Brigham and Women's Hospital
Founding Member, Mass General Brigham

Ultrasound for the Clinical Nephrologist

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- Clinical focus: Ultrasound/Interventional Nephrology
- Research focus: Imaging and Hemodynamics

Brigham and Women's Hospital
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NAMSA – clinical events committee

HARVARD MEDICAL SCHOOL
TEACHING HOSPITAL

Objectives

Highlight the use and interpretation of renal ultrasound while looking at ultrasound images

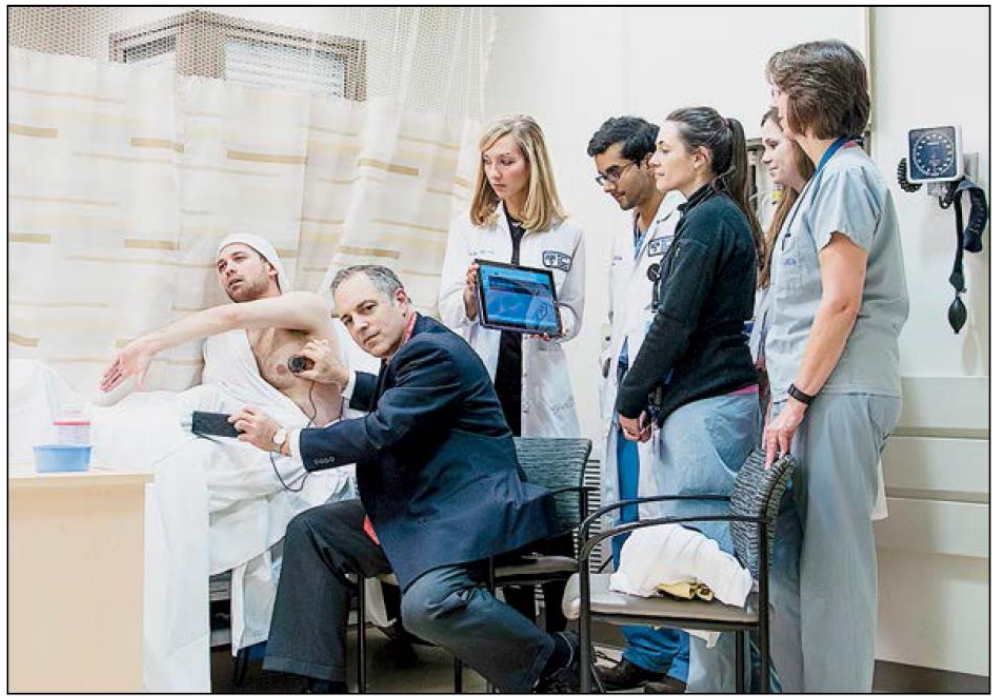
Review strengths and limits of ultrasound and appropriateness of imaging studies in nephrology

Introduce other applications of point of care ultrasound in nephrology

Ultrasound – the extension of your physical exam

Laennec at a Patient's Bedside, by Théobald Chartran, 1816.

"Laënnec à l'hôpital Necker ausculte un phtisique devant ses élèves" ("Laennec examines a consumptive patient with a stethoscope in front of his students at the Necker Hospital," monaural stethoscope in his hand).



The Authors Demonstrating Modern Electronic Auscultation, 2015.

The technology involved is a ThinkLabs One stethoscope, linked to a Jambox speaker and a Microsoft Pro3 tablet with the displayed and annotated phonocardiogram. Photo taken at Brigham and Women's Hospital, Boston.

Case 1

A 24-y o F, sudden onset of swelling and discomfort in her legs

BP136/89, HR 88, 97.5, 115 lbs (prior 100 lbs), edema

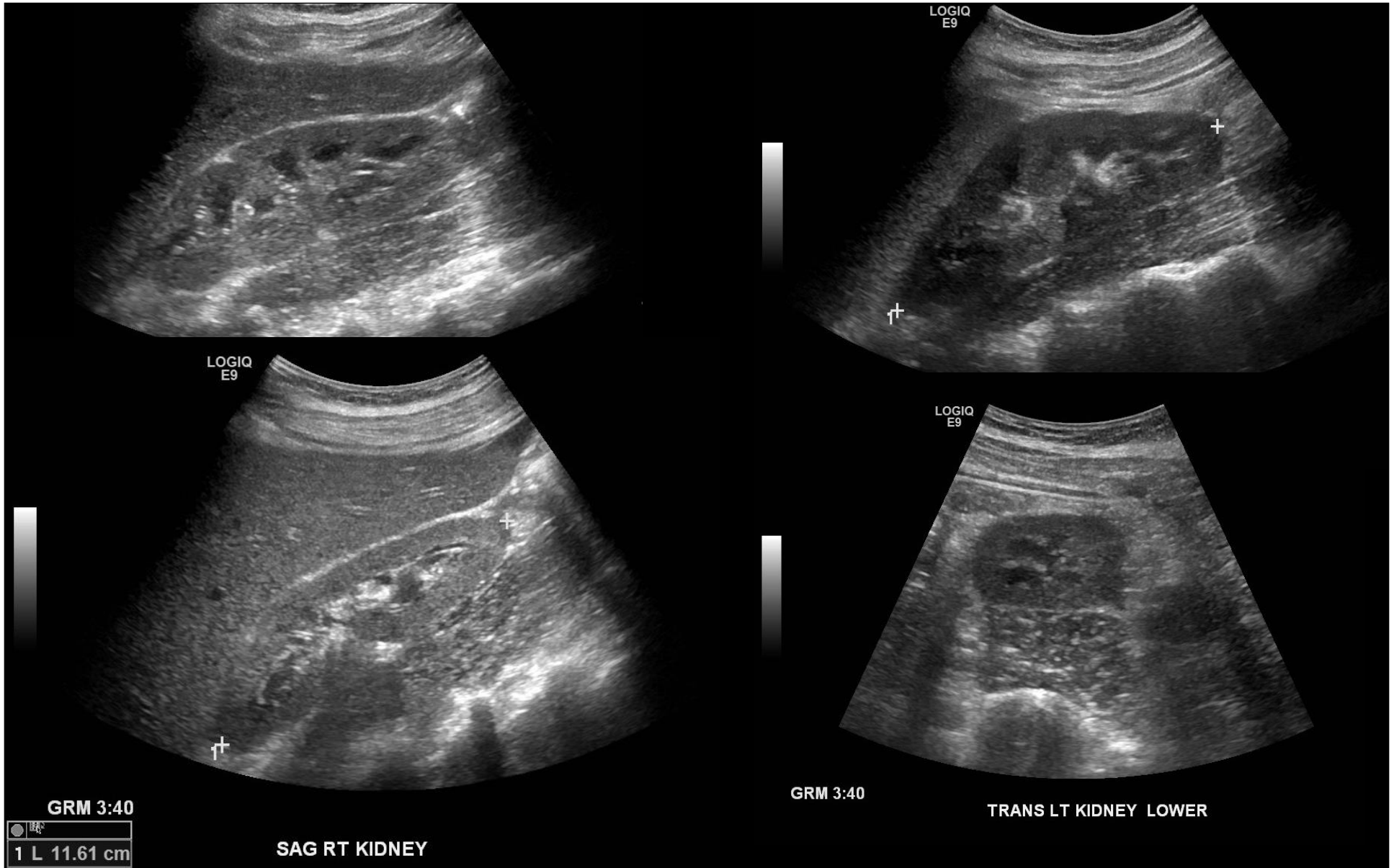
NA 130 mmol/l, K 5.1 mmol/l, Creat. 3.6mg/dl, BUN 72 mg/dl, bicarb 20 mmol/l

UA: +RBCs, ++WBC, +Protein.

Renal Ultrasound

Right Kidney

Left Kidney

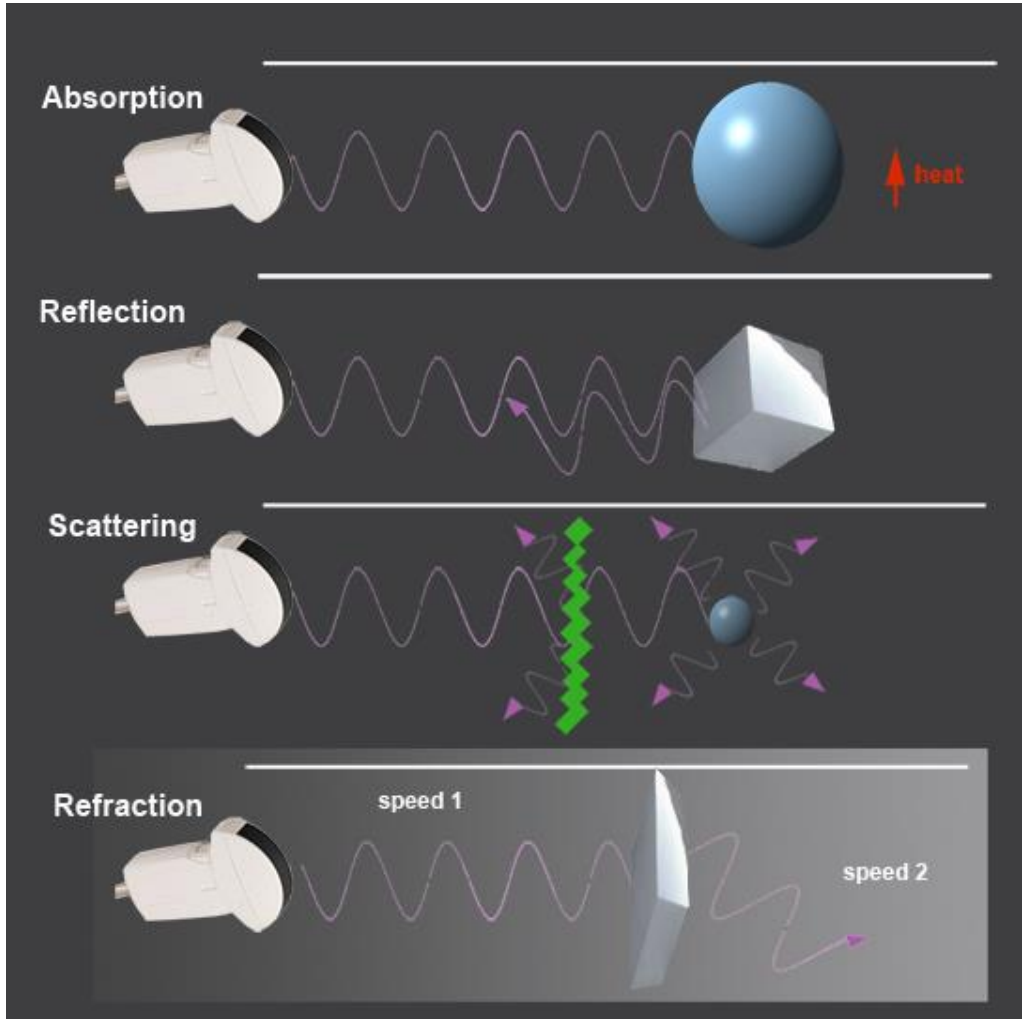


Questions

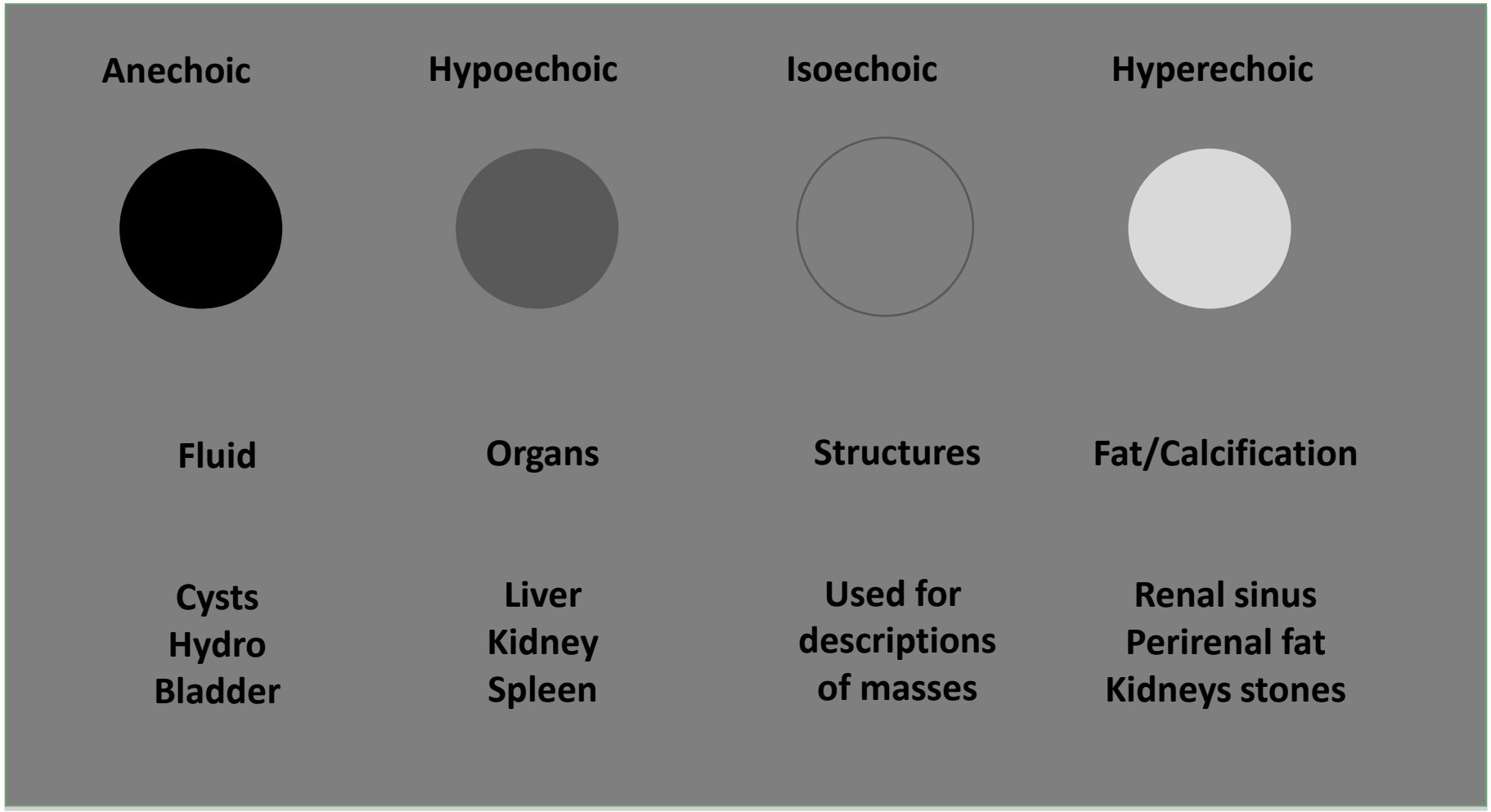
Kidney Ultrasound

a) Normal size kidney, no right hydronephrosis
b) Normal size kidney with right hydronephrosis
c) Normal size kidneys with cysts on the right
d) Small kidneys without hydronephrosis
e) Small kidneys with right hydronephrosis

Basics of Ultrasound

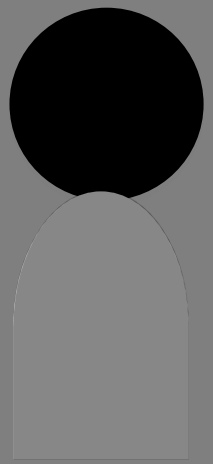


Basics of Ultrasound



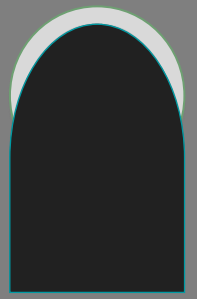
Basics of Ultrasound

Dorsal enhancement



Cysts
Bladder

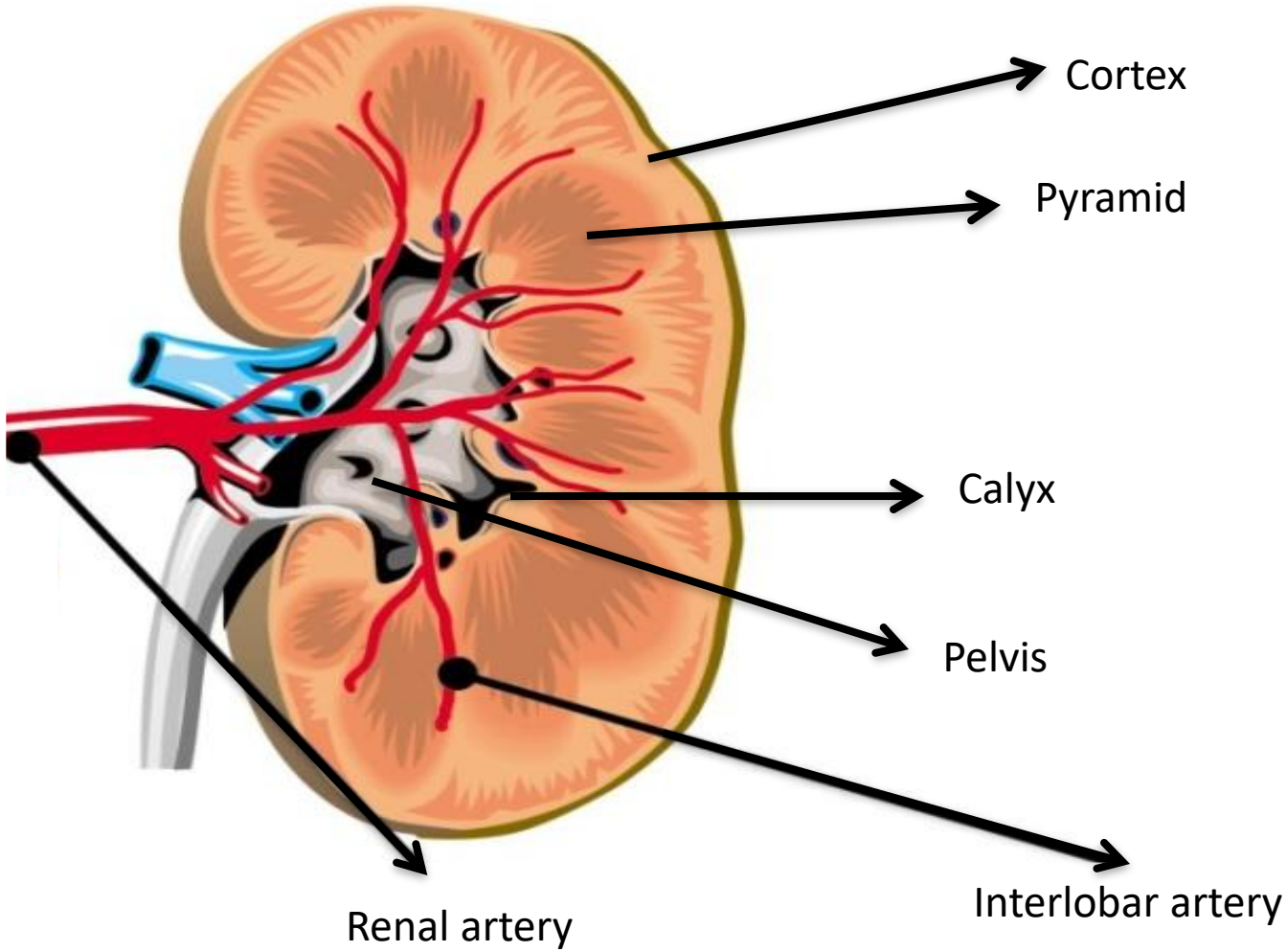
Shadowing
Extinction of signal



Stone
Bone

Nephrolithiasis

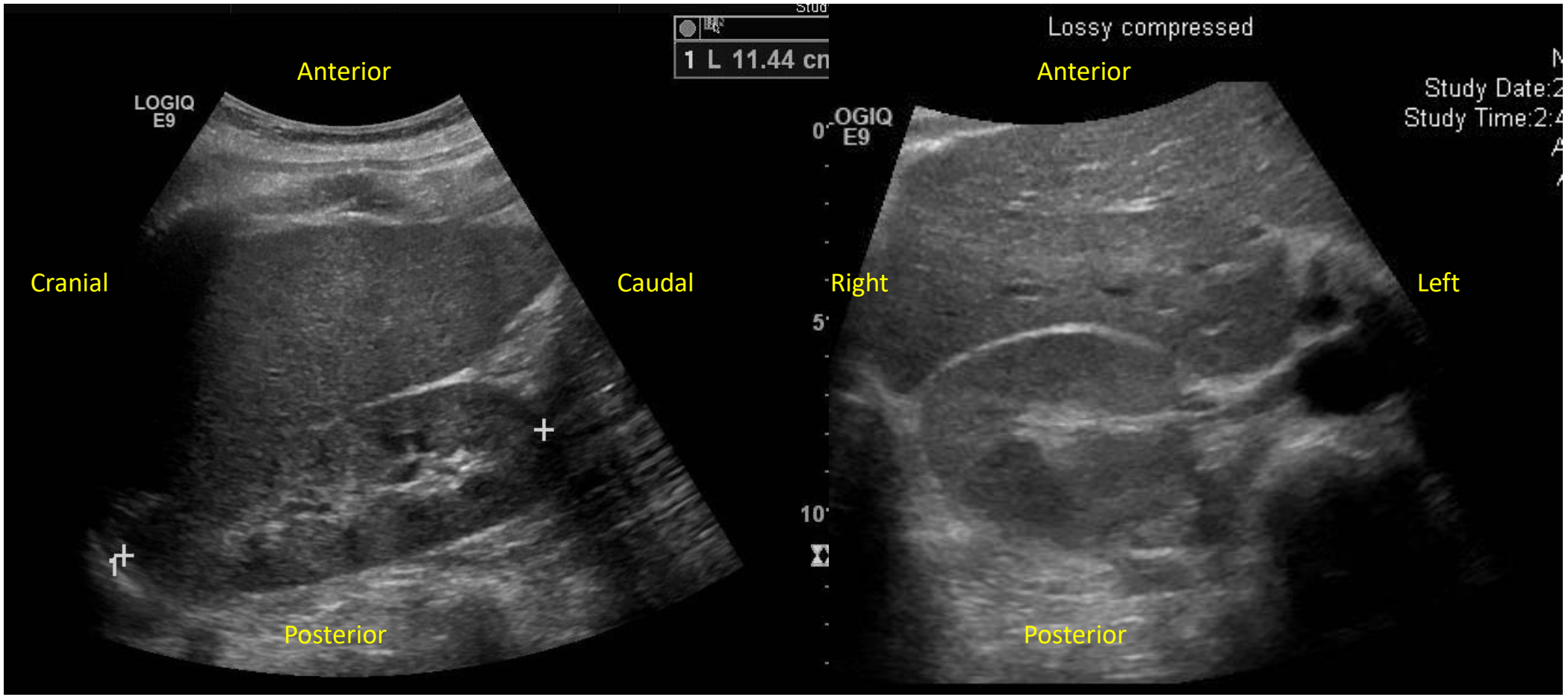
Anatomy


Cortex
Pyramid
Calyx
Pelvis
Renal artery
Interlobar artery

Kidney Ultrasound

Longitudinal

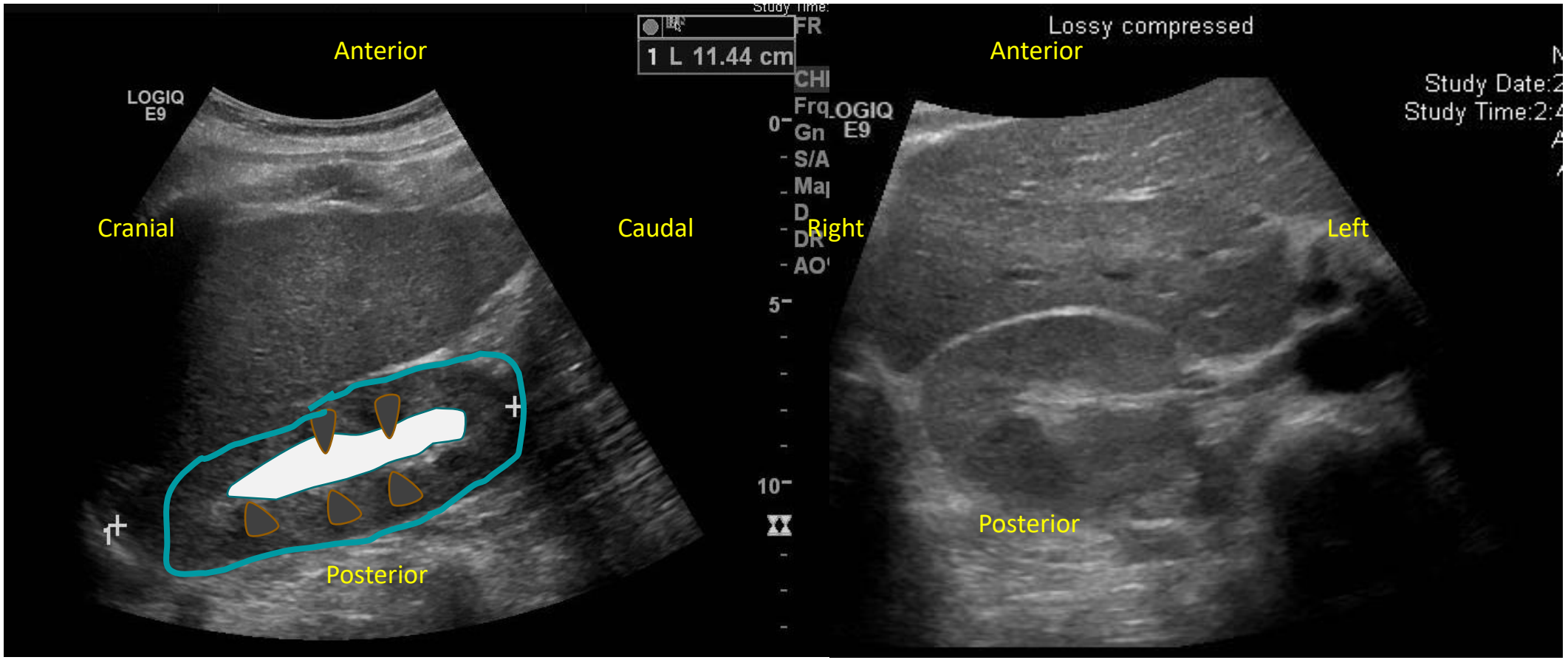
Transversal



Kidney Ultrasound

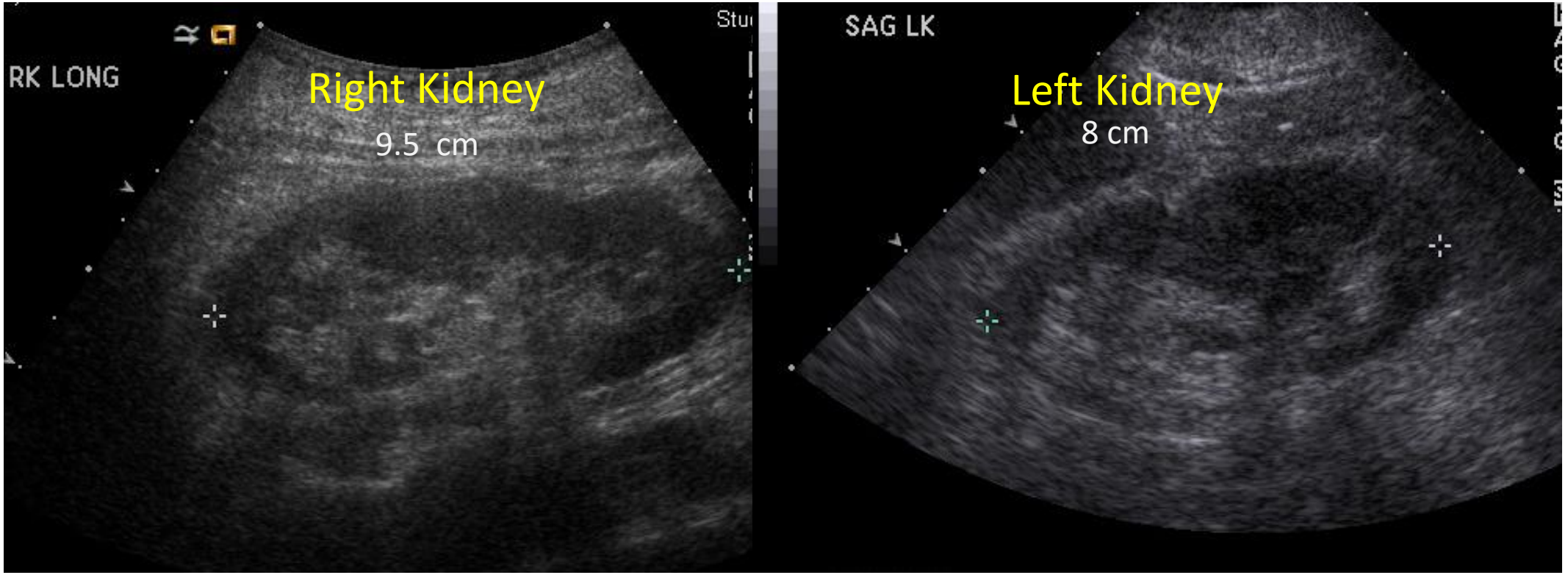
Longitudinal

Transversal



Size – normal 10-12 cm

Difference of > 1cm indicates scarring
vascular, postpyelonephritic or postobstruction



Size does not necessarily tell you anything about function

Size – Large > 12 cm

Diabetes

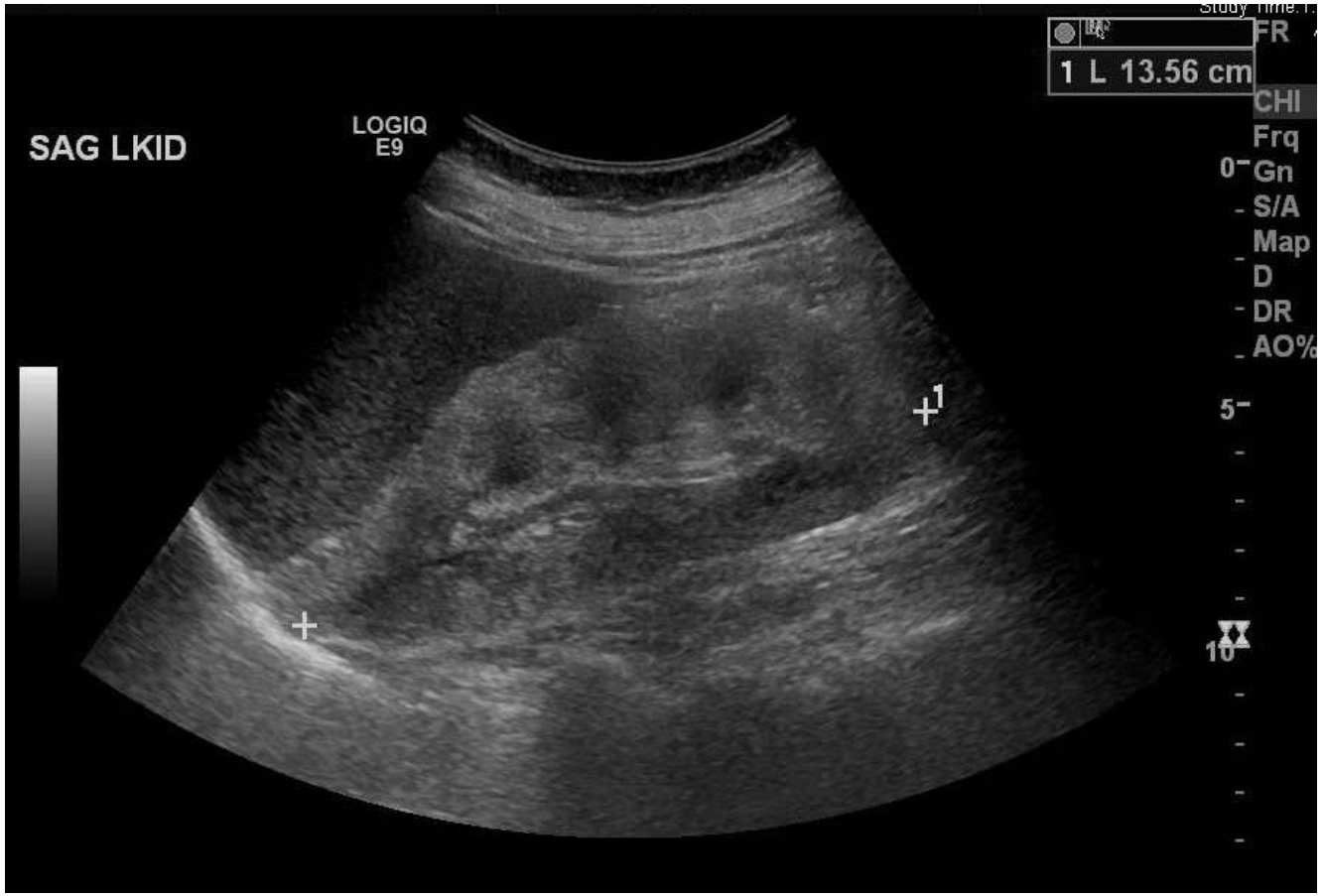
Preeclampsia

Acute parenchymal disorder (acute GN, AIN, RV thrombosis)

Infiltrative disease (MM, amyloidosis, lymphoma)

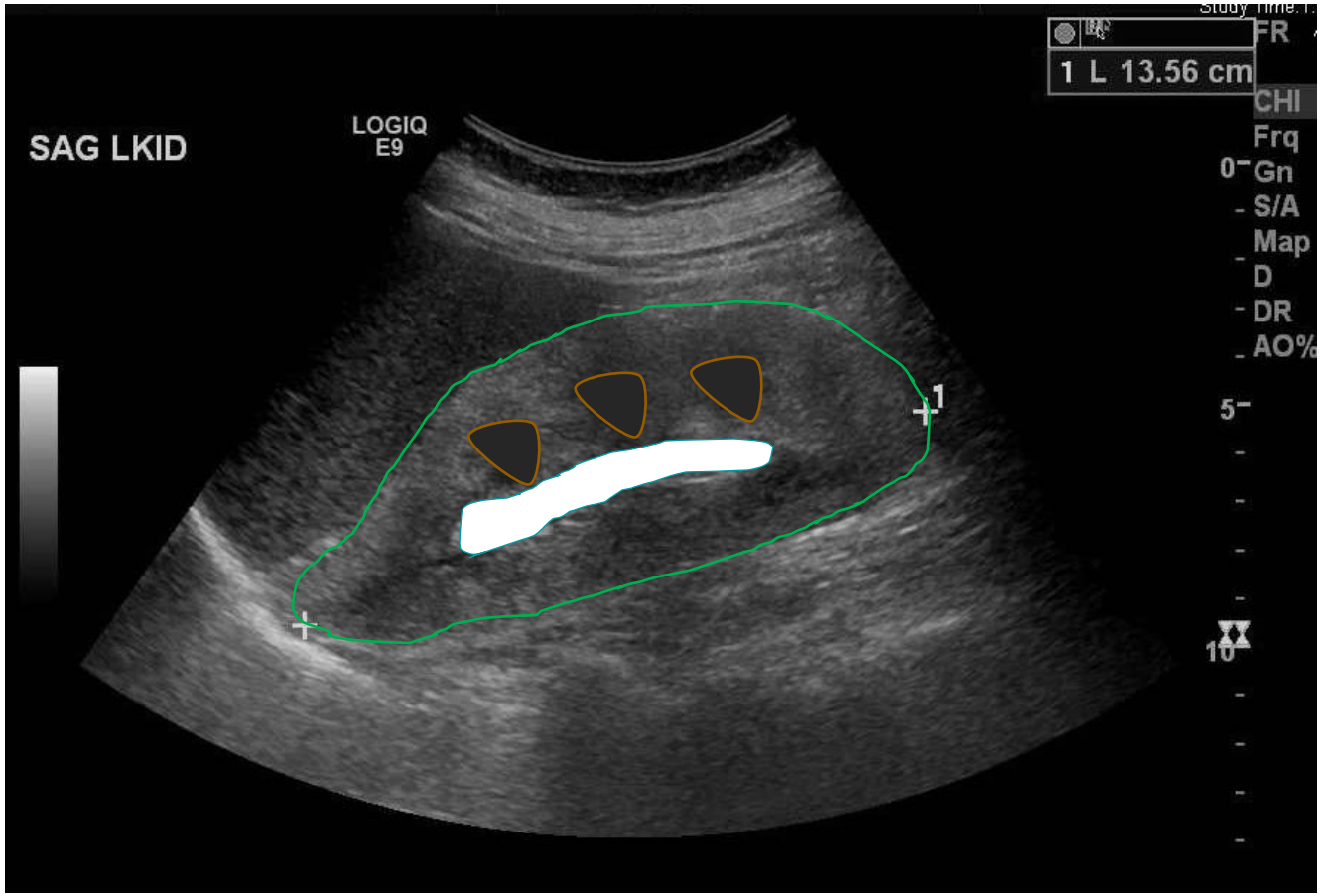
Echogenicity

Increased echogenicity of the cortex - medical disease



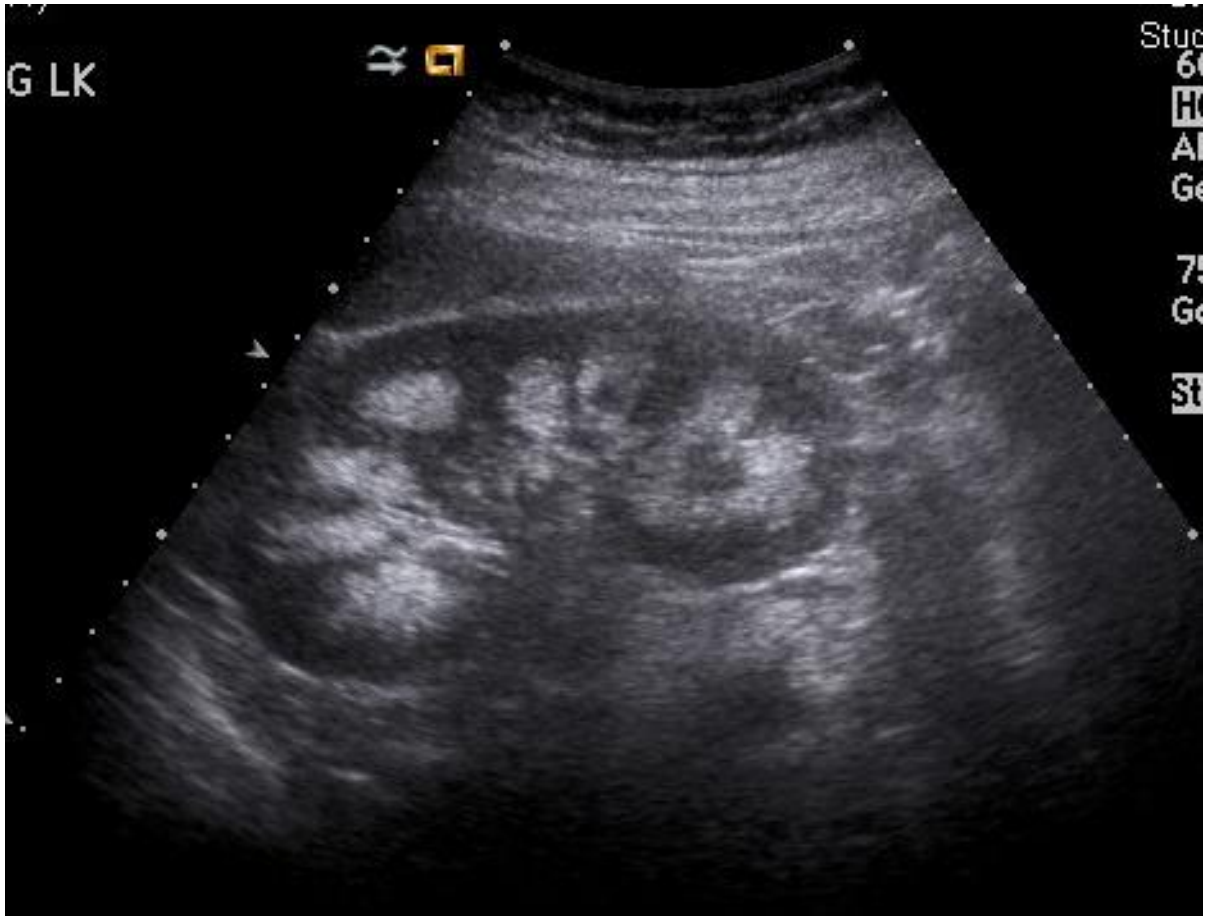
Echogenicity

Increased echogenicity of the cortex - medical disease



Echogenicity

Increased echogenicity of the pyramids – medullary nephrocalcinosis



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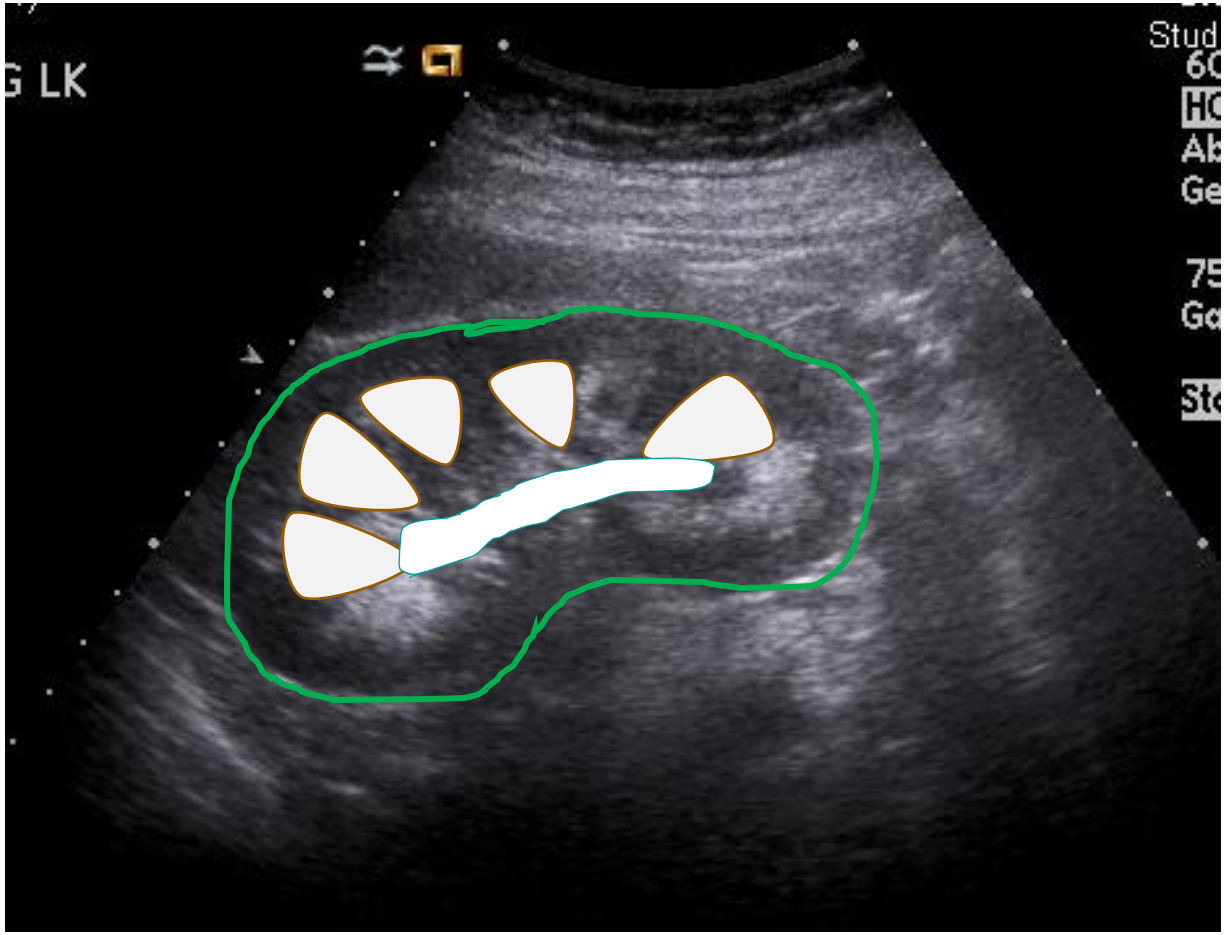
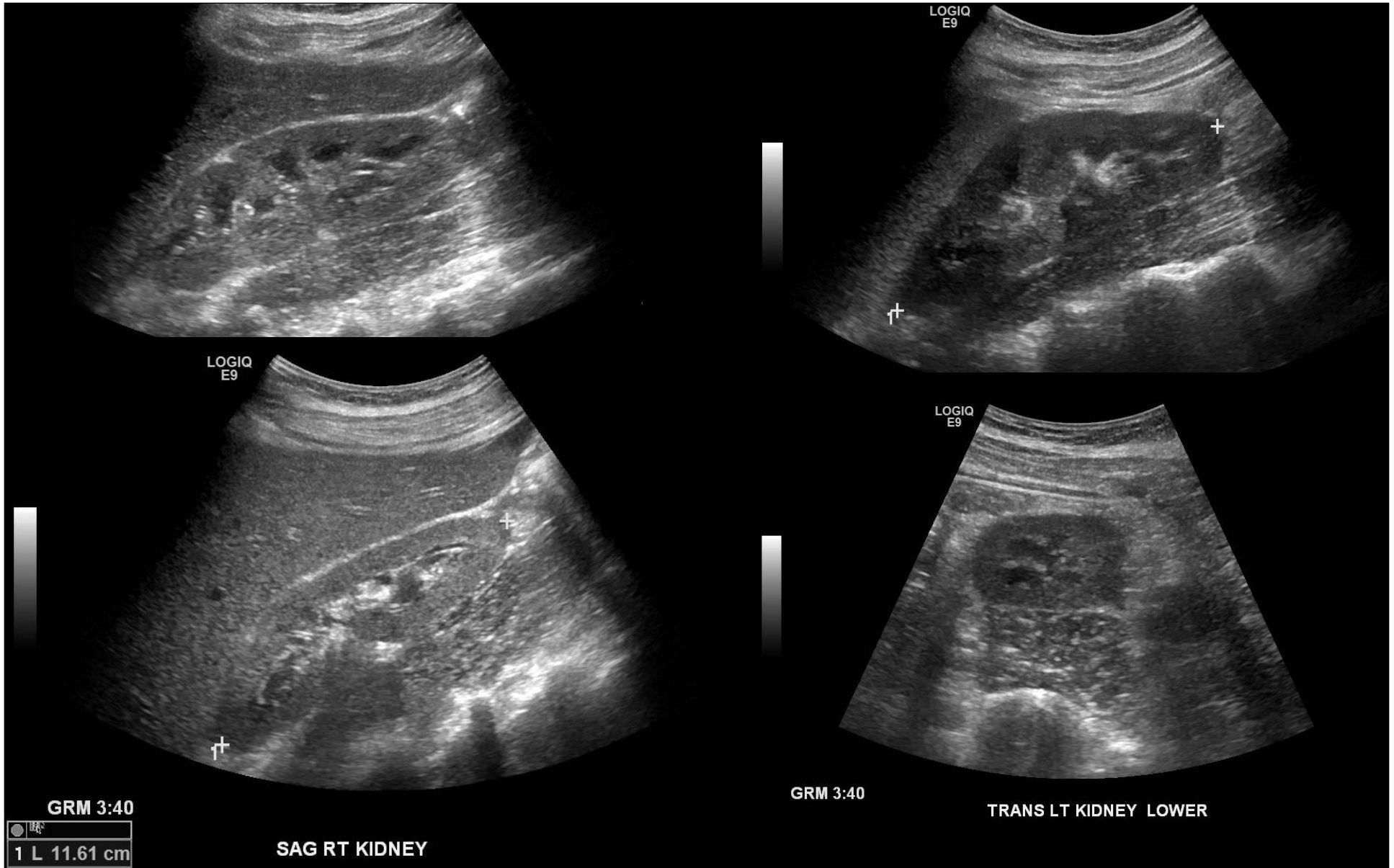


Renal Ultrasound

Right Kidney

Left Kidney



Case 2

57-y-o man with 5 days of flank pain. Worst pain ever, N/V

125/49, HR 108, 99.5, in distress, abdomen distended, tender R

Creatinine 2.3 mg/dl, BUN 57 mg/dl, K 3.8,

UA: ++RBC, +WBC,

Question

Most appropriate imaging?

a) CT – angiogram with contrast

b) CT-urogram with contrast

c) Renal ultrasound and a KUB

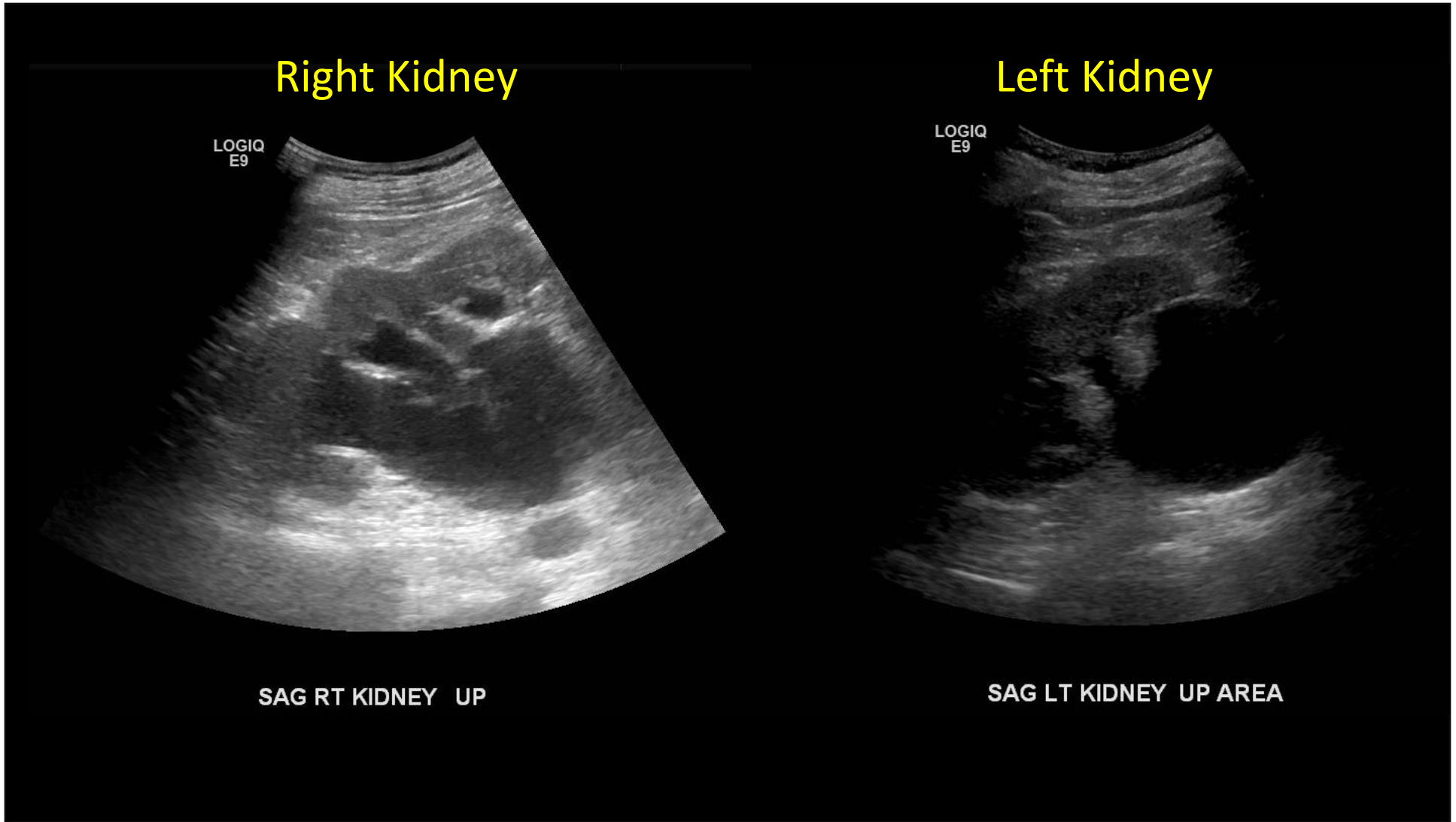
d) Renal ultrasound with Color/Doppler

e) Nuclear scan with Furosemid

ACR Appropriateness Criteria

AKI	Ultrasound +/- Doppler
CKD	Ultrasound +/- Doppler
Renal TX dysfunction	Ultrasound +/- Doppler
Recurring stone disease	Ultrasound
	CT non contrast
Hematuria	CT with and without contrast
	Ultrasound in patients with parenchymal disease
Flankpain	CT without and with contrast
	US of kidneys, bladder and retroperitoneum + KUB
	CT without contrast
Renal Mass	CT without and with contrast or MRI with contrast
	Ultrasound of kidneys with Doppler
Renal artery stenosis	MRA with contrast
	Ultrasound kidney and Doppler or non-contrast MRA

Case 2


Right Kidney
LOGIQ
E9
SAG RT KIDNEY UP
Left Kidney
LOGIQ
E9
SAG LT KIDNEY UP AREA

Case 2

What do the images show?

a) Normal kidneys bilaterally

b) Normal R kidney and cyst on the left

c) Normal L kidney and hydronephrosis on the right

d) Hydronephrosis bilaterally

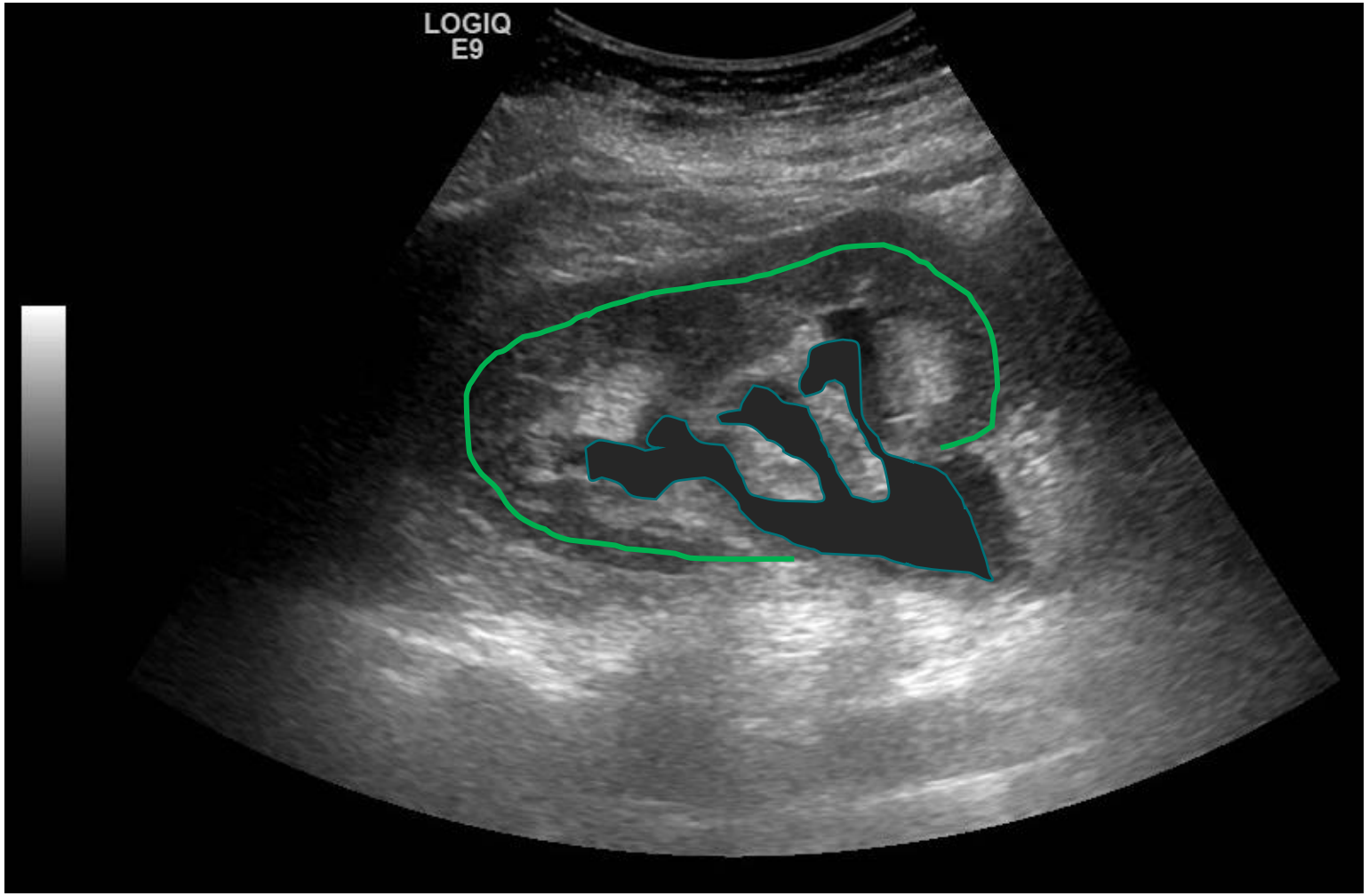
e) Hydronephrosis on the right and cyst on the left

Hydronephrosis

Mild

Hydronephrosis

Mild

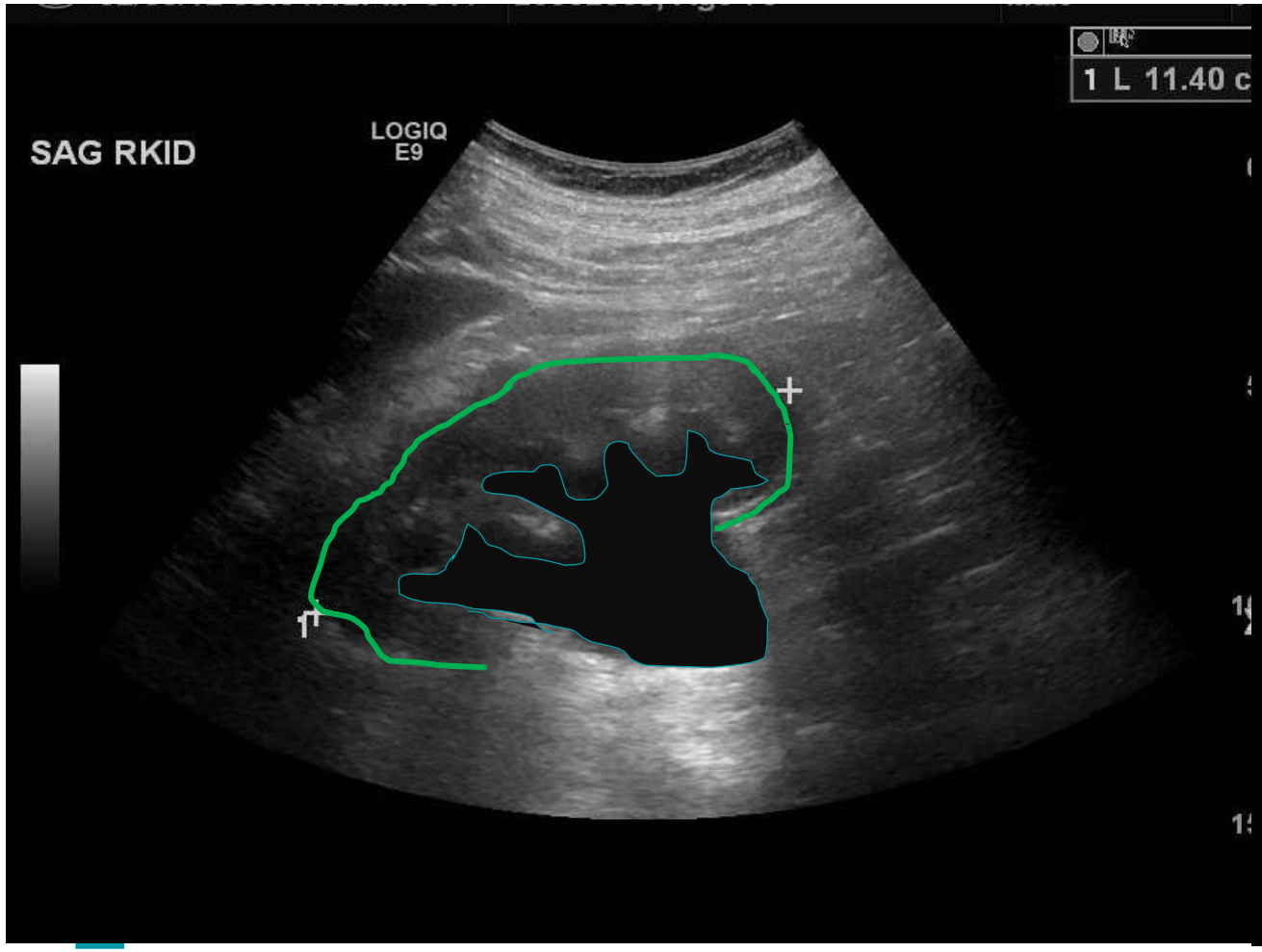


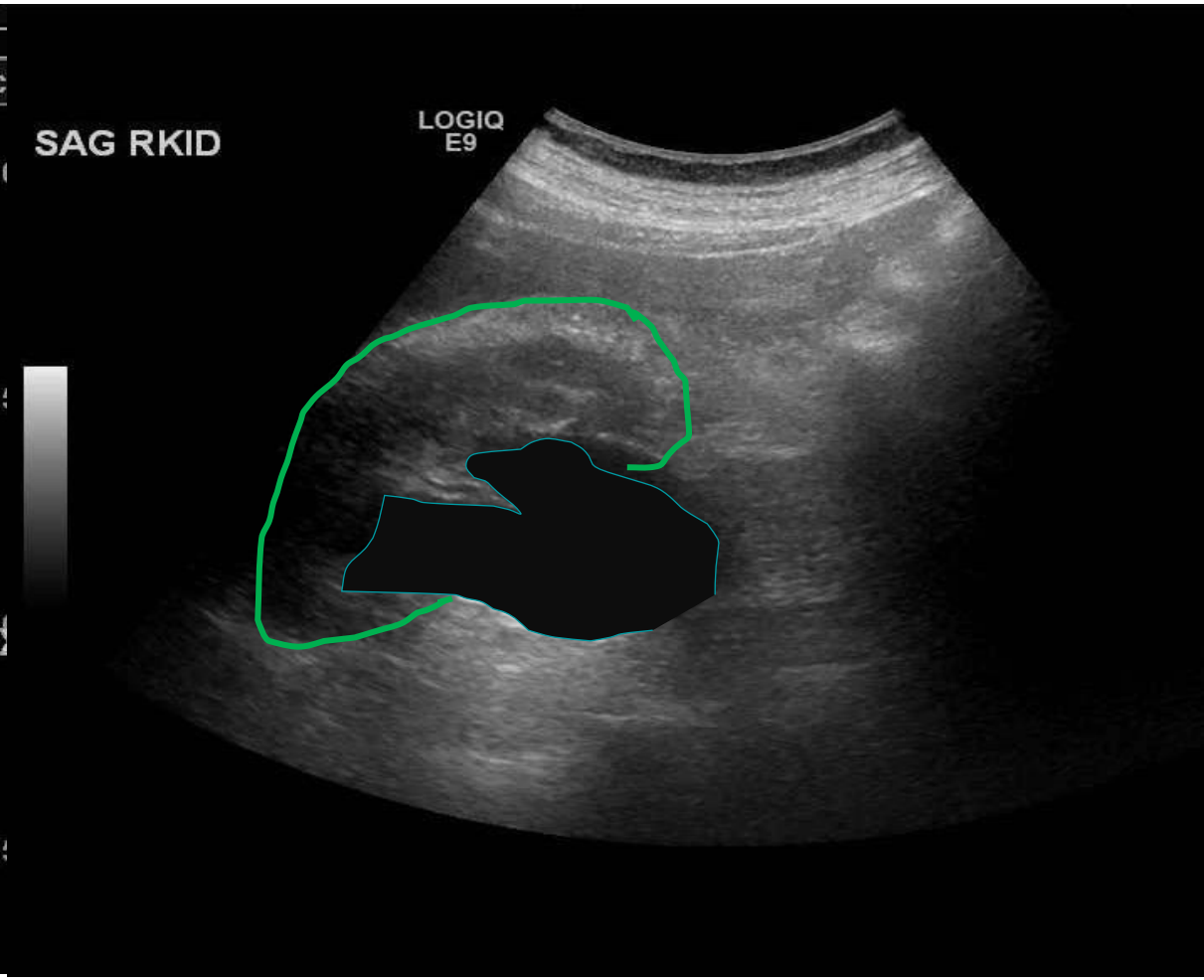
Hydronephrosis

Moderate

Hydronephrosis

Moderate

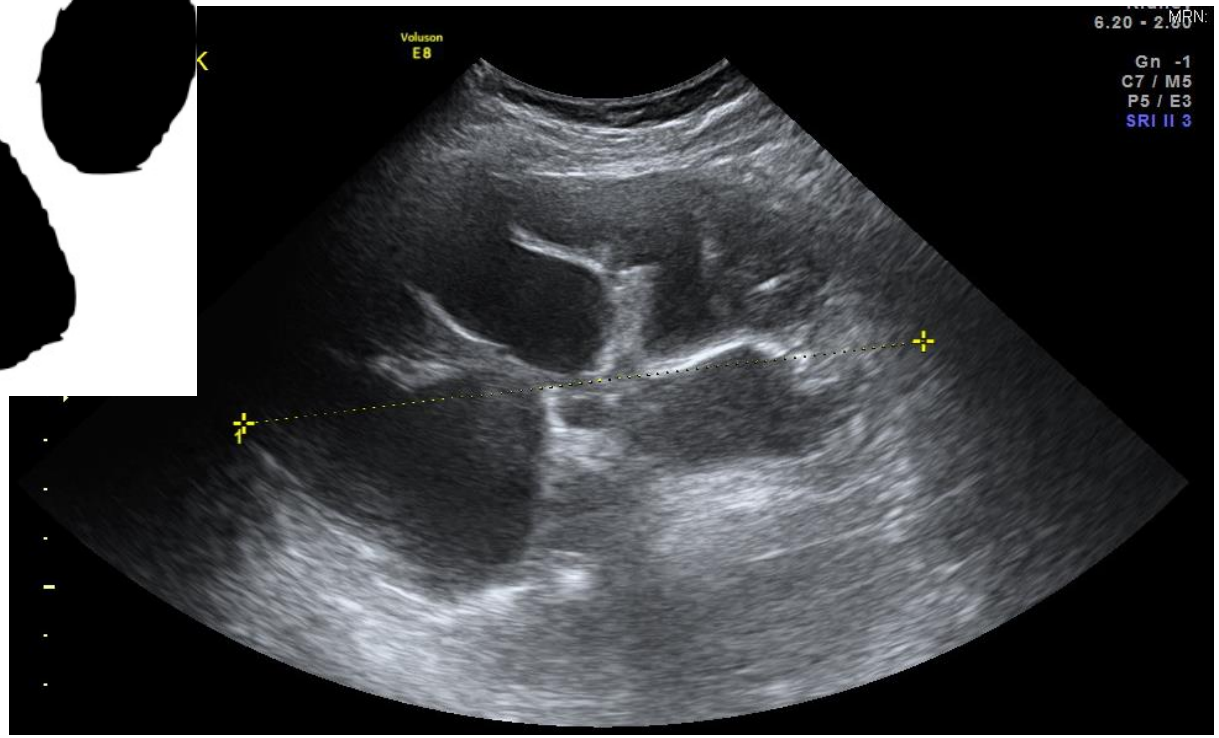




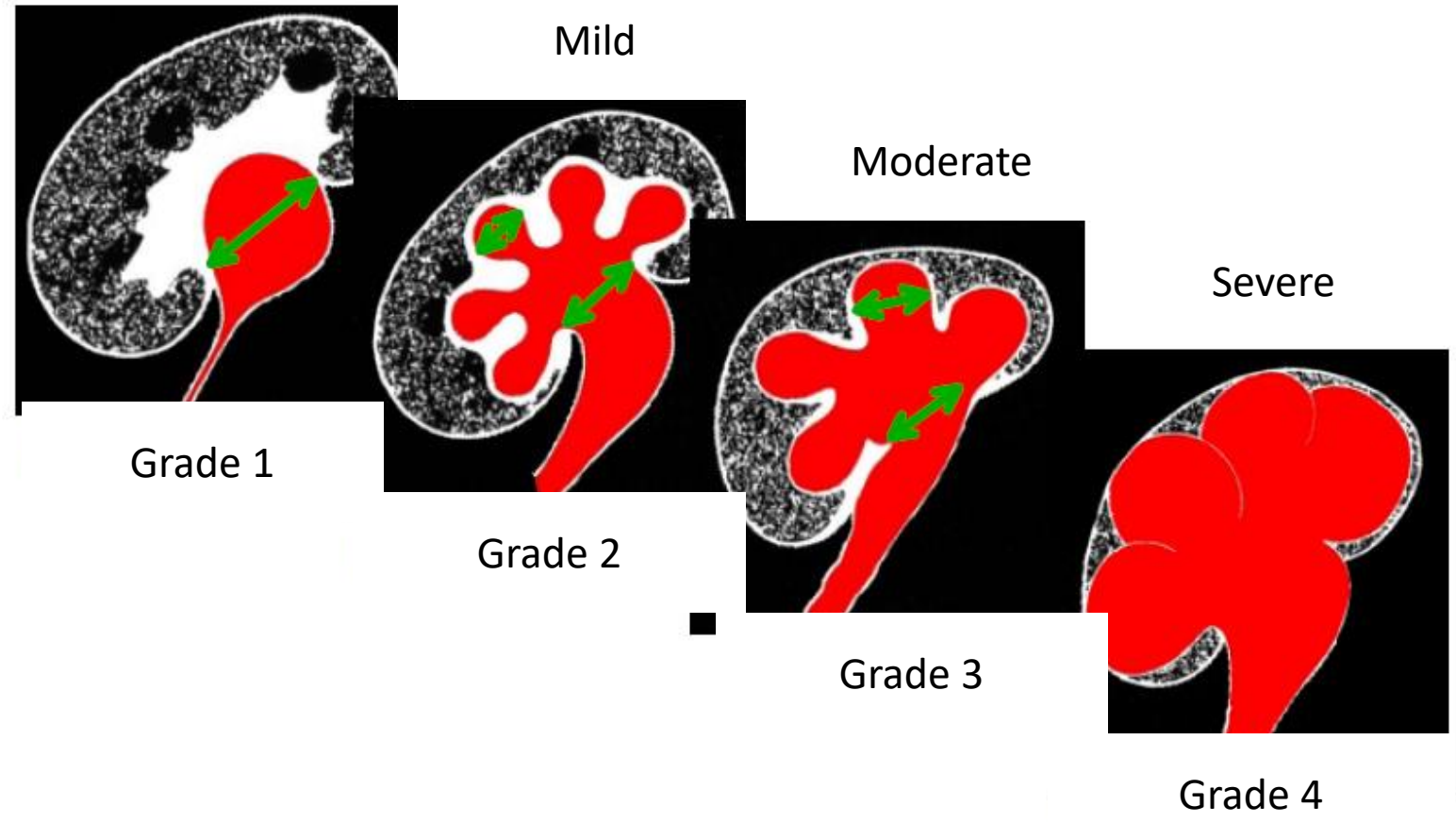
Hydronephrosis

BEAR-PAW

Severe



Hydronephrosis



Hydronephrosis - Pittfalls

False negative findings – obstruction without seeing hydronephrosis

- Retroperitoneal fibrosis
- Retroperitoneal tumors
- Prerenal states/volume depletions
- Early and sudden obstruction

False positive results – hydronephrosis without obstruction

- Pregnancy
- Vesicoureteral reflux
- After relief of obstruction
- Megacystis-megaureter syndrome
- Full bladder
- UTI
- Brisk diuresis as e.g. in nephrogenic diabetes insipidus

Nuclear Scan

Radionuclide Renogram

Tc99 MAG3 or DTPA

Qualitative evaluation of overall renal function and calculation of differential renal function as well as assessment of perfusion

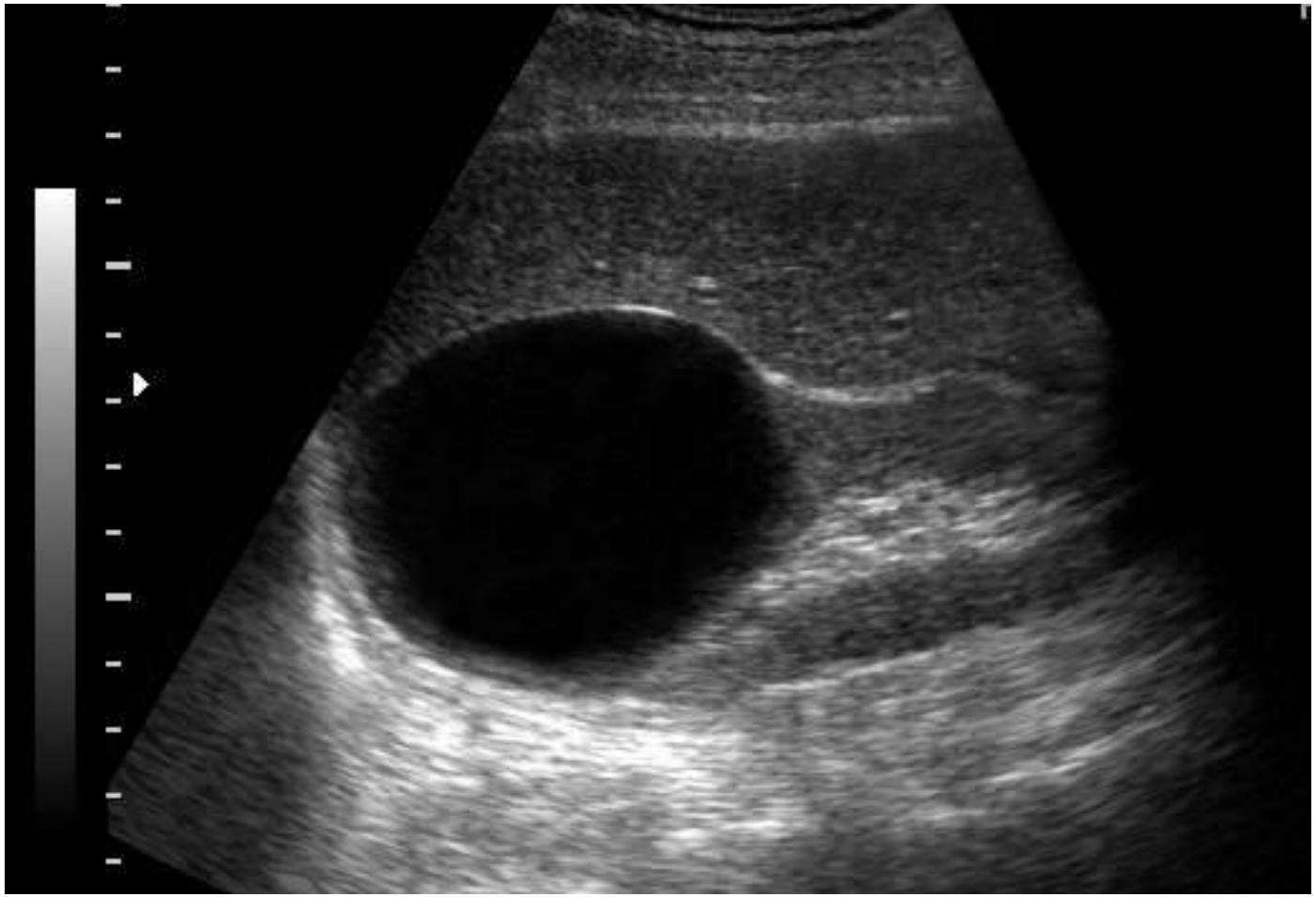
Diuretic Renography

Tc 99 MAG 3 or DTPA + 20-40 mg Furosemide i.v.

Differentiates a dilated but non-obstructed collecting system from dilated system with urodynamically significant obstruction

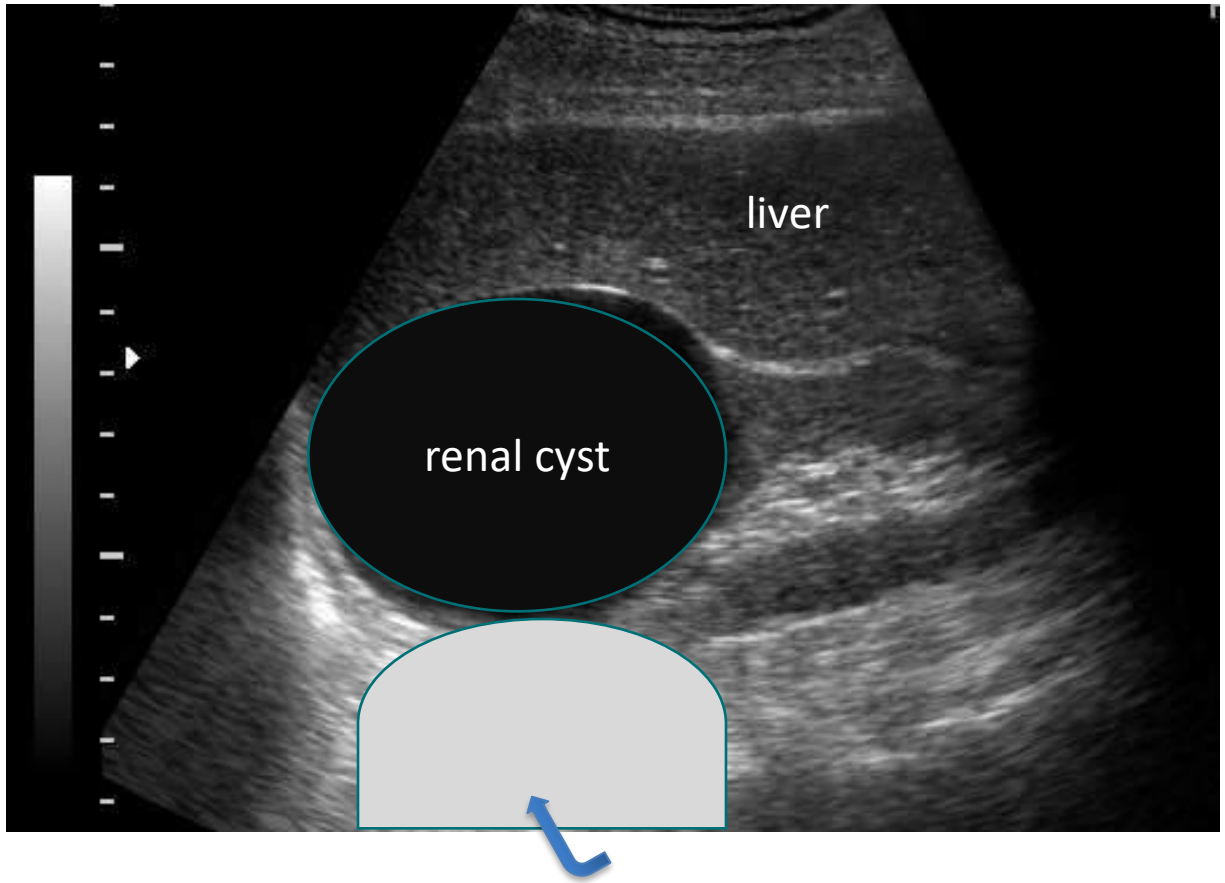
Cysts

Completely anechoic round structure- Simple cyst



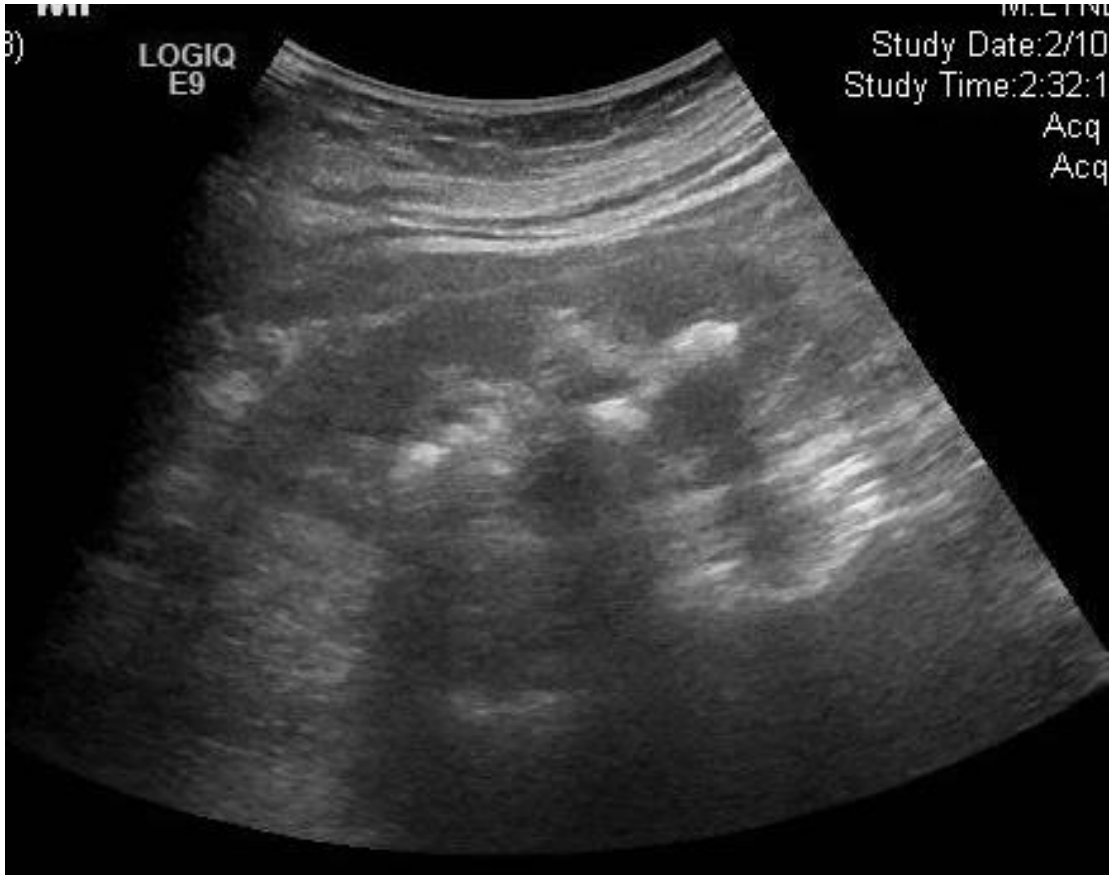
Cysts

Simple Cyst – completely anechoic round structure



Nephrolithiasis

Kidney with hyperechoic areas with acoustic shadowing



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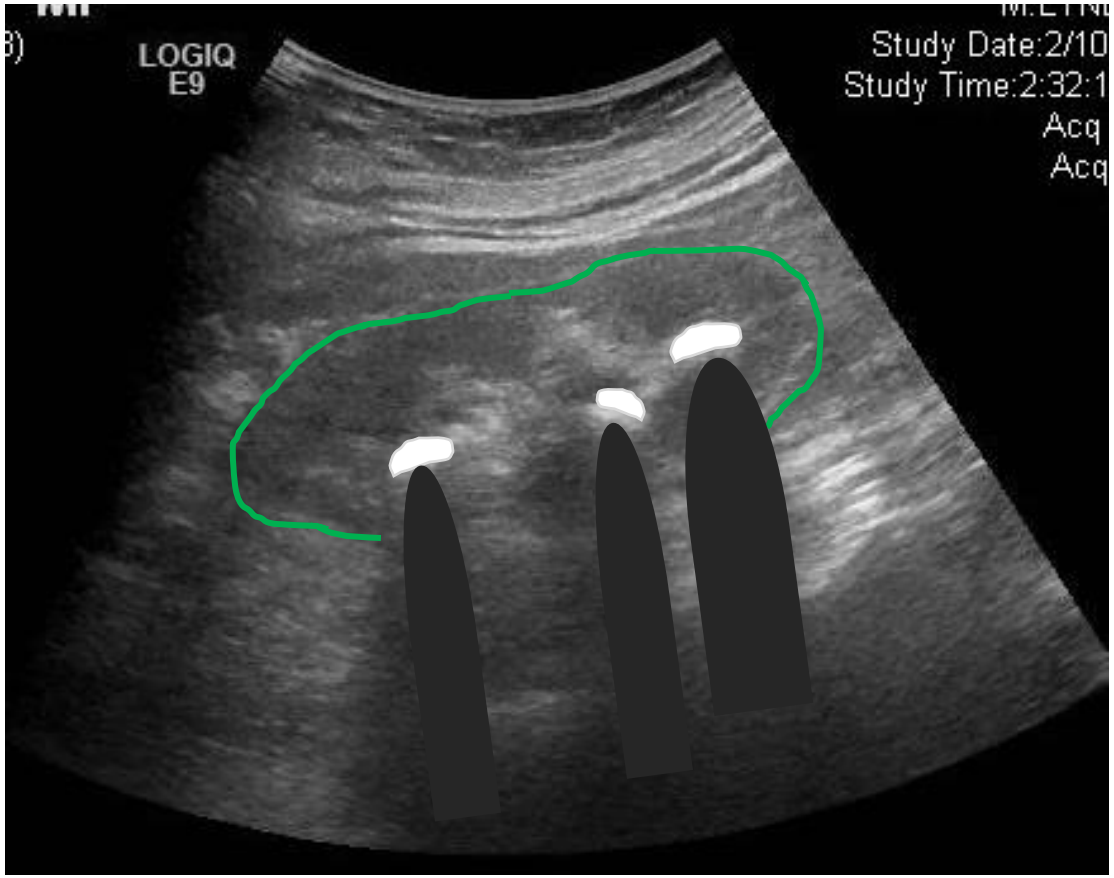
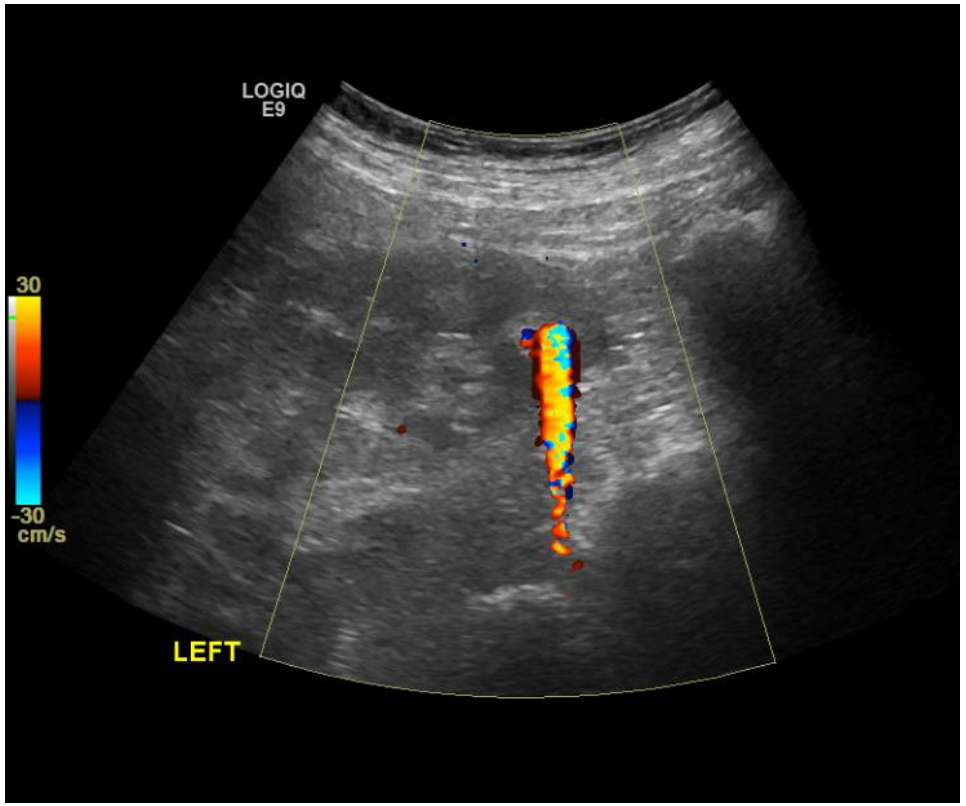
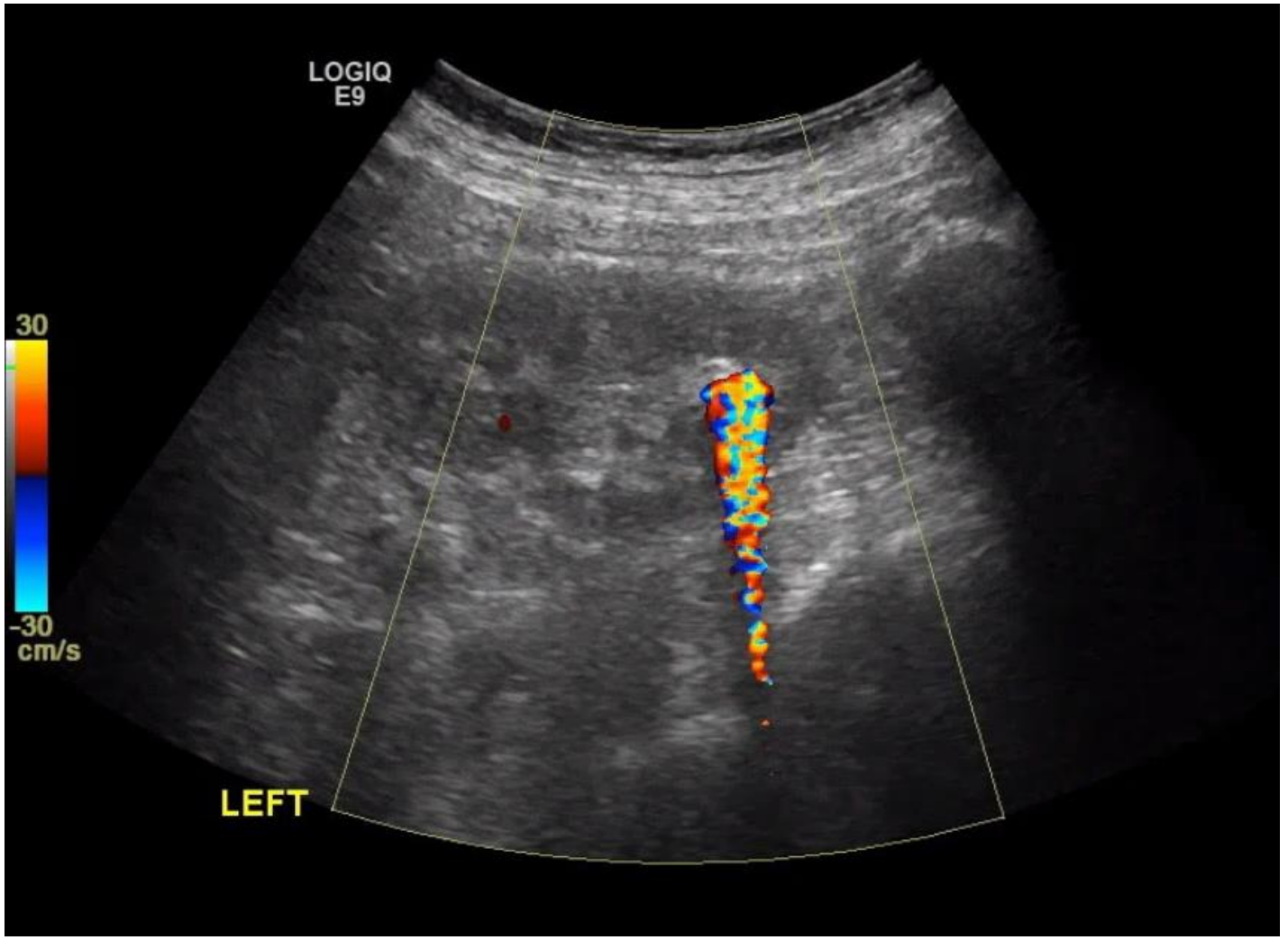
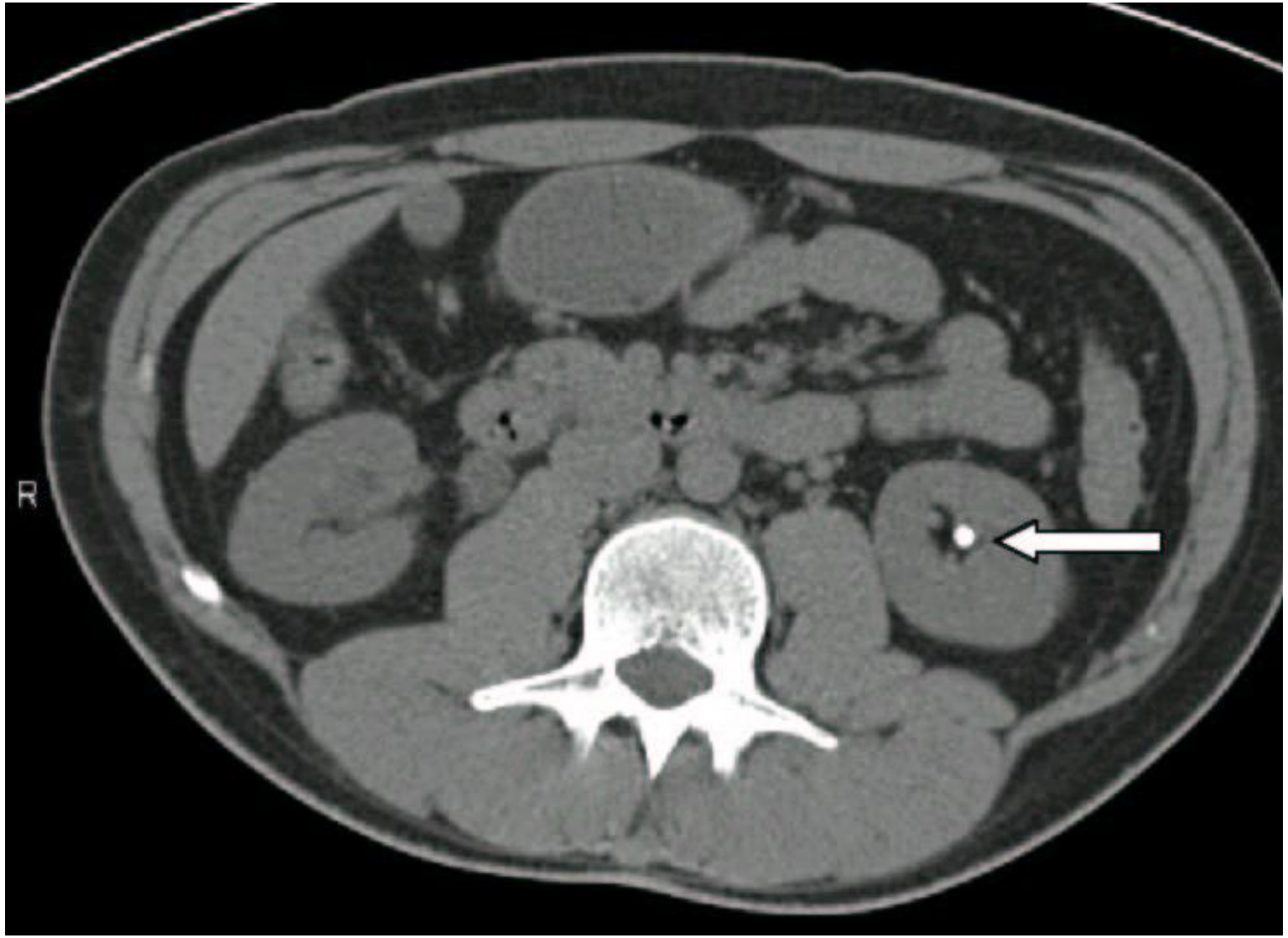


TWINKLING





Nephrolithiasis – Non contrast CT



Question

Most appropriate imaging?

a) CT – angiogram with contrast

b) CT-urogram with contrast

c) Renal ultrasound and a KUB

d) Renal ultrasound with Color/Doppler

e) Nuclear scan with Furosemid

Role of B-mode Ultrasound

Size and aspect of kidneys	***
Hydronephrosis	***
Polycystic kidney disease	***
Bladder size and aspects, postvoidresiduals	***
Perinephric fluid collections	***
Nephrolithiasis	**
Cysts and tumors	**
Biopsies	**

All patients with renal disease should obtain a renal ultrasound

Role of B-mode Ultrasound – Kidney Transplant

Possible questions

Size and aspect of kidneys

Hydronephrosis

Perinephric fluid collection

Bladder

Nephrolithiasis

Biopsies

Important to perform serial exams!

Role with Color and Doppler

Renal artery stenosis	***
Transplant kidney perfusion	***
Arteriovenous fistulas in kidneys	***
Transplant renal vein thrombosis	***
Evaluation of renal tumors	**
Renal vein thrombosis native kidney	*

Kidney Ultrasound

Pro:

- Inexpensive
- Non invasive
- Non toxic
- Easy to repeat and use for follow up

Contra:

- Operator dependent

BUT – everything in medicine and radiology is OPERATOR AND READER DEPENDENT

POCUS – renal ultrasound – the SECONDS checklist

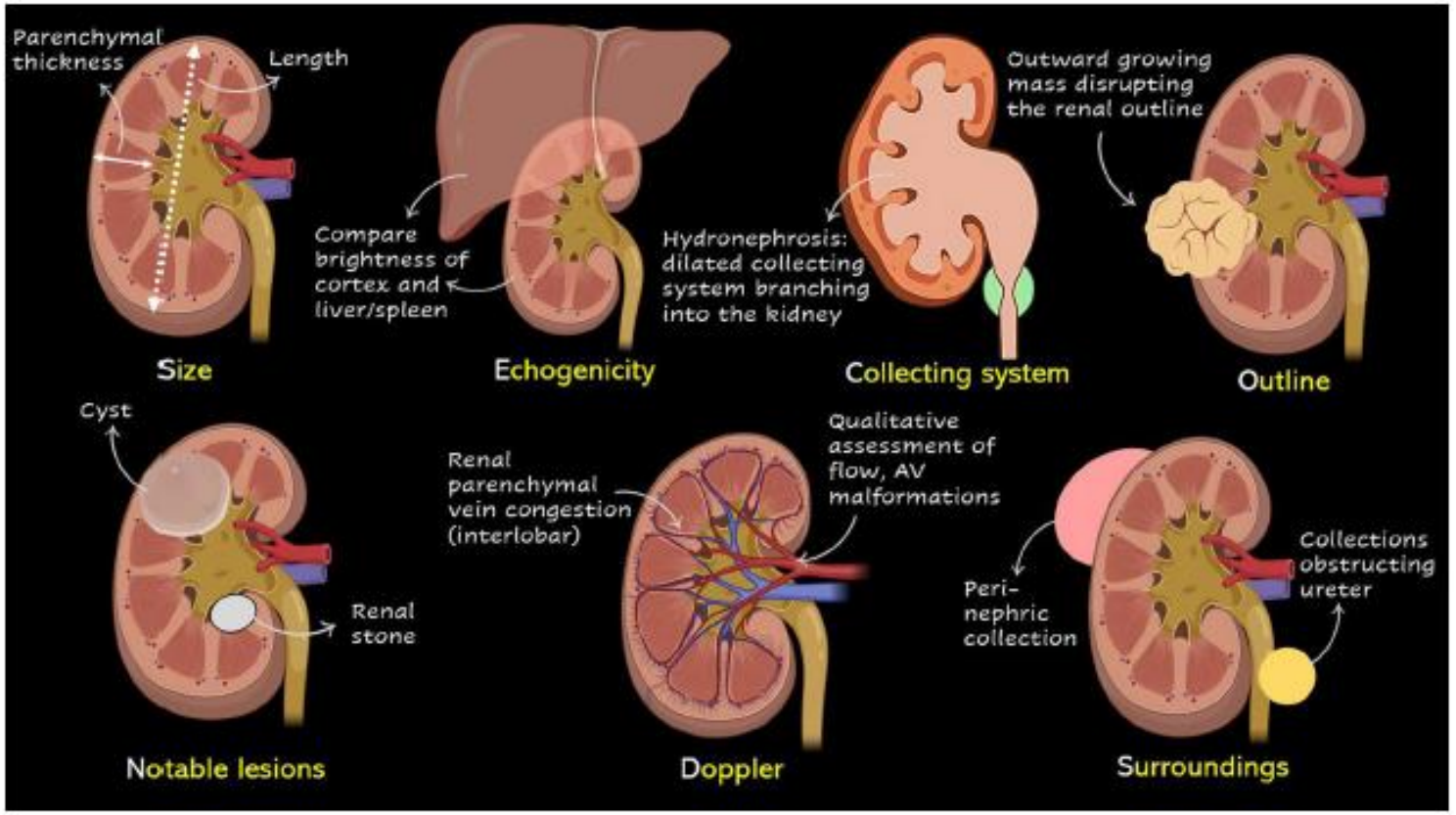


Fig. 1 Summary of the SECONDS checklist for interpretation of point-of-care renal ultrasound. Illustration made using Biorender®

Korotala – Clinical and Experimental Nephrology 2022

POCUS

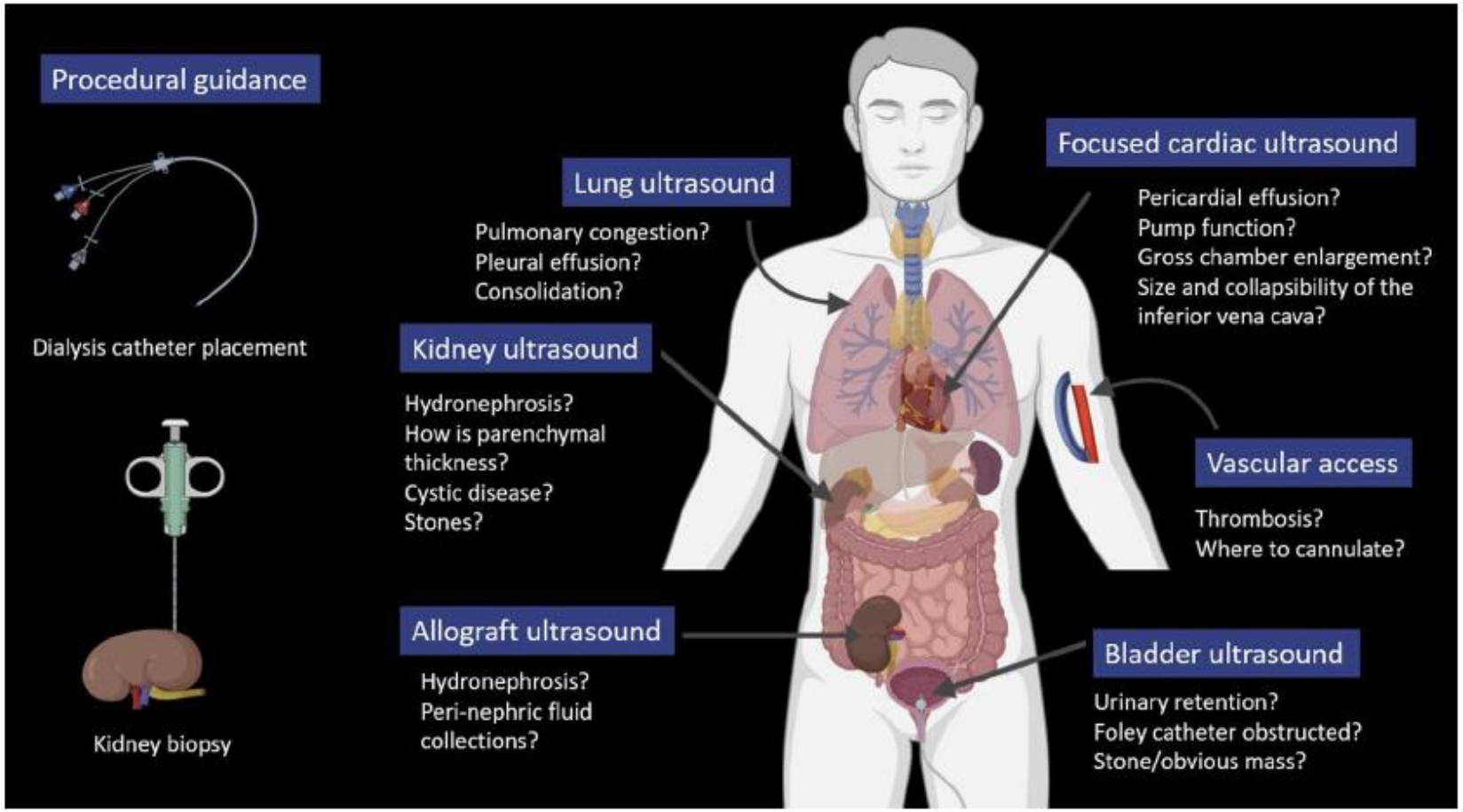


Figure 1. Basic nephrology-related point of care ultrasonography: organs examined and common clinical questions encountered are shown. Created with BioRender.com.

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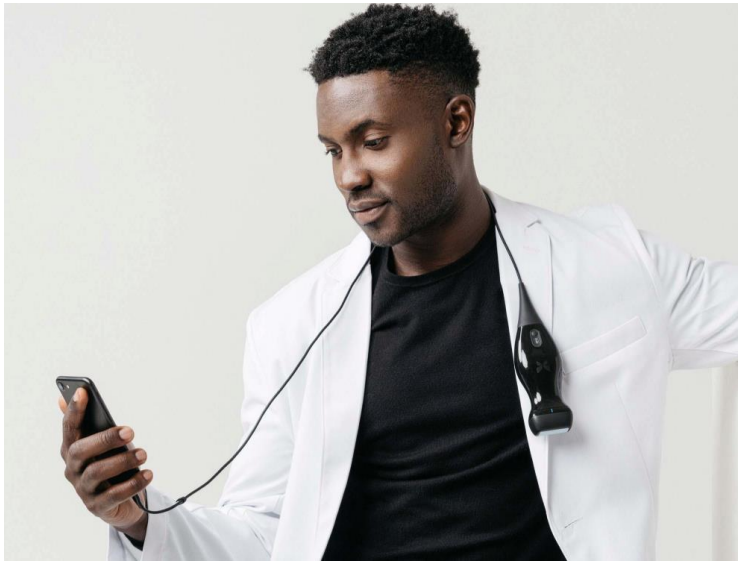
POCUS – Volume Status

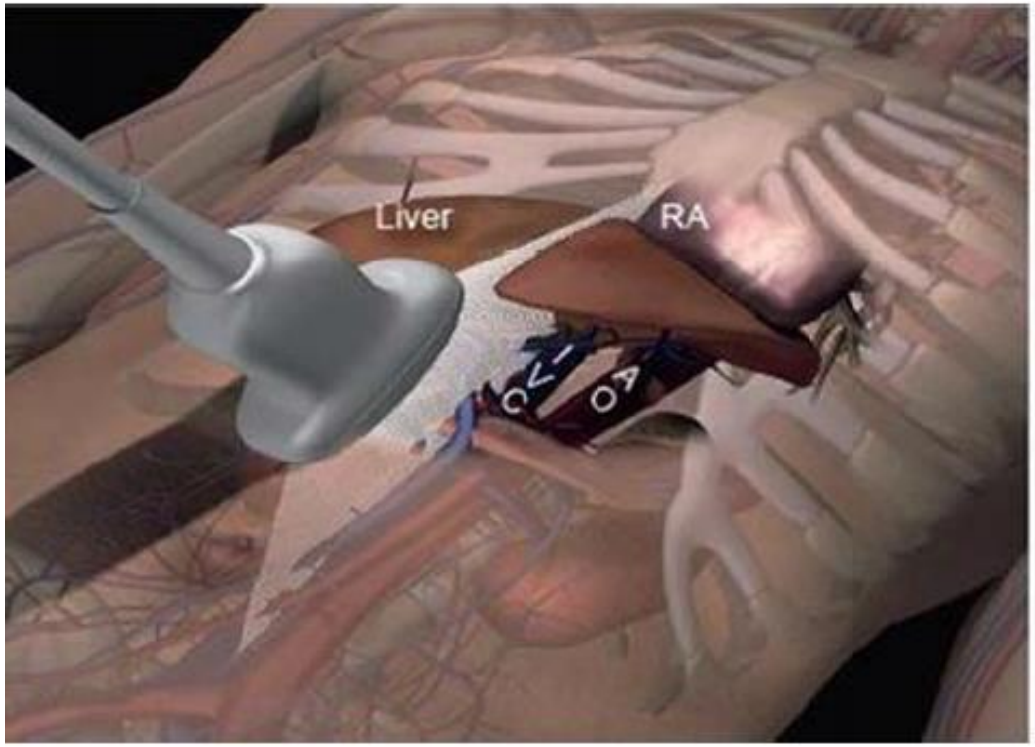
Abdominal Ultrasound
IVC Diameter and collapsibility
Pleural effusion
Ascites

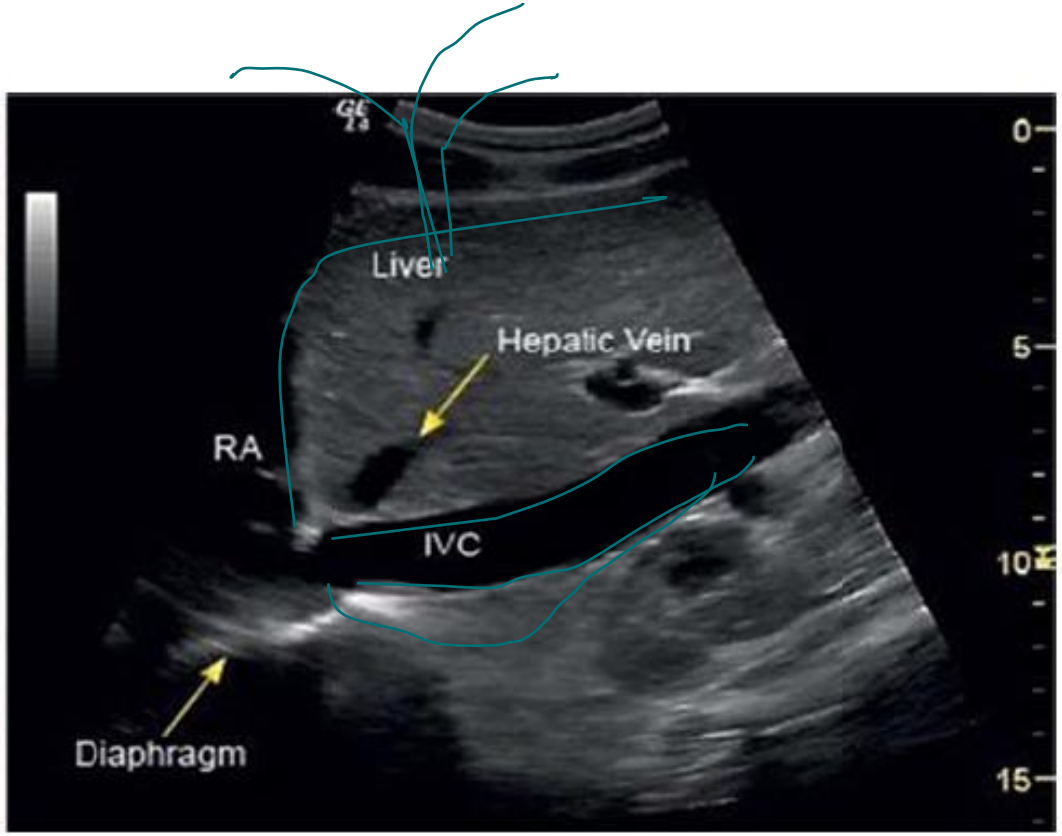
Cardiac Ultrasound
EF, pericardial effusion

Lung Ultrasound
B lines
A lines



IVC - Ultrasound

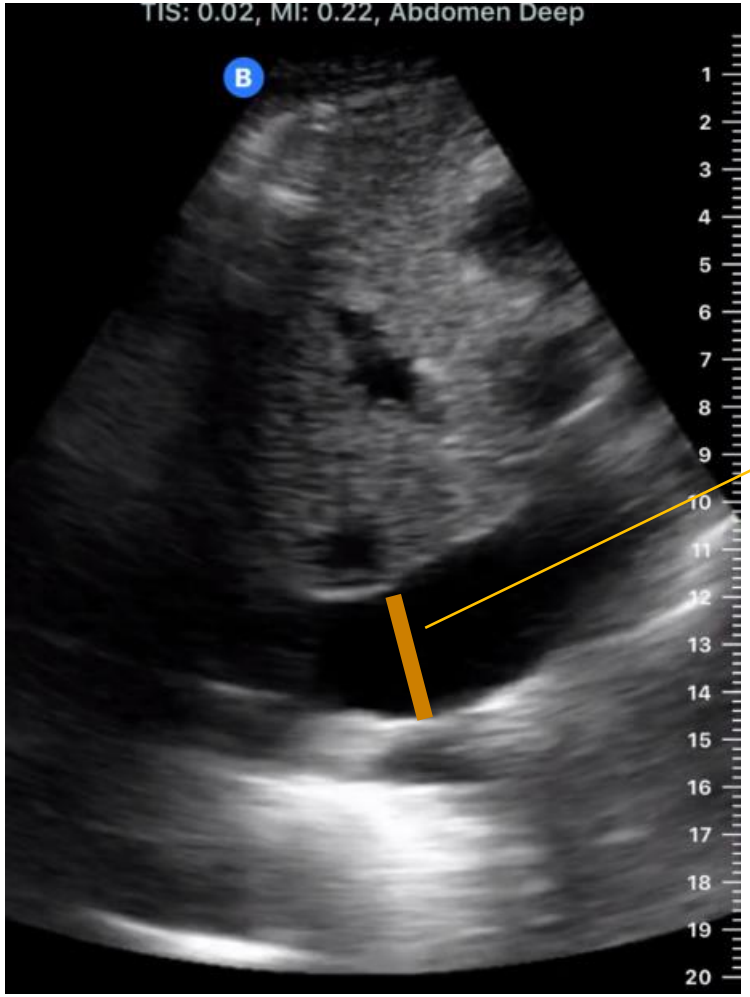




Happy Whale Sign

IVC Ultrasound

IVC - Ultrasound



Wide + non collapsing = elevated CPV

Measured at 2-3 cm from RA

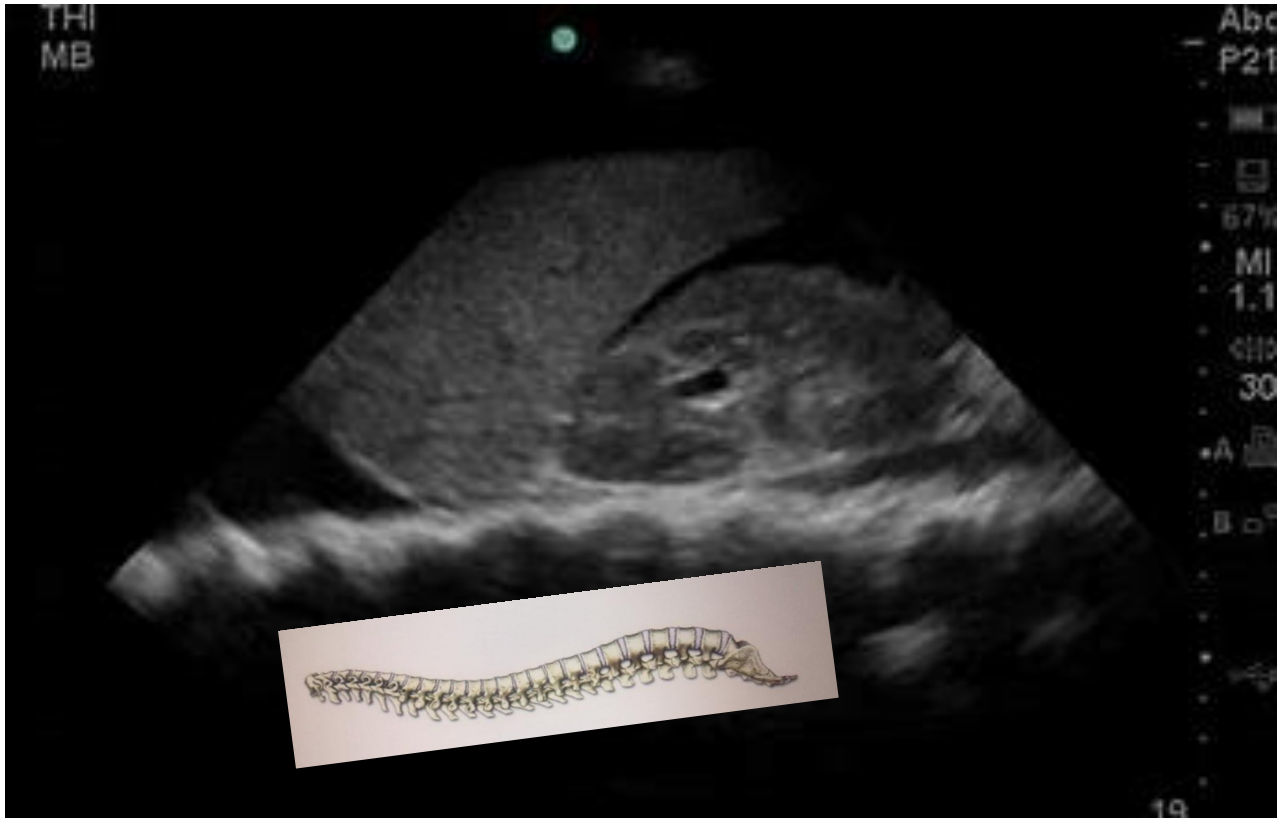
IVC Size cm	Percent collapse %	RA Pressure, mm Hg
< 1.5	Total collapse	0-5
1.5-2.5	> 50%	6-10
1.5-2.5	< 50%	10-15
> 2.5	No collapse	> 15

Pleural effusion

Mirror Image Artifact

No Pleural effusion

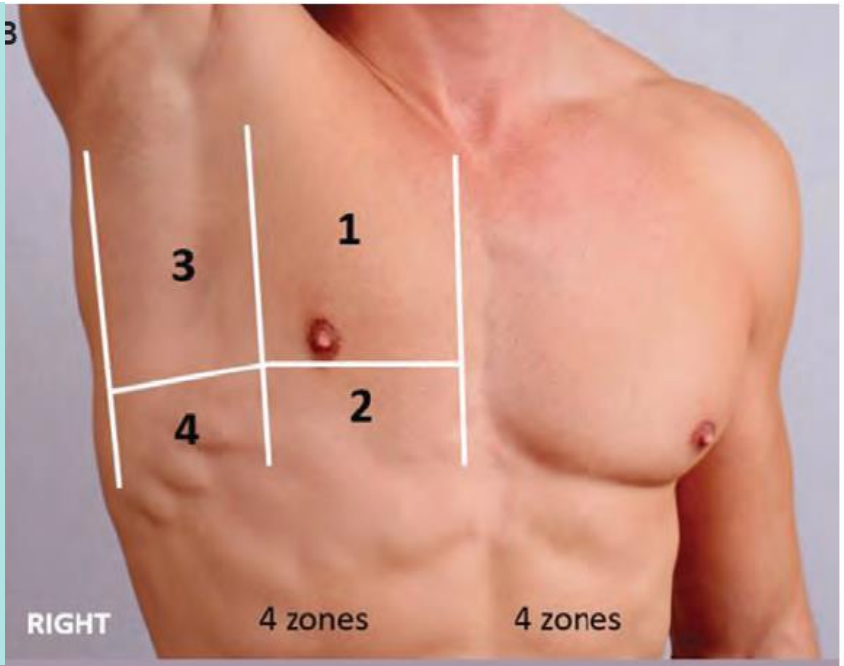
Positive spine sign



Pleural effusion

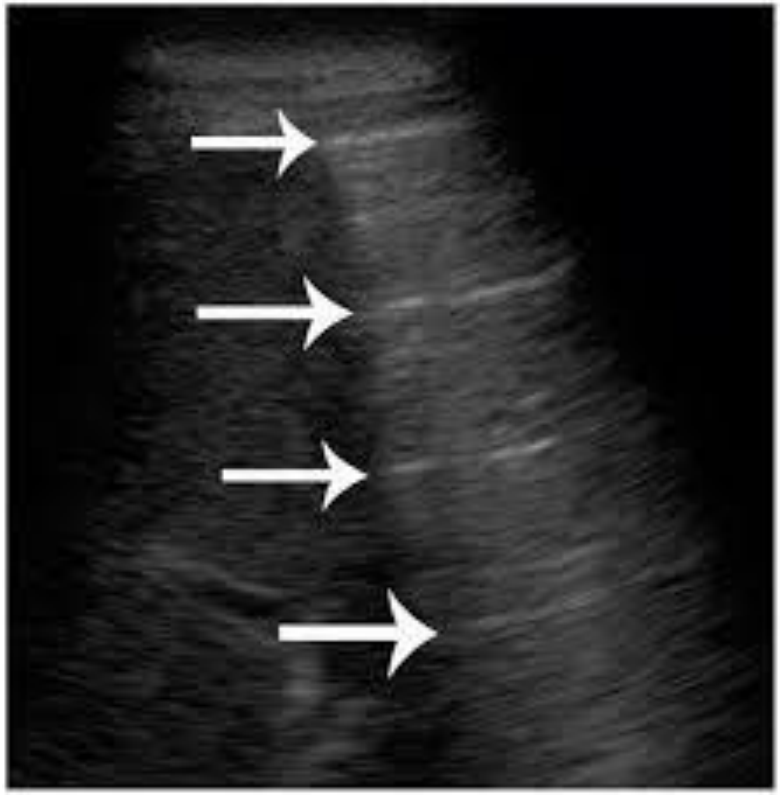
Lung Ultrasound

8 Zone Lung Ultrasound



Lung Ultrasound

A- Lines

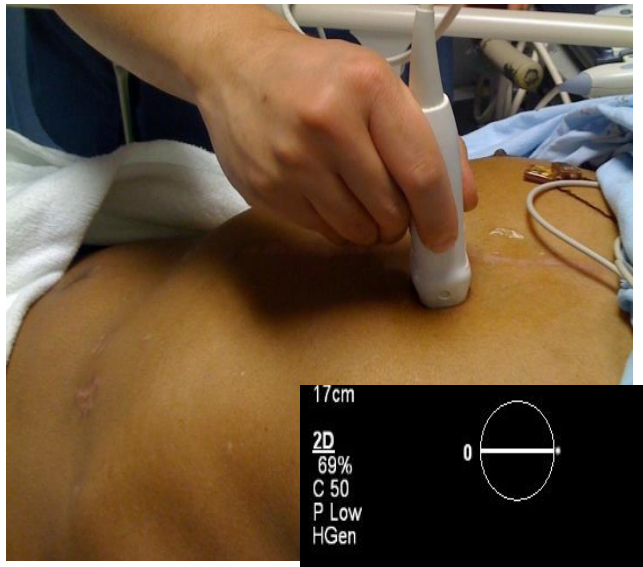


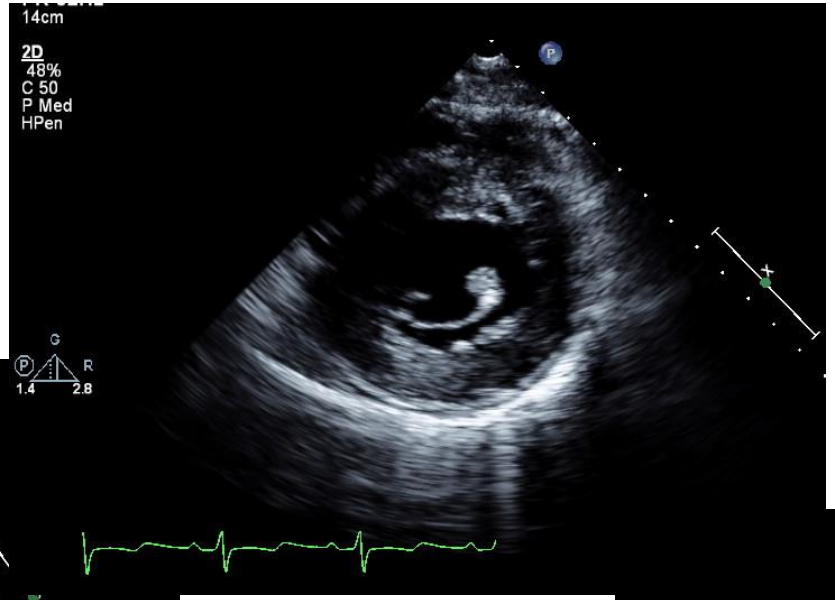
Aerated lung

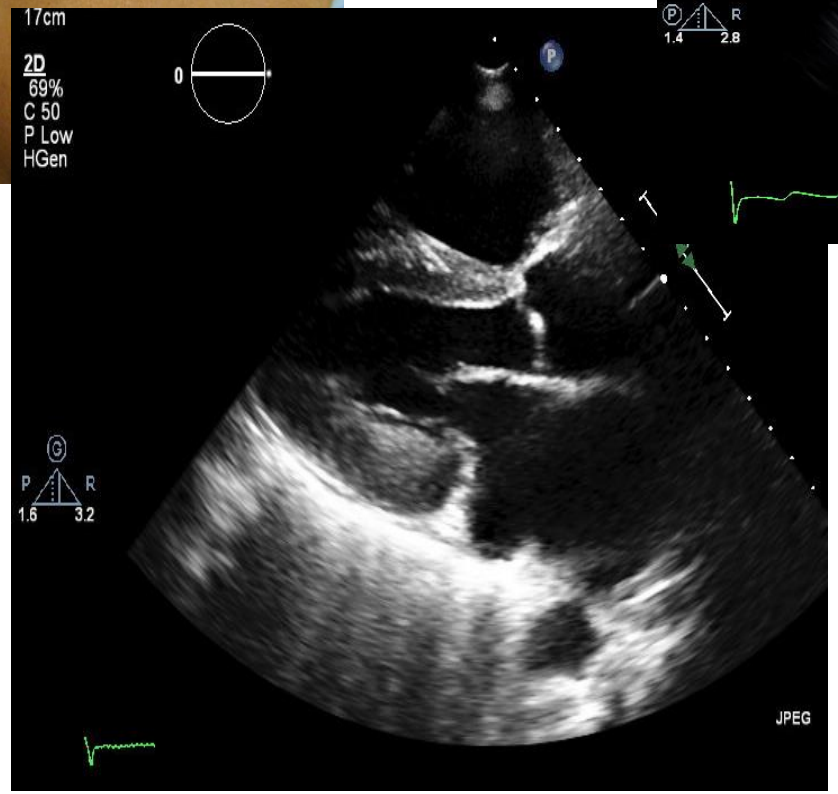
B- Lines

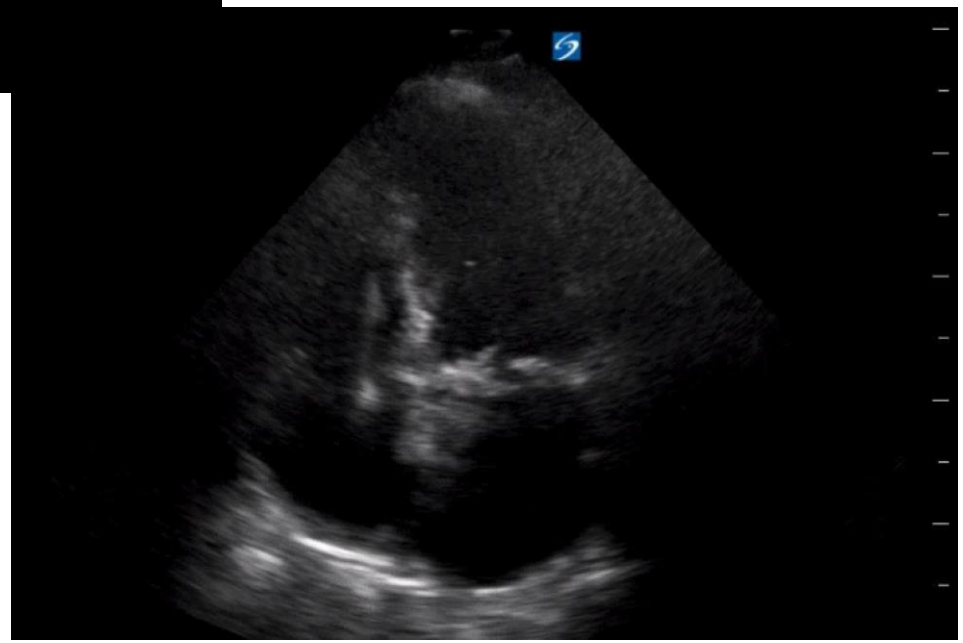
Interstitial thickening
Most frequently fluid

Echo – PSAX, PLAX, 4Chamber

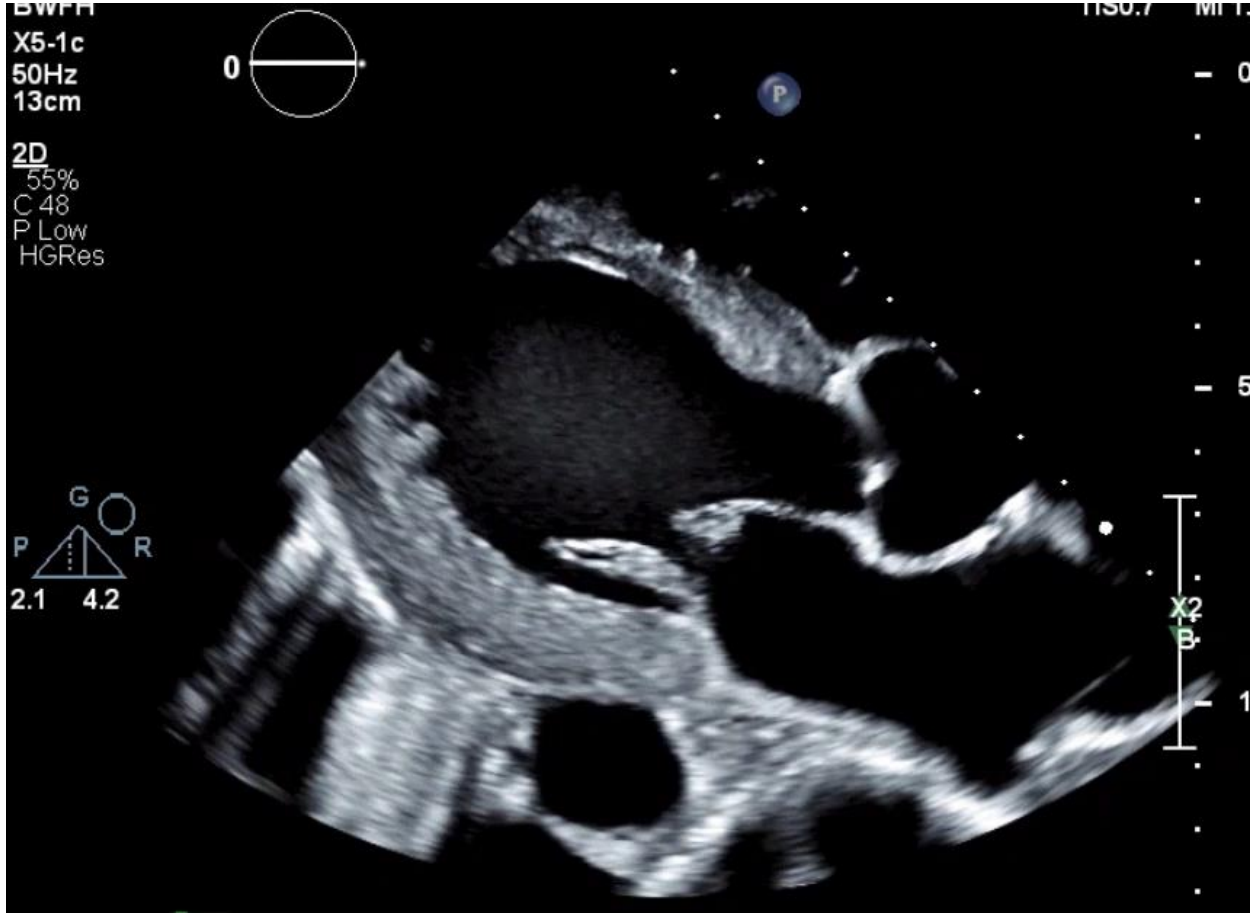




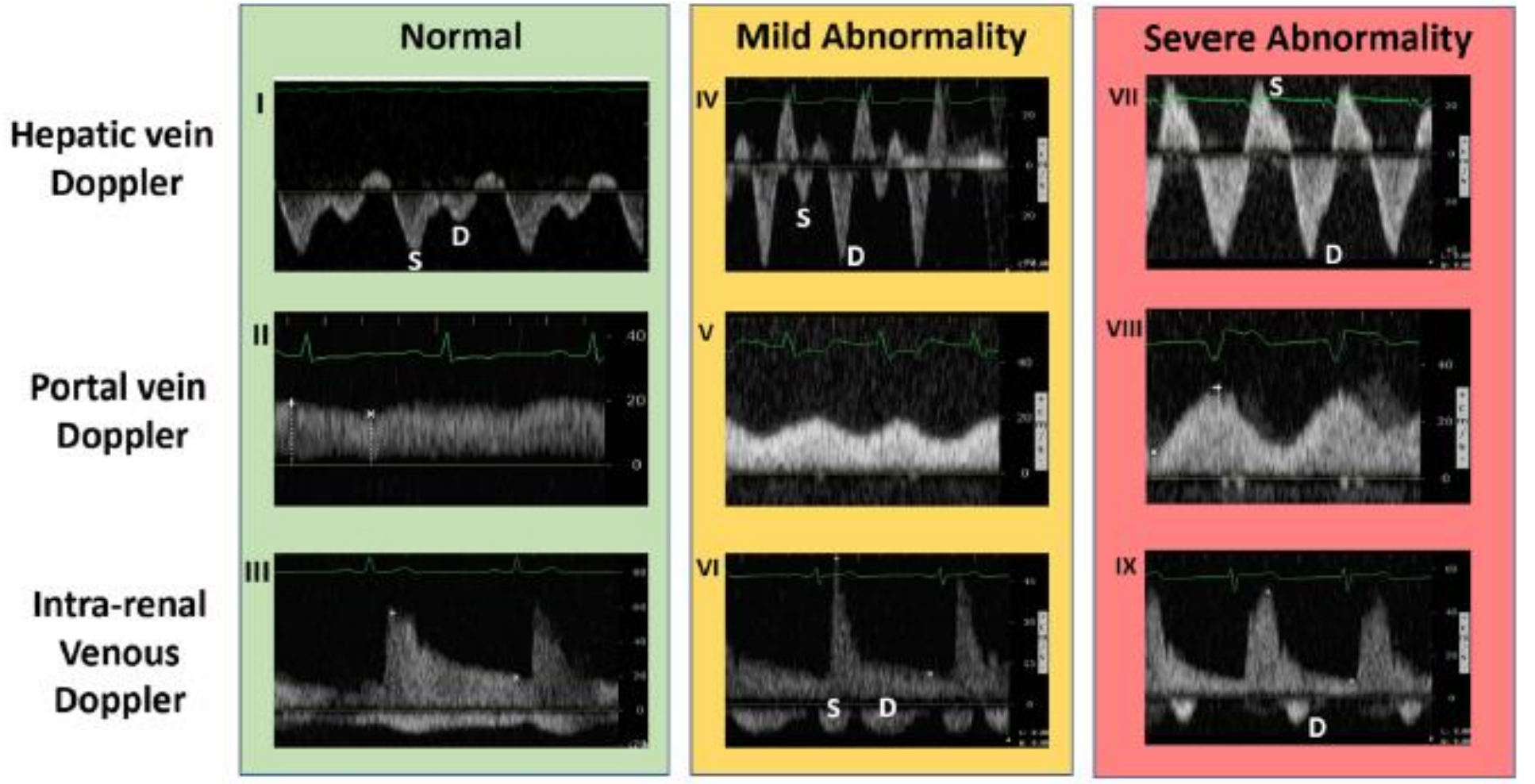




ECHO – Parasternal long axis
Estimating Pump function
Normal or Decreased



Vexus – venous ultrasound with Doppler
Venous congestion



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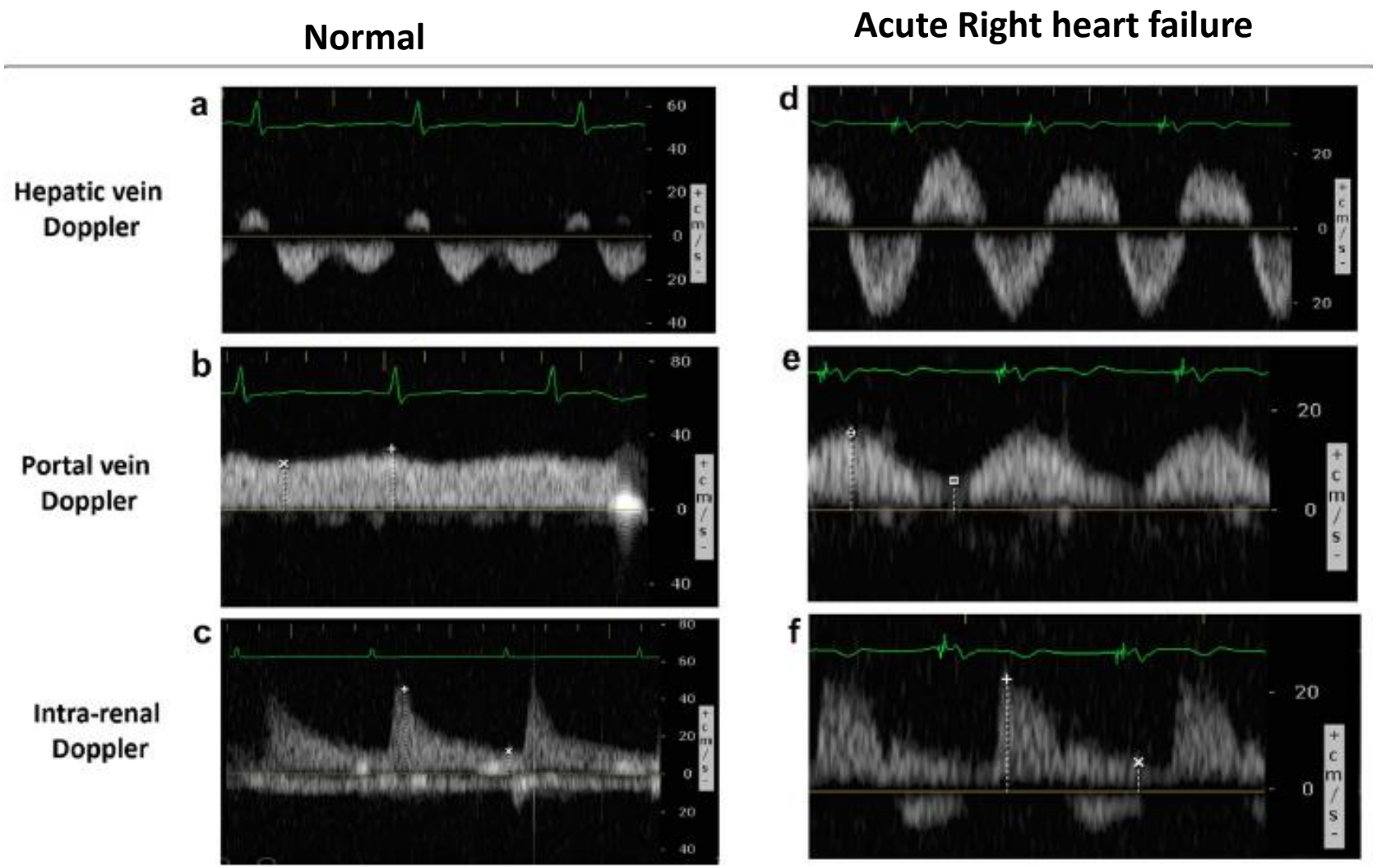
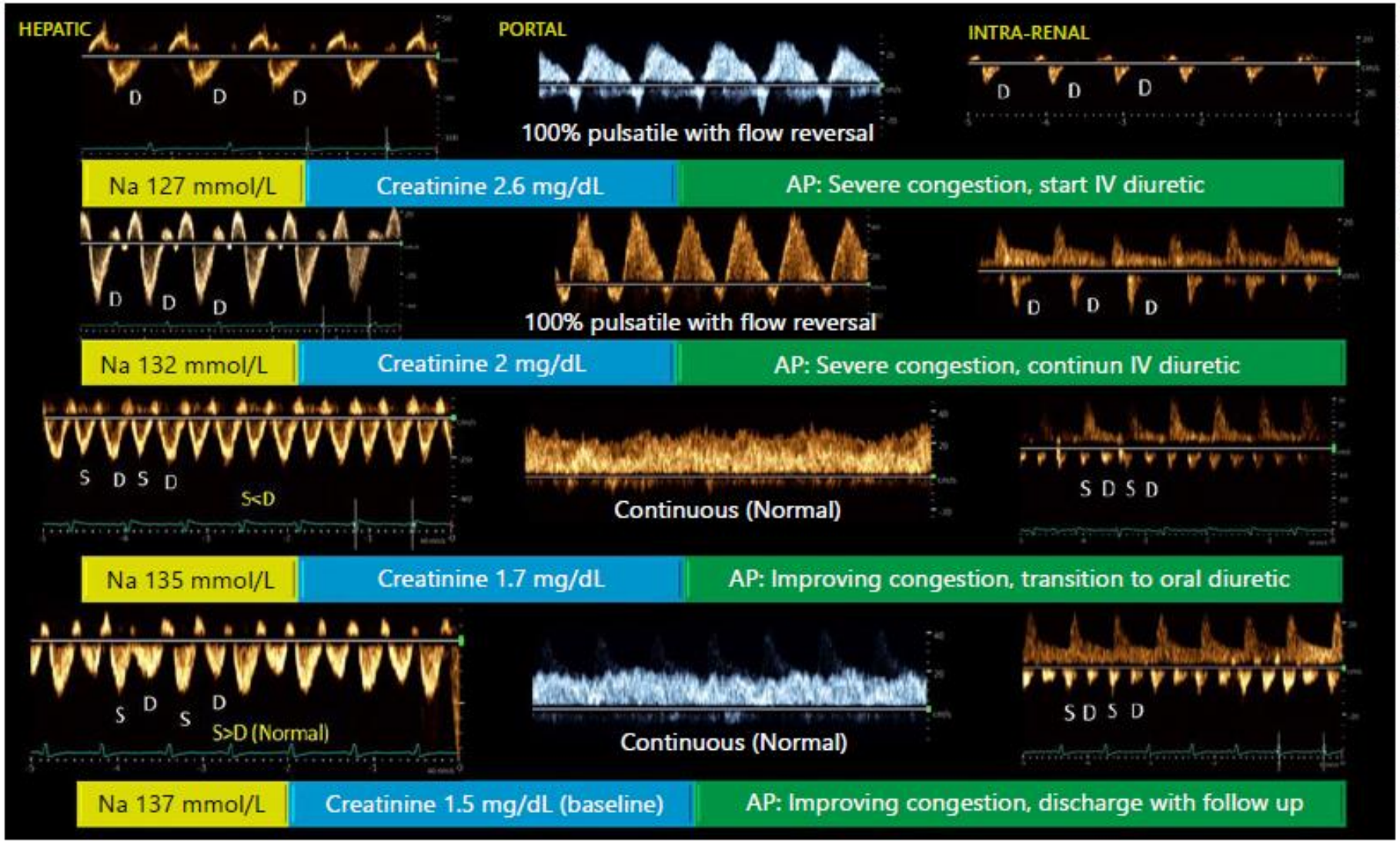
Vexus - Heart failure



Beaubien-Souligny W et al Ultrasound Journal 2020

Vexus –Hyponatremia



POCUS for redefining AKI in liver disease

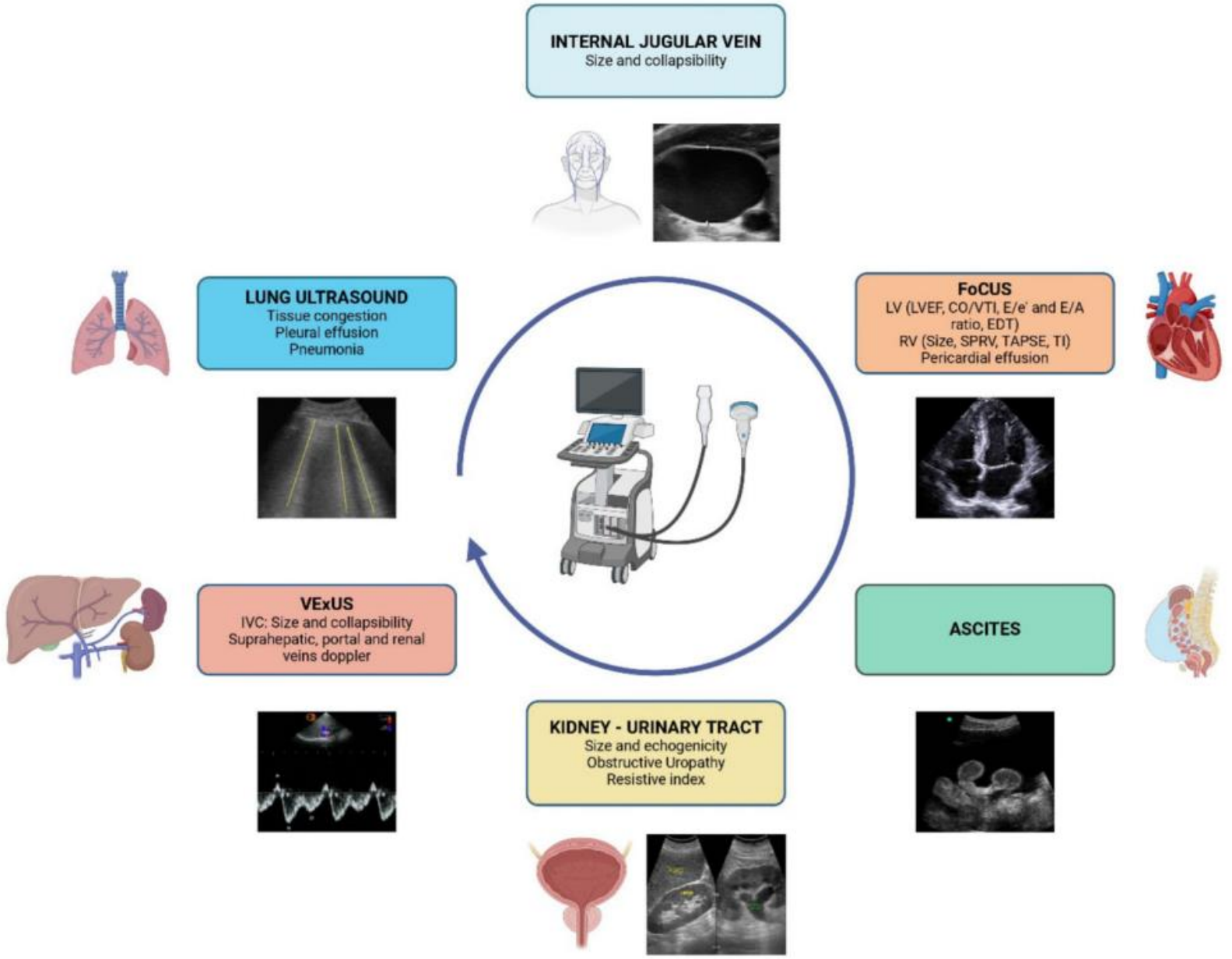


Figure 2: AKI and cirrhosis: multiorgan ultrasound assessment. LVEF: left ventricular ejection fraction; CO: cardiac output; EDT: E wave deceleration time; RV: right ventricle; SPRV: systolic pressure of the RV; TAPSE: tricuspid annular plane systolic excursion; TI: tricuspid insufficiency. Created with BioRender.com.

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Take home messages

Every nephrology patient should have kidney ultrasound

Look at images and not just the interpretation

Do it yourself: POCUS

Different imaging techniques have different strengths and weaknesses, and they are complementary

Multiorgan POCUS can help assess volume status in different nephrology scenarios

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