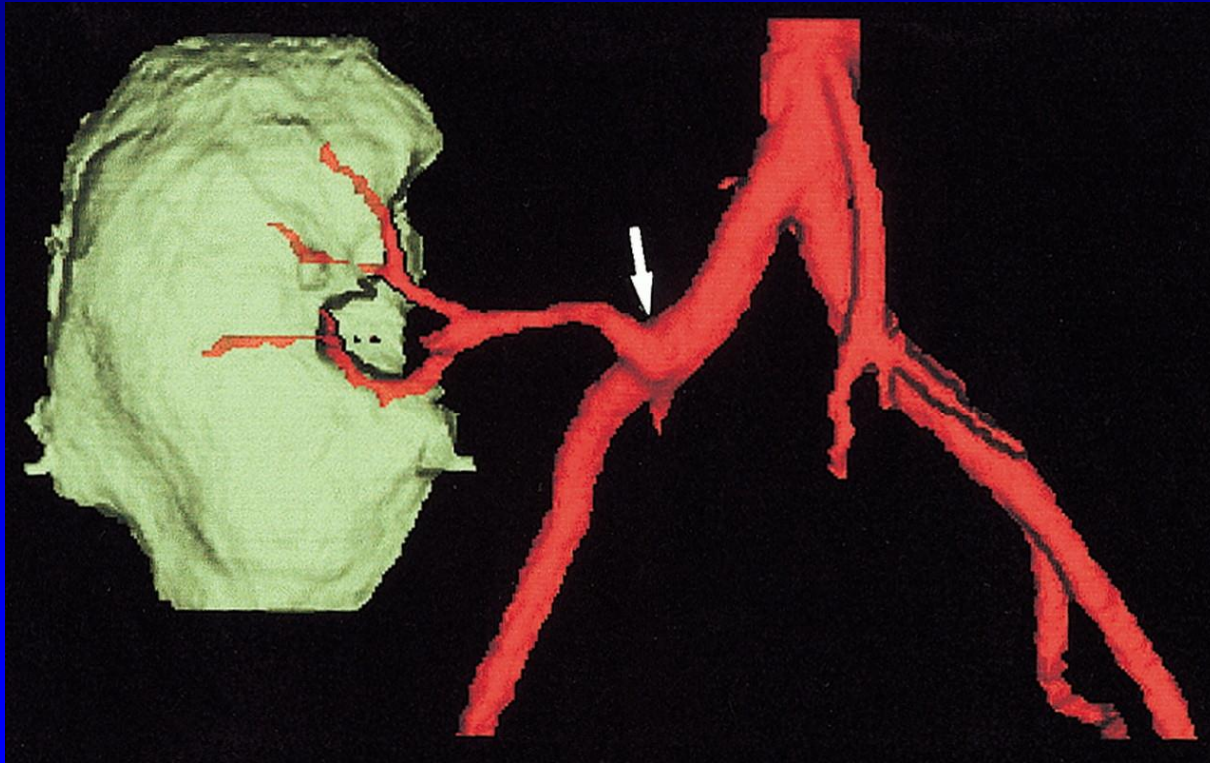


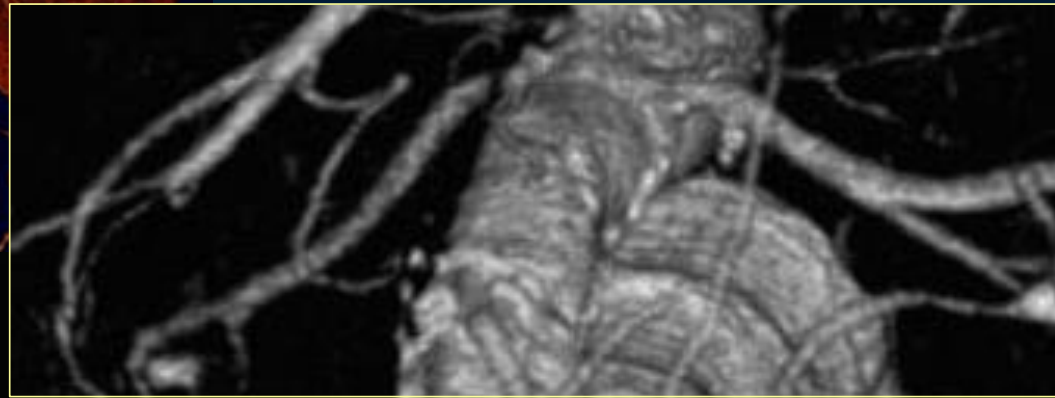
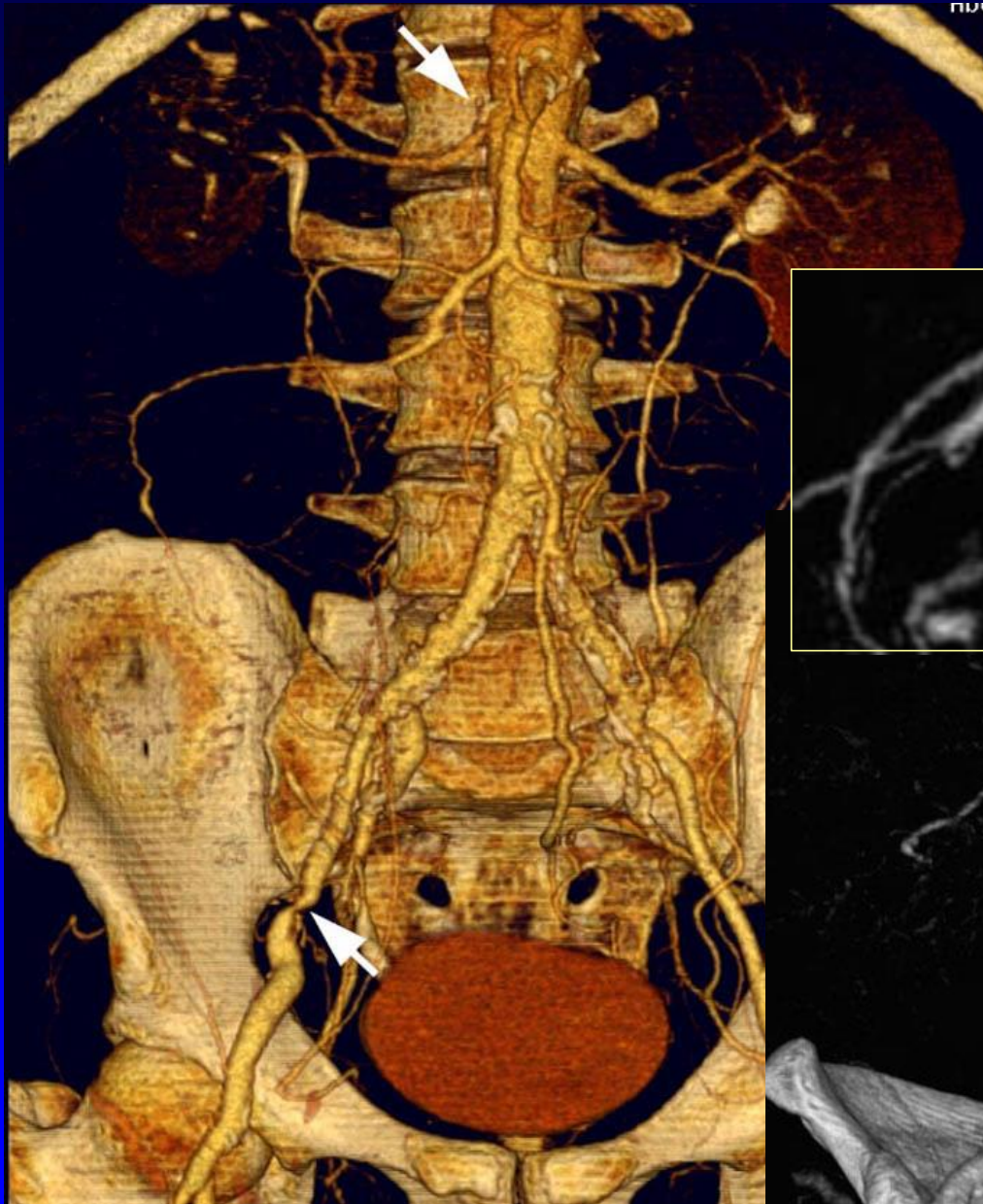
# Renal Nuclear Medicine

John Buscombe

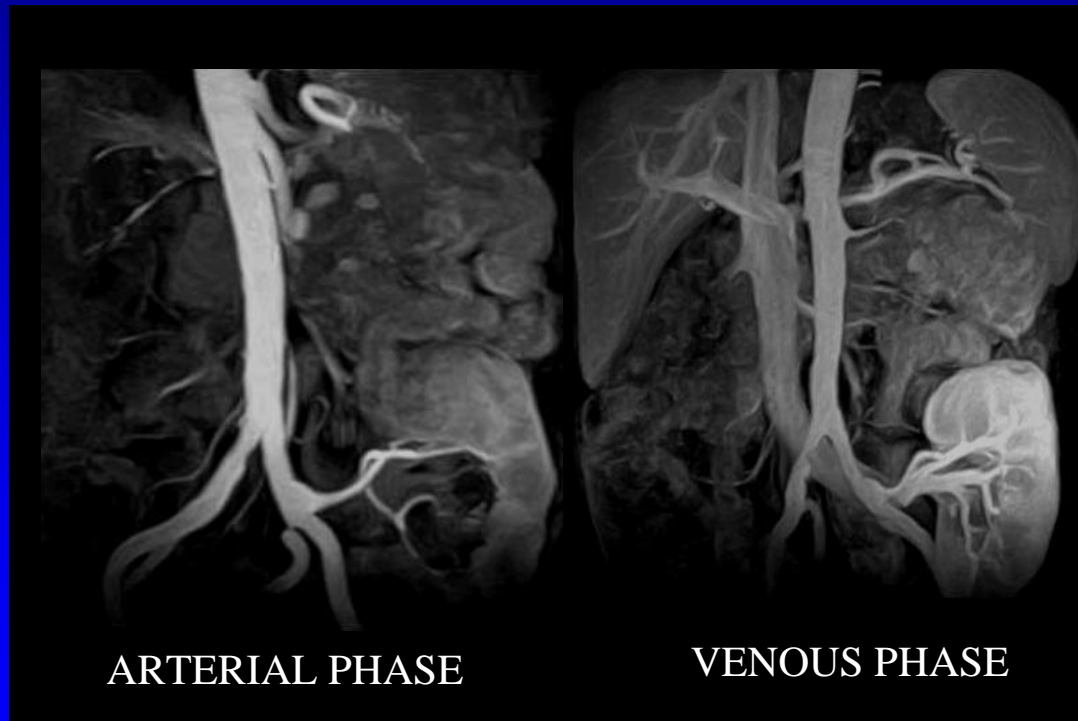
Why bother?  
CT can do it



# Concomitant Stenoses



Why bother?  
MR can do it.



# NUCLEAR MEDICINE Is Functional Imaging

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- To visualise an organ needs a contrast with the surrounding tissue.
- Radiography/CT needs difference in density.
- MRI needs difference in protons.
- Ultrasound needs difference in reflectivity.
- Nuclear Medicine needs difference in function.

# Functional Imaging

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## Tracers

- Tracer is substance added to a physiological pathway, which is handled by that pathway but does not disturb it.
- Requires small chemical amount of material, but high contrast with tissue which does not contain pathway.
  - Tc-99m-DTPA is a tracer for glomerular\_filtration
  - Intra-coronary angiographic contrast is not a tracer for coronary flow.

# Functional Imaging

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- FUNCTIONAL IMAGING NEEDS TRACERS
- Need to study whole organ over an appropriate time interval.



# Renal Function?





# Total renal function

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- No pure imaging method works
- Best is to measure GFR with Cr-51-EDTA or Tc- 99m-DTPA and blood sampling.
- Single-kidney GFR from total + divided function.

# Renal Blood Flow

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- No good measure of absolute RBF.
- Various *indices* of renal blood flow.
  - Peters et al RBF/CO
  - Transplant perfusion index
  - (ERPF/MAG3)

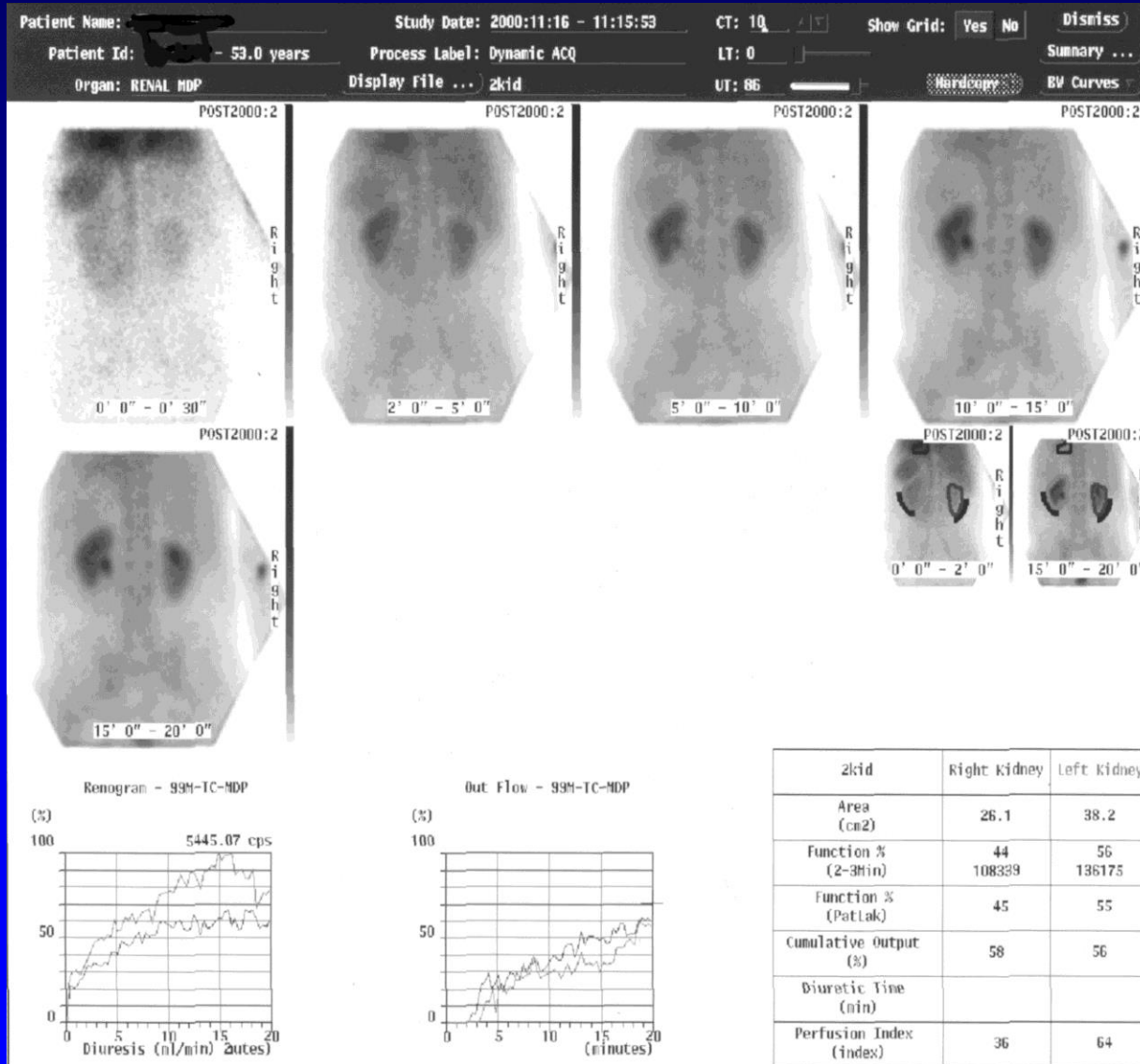
# Imaging Function

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## Which Function? Which Agent?

- Glomerular Filtration
  - Tc-99m-DTPA
  - Tc-99m-MDP
- Glomerular Filtration + Tubular Function
  - Tc-99m-MAG3
- Tubular Function
  - Tc-99m-DMSA

# MDP (Medronate) renal imaging



# Imaging divided function

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- Rate of uptake of dynamic tracer
  - Integral/slope methods
  - Rutland/Patlak plot
- Degree of retention of static tracer
- NB Need to correct for background activity

# Function involves time

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Radiation Dose in Nuclear Medicine does not depend on time - therefore:

- Can image time-dependent changes
  - Transit
  - Ureteric peristalsis
- Can *measure* changes
  - Response to stimulus
    - <Frusemide
    - <Captopril
    - <Aspirin
    - <Exercise



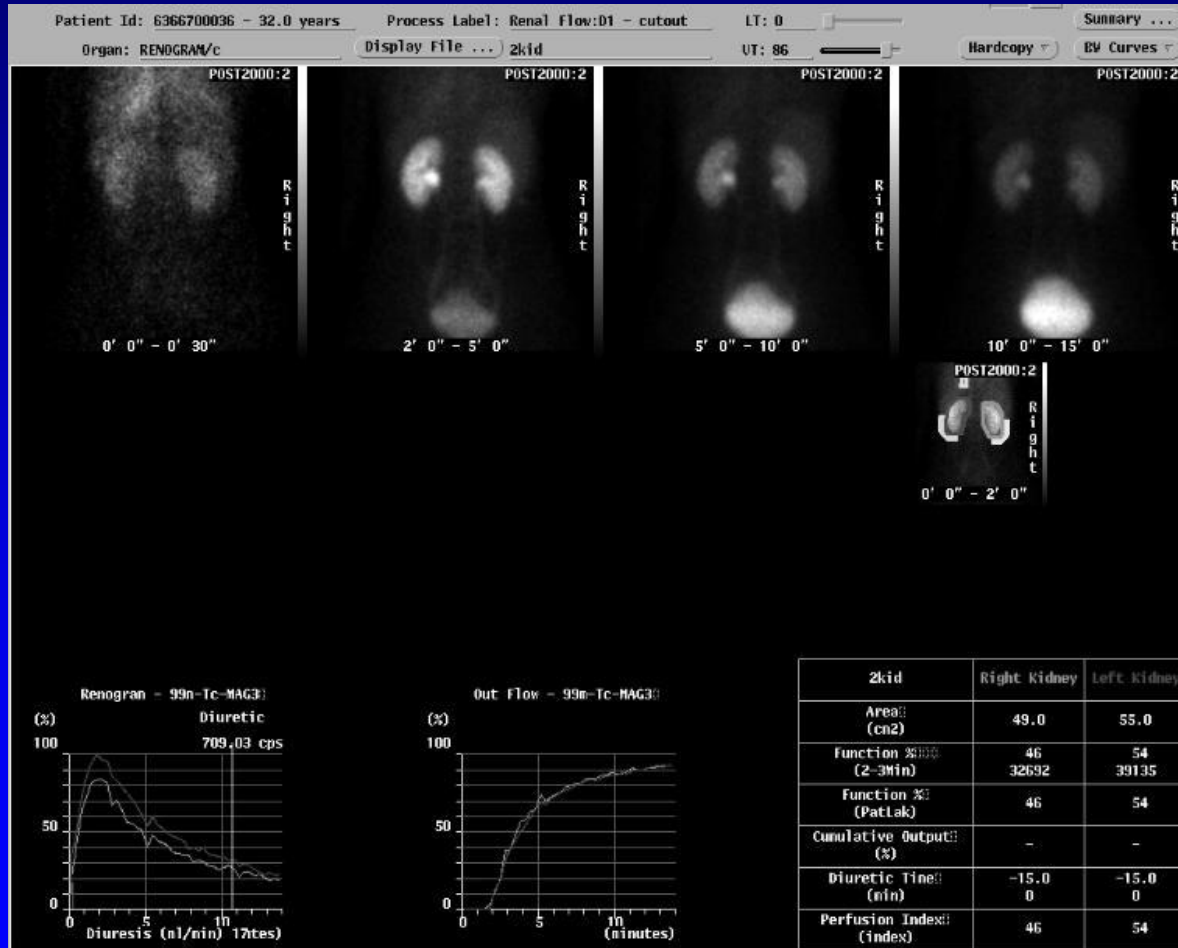
# Functional Imaging

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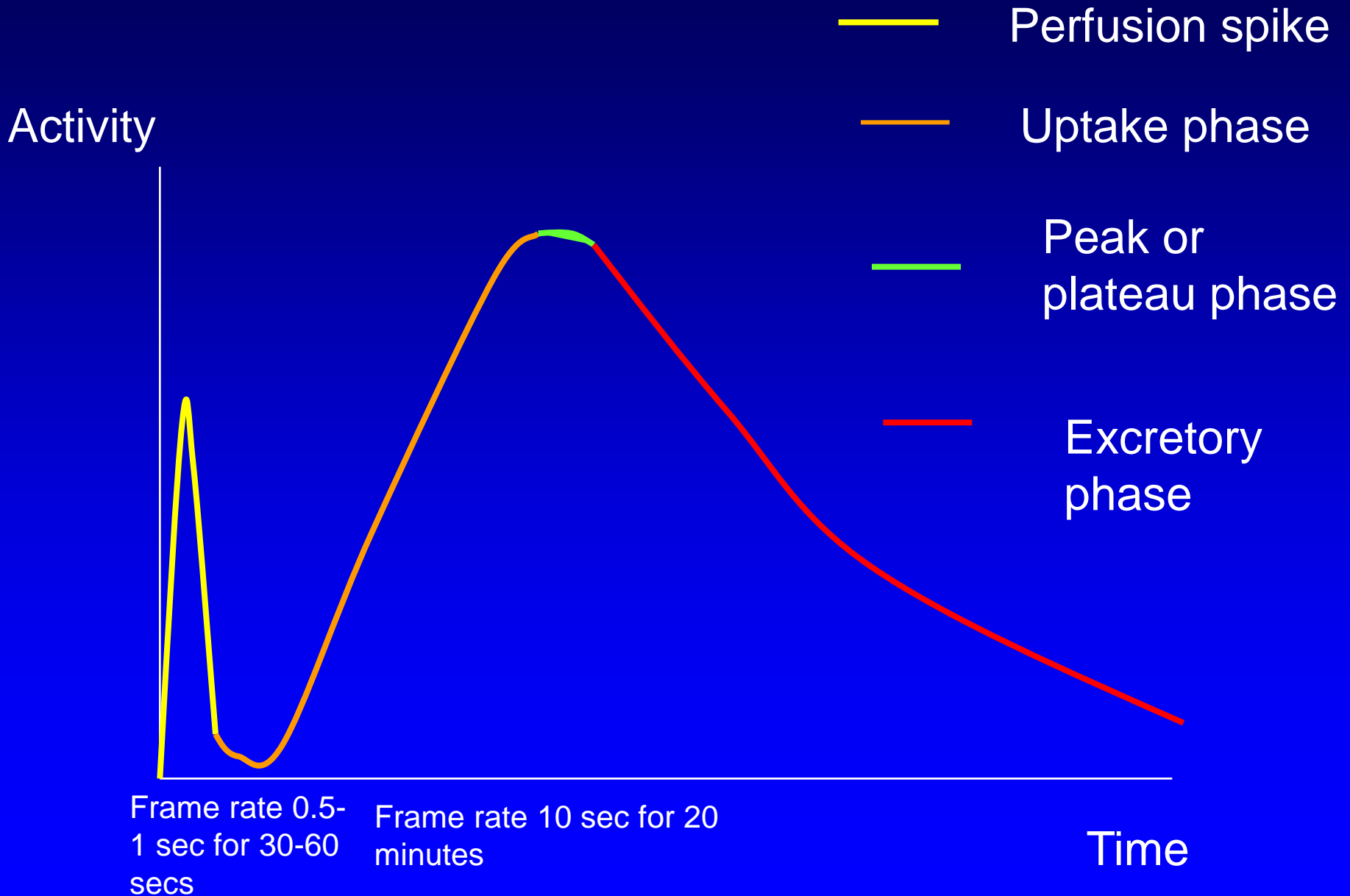
## Dynamic renal imaging

- Assess relative renal perfusion
- Estimate divided function
- Estimate parenchymal clearance and retention
- Assess drainage
- Measure response to diuresis
- Image ureteric peristalsis

# Normal renal study MAG3



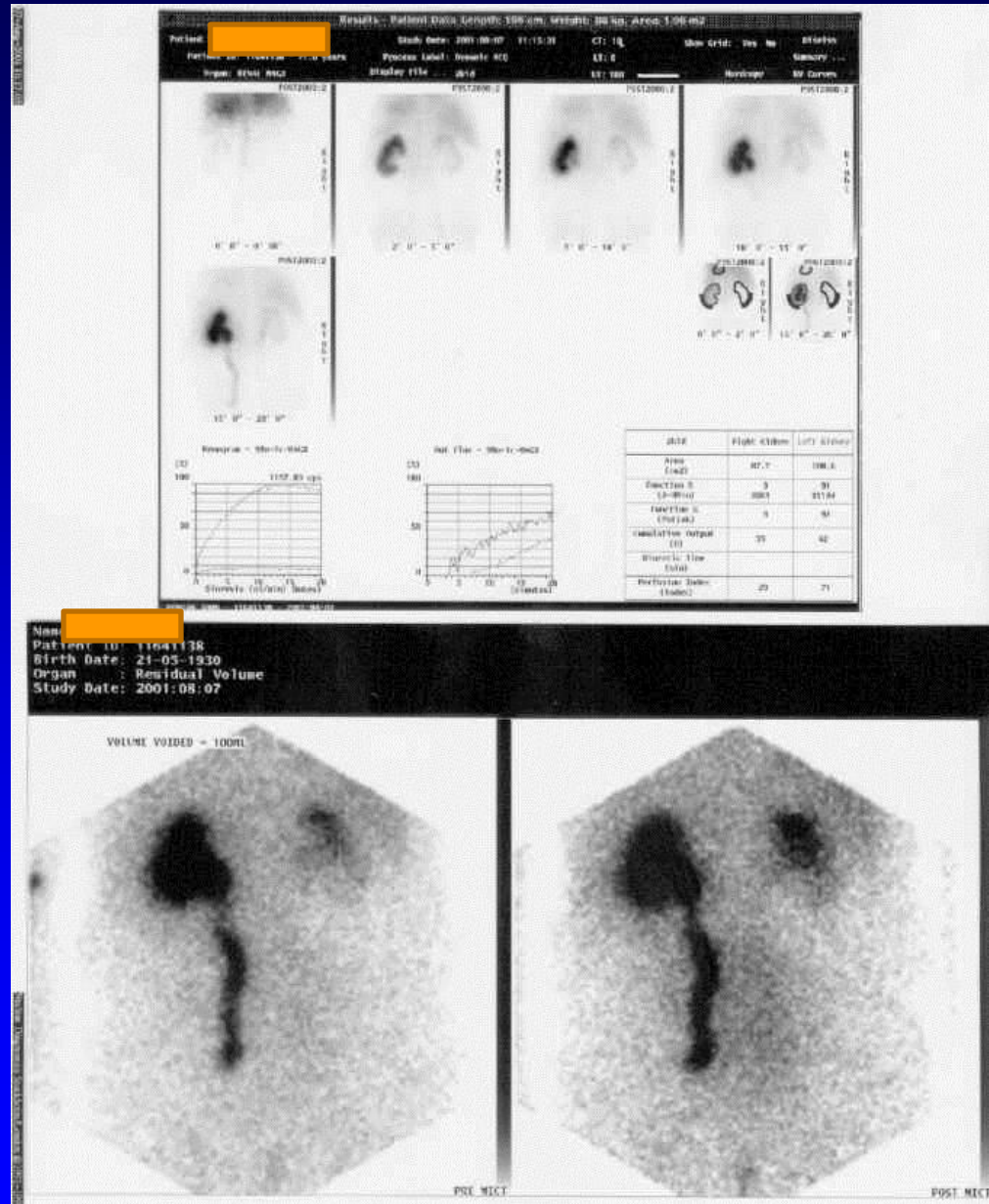
# The renogram



# Renal impairment



We can only show current, not potential, function



# Functional Imaging

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## Response to Stress

- Frusemide-induced Diuresis
- Renal Vascular Stress
  - Captopril
  - Aspirin
  - Exercise
- Prostaglandin Inhibitors
  - Diclofenac (Voltarol)



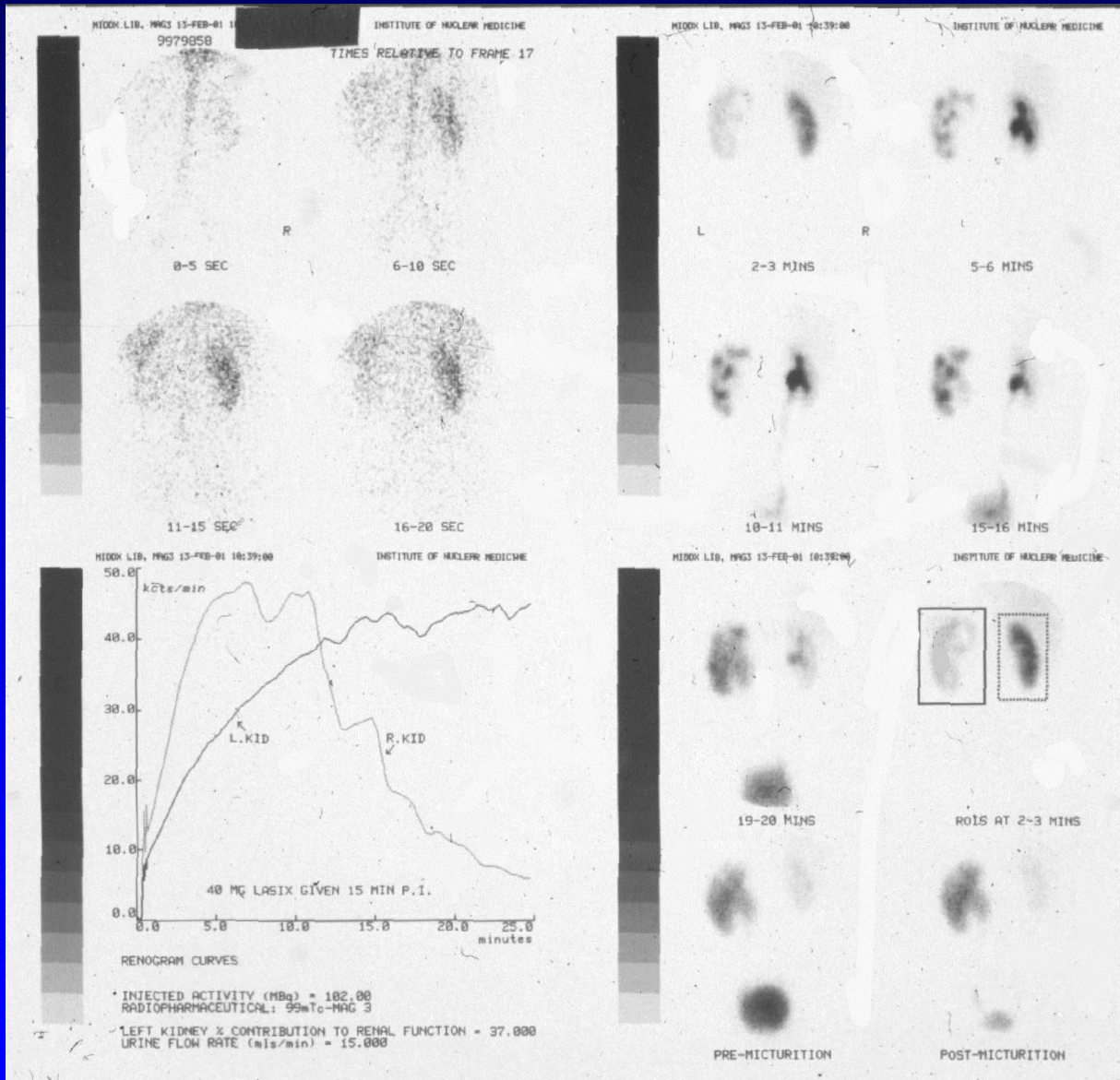
# Stress Response

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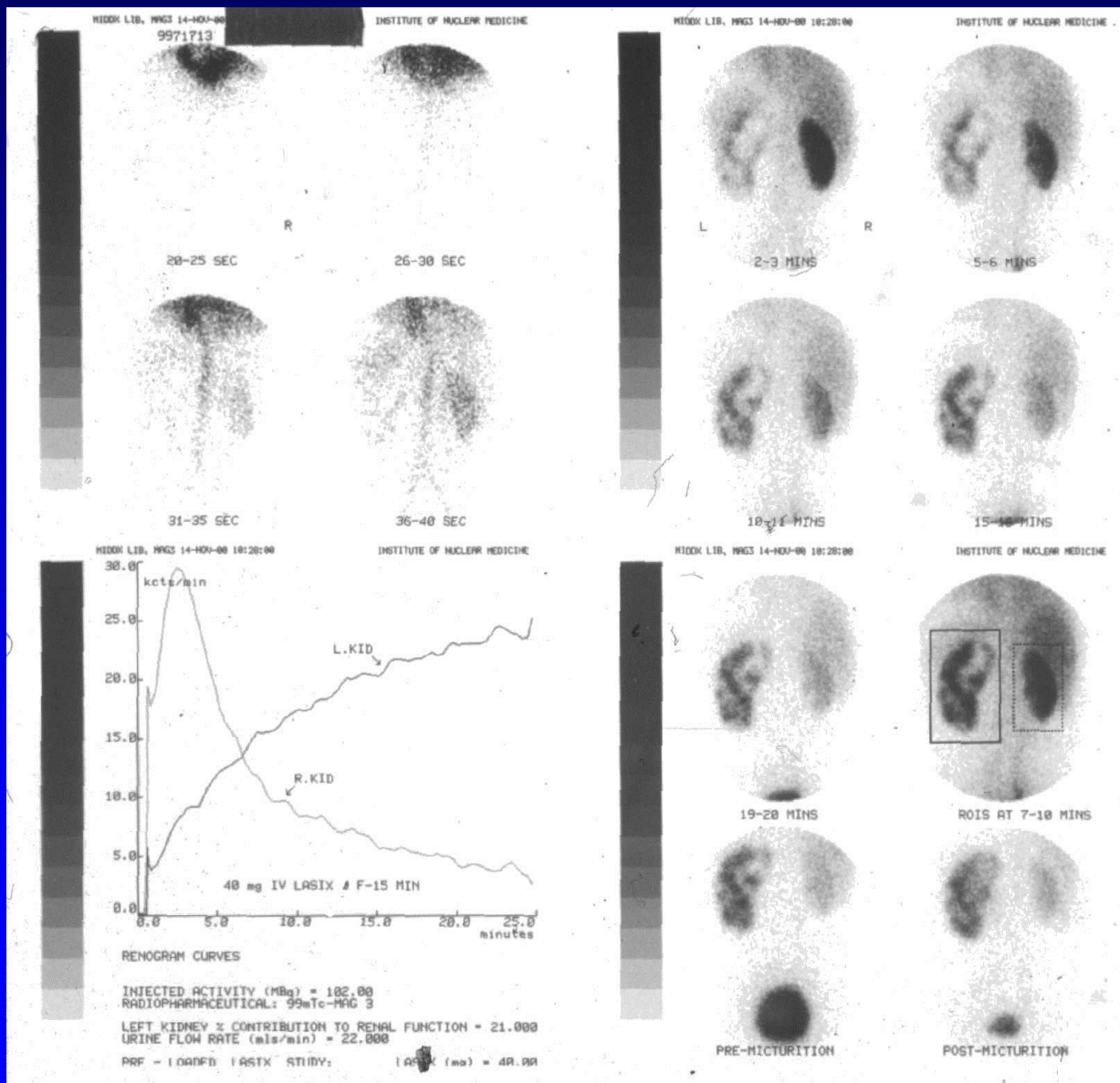
## Diuresis

- Definition of obstruction
  - ◁ Inability to cope with urine flow
- ⑧ Need adequate diuresis
  - Adequate hydration
  - Lasix 15 min before (F-15)
  - Measure diuresis
- Quantitate response
  - Cumulative output

# F + 15



# F-15



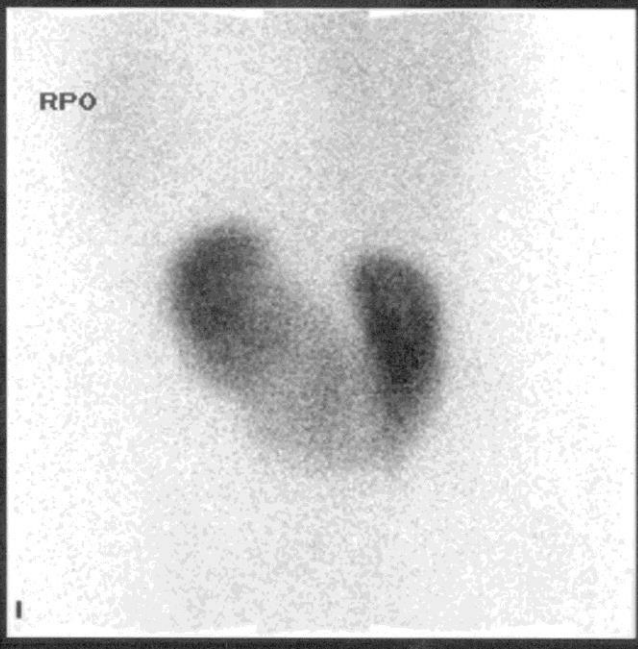
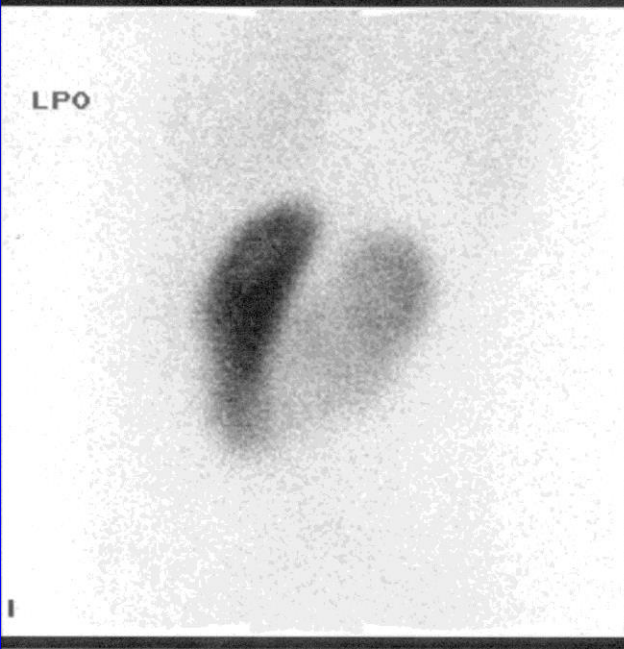
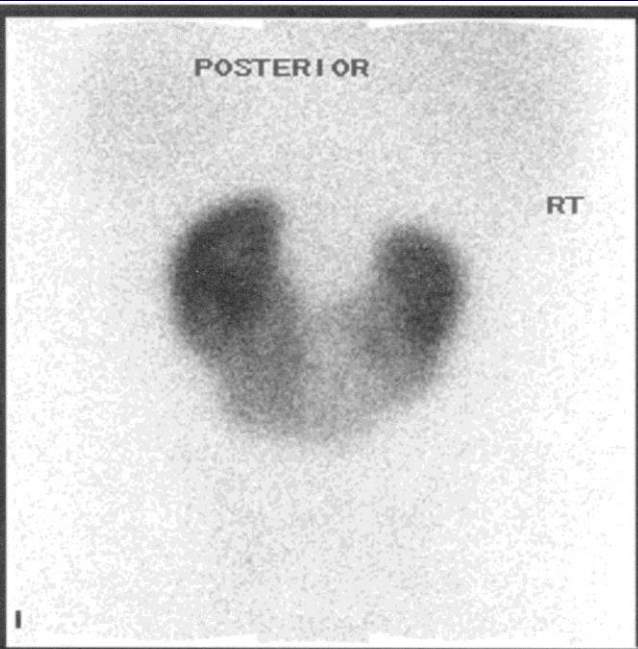
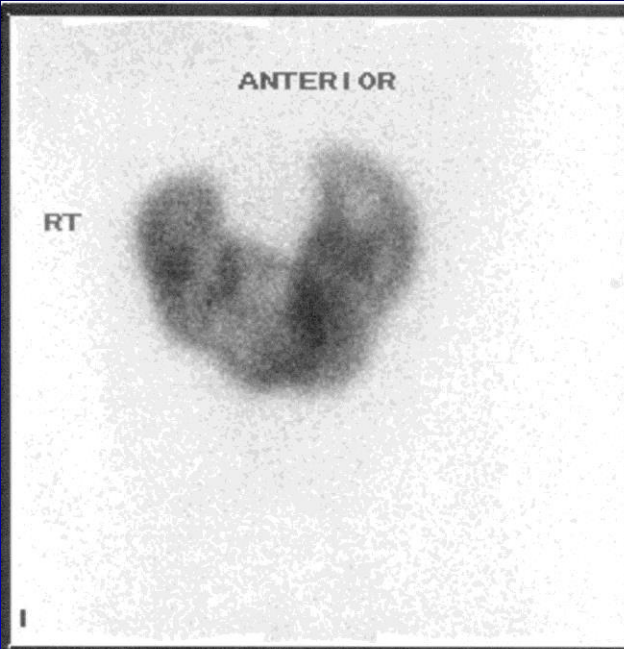
# Functional Imaging

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## Static renal imaging

- Images localisation of function (and of loss of function)
- Estimate divided function
- Allows localisation of kidney tissue
- SPECT gives better impression of shape
- BUT is non-specific (what is a scar?)
- Does it happen in adults? If so whom?





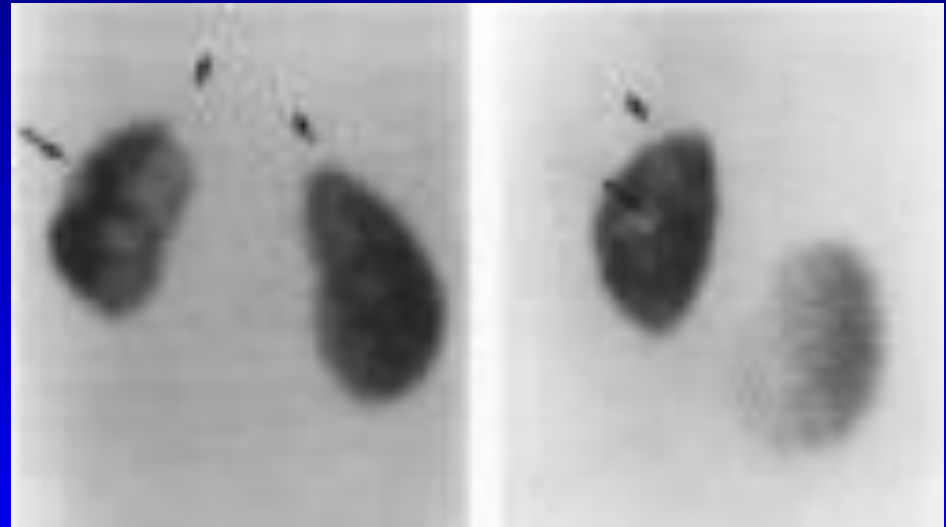
# Use of DMSA

- In children most commonly used to look for scars
- Can be used to look for acute infection (which is why 4-6 months must elapse after last UTI till DMSA)
- Use in children liver 5 and adults less clear
- But can be combined with GFR to predict GFR after nephrectomy



# Patterns of activity-acute infection

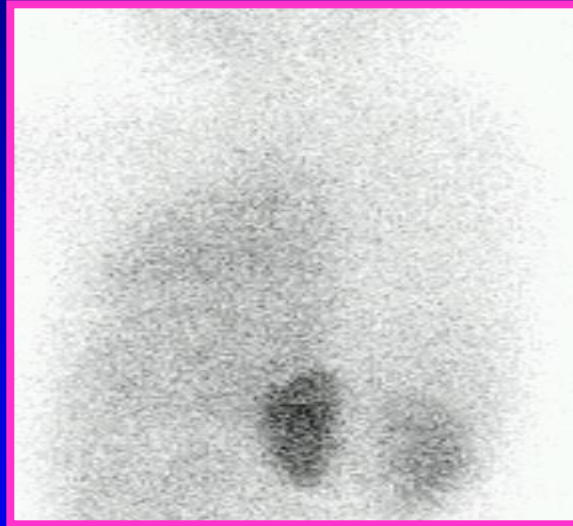
- Convex defect
- Concave defect
- Fuzzy edge
- Will need re-scanning 6 months later to see if scars



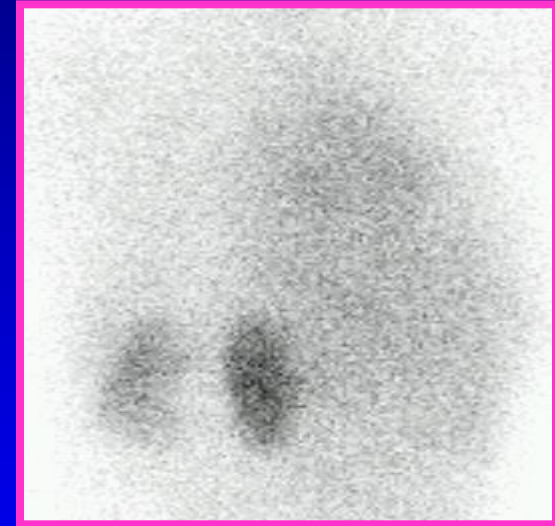
**POST**



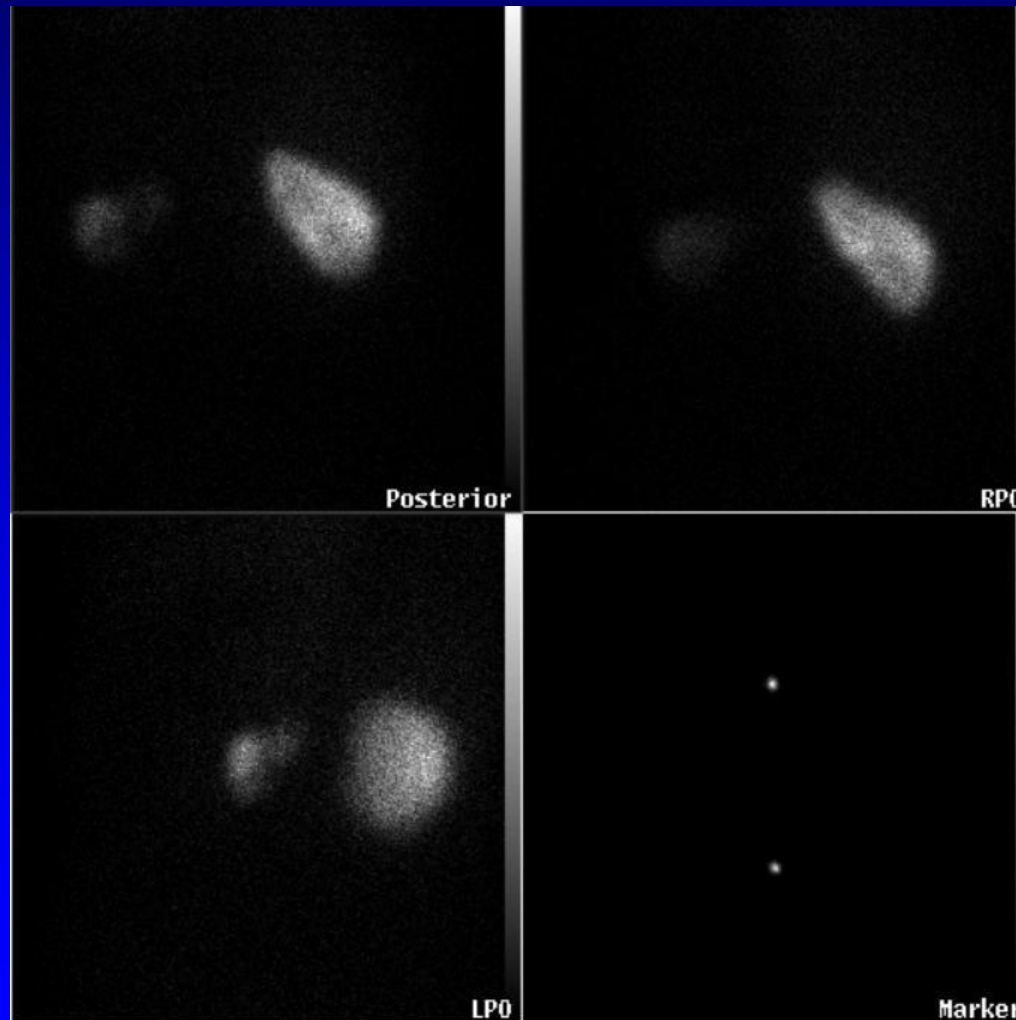
2 week old only one kidney seen on intra-uterine ultrasound



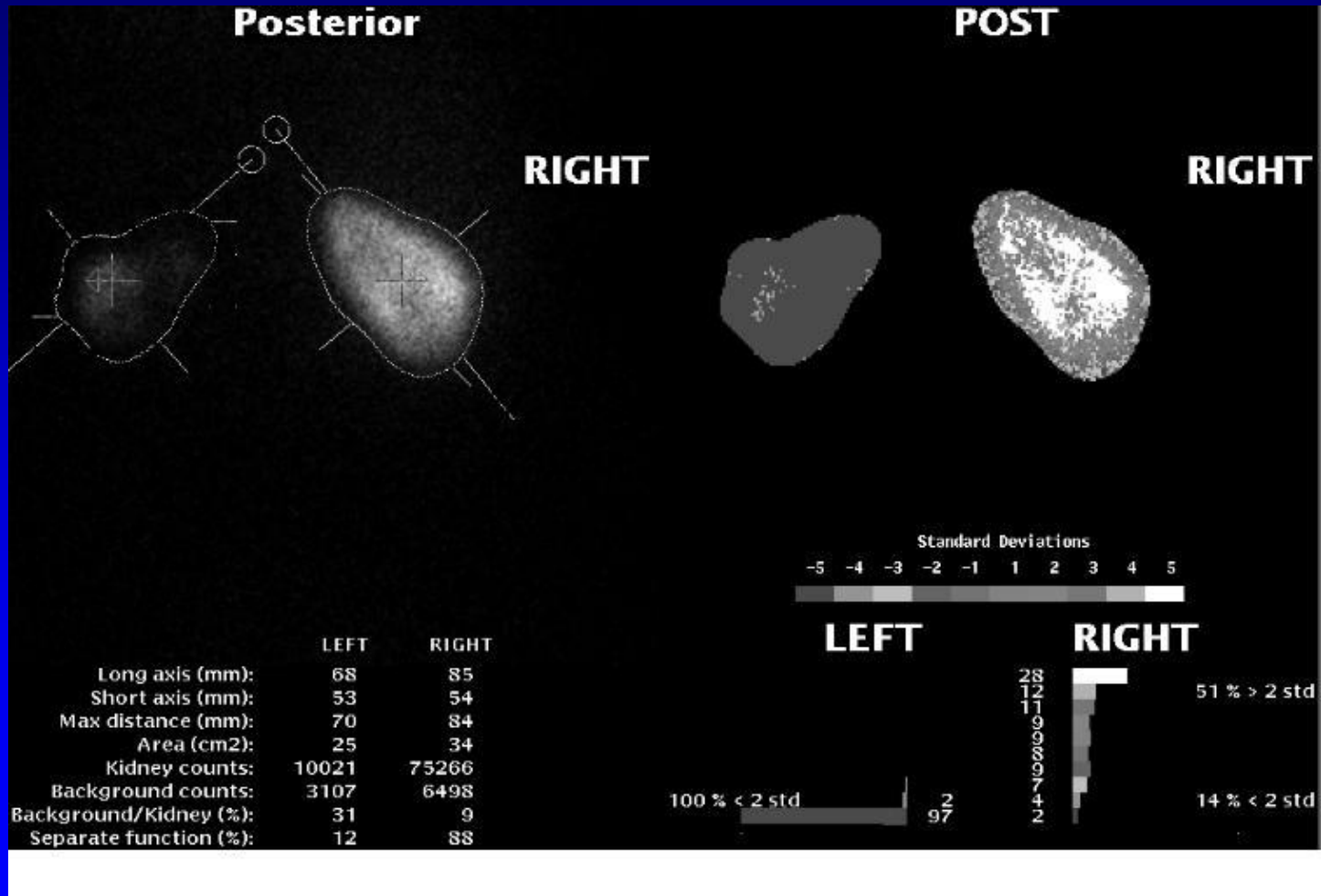
**RPO**



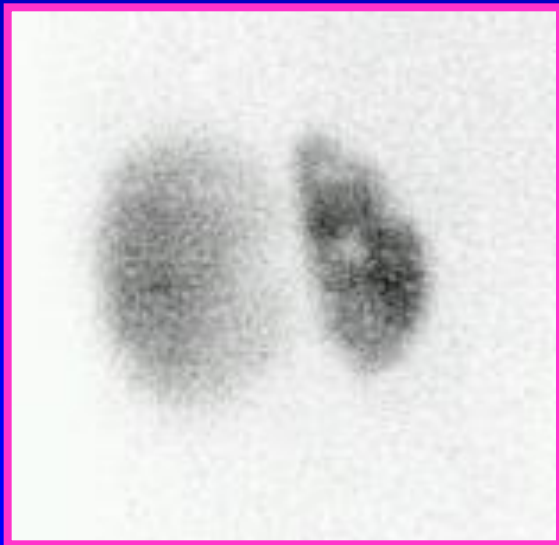
# 5 year old with Hx of UTIs



# Divided function



Scars in  
right  
kidney



# Who to scan?

- Controversy re-started
- Was any child under 6 with one episode of UTI
- Now less clear the we can justify radiation
- Now needs more than one infection unless with an organism other than *e.coli*
- No evidence that old or new approach WILL reduce adult hypertension



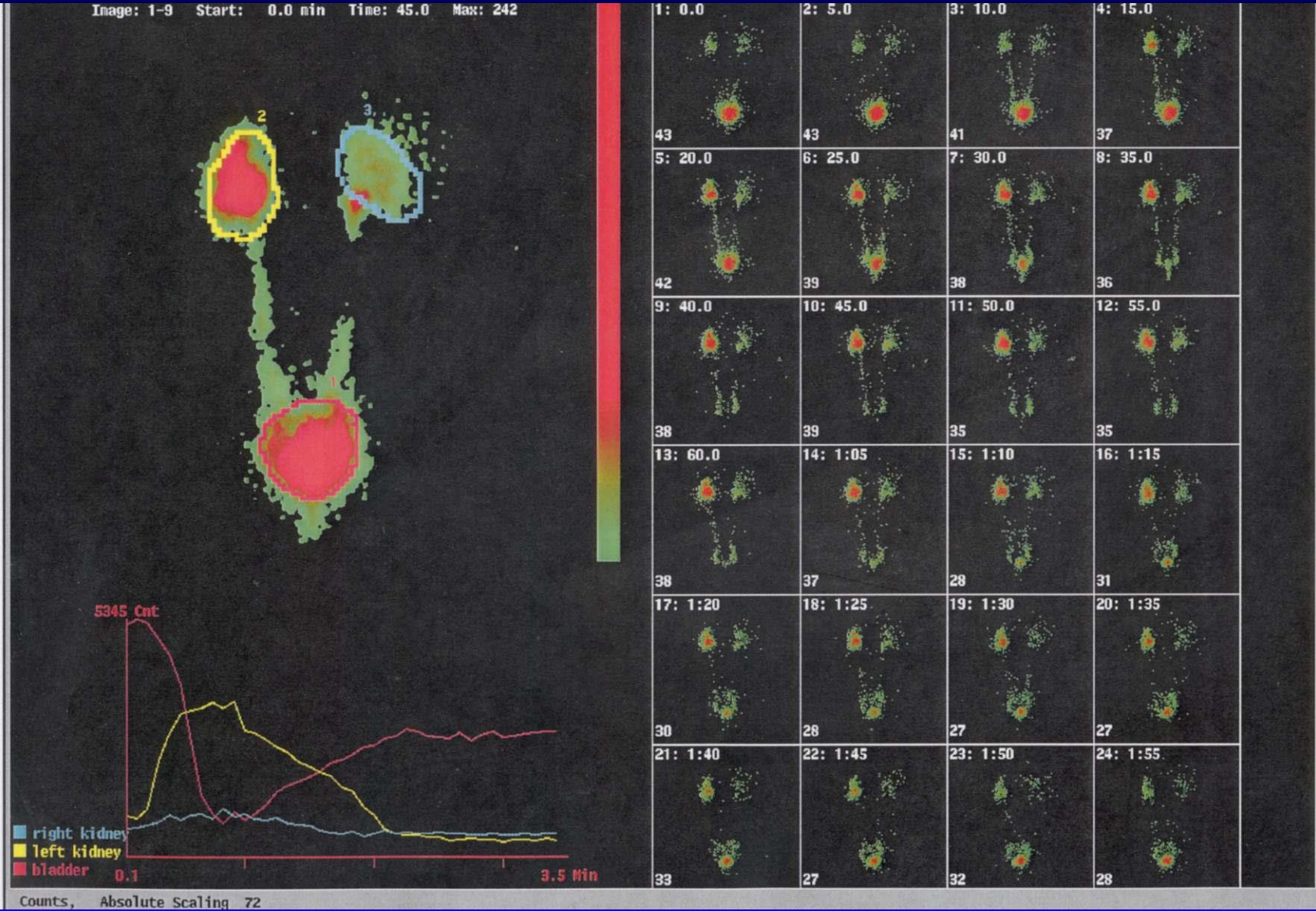
# Functional Imaging

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## Isotope Cystography

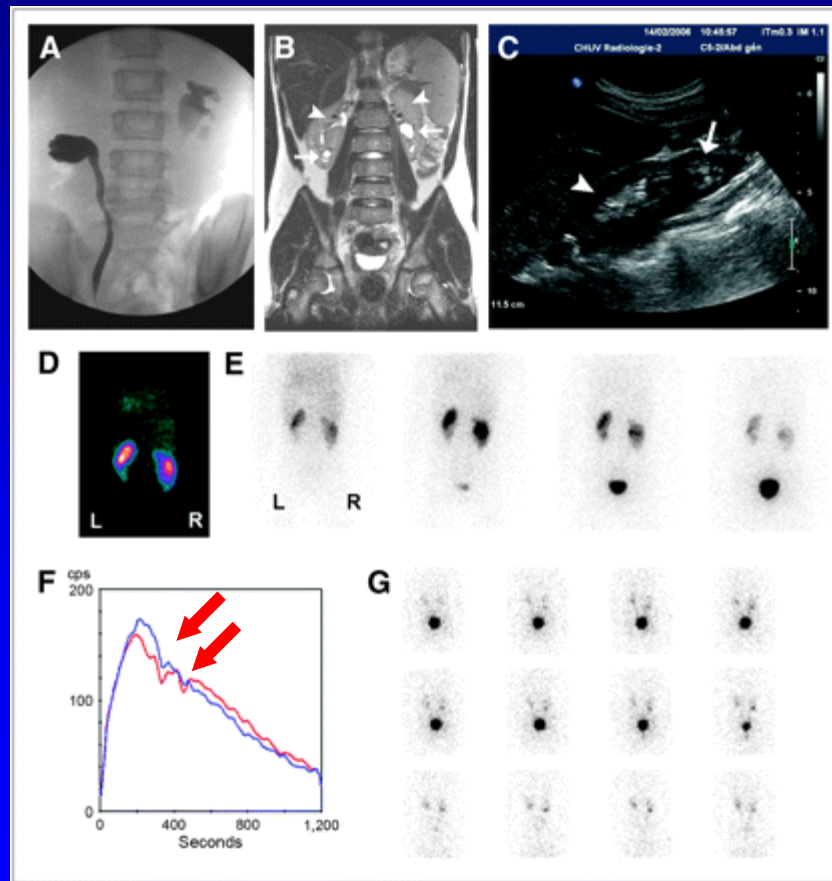
- Direct cystography is not functional (even if it gives some functional/volume answers).
- Indirect cystography is functional.
  - Good in children with bladder control
  - Good for follow-up
  - Doesn't show anatomy
  - Needs good patient co-operation for acquisition

# Reflux study



# Reflux in a duplex kidney

Arrows show episodes of yo-yo reflux from lower to upper moiety



# Functional Imaging

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## Single Kidney GFR

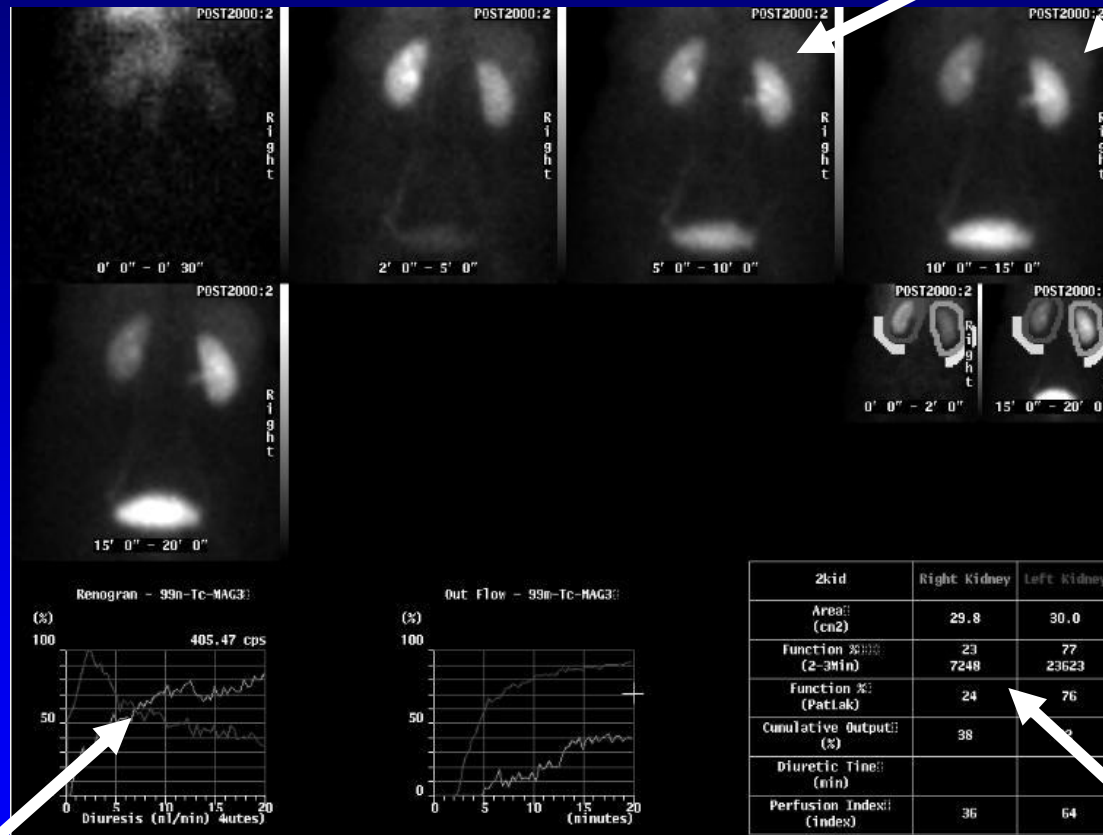
- Probably most useful parameter for looking at change.
- Needs total + divided function
- Proven value in RAS and UTI

# Captopril renography

- To look for renovascular disease
- 2 peaks young FMD and older AthScl
- Do base line study if abnormal then do not do post captopril
- If baseline normal give 25mg captopril
- If RVD captopril will shut down ACEdrive on affected kidney
- Delayed peak, reduced divided function and delayed parenchymal transit

# Renogram in RAS (on ACEI)

Parenchymal retention



Delayed peak

Reduced divided function

# Selection of hypertensive patients

- Presented to hospital
- Asymmetric renal size
- Unexpected renal failure
  - especially after ACE inhibitor therapy
- Diabetes
- Difficulty in control of hypertension
- “Flash” pulmonary oedema



# European Multicentre Study

- 454 patients from 19 centres
  - ALL had angiography
- 244 with renal artery stenosis
- Tc-99m-DTPA
  - 183 normal
  - 197 stenosis
    - 124 (33%) > 70% stenosis

# European Multicentre Study

- Interventions:
  - 76 angioplasty
  - 39 surgical bypass
  - 6 nephrectomy
- Follow-up
  - 87 3 months
  - 57 6 months
  - 36 12 months

# European Multicentre Study

- Best sensitivity:
  - Post-Captopril DTPA – 95%
- Best specificity:
  - Change in function or transit – 85%
- Correlation with blood pressure normalisation – 90%

# Selection of hypertensive patients

- Presented to hospital
- Asymmetric renal size
- Unexpected renal failure
  - especially after ACE inhibitor therapy
- Diabetes
- Difficulty in control of hypertension
- “Flash” pulmonary oedema

# Captopril protocol 1

- Baseline renogram (DTPA or MAG3)
- Repeat study 60-90 min after 25 mg oral Captopril
  - Stop oral ACEI / Losartan 3-5 days
  - Stop diuretics 5 days
  - Avoid sodium depletion
  - Clear fluids only for 4h

# Captopril protocol 2

- On arrival, check compliance
- Put on couch
  - check veins
  - put on b/p cuff
  - check doctor present
- Give captopril (?crushed) + fluids
- Monitor blood pressure
- Give i/v saline (if necessary).

# Captopril renography

- Patient voids - time noted
- Supine renography with MAG3 or DTPA
- Bolus injection
- 1/sec for 40 secs; 1/20 secs for 20 min
- Erect image
- Patient voids - time and volume noted



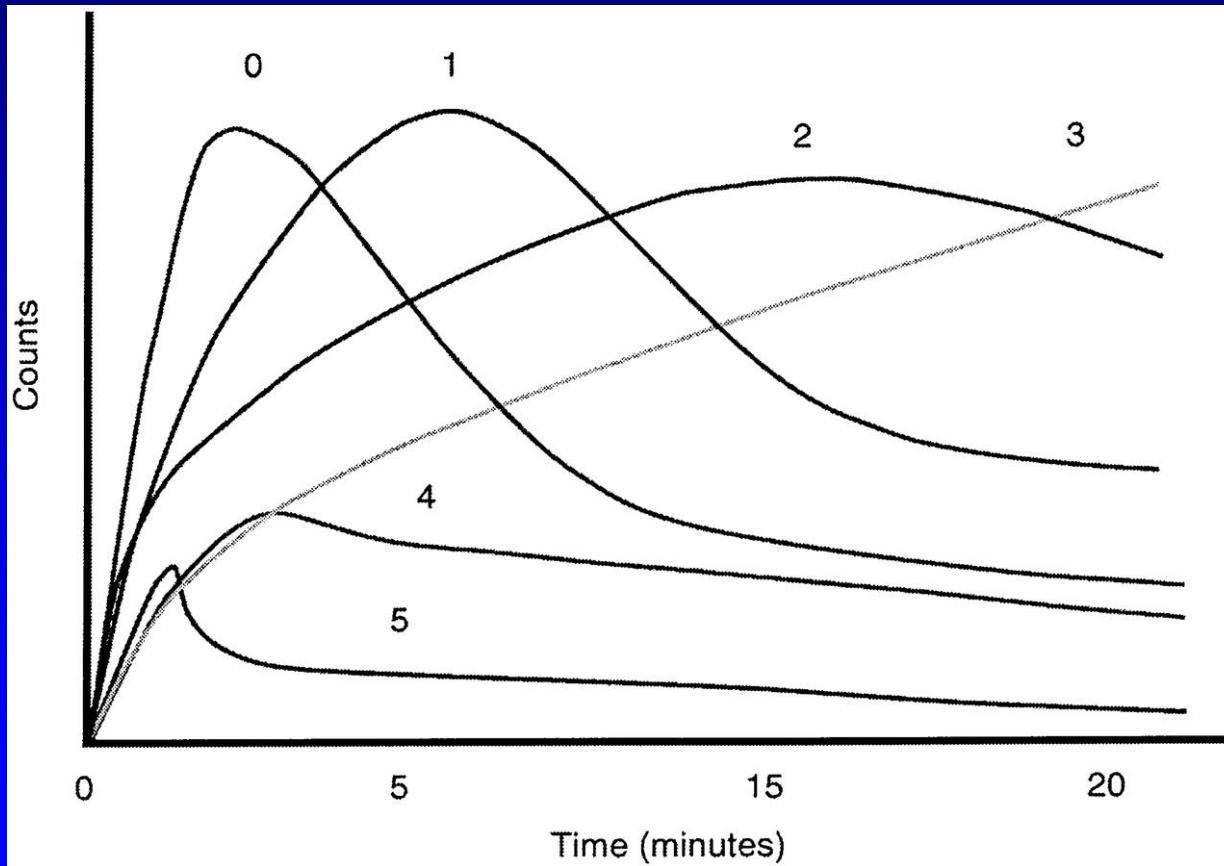
# Data analysis

- Summed images, displayed on absolute scale
  - 0-2 min
  - 4-6 min
  - 12-14 min
  - 18-20 min
- Automatic renal ROIs based on 2-min image
- Peri-renal background
- Basic curve analysis

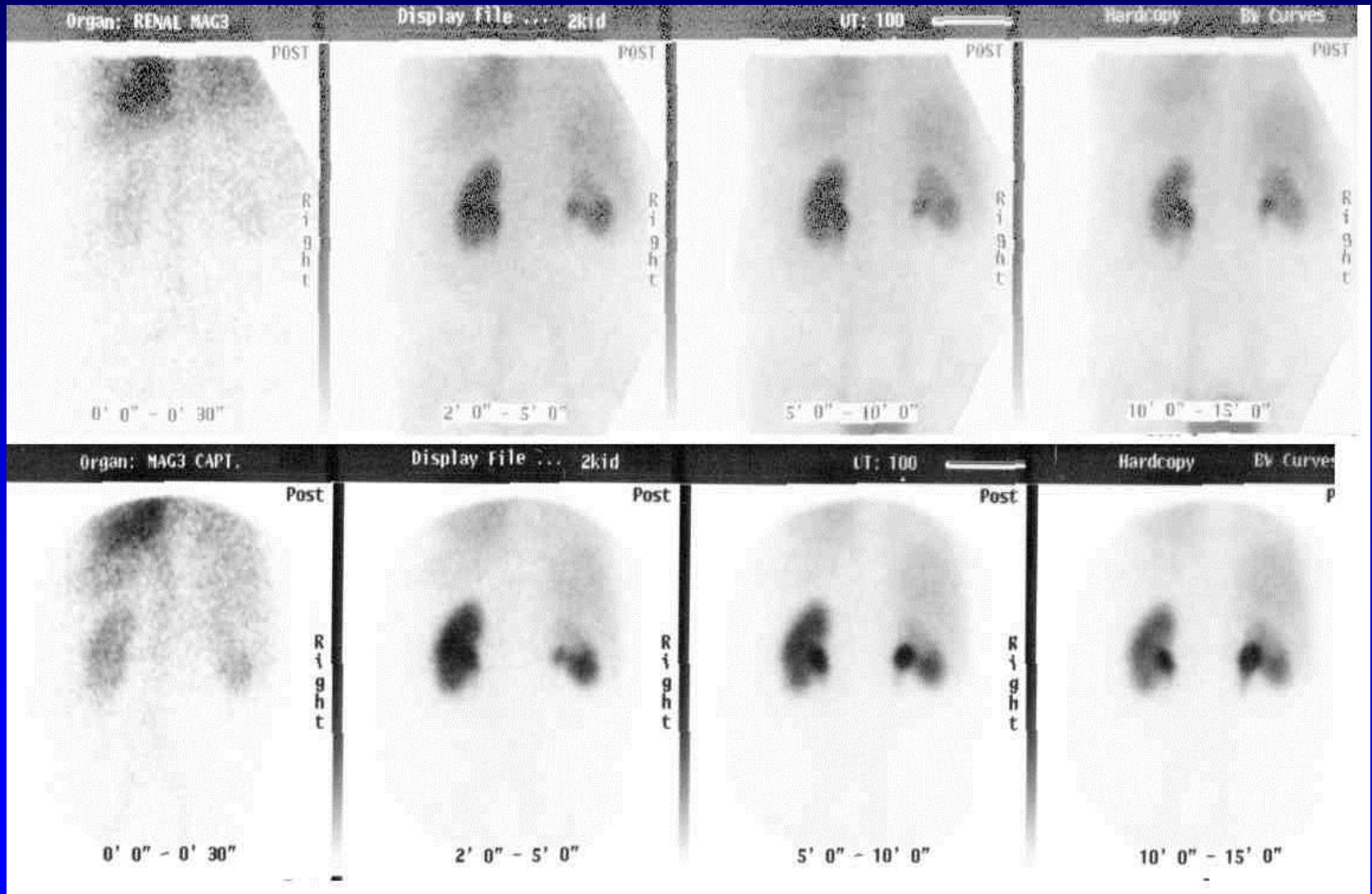
# Criteria for analysis

- 5% or greater change in divided function
- >1 grade change in renogram = high probability
- 1 grade change in cortex = high probability

# Consensus meeting grading of renogram curves for Captopril



# It's not always so easy.....



# Renal transplantation

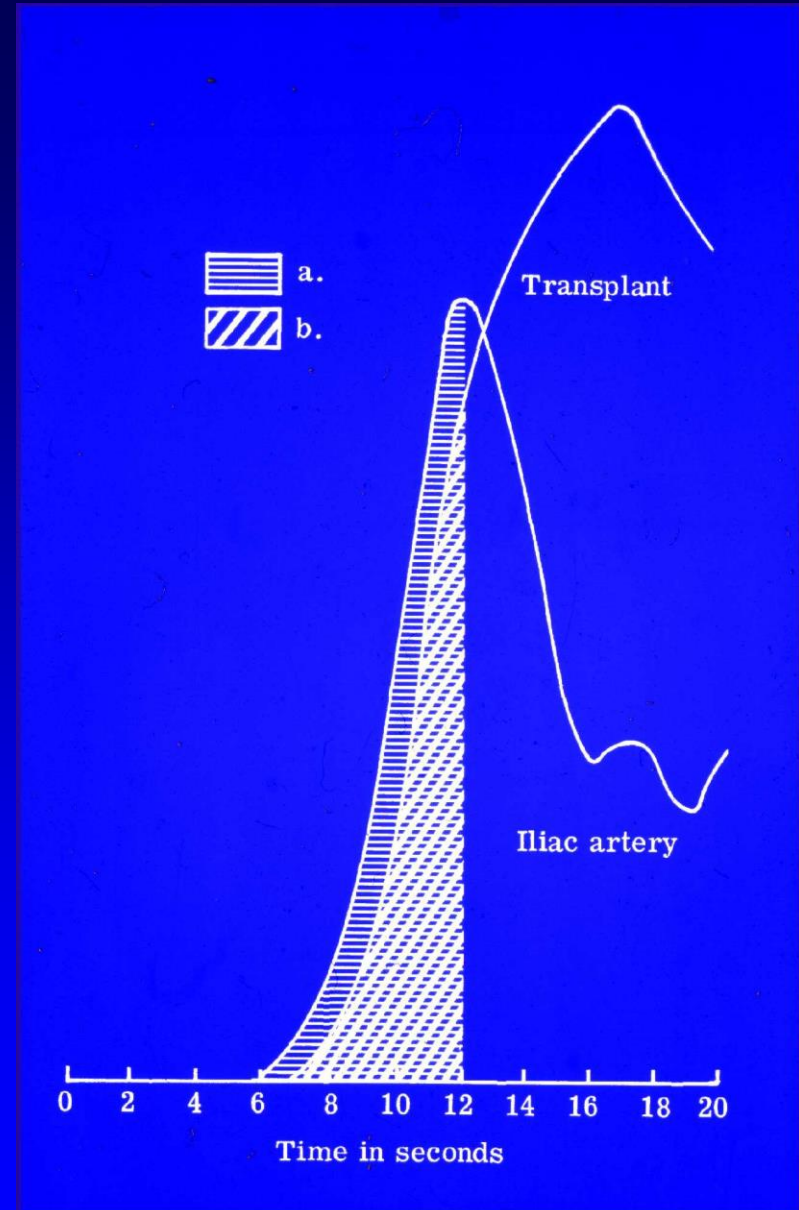
## Where can imaging help?

- Donor assessment
- Acute post-operative complications
- Early post-transplant period
- Late post-transplant period

# Perfusion Index Hilson 1976!

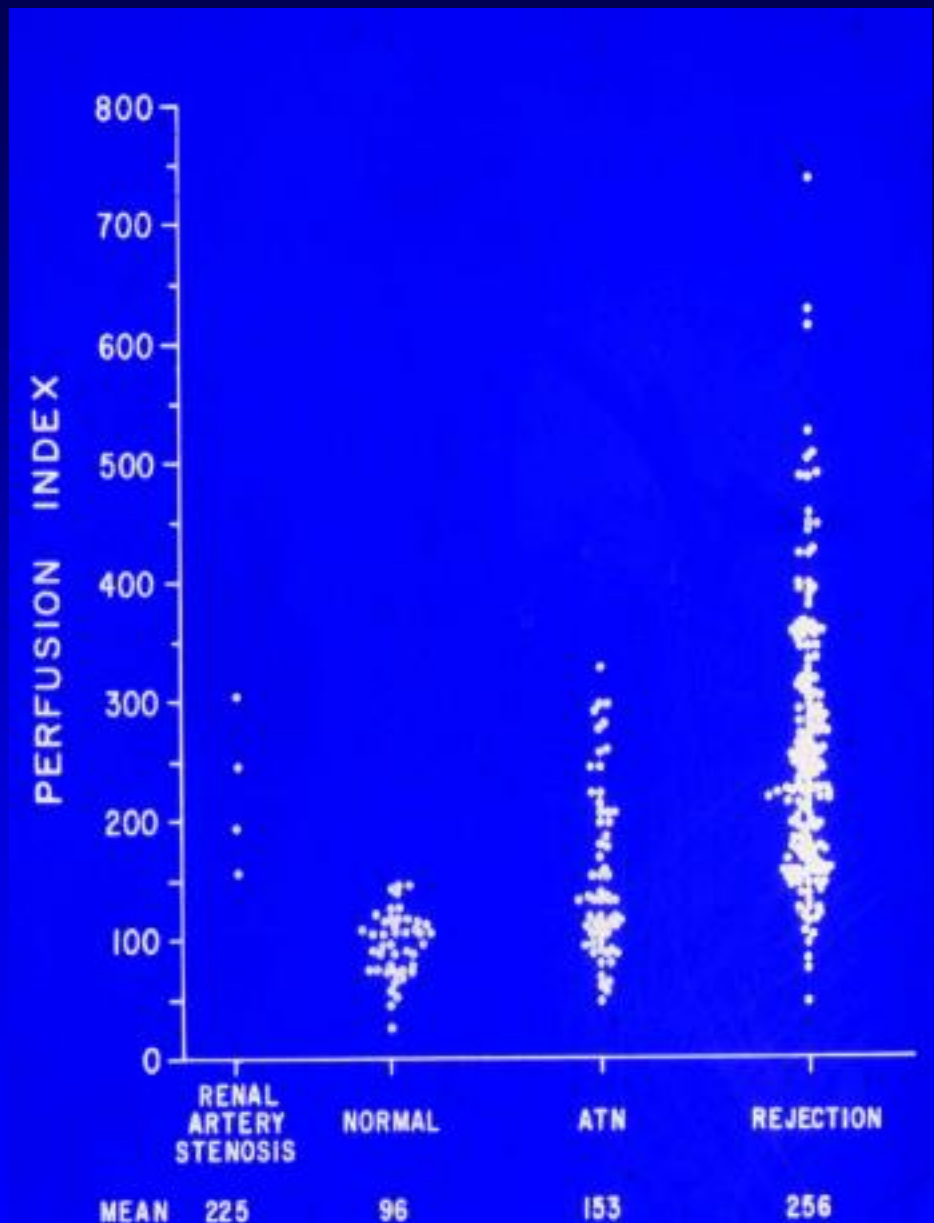
Since 1976

- FNA/biopsy have become safer
- New drugs have slowed down rejection

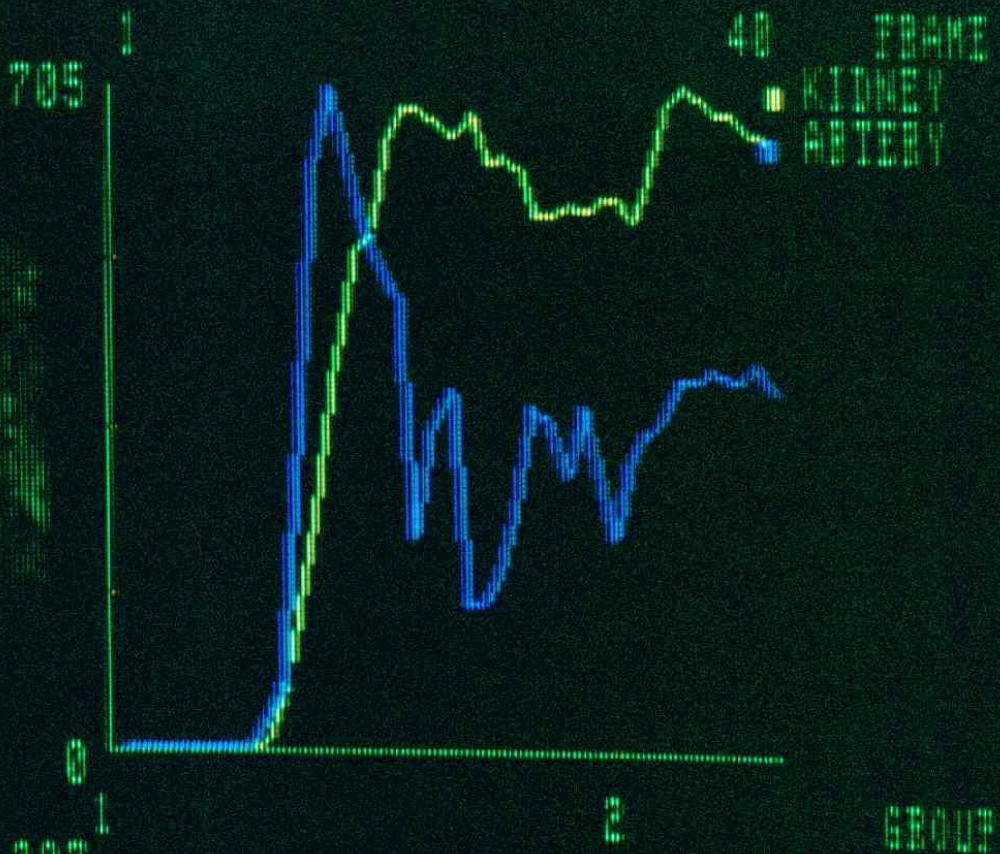
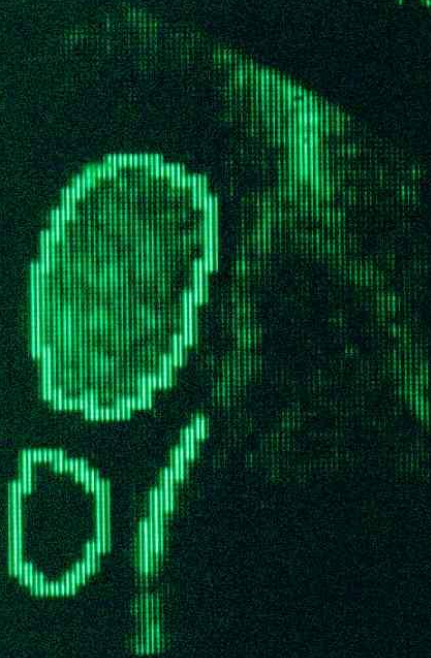


# Results

CHANGE  
Is  
Important







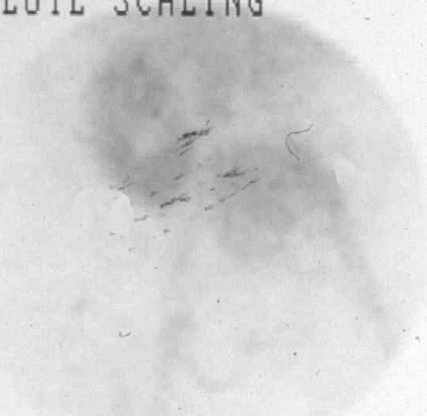
P0 FLOW INDEX  
P1 +/-  
P2 UPTAKE

207  
20.7  
224

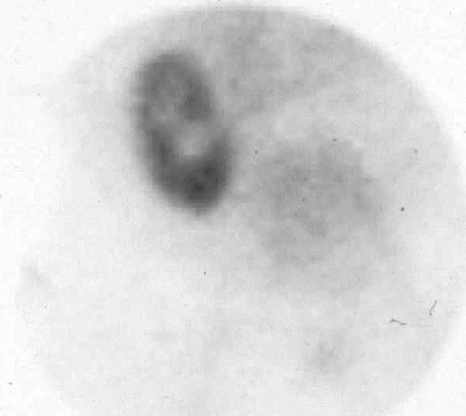
GROUP

# ATN – MAG3

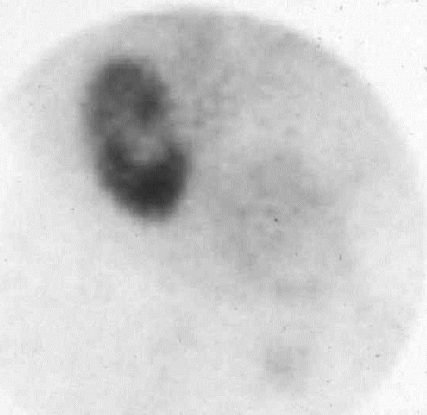
ABSOLUTE SCALING



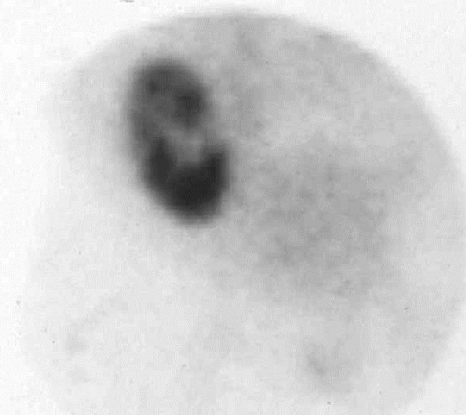
0 - 2 MIN



6 - 8 MIN



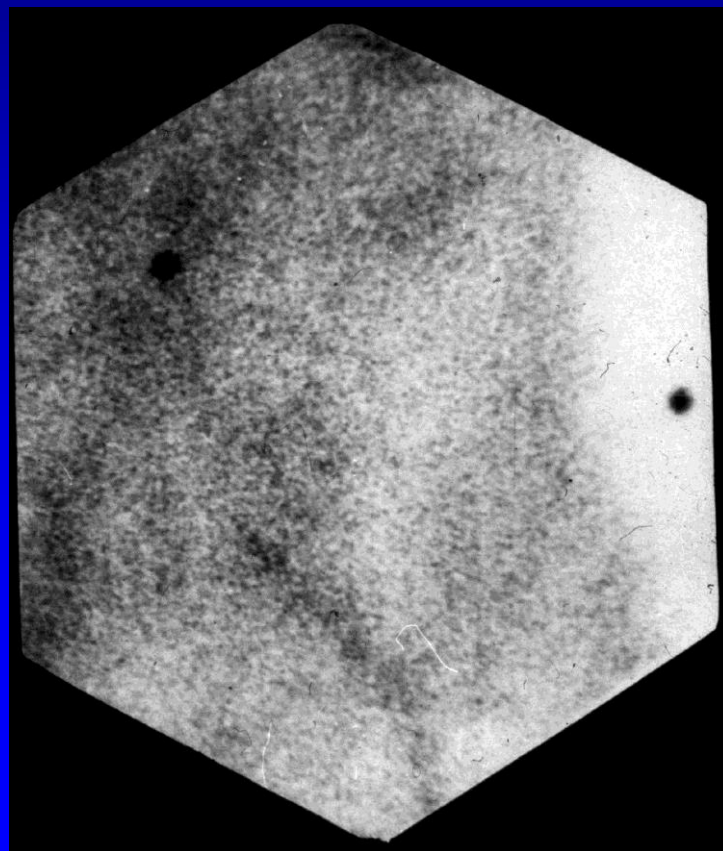
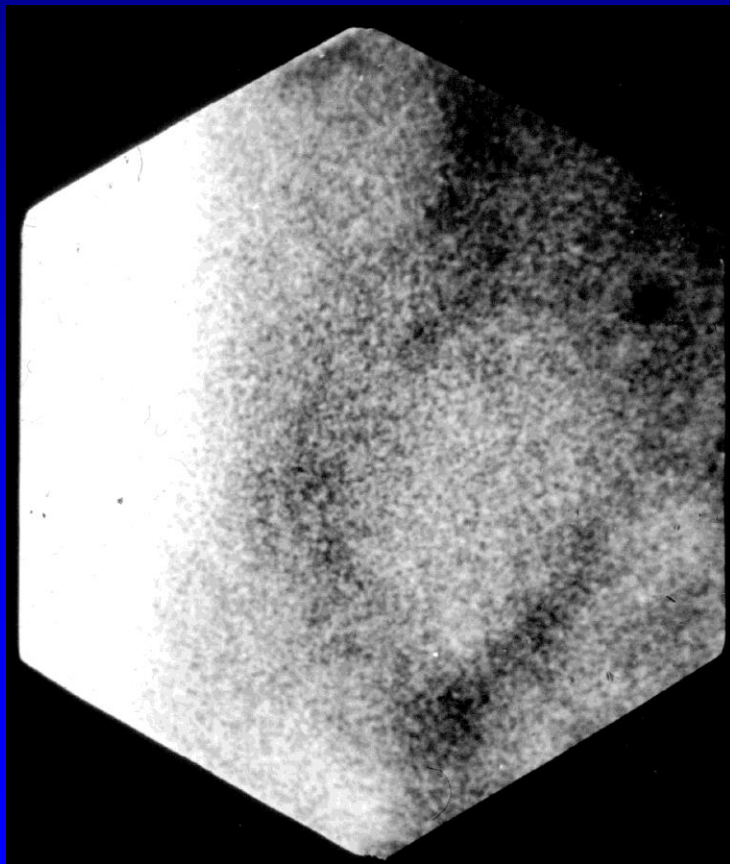
12-14 MIN



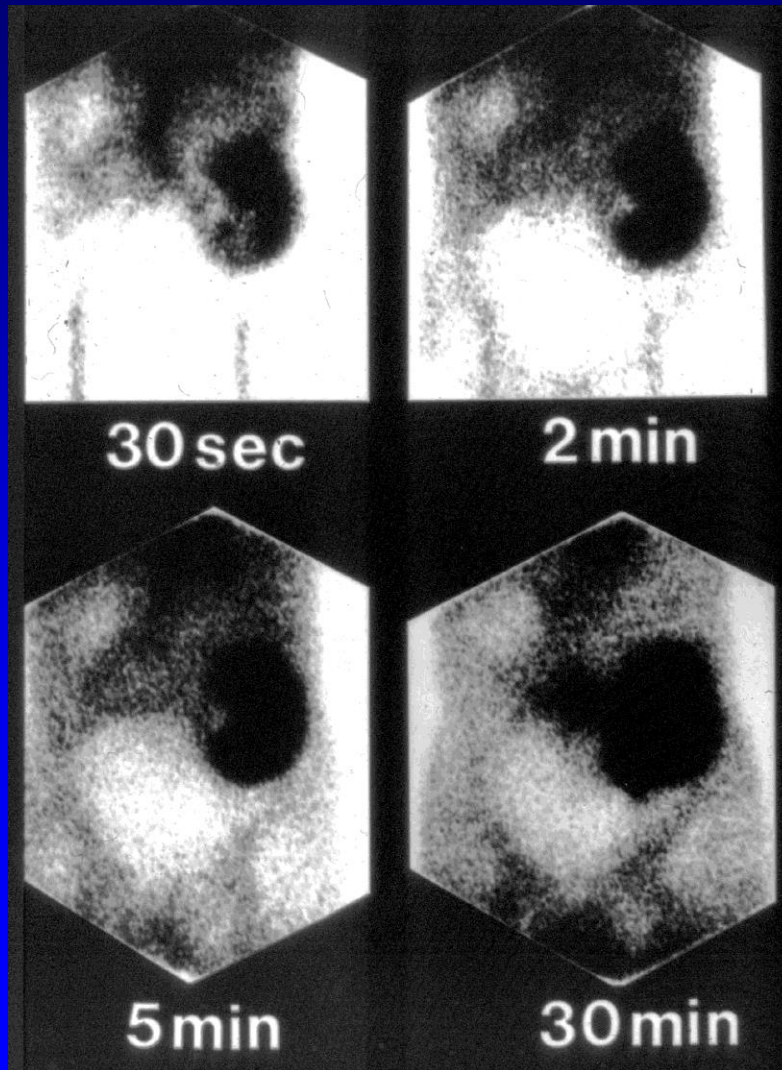
18-20 MIN



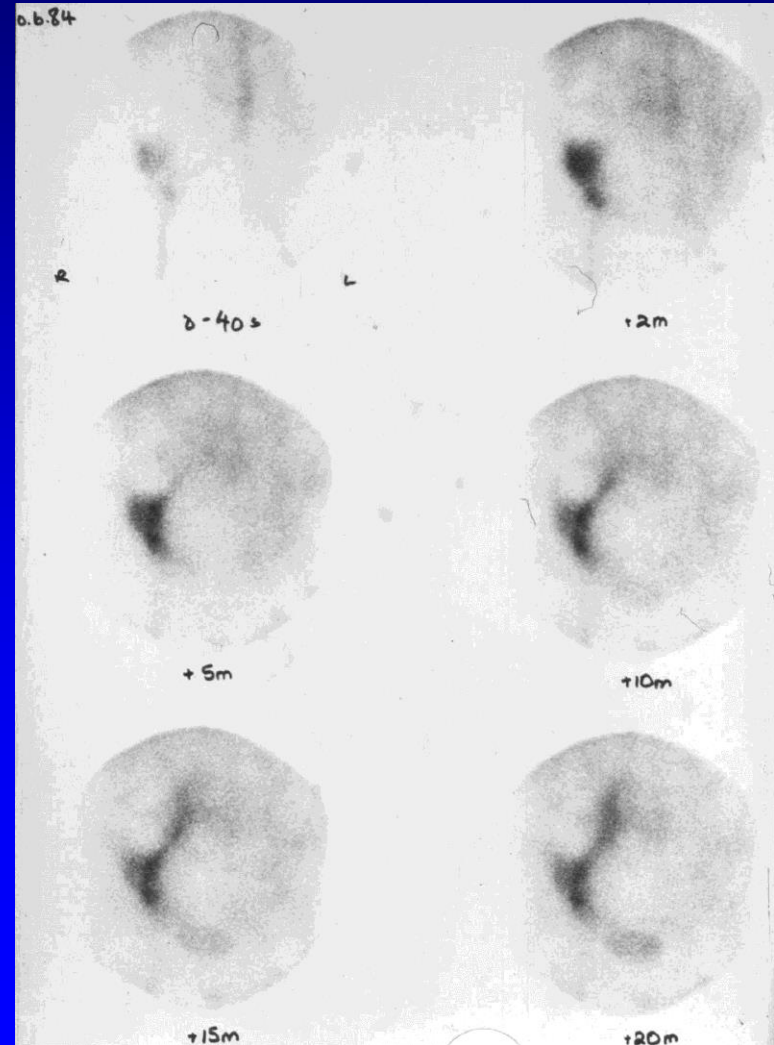
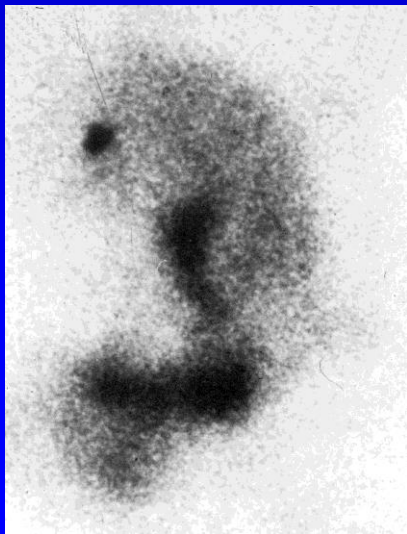
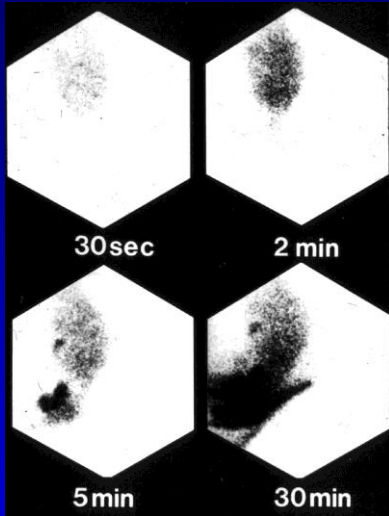
# “Black Holes”



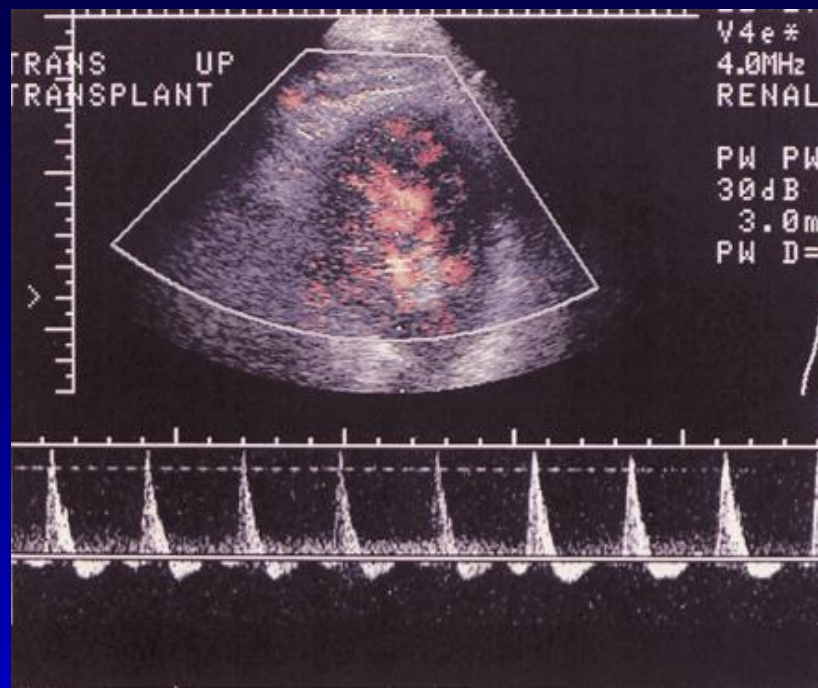
# Lymphocoele



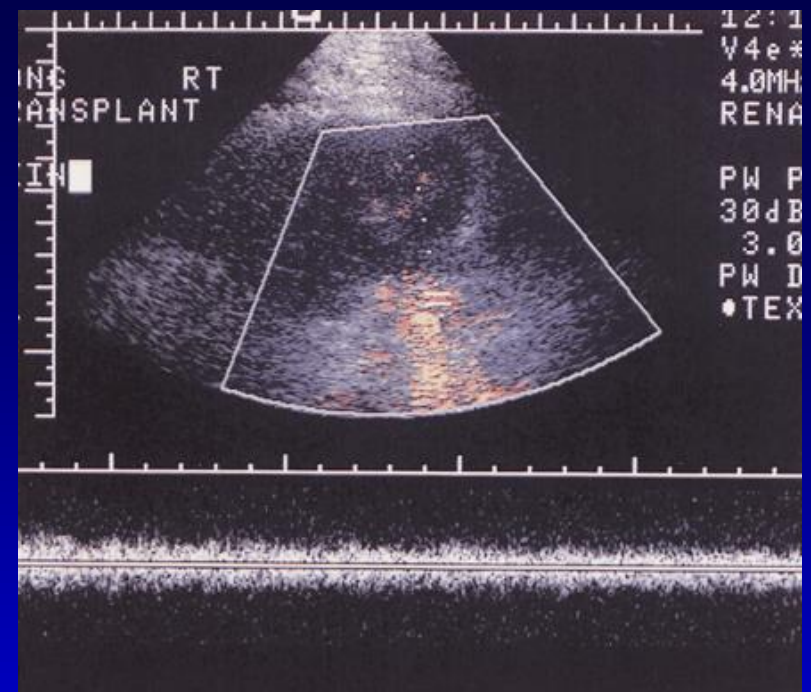
# Leaks







**Figure 18a.** Severe transplant rejection. **(a)** Duplex color Doppler US image shows a spectral waveform in which the arterial flow in diastole is reversed. Differential diagnosis for this finding includes acute tubular necrosis and renal vein thrombosis. **(b)** On another duplex image, the spectral waveform shows that the renal vein is patent, thus the diagnosis of renal vein thrombosis is excluded. Findings from biopsy confirmed transplant rejection.



**Figure 18b.** Severe transplant rejection. **(a)** Duplex color Doppler US image shows a spectral waveform in which the arterial flow in diastole is reversed. Differential diagnosis for this finding includes acute tubular necrosis and renal vein thrombosis. **(b)** On another duplex image, the spectral waveform shows that the renal vein is patent, thus the diagnosis of renal vein thrombosis is excluded. Findings from biopsy confirmed transplant rejection.

# MAG3 vs Doppler US

- MAG3
- Quantifiable and reproducible
- Can reliably identify infarcted kidney
- Able to find slow leaks
- Doppler US
- No radiation
- Bed side test
- Resistive index correlates well with rejection but not reproducible

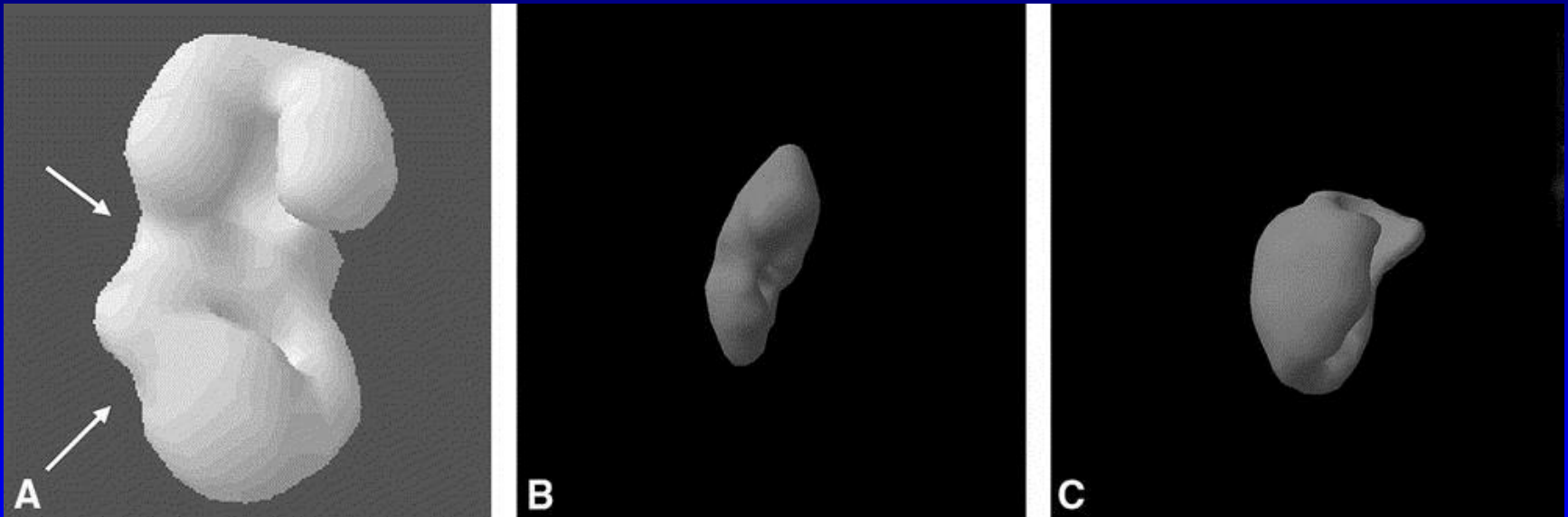


# Dupont et al Transplantation 2007

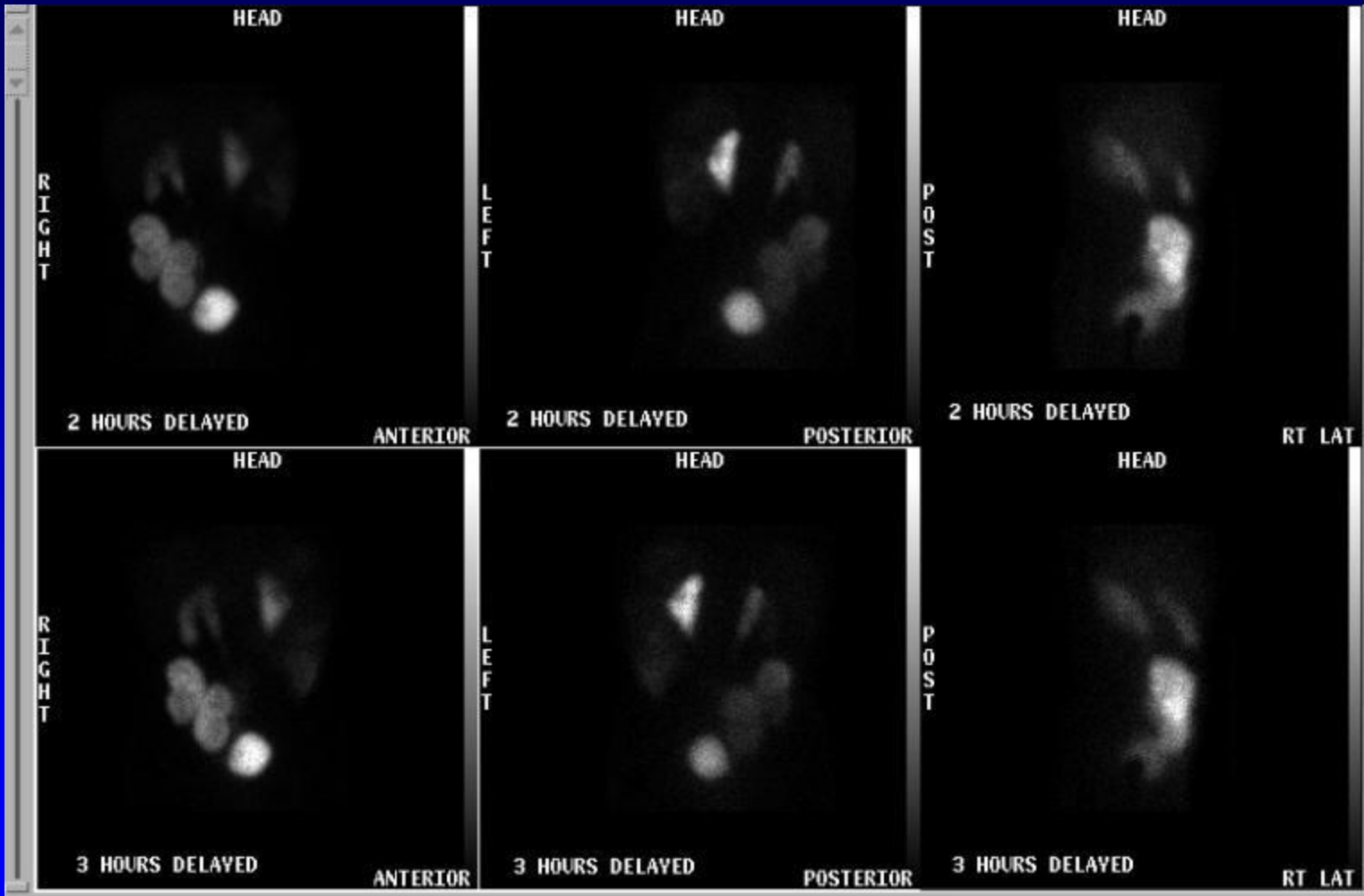
**TABLE 2.** Comparison of 99m Tc-DMSA SPECT findings in renal allograft recipients with and without a history of recurrent urinary tract infection.

	<u>Recurrent UTIs (%)</u>		<u>Controls (%)</u>	
	Reflux	No reflux	CAN	Vascular occlusion
N	15	17	11	8
No scars	2 (13)	6 (33)	8 (73)	0 (0)
One focal defect	5 (33)	3 (18)	3 (27)	0 (0)
Two focal defects	2 (13)	3 (18)	0 (0)	0 (0)
>Two focal defects	6 (40)	5 (29)	0 (0)	0 (0)
Any focal defect	13 (87)	11 (65)	3 (27)	0 (0)
Segmental defect	0 (0)	0 (0)	0 (0)	8 (100)

# Dupont et al DMSA SPECT in Tx



A=scar, B=rejection , C=vascular damage



# Chinese Proverb

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"It's not what a cat looks like that matters, it's how well he catches mice"

