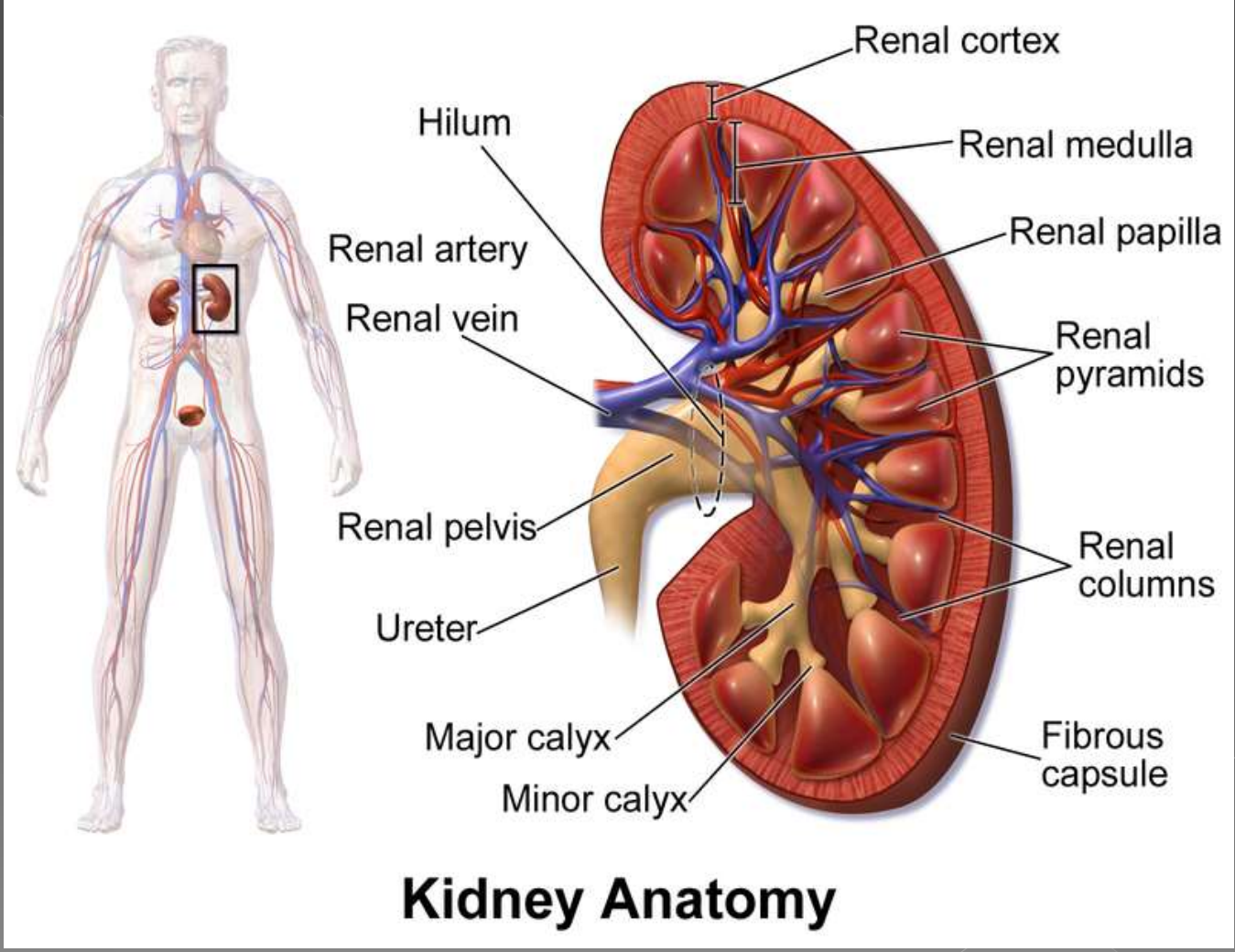
A Brief Introduction to Nuclear Nephrology (DTPA renogram)

Dr. Md. Sunny A. Chowdhury
Director
INMAS Kushtia

Anatomy

Position:

- Posterior abdomen
- At the level L1-3
- RK is slight inferior to LK

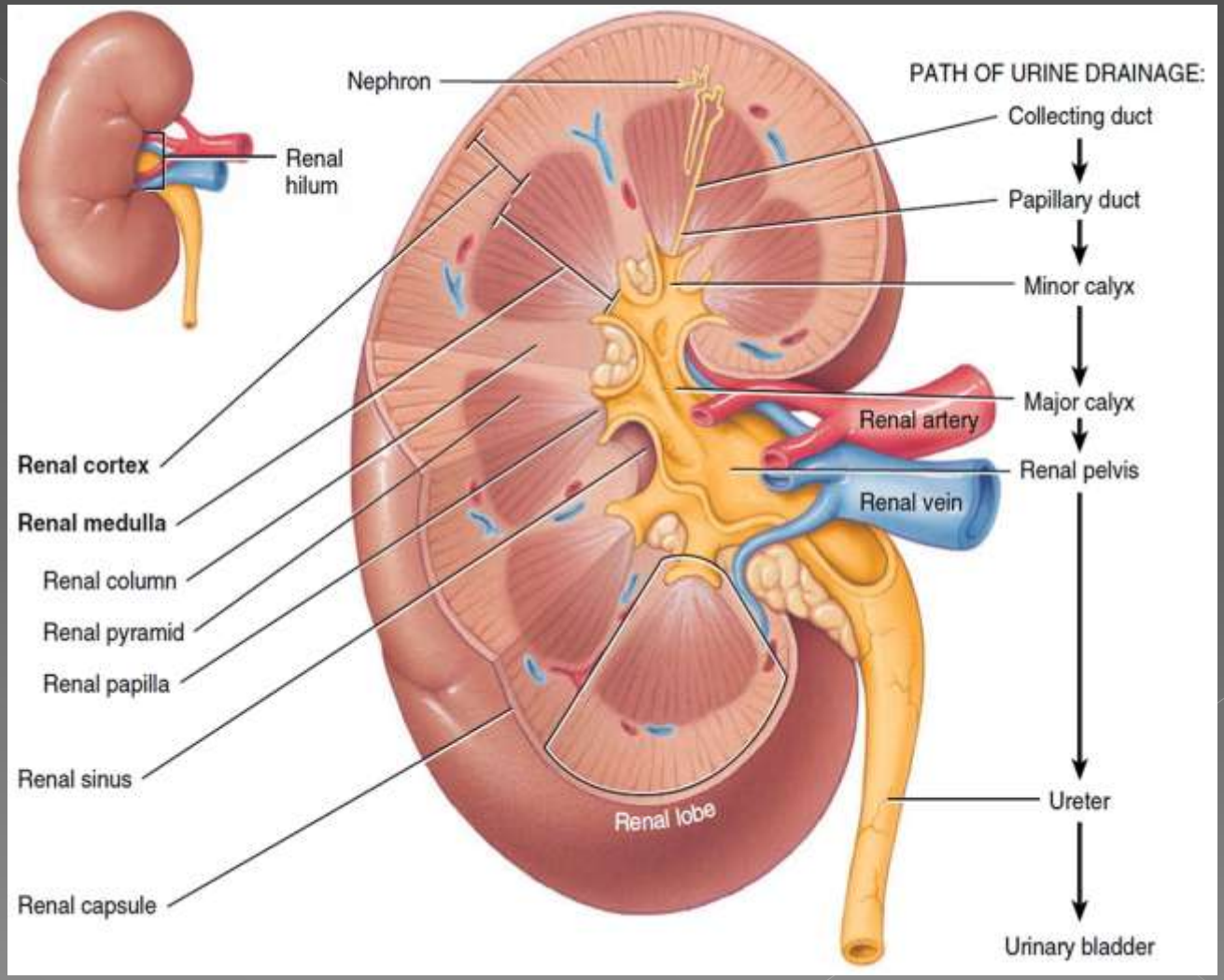


Anatomy (cont)

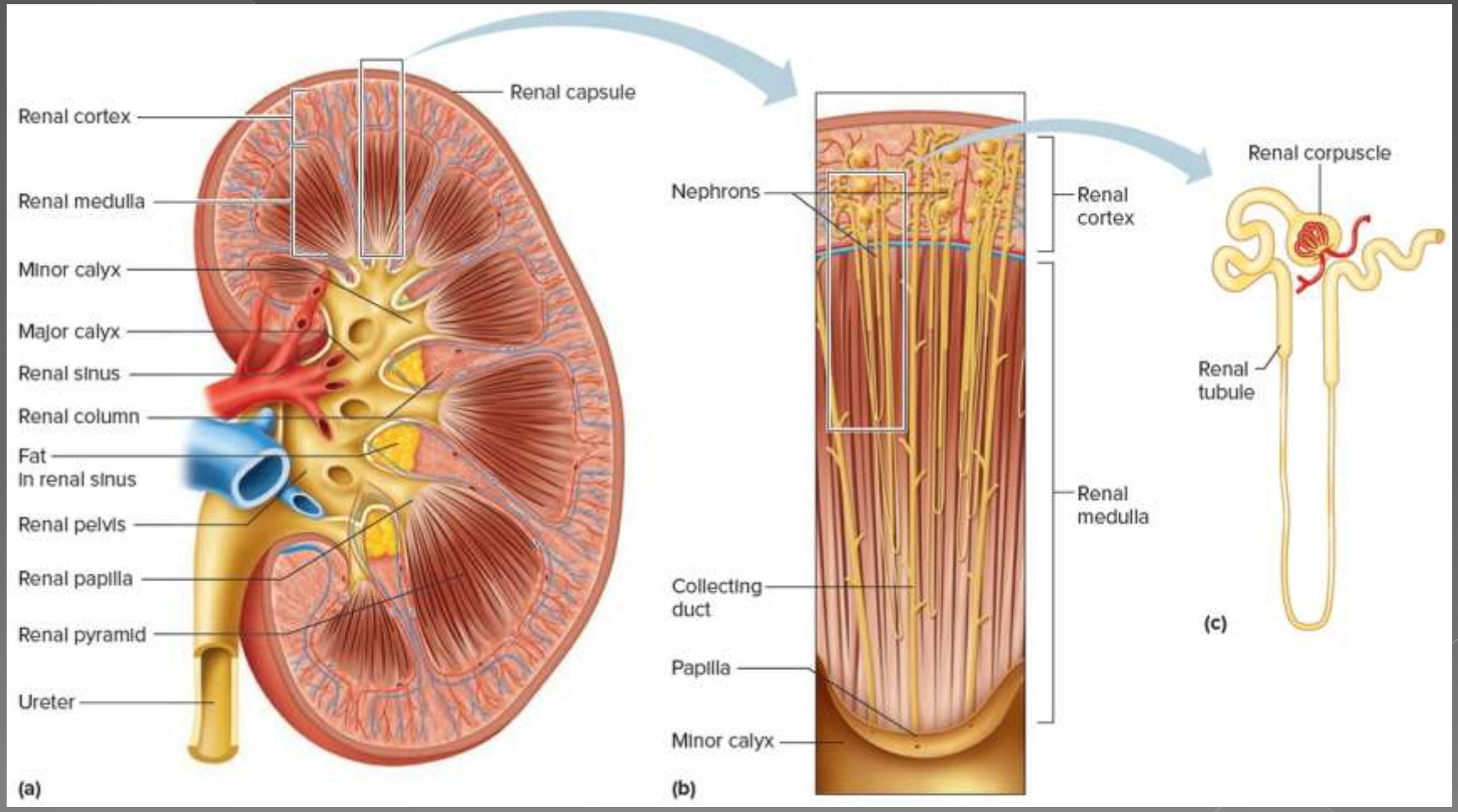
Outer cortex:
- Glomeruli
- PCT

Inner medulla:
- Renal pyramids
  - CT
  - LH

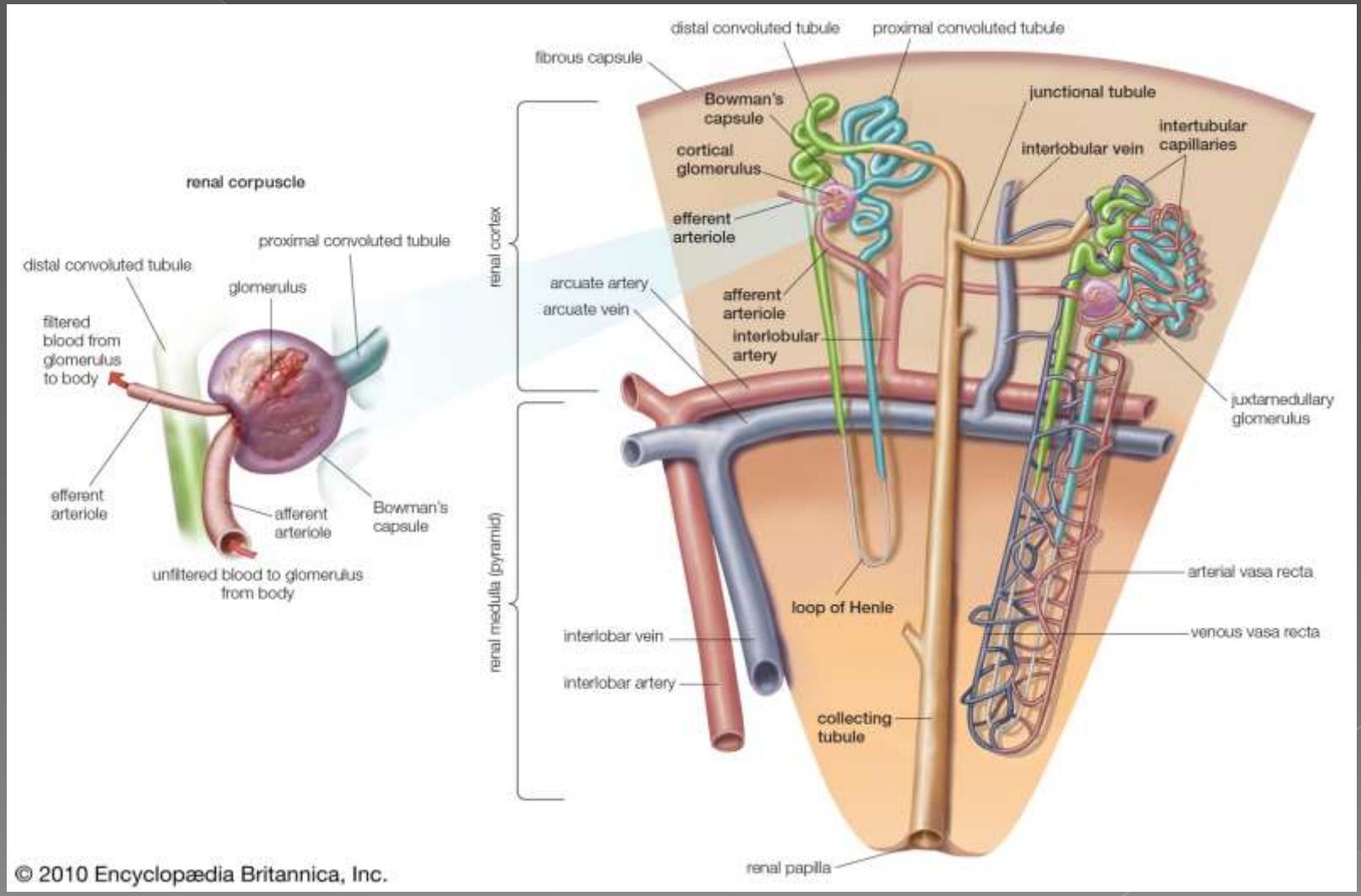
Apex of pyramid (Papilla) > Minor Calyces > Major Calyces > Renal pelvis > Ureter



Anatomy (cont)



Anatomy (cont)



Renal plasma flow & function

Renal plasma flow:
- 20% of Cardiac Output
- 600 ml/min

Plasma clearance:
- Glomerular filtration - 20%
- Tubular secretion – 80%

Glomerular filtration rate –
120 ml/min

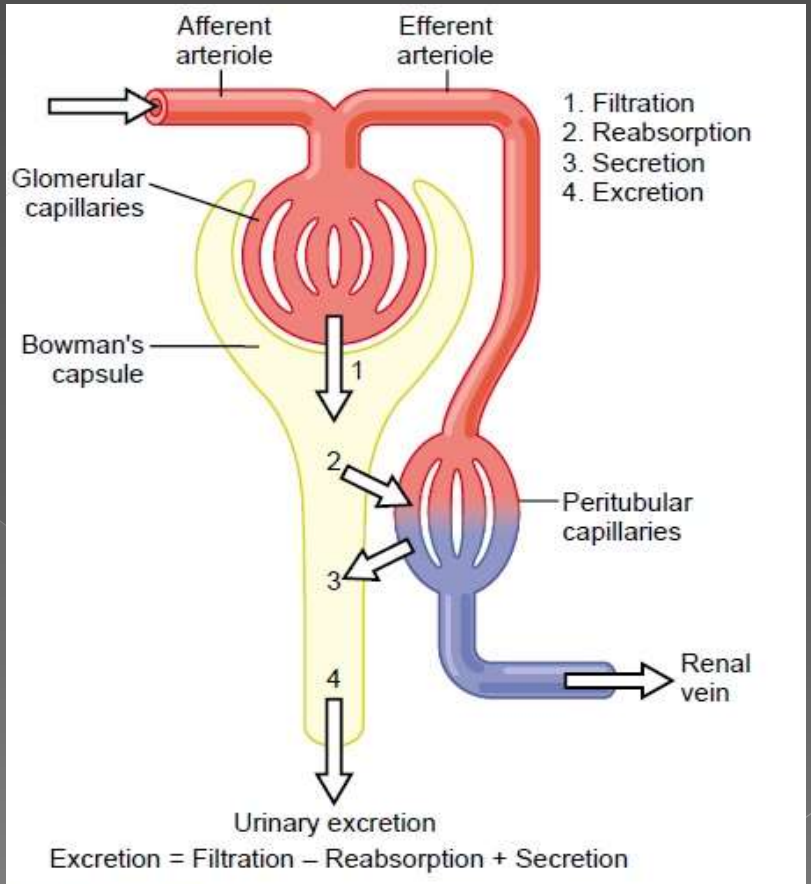


Figure 26–8

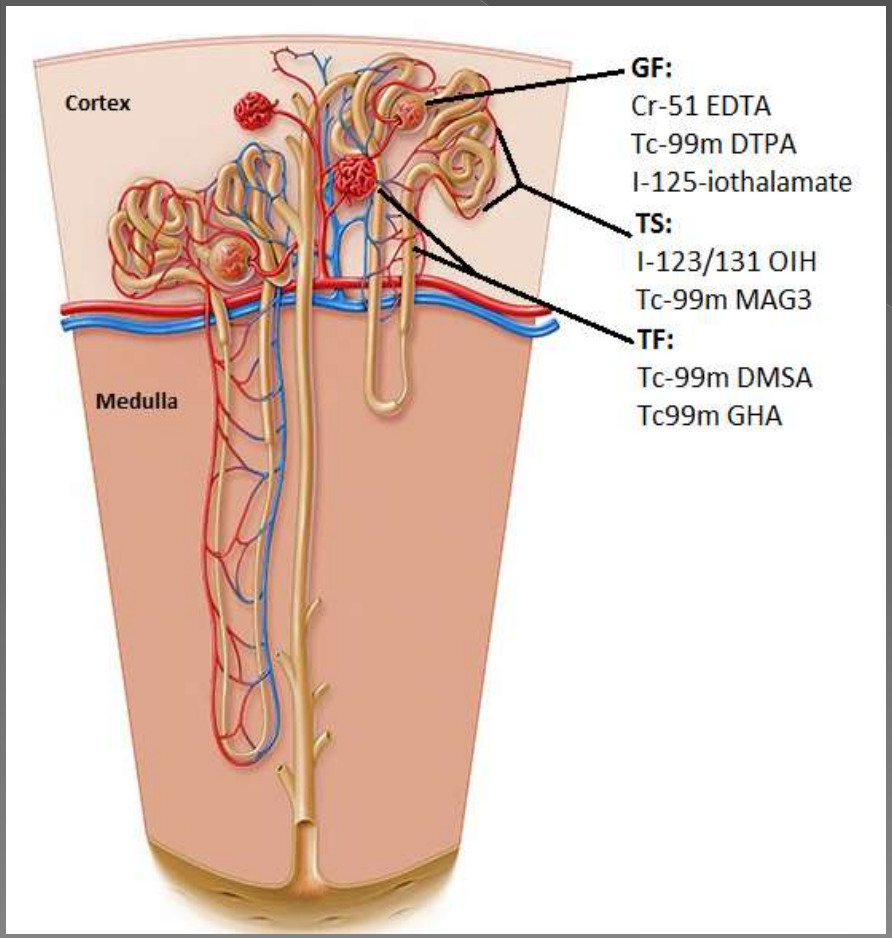
Basic kidney processes that determine the composition of the urine. Urinary excretion rate of a substance is equal to the rate at which the substance is filtered minus its reabsorption rate plus the rate at which it is secreted from the peritubular capillary blood into the tubules.

Renal radiopharmaceuticals

- C-14 or H-3 inulin
- I-125 diatrizoate
- I-125 iothalamate
- Cr-51 EDTA
- Co-57 vit B12
- In-111 or Yb-169 or Tc-99m DTPA/MAG3
- C-14 or H-3 PAH
- I-123 or I-131 OIH
- I-123 or I-131 iodopyracet
- Tc-99m glucoheptonate
- Tc-99m DMSA

	Agents
Perfusion	MAG3, DTPA, GHA
Morphology	DMSA, GHA
Obstruction	MAG3, DTPA, OIH
Relative function	All
GFR	Iothalamate, EDTA, DTPA
ERPF	MAG3, OIH

Renal radiopharmaceuticals (cont)



	GF	TS	TF
TC-99m DTPA	>95%		
Tc-99m MAG3	<5%	>95%	
I-131 OIH	20%	80%	
Tc-99m GHA	40-60%		20%
Tc-99m DMSA			60%

Renal radiopharmaceuticals (cont)

MAG3:

- Most commonly used.
- Protein bound, not filtered, almost entirely tubular secretion.
- Does not measure GFR.
- High extraction efficiency-Better performance, less radiation dose.
- Significant anatomical detail.

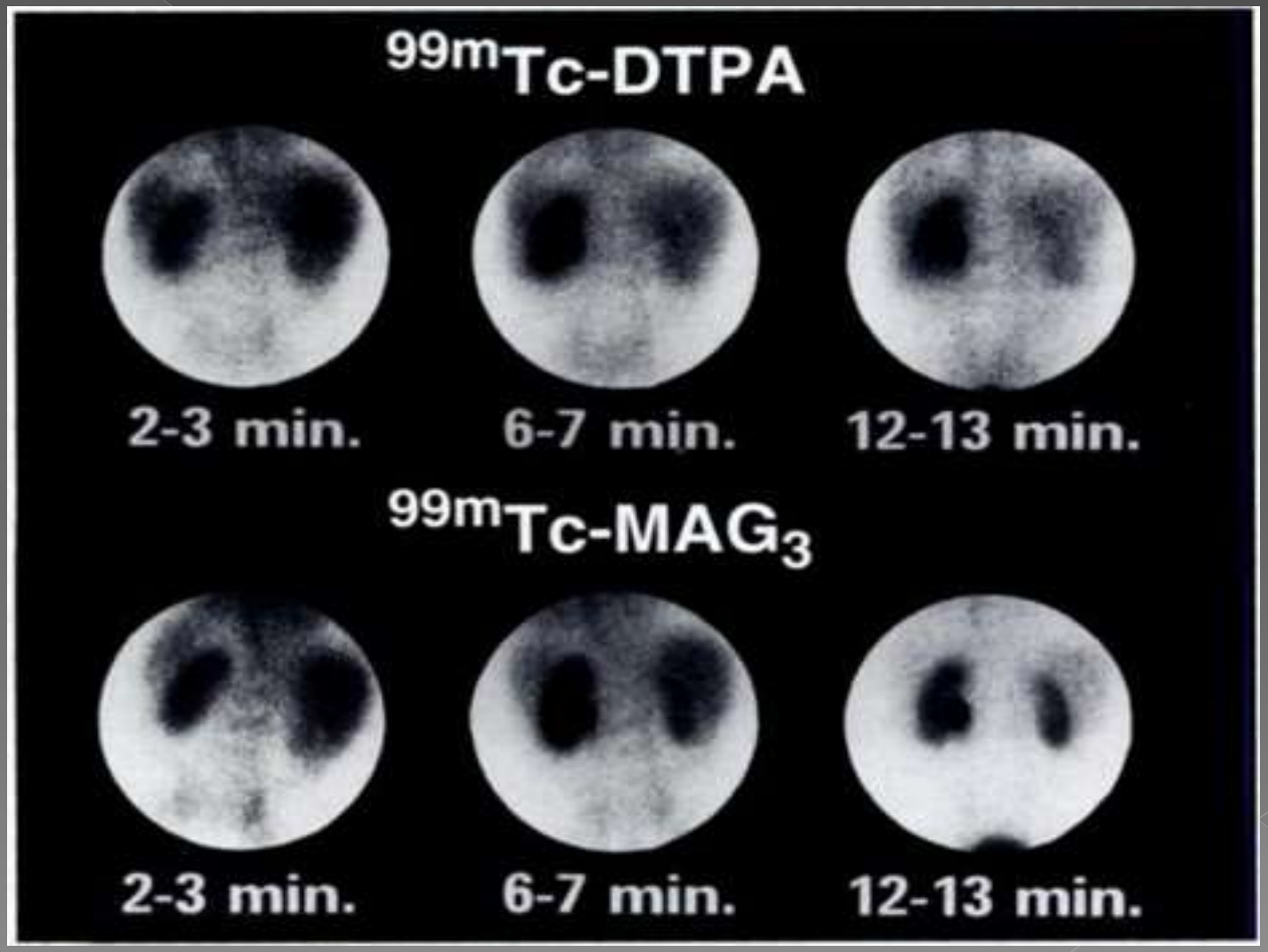
DTPA:

- Cleared via GF, thus can calculate GFR.
- Low extraction efficiency – high background activity, inferior image quality, high radiation dose.
- Not ideal for renal failure.

DMSA:

- Stable cortical accumulation – mostly in PCT.
- Anatomical (cortical) info and accurate differential renal function.

DTPA vs MAG3


99mTc-DTPA
2-3 min.
6-7 min.
12-13 min.
99mTc-MAG3
2-3 min.
6-7 min.
12-13 min.

Dosimetry

Organ	Tc-99m DTPA	Tc-99m MAG3	Tc-99m DMSA
	mSv/MBq		
Kidney	0.0057	0.0041	0.19
Bladder wall	0.077	0.0015	0.015
Marrow	0.0022	0.0011	0.0041
Effective dose	0.0082	0.0012	0.0016

ICRP annual dose limit 1 mSv

Dynamic study

- **Renogram**
  - Conventional
  - Diuretic renogram
  - Captopril renogram
- **GFR estimation**
- **Renal perfusion imaging**

Advantage – Simple, Convenient, Reproducible, Less time consuming.



Principle

Injection of Gamma ray emitting RP which are taken up and excreted by the kidney that can be monitored by a computer linked Gamma Camera.

Fig: Dual Head Gamma Camera.

Renogram

- Two part: Renal blood flow, renal function (uptake+cleraance)

  - Renal blood flow – assessed in the first pass of radiotracer bolus to the kidney

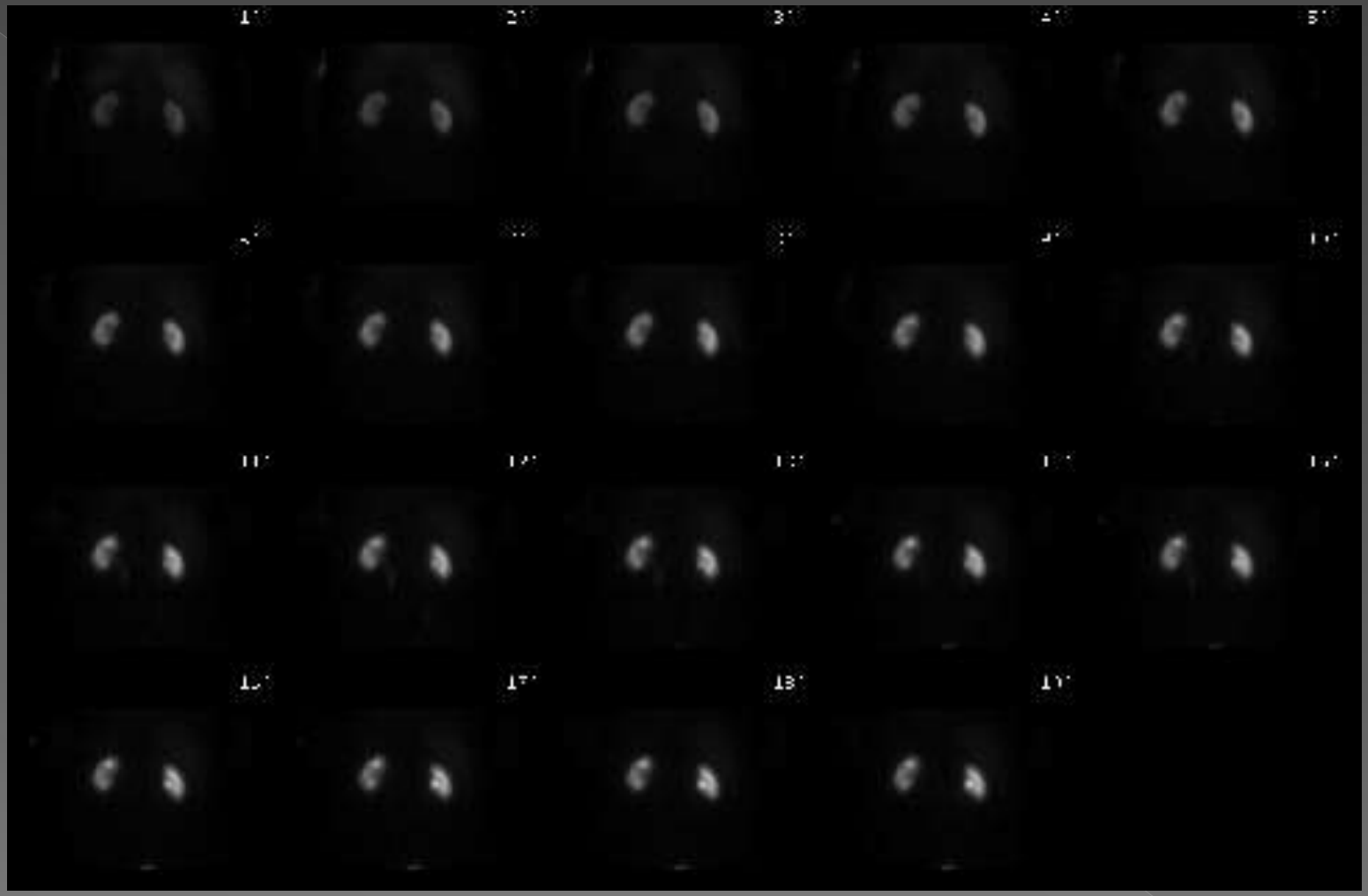
  - Renal function – assessed over next 25-30 mins by uptake and clearance

- Radiopharmaceuticals– Tc-99m **DTPA**/MAG3

Patient preparation

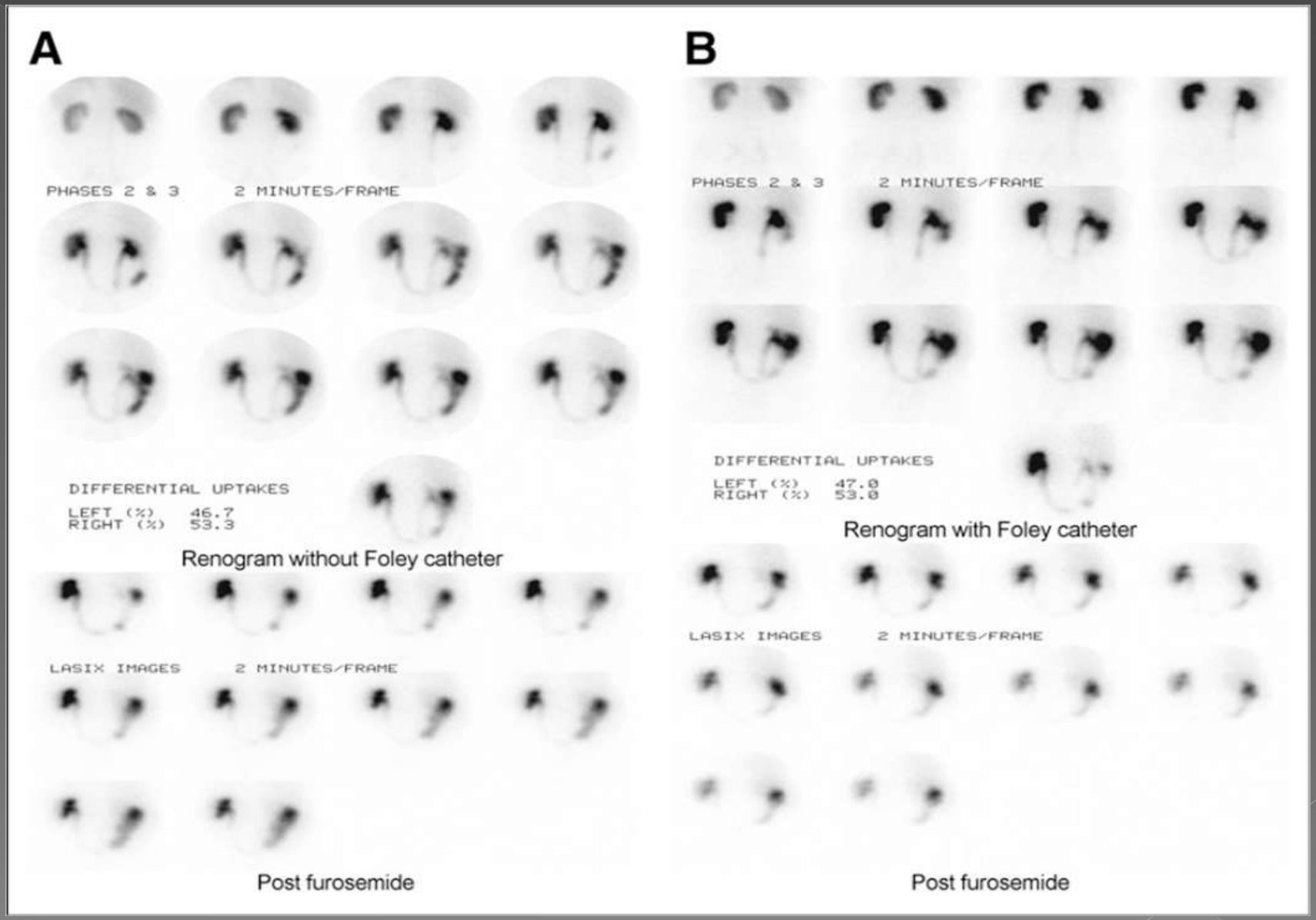
- Well hydrated – 1 hour before study, over 30 mins
  a) adult- ~500 ml
  b) children-10-15 ml/kg 1/3 NS (with 5% Dextrose<1yr)

- Any medication – diuretic, antihypertensive
- Any known anatomic abnormality – Ectopia, HSK
- Void before injection and after study
- Catheterization – BOO, Neurogenic bladder, children
- Sedation



Posterior radionuclide study demonstrates prompt, symmetric perfusion to both kidneys. Sequential images show the kidneys to be of normal size and morphology. There is progressive uptake of tracer by both kidneys with increasing accumulation of tracer in the renal parenchyma over the ensuing twenty minutes of image acquisition. <u>There is some degree of excretion into the renal calyces, but overall, the excretion is markedly diminished.</u>

Effect of dehydration



Effect of catheterization

Protocol

- Radiopharmaceuticals

Radiophamaceutical	Children	Adult
Tc-99m DTPA	0.1 mCi/kg	2.5-5 mCi
Tc-99m MAG3	0.05 mCi/kg	5-10 mCi

- Instrumentation – Low energy all purpose, high resolution, parallel hole

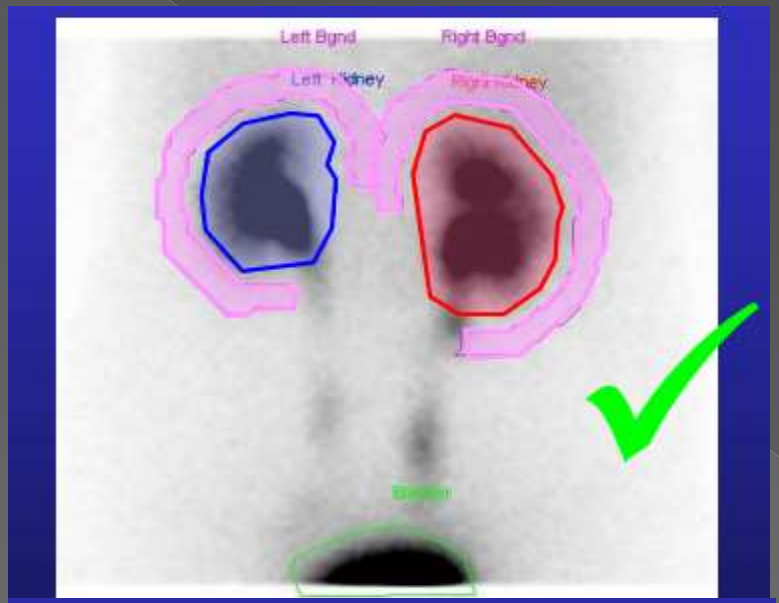
- Position –Supine with camera posterior in routine, camera anterior in transplant kidney, pelvic ectopic/HSK

Protocol (cont)

- Acquisition:
  - Flow: 1-2 sec frame for 1 min
  - Dynamic: 15-30 sec frame for 25-30 mins

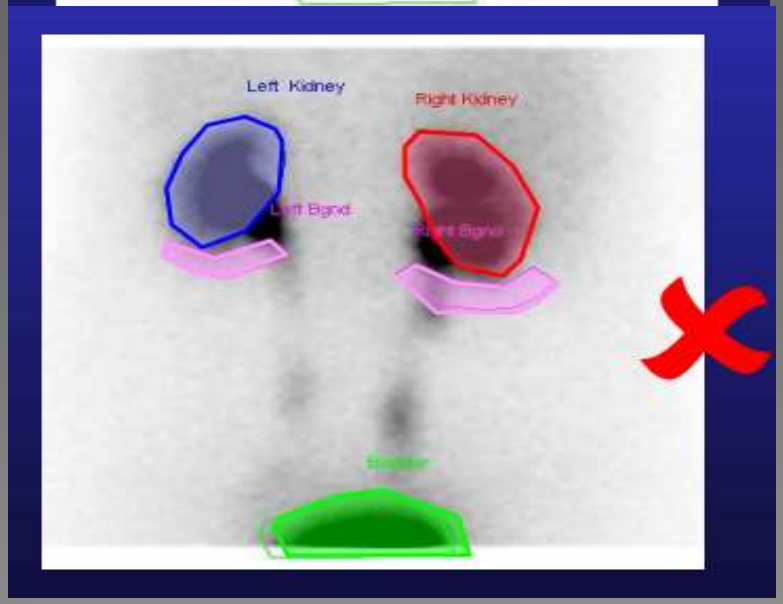
- Image Processing:
  - Drawing ROI around kidney
  - Drawing background area
  - Creating time activity curve (TAC) for flow and dynamic phase
  - Differential function calculation

ROI & background drawing



DO

- Include renal pelvis in kidney ROI
- Make kidney regions big enough to include any small movement
  - Too big is better than too small
- Use mixture of blood and tissue in background ROI



DON'T

- Cut off the renal pelvis
- Let background cross ureters
- Make background ROIs too small
  - Low counts → large uncertainty

Interpretation

- **1st phase:**
  - **Vascular/flow phase:** Aorta to kidney - ~3 sec
  - Judged by first few 1-2 sec flow frames
  - Any asymmetry in tracer activity – abnormal perfusion of the side of decreased and delayed activity
  - Any small or scarred kidney – less flow due to decreased parenchymal active tissue volume



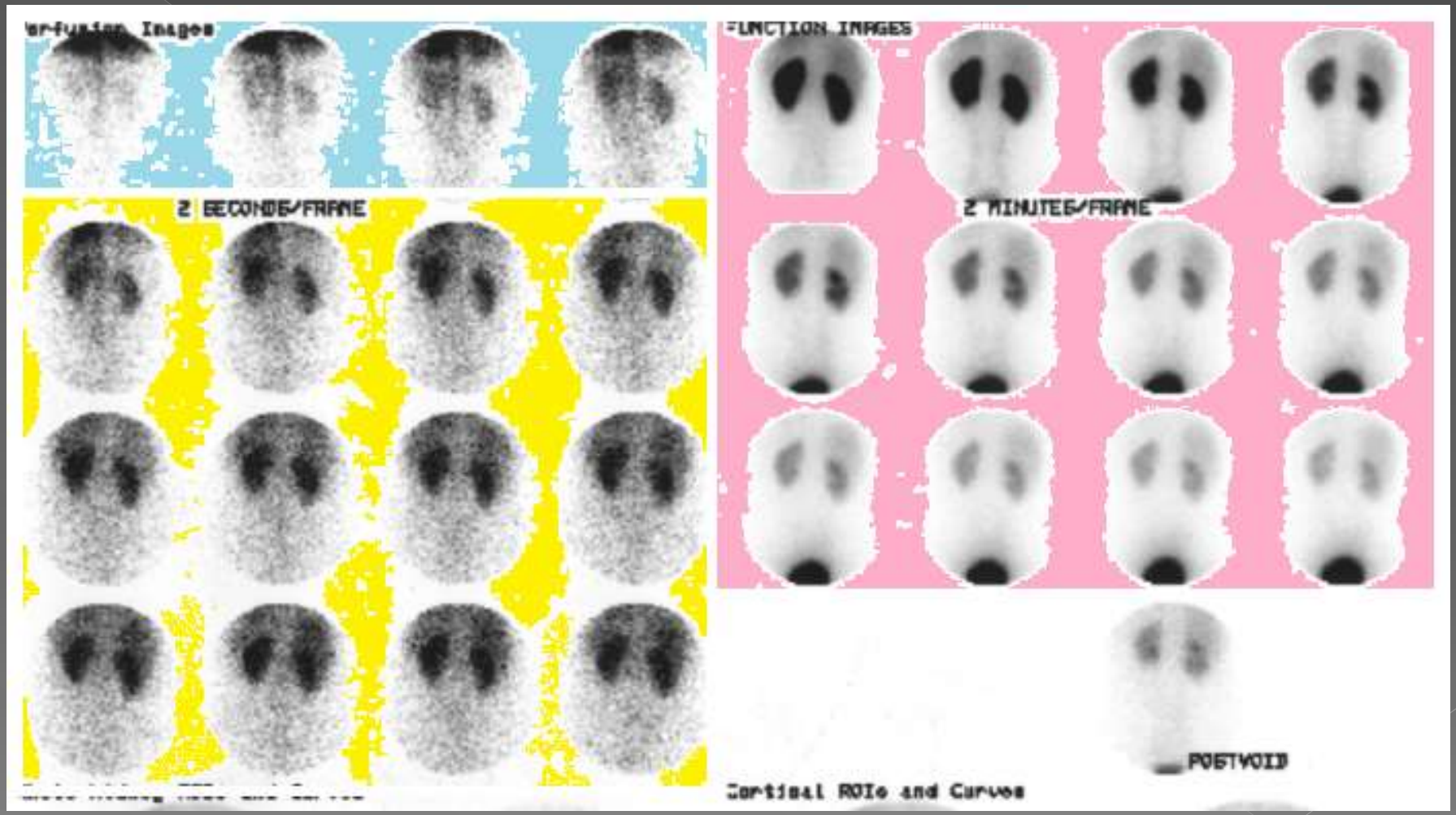
Interpretation (cont.)

- **2nd phase:**
  - **Parenchymal phase/cortical uptake phase:** parenchymal accumulation of tracer, kidney to background- **1 to 3 mins (peak <5 mins).**
  - If decreased function in any side-rate of uptake is delayed and amount is reduced in a specific time period relative to better functioning kidney.
  - **"Flip-flop" pattern** – poor functioning side shows initial low uptake but later higher than better functioning side which has already excreted radiotracer.

Interpretation (cont.)

- **3rd phase:**
  - **Washout/clearance phase:** calyces and pelvis begin to fill by **3 mins.** Over **next10-15 mins** activity of kidney and collecting system decreases. Most of the radiotracer clears to bladder by the end of the study.
  - Lack of clearance or overlap of pelvicalyceal area on cortex suggests **hydronephrosis**.
  - Normal ureter may/may not be seen. Prolonged, unchanging or increasing activity in ureter suggest dilatation. Ureteral activity persist after clearance from kidney suggests **reflux.**

Normal renogram images



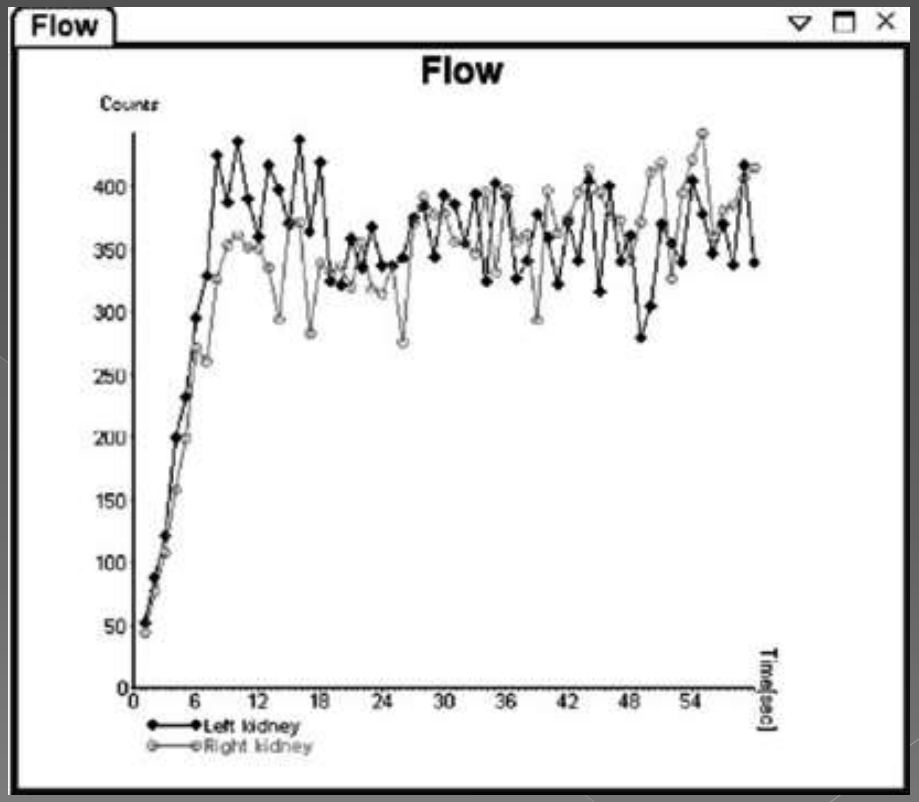
- Perfusion phase
- Parenchymal phase
- Washout phase

TAC

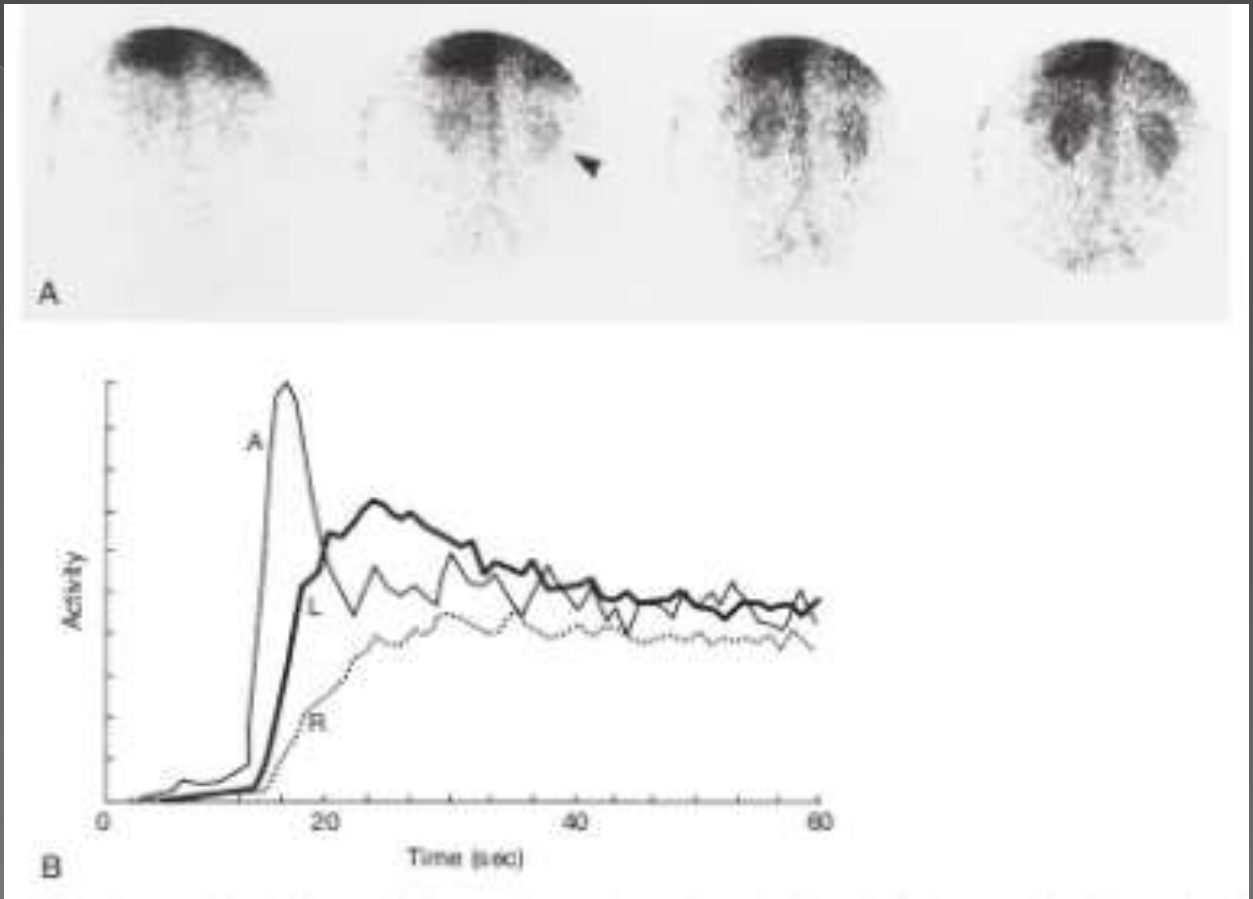
- Computer generated.
- Dynamic visual presentation of changes in activity in a specific ROI over the course of study.
- Separate curve for perfusion and dynamic function of study.

Perfusion Time-Activity Curve

- Shows blood flow to each kidney compared to arterial flow.
- ROI – kidneys and nearby major artery (AA, IA).
- Initial 60 sec flow.
- Relative flow is visualized by comparing the upslope of curve



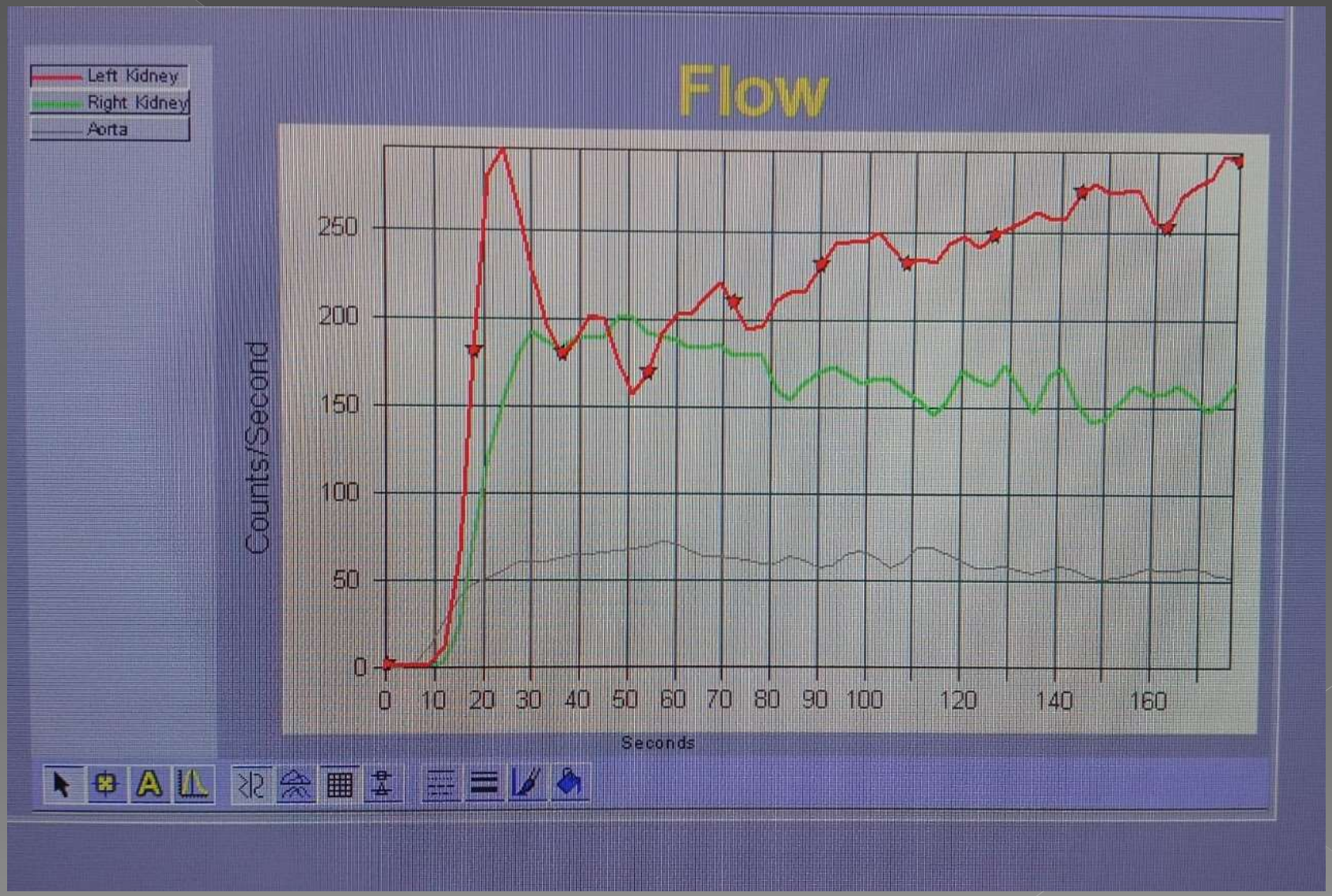
Perfusion TAC



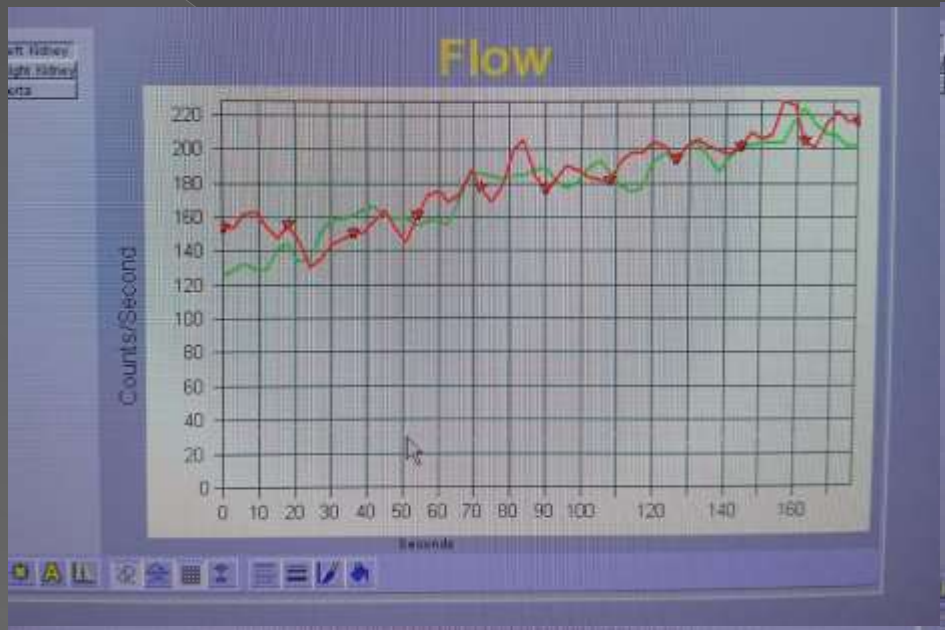
A. Renal flow analysis: shows moderately delayed and decreased flow to right kidney (arrow)

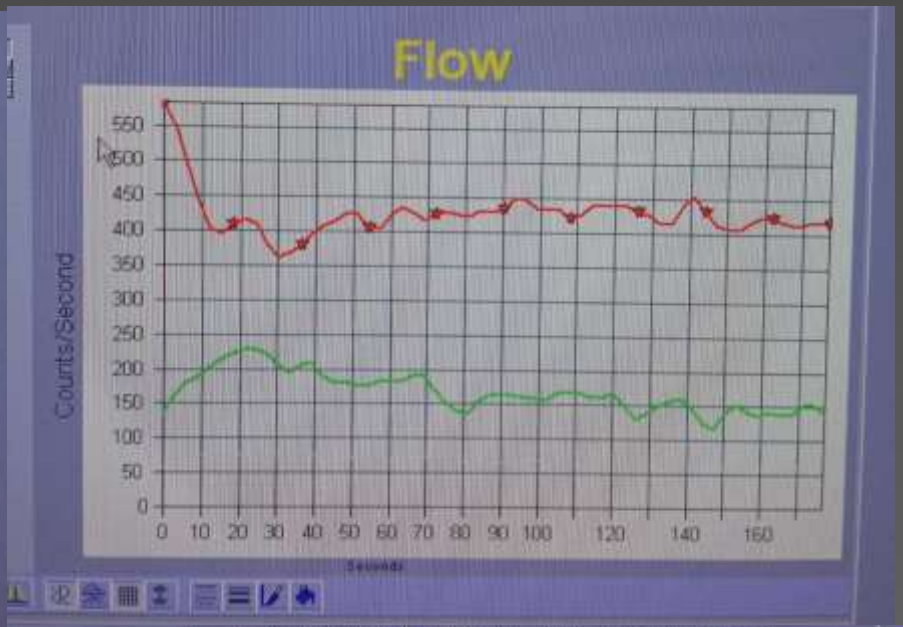
B. TAC confirms image finding: Initial upslope of right kidney (R) delayed compared to aorta and left kidney (L).

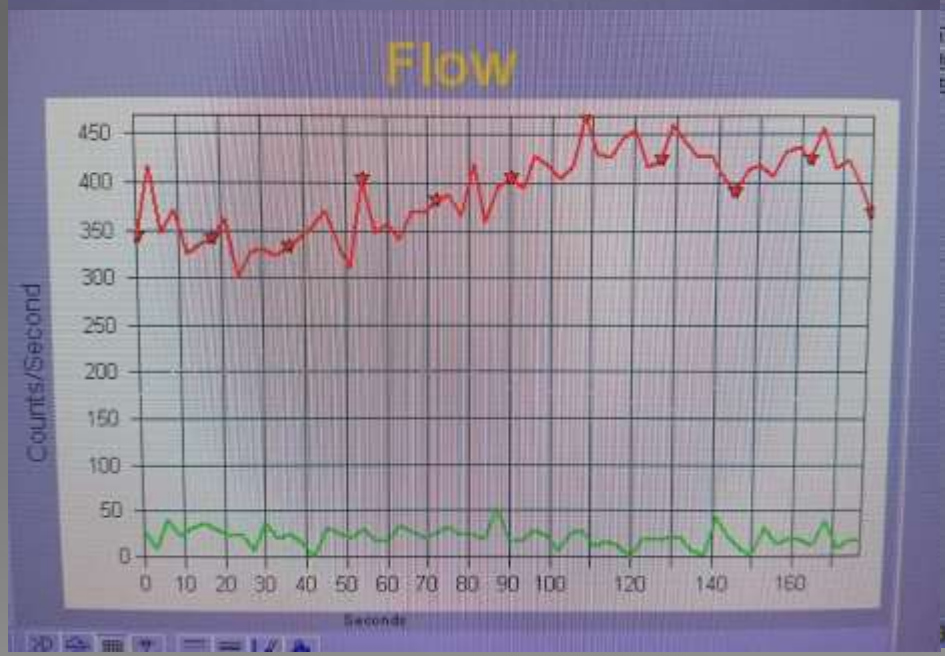
INMAS Kushtia samples



Perfusion curves



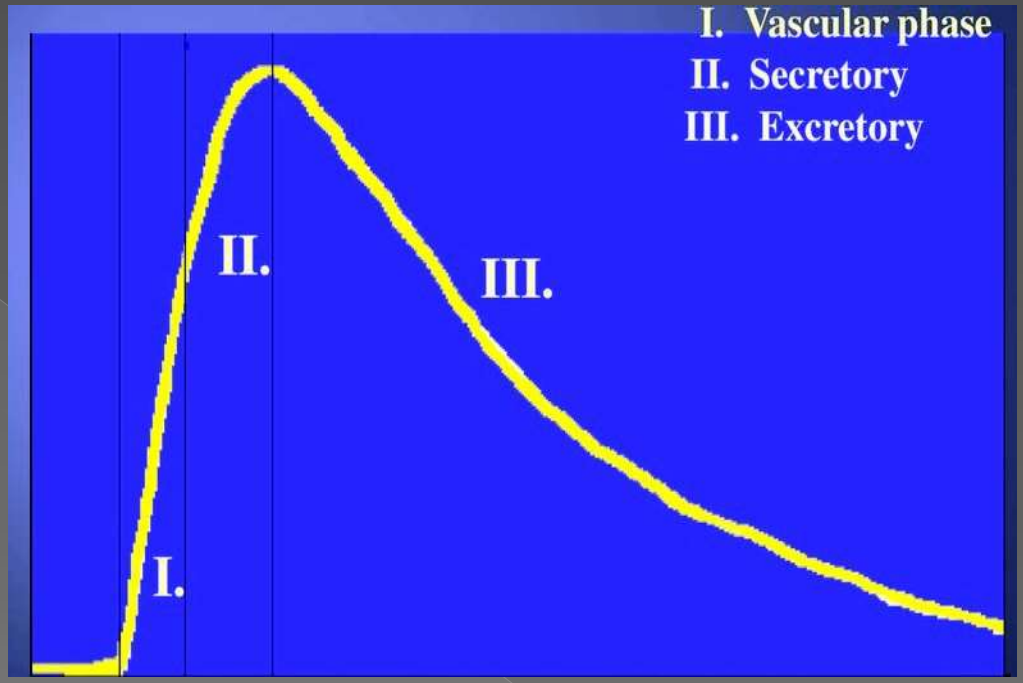






Dynamic Time-activity Curve

- Shows blood flow (vascular), cortical uptake (secretory) and clearance (excretory) phases.
- ROI – kidneys
- About 30 mins.
- Various values can be derived from dynamic TAC- peak activity (Tmax), uptake slope, clearance rate, T1/2 etc.
- Differential activity to note.



*** Must be interpreted in conjunction with sequential images.

Differential function

$$\% \text{ function of RK} = \frac{\text{total counts in right kidney ROI}}{\text{total counts in right kidney ROI} + \text{total counts in left kidney ROI}} \times 100\%$$

- Normal : 50/50 – 56/44
- Borderline : 57/43 – 59/41
- Abnormal : >60/40

- Computer generated.
- Does not indicate whether overall renal function normal or abnormal.
- Indicate % of functional contribution of each kidney to total function.

Measuring renal function

- **GFR Estimation**
- Camera based method – no blood sampling, only few minutes
- Known dose of Tc-99m DTPA counted from a set distance of camera face > count rate measure> post injection count> actual administered dose (Standard) count rate > imaging for 6 minutes > region of interest draw around kidney> background count rate > formula based attenuation correction of count from various renal depth according to height-weight > fraction of standard taken up by kidney in 1-2.5 minutes

INMAS Kushtia result sample

INSTITUTE OF NUCLEAR MEDICINE AND ALLIED SCIENCES (INMAS), KUSHTIA
Abdul Aziz ID: 16102024 SEX: M
STUDY: DTPA Renogram with GFR STUDY DATE: 16-Oct-2024

Kidney



Aorta

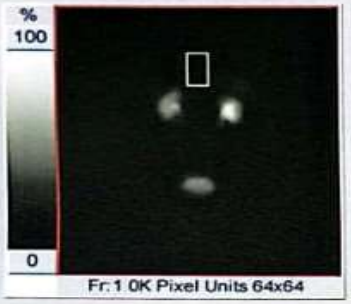




Table of Patient Parameters

Parameters	Values
Renal Protocol	Gates GFR (DTPA)
Kidney Depth Method	Standard
Patient Name	Abdul Aziz
Patient ID	16102024
Sex	Male
Age	49
Height	172.0 cm
Weight	70.0 kg
Body Surface Area	1.84 m²
Reference BSA	1.73 m²
Split Uptake Interval (min)	2.0 - 3.0
Radiopharmaceutical	5.0 mCi 99m Technetium DTPA
Presyringe Counts (Kcpm)	1120
Postsyringe Counts (Kcpm)	129
Net Injected Counts (Kcpm)	990
Method	Adult
Hematocrit	0.00

Kidney





Flow

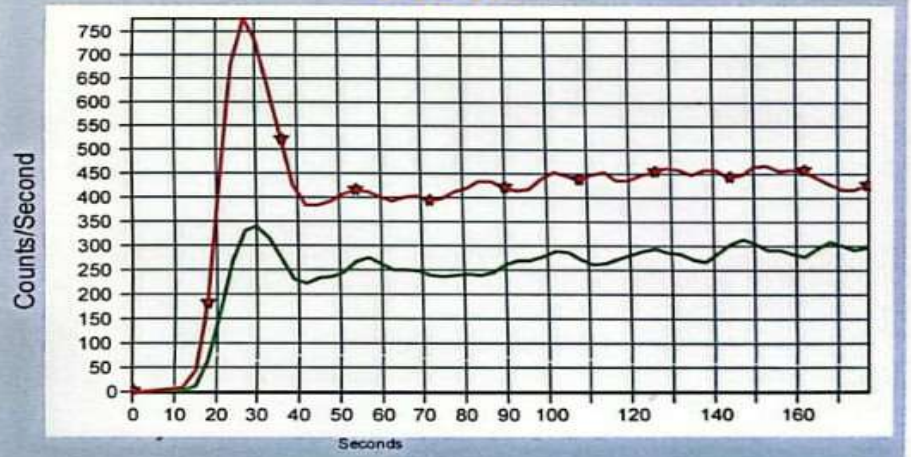


Table of Result Summary

Parameters	Left	Right	Total
Curve Fit	Off	Off	
Split Function (%)	60.4	39.6	
Kidney Counts (cpm)	67787	44441	112227
Kidney Depth (cm)	6.072	6.113	
Uptake (%)	6.844	4.487	11.3
GFR (ml/min)	63.0	41.3	104.4
Normalized GFR (ml/min)			98.1
GFR Low Normal (ml/min)			78.0
Mean GFR (ml/min)			101.0
Time of Max (min)	0.450	0.450	

Clinical application

- **Urinary tract obstruction**
  - Can lead to recurrent infection>diminished function>progressive loss of nephrons> parenchymal atrophy
  - If high grade obstruction is corrected promptly>function can fully recover
  - Ultrasonogram – hydronephrosis
  - Differentiate true/mechanical obstruction and nonobstructive dilatation/functional obstruction

  - **Renography with diuretic (furosemide) challenge**

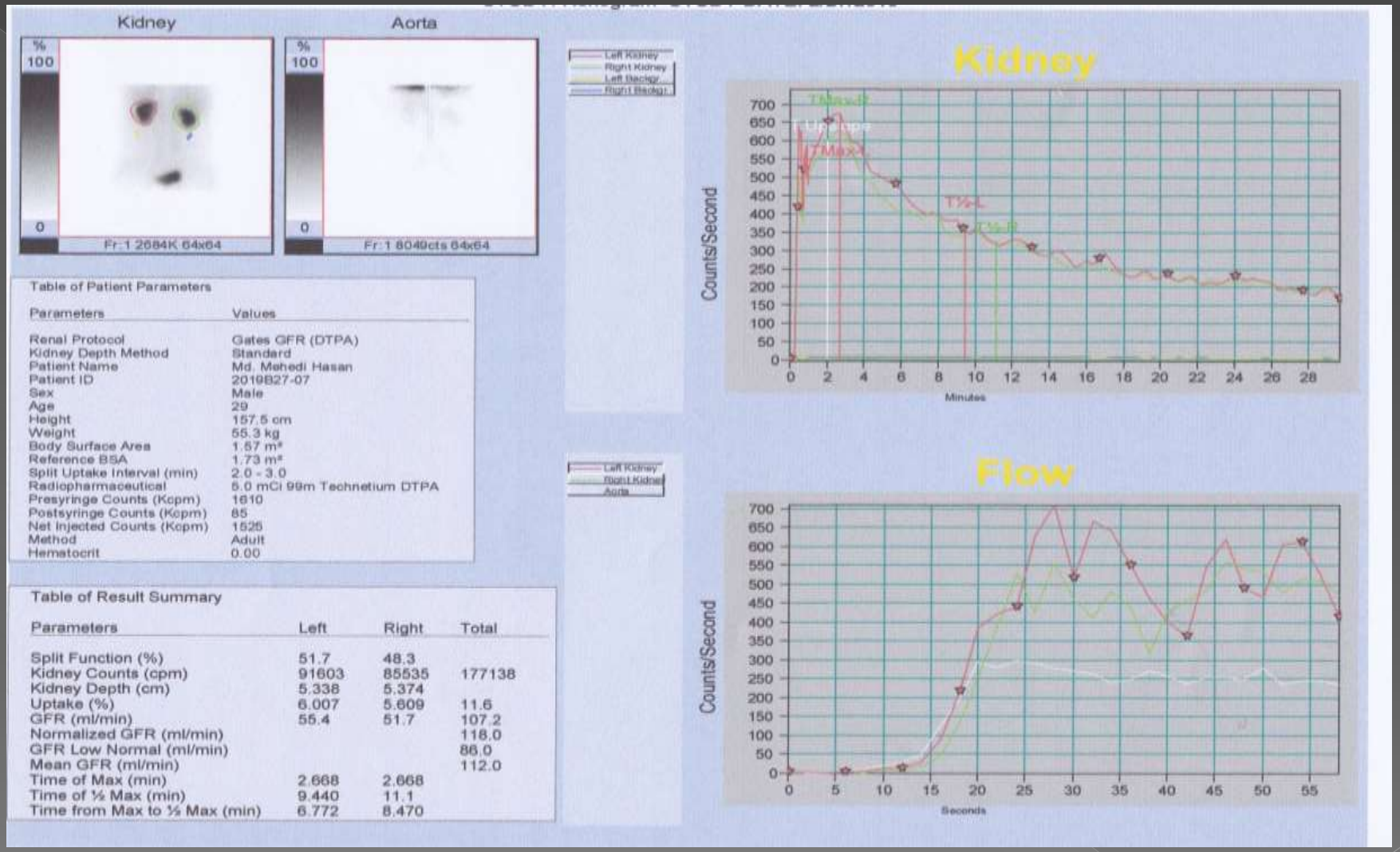
Diuretic renography

To distinguish- true obstruction from non-obstructive dilatation.
- Effect of obstruction.

Principle

- If a pelvicalyceal system is dilated but non-obstructed, increase in urinary flow rate through the effect of diuretic will lead to rapid washout of tracer.

- If the pelvicalyceal system is obstructed, the urinary flow will be impaired and appears as gradually increased pelvicalyceal tracer retention.



Features:

- 29 years old male patient.
- S. Creatinine – 1 mg/dl
- USG – Normal parenchymal findings.

Normal DTPA renogram.

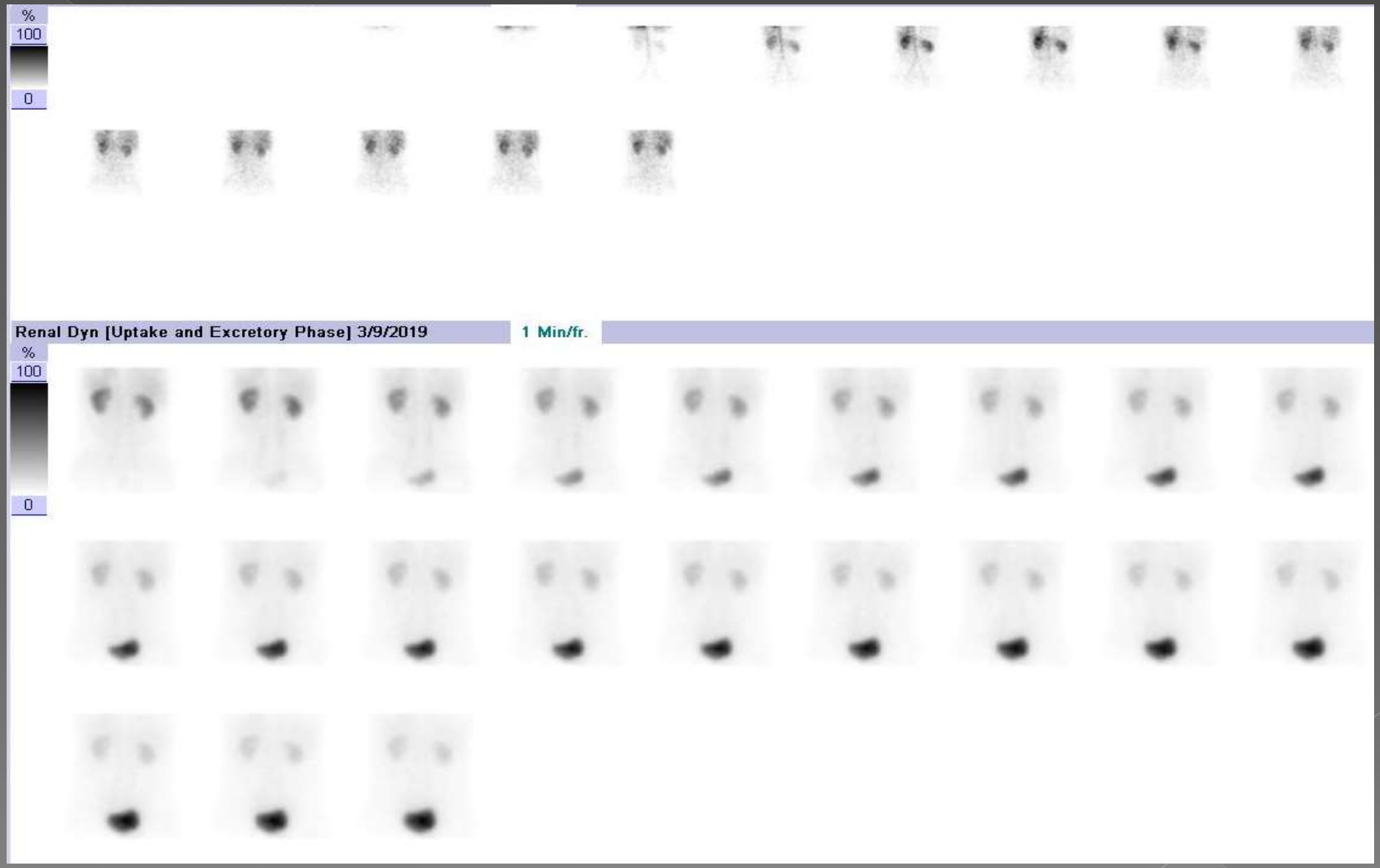
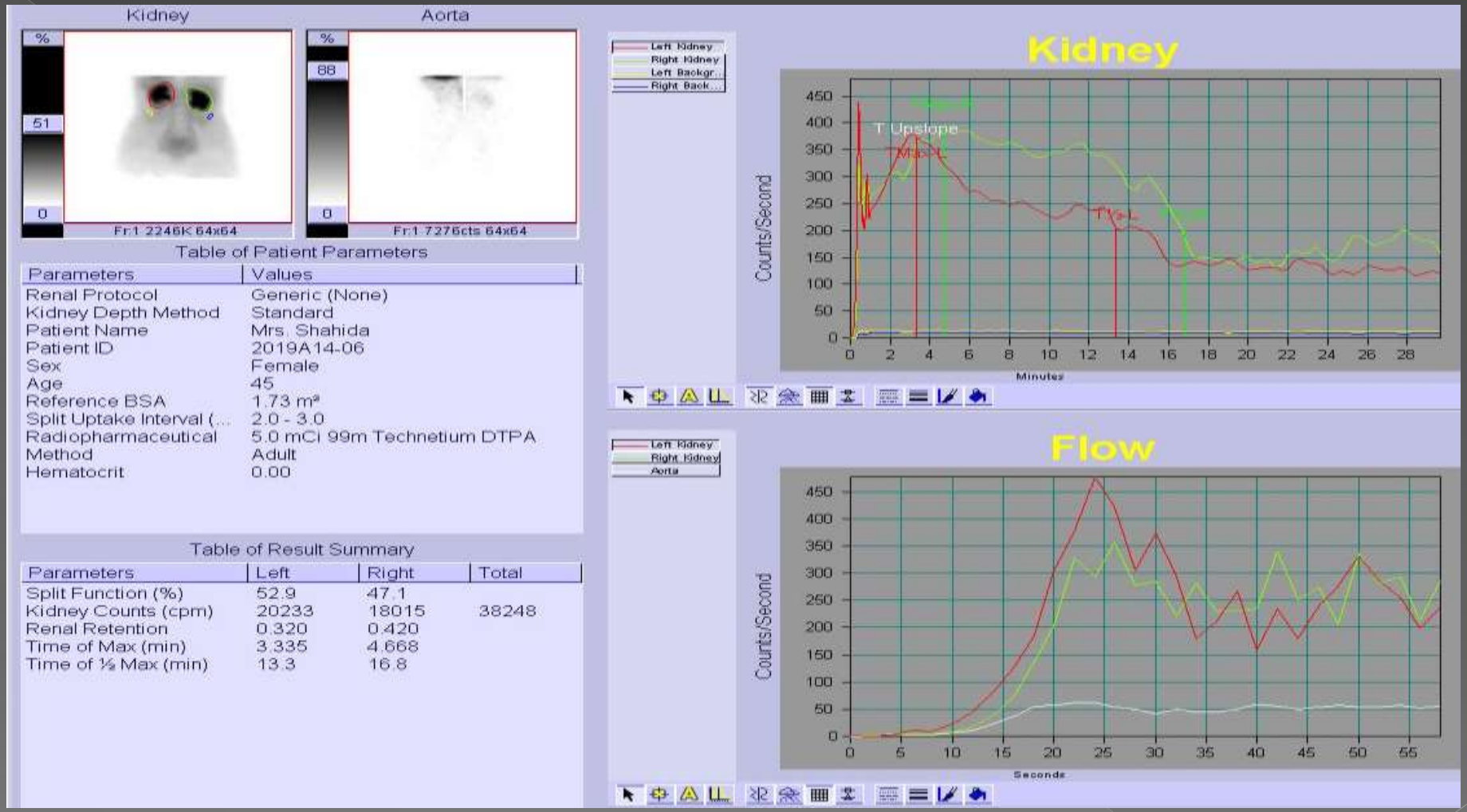


Fig: Sequential image. **Normal DTPA renogram.**



Features:

- 45 years old female.
- S. Creatinine – 0.64 mg/dl.
- USG – Mild pelvicalectasia in right kidney.

Functional obstruction (Right kidney)

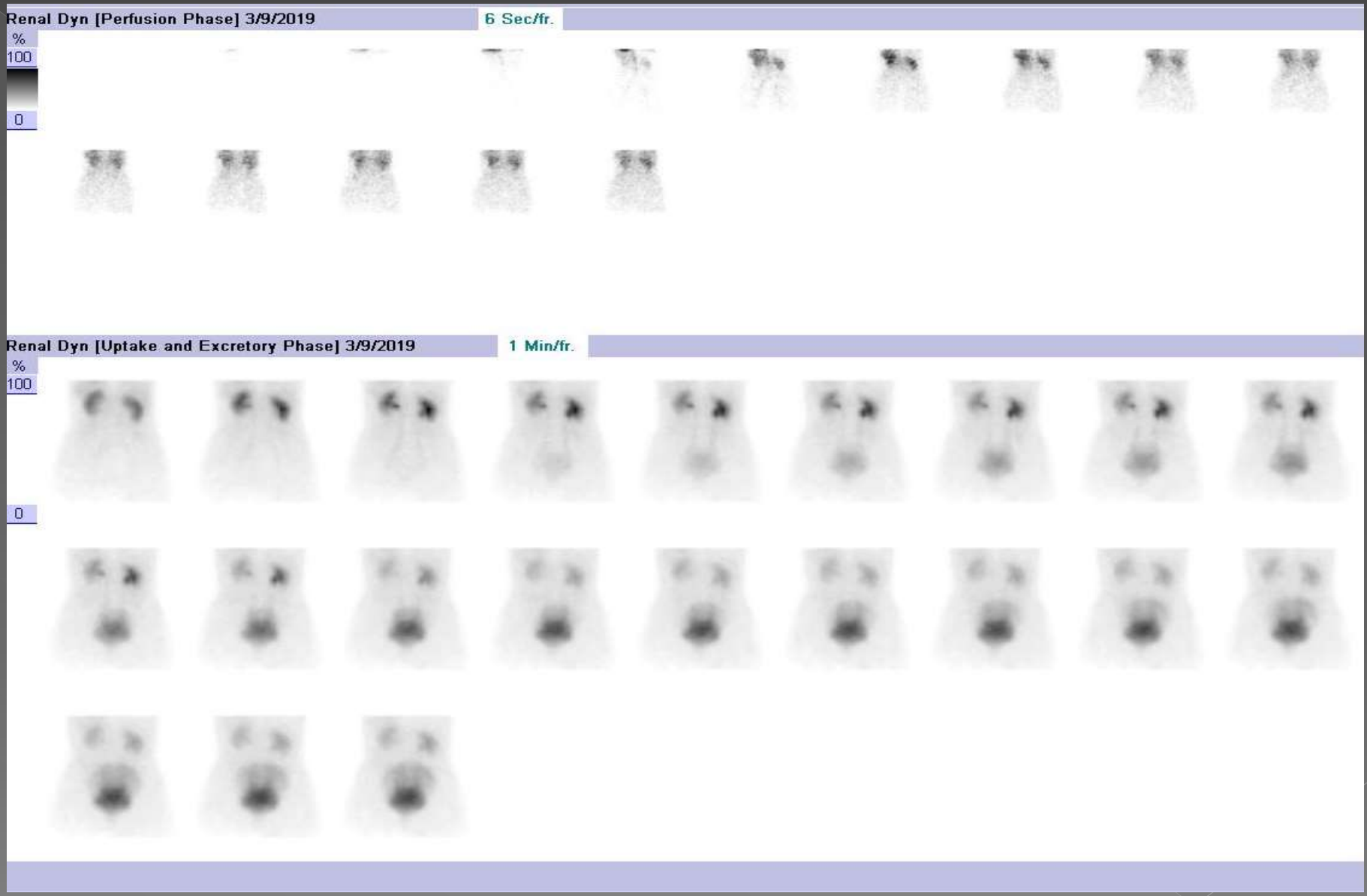
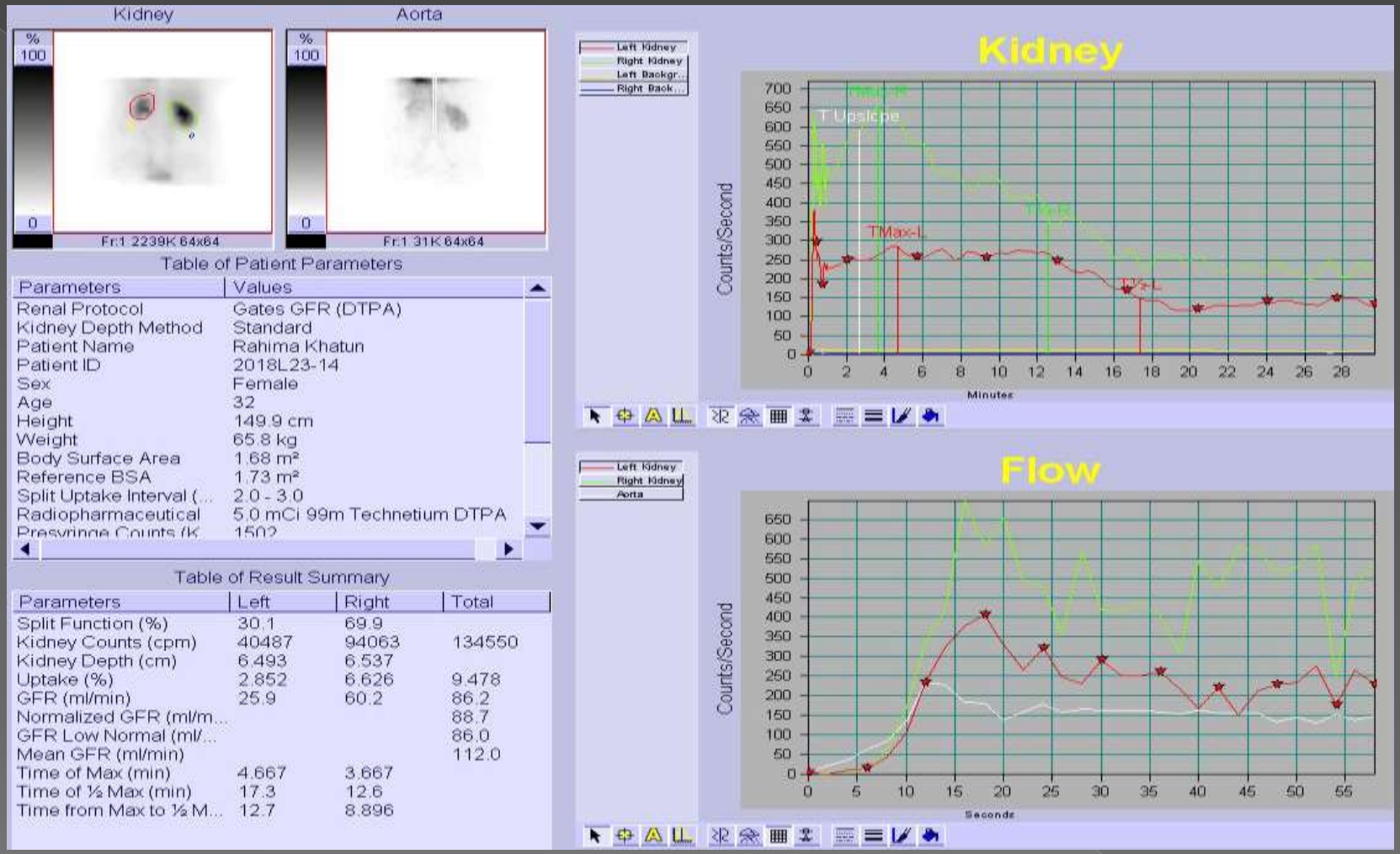


Fig: Sequential image.

Functional obstruction (Right kidney)



Features:

- 32 years female with history of operation in left kidney.
- S. Creatinine – 1.0 mg/dl.

Parenchymal insufficiency with functional obstruction (Left).

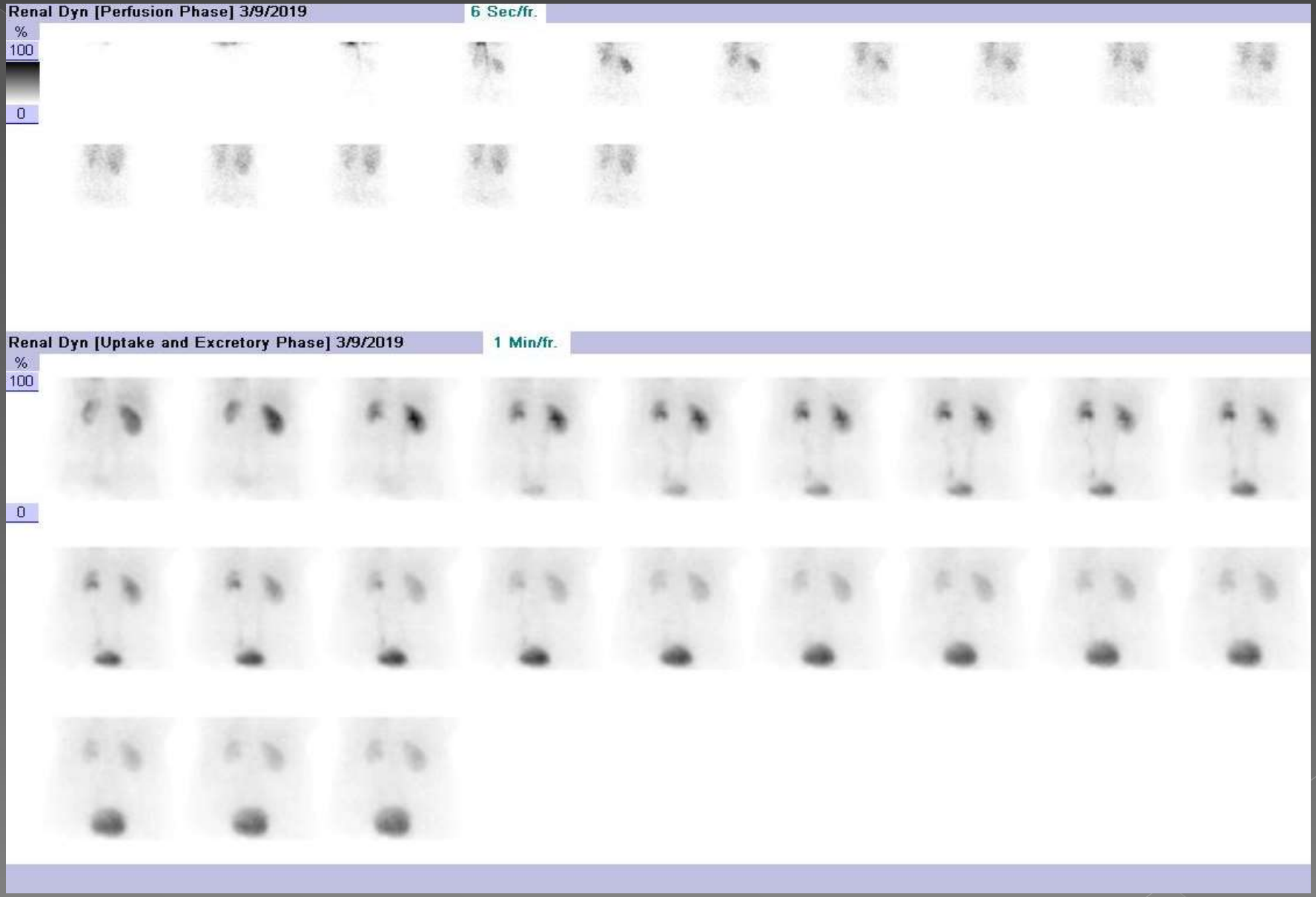
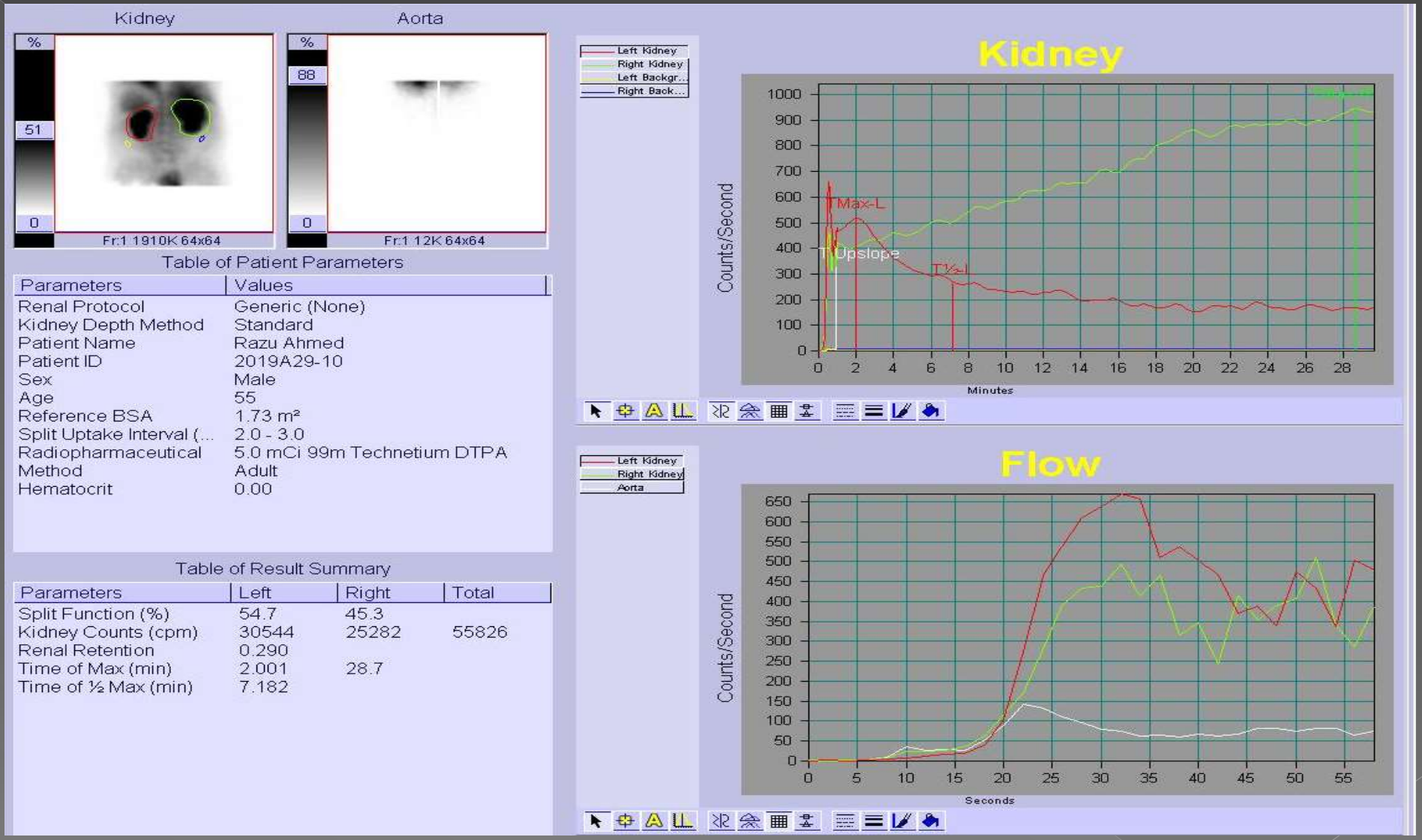


Fig: Sequential image.

Parenchymal insufficiency with functional obstruction (Left).



Features:

- 45 years old male patient with loin pain.
- S. Creatinine – 1.1 mg/dl.
- USG – Multiple stone and simple cysts in right kidney.

Parenchymal insufficiency with true obstruction (Right kidney).

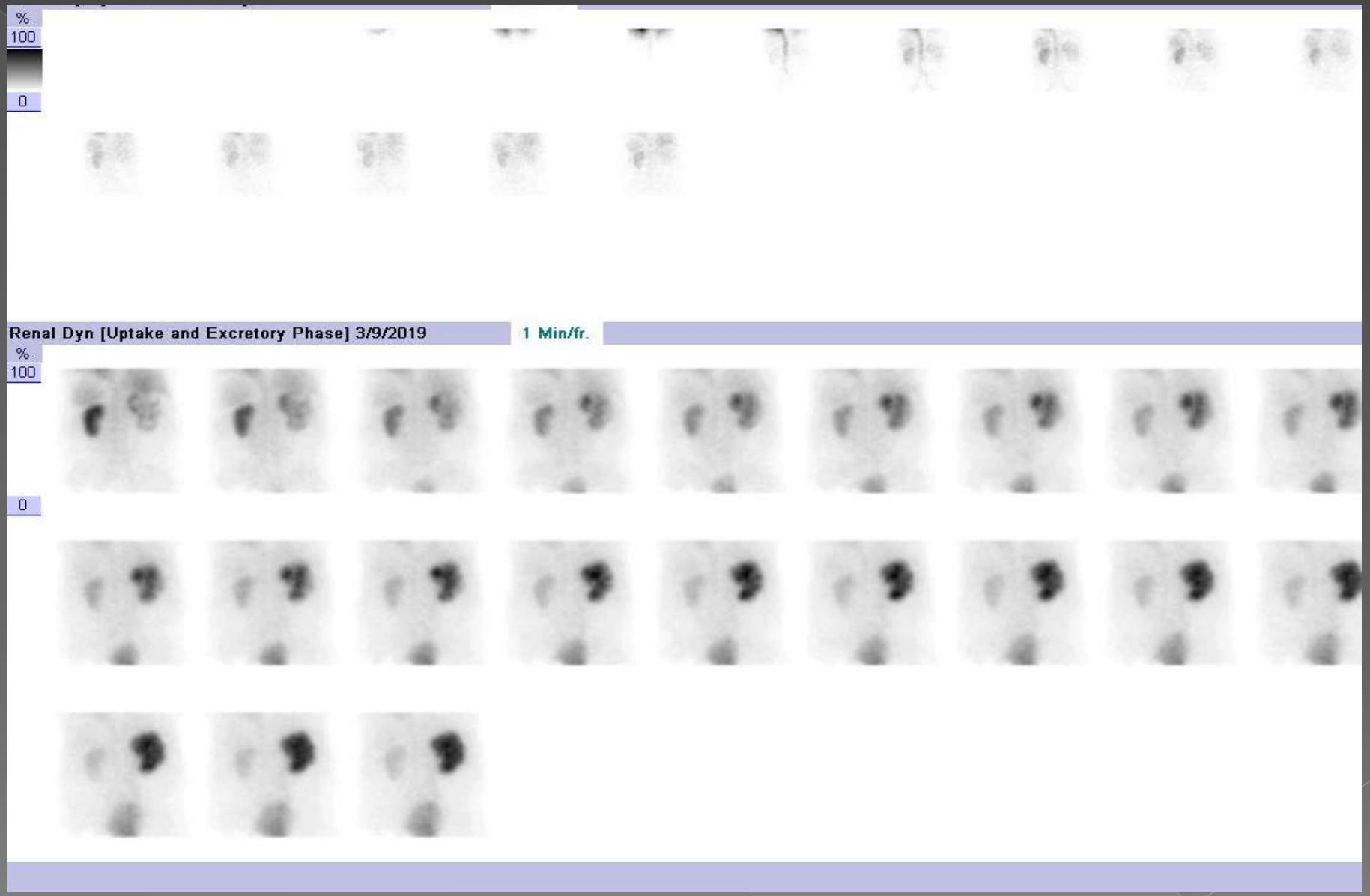
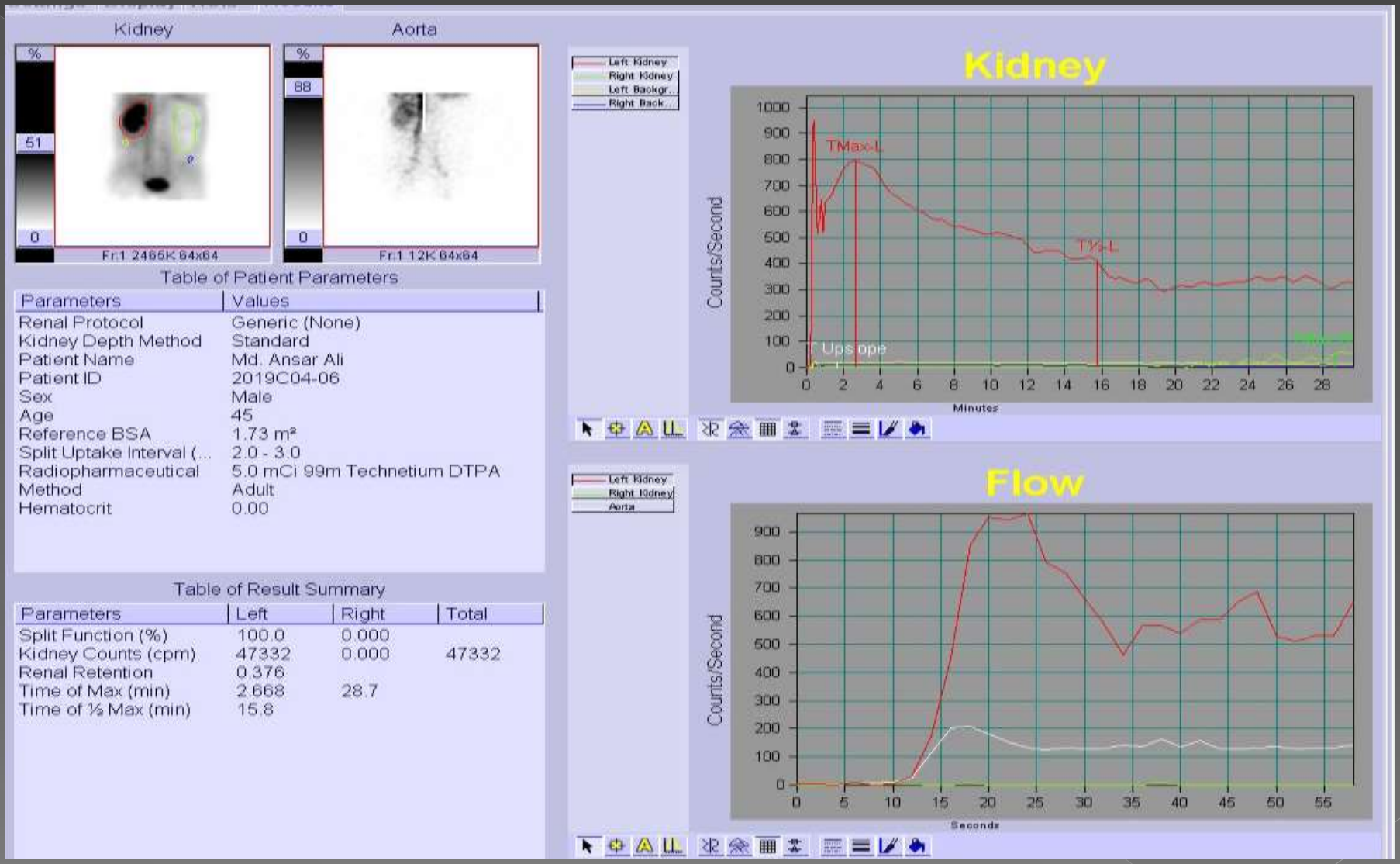


Fig: Sequential image.

Parenchymal insufficiency with true obstruction (Right kidney).



Features:

- 45 years old male patient.
- S. Creatinine – 0.9 mg/dl.
- USG – Gross hydronephrotic change in right kidney.

Non-functioning (Right kidney).

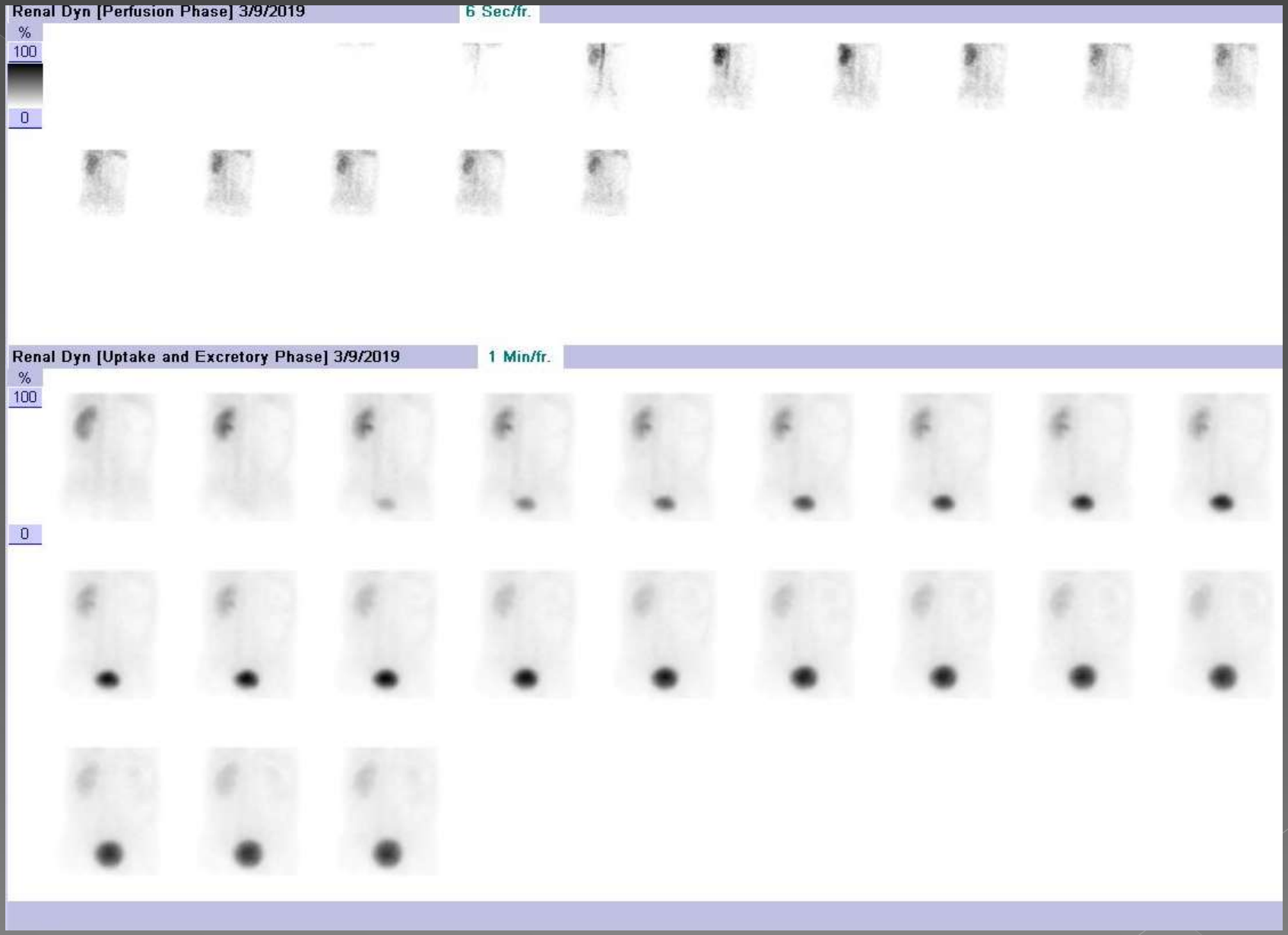
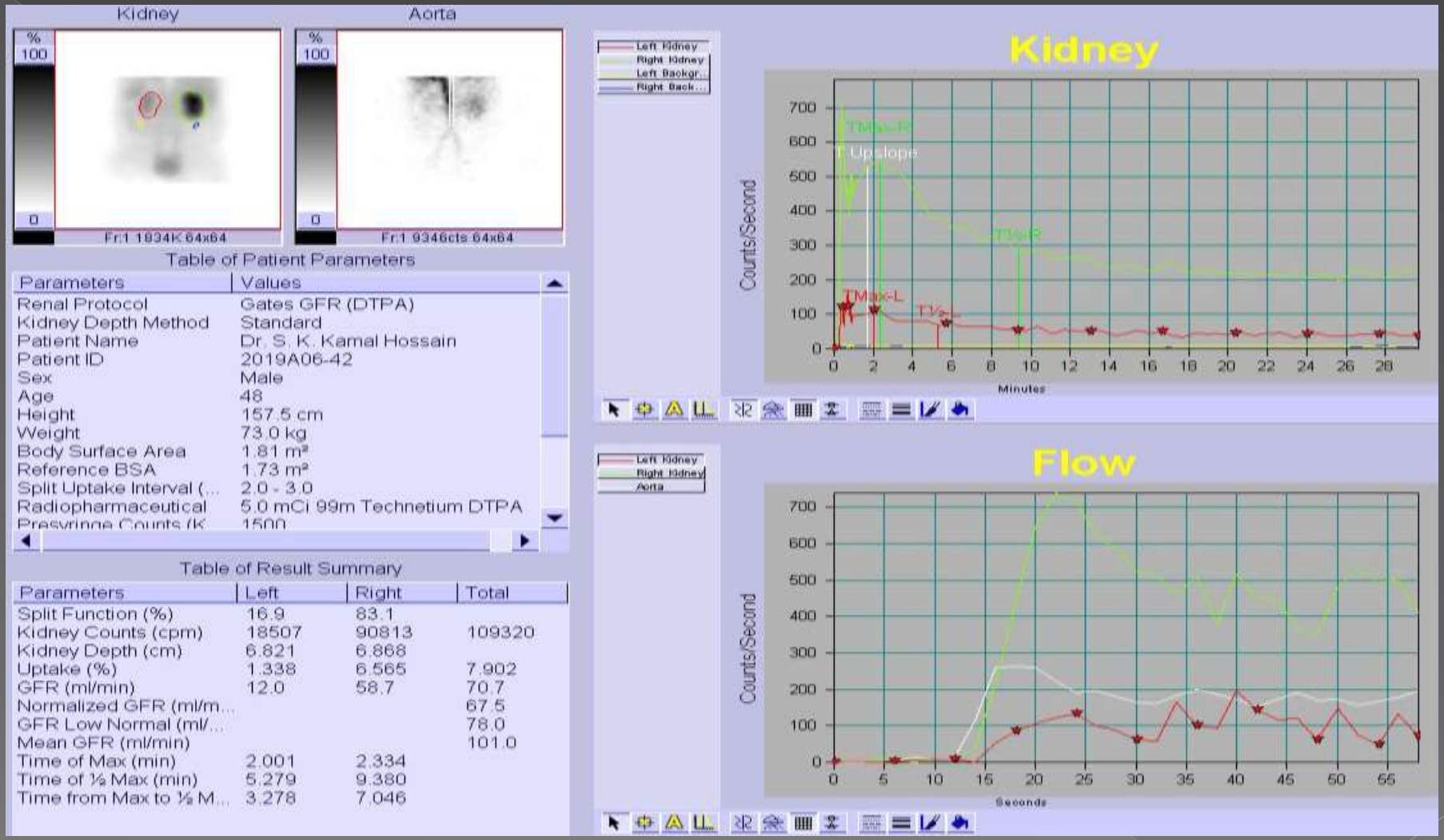


Fig: Sequential image.

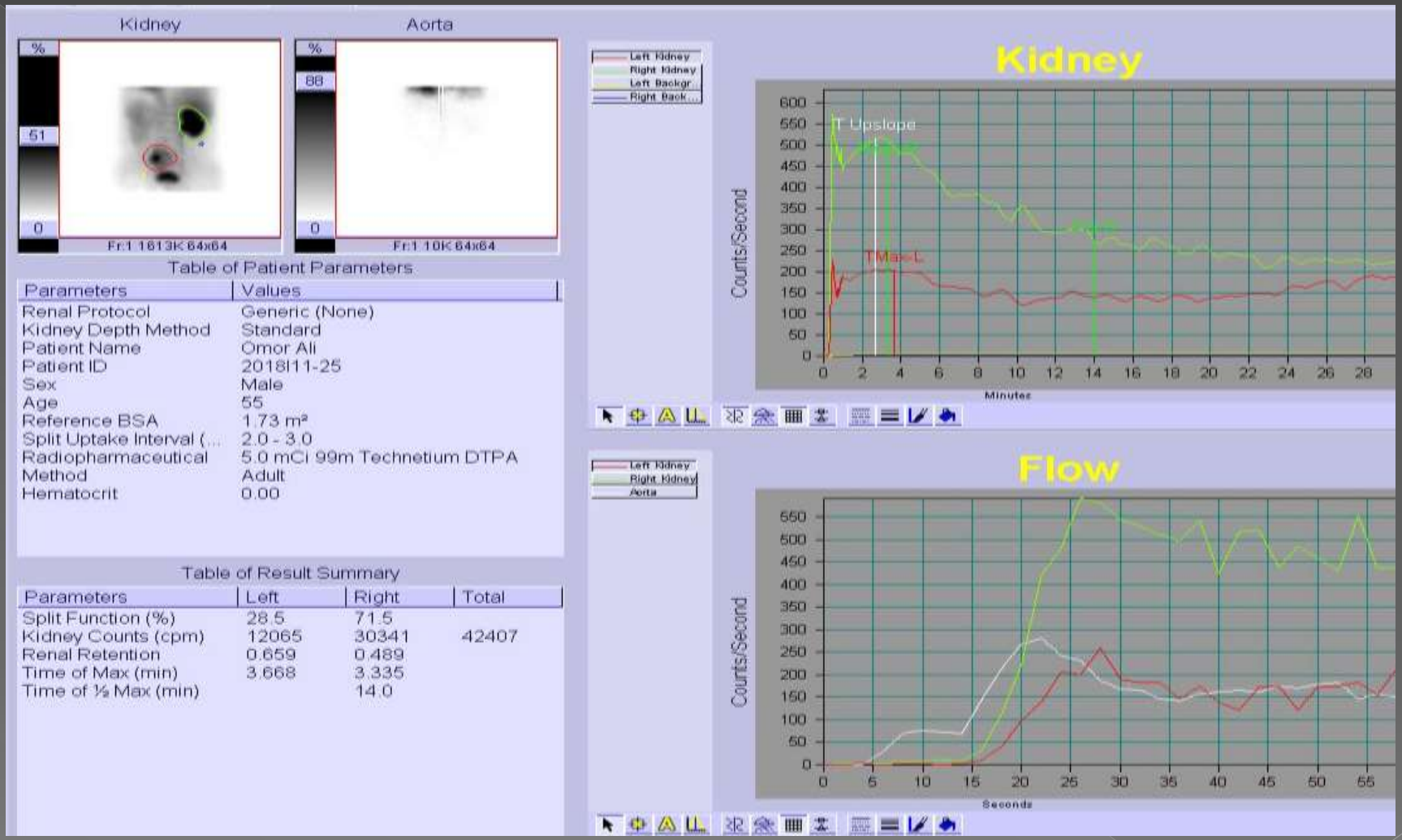
Non-functioning (Right kidney).



Features:

- 48 years old male patient with hypertension.
- Angiogram- renal artery stenosis.

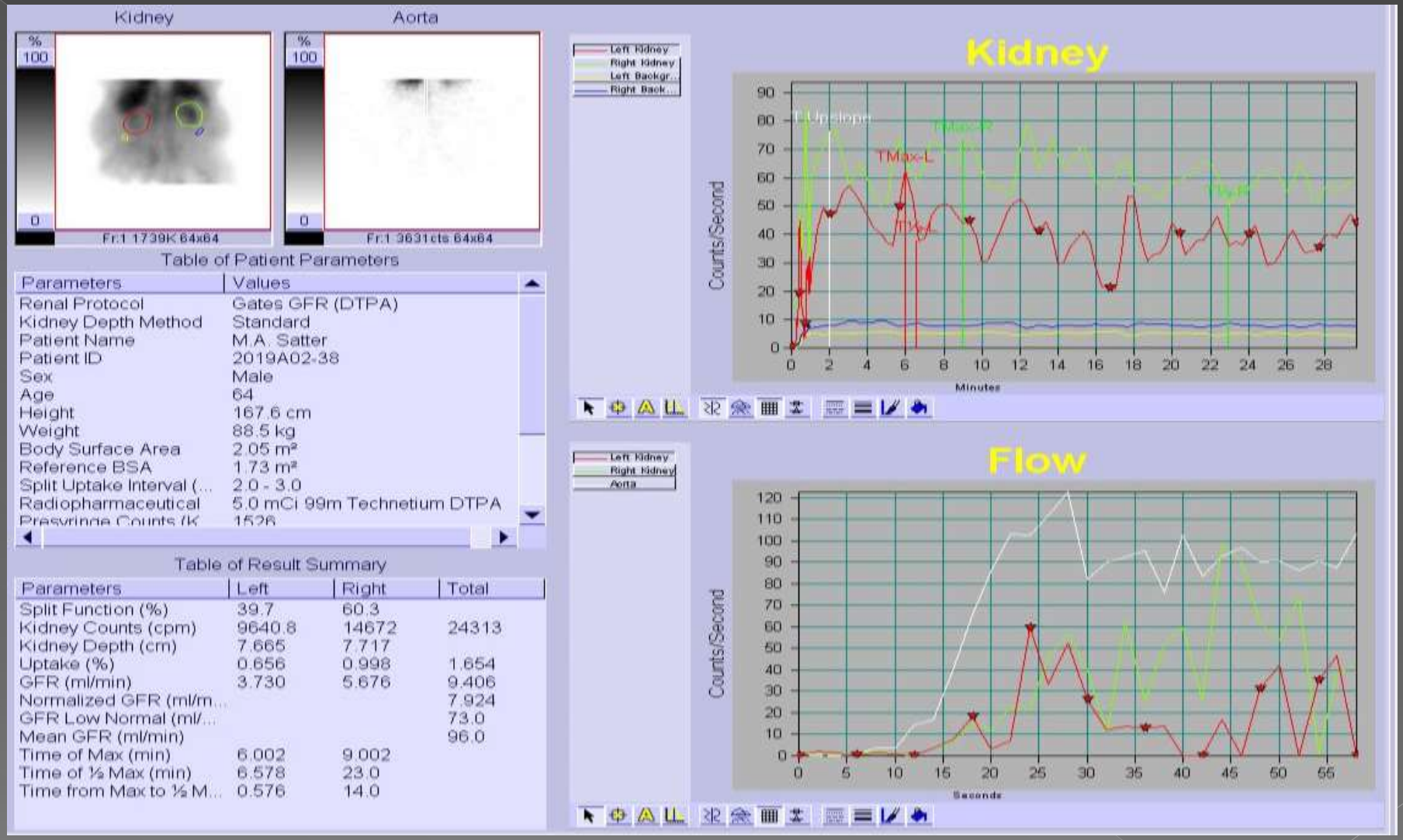
Severe parenchymal disease (Left kidney).



Features:

- 55 years old male patient with left loin pain.
- USG-Pelvic ectopic Left kidney

Ectopic pelvic left kidney.



Features:

- 64 years old male patient with chronic renal parenchymal disease.
- S. Creatinine – 7.5 mg/dl

Severe parenchymal disease (Both kidney).


Thank
you