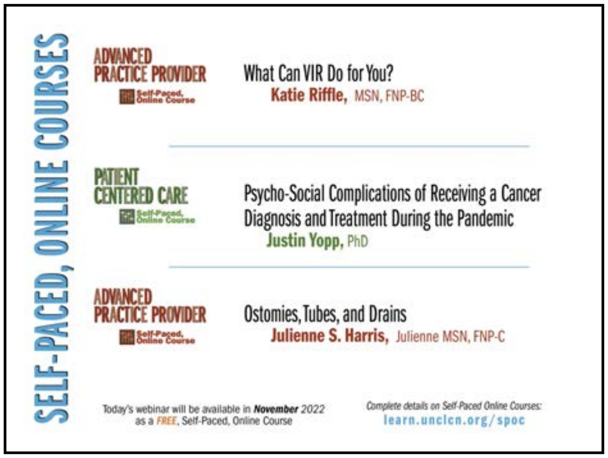
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