



Brigham and Women's Hospital

Founding Member, Mass General Brigham

Ultrasound for the Clinical Nephrologist

**Adina S. Voiculescu MD, FASDIN
Associate Physician Renal Division
General and Interventional Nephrology
Brigham and Women's Hospital
Assistant Professor
Harvard Medical School**



Adina Voiculescu, MD, FASDIN



University of Dusseldorf Medical School/Germany

Nephrology Fellowship – Mass General Brigham

General and Interventional Nephrologist

Director of Ultrasound in Nephrology, BWH

Assistant Professor of Medicine@ HMS

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

None

August 2022

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.

"Laennec à l'hôpital Necker ausculte un phthisique 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

BP 136/89, 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

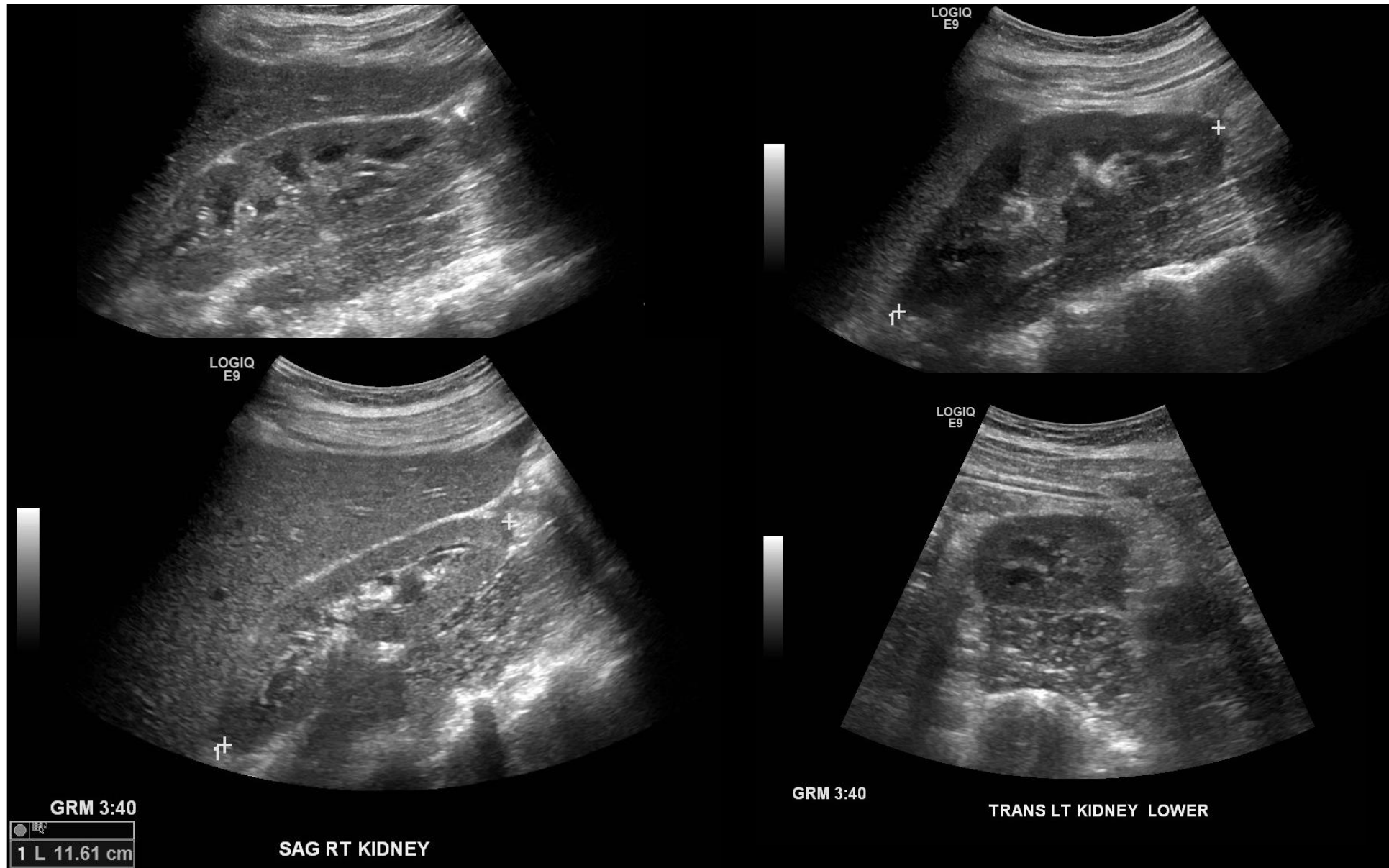
UA: +RBCs, ++WBC, +Protein.



Renal Ultrasound

Right Kidney

Left Kidney



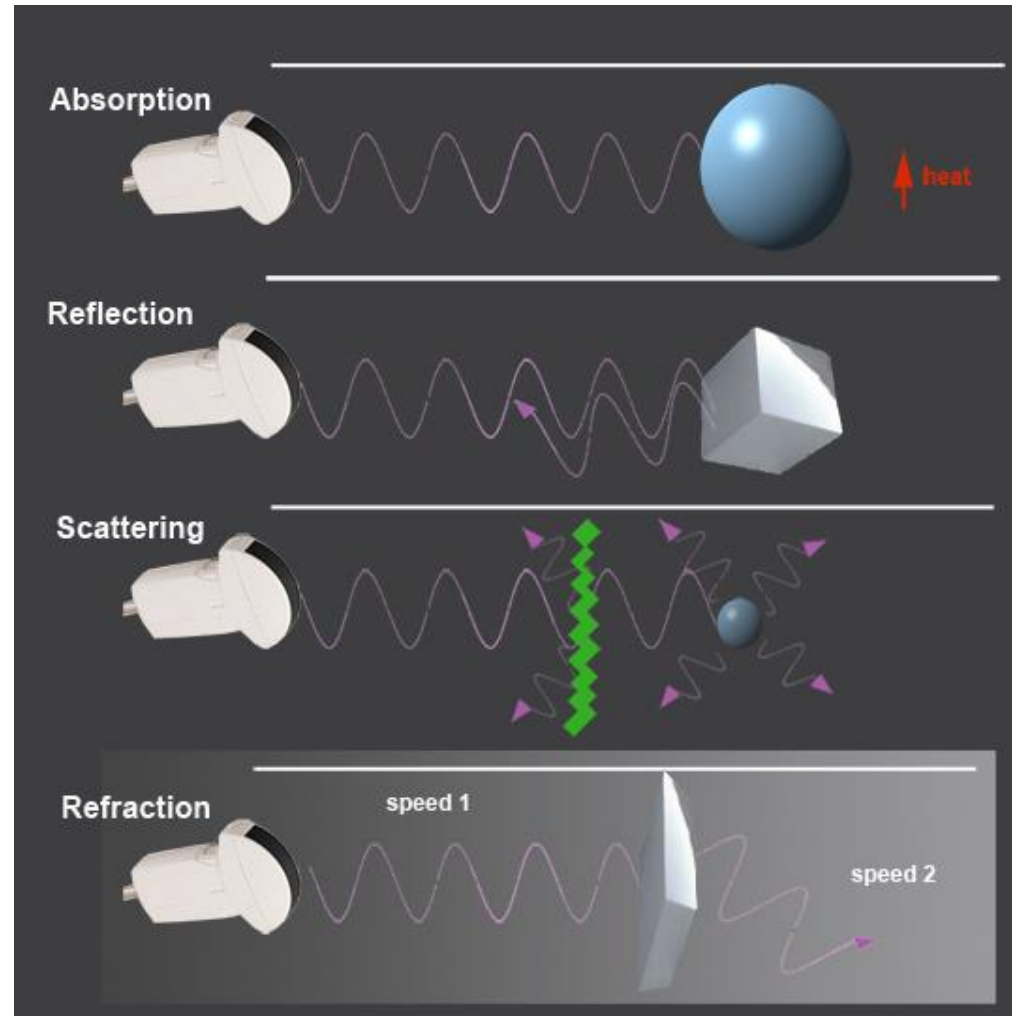
Questions

Kidney Ultrasound

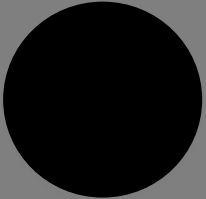
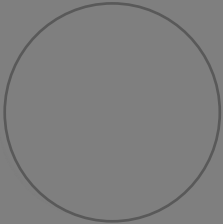
- a) Normal size kidney, no right hydronephrosis
- b) Normal size kidney with right hydronephrosis
- c) Normal size kidneys with cysts on the right
- d) Small kidneys without hydronephrosis
- e) Small kidneys with right hydronephrosis



Basics of Ultrasound



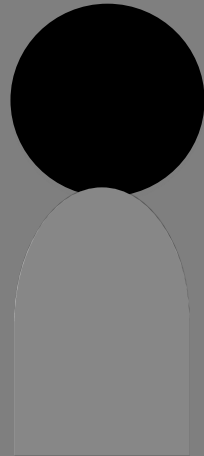
Basics of Ultrasound

Anechoic	Hypoechoic	Isoechoic	Hyperechoic
			
Fluid	Organs	Structures	Fat/Calcification
Cysts Hydro Bladder	Liver Kidney Spleen	Used for descriptions of masses	Renal sinus Perirenal fat Kidneys stones



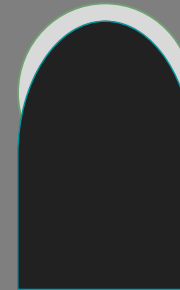
Basics of Ultrasound

Dorsal enhancement



Cysts
Bladder

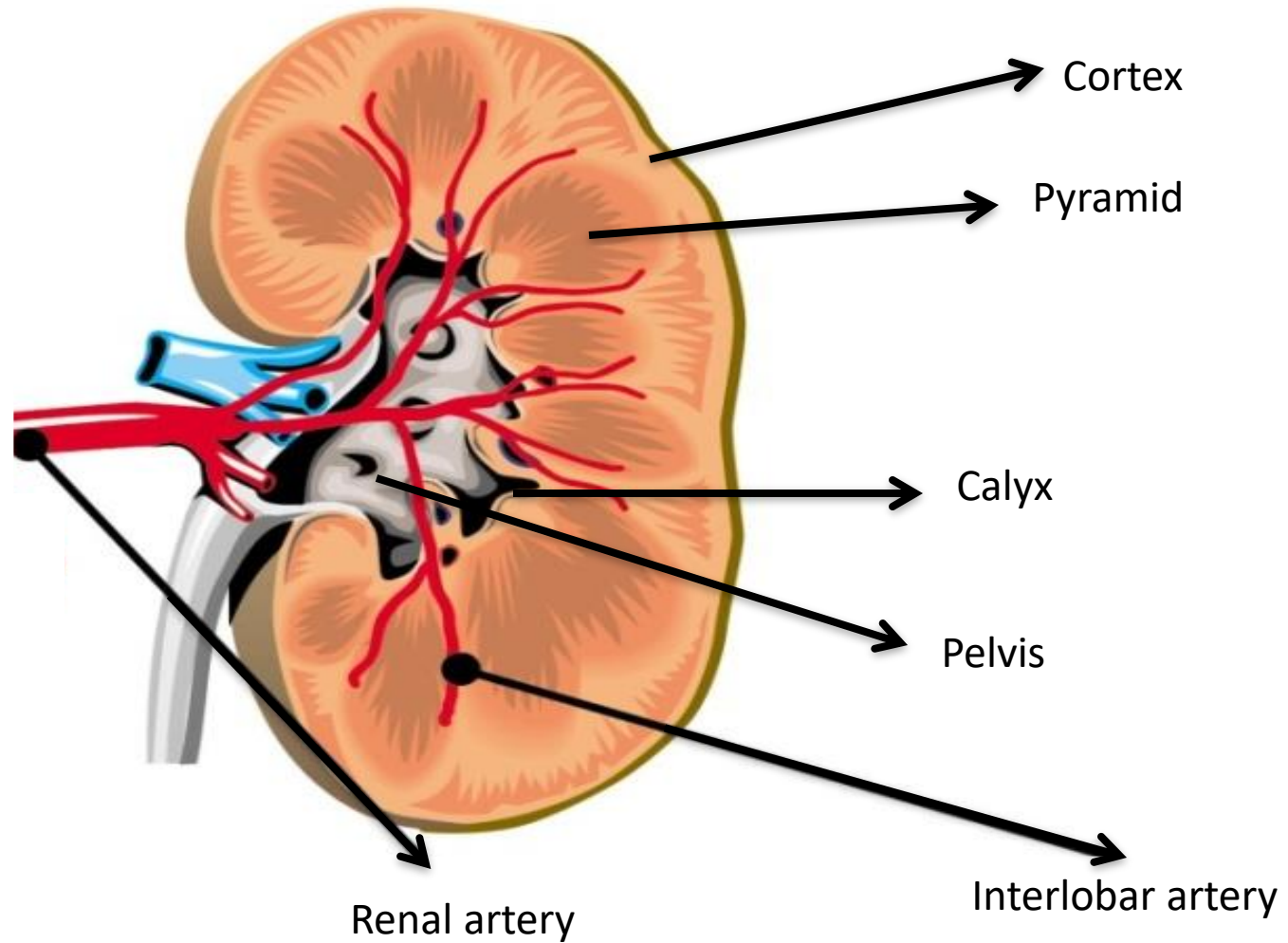
Shadowing
Extinction of signal



Stone
Bone

Nephrolithiasis

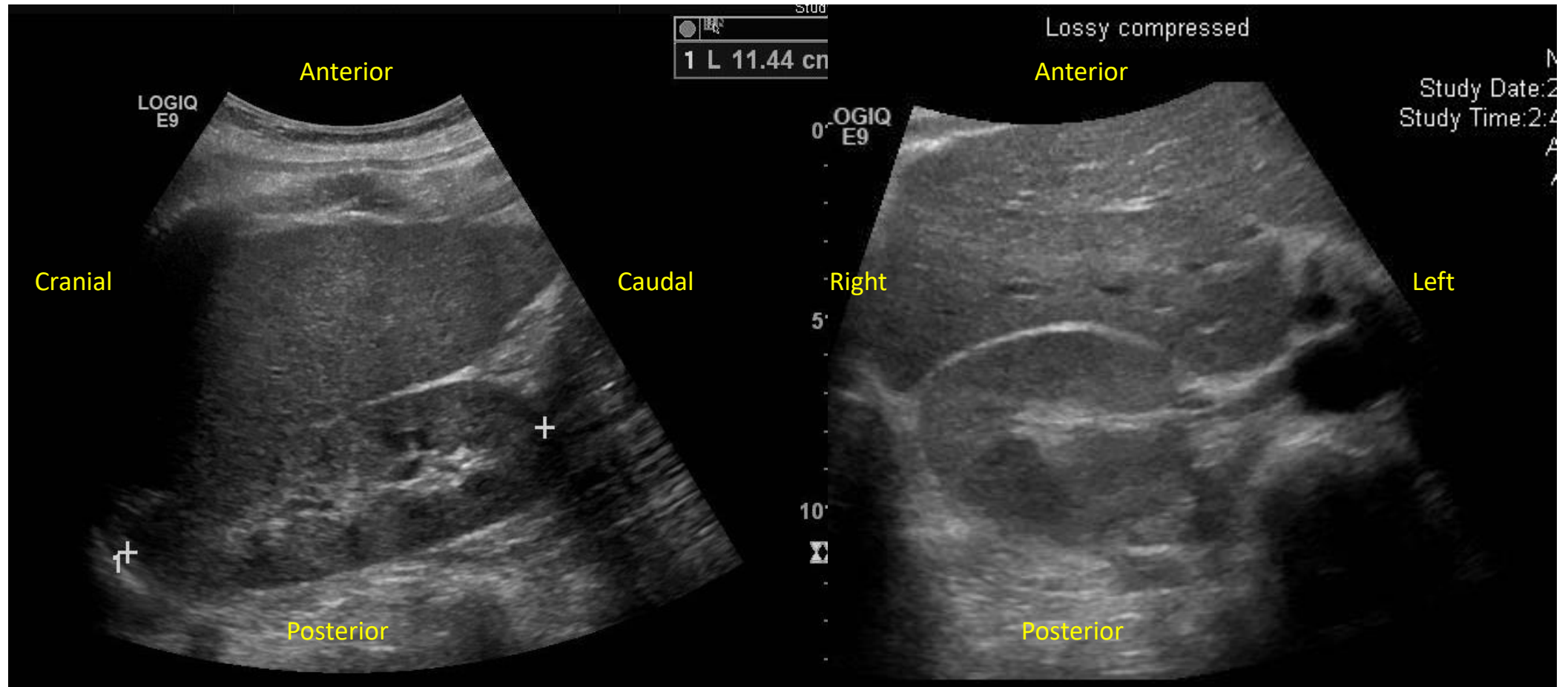
Anatomy



Kidney Ultrasound

Longitudinal

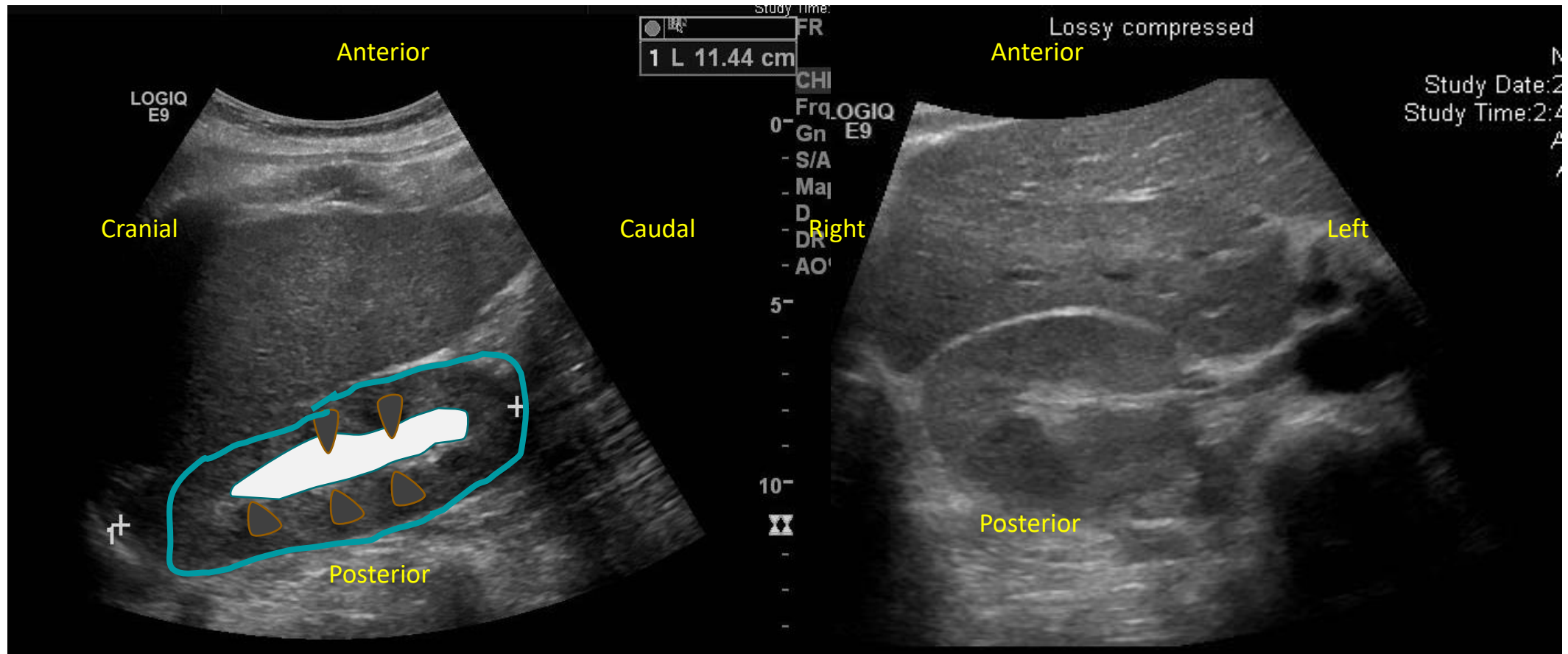
Transversal



Kidney Ultrasound

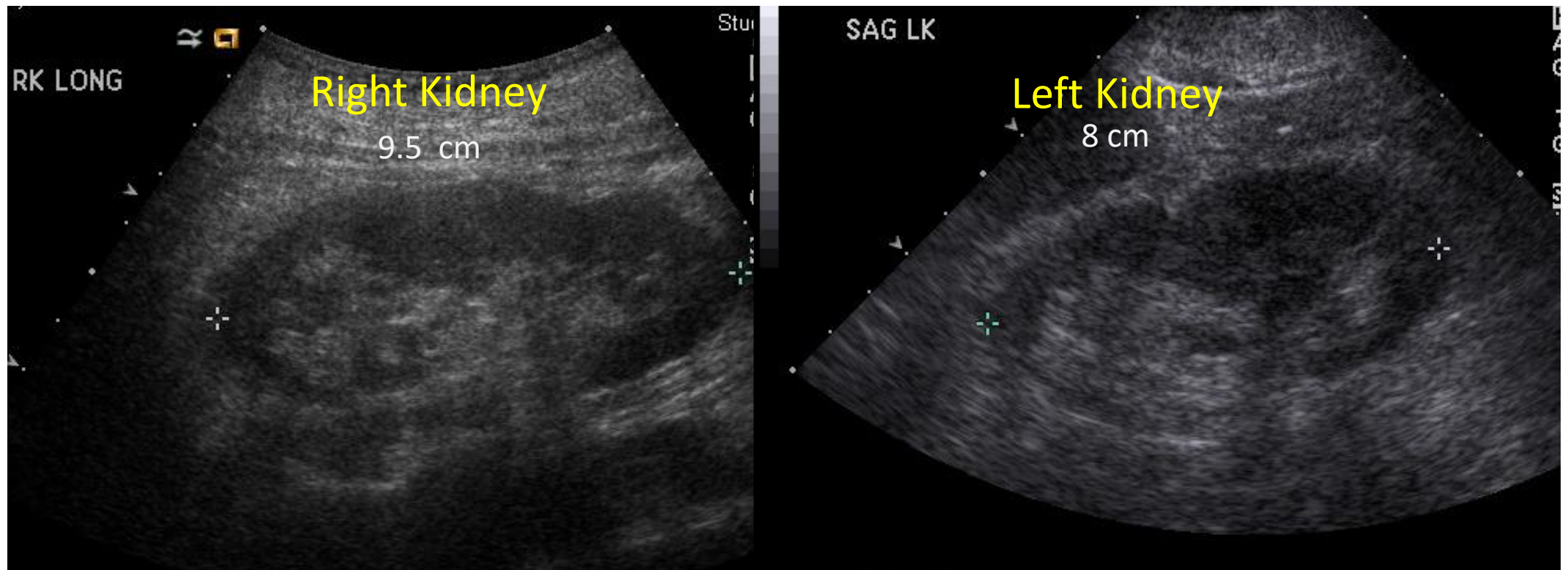
Longitudinal

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

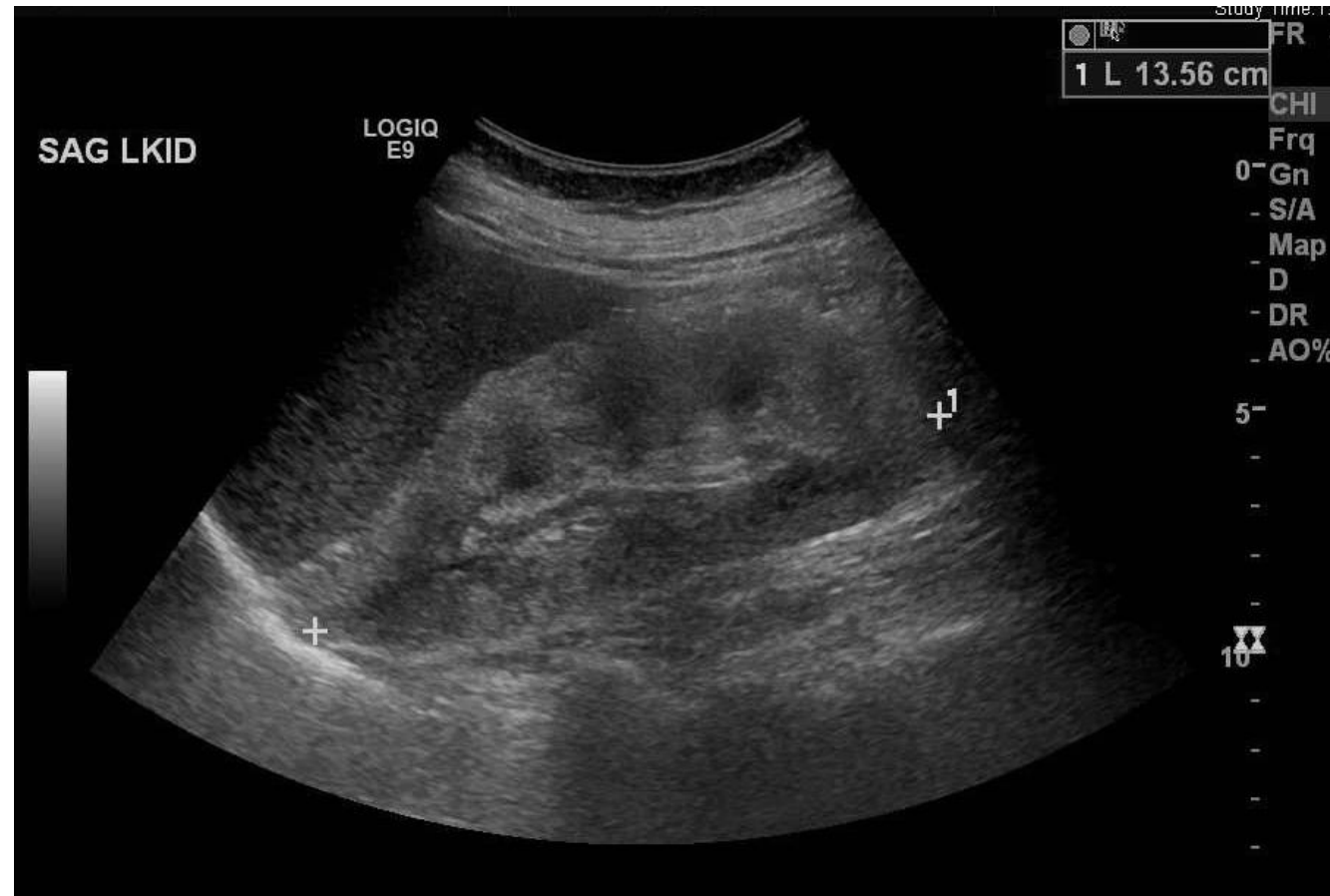
Acute parenchymal disorder (acute GN, AIN, RV thrombosis)

Infiltrative disease (MM, amyloidosis, lymphoma)



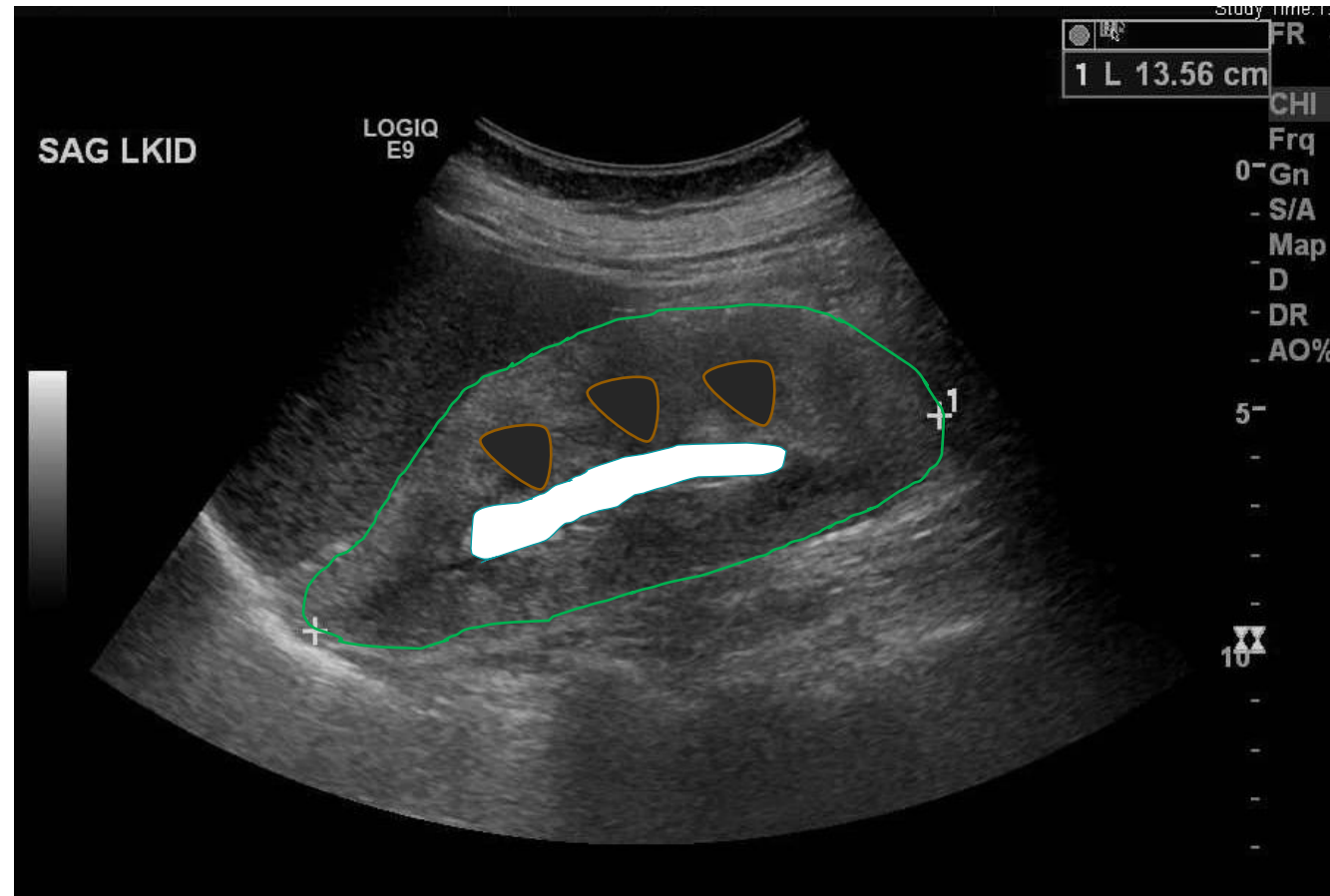
Echogenicity

Increased echogenicity of the cortex - medical disease



Echogenicity

Increased echogenicity of the cortex - medical disease



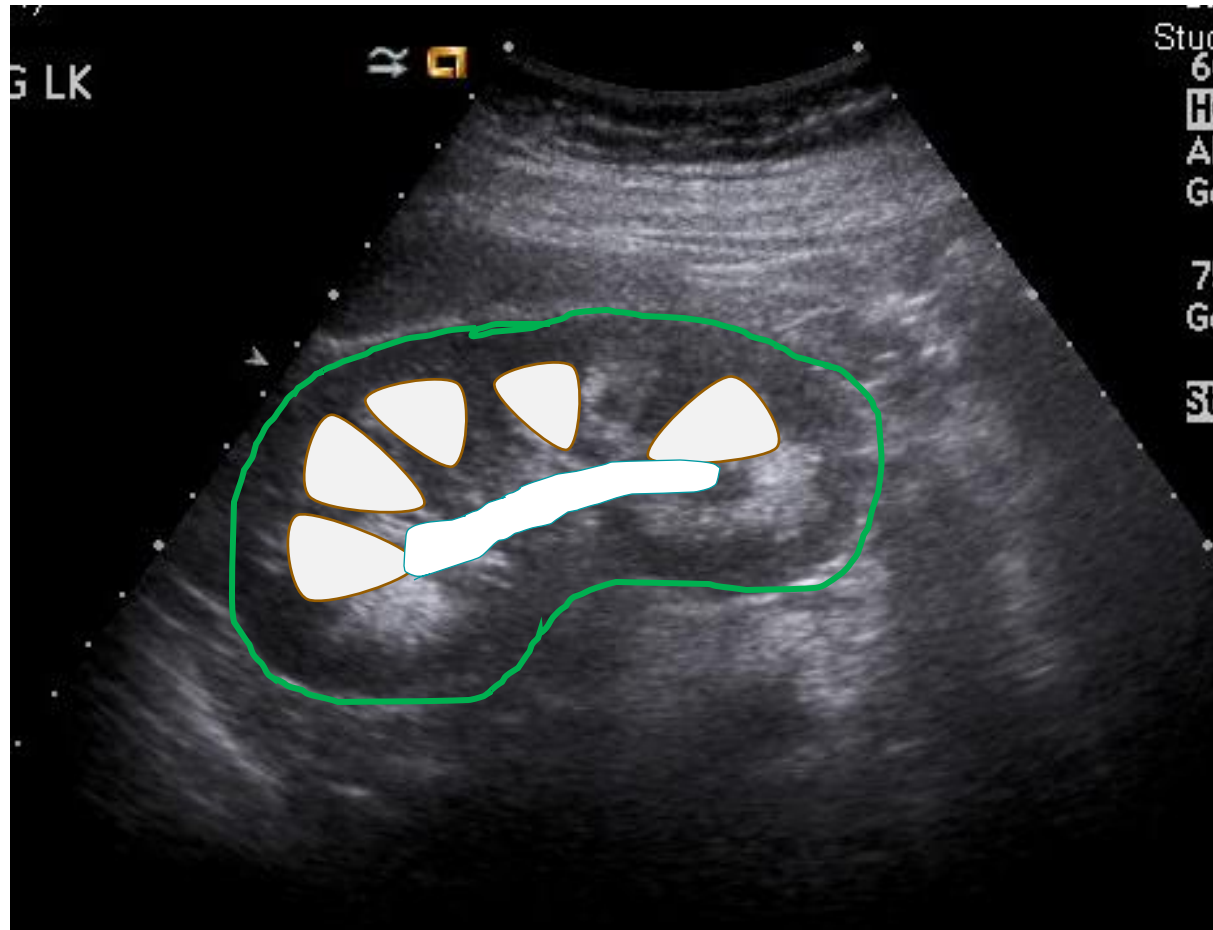
Echogenicity

Increased echogenicity of the pyramids
– medullary nephrocalcinosis



Echogenicity

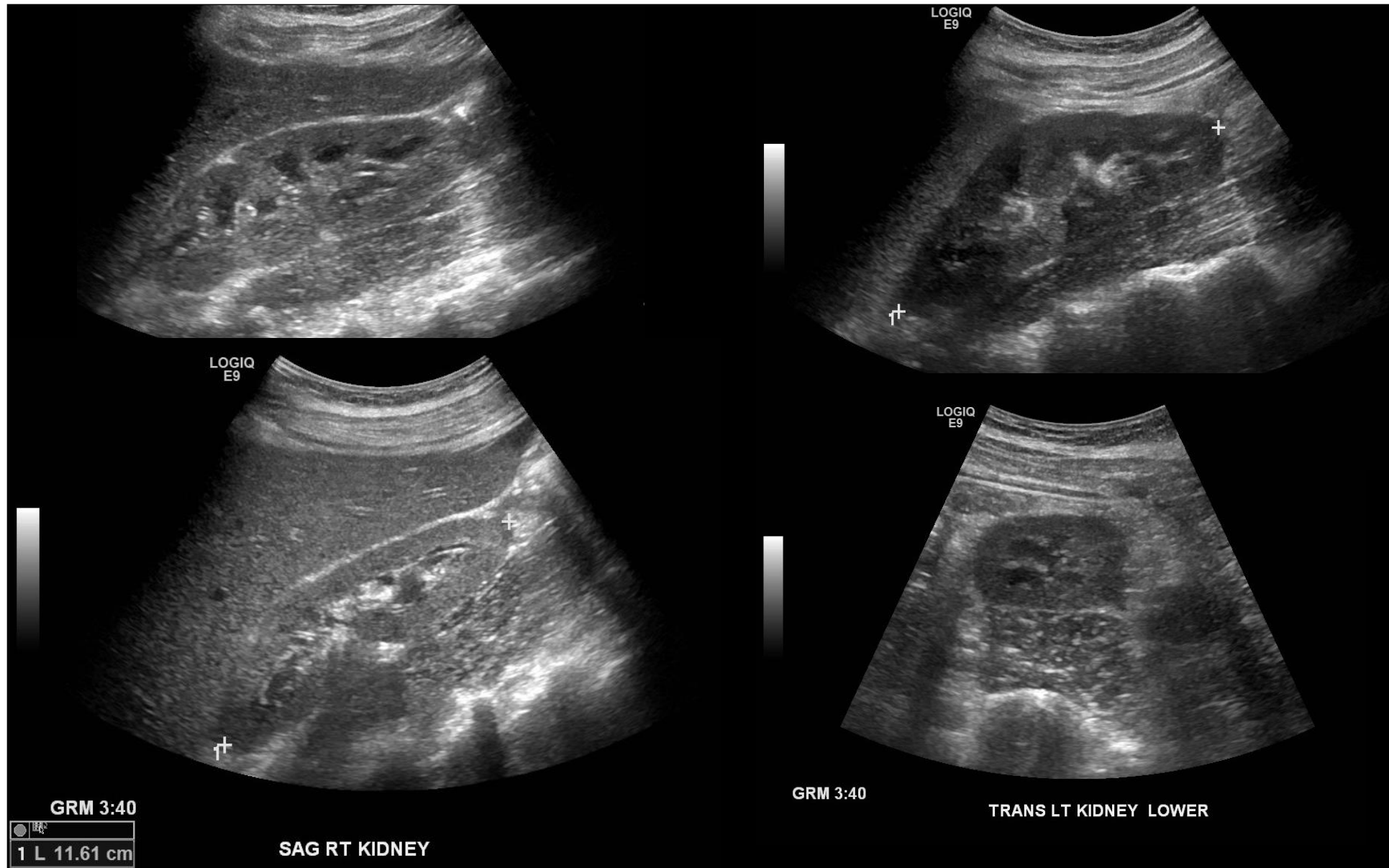
Increased echogenicity of the pyramids
– medullary nephrocalcinosis



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



SAG RT KIDNEY UP

Left Kidney



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

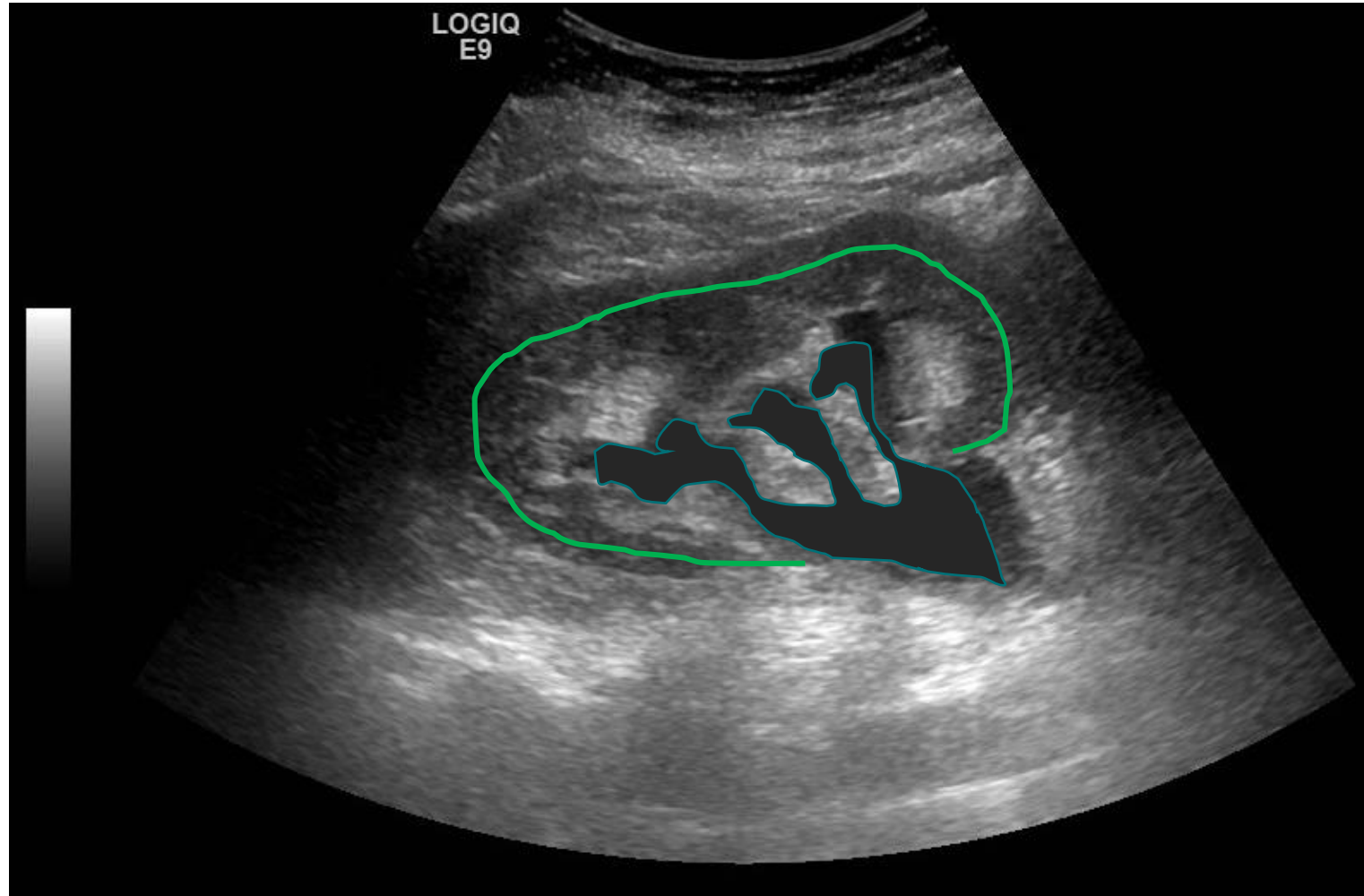
Hydronephrosis

Mild



Hydronephrosis

Mild



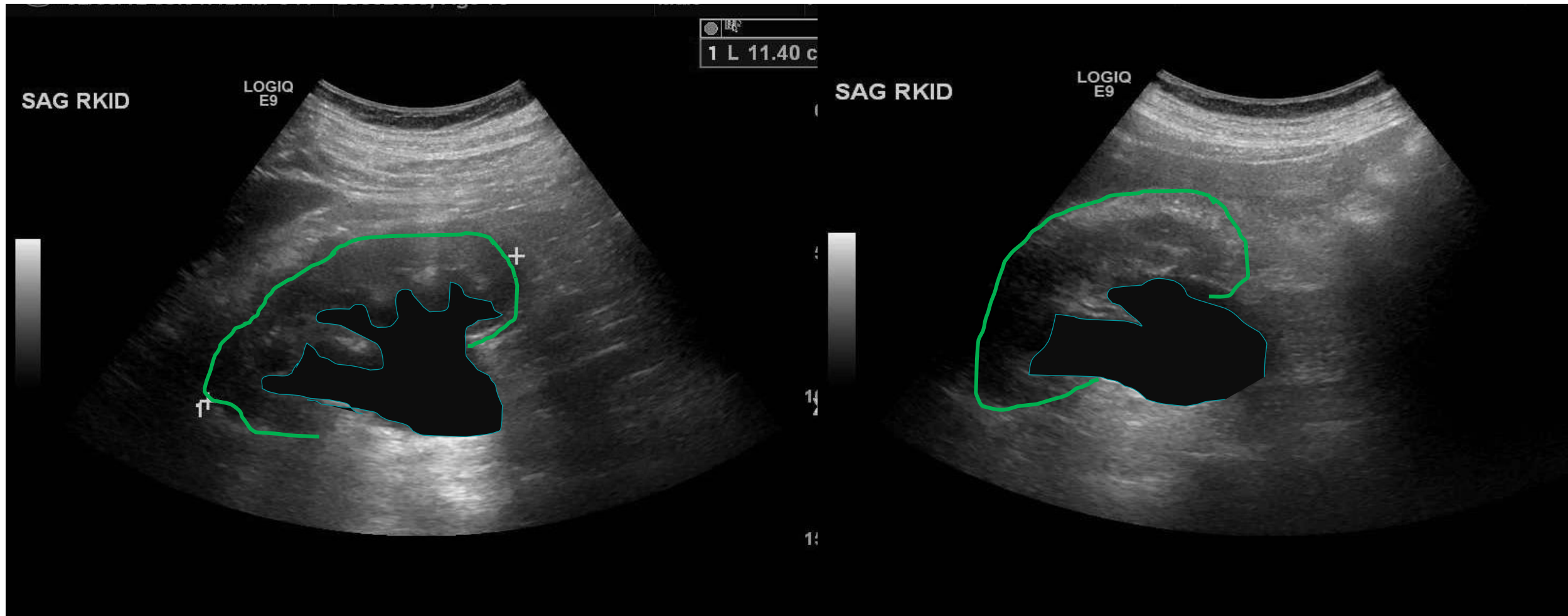
Hydronephrosis

Moderate



Hydronephrosis

Moderate

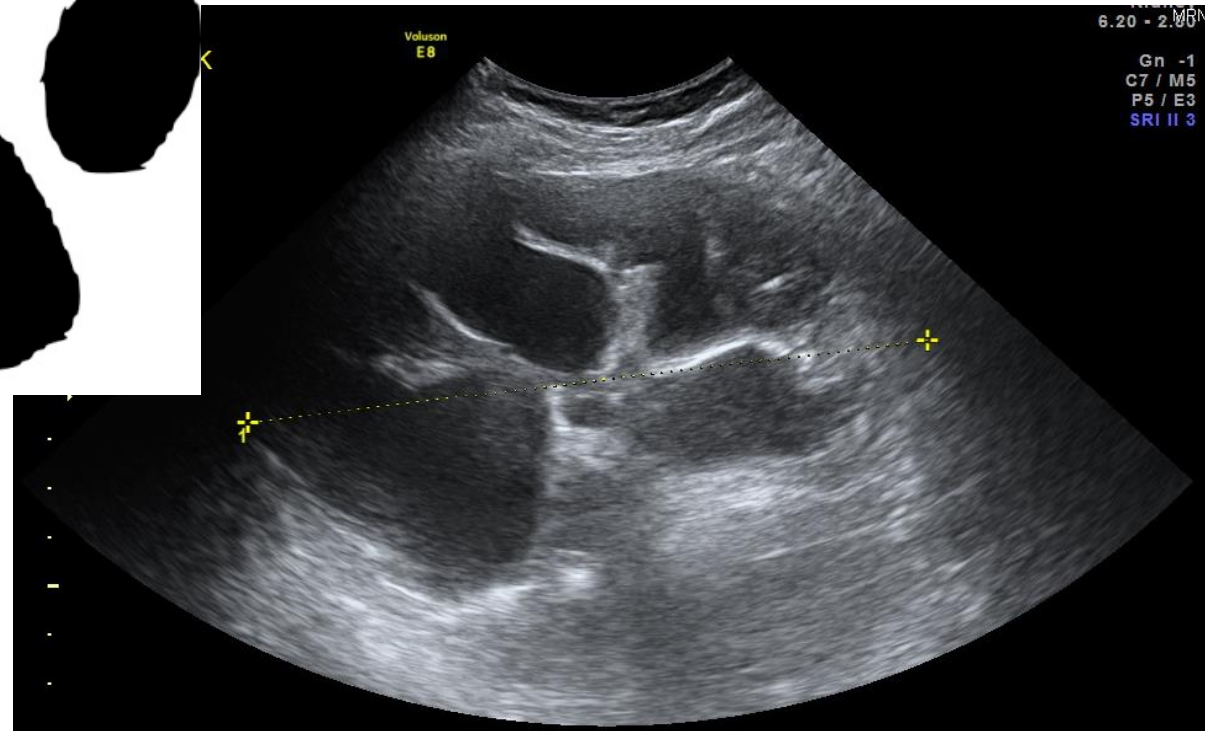


Hydronephrosis

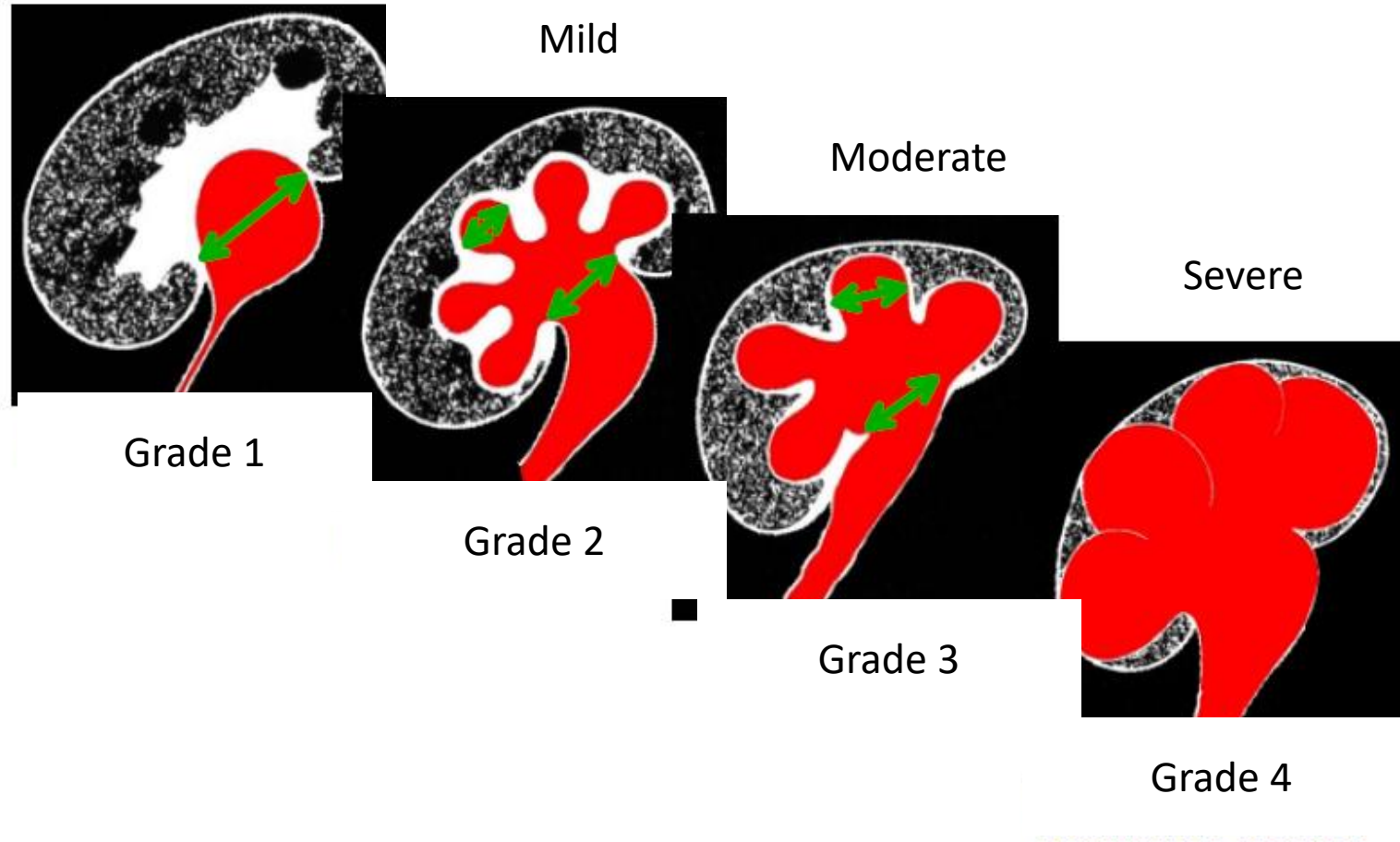
Severe



BEAR-PAW



Hydronephrosis



Hydronephrosis - Pitfalls

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

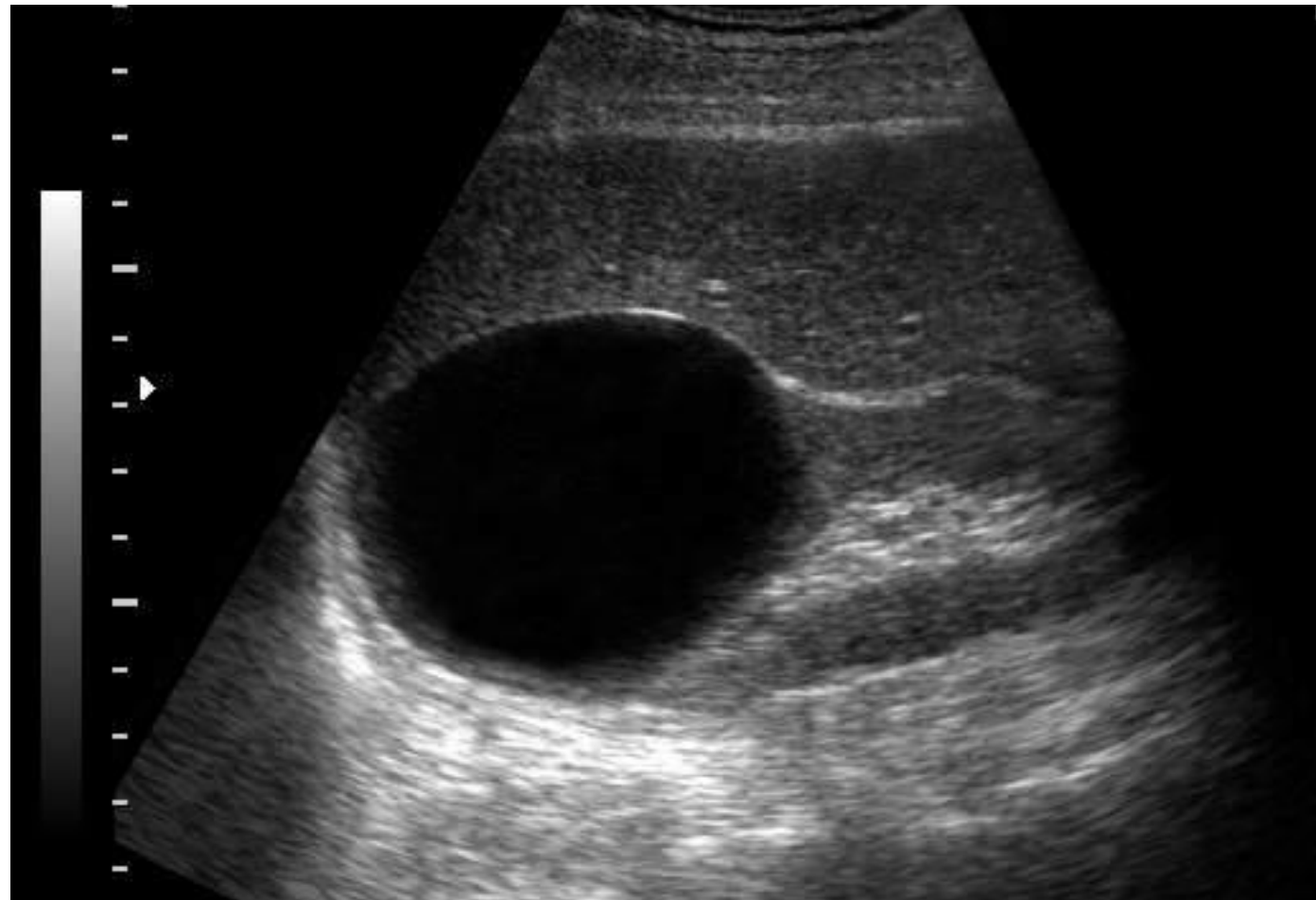
Tc 99 MAG 3 or DTPA + 20-40 mg Furosemide i.v.

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



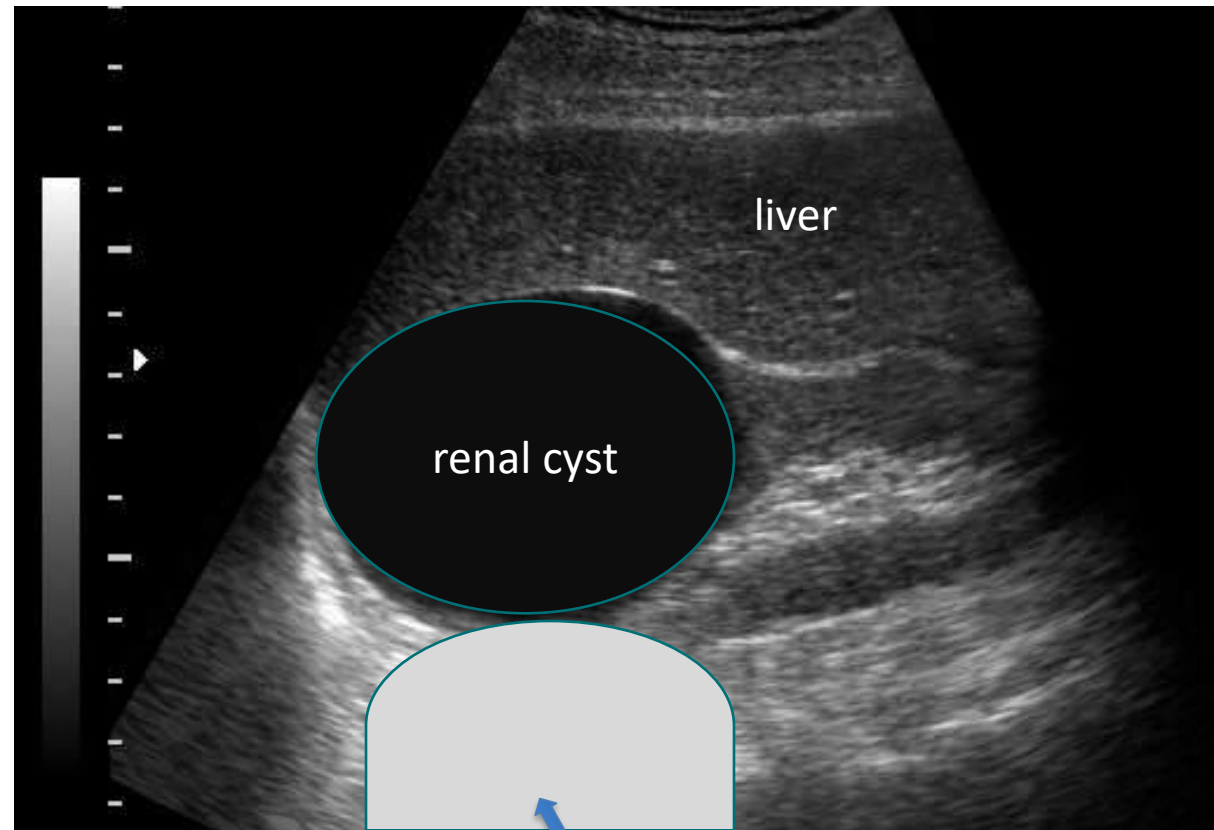
Cysts

Completely anechoic round structure- Simple cyst



Cysts

Simple Cyst – completely anechoic round structure



posterior enhancement

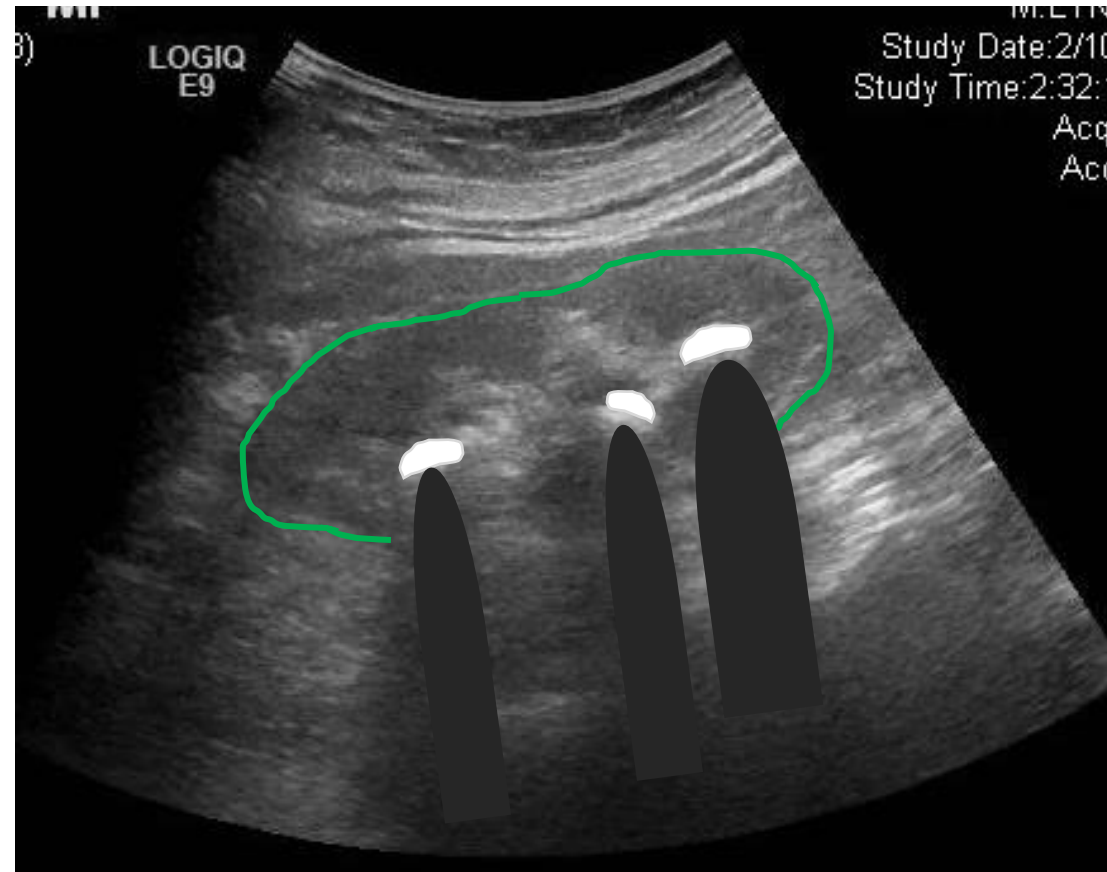
Nephrolithiasis

Kidney with hyperechoic areas with acoustic shadowing

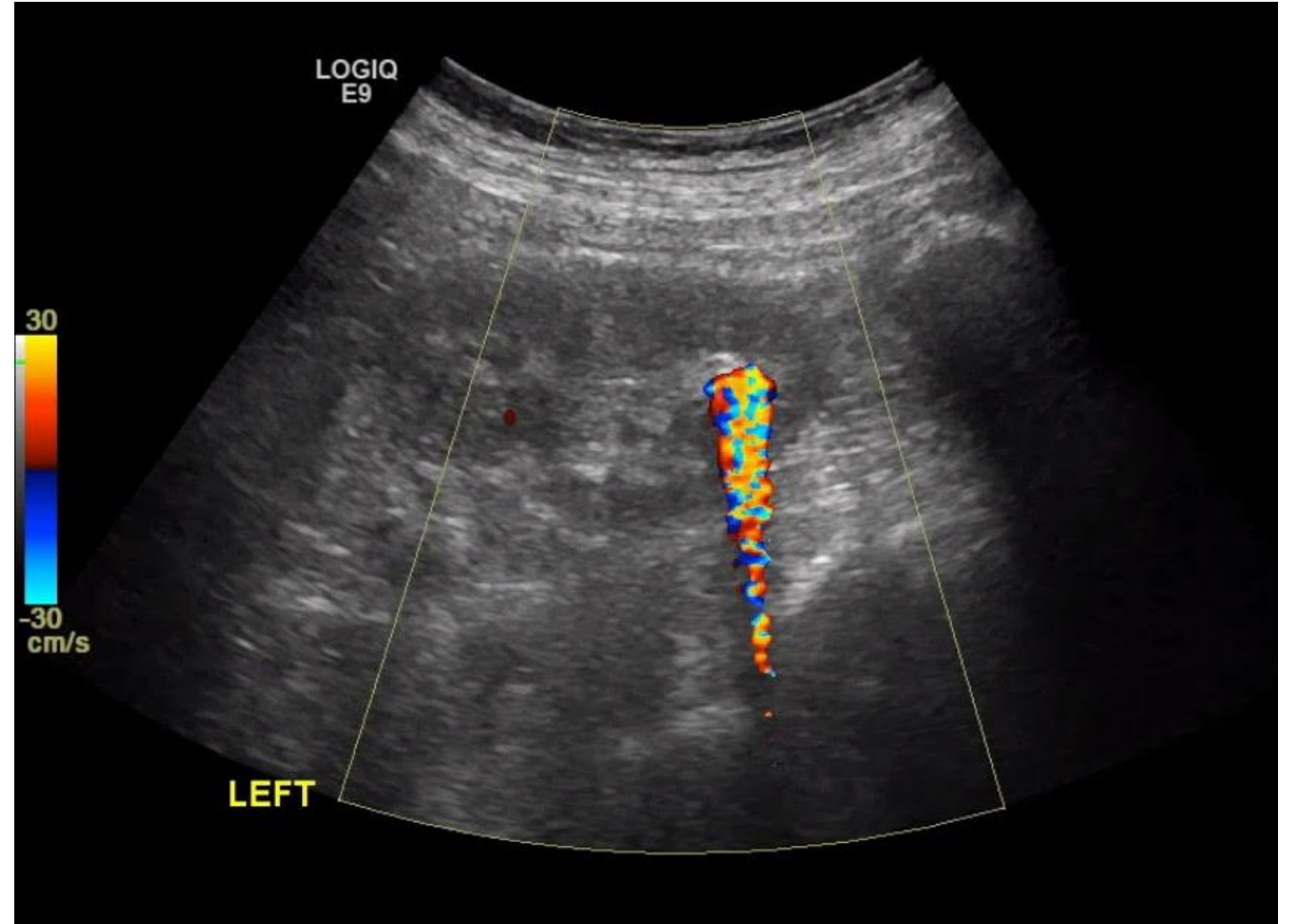
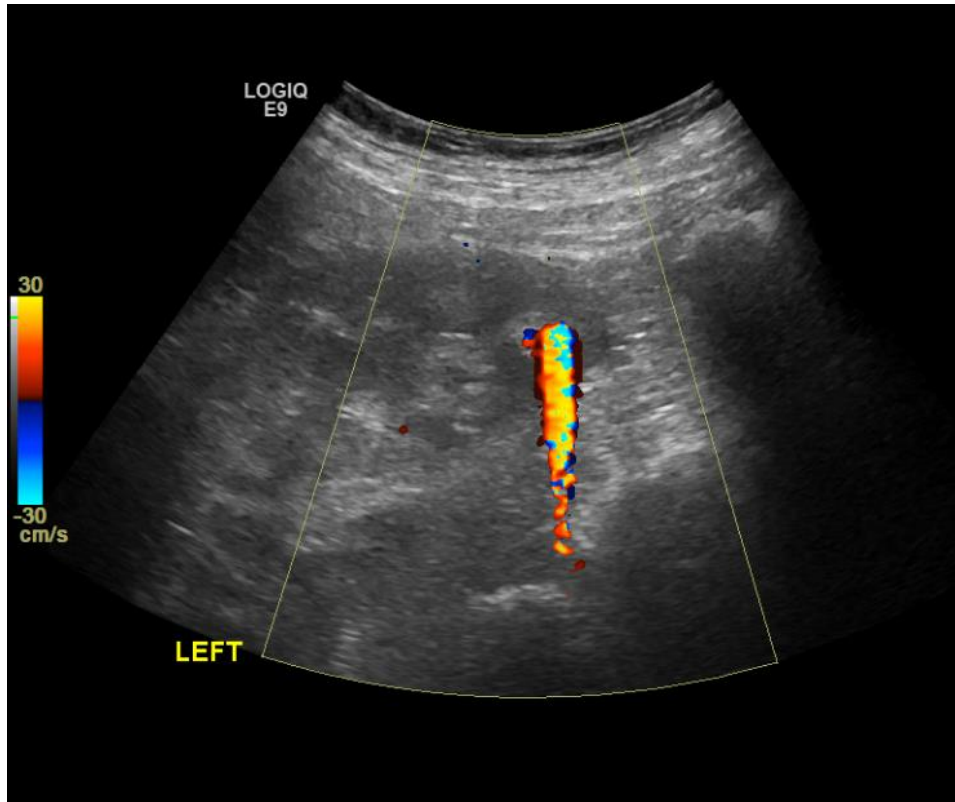


Nephrolithiasis

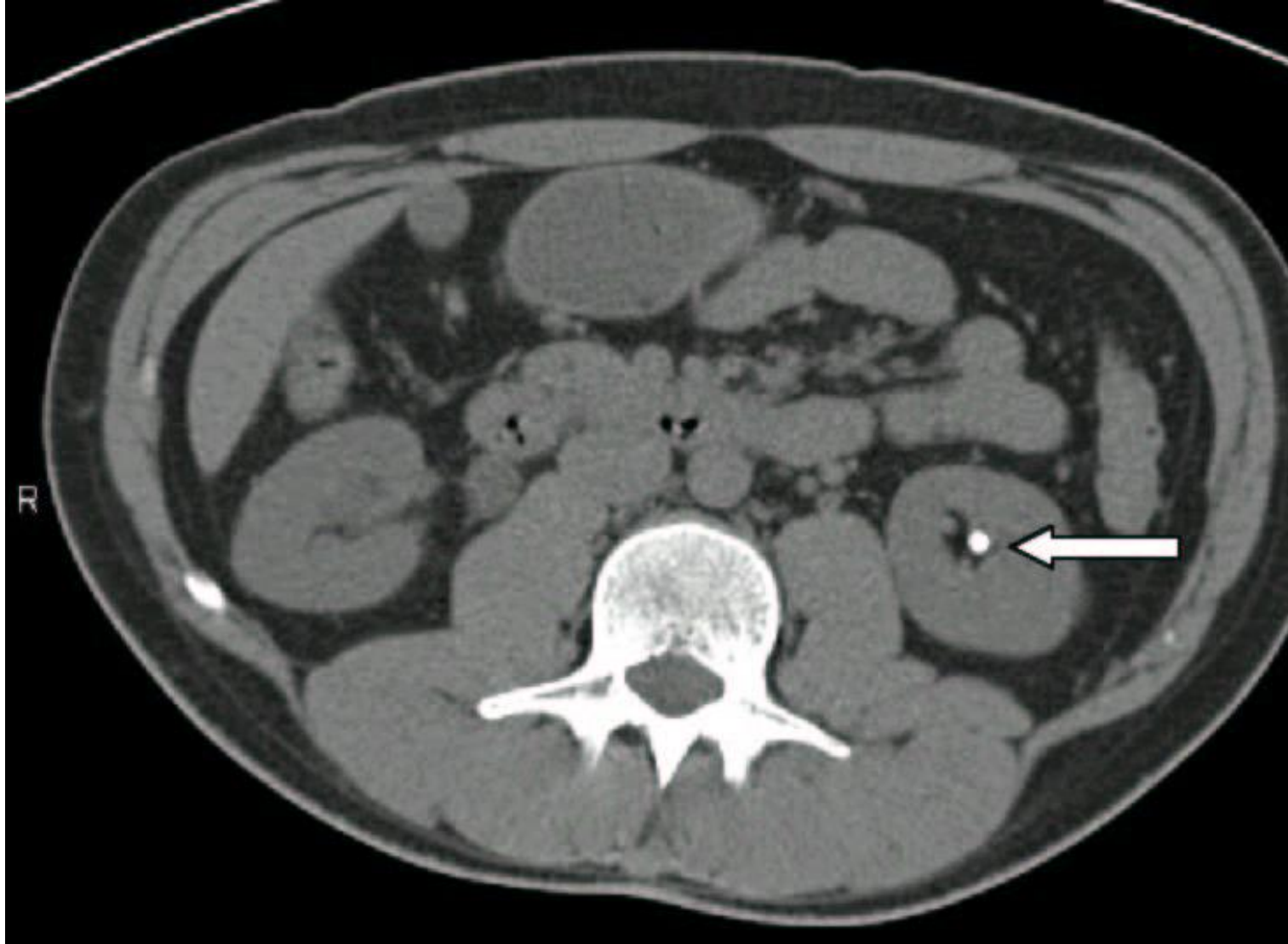
Kidney with hyperechoic areas with acoustic shadowing



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, postvoid residuals	***
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 IN NEPHROLOGY -RENAL ULTRASOUND - SECONDS checklist

Clinical and Experimental Nephrology (2022) 26:486–487

487

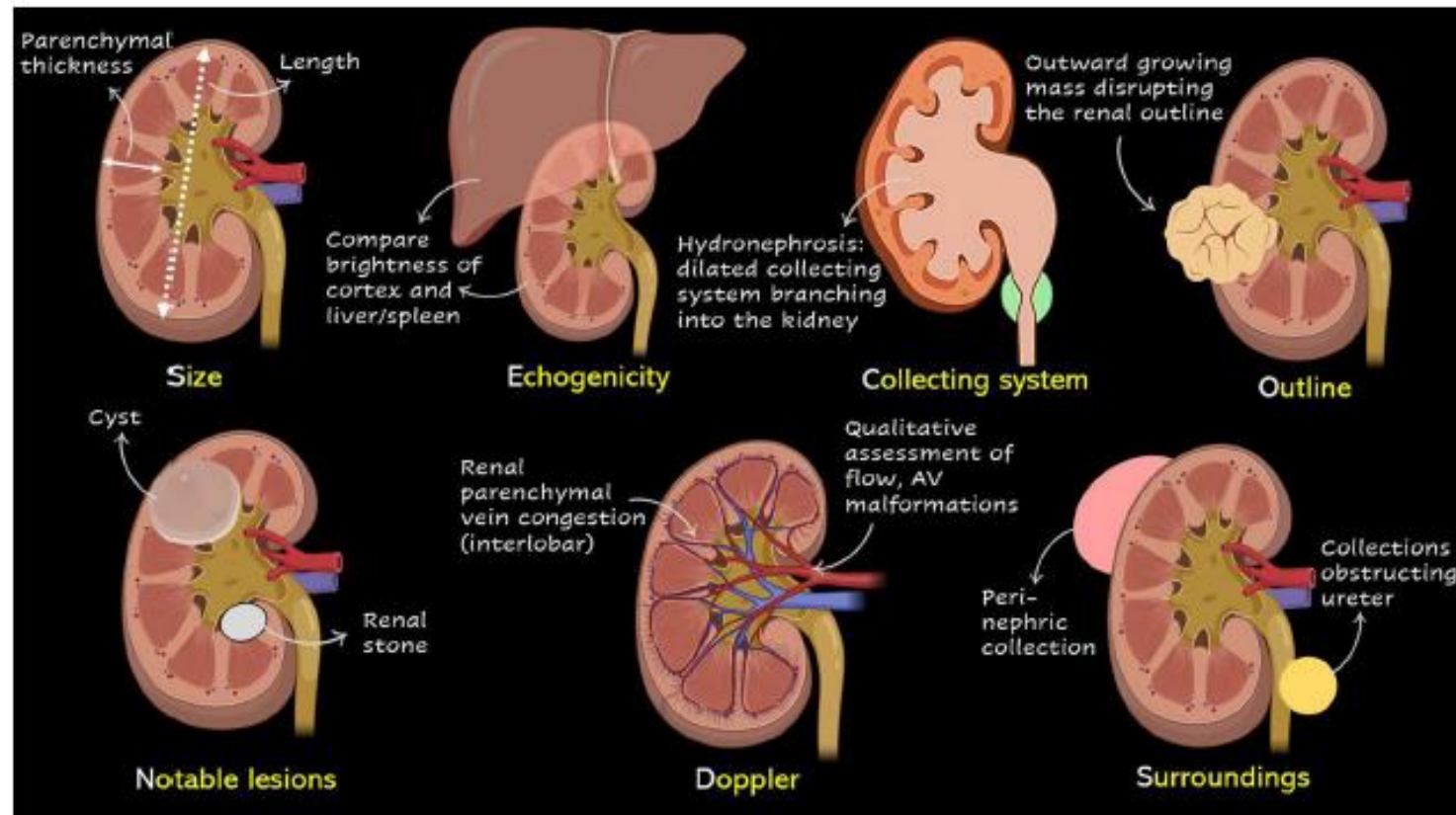


Fig. 1 Summary of the SECONDS checklist for interpretation of point-of-care renal ultrasound. Illustration made using Biorender®

POCUS IN NEPHROLOGY – MULTIPLE APPLICATIONS

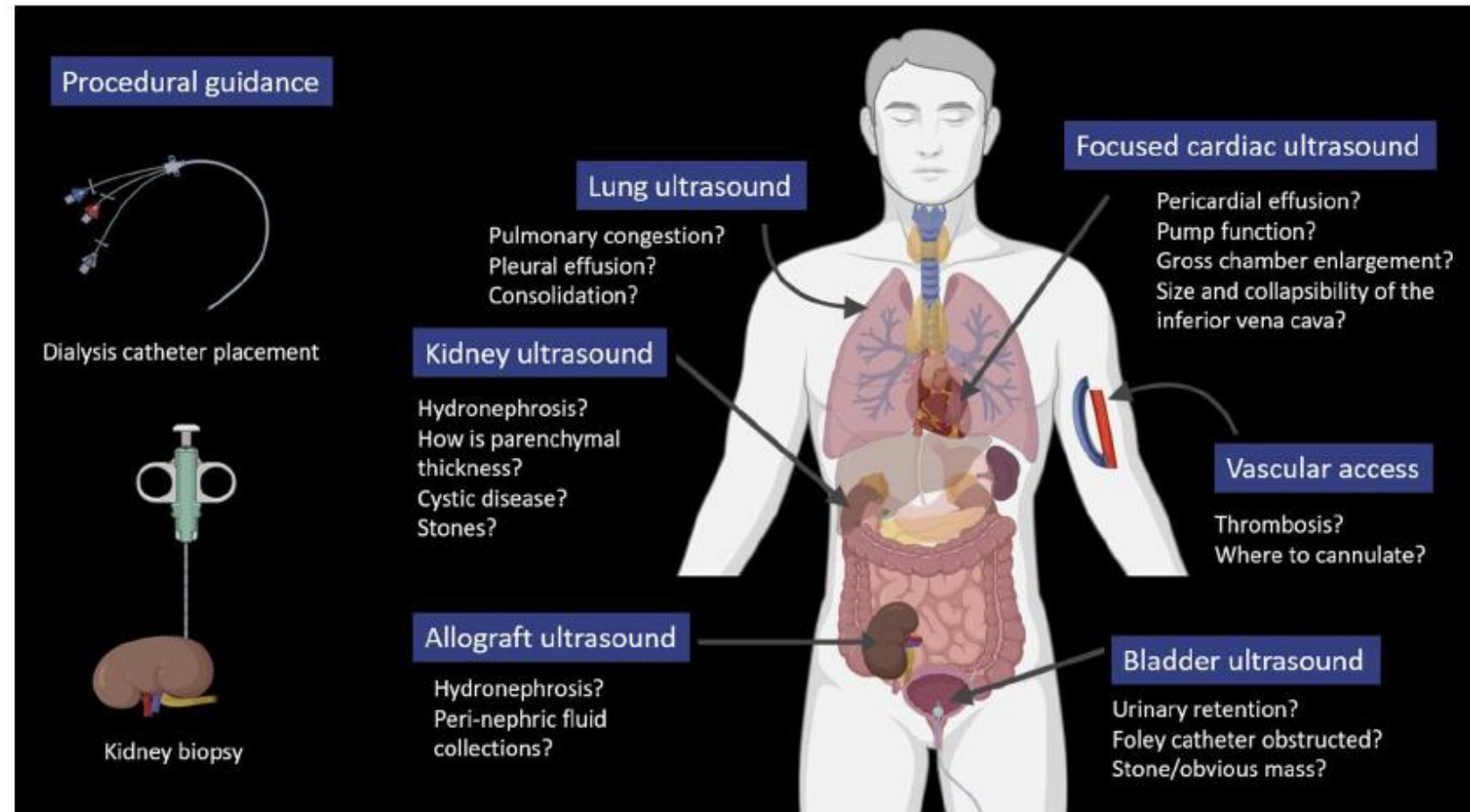


Figure 1. Basic nephrology-related point of care ultrasonography: organs examined and common clinical questions encountered are shown. Created with [BioRender.com](https://www.biorender.com/).

POCUS – Volume Status

Abdominal Ultrasound

IVC Diameter and collapsibility

Pleural effusion

Ascites

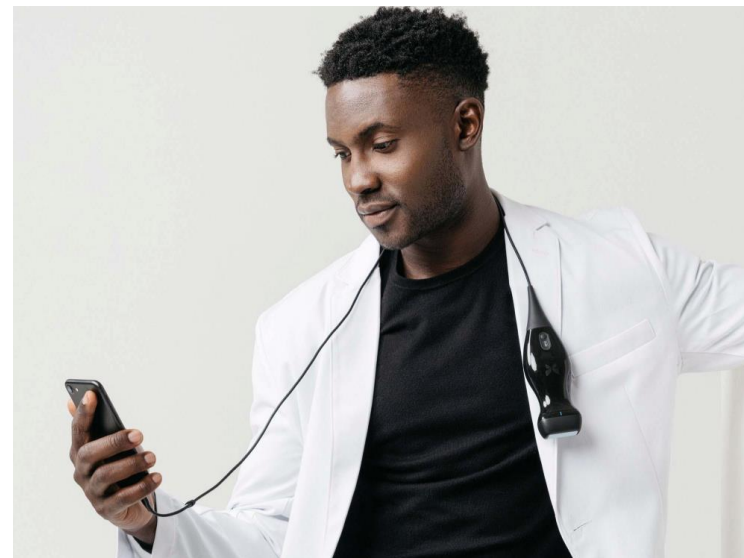
Cardiac Ultrasound

EF, pericardial effusion

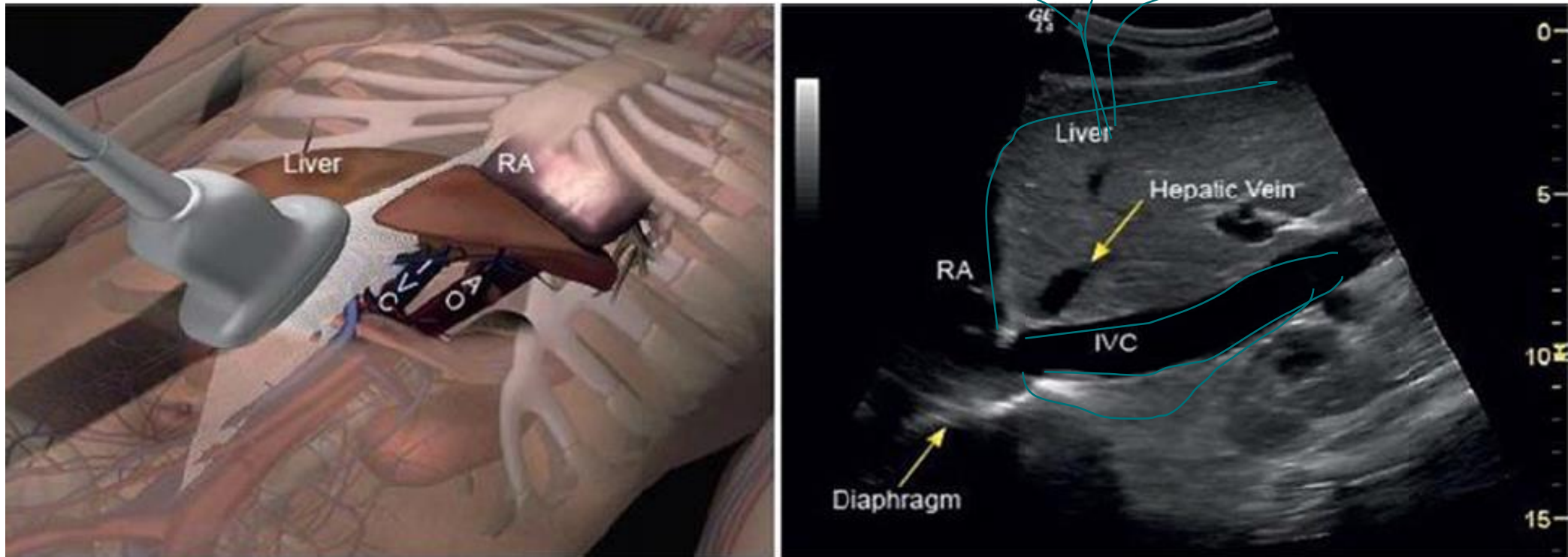
Lung Ultrasound

B lines

A lines



IVC - Ultrasound

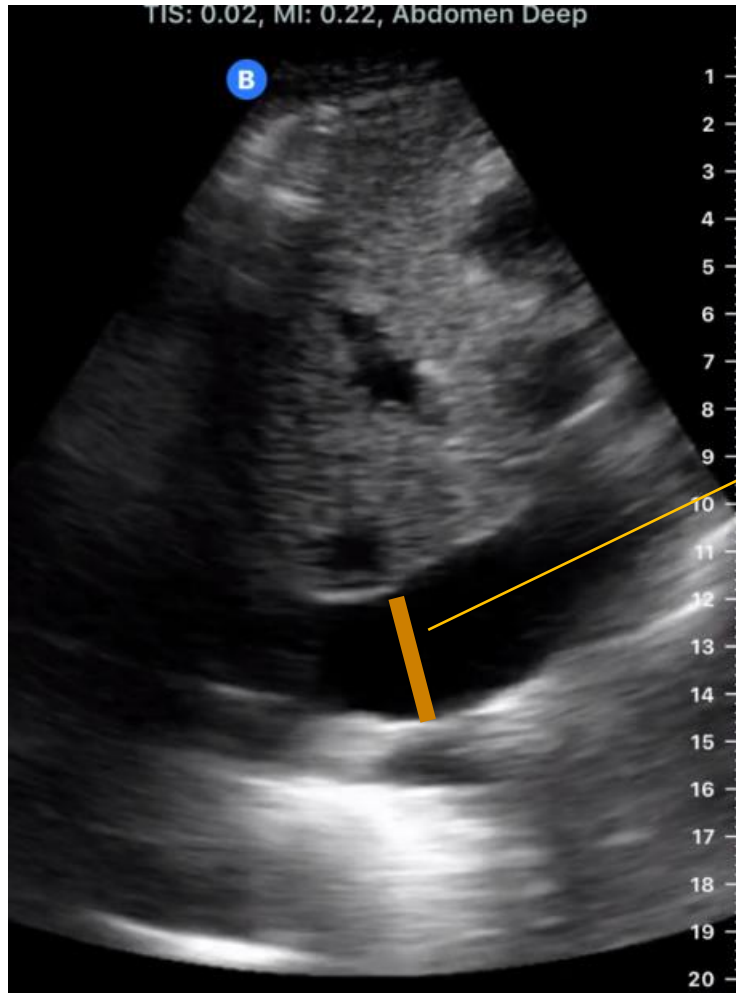


Happy Whale Sign

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

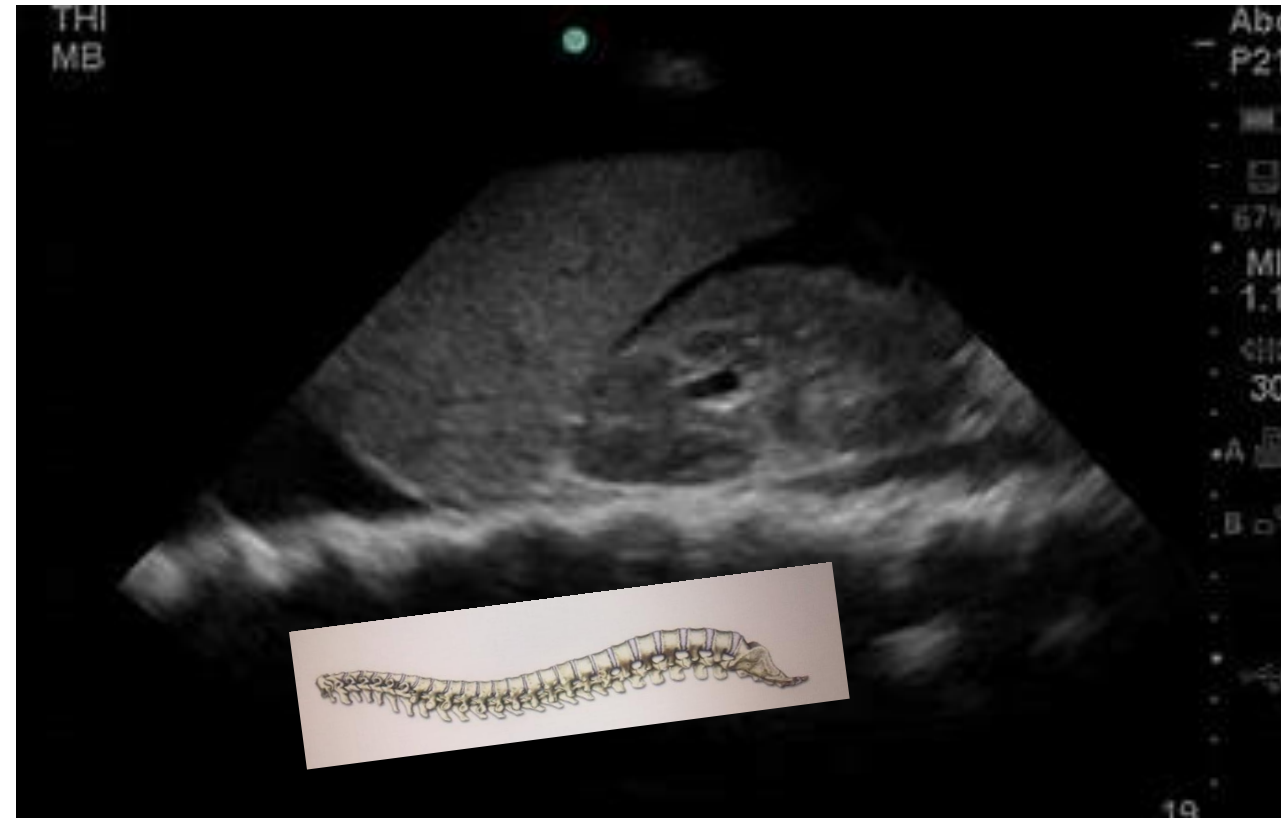
Pleural effusion

Mirror Image Artifact



No Pleural effusion

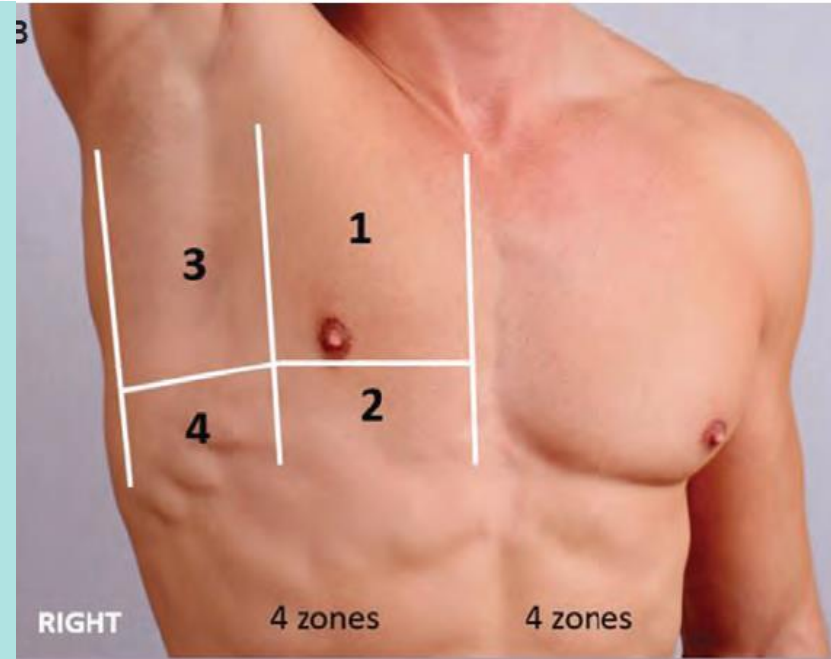
Positive spine sign



Pleural effusion

Lung Ultrasound

8 Zone Lung Ultrasound



Lung Ultrasound

A- Lines



Aerated lung

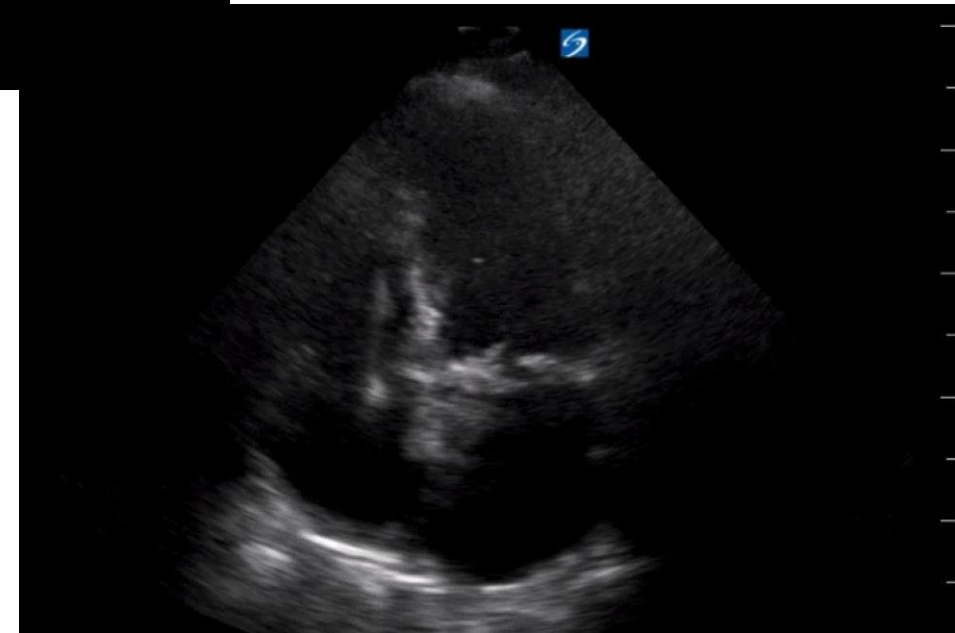
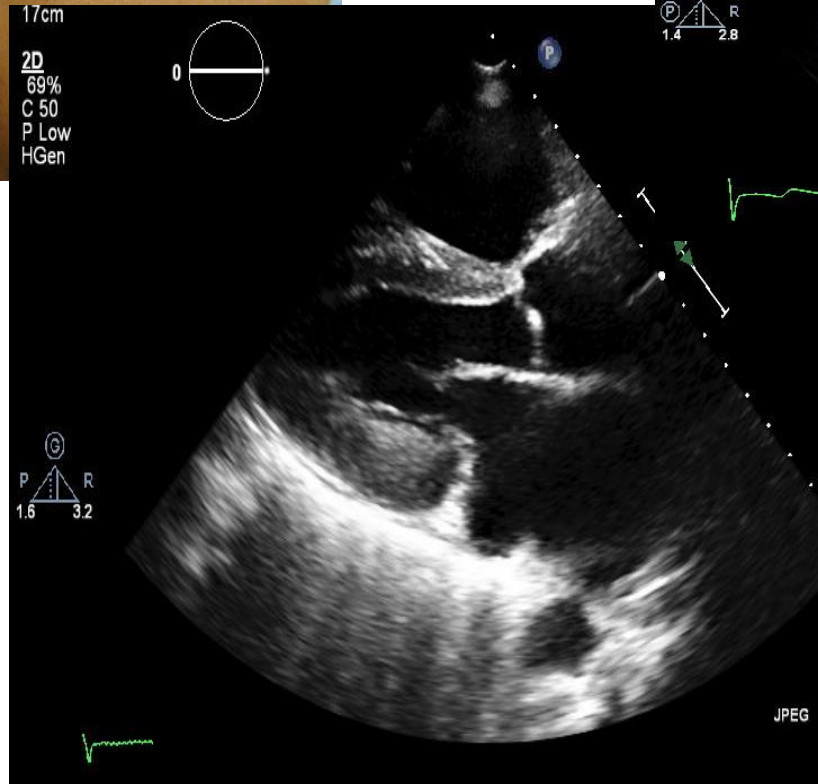
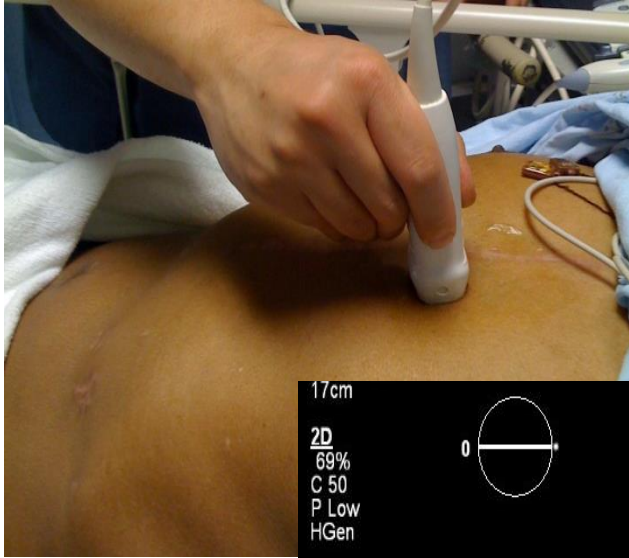
B- Lines



Interstitial thickening
Most frequently fluid



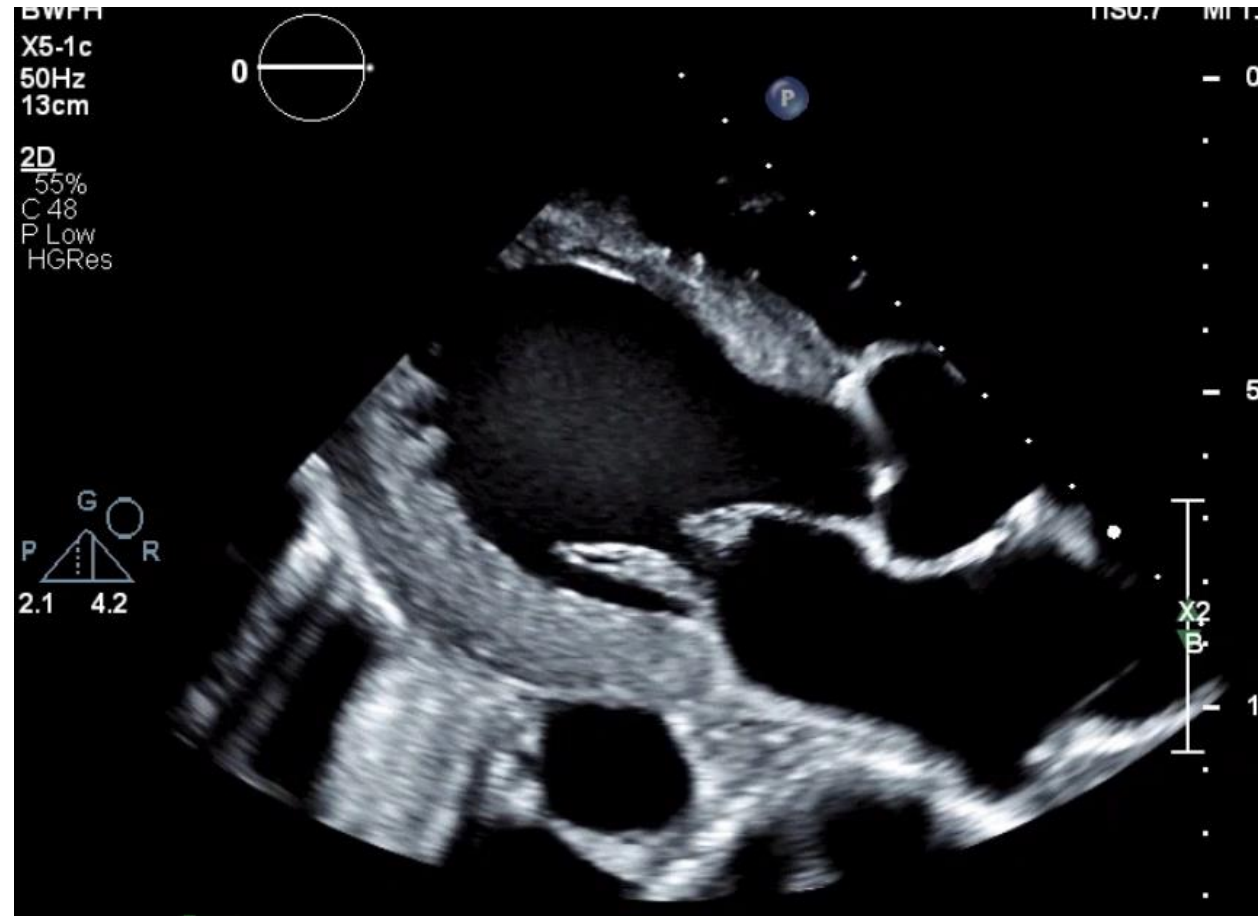
Echo – PSAX, PLAX, 4Chamber



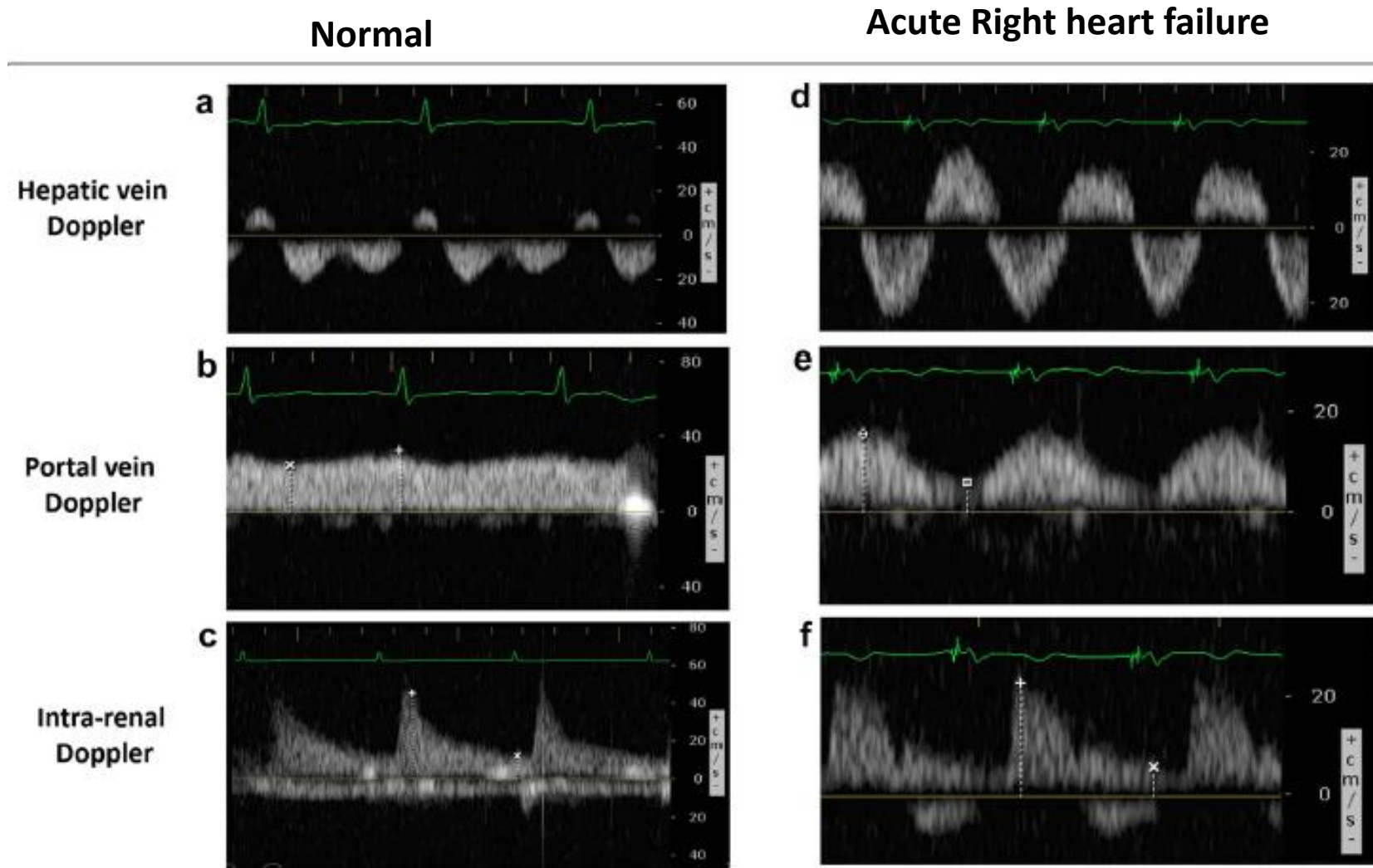
ECHO – Parasternal long axis

Estimating Pump function

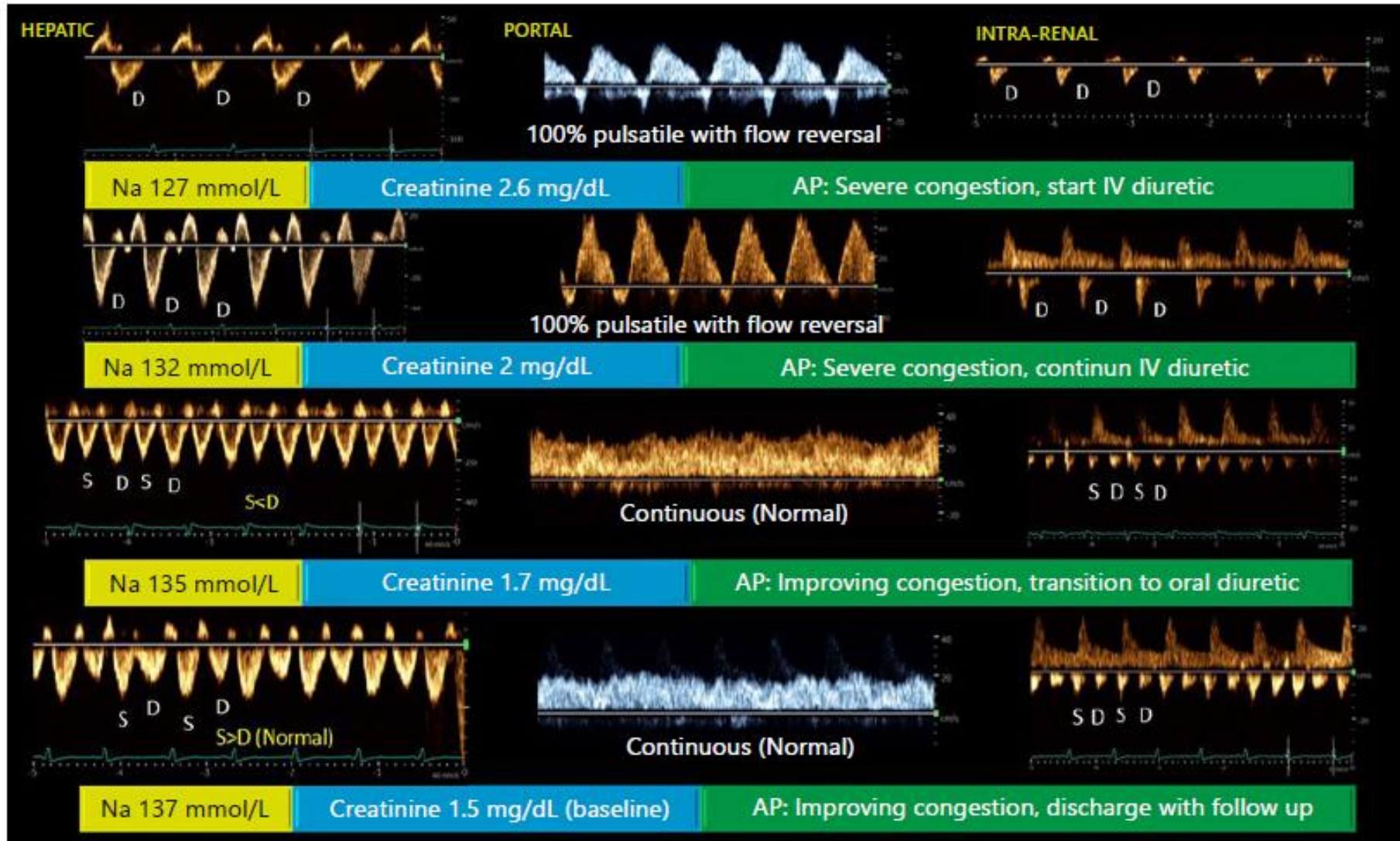
Normal or Decreased



Vexus - Heart failure



Vexus –Hyponatremia



POCUS for redefining AKI in liver disease

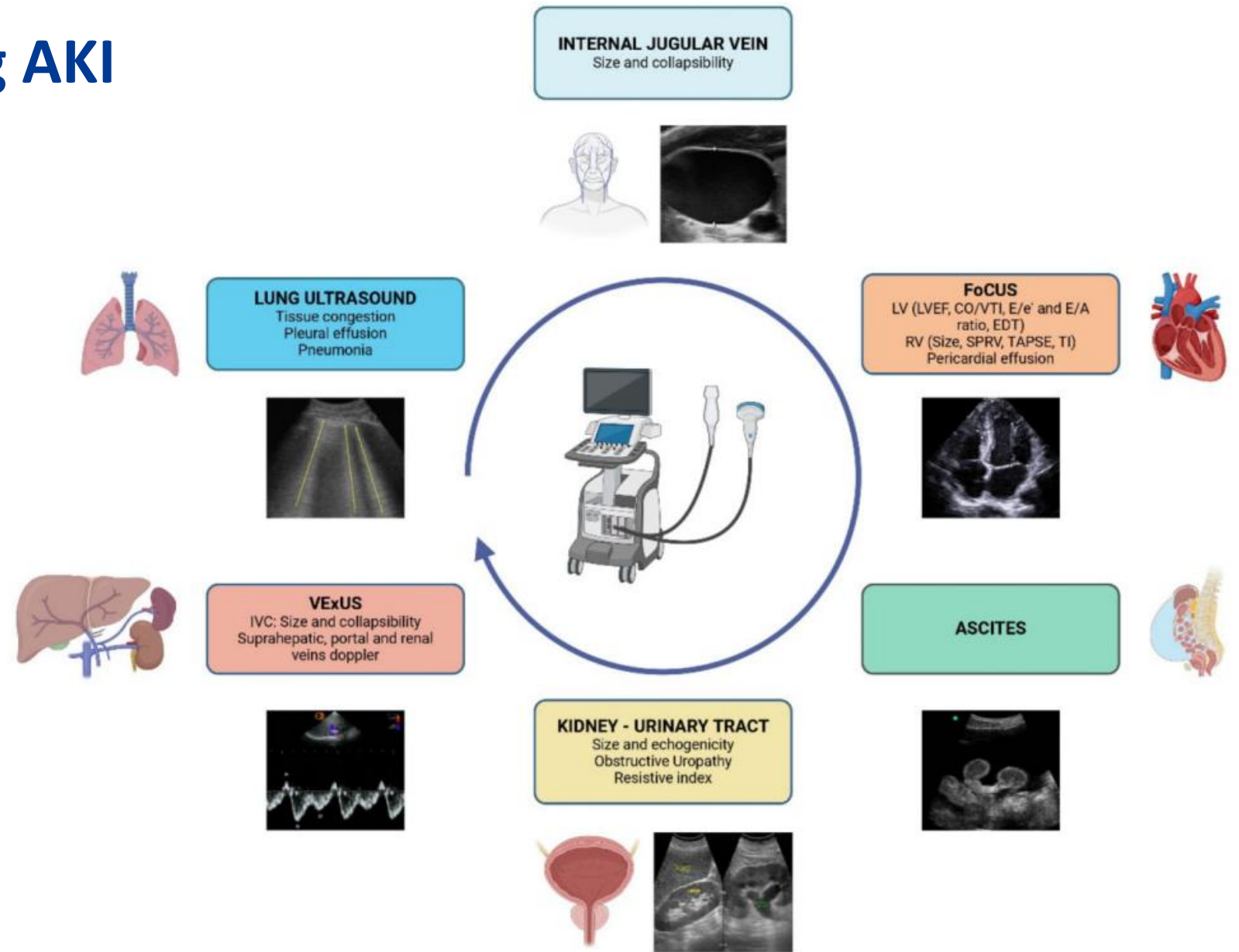


Figure 2: AKI and cirrhosis: multiorgan ultrasound assessment. LVEF: left ventricular ejection fraction; CO: cardiac output; EDT: E wave deceleration time; RV: right ventricle; SPRV: systolic pressure of the RV; TAPSE: tricuspid annular plane systolic excursion; TI: tricuspid insufficiency. Created with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

Take home messages

Every nephrology patient should have a **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 to assess volume status in multiple nephrology scenarios



References

1. O'Neill C: Sonographic evaluation of renal failure. AJKD 35(6): 1021-1038, 2000
2. Gosmanova E et al. Application of ultrasound in Nephrology practice, Adv Chronic Kidney Disease, 16(5):396-404, 2009
3. Moving Points in Nephrology: Renal relevant radiology. Clinical Journal of the American Society of Nephrology, February 2014
4. American College of Radiology – Appropriateness criteria for selection of radiologic imaging: <http://www.acr.org/quality-safety/appropriateness-criteria>
5. Niyyar VD et al. Point of care ultrasound in Nephrology. Kidney International 93: 1052-1059, 2018
6. Ross, D et al: Lung Ultrasound in End stage renal disease. Clinical Kidney Journal 11: 172-178, 2018
7. Argaiz E et al: Comprehensive assessemnt of Fluid Status by Point of Care Ultrasonography. Kidney 360, 1326–1338, 2021
9. ASDIN (American Society of Diagnostic and Interventional Nephrology) website
10. Beaubien-Souligny W et al. Quantifying systemic congestion with POCUS: development of the venous excess ultrasound grading system. Ultrasound Journal 2020
11. Korotala A et al– An Introduction to Point of Care Ultrasound: Laennec to Lichtenstein Adv Chron Kidney Dise 2021
12. Korotala A – Point of Care Renal Ultrasound: the Seconds checklist. Clinical and Experimental Nephrology 2022
13. Argaiz E et al. Bedside Ultrasound in the management of Cardiorenal Syndromes. Cardiorenal Medicine 2023

