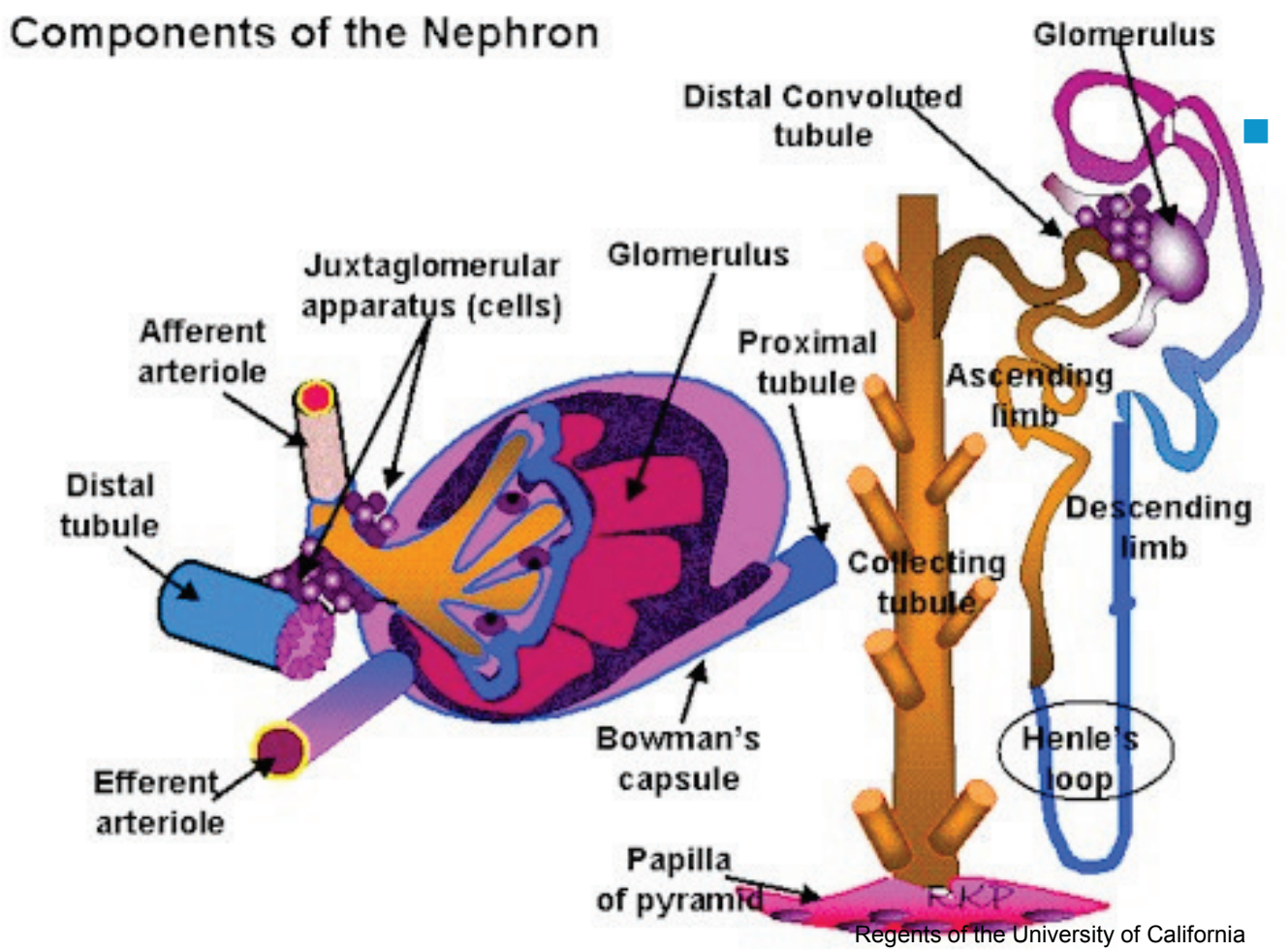
VGHKS

Nuclear Imaging - GU System

Physiology

- Excretory function:
  - Passive filtration through the glomerulus
  - Active secretion by the tubules
- Normal glomerular filtration rate (GFR): 125 ml/min
- inulin



Radiopharmaceuticals

- Tubular secretion:
  - ^{131}I-OIH
  - ^{99m}Tc-MAG3: 95% proximal tubules, <5% filtration, extraction fraction 40-50%
- Glomerular filtration:
  - Tc-DTPA
- Cortical: bind to renal tubules
  - ^{99m}Tc-DMSA: bind to proximal tubules

Reference: 1. NM in clinical Dx and Tx p1570 2. Fundamentals of nuclear pharmacyp277-286	^{123}I/ ^{131}I - OIH	Tc-MAG3	Tc-DTPA	Tc-glucoheptonate	Tc-DMSA
Extraction fraction	**88%** → 60% at 1st hr	54 % (40%)	20%		4-8%
Protein binding	70%	**90%**	**5-10% (<2%)**	50-75%	75%
Glomeruli	20%	<5%	100%	+	20%
Proximal tubular excretion		95 %	0%		100 %
Distal tubular	80%	0 %	0%	+	0 %
% in urine		70% at 30 min	100 % by 6 h		10 % by 6 h

Clinical applications

- Diffuse renal disease
- Vascular abnormalities
- Obstructive uropathy
  - Routine functional imaging and renography
  - Diuretic renography
- Pediastric hydronephrosis
- ACEI (captopril) renography
- Acute pyelonephritis
- Renal masses
- Radionuclide cystography
- Renal transplant evaluation

Radionuclide renal evaluation

1. Functional imaging: perfusion and function
2. Renography: time-activity curves
3. Quantification of renal function: GFR, ERPF
4. Anatomic imaging: renal cortex

1. Functional renal imaging

- Renal perfusion imaging
  - Posterior projection: native kidneys
  - Anterior projection: transplanted kidney
- Renal function imaging
  - ^{99m}Tc-MAG3
    - Maximal parenchymal activity: 3-5 mins
    - Collecting system and UB: 4-8 mins

2. Renography

- Time-activity curve:
  - uptake and excretion of a radiopharymaceutical by the kidneys
- ^{99m}Tc-MAG3(tubular secretion)
  - Three phases
    - Vascular transit phase: 30-60 s
    - Cortical or tubular concentration phase: 1-5 min
    - Clearance or excretion phase
- Well-hydration

2. Renography

- Time to peak activity: 3-5 mins
- Relative renal uptake ration at 2-3 mins: <40% abnormal
- Half-time excretion: normal 8-12 mins
- Differential cortical retention at 15 mins: differences >20% abnormal
- The 20-mins-to-peak count ratio:normal <30%

3. Quantitation of renal function

- GFR:
  - Inulin- entirely filtered
  - ^{99m}Tc-DTPA
- Renal plasma flow:
  - I-131 PAH and I-131 OIH: both filtered and secreted by the tubules
  - ^{99m}Tc-MAG3: primarily secreted by the tubules
  - Effective RPF (ERPF)
- Plasma sample-based clearances
- Camera-based clearances

4. Anatomic (cortical) imaging

- Space-occupying lesions
- Functional pseudotumors
- Edema
- Scarring associated with acute or chronic PN: children
  - ^{99m}Tc-DMSA, ^{99m}Tc-glucoheptonate

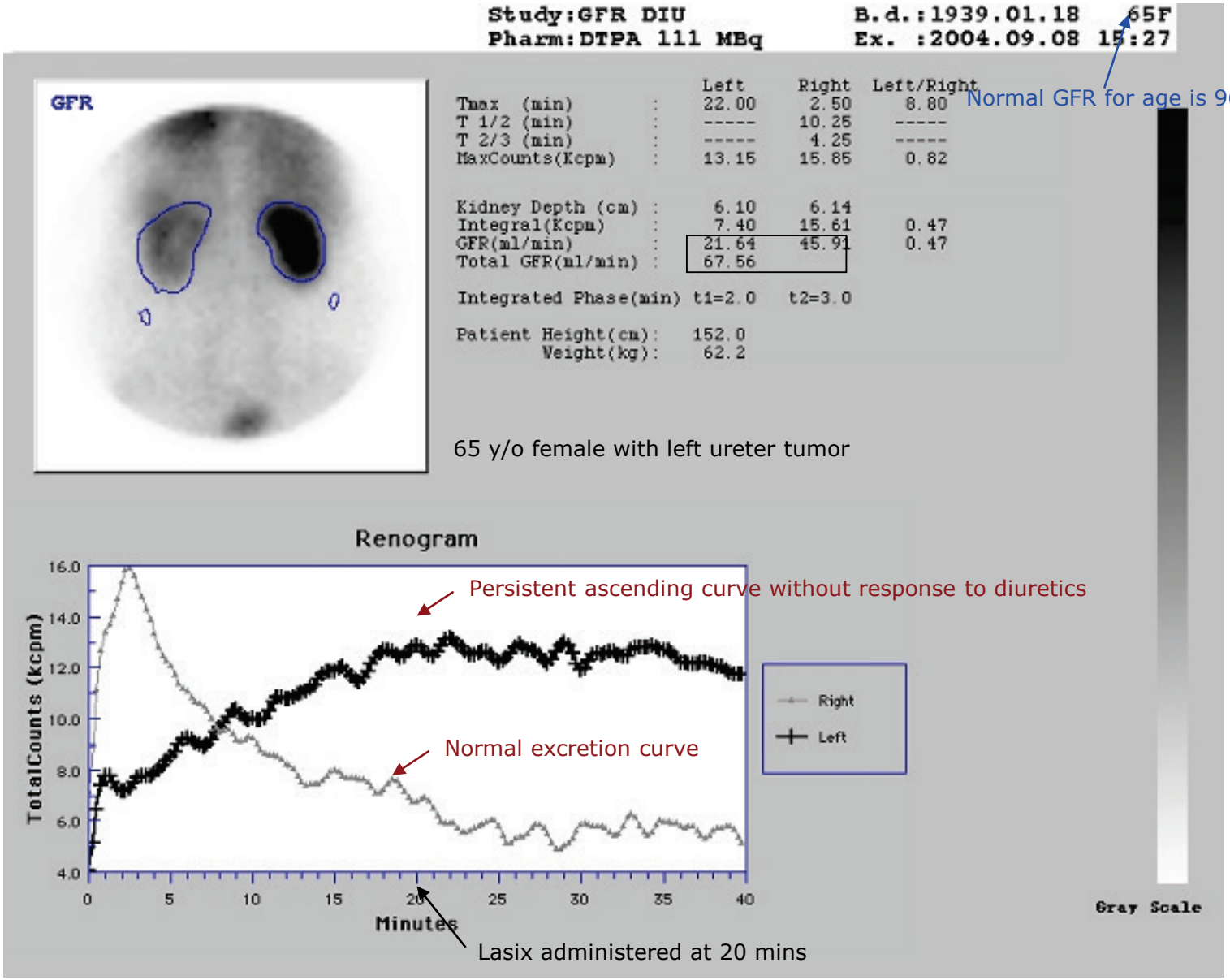
In our institute – GU system

1. Diuretic renogragm (GFR)
2. Captopril renography
3. DMSA scan
4. Direct radionuclide cystography (DRC)

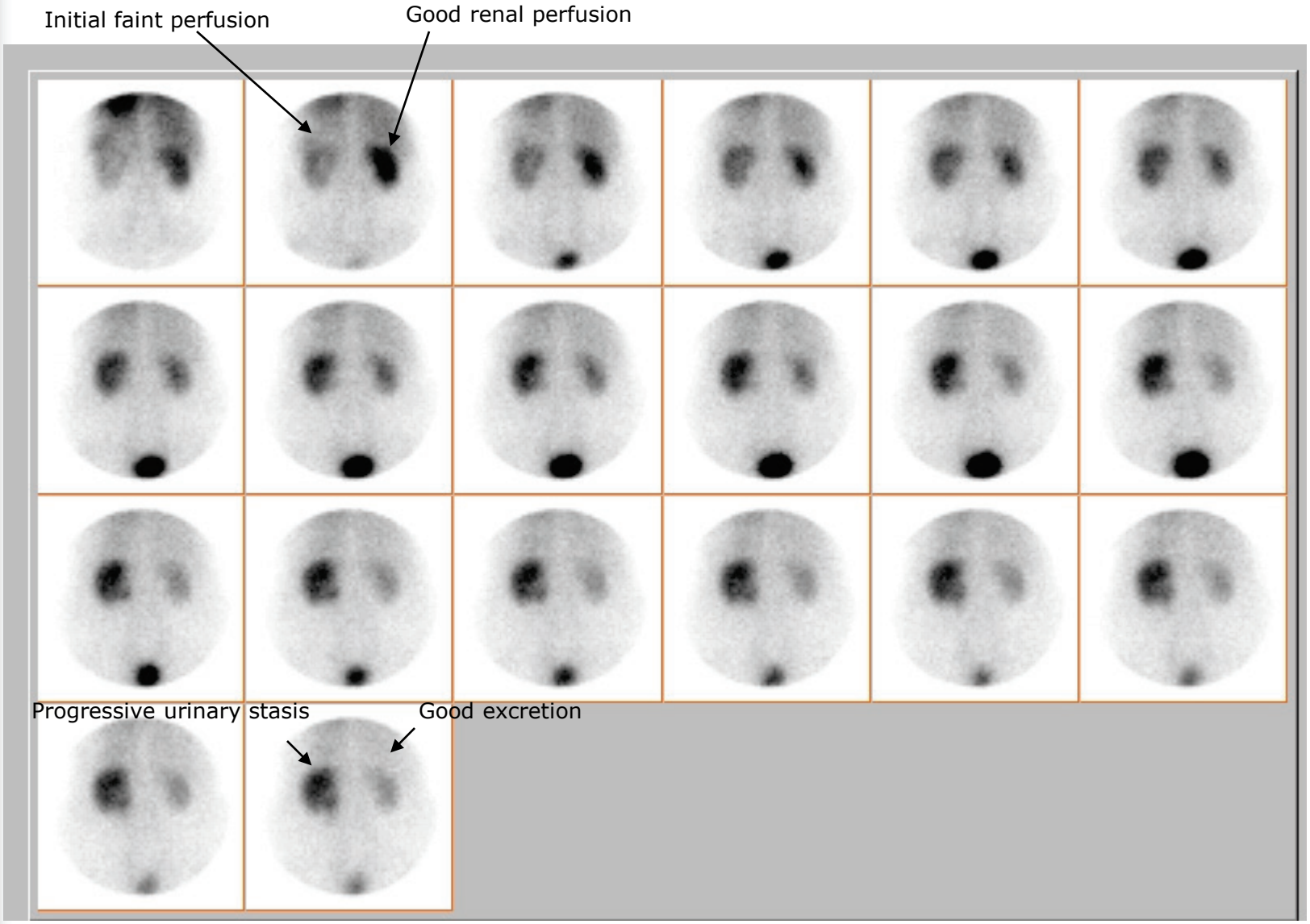
1. GFR protocol

- ^{99m}Tc-DTPA 3 mCi, furosemide 40 mg
- Posterior projection
- Serial imaging 40 mins

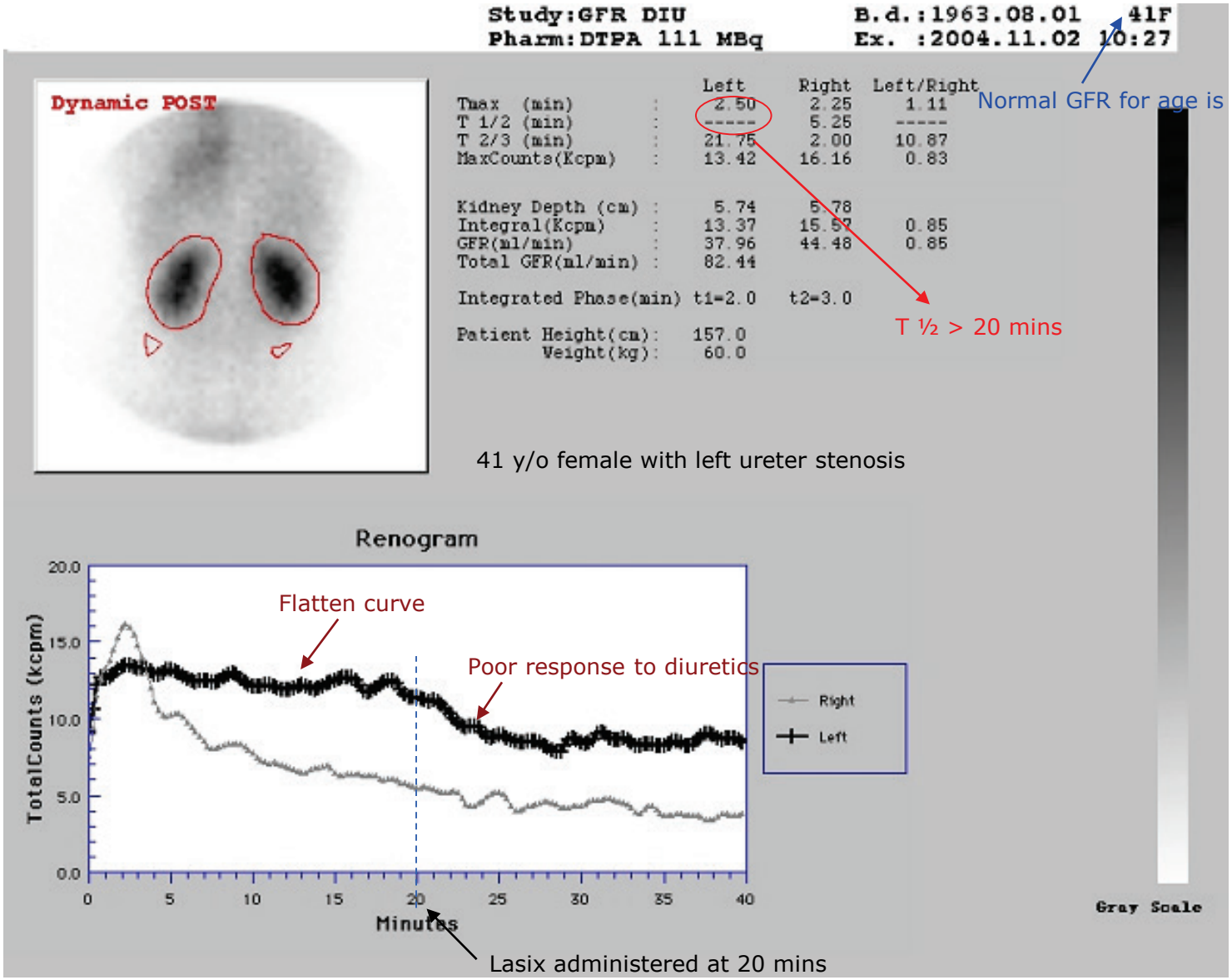
Obstructive uropathy



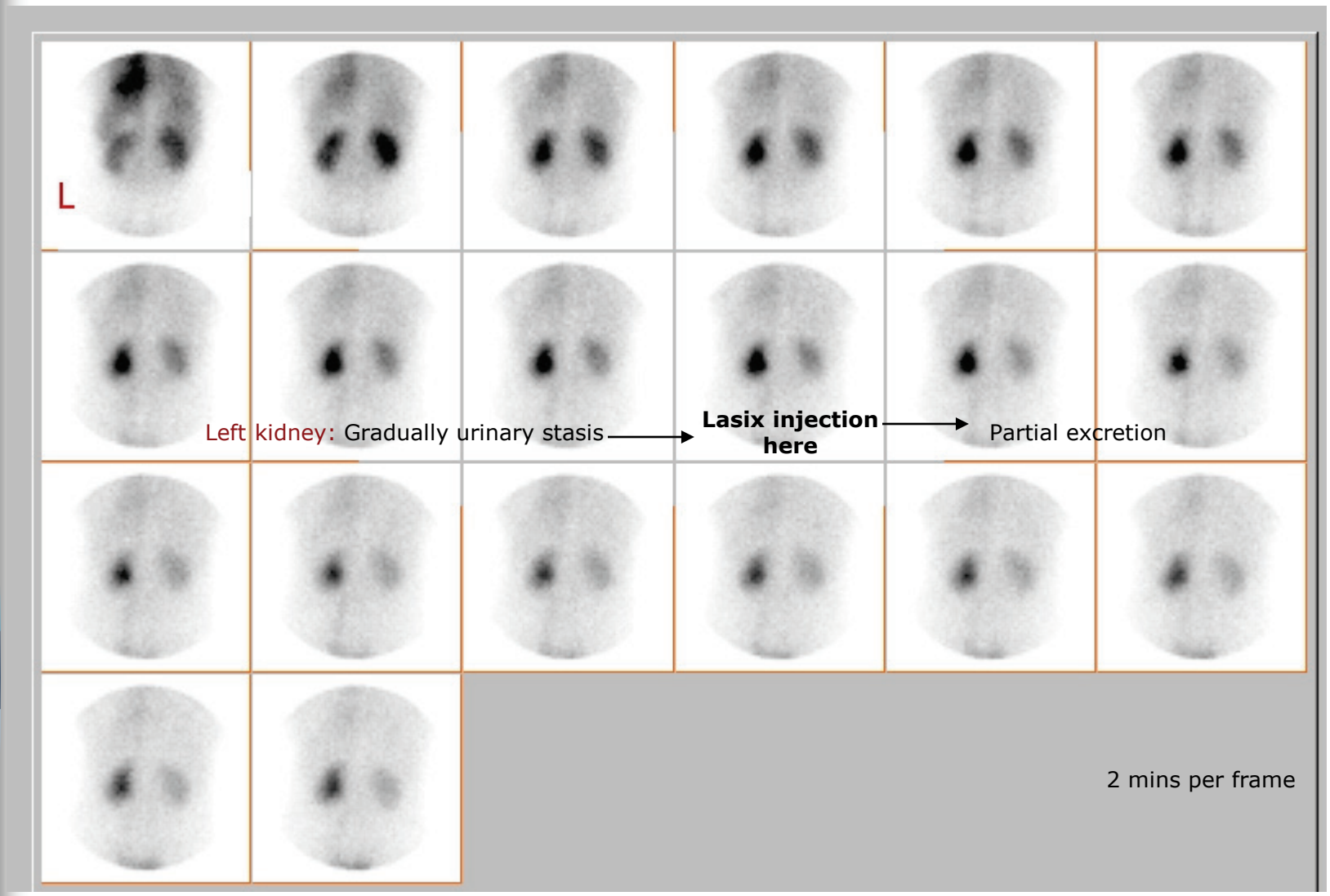
Obstructive uropathy



Obstructive uropathy

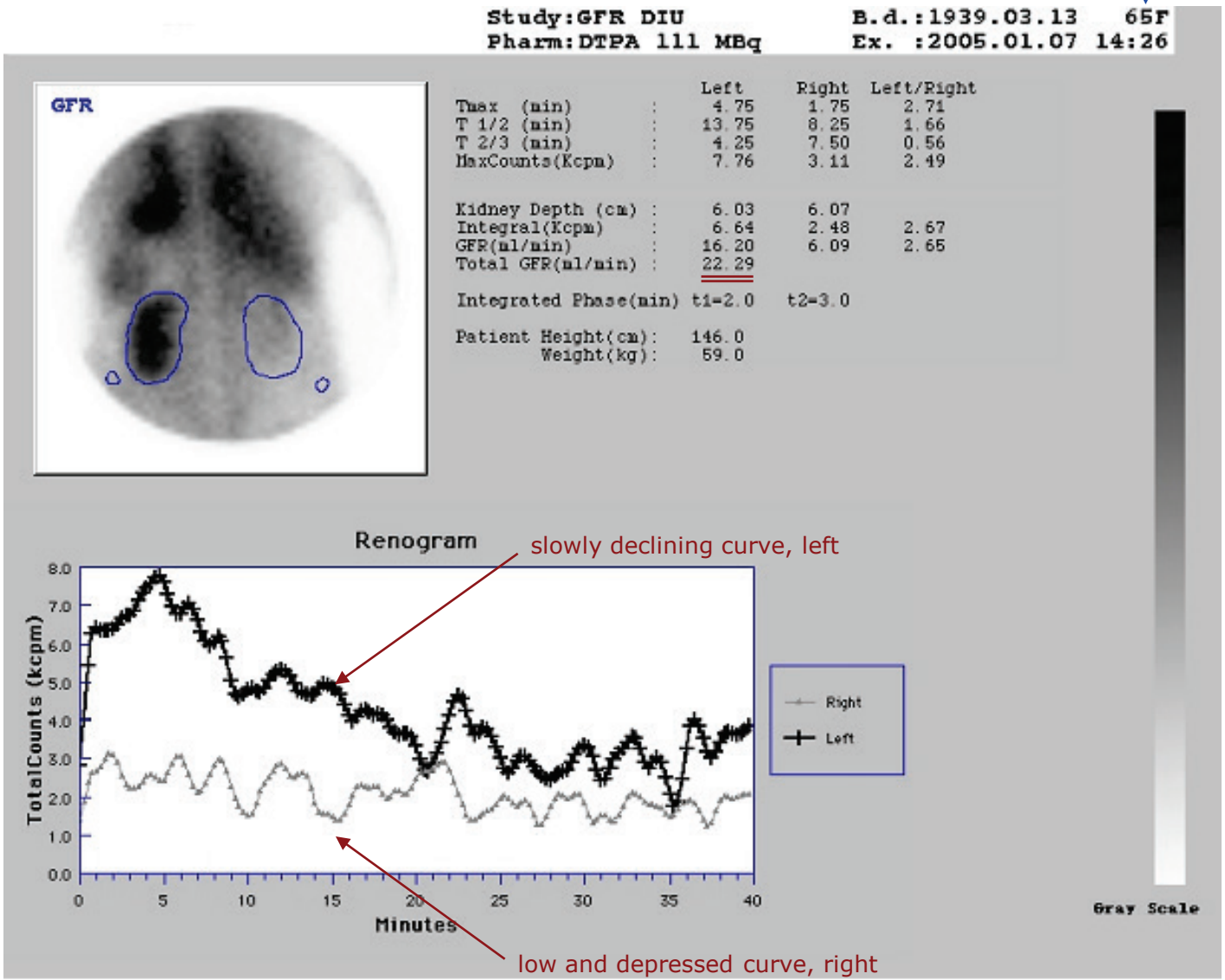


Obstructive uropathy



Bilateral poor renal function

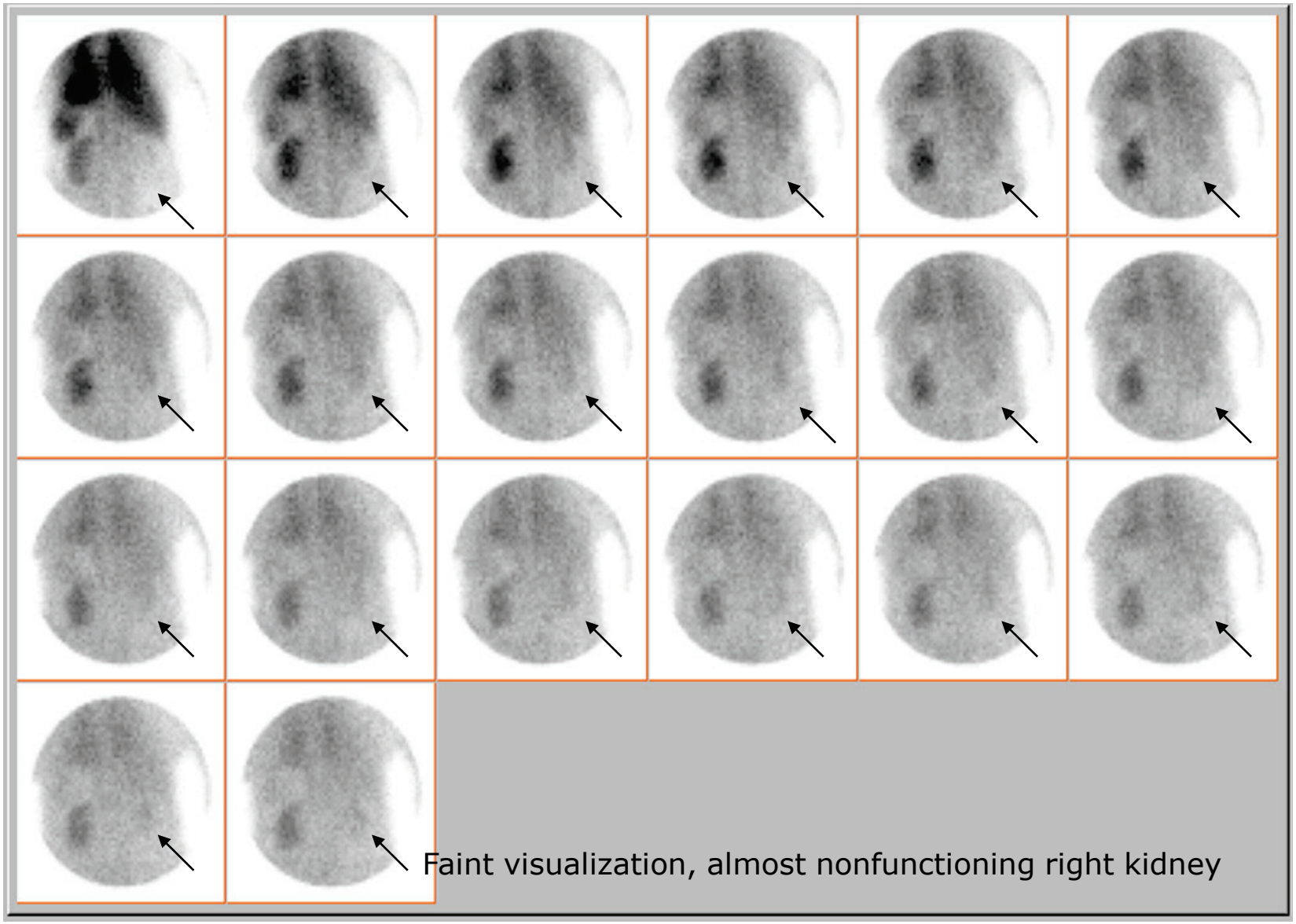
Normal GFR for age is 73 – 96 ml/min



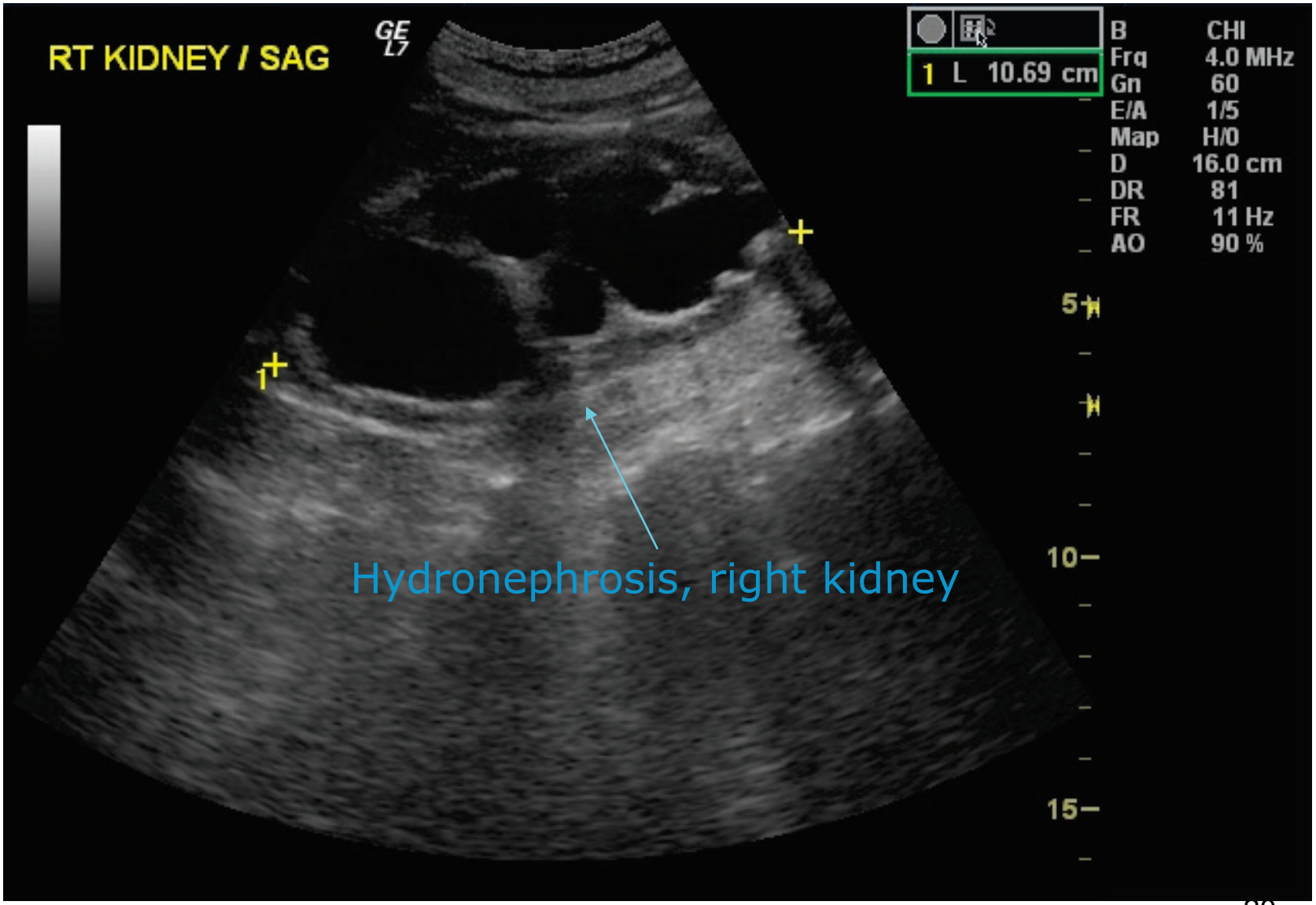
slowly declining curve, left

low and depressed curve, right

Bilateral poor renal function



Bilateral poor renal function

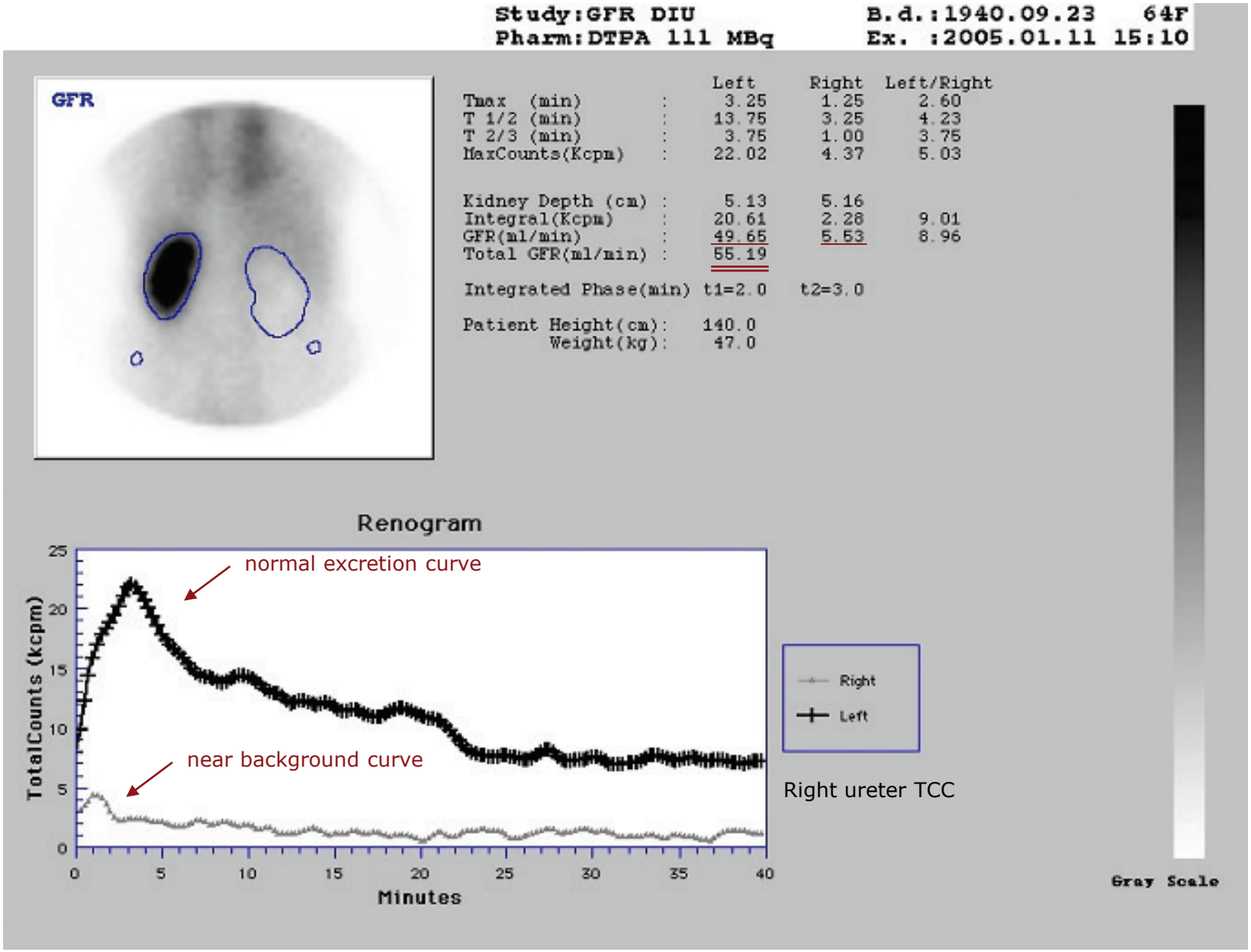


Bilateral poor renal function

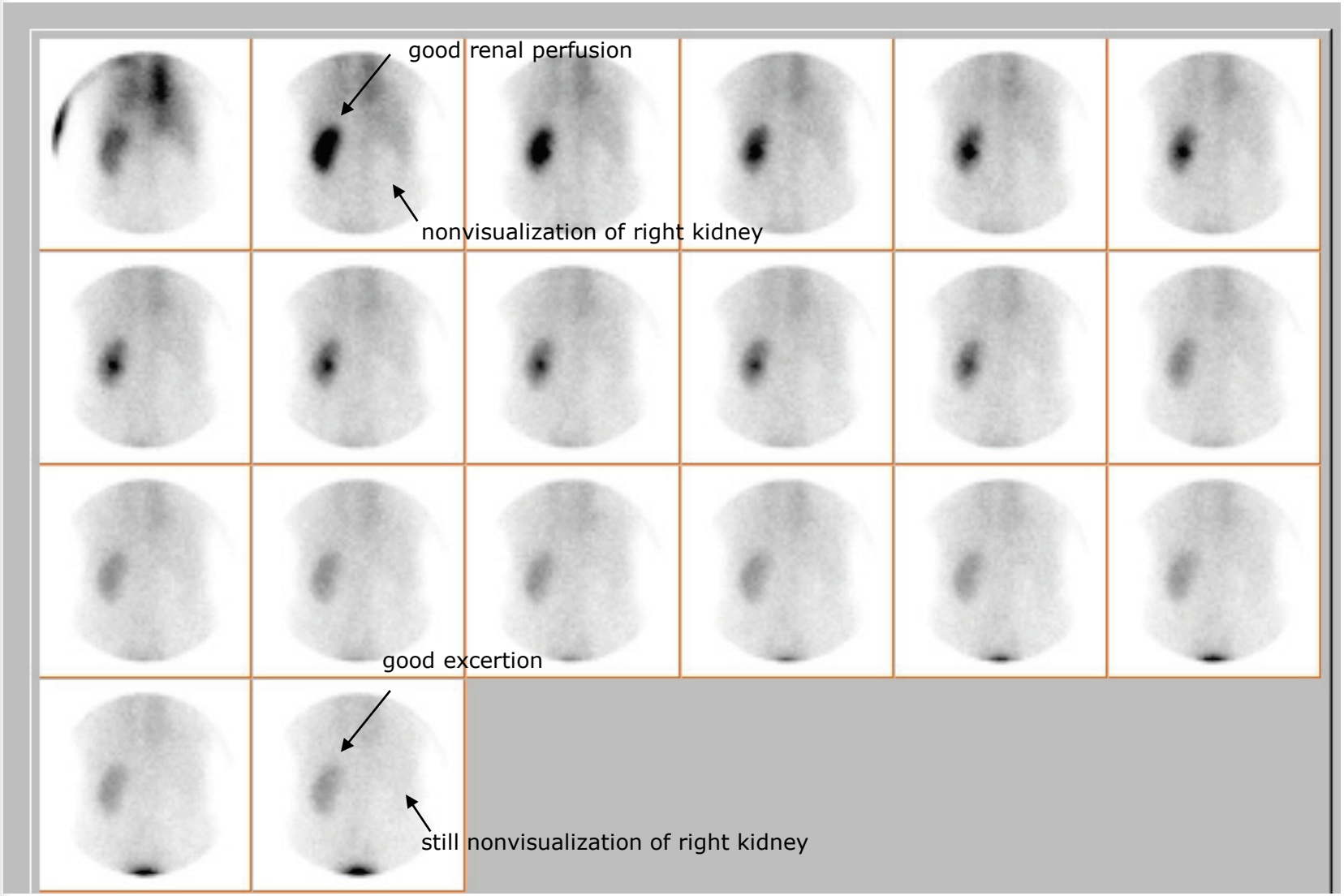
Cortex thinning, right kidney

TCC of right ureter with hydroureter

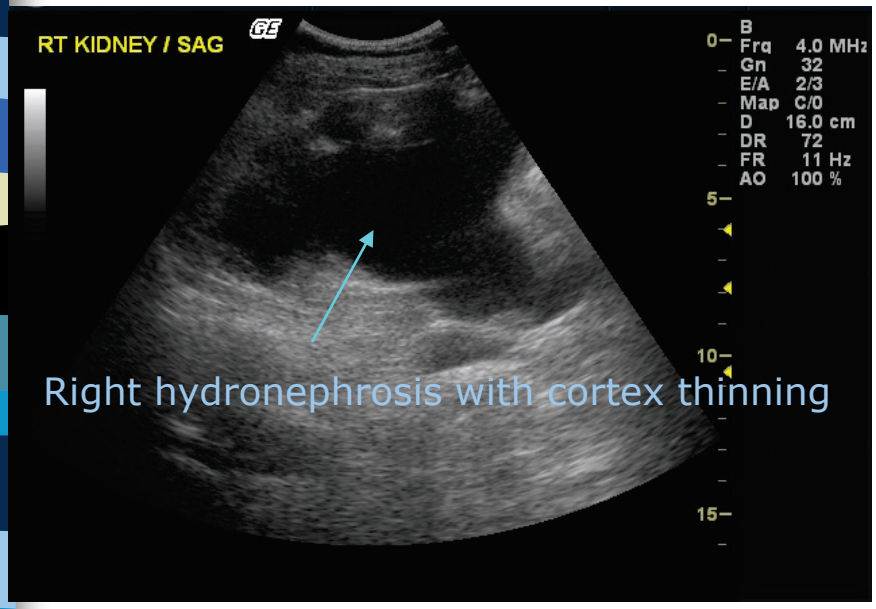
Non-functioning right kidney

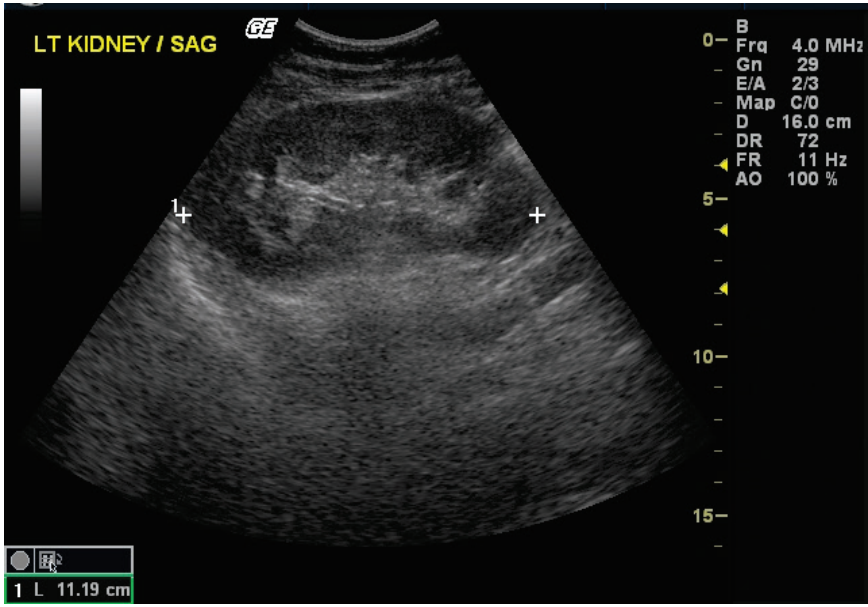


Non-functioning right kidney

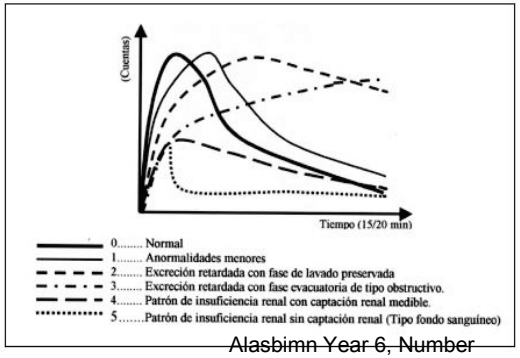


Non-functioning right kidney





2. Captopril renography

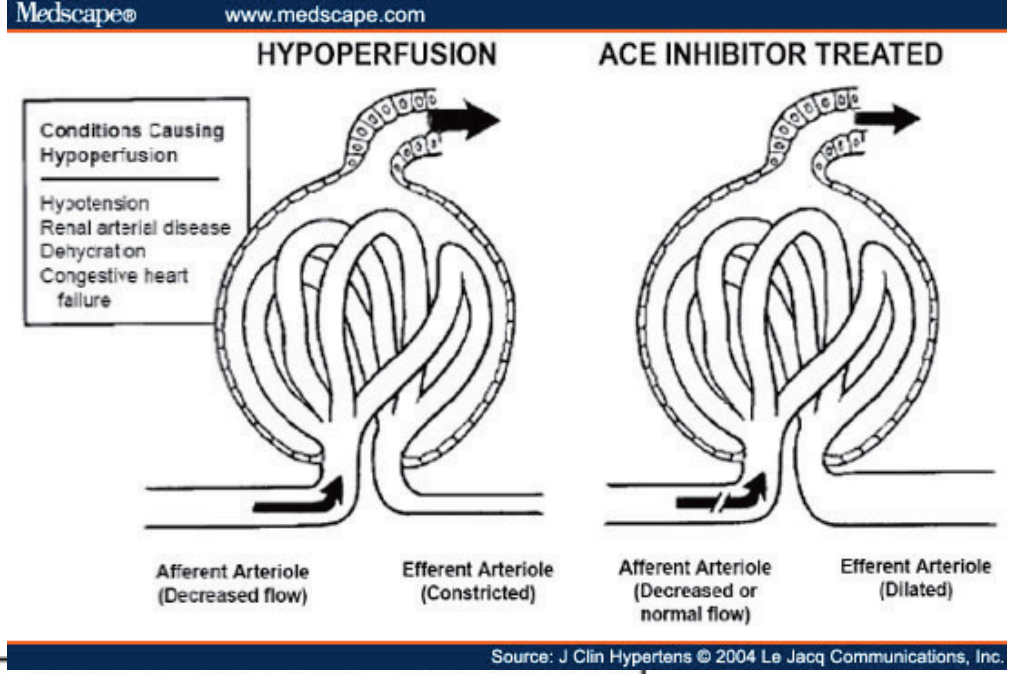


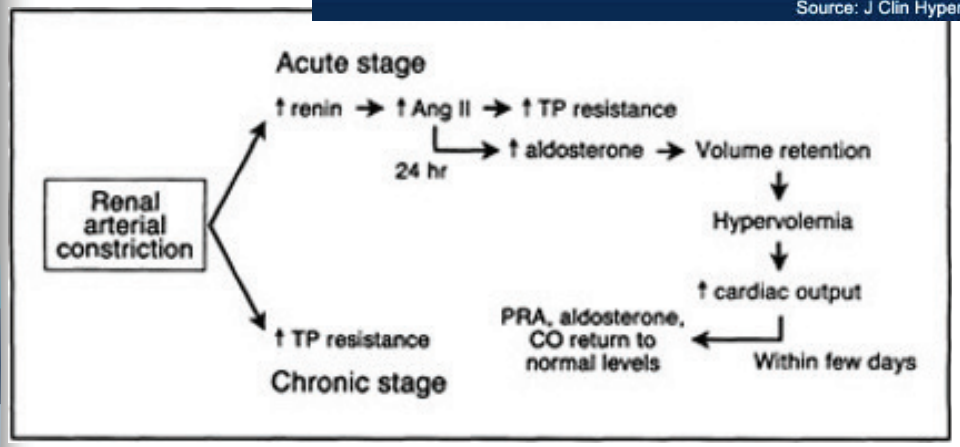
Alasbimn Year 6, Number 22, October 2003

- Selection criteria
  - Initial presentation of HTN, > 60 y/o or < 20 y/o
  - Severe or accelerated HTN resistant to medication
  - HTN previously well controlled but now difficult to manage medically
  - HTN in patients with other vascular disease
  - Unexplained renal dysfunction in patients with recent onset of HTN
  - Unexplained HTN in patients with abdominal bruits

- Captopril (ACEI): dilate efferent arteriole
- Dx criteria:
  - worsening of the renogragm curve
  - reduction in relative uptake
  - prolongation of the renal and parenchymal transit time
  - increase in the 20 min/peak ratio and prolongation of the T_{max}
- Scintigraphic abnormalities are best demonstrated with renal artery stenosis of 60%-90%.

2. Captopril renography





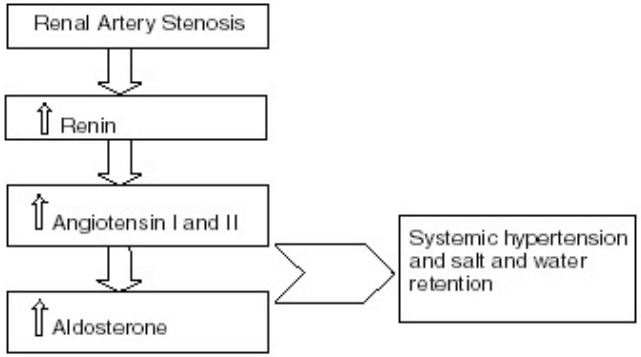
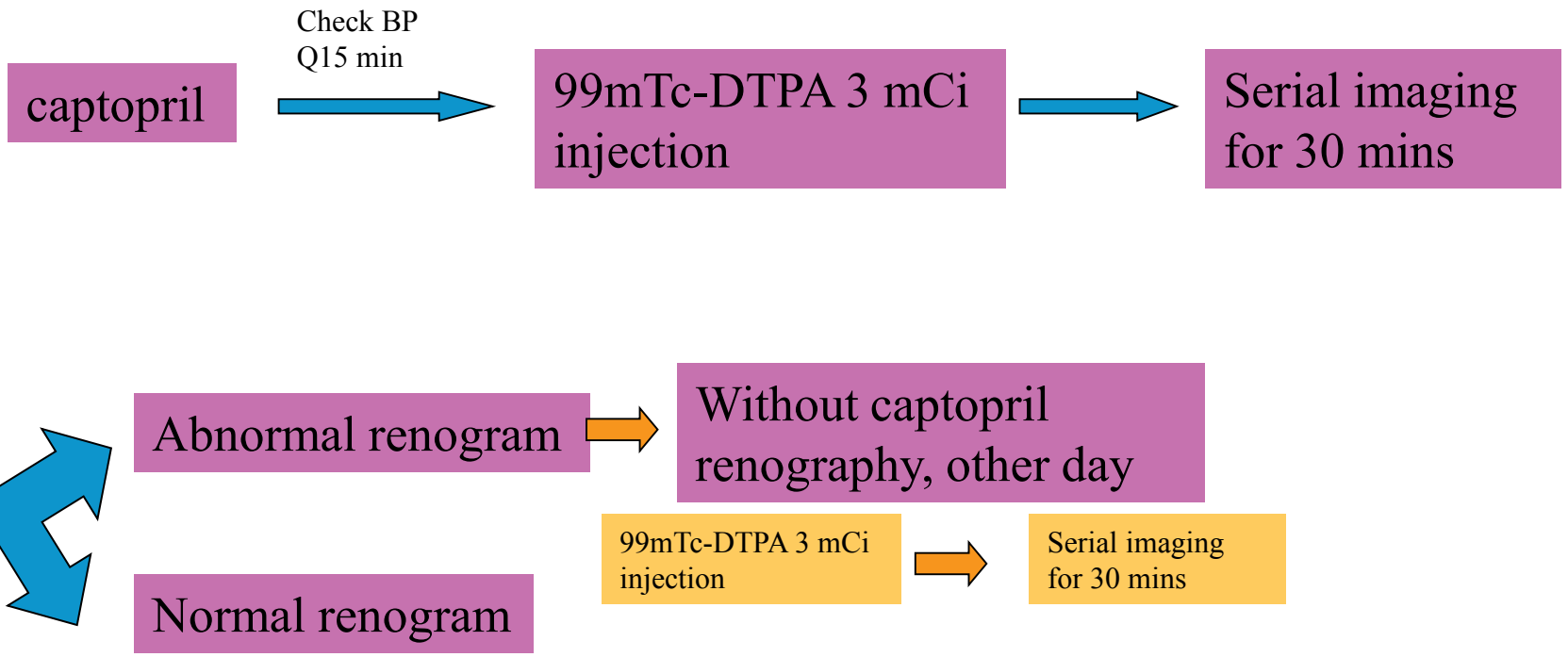


Fig. 1. Changes in renal plasma flow (*RPF*), glomerular filtration rate (*GFR*), and urine sodium excretion (*U Na*) induced by alterations in renal arterial pressure. Expression *n normal* indicates that normal sodium excretion is increased by the factor n—numbers given in ordinate. (From Romero and associates.[2] By permission.)

indianheartjournal.com/NOVDEC_HTML/art04.html

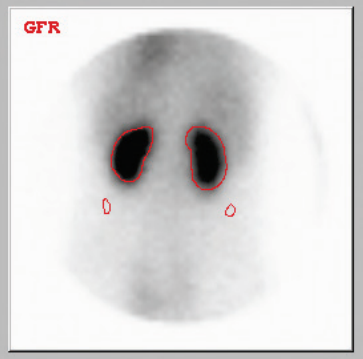
Mayo Clin Proc. 1997;72:251-260

2. Captopril protocol



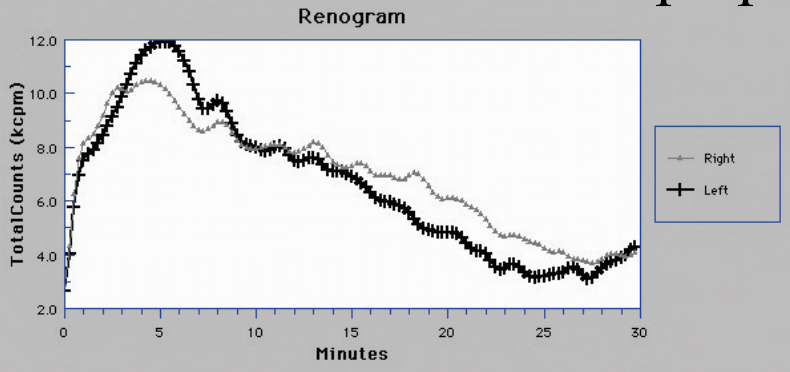
Renal artery stenosis

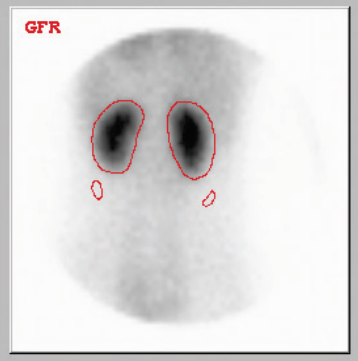
14 y/o girl with hypertension, R/O renal artery stenosis



		Left	Right	Left/Right
Tmax (min)	:	5.25	4.25	1.23
T 1/2 (min)	:	11.75	18.00	0.65
T 2/3 (min)	:	5.00	12.25	0.40
MaxCounts(Kcpm)	:	11.90	10.45	1.13
Kidney Depth (cm)	:	5.01	5.04	
Integral(Kcpm)	:	9.32	10.00	0.93
GFR(ml/min)	:	37.99	40.94	0.92
Total GFR(ml/min)	:	78.94		
Integrated Phase(min)		t1=2.0	t2=3.0	
Patient Height(cm)	:	156.0		
Weight(kg)	:	51.0		

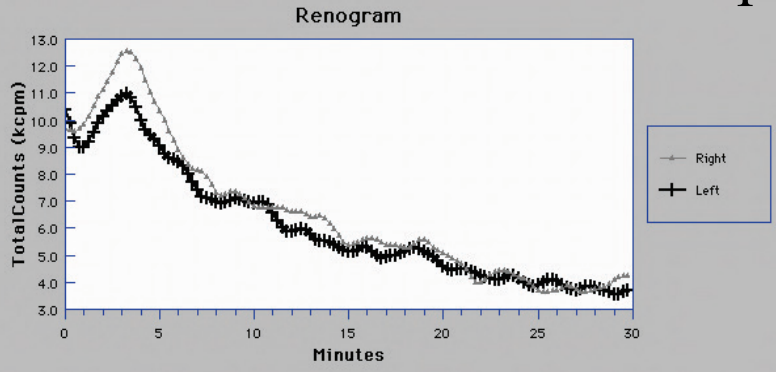
With captopril





		Left	Right	Left/Right
Tmax (min)	:	3.25	3.25	1.00
T 1/2 (min)	:	11.00	10.75	1.02
T 2/3 (min)	:	4.00	3.25	1.23
MaxCounts(Kcpm)	:	10.96	12.54	0.87
Kidney Depth (cm)	:	5.01	5.04	
Integral(Kcpm)	:	10.60	11.93	0.88
GFR(ml/min)	:	41.58	47.04	0.88
Total GFR(ml/min)	:	88.62		
Integrated Phase(min)		t1=2.0	t2=3.0	
Patient Height(cm)	:	156.0		
Weight(kg)	:	51.0		

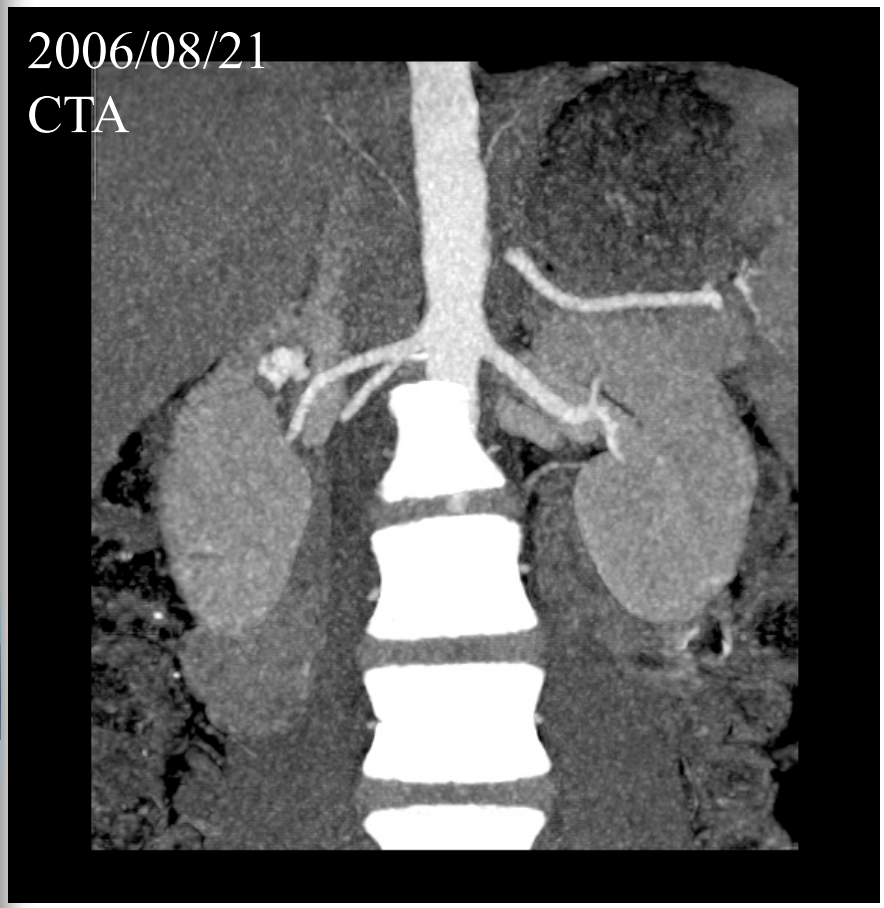
Without captopril

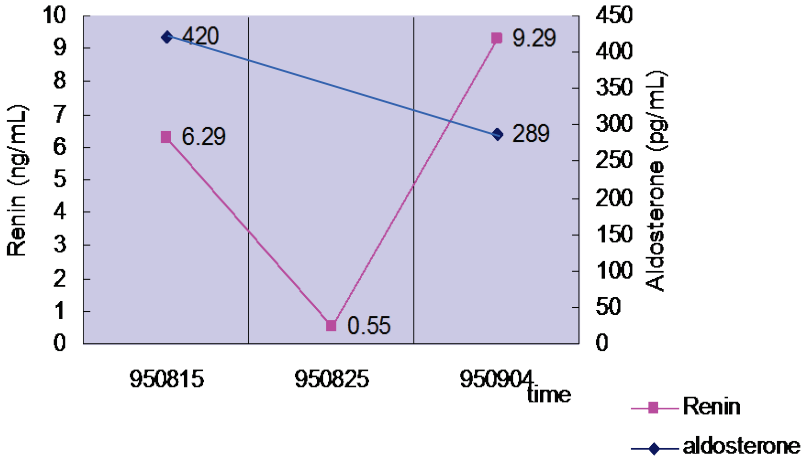


Mild degree of bilateral renal artery stenoses are considered, more severe on the right.

2. Captopril renography

Renal artery stenosis





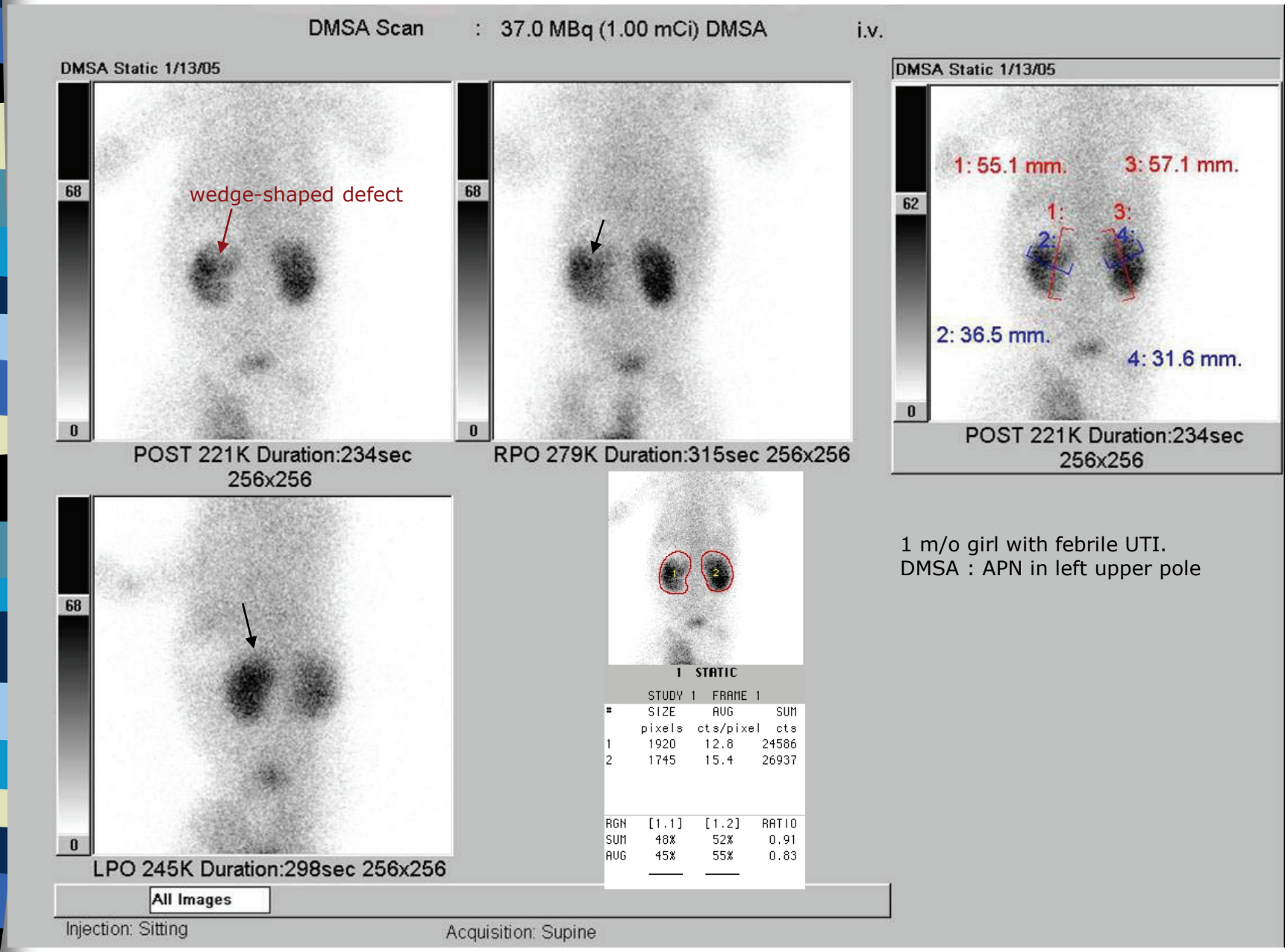
Cath: bilateral small distal renal arterial branches and bifurcation of R't renal artery with one small aneurysm in the upper pole.

3. DMSA scan protocol

- 99mTc-DMSA 5 mCi (children age+1/age+7 * 5)
- Imaging 2-4 hours later after injection (static views and SPECT)

3. DMSA

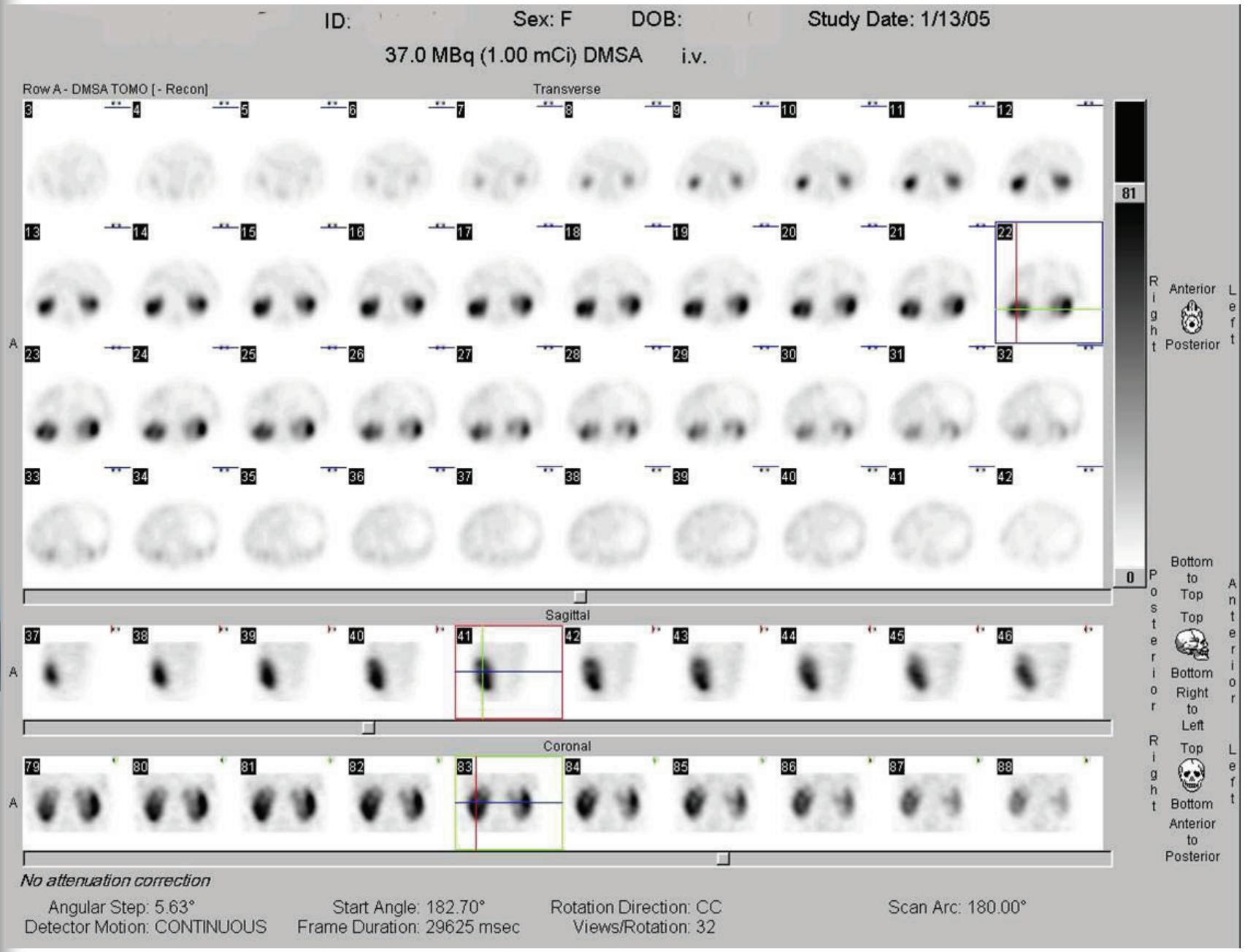
APN



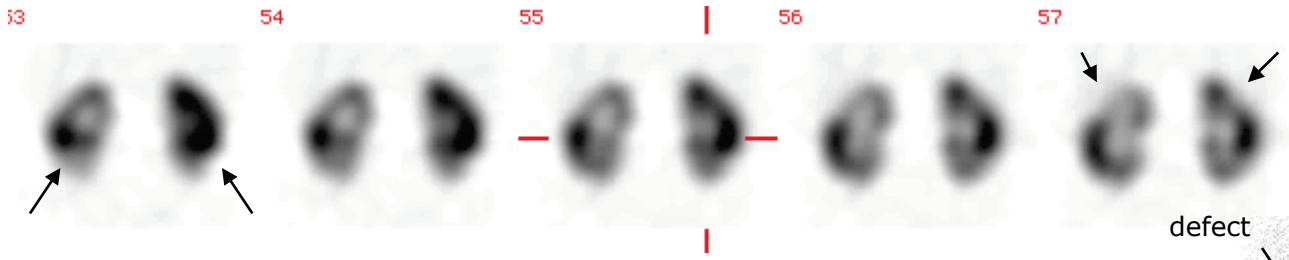
1 m/o girl with febrile UTI.
DMSA : APN in left upper pole

3. DMSA

APN

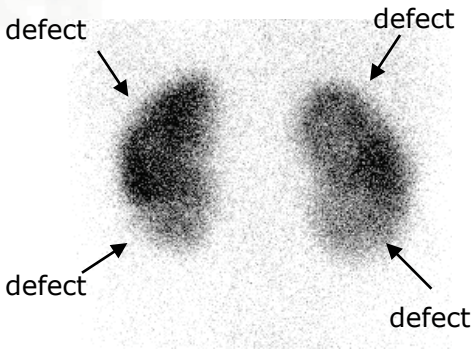

ID:
Sex: F
DOB:
Study Date: 1/13/05
37.0 MBq (1.00 mCi) DMSA i.v.
Row A - DMSA TOMO [- Recon]
Transverse
Sagittal
Coronal
81
0
Right
Anterior
Posterior
Left
Bottom to Top
Top
Bottom
Right to Left
Top
Bottom
Anterior to Posterior
No attenuation correction
Angular Step: 5.63°
Detector Motion: CONTINUOUS
Start Angle: 182.70°
Frame Duration: 29625 msec
Rotation Direction: CC
Views/Rotation: 32
Scan Arc: 180.00°

Scar formation



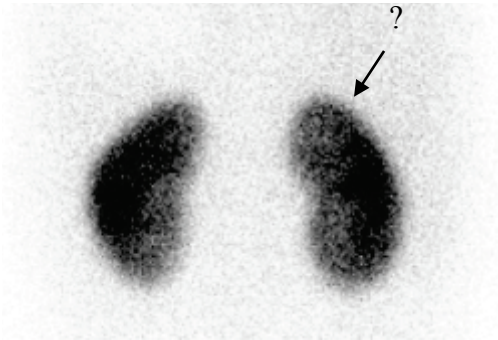
2002-11-26 after UTI

Bilateral VUR

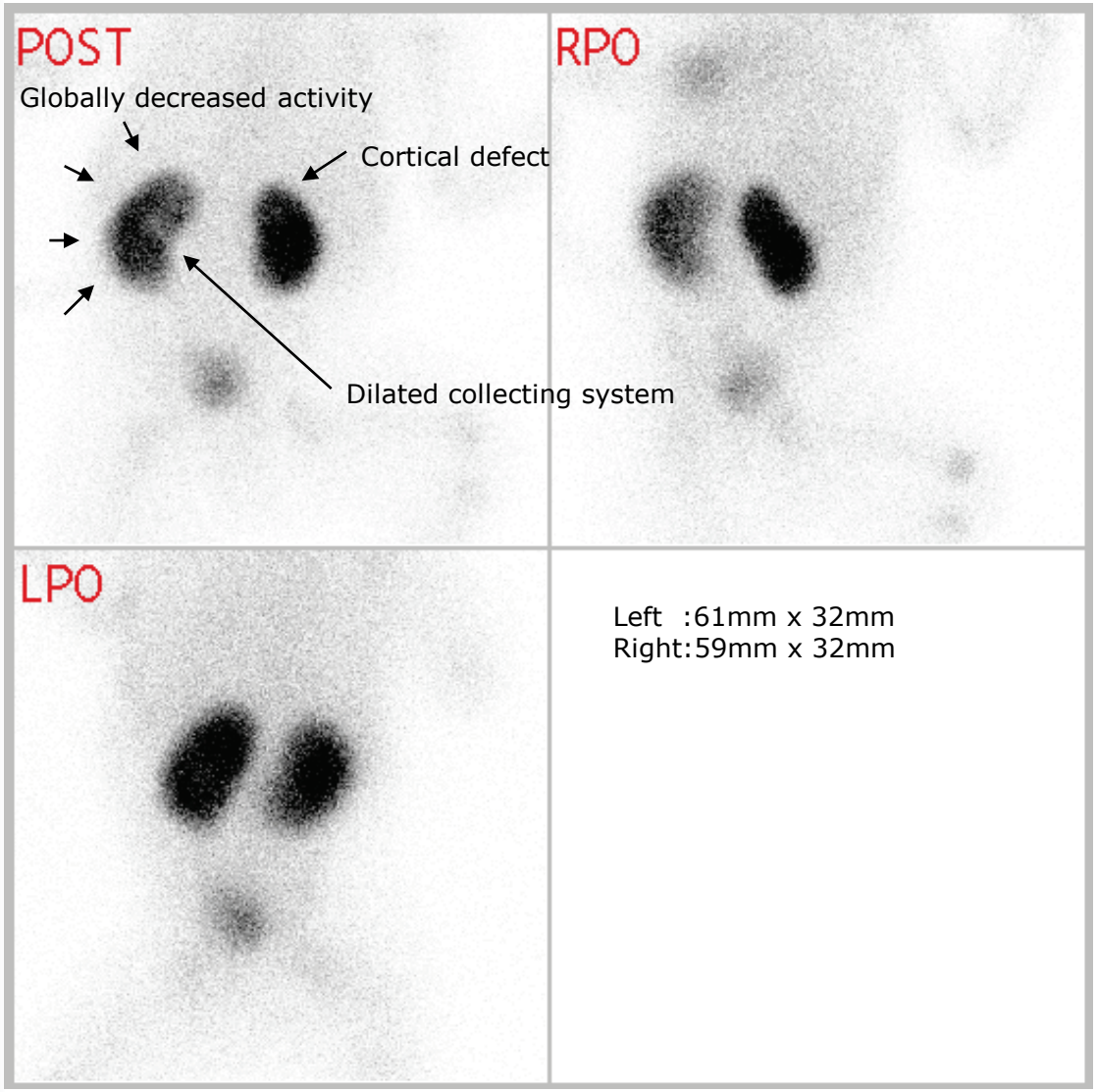


Decreased cortical uptake, suggesting scar formation

2004-09-07 follow-up
after surgery for VUR

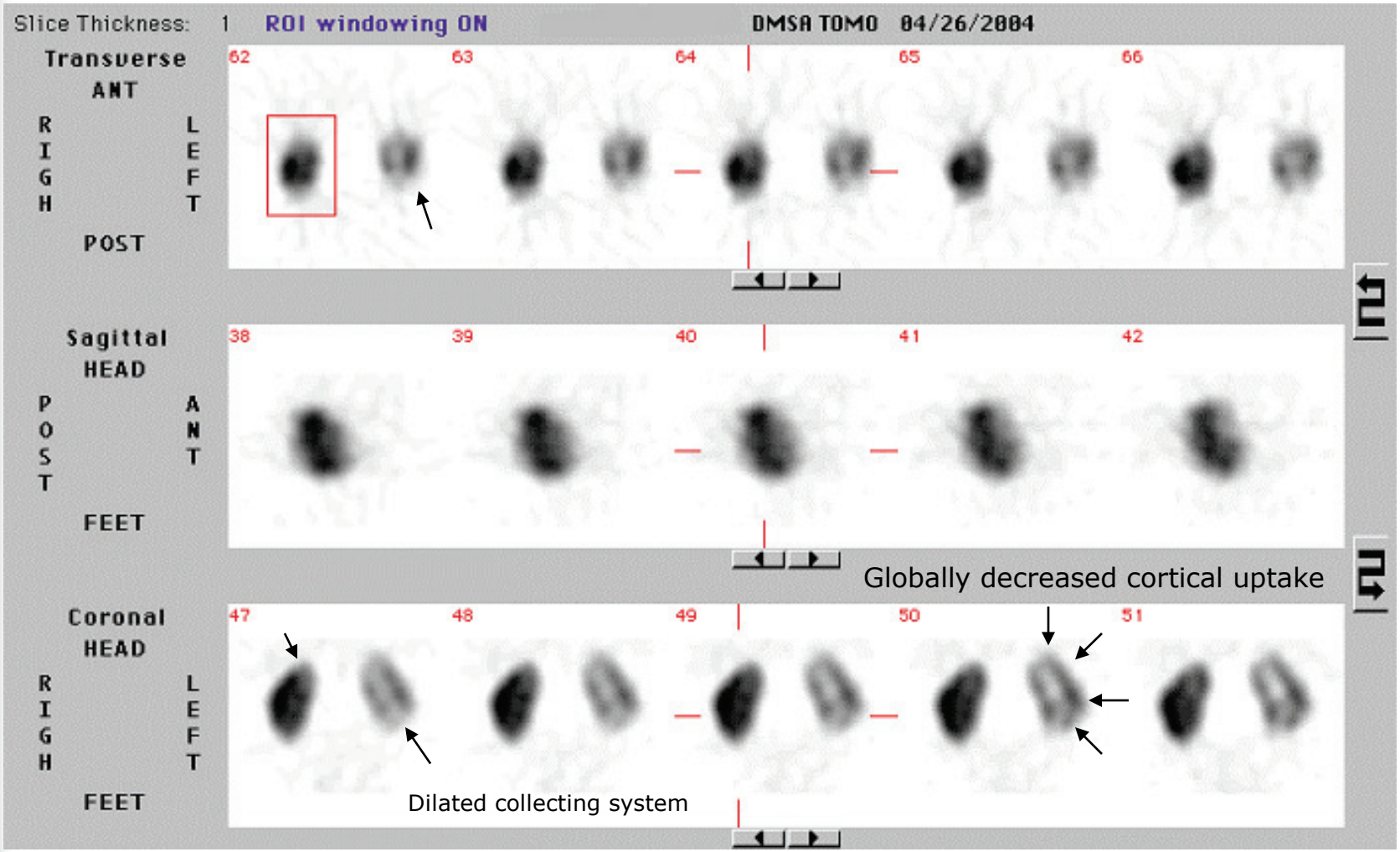


Hydronephrosis



- 5 m/o boy with left UPJ stenosis and UTI
- Sono: left severe hyronephrosis
- GFR: left obstructive uropathy

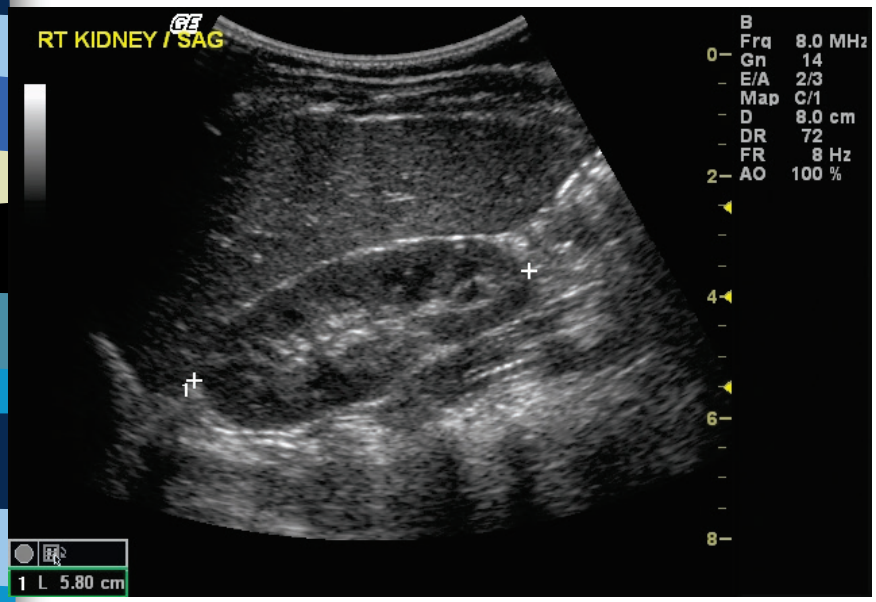
Hydronephrosis

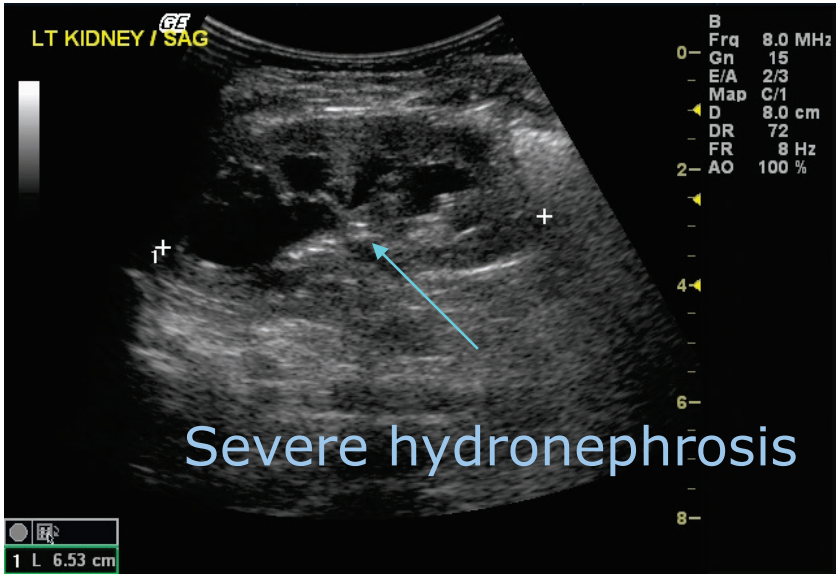


Imp:

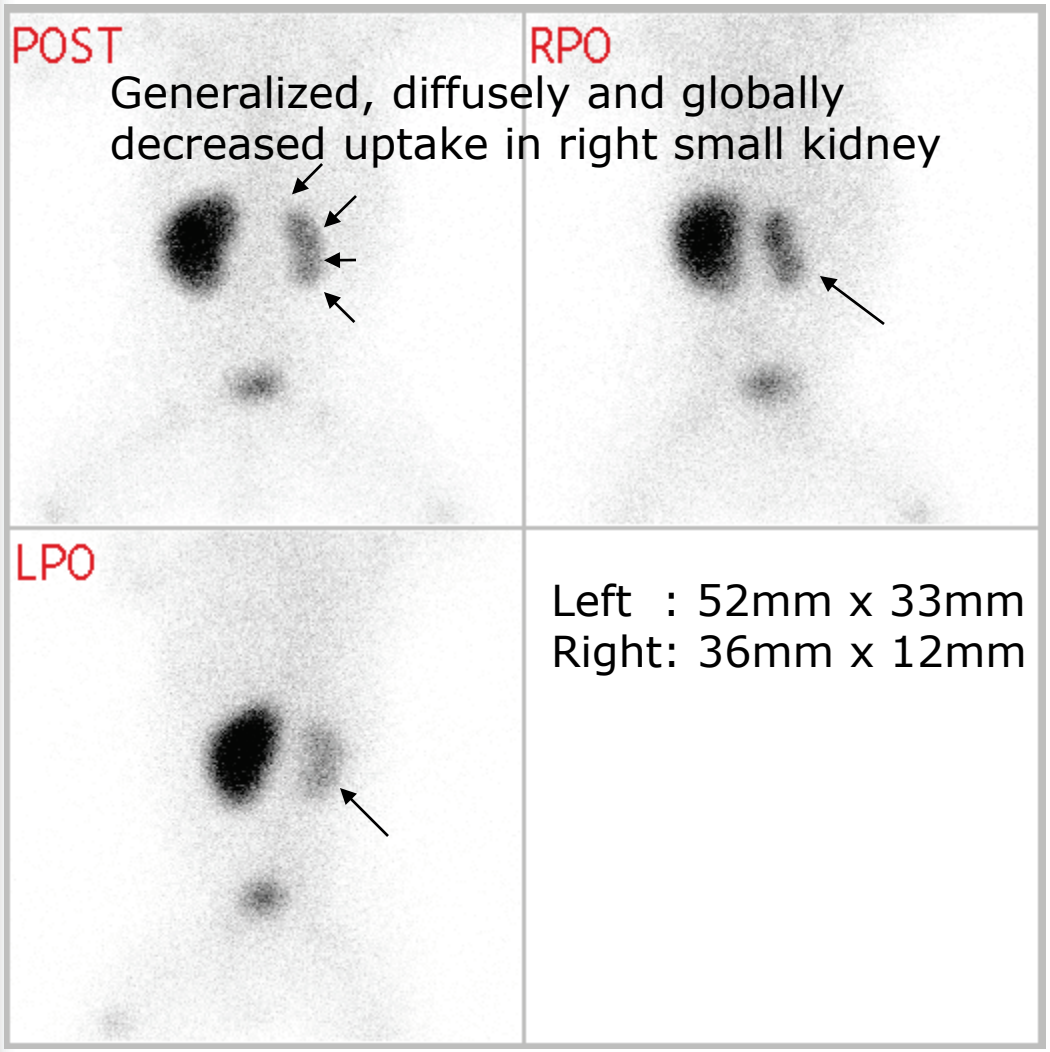
1. APN, right upper pole
2. hydronephrosis or global APN on the left

Hydronephrosis



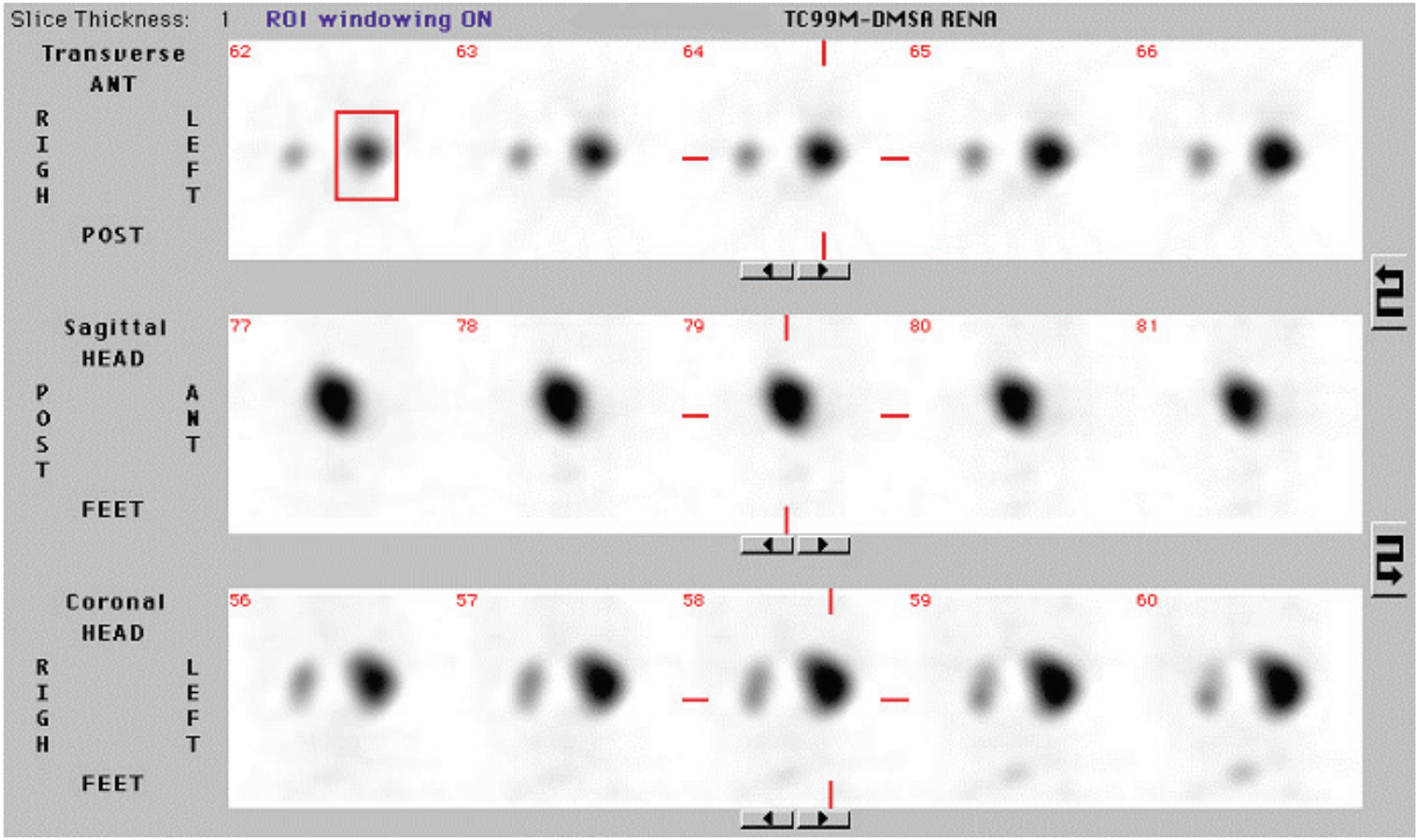


Right renal hypoplasia



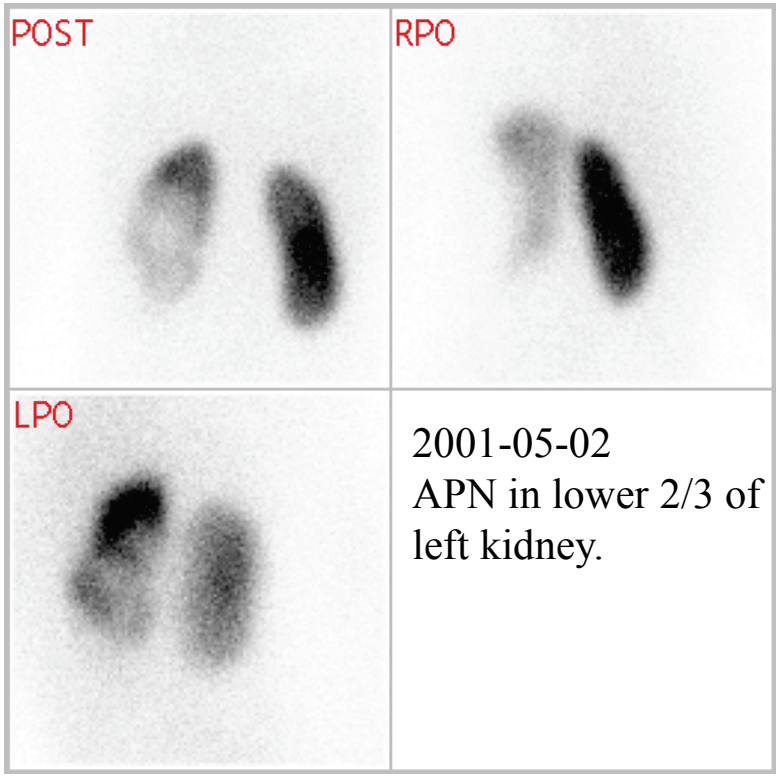
- 2 m/o boy with UTI
- Sono: small right kidney
- DRC: right VUR
  grade 3-4

Right renal hypoplasia

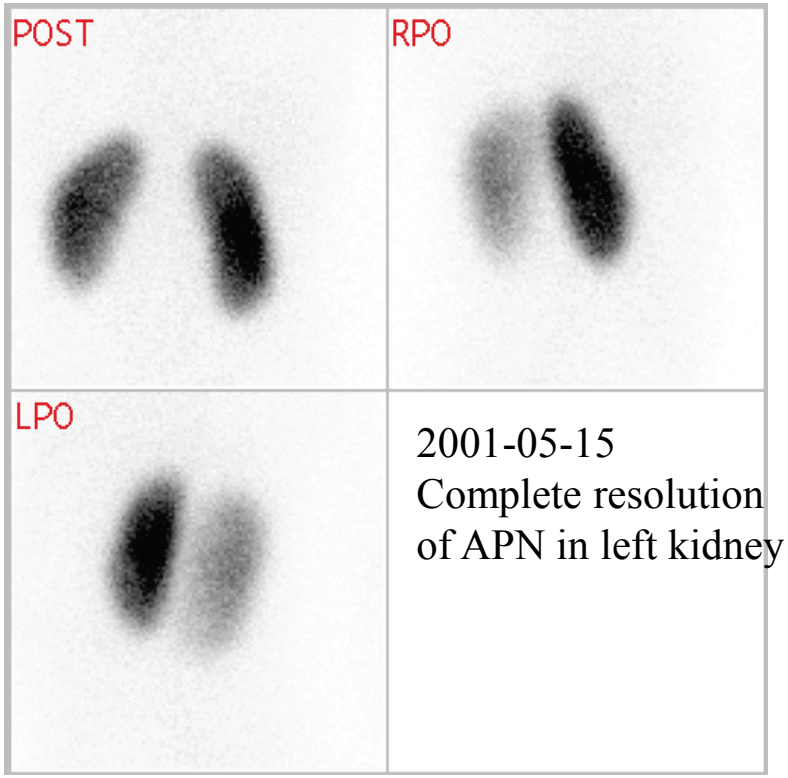


- No definite cortical loss on both sides
- Imp: Either APN or congenital hypoplasia on the right

Resolution of APN



2001-05-02
APN in lower 2/3 of left kidney.



2001-05-15
Complete resolution of APN in left kidney

- It's our understanding that the girl is a case of left moderate VUR with APN and recurrent UTI.

4. Direct radionuclide cystography (DRC)

- VUR is a common pediatric disease (1~2%)
- Children with UTI : 1/3 have VUR
- Complication : APN, renal scar or renal failure
- Early diagnosis and early treatment
- DRC is the method of choice for screen and follow up

DRC vs. VCUG

	DRC	VCUG
Anatomy	low (mild, mod, severe)	high (grade 1~5) 勝
Radiation Dose	low 勝	high (x50)
Continuous Monitoring	yes 勝	less likely
* Sensitivity in VUR (children)	91% 勝 especially transient VUR and younger group (except grade I)	45%
Follow-up	common	less common

* C.J. Mclaren : Direct comparison of radiology and unclear medicine cystograms in young infants with vesico-ureteric reflux

* Aysun Sukan : Comparison of direct radionuclide cystography and voiding direct cystography in detecting of vesicoureeral reflux

DRC Scan Protocol (1)

- γ-camera & collimator

DRC Scan Protocol (2)

- ^{99m}Tc DTPA
  (*0.5-1 mCi)*

DRC Scan Protocol (3)

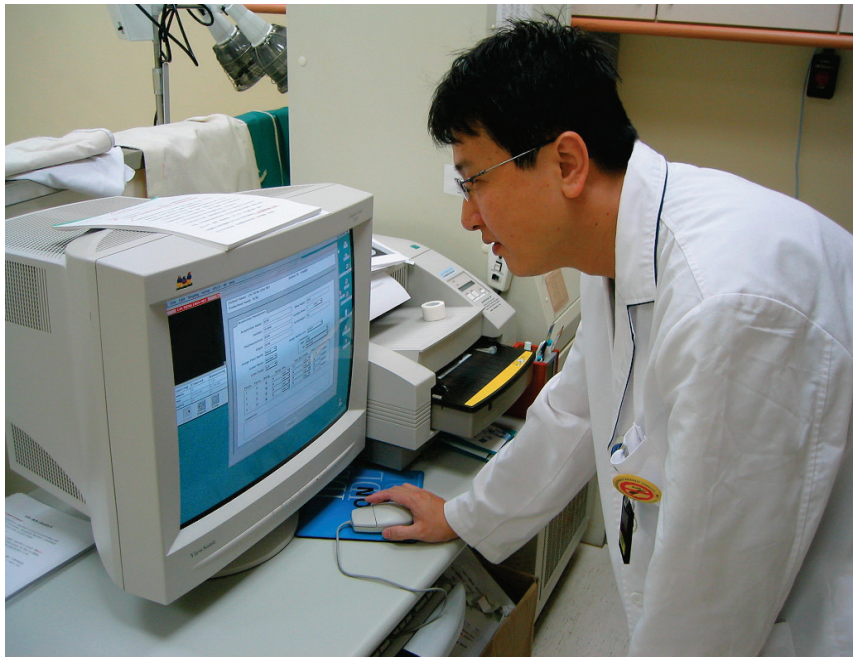
- On Foley Cath.

DRC Scan Protocol (4)

- Warmed N/S 500 c.c.
- Supine position

DRC Scan Protocol (5)

- Add *0.5-1 mCi* ^{99m}Tc DTPA via indwelling Foley cath
- Serial images acquired at the same time *(15 sec / frame)*



DRC Scan Protocol (6)

Expected Bladder Volume:

- < 1 y/o:

  $EBV_{(ml)} = BW_{(kg)} \times 7$

- > 1 y/o:

  $EBV_{(ml)} = (Age_{(year)} + 2) \times 30$

DRC Scan Protocol (7)

- Remove Foley Cath.

- Ask him/her to void

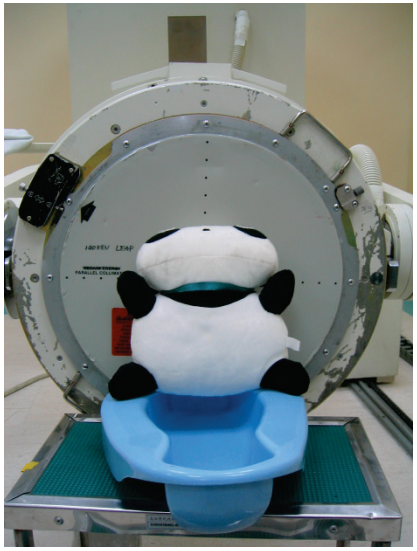
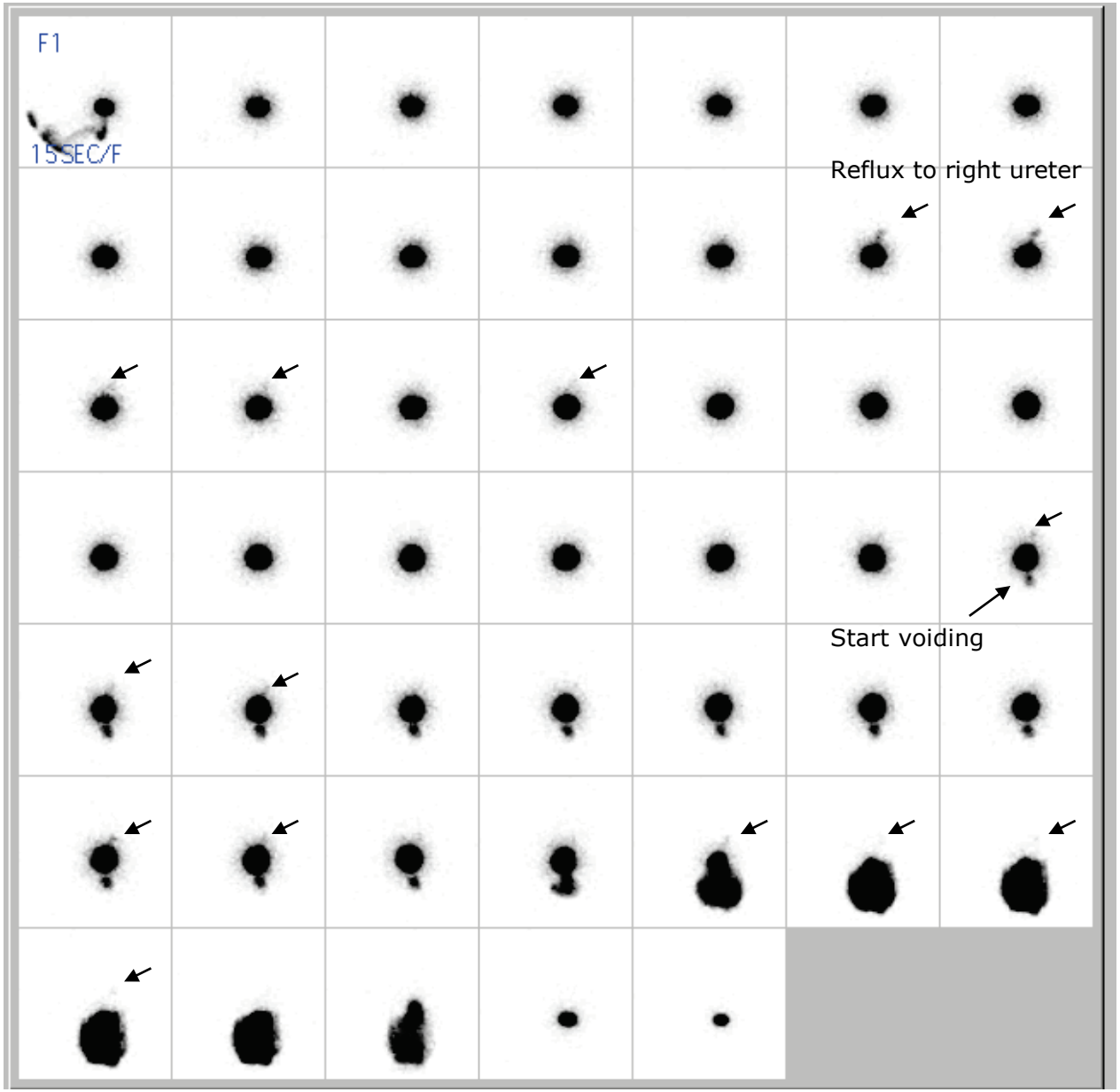


Image interpretation

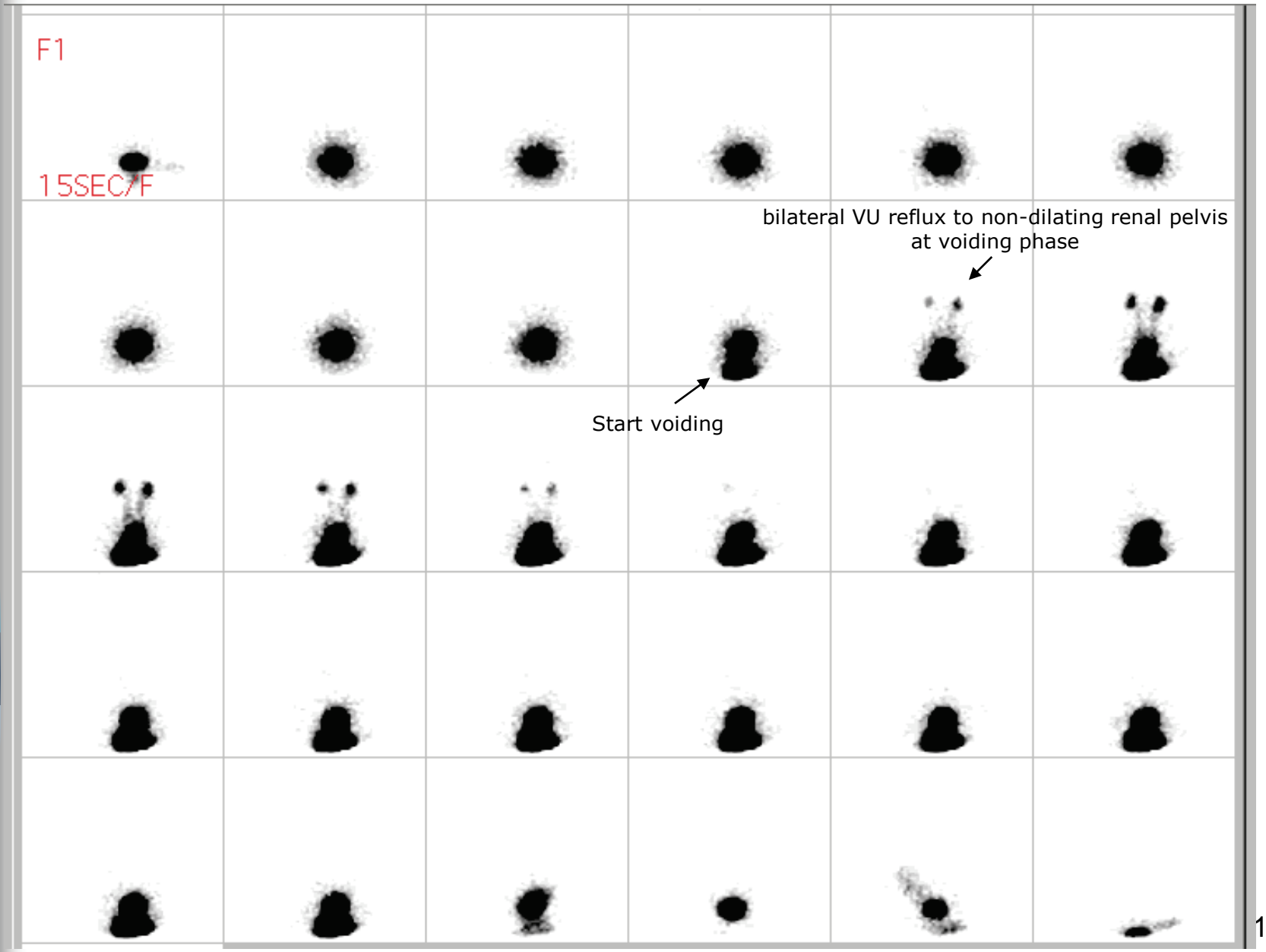
- Anatomic Grading:
  - ① mild confined to ureter
  - ② moderate to non-dilated renal pelvis
  - ③ severe to dilated ureter and renal pelvis

- Functional Grading:
  - ① transient at filling or voiding phase only
  - ② persistent at both filling and voiding phases

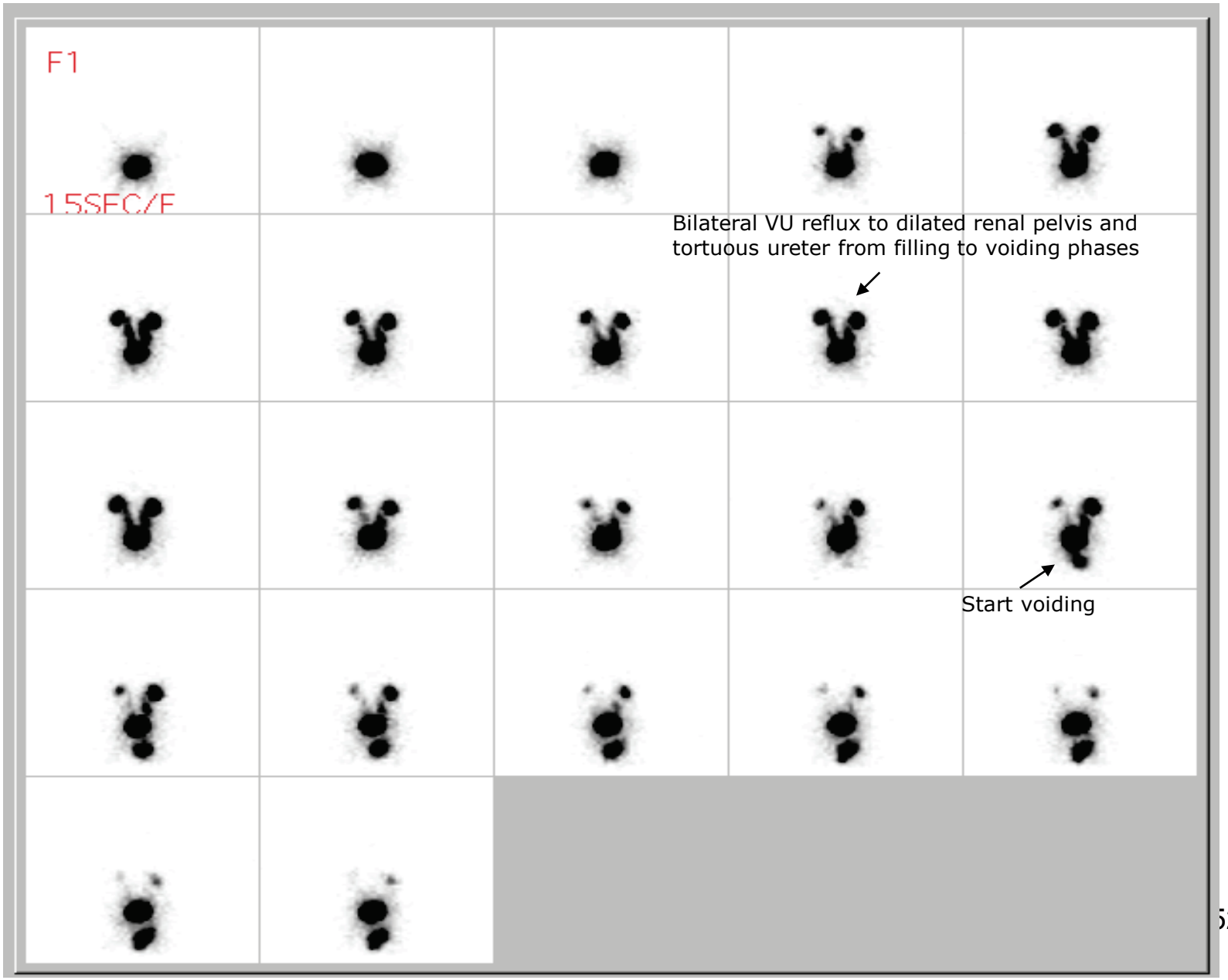
Transient mild VUR



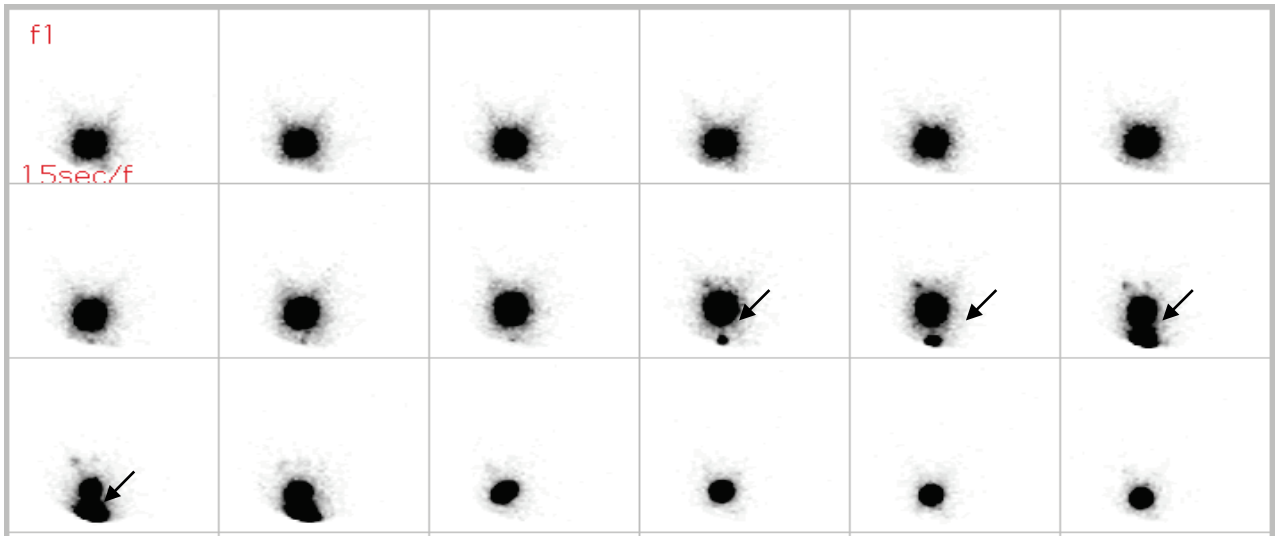
Moderate & one phase VUR



Severe & two phases VUR



Spontaneous Resolution of VUR



2004-03-23
bilateral moderate VUR more on the left.

2005-03-23
spontaneous resolution of VUR