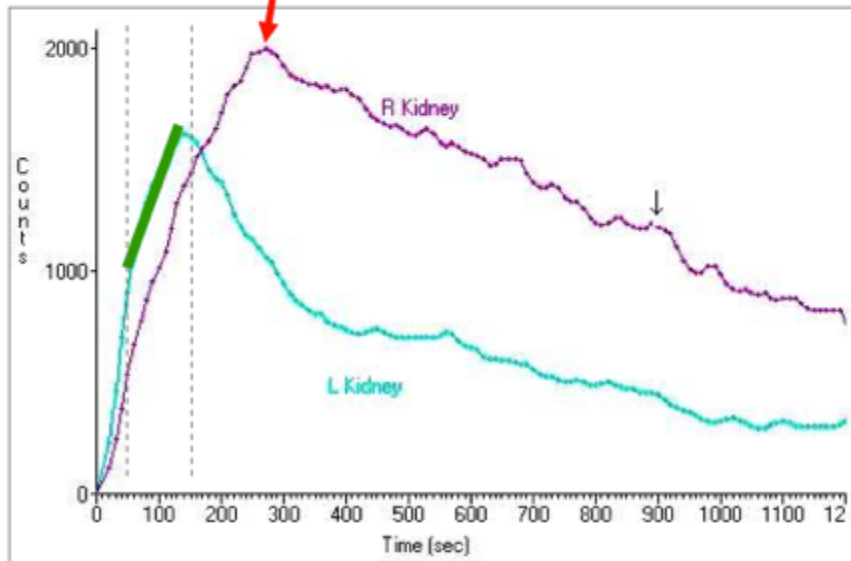


Tmax



Phase 2:

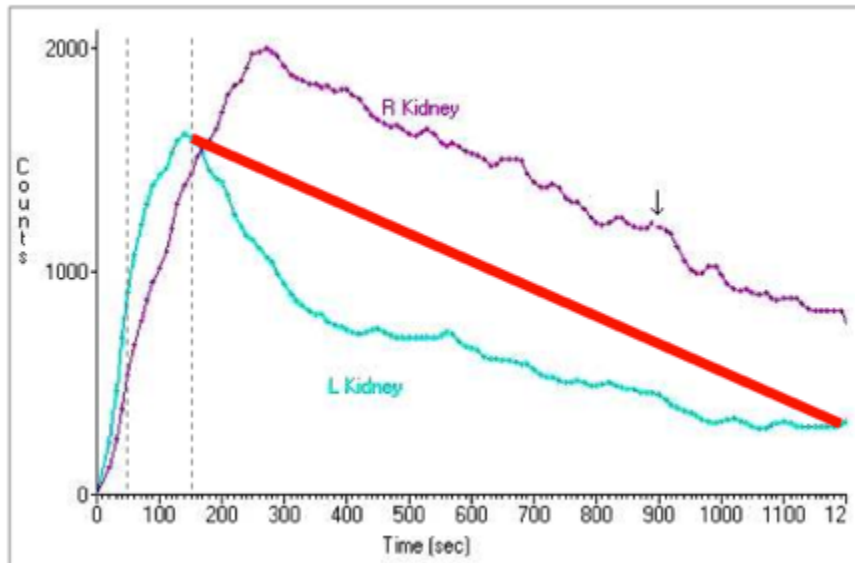
- 2–3 min post injection
- Tracer accumulates in kidney
- no excretion
= **renal uptake**

Tmax = curve peak

- equilibrium between uptake and excretion.

PITFALL

- not representative of DRF.
- does not indicate start of excretion.

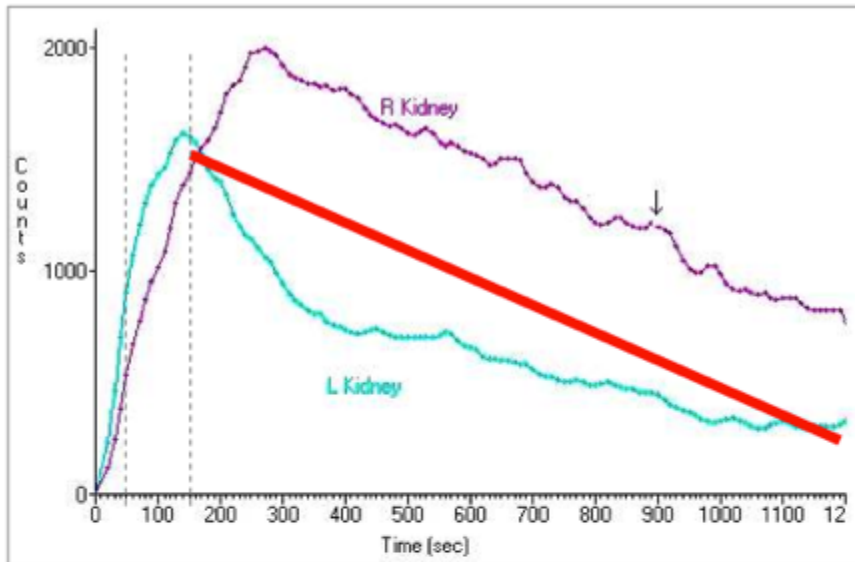


Phase 3:

- Tracer starts clearing
= **renal drainage**

Options for Phase 3 are:

- **decreasing activity:**
 - preserved drainage
- **flat curve:** equilibrium
 - amount cleared tracer = amount excreted tracer
- **increasing activity:** ectasia and urinary tract dilatation
 - without obstruction
 - with obstruction



Phase 3:

- Tracer starts clearing
= **renal drainage**

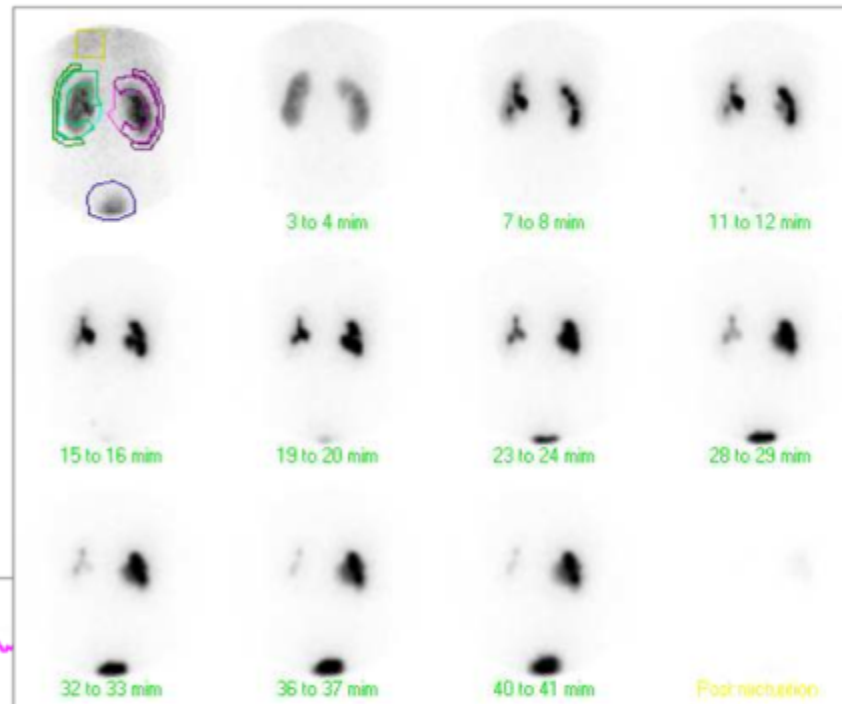
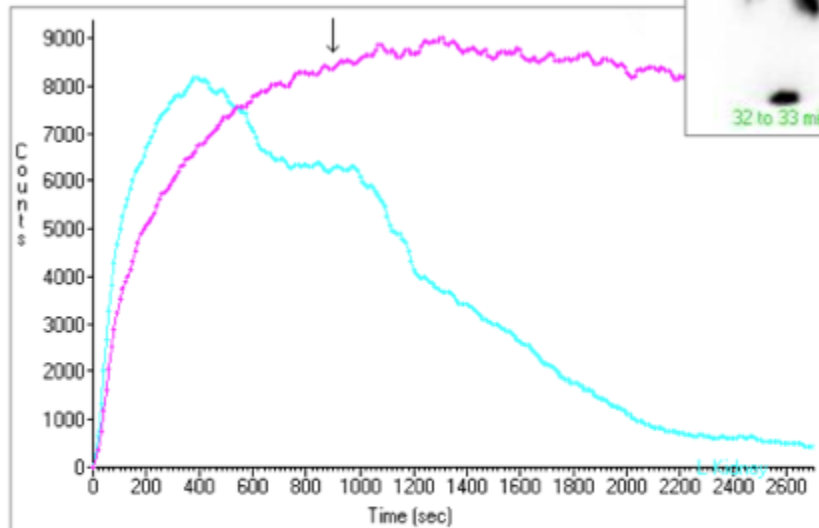
Diuretic enhancement:

Furosemide: increases glomerular filtration.

- **wash-out** if no obstruction present
- **retention** if partial obstruction exists

INTERPRETATION

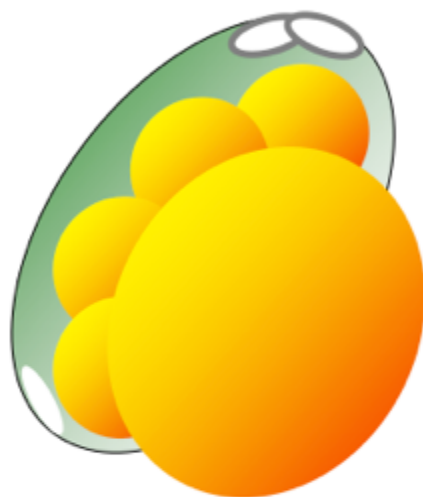
- Images
- Curves
- Quantitative parameters



FUNCTION → NORMAL
→ DECREASED
→ FOCAL LESIONS

DRF

Interpretation of diuretic
renogram in children:
problems and **pitfalls**



DRAINAGE
EXCRETION → YES
→ NO

RENAL EXCRETION

- after diuretic
- after micturation
- after gravity

DRF – Differential Renal Function

DRF is **independent** of

- degree of hydronephrosis
 - hydration status
 - bladder emptiness
 - gravity
 - diuretic administration
-

DFR

PITFALLS

WRONG
ESTIMATION
OF RENAL
FUNCTION

1. LOW signal / background (BKG)

- Renal insufficiency.
- DTPA instead of MAG_3 in young children.

2. Inappropriate BKG ROI

- DFR influenced by extra-renal interstitial activity included in BKG ROI.
- Consensus regarding BKG subtraction ROI: peri-renal area.
- Problem: severe dilatation and very young patients (renal contour similar to body contour). In this case, draw BKG ROI below kidney.

3. Technical errors

- Injection problems.
- Poor labelling (MAG_3 : liver, stomach).
- Patient motion.
- Wrong timing initiation of acquisition.

DRF – Differential Renal Function

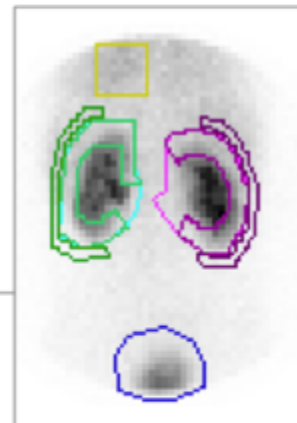
Renal curves corrected by extra-renal BKG activity

DRF calculation

2 widely accepted algorithms:

- integral method = DRF-int
- Rutland-Patlak method = DRF-RP

DRF (integral)	49 %	51 %
DRF (Rutland-Patlak)	48 %	52 %



Recommendation

- use both methods
- if similar results, quality control is OK +++

DRF – Differential Renal Function

F-15 / F0

DRF calculation – integral method

If diuretic is given before (15 min) or simultaneously:

- there is increased renal transit time
- risk of underestimation of DRF

Solution

Compare:

- T_{max} (renogram peak)
- with interval used to calculate DRF (usually 1-2')

If T_{max} < 2 min, change to lower interval (30-90")

DRF – Differential Renal Function

Normal range: 45–55%

- It is a relative measure of renal function.
- DRF may reflect changes due to contralateral kidney:
 - ✓ contralateral kidney damage
 - ✓ compensatory function of contralateral kidney

Estimation of absolute renal function – GFR

- Gamma-camera method:
 - ✓ unaccurate
 - ✓ great variations, especially in young children
 - ✓ no consensus
- Plasma sampling method:
 - ✓ ^{99m}Tc -DTPA or ^{51}Cr -EDTA
 - ✓ more accurate

Supra-normal function > 55%

- Technical error?
- Hiperperfusion / hiperfiltration of “obstructed” kidney?
- Relative to increased renal size?
(DRF-integral detects greater values in larger kidneys)
- More frequent in younger children
- 11 % with DRF-integral method
- 8 % with DRF-RP method
- only 5 % if FRD-integral and FRD-RP are coincident
- To obtain a robust measure of DRF in youngsters:
 - ✓ quality control (motion, injection, etc.)
 - ✓ correct BKG subtraction (ROI)

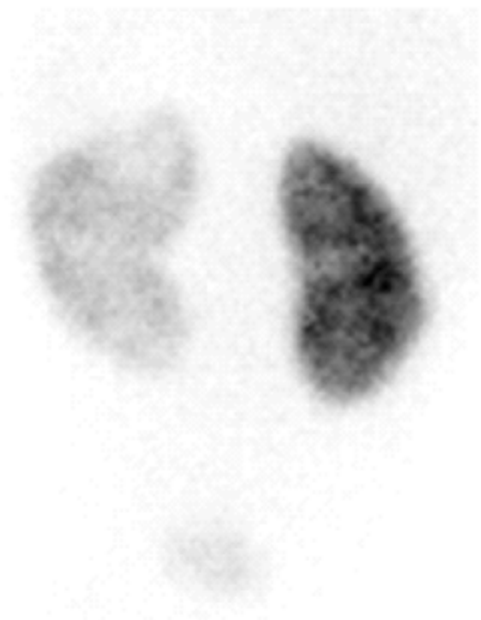
Robustness of estimation of differential renal function in infants and children with unilateral prenatal diagnosis of a hydronephrotic kidney on dynamic renography. How real is the supranormal kidney?

Gordon, I. EJNM, in press

Contradictory Supranormal Function in Hydronephrotic Kidneys: Fact or Artifact on Pediatric MAG-3 Renal Scans?

Clin Nucl Med 2005; 30:91-96

PREDICTION OF RENAL FUNCTION DETERIORATION

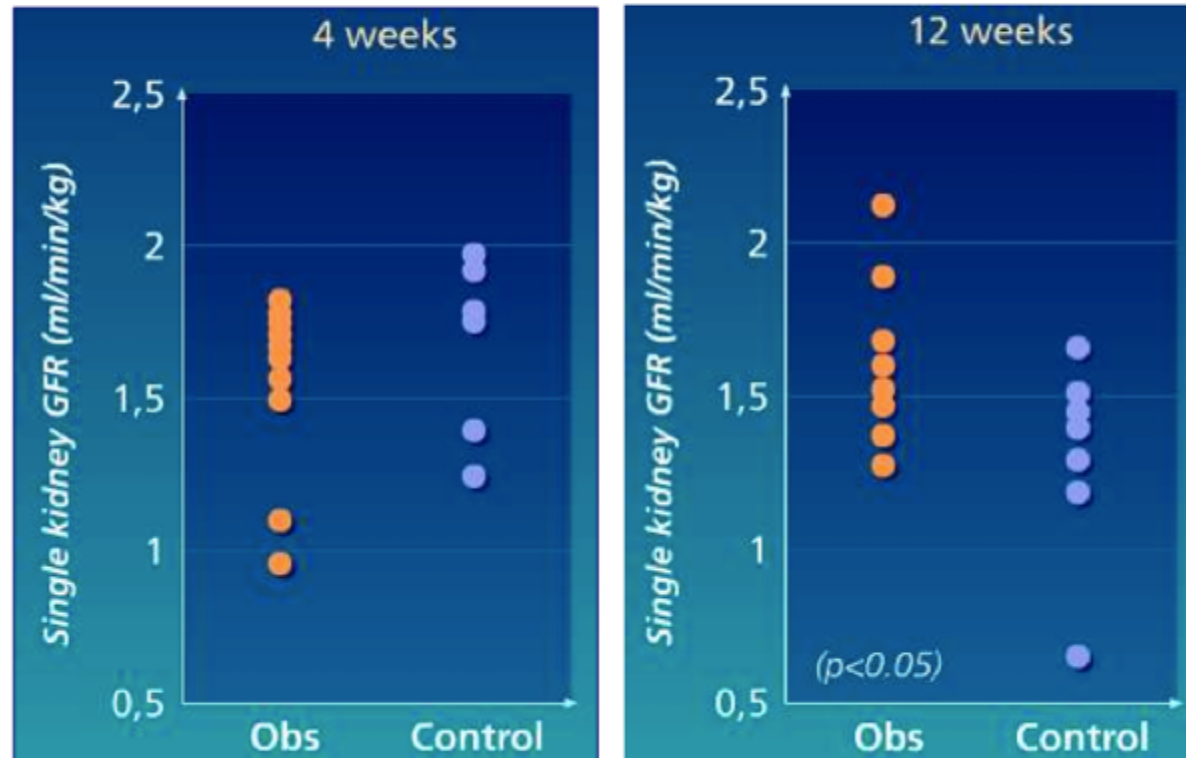


Partial obstruction:

- affects nephrogenesis
- may cause hyperfiltration

Experimental Hydronephrosis

Obstructed kidney increases glomerular filtration (GF) between weeks 4 and 12 post- partial renal obstruction



Frokiaer, J

DRF – Differential Renal Function

If mentioned mistakes are avoided, DRF is:

- A robust method to measure relative renal function.
- Accurate: < 5 % inter-observer variability.
- A decrease >5-10 % means deterioration.

PITFALLS

- ROIs: similar renal and body contours.
- Time interval for DRF calculation.
 - ✓ 30-90 sec F0
 - ✓ 1– 3 min F+15
- MAG3 and dosis: adequate signal-BKG ratio.

METHODS FOR QUANTIFICATION OF **EXCRETION**

- after diuretic
- after micturation
- after gravity

Based on the **curve response post-furosemide**

- % drainage 5-10 min
- T_{1/2} post-diuretic

- F15
- F20

Based on **residual activity**

- ROE = renal output efficiency
- PEE = pelvic excretion efficiency
- NORA₂₀=normalized residual activity

- ✓ after diuretic
- ✓ after micturition

- F-15
- F0

Validation of renal output efficiency as an objective quantitative parameter in the evaluation of upper urinary tract obstruction.

Chaiwatanarat, Padhy, Bomanji, Nimmon, Sonmezoglu, Britton. J Nucl Med. 1993, 34: 845-8

Assessment of drainage in PUJ dilatation: Pelvic Excretion efficiency as an index of renal function

Anderson, Rangarjan, Gordon. Nucl Med. Commun 1997, 18: 823-826

NORA: A simple and reliable parameter for estimating renal output with or without furosemide challenge

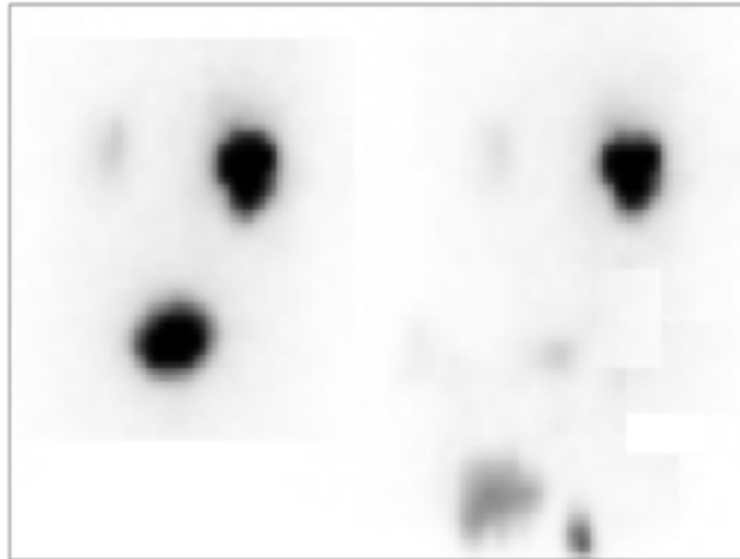
Piepsz, Tondeur, Ham. Nucl Med Commun 2000; 21: 317-23

Micturation

Equal or more important than
diuretic administration

Gravity

Important for drainage of
whole
urinary tract



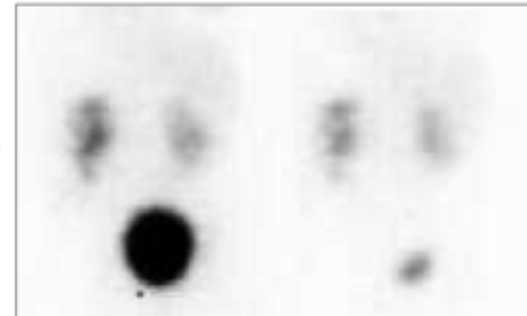
Pitfall:

Renogram commenced with full bladder can simulate
BILATERAL FUNCTIONAL OBSTRUCTIVE PATTERN

→ **POST-MICTURATION**

→ **POST-GRAVITY**

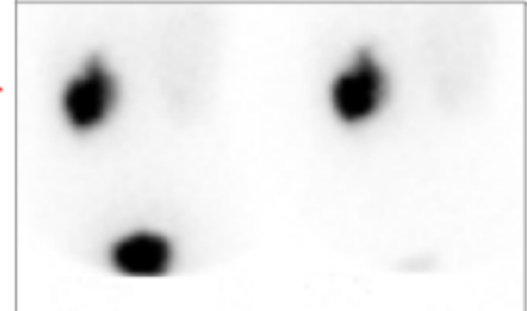
NO change in renal retention



LESS renal retention



MORE renal retention



METHODS FOR QUANTIFICATION OF **EXCRETION**

- after diuretic
- after micturation
- after gravity

PITFALLS

Causes affecting RENAL EXCRETION results:

- Full bladder
- Inappropriate hydration
- No post-gravity imaging
- Immature renal function (newborns) or renal insufficiency
- Large volume of excretory structures (renal pelvis)
- Increased compliance of excretory structures

**LOW
EXCRETION**

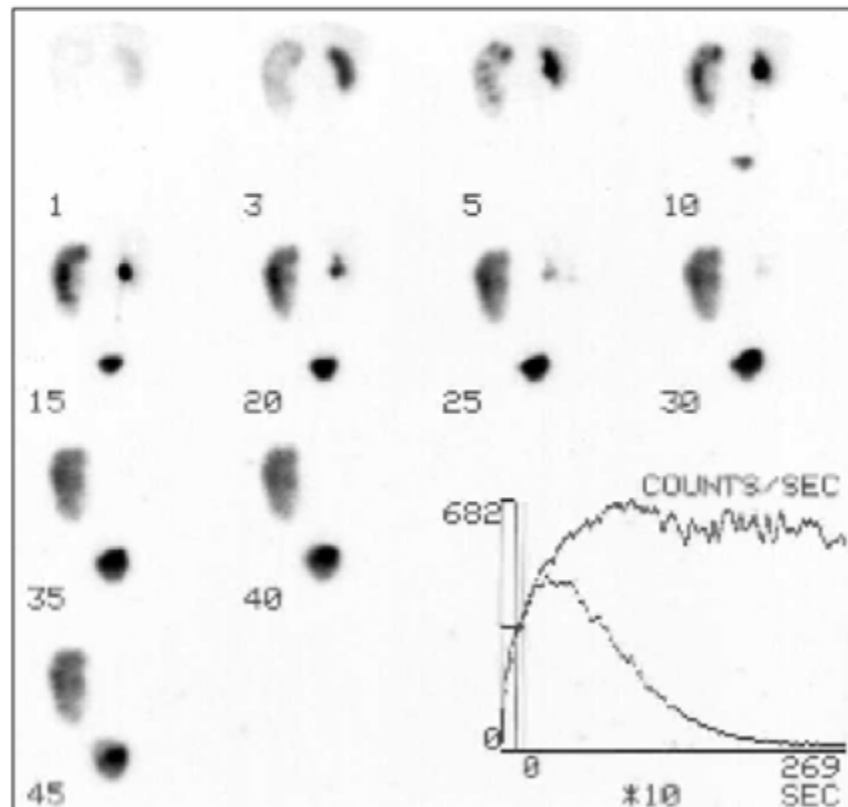
*RENAL PELVIS VOLUME DURING DIURESIS IN CHILDREN WITH HYDRONEPHROSIS:
IMPLICATIONS FOR DIAGNOSING OBSTRUCTION WITH DIURETIC RENOGRAPHY
Koff. J Urol 2005 174, 303-307,*

- **LARGE CAVITIES**
Severe dilated structures
- **INCREASED COMPLIANCE**
Structures with great capacity to dilate

Furosemide

↑ volume

↑ pressure

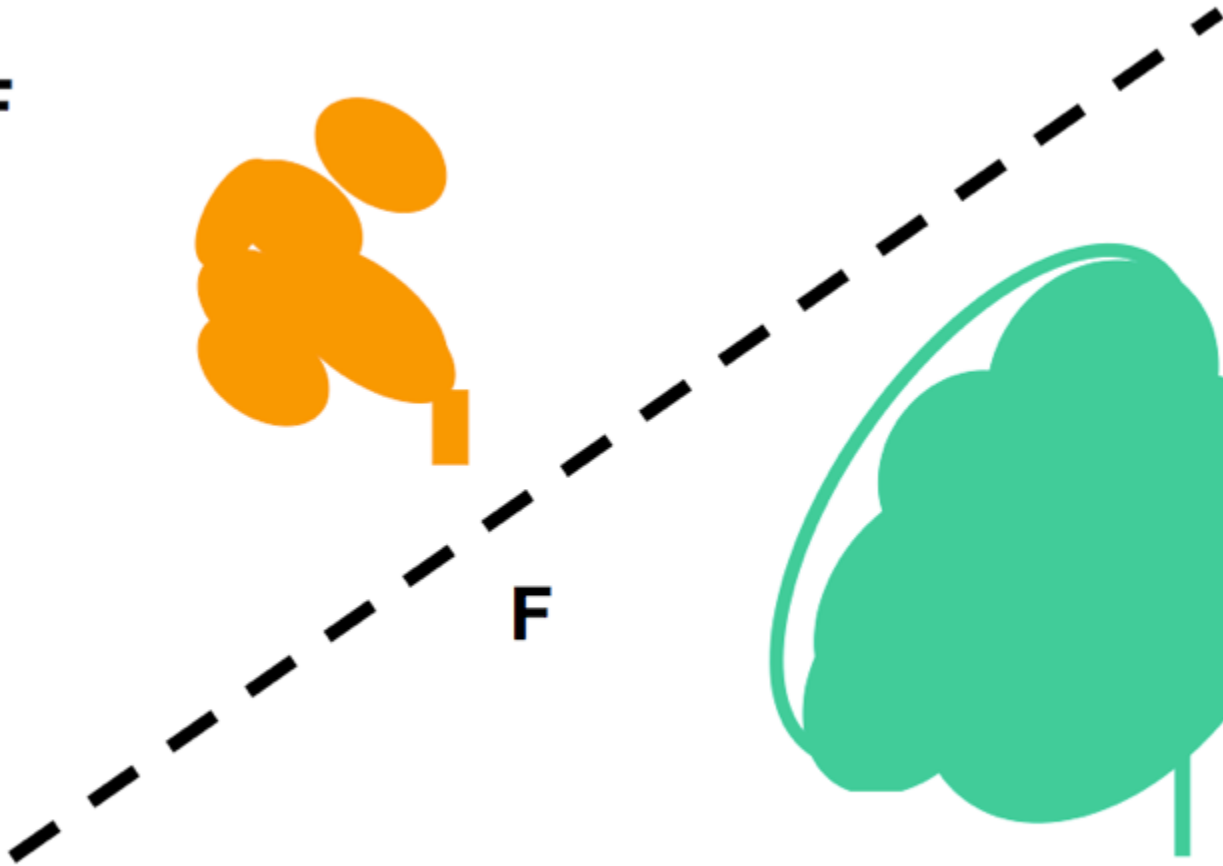


Pelvic volume: 1

F



F



Pelvic volume: 4



T 1/2 after diuretic:

- not useful as obstructive parameter
- renal pelvis dilates after diuretic
- tracer dilutes in renal pelvis
- Koff:
 - ✓ found increased T1/2 post-diuretic in 40% of patients
 - ✓ but there was no obstruction
 - ✓ more frequent in <2 years old
 - ✓ more frequent in children with large volume of renal pelvis

Impaired drainage on diuretic renography using half-time or pelvic excretion efficiency is not a sign of obstruction in children with a prenatal diagnosis of unilateral renal pelvic dilatation

*Amarante, Anderson, Gordon
J Urol, 169, 1828–1831, 2003*

*Renal pelvis volume during diuresis in children with hydronephrosis
implications for diagnosing obstruction with diuretic renography*

*Koff, Binkovitz, Voley, Jayanthi
J urol, 174, 303–307, july 2005*

METHODS FOR
QUANTIFICATION OF
EXCRETION

- after diuretic
- after micturation
- after gravity

Drainage can be best quantified using tools to measure **RESIDUAL ACTIVIDAD:**

- **ROE** : renal output efficiency
- **PEE** : pelvic excretion efficiency
- **NORA** : normalized residual activity

METHODS FOR
QUANTIFICATION OF
EXCRETION

- after diuretic
- after micturation
- after gravity

Drainage can be best quantified using tools to measure **RESIDUAL ACTIVIDAD:**

- **ROE** : renal out

Especially if diuretic administration time:

- F-15
- F0

- **PEE** : pelvic excretion efficiency

- **NORA** : normal

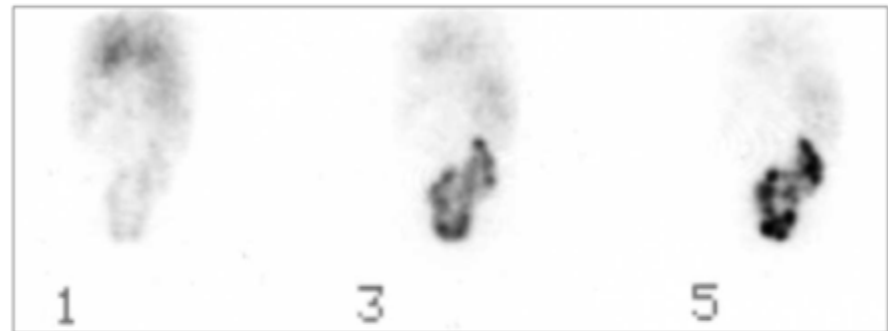
These parameters take into account
RENAL FUNCTION

→ **Catheter only necessary if:**

- **VUR +++++**

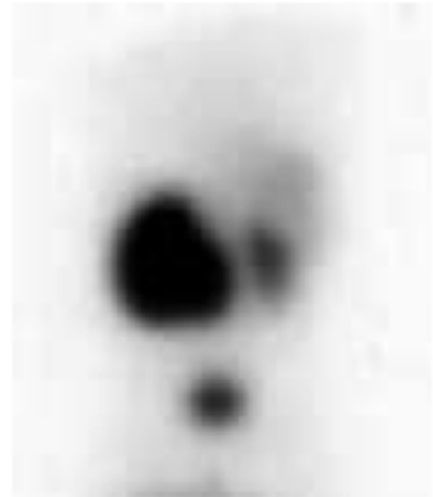


- **Ectopic kidney**



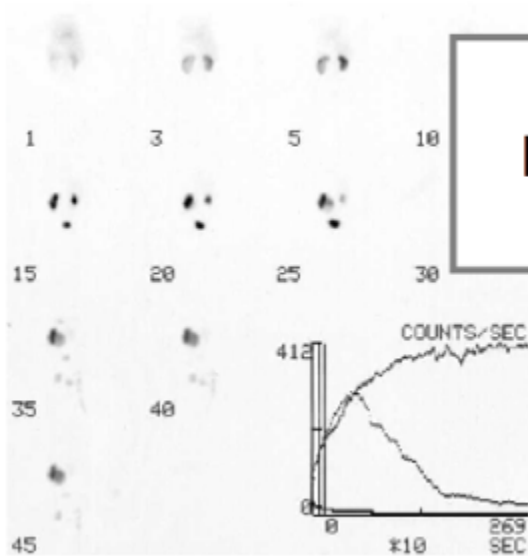
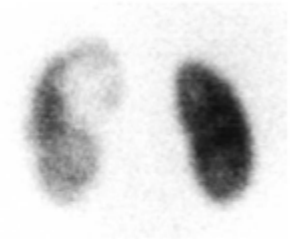
Low renal function in neonatal period

- Increased parenchymal transit time
- Lower diuretic effect
- Low amplitude of the renogram



- renography can be done from birth
- advisable > 4 weeks
- MAG3: non toxic for kidney
very low dosimetry

INTERPRETATION OF DIURETIC RENOGRAM IN CHILDREN



PROCEDURE:

- Technique
- Patient preparation

INTERPRETATION:

- Images
- Curves
- Quantitative parameters

OBSTRUCTIVE PROFILE ???



Indications for SURGERY

- **Progressive hydronephrosis**
- **Absent or poor diuretic response**
- **Deterioration of renal function**
- **Infection**

- *Drainage can vary with physiologic conditions*
- Drainage spontaneously improves with time
- Surgery improves drainage

- Good drainage = good prognosis
- Impaired drainage = possible obstruction

*Congenital unilateral hydronephrosis:
a review of the impact of diuretic renography on clinical treatment
ESKILD-JENSEN, GORDON, PIEPSZ, FRØKIÆR
J Urol 173, 1471-1476, 2005*

INTERPRETATION CRITERIA

- **Renal function**

- ✓ DRF: normal, $\uparrow$ $\downarrow$
- ✓ Cortical optimized image
 - diffuse decreased uptake
 - focal cortical lesions

- **Renal size:** normal, $\uparrow$ $\downarrow$

- **Curves**

- **Transit time**

- **Dynamic images:** urinary tract

- ✓ dilated
- ✓ non dilated

- **Drainage:** diuretic, micturation, gravity

- ✓ OER
- ✓ PEE
- ✓ NORA
- ✓ PMI

$\uparrow$ Pelvic pressure
 $\downarrow$ Bladder pressure



Drainage $\uparrow$ or =



«"OBSTRUCTIVE PATTERN"»

- **Renal function**

- ✓ DRF-auc
- ✓ DRF-decon
- ✓ cortical image

low / decreased



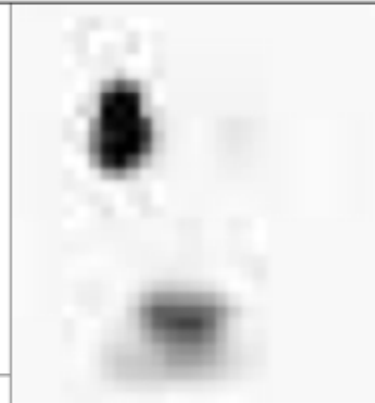
- **Drainage**

- ✓ diuretic
- ✓ gravity
- ✓ bladder emptying

- **Quantification**

- ✓ OER
- ✓ PEE
- ✓ NORA
- ✓ PMI

low / decreased



PITFALLS



Frequently, diuretic renography is performed without considering:

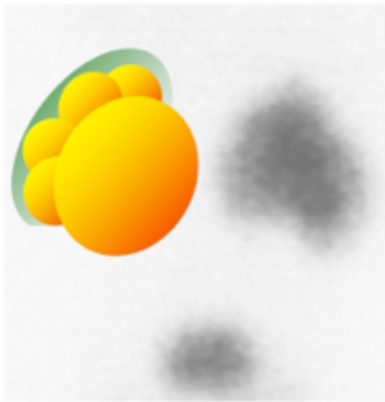
- previous hydration
- renal function
- renal pelvis size
- gravity
- bladder emptying

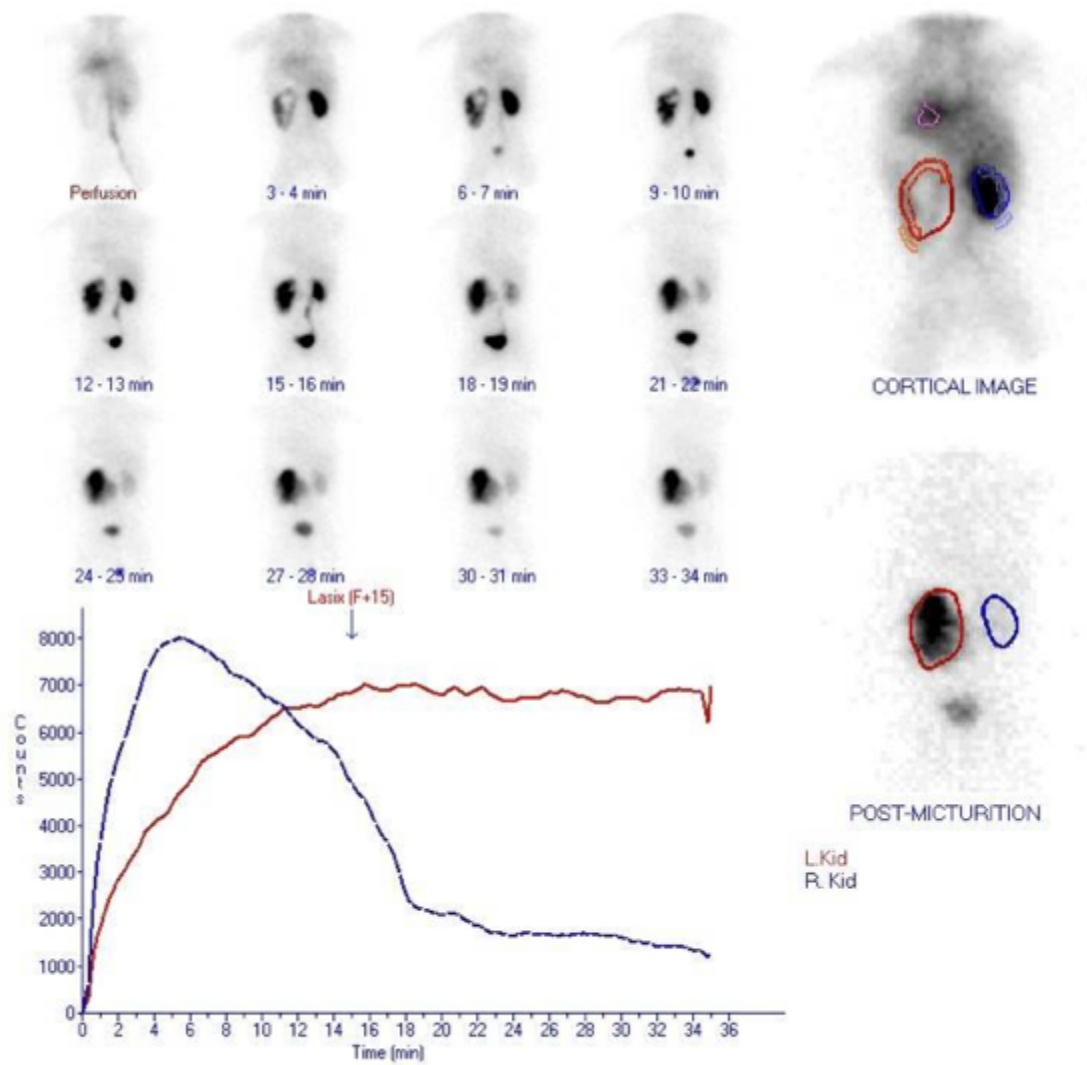
Technical errors should also be considered:

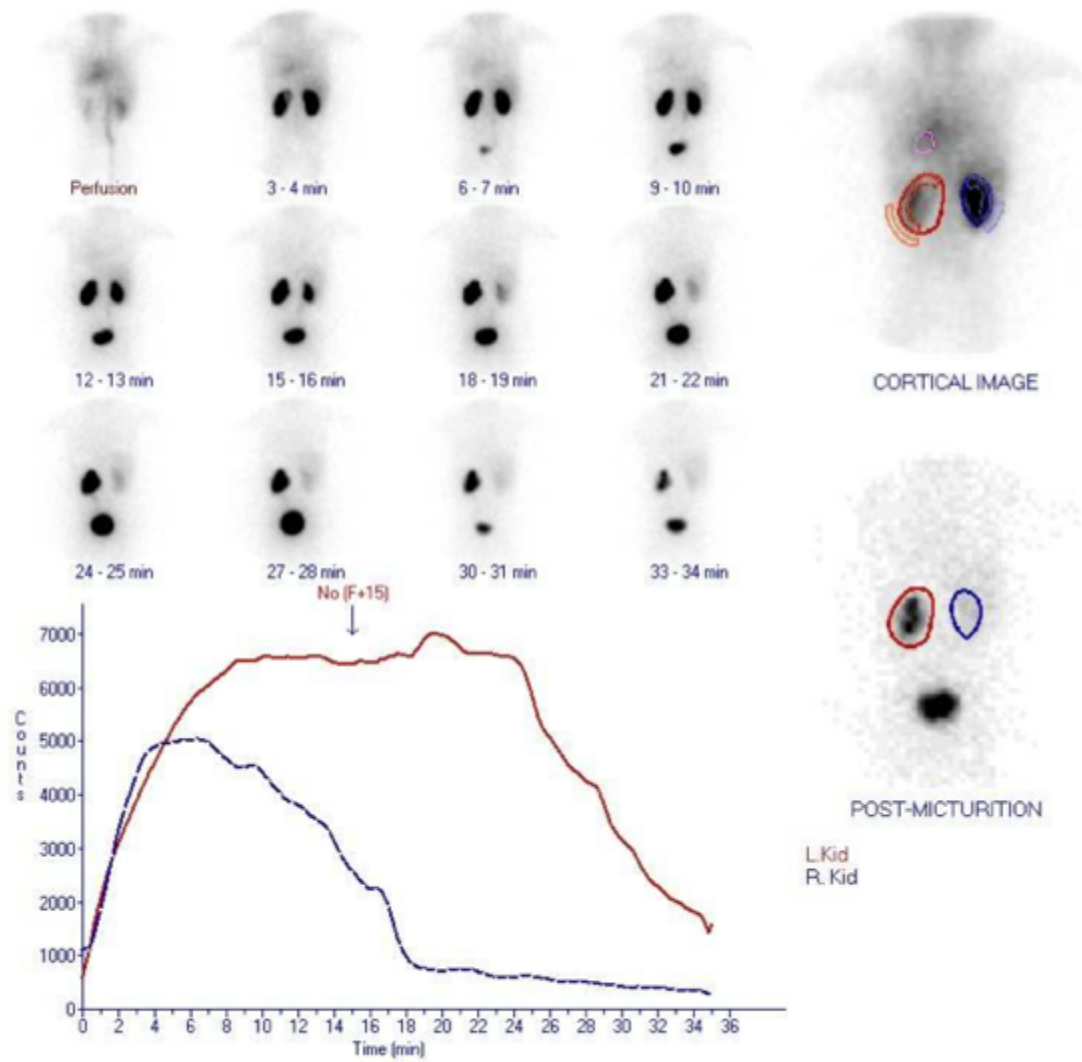
- radiopharmaceutical labelling
- injection technique
- patient motion
- diuretic injection
- urine contamination
- ROI delineation

Conclusion:

IF DIURETIC RENOGRAPHY IS **WELL STANDARDIZED**
AND POTENTIAL **PITFALLS** CONSIDERED, IT IS A
VALUABLE AND REPRODUCIBLE METHOD TO OBTAIN
INFORMATION ON **DRE** AND **RENAL DRAINAGE**







Evaluation of Renovascular Hypertension

Captopril Renal Scan
(ACEI Renography)

Renovascular Disease

- ❖ Renal artery stenosis (RAS)
- ❖ Ischemic nephropathy
- ❖ Renovascular hypertension (RVH)

RAS $\neq$ RVH

Renovascular Hypertension

- ❖ Caused by renal hypoperfusion
 - Atherosclerosis
 - Fibromuscular dysplasia
- ❖ Mediated by renin - AT - aldosterone system
- ❖ Potentially curable by renal revascularization

Renovascular Hypertension

❖ Prevalence

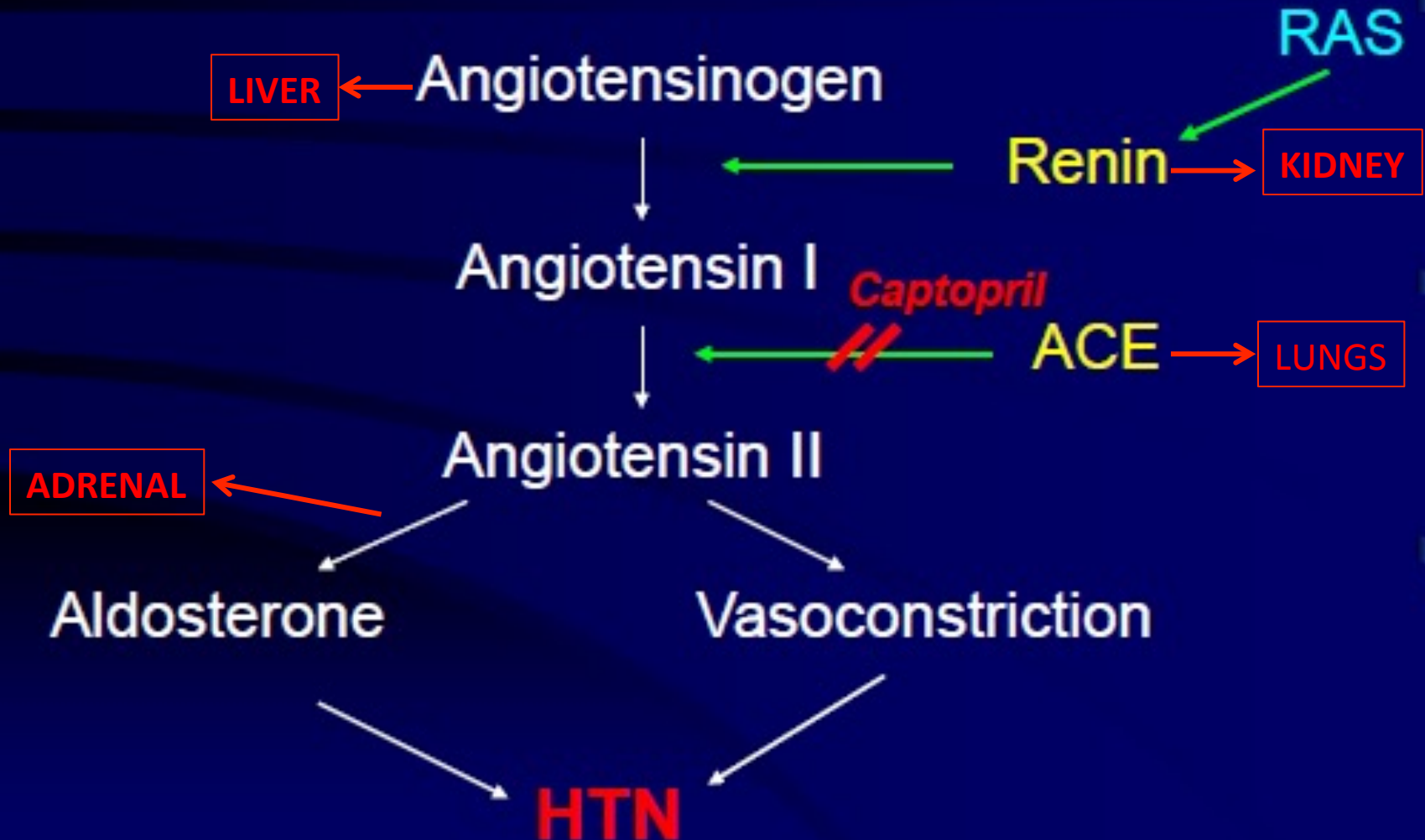
- <1% unselected population with HTN

❖ Clinical features

- Abrupt onset HTN in child, adult < 30 or > 50y
- Severe HTN resistant to medical Rx
- Unexplained or post-ACEI impairment in ren fct
- HTN + abdominal bruits

If these present - moderate risk of RVH (20-30%)

Renin-Angiotensin System



Diagnosis of RAS

- ❖ Gold std: angiography
- ❖ Initial non-invasive tests:
 - ACEI renography
 - Duplex sonography
- ❖ Other tests:
 - MRA - insensitive for distal / segmental RAS
 - Captopril test (PRA post-C.) - low sensitivity
 - Renal vein renin levels

ACEI Renography

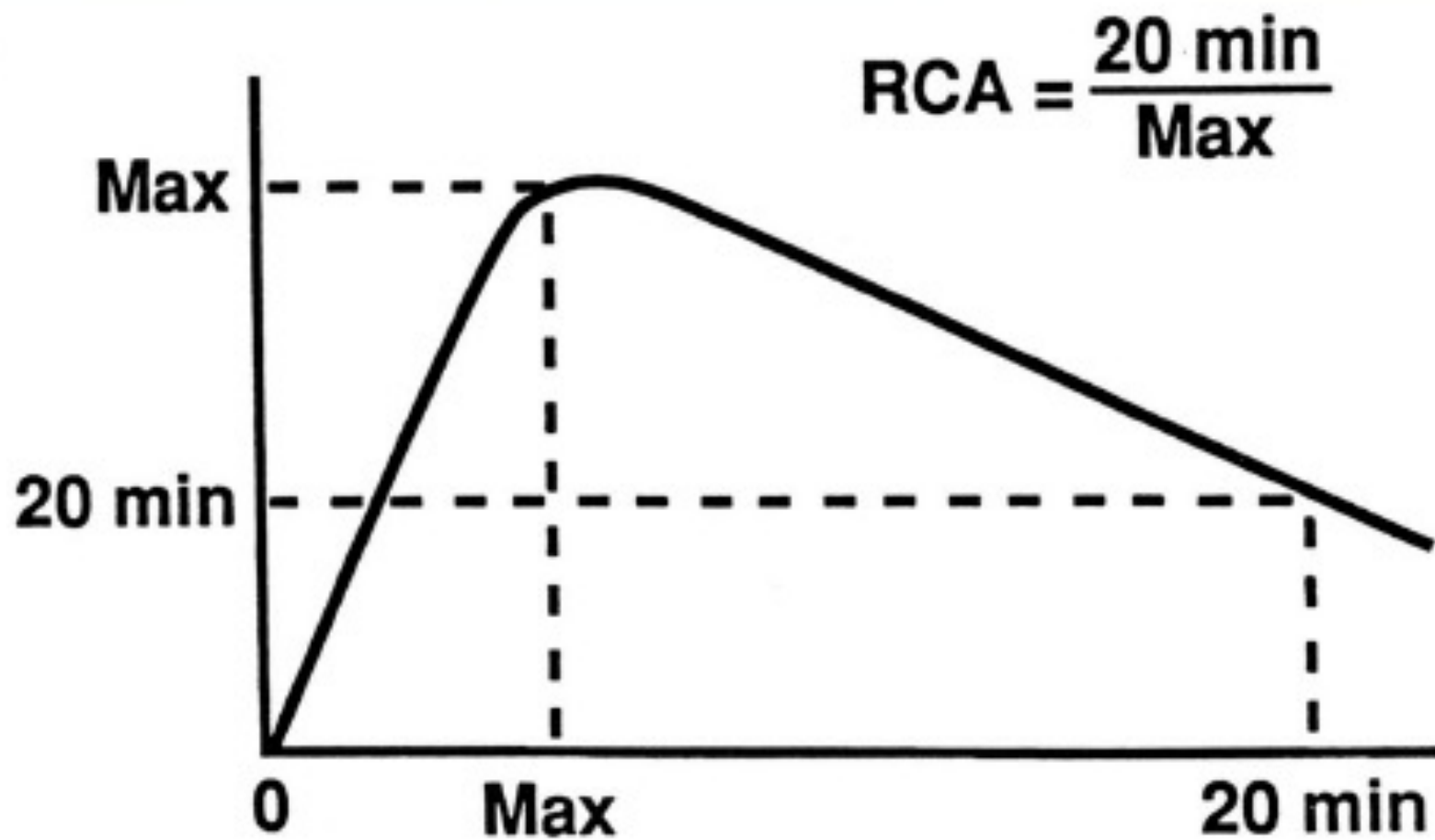
ACEI Renography

Patient Preparation

- ❖ Off ACEI & ATII receptor blockers x 3-7 days
- ❖ Off diuretics x 5-7d
- ❖ No solid food x 4 hrs
- ❖ Patient well hydrated
 - 10 ml/kg water 30-60 min pre- and during test
- ❖ ACEI
 - Captopril 25-50 mg po (crushed), 1 hr pre-scan
 - Enalaprilat 40 $\mu\text{g/kg}$ iv (2.5 mg max), 15 min pre-scan
 - Monitor BP q 15 min

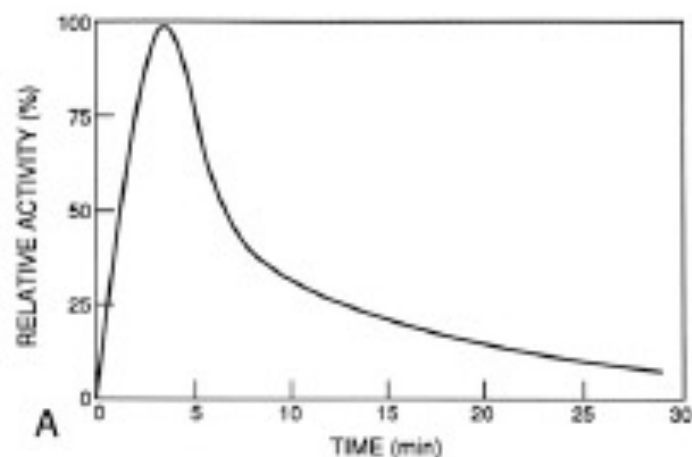
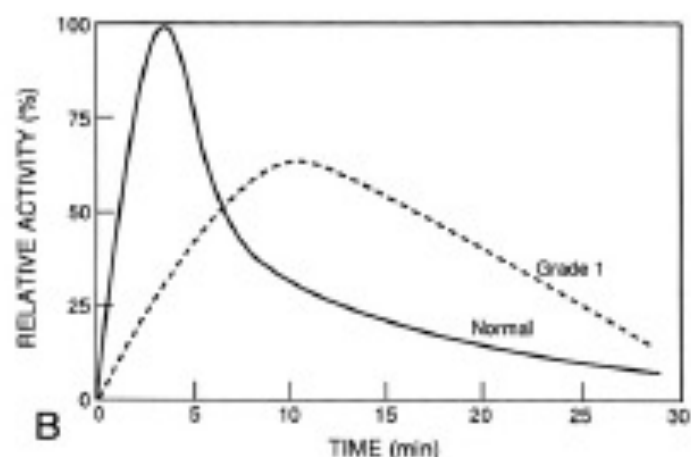
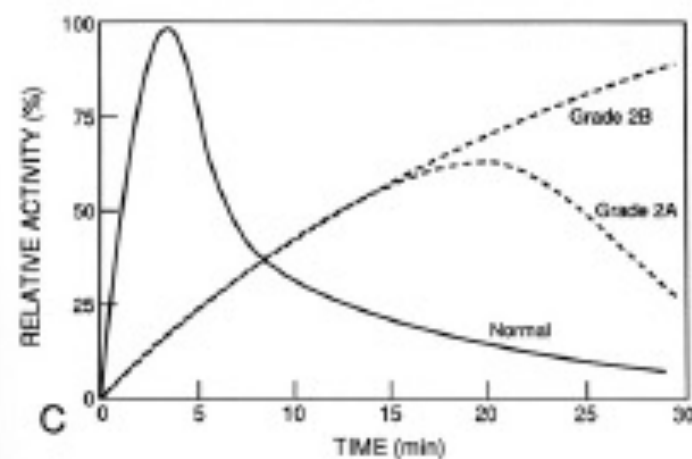
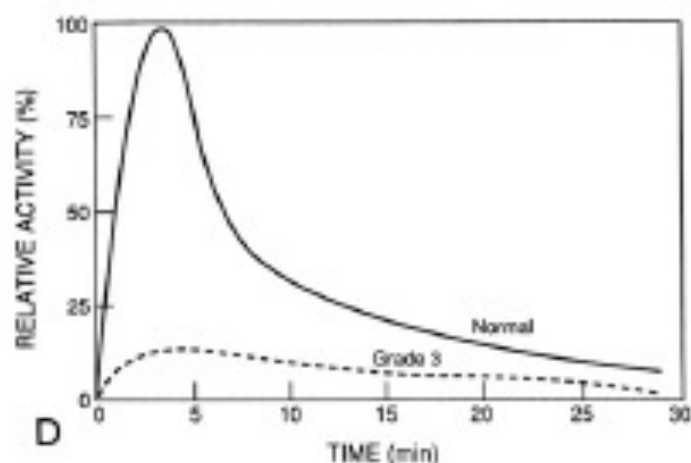
ACEI Renography Procedure

- ❖ Tracer: Tc-99m MAG3 (or DTPA)
- ❖ Protocol: 1 day vs. 2 day test
 - 1 day test: baseline scan (1-2 mCi) followed by post-Capto scan (8-10 mCi)
 - 2 day test: post-Capto scan, only if abnormal >> baseline
- ❖ Acquisition: flow & dynamic x 20-30 min.



ACEI Renography

Grading renogram curves



ACEI Renography

Diagnostic Criteria

❖ MAG3: ipsilateral parenchymal retention

p.C.

- change in renogram curve by ≥ 1 grade
- RCA_{20} increase by $\geq 15\%$ (e.g. from 30% to 45%)
- T_p increase by ≥ 2 min or 40% (e.g. from 5 to 7')

❖ DTPA: ipsilateral decreased uptake

- Decrease in relative uptake $\geq 10\%$
(e.g. from 50/50 to 40/60), change of 5-9% - intermediate
- change in renogram curve by ≥ 2 grades

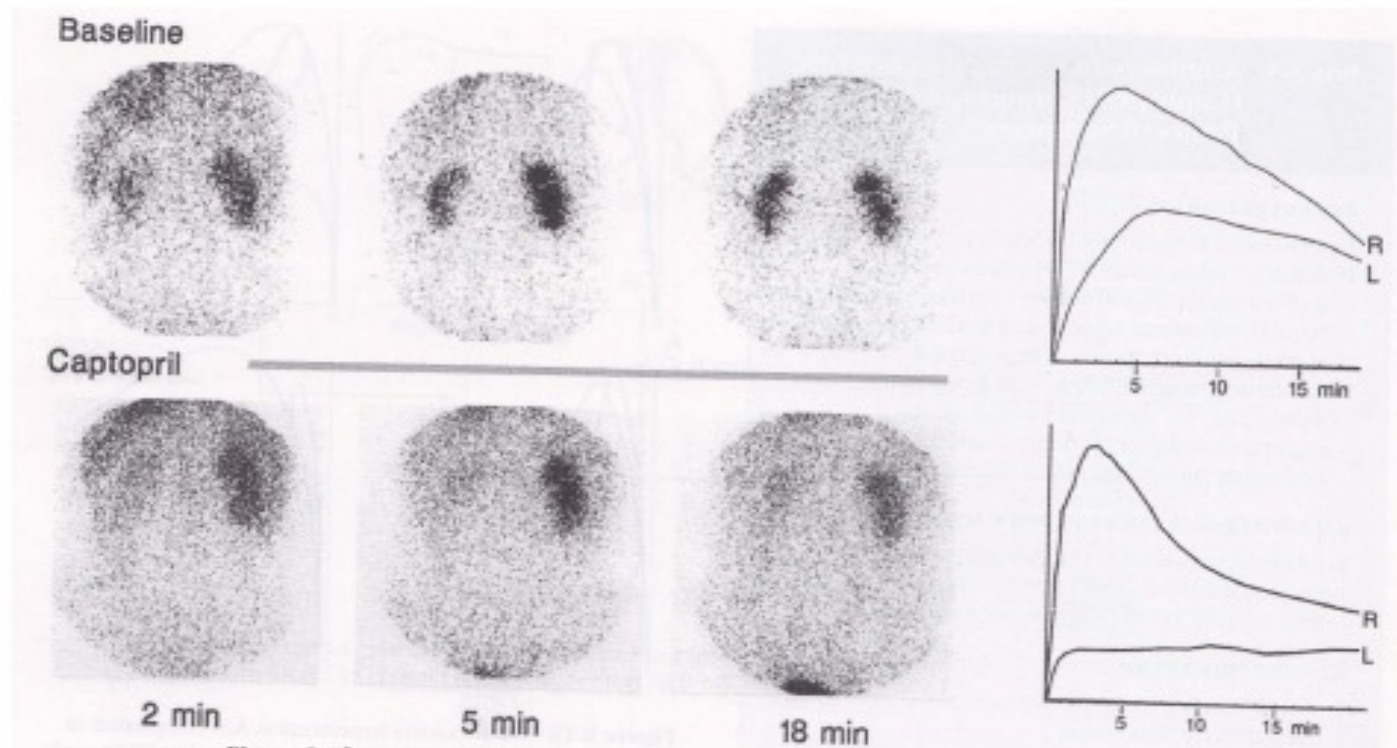
ACEI Renography Interpretation

- ❖ High probability RVH ($>90\%$)
 - Marked C-induced change
- ❖ Low probability RVH ($<10\%$)
 - Normal Captopril scan
 - Abnormal baseline, improved p-C.
 - Type I curve - pre- and post-C.
- ❖ Intermediate probability RVH
 - Abnl baseline, no change p-C.

ACEI Renography

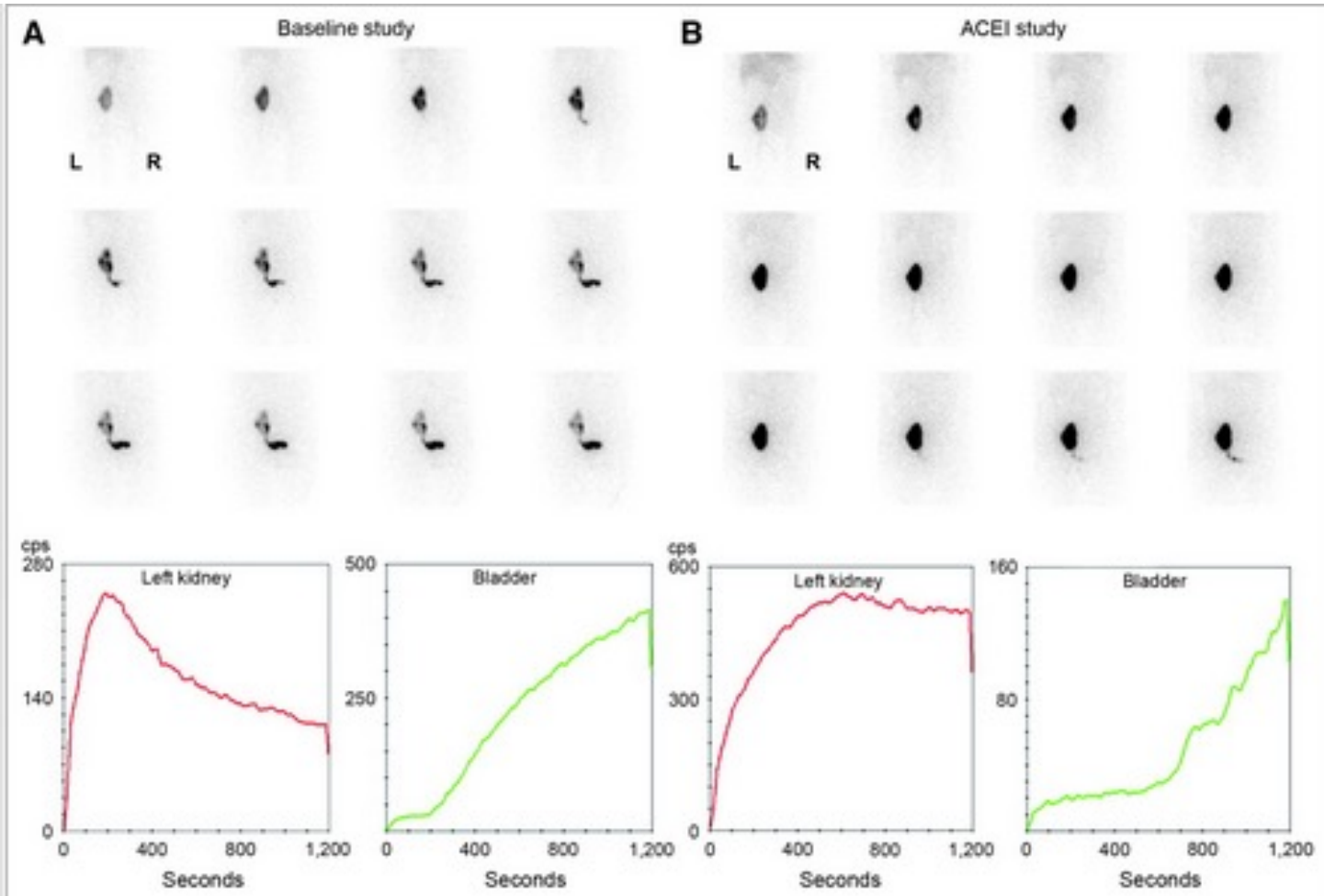
- ❖ In normal renal function - sens/spec ~ 90%
- ❖ In poor renal fct / ischemic nephropathy, ACEI renography often indeterminate
>>> do MRA, Duplex US, angio

RVH with DTPA

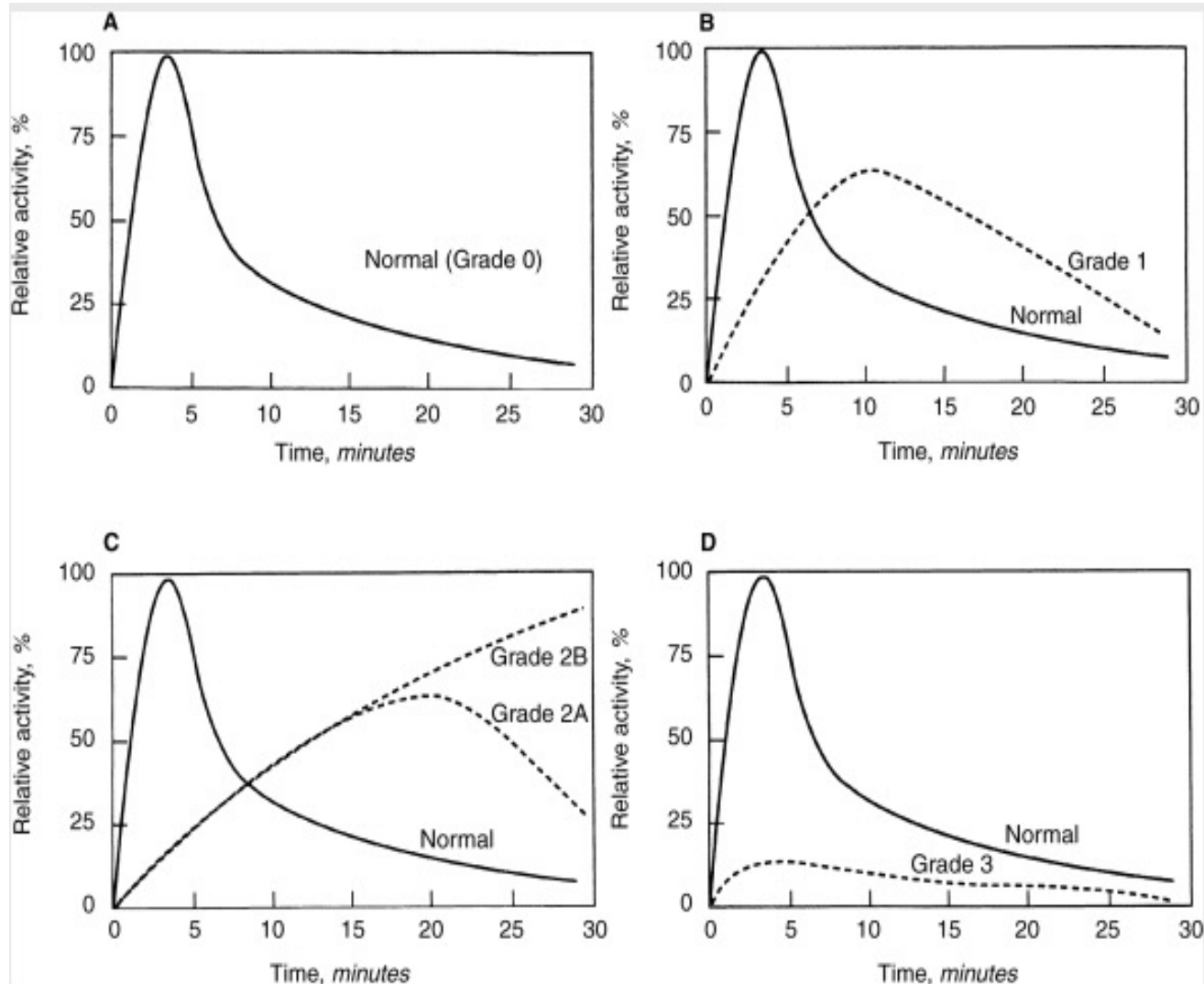


Effect of renovascular hypertension on Tc99DTPA

RVH with MAG 3



Renogram pattern with ACE



Renogram pattern with ACE

- A = normal TAC curve (grade 0)
- B = peak mildly delayed but greater than 5 min and with delayed excretion (grade 1)
- C = very delayed uptake but some wash out (grade 2A)
- C = extremely delayed uptake with no wash out (grade 2B)
- D = complete renal failure where blood pool moves through the kidney without an extraction phase

Evaluation of Renal Infection

Renal Morphology Scan
(Renal Cortical
Scintigraphy)

UTI

❖ VUR

- risk factor for PN,
- not all pts w PN have VUR

❖ PN may lead to scarring >>> ESRD, HTN

- early Dx and Rx necessary

❖ Clinical & laboratory Dx of renal involvement in UTI unreliable

Renal Cortical Scintigraphy

Indications

- ❖ Determine involvement of upper tract (kidney) in acute UTI (acute pyelonephritis)
- ❖ Detect cortical scarring (chronic pyelonephr.)
- ❖ Follow-up post Rx

Renal Cortical Scintigraphy

Procedure

❖ Tracers

- Tc-99m DMSA
- Tc-99m GHA

❖ Acquisition

- 2-4 hrs post-injection
- parallel hole posterior
- pinhole post. + post. oblique (or SPECT)

❖ Processing: relative fct

Renal Cortical Scintigraphy

Interpretation

❖ Acute PN

- single or multiple “cold” defects
- renal contour not distorted
- diffuse decreased uptake
- diffusely enlarged kidney or focal bulging

❖ Chronic PN

- volume loss, cortical thinning
- defects with sharp edges

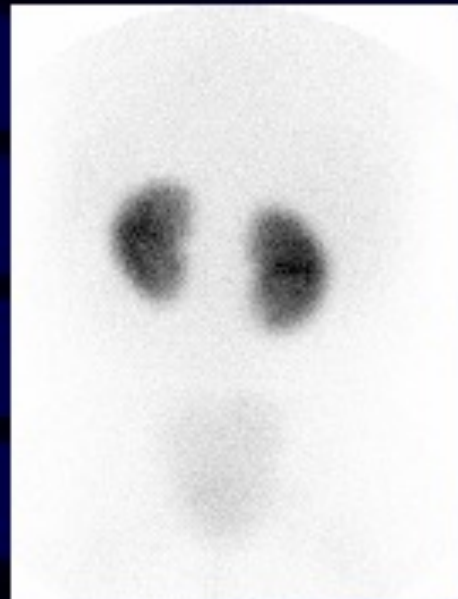
❖ Differentiation of AcPN vs. ChPN unreliable

Renal Cortical Scintigraphy

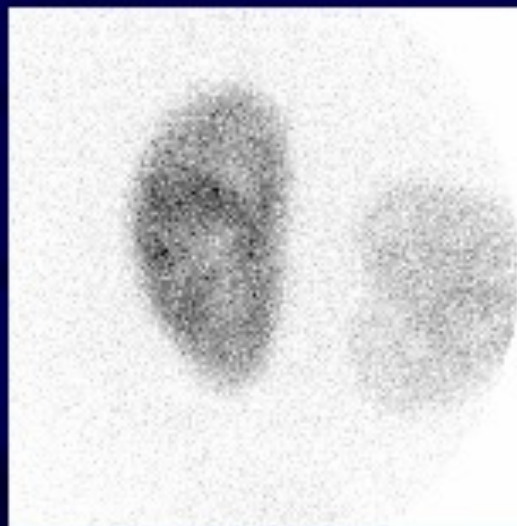
“Cold Defect”

- ❖ Acute or chronic PN
- ❖ Hydronephrosis
- ❖ Cyst
- ❖ Tumors
- ❖ Trauma (contusion, laceration, rupture, hematoma)
- ❖ Infarct

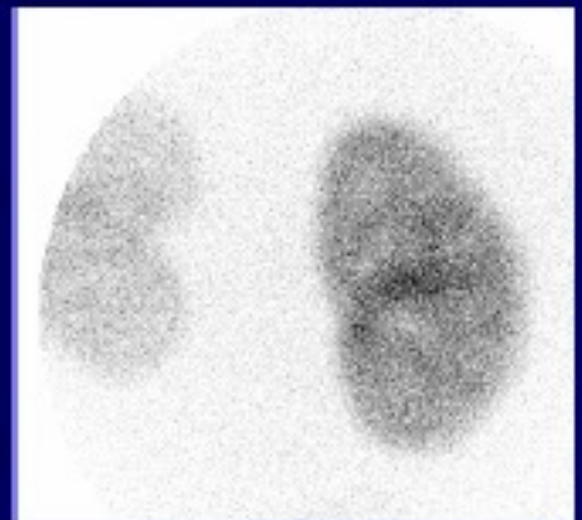
Normal DMSA



pinhole



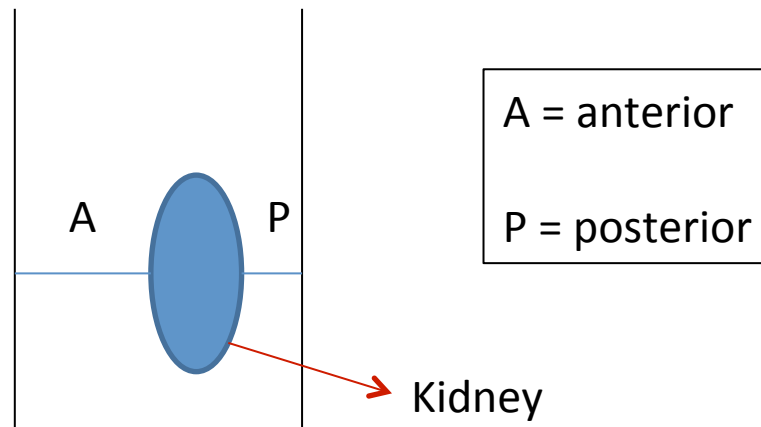
LPO



RPO

Geometric mean

- Right kidney = $\sqrt{(A + P)(\text{right kidney})} / A \times P$
(right kidney)
- Left kidney = $\sqrt{(A + P)(\text{left kidney})} / A \times P$
(left kidney)

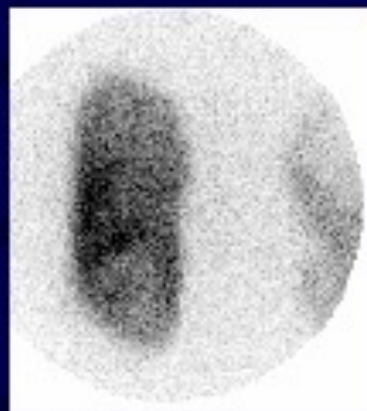


Acute pyelonephritis DMSA

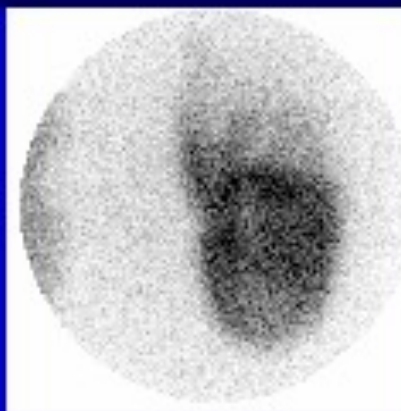
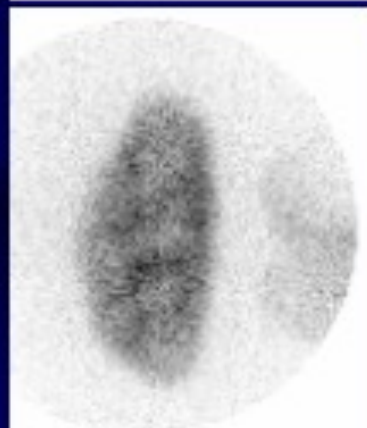
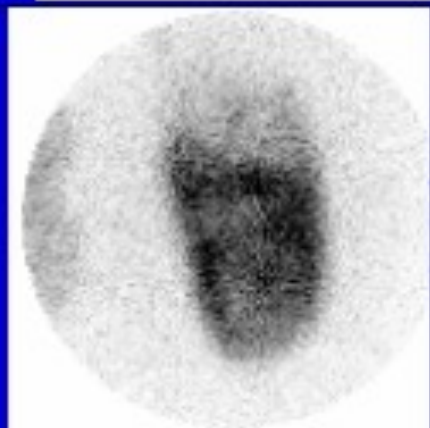


LEAP

post L



post R



LPO

pinhole

RPO

Renal Cortical Scintigraphy

Congenital Anomalies

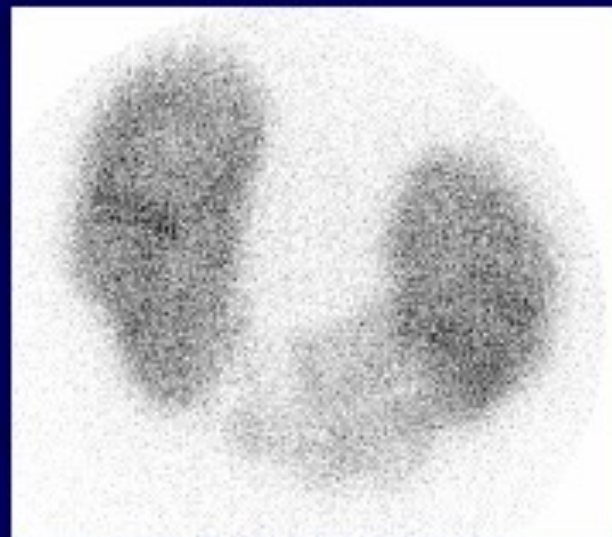
- ❖ Agenesis
- ❖ Ectopy
- ❖ Fusion (horseshoe, crossed fused ectopia)
- ❖ Polycystic kidney
- ❖ Multicystic dysplastic kidney
- ❖ Pseudomasses (fetal lobulation, hypertrophic column of Bertin)

DMSA

horseshoe kidney



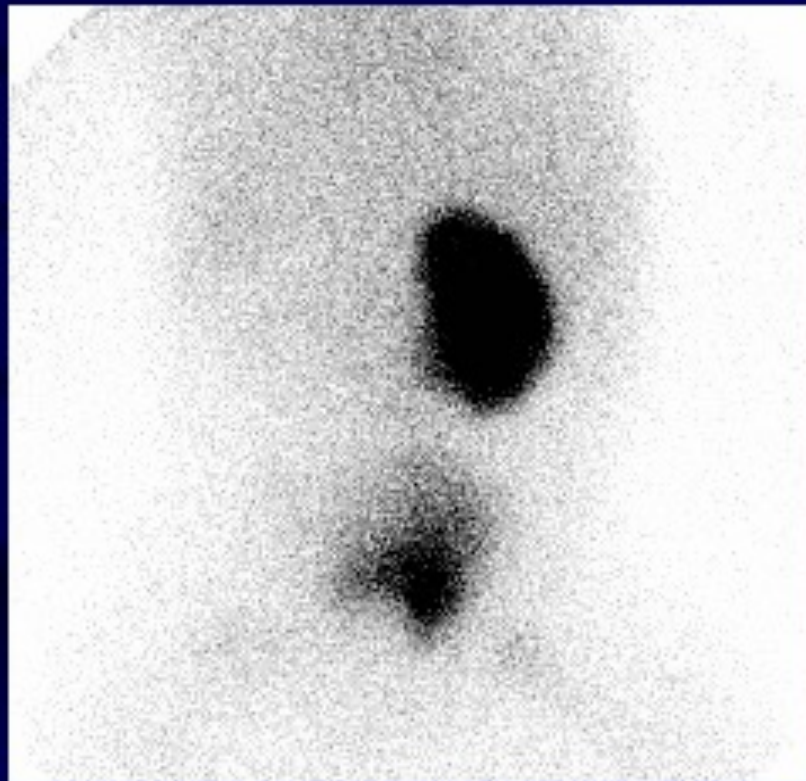
parallel



pinhole

DMSA

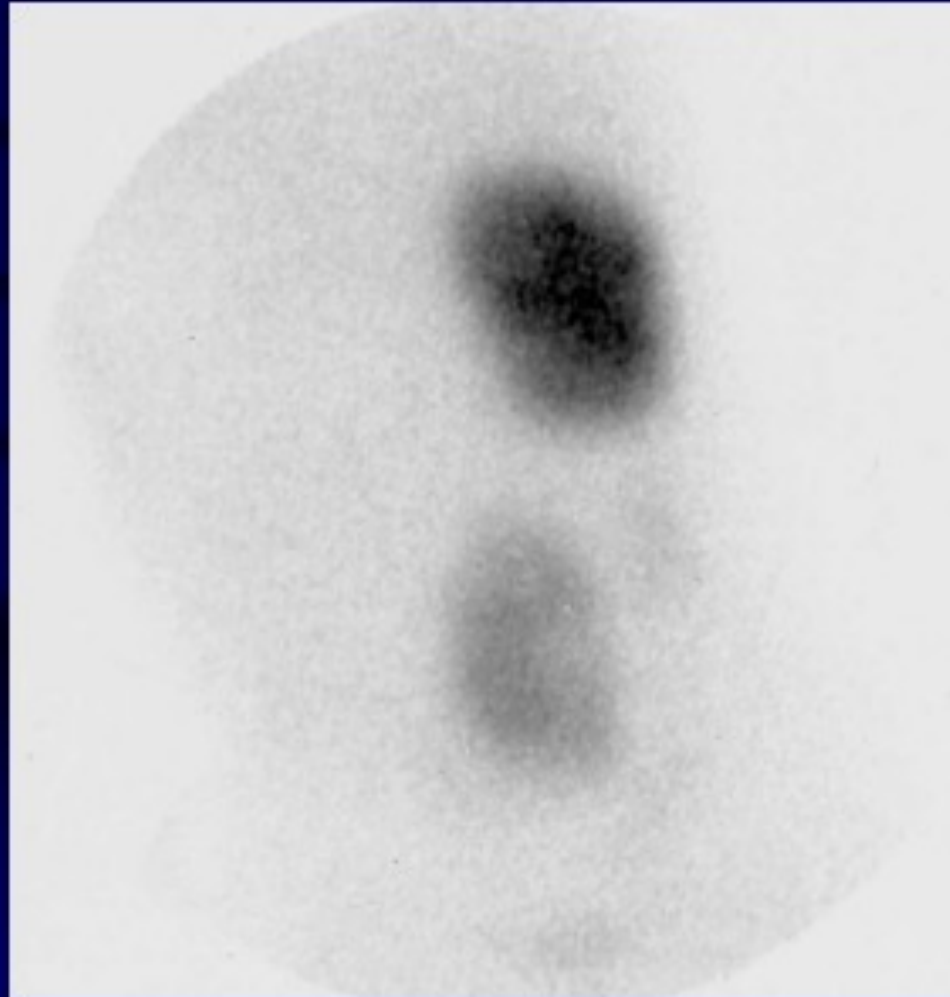
Lt Agenesis



parallel

GHA

Crossed ectopia



74%

26%

Radionuclide Cystogram

Indications

- ❖ Evaluation of children with recurrent UTI
 - 30-50% have VUR
- ❖ F/U after initial VCUG
- ❖ Assess effect of therapy / surgery
- ❖ Screening of siblings of reflux pts.

Methods

Direct

- ❖ Tc-99m S.C. or TcO₄

Advant. ❖ via Foley

- ❖ can do at any age

Disadv. ❖ VUR during filling

- ❖ catheterization

Indirect

- ❖ Tc-99m DTPA or Tc-99m MAG3

- ❖ i.v.

- ❖ no catheter

- ❖ info on kidneys

- ❖ need pt cooperation

- ❖ need good renal fct

Direct Cystography

- ❖ 1 mCi S.C. in saline via Foley
- ❖ Fill bladder until reversal of flow
 - (bladder capacity = $(\text{age} + 2) \times 30$)
- ❖ Continuous imaging during filling & voiding
- ❖ Post void image
- ❖ Record
 - volume instilled
 - volume voided
 - pre- and post- void cts

RN Cystogram vs. VCUG

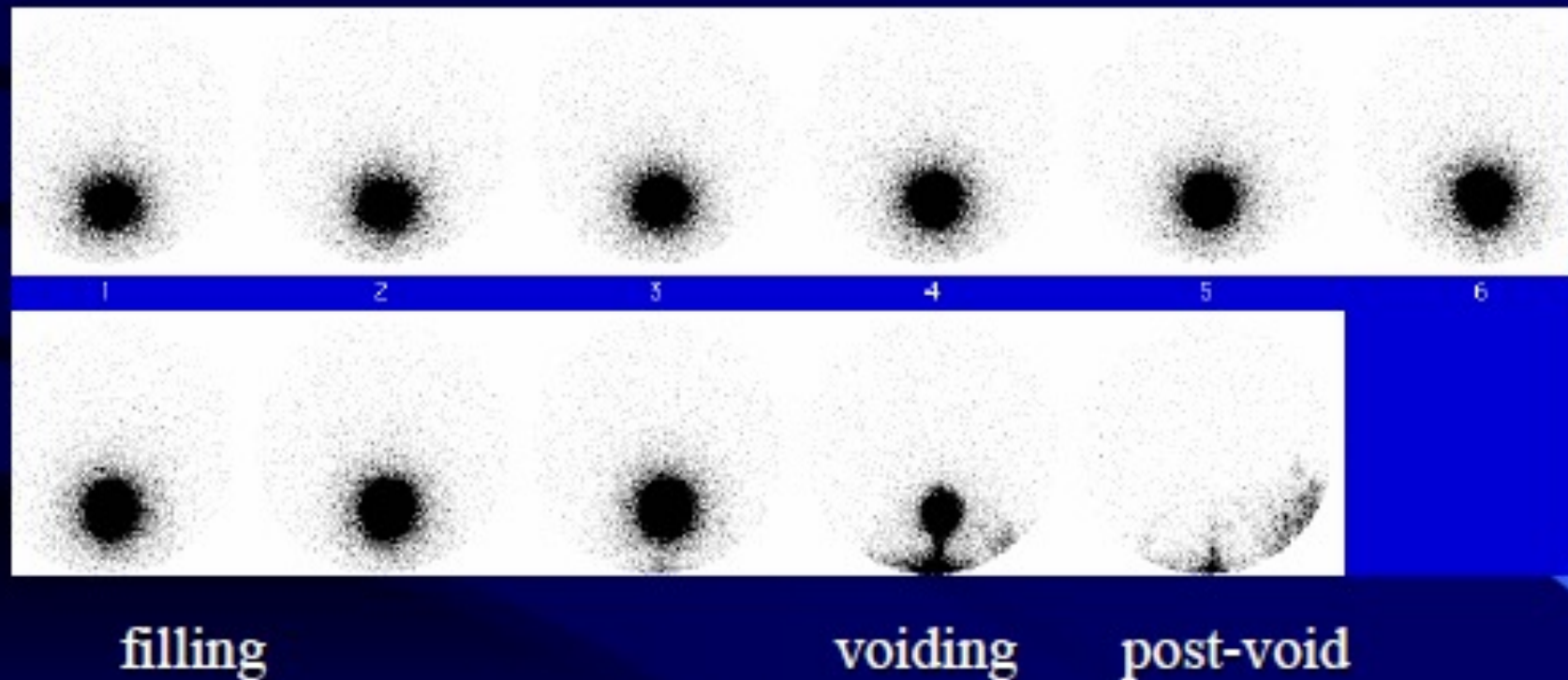
Advantages

- ❖ Lower radiation dose
(5 vs 300 mrad to ovary)
- ❖ Smaller amount of reflux detectable
- ❖ Quantitation of post-void residual volume

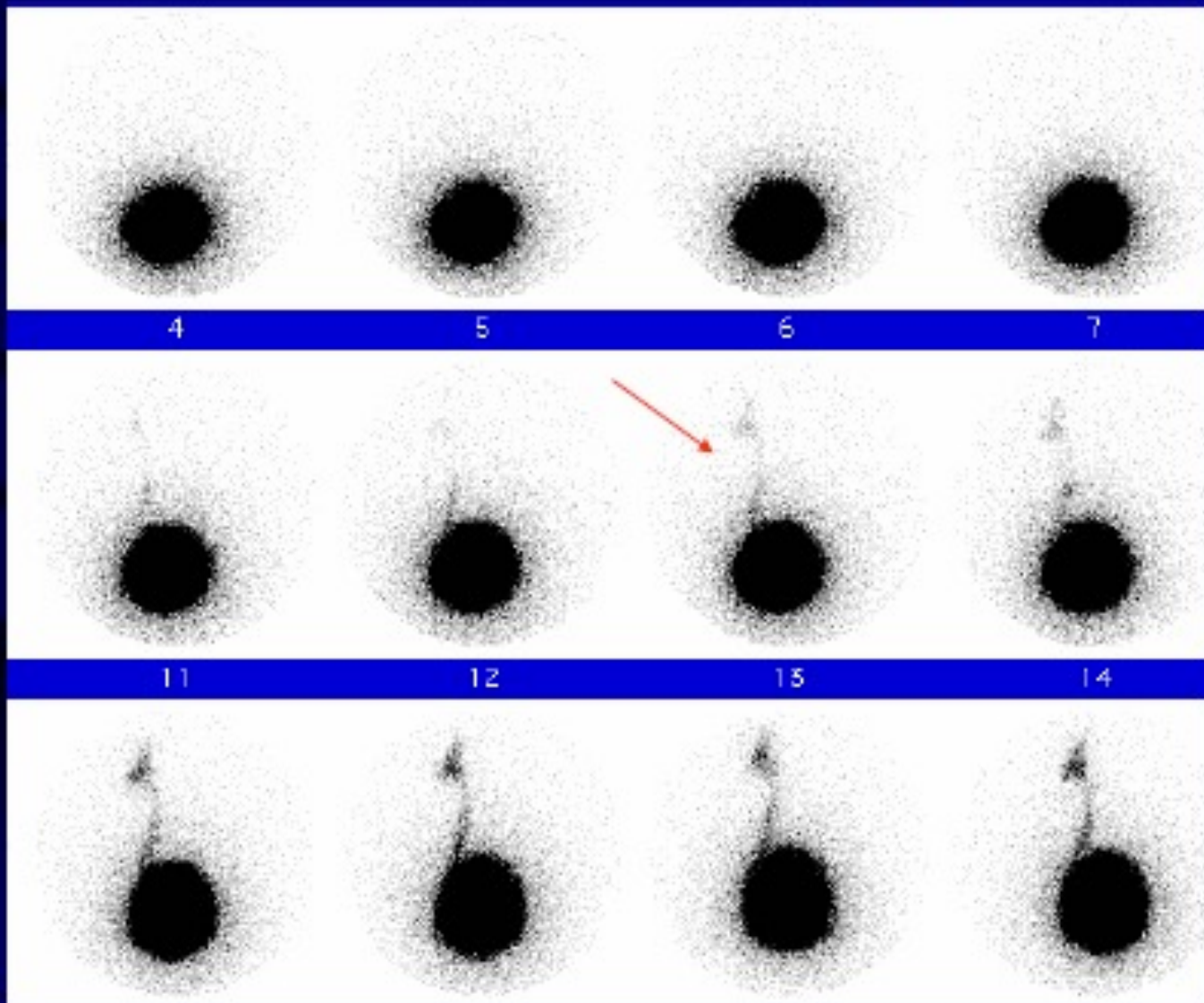
Disadvantages

- ❖ Cannot detect distal ureteral reflux
- ❖ No anatomic detail
- ❖ Grading difficult

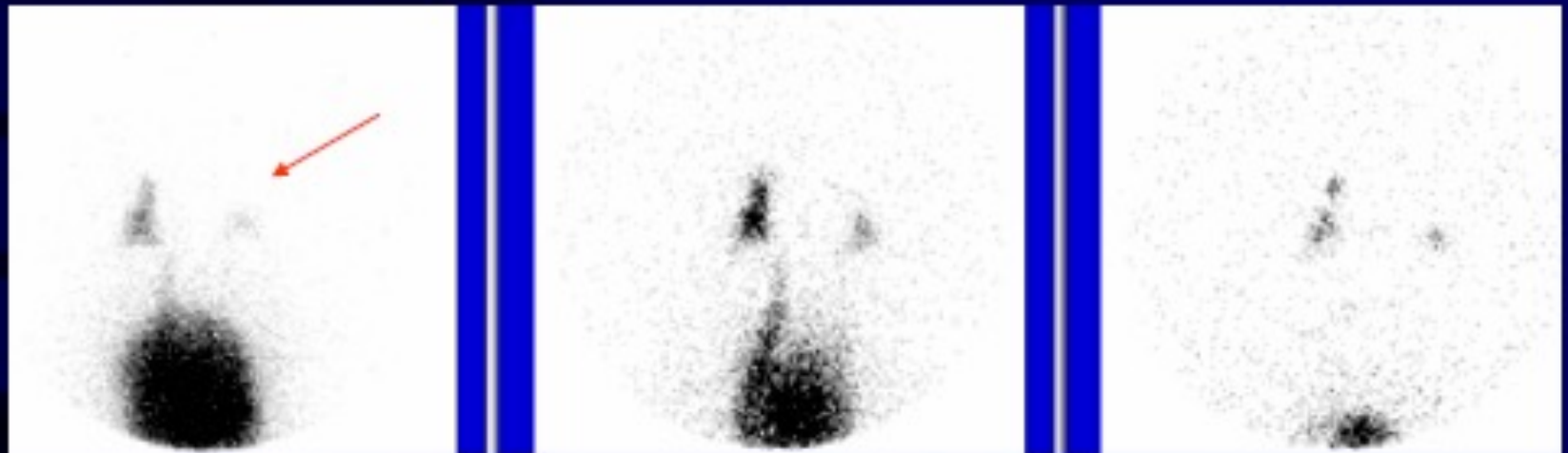
Normal cystogram



VUR - filling phase



VUR - voiding phase & post-void



B

II) RENAL TRANSPLANT EVALUATION

- Kidney for transplant from:
 - deceased donor(cadaveric)
 - living related donor
 - living unrelated donor
- 1 year allograft survival rates:
 - 90-94%-LR donor
 - 88-90%-cadaveric

- Use tripple tx:

- Glucocorticoid

- Calcineurin inhibitors + acrollimus / < often cyclosporin)

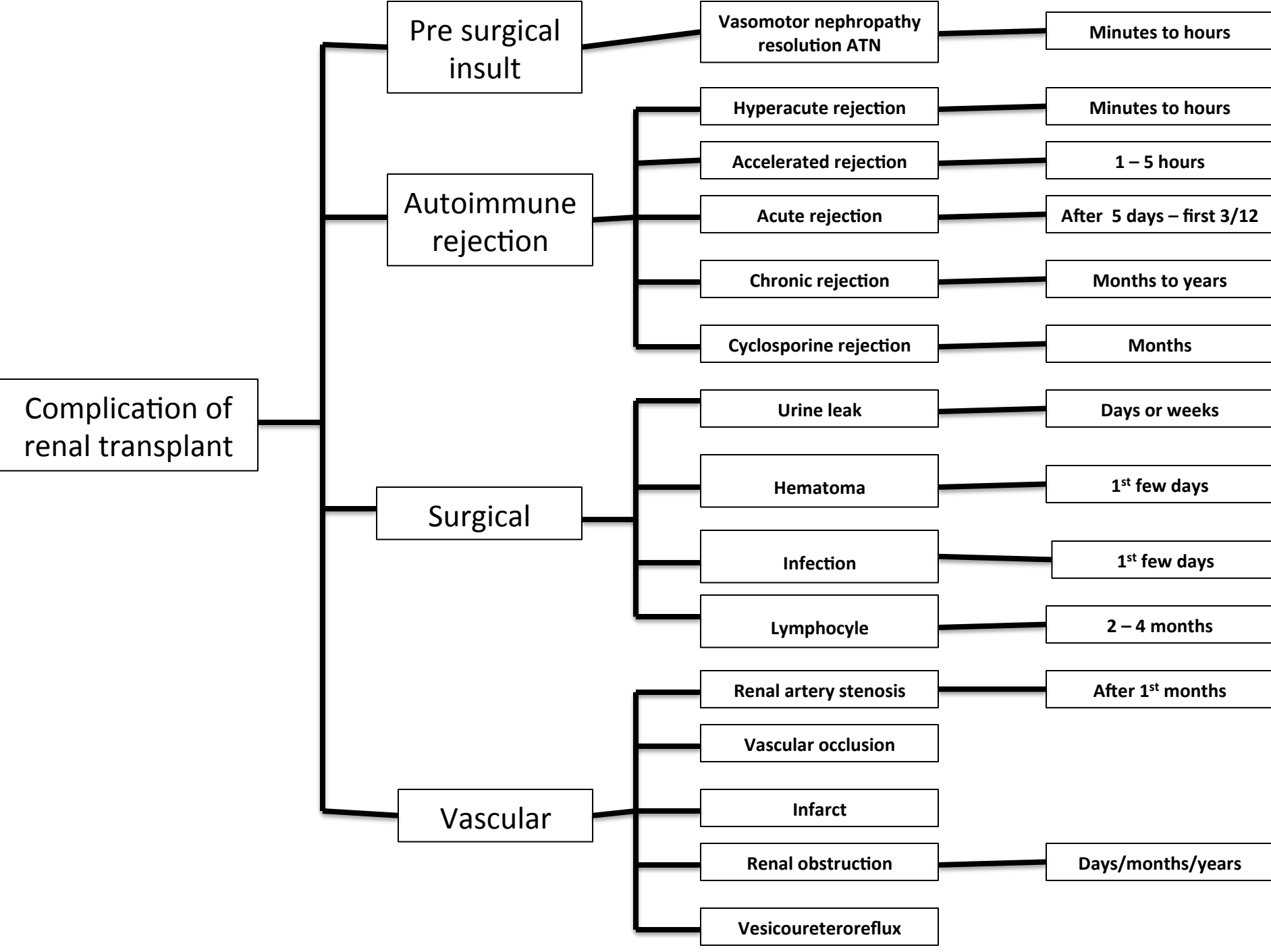
- antiproliferative agent (azathioprine) → - mitosis and suppress lymphocytes proliferation

- anti interleukin (IL)-2 monoclonal antibodies

COMPLICATION AFTER RENAL TX

Complication	Time of occurrence
MEDICAL	
Presurgical insult	
Vasomotor nephropathy(ATN)	Min-H
Autoimmune rejection	
Hyperacute rejection	Min-H
Accelerated rejection	1-5/7
Acute rejection	>5/7-3/12
Chronic rejection	Months-years
Cyclosporin toxicity	Months
SURGICAL	
Urine leak	Days/weeks
Hematoma	First few weeks
Infection	First few days
Lymphocele	2-4/12

Vascular	
RAS	After 1 st month
Vascular occlusion	
Infarct	
Renal obstruction(mass/calculi/stricture)	Days/months/years
VUR	



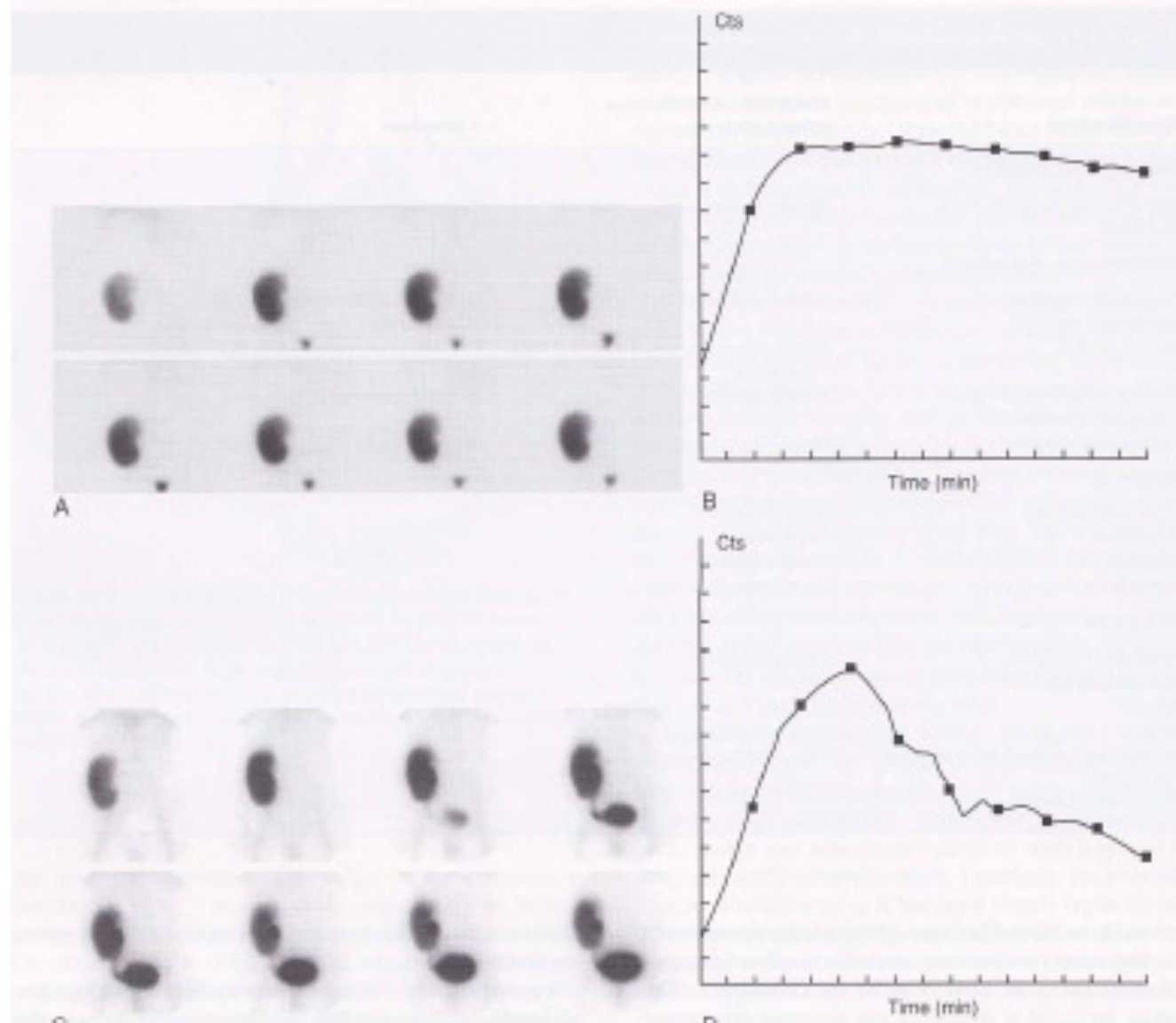
MEDICAL COMPLICATION

□ *Vasomotor nephropathy(ATN)*

- ischaemic response damaging the kidney at some point prior to completing treatment
- functional impact ranges from mild, rapidly resolving to a slower recovery/ total anuria (non oligouric ATN)
- most common in cadaveric transplant (50%), living donor (5 %)
- Renal failure will be impaired at the time of treatment & should recover spontaneously beginning after treatment & continue over 1-2 /52

⊙ *Vasomotor nephropathy (cont..)*

- Normal perfusion but poor function with delayed cortical clearance & reduce urine excretion.
- seen on baseline study in the 1st 24-48H following surgery
- severe cortical retention/ function that does not rapidly improve in serial study has strong negative prognostic implications
- usually resolves spontaneously over 1-3/52. If not ? New ischemic/nephrotoxic insult/acute rejection



Vasomotor nephropathy (ATN)

□ *Hyperacute rejection*

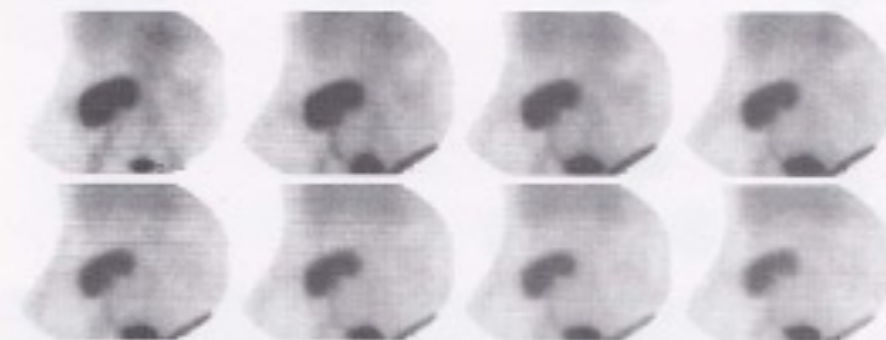
- careful HLA immunologic matching eliminates the problem

□ *Accelerated acute rejection*

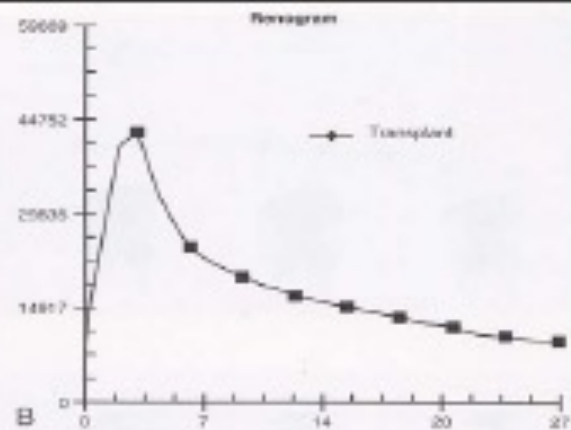
- uncommon but occurs in patient with antibodies already in the system, as in sensitization from pregnancy/ multiple blood transfusion
- rejection develops in the 1st 3-5 /7 following transplant but unlike hyperacute, it responds to treatment

□ *Acute rejection*

- relative frequent transplant complication
- not typically occur until at least 5-7/7 after transplant, most common in the 1st 3/12
- typically, patient becomes desensitize to the allograft over time
- rarely seen after 1 year in patient taking appropriate immunosuppressive treatment
- Caused by 2 immunologic pathways: T cell, humoral antibody,
- clinically, patient febrile, swollen and painful allograft
- lab: increase creatinine & ESR



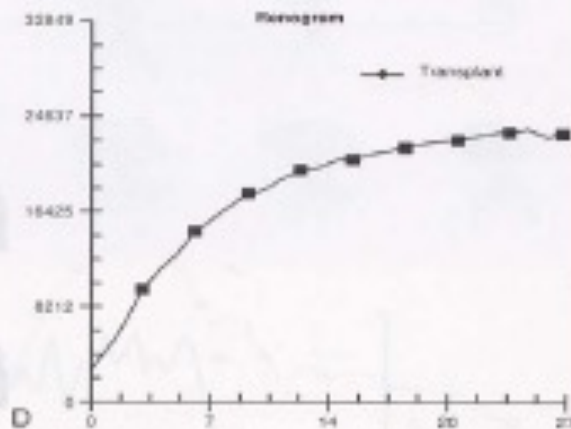
A



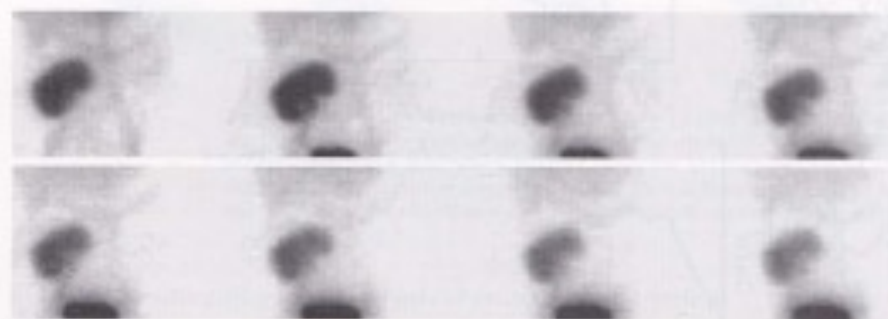
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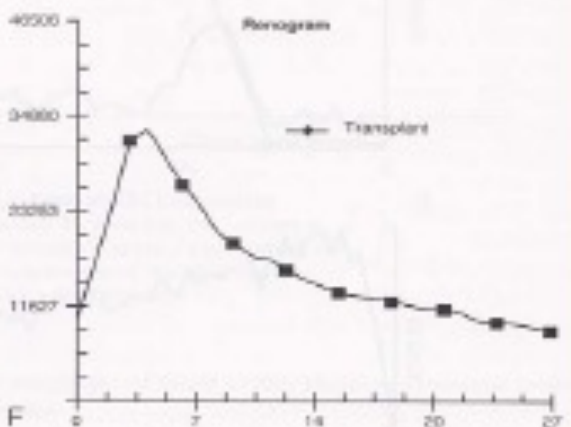
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D



E



F

Acute transplant rejection

	Baseline scan	Follow up scan	Perfusion	Renal Transit time
Acute rejection	Normal	Worsens	Reduced	Increased
ATN	Abnormal	Improves	Normal	Increased

□ *Chronic rejection*

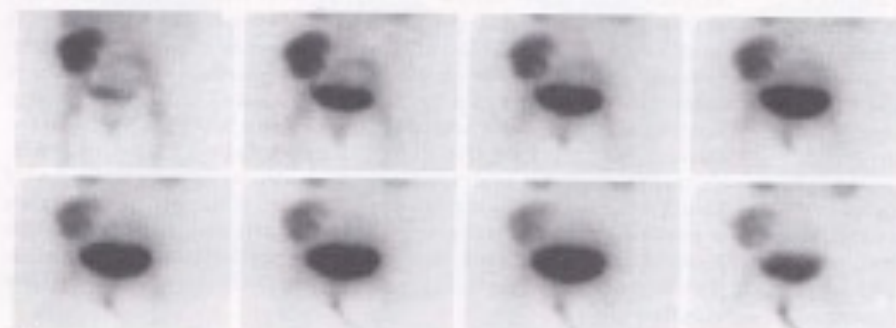
-cumulative, delayed & irreversible

-Etiology:

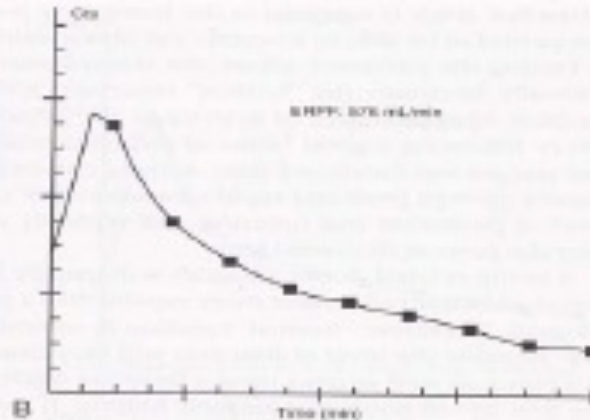
- 1)vascular constriction
- 2)chronic fibrosis
- 3)tubular atrophy
- 4)glomerulosclerosis from immunologic & non humoral etiology

- Over months -years, this fibrosis cause cortical loss & reduce function
- Dilatation of the collecting system may occur as the cortex thins
- Risk factor for early development:
 - i) damage from early ATN
 - ii) prior severe rejection
 - iii)subclinical rejection
 - iv) long term calcineurin inhibitor treatment

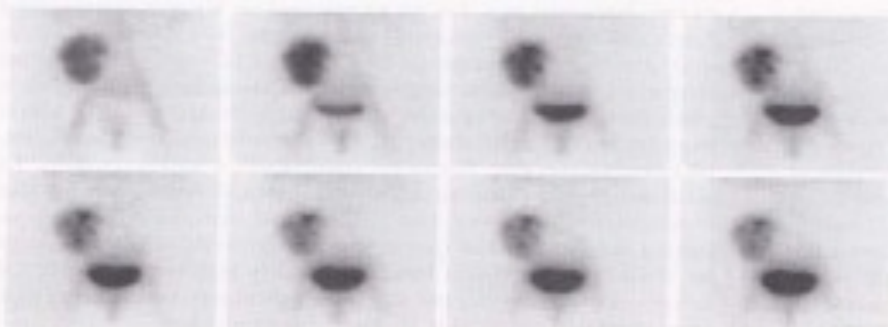
- *Immunosuppressive drug toxicity*
-cyclosporin



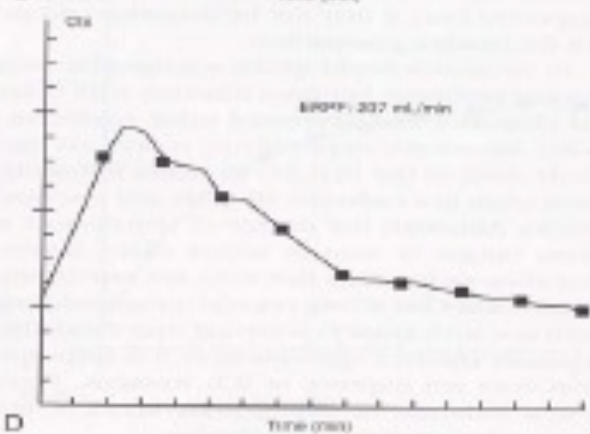
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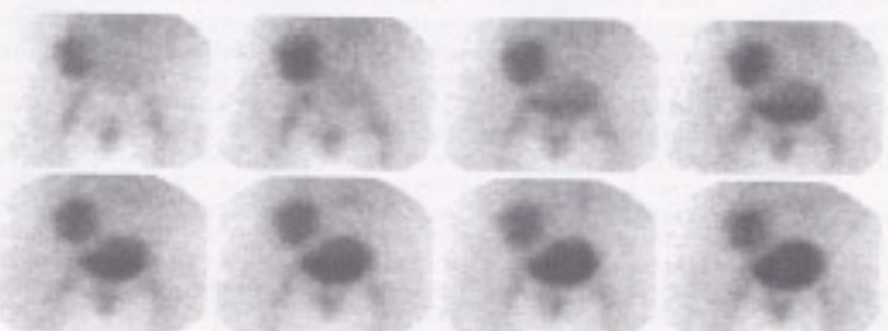
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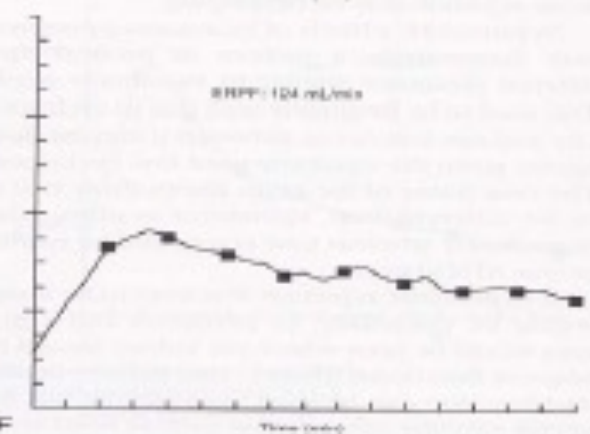
C



D



E



F

Figure Chronic renal allograft nephropathy

SURGICAL COMPLICATION

□ Vascular Occlusion

1)arterial thrombosis< 1 %(related to kinking/ difficulty performing the anastomosis with a short donor artery)

2)Renal Vein Thrombosis (RVT)

-seen in the native kidney as a complication of septicemia, dehydration & nephrotic syndrome

-manage medically & function may recover

-in transplanted kidney, RVT may occur as post op complication/ related to autoimmune problems

-thrombus lead to infarct & hemorrhage

-effect is severe with loss of allograft due to no venous collateral to drain the kidney

❑ *Arterial stenosis*

- should be suspected in patient who develop HPT following surgery
- may occur up to 10% of pt

❑ *Urinary leak*

- necrosis of the ureteral anastomosis in the immediate post operative period

❑ *Ureteral obstruction*

- causes: 1) kinking of ureter 2) extrinsic mass compression(hematoma/lymphocele) 3) intraluminal obstruction(blood/calculus) 4) periureteral fibrosis

-Hydronephrosis from obstruction must be differentiate from dilatation caused by reflux

□ *lymphoceles*

- transplanted kidney has no lymphatic connection
- so, lymphocele can form in the transplant bed
- May occur up to 10%
- -seen 2-3/12 post transplant

- *Nephrotoxic effects on immunosuppressive tx*

- demonstrate ~ ATN(prompt uptake & delayed clearance)

- To differentiate, ATN is seen immediately where as time is required for nephrotoxicity/true ATN to occur

1. Static radionuclide imaging of kidney

- A. Tc 99m DMSA is the radionuclide of choice
- B. Tc 99m DMSA is the best for imaging pseudotumor of kidney
- C. DMSA can measure relative tubular mass
- D. DMSA can detect of areas of renal ischemia
- E. Optimum time for DMSA scanning is one week after onset of symptoms in infection

1. Static radionuclide imaging of kidney

- TTFFF

2. MAG 3 scintigraphy

- A. Best method for assessment of scarring in children
- B. Prolonged transit time in dilated system
- C. Reliable for diagnosis of obstruction in renal failure
- D. Prolonged parenchymal transit time in renal artery stenosis
- E. Patients are dehydrated before study

2. MAG 3 scintigraphy

- FTFTF

3. Renal scintigraphy

- A. For captopril test, ACE inhibitors should be withheld on the day of the test
- B. MAG 3 is used for assessing renal scarring
- C. DMSA is superior to MAG 3 for both dynamic and structural assessment
- D. Radiation is lower for MAG 3
- E. 100% of MAG 3 is excreted by tubular secretion

3. Renal scintigraphy

- FTFTF

4. Renal scintigraphy

- A. DMSA images are acquired within one hour of injection to avoid artifacts
- B. DTPA is isotope of choice for dynamic renal scans
- C. Kidney/background ratio is better for MAG 3 than DTPA
- D. ^{123}I can be produced only by cyclotron
- E. Hippuran is completely cleared by glomerular filtration

4. Renal scintigraphy

- FFTTF

5. Renal scintigraphy

- A. The glomerular filtration rate of DTPA is 500 ml/min
- B. DTPA is completely cleared by tubular filtration
- C. The maximum diuresis occurs within 2 minutes of diuretic administration
- D. Images are acquired between 5-10 minutes for perfusion in transplants
- E. Post void film is indicated in cases of stasis

5. Renal scintigraphy

- FFFFT

6. Static renal scans are indicated in the following instances

- A. Horseshoe kidney
- B. Renal agenesis
- C. Column of bertin
- D. Individual renal function
- E. UTIs

6. Static renal scans are indicated in the following instances

- TTTT

7. Recognised indication of dynamic nuclear scanning

- A. Hypertension
- B. Renal transplantation
- C. Renal trauma
- D. Reflux
- E. Tumor

7. Recognised indication of dynamic nuclear scanning

- TTTTF

9. Abnormal bone uptake in kidney

- A. Radiation
- B. Chemotherapy
- C. Papillary necrosis
- D. Multiple myeloma
- E. Amyloidosis

9. Abnormal bone uptake in kidney

- TTFTF

10. In urinary tract obstruction

- A. A DMSA scan always estimates renal function more accurately than DTPA scan
- B. Even if a kidney contributes less than 10% to the total GFR, it's function will usually improve if the obstruction is relieved
- C. Failure of the collecting systems to empty on standing confirms the presence of obstruction
- D. Lower urinary tract obstruction may be missed on a DTPA study
- E. Giving furosemide during a DTPA study results in a greater specificity for diagnosing PUJ obstruction than giving it at the start of the study

10. In urinary tract obstruction

- FFFFTF

11. Concerning radionuclide studies

- A. DMSA gives an accurate assessment of overall renal function in renal tubular acidosis
- B. DTPA studies can reliably exclude obstruction in dehydrated patient
- C. A tissue injection can give a false positive result for obstruction
- D. An aortic aneurysm can be excluded if a dilated aorta is not seen on the blood flow renogram images
- E. Visualization of a ureter on a renogram is abnormal

11. Concerning radionuclide studies

- FFTFF

12. Concerning radionuclide studies in acute renal failure

- A. ATN typically can be distinguished from other causes of acute renal failure
- B. On a DTPA study in pre renal failure, there is impaired renal blood flow, poor uptake, delayed intrarenal transit and little or no excretion
- C. A rising T/A curve on DTPA study confirms obstruction
- D. In ATN , a horizontal third phase to the T/A curve in a DTPA study indicates that recovery is occurring
- E. MAG 3 is agent of choice

12. Concerning radionuclide studies in acute renal failure

- TFFTT

13. Concerning renogram and renal transplants

- A. On a DTPA scan, rejection can be distinguished from cyclosporine A toxicity
- B. Arterial thrombosis can be distinguished from venous occlusion
- C. A high perfusion index means that there is a good blood supply to the transplant
- D. Arterial occlusion can be detected on a DTPA study even if an earlier one has shown ATN from which the patient has not yet recovered
- E. Vesicoureteric reflux is the commonest cause of pelviureteric dilatation
- F. A urinary leak can be excluded if it is not shown in early images

13. Concerning renogram and renal transplants

- FFFTTF

14. Concerning MAG 3

- A. A kit reconstituted first thing in the morning remains usable until the ^{99m}Tc decays
- B. MAG 3 has a smaller volume of distribution than DTPA
- C. Liver and biliary activity may be seen
- D. MAG 3 measures GFR more accurately than DTPA
- E. The radiation dose from a MAG 3 study is less than from DTPA

14. Concerning MAG 3

- FTTF

15. In renal tract infections

- A. In acute pyelonephritis, there may be area of decreased perfusion on the flow study
- B. In a patient with UTI, a small smooth kidney is unlikely to be due to chronic pyelonephritis alone
- C. The overall sensitivity of DMSA is increased by SPECT
- D. A recognised feature of established scars is that they become more prominent with time
- E. Renal parenchymal involvement can be predicted from clinical and lab parameters
- F. Most acute parenchymal defects develop into cortical scars

15. In renal tract infections

- TFFTFF

16. Concerning vesicoureteric reflux

- A. In patients who reflux, 20% reflux only during micturition
- B. Reflux seen on direct scintigraphy cystography correlates closely with the results of an MCUG
- C. Any reflux is a risk factor for pyelonephritis
- D. Renal scarring occurring after an episode of acute pyelonephritis is independent of continued reflux
- E. A recognised appearance on a DMSA scan of a kidney damaged by infection is a normal size kidney with reduced function
- F. Reflux occurring after the age of 3 yrs in patients with normal DMSA scans is probably irrelevant
- G. A 1 yr old with their first proven UTI and hydronephrosis on US should have a DMSA and an MCUG

16. Concerning vesicoureteric reflux

- TFFFTTF

17. In ACE I renography

- A. With longstanding total occlusion of the renal artery, there can be no uptake in the affected kidney
- B. Branch arterial stenosis can be detected
- C. In a patient with solitary kidney, ACE I renography may result in acute renal failure
- D. Furosemide is recommended at the start of the test to improve specificity
- E. In a MAG 3 study, a continually rising curve indicates a haemodynamically significant stenosis

17. In ACE I renography

- FTTTT

18. Renal radionuclide imaging

- A. Can distinguish between renal contusion and infarction
- B. Can detect radiation nephritis 3 wks after treatment
- C. Can detect central cysts more easily than peripheral ones
- D. A phantom kidney may be seen after nephrectomy
- E. A phantom kidney, if due to mesenteric vessels more commonly occurs on the right

18. Renal radionuclide imaging

- TTFTF

19. The following are causes of a flattened DTPA curve

- A. Hypovolaemia
- B. Hypoplastic kidney
- C. Recent contrast angiogram
- D. After extracorporeal shock wave lithotripsy
- E. Severe cyclosporine toxicity

19. The following are causes of a flattened DTPA curve

- TTTT

20. In DTPA renal scan

- A. The examination is contraindicated in renal failure
- B. Fluid restriction is mandatory
- C. Vascular phase is acquired immediately after injection
- D. The acquisition is performed with patient facing the camera
- E. Calculation of GFR takes the background into consideration

20. In DTPA renal scan

- TFTFT

What percentage of renal plasma flow is filtered through the glomerulus and what percentage is secreted by the tubules

What percentage of renal plasma flow is filtered through the glomerulus and what percentage is secreted by the tubules

- 20% of renal plasma flow is cleared by glomerular filtration.
- 80% by tubular secretion.

Which radiopharmaceuticals are most often used clinically for measurement of GFR and ERPF?

Which radiopharmaceuticals are most often used clinically for measurement of GFR and ERPF?

- GFR : Tc-99m DTPA
- ERPF : I-131 OIH (iodohippurate) or Tc-99m MAG3
- However Tc-99m MAG3 does not actually measure ERPF and a correction factor based on proportional clearance compared with I-131 OIH must be applied.

What is the percentage of cortical binding of Tc-99m DMSA and Tc-99mGH?

What is the percentage of cortical binding of Tc-99m DMSA and Tc-99mGH?

- Tc-99m DMSA :40-50%
- Tc-99m GH : 10-20%

What is Webster's rule?

What is Webster's rule?

- Pediatric radiopharmaceutical doses can be estimated using the formula $(\text{age} + 1)/(\text{age} + 7) \times \text{adult dose}$.

The time to peak activity of a renal time activity curve (TAC) represents:

- A. The end of extraction
- B. The beginning of renal clearance
- C. The time point at which the amount of cortical uptake of the radiopharmaceutical is equal to clearance

The time to peak activity of a renal time activity curve (TAC) represents:

- FFT

What are the general method for calculating absolute GFR?

What are the general method for calculating absolute GFR?

- Blood sampling, blood sampling and urine collection and camera based methods.

At what step in the renin-angiotensin-aldosterone cascade does captopril work?

At what step in the renin-angiotensin-aldosterone cascade does captopril work?

- Captopril blocks the conversion of angiotensin I to angiotensin II in the lung.

Which of these factors effects the accuracy of diuresis renography?

- A. State of hydration
- B. Renal function
- C. Dose of diuresis
- D. Radiopharmaceutical
- E. Bladder capacity

Which of these factors effects the accuracy of diuresis renography?

- TTTT

What is the most sensitive technique for diagnosing scarring secondary to reflux?

What is the most sensitive technique for diagnosing scarring secondary to reflux?

- Tc-99m DMSA

How can radionuclide imaging
differentiate upper from lower UTI?

How can radionuclide imaging differentiate upper from lower UTI?

- Upper UTI or pyelonephritis , Tc-99m DMSA shows tubular dysfunction, manifested by decreased uptake.
- This is a reversible process.
- With appropriate therapy, tubular will return in 3 – 6 months.
- Upper UTI has prognostic implication because it may lead to subsequent renal scarring, HPT and renal failure.

What is meant by direct vs indirect cystography and which is the preferred method in detecting VUR?

What is meant by direct vs indirect cystography and which is the preferred method in detecting VUR??

- Direct cystography is sensitive, requiring urinary tract catheterization and infusion of radiotracer into the bladder. Reflux can be detected during bladder filling and voiding.
- Indirect method, where a routine renogram is initially performed, cannot be used to detect reflux during the bladder filling stage because radiotracer is flowing through the collecting system antegrade.

What is the common development abnormality leading testicular torsion?

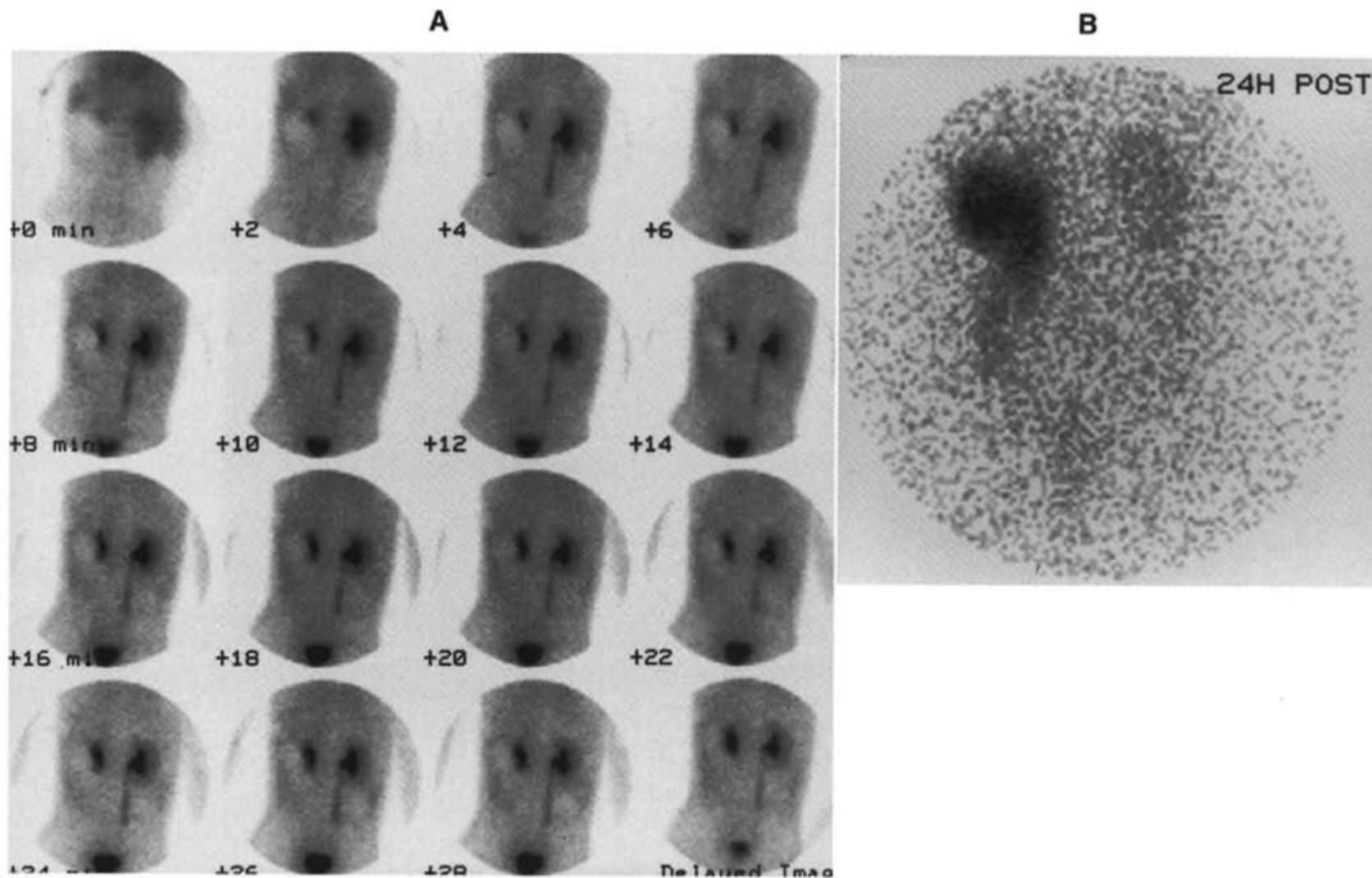
What is the common development abnormality leading testicular torsion?

- The bell-clapper testis

What is the difference in blood supply to the testis and scrotum?

What is the difference in blood supply to the testis and scrotum?

- The testes receive the blood from testicular artery.
- Scrotum receives supply from the pudendal vessels.

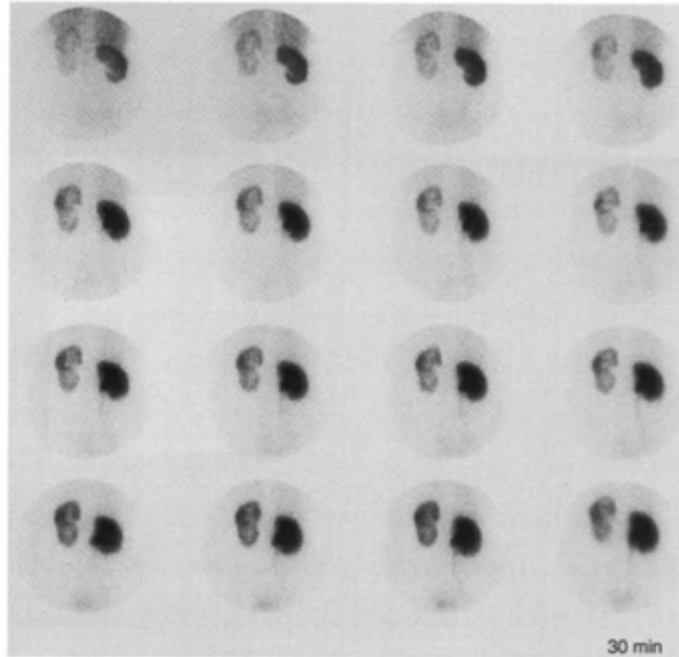


A 55-year-old woman with a history of renal stones is evaluated for recent onset of flank pain. ^{99m}Tc DTPA 30-minute dynamic radionuclide renogram (A) and 24-hour delayed image (B) are shown.

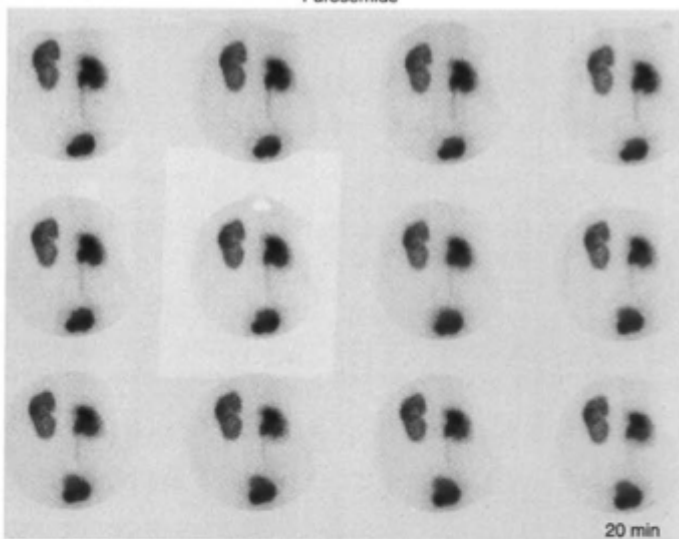
1. What are the scintigraphic findings?
2. Explain the changing imaging findings.
3. What is the diagnosis?
4. What is the likely cause?

Urinoma

1. A photopenic region, best seen on early images, involves most of the left renal fossa. Only the upper pole is functioning. Urinary clearance into the left renal pelvis appears displaced medially by the photopenic defect. The right pelvic and upper 2/3 of the ureter fill. Poor clearance bilaterally. Delayed images show increased uptake in the region of the initial cold defect and inferior to it.
2. The cold defect is a urinoma with an attenuating mass effect. Over time the radioactive urine enters this space and mixed with the nonradioactive urinoma. Activity in the region of the urinoma increases over time while the earlier seen kidney and background activity have cleared.
3. Activity urinary leak and urinoma.
4. Urinary tract obstruction.



Furosemide

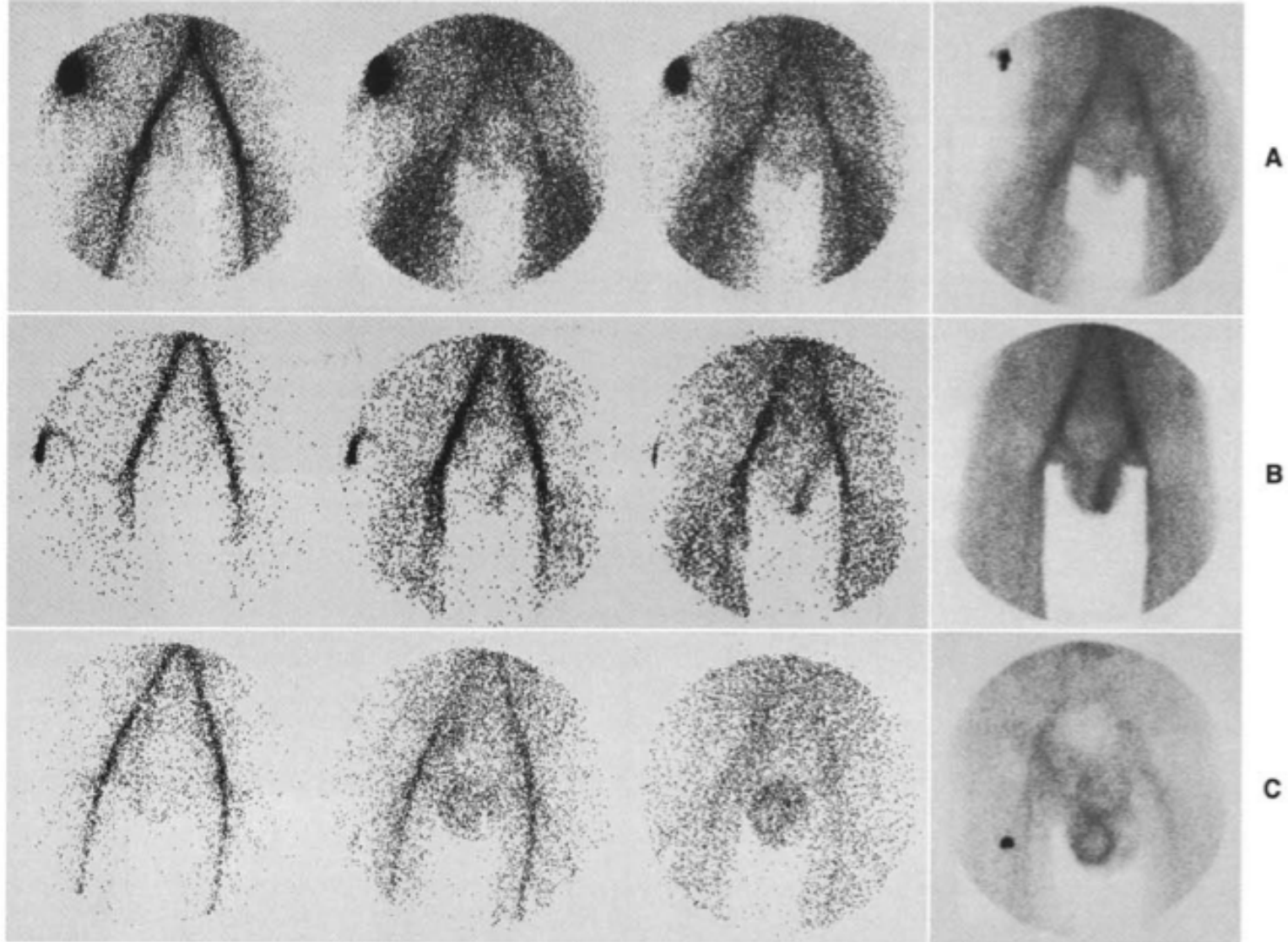


A 51-year-old woman with metastatic cervical cancer and new hydronephrosis on CT.

1. Describe the scintigraphic findings.
2. What is the diagnosis before and after the administration of diuretic (furosemide)?
3. What imaging finding should you see before administering furosemide?
4. How do you calculate differential renal function?

Bilateral obstruction

1. Left kidney; delayed and decreased cortical uptake, no clearance into the calyces or pelvis. Right kidney; prompt uptake and clearance into the collecting symptom, faint persistent visualization of the right ureter and, poor response to furosemide.
2. Before furosemide; high grade obstruction on the left and HN on the right, suspicious of obstruction. A furosemide high grade obstruction on the left and obstruction on the right.
3. Filling of the renal collecting system.
4. Percent radiopharmaceutical uptake by each kidney divided by total renal uptake between 1 and 3 minutes (before clearance into the pelvicalycial system)

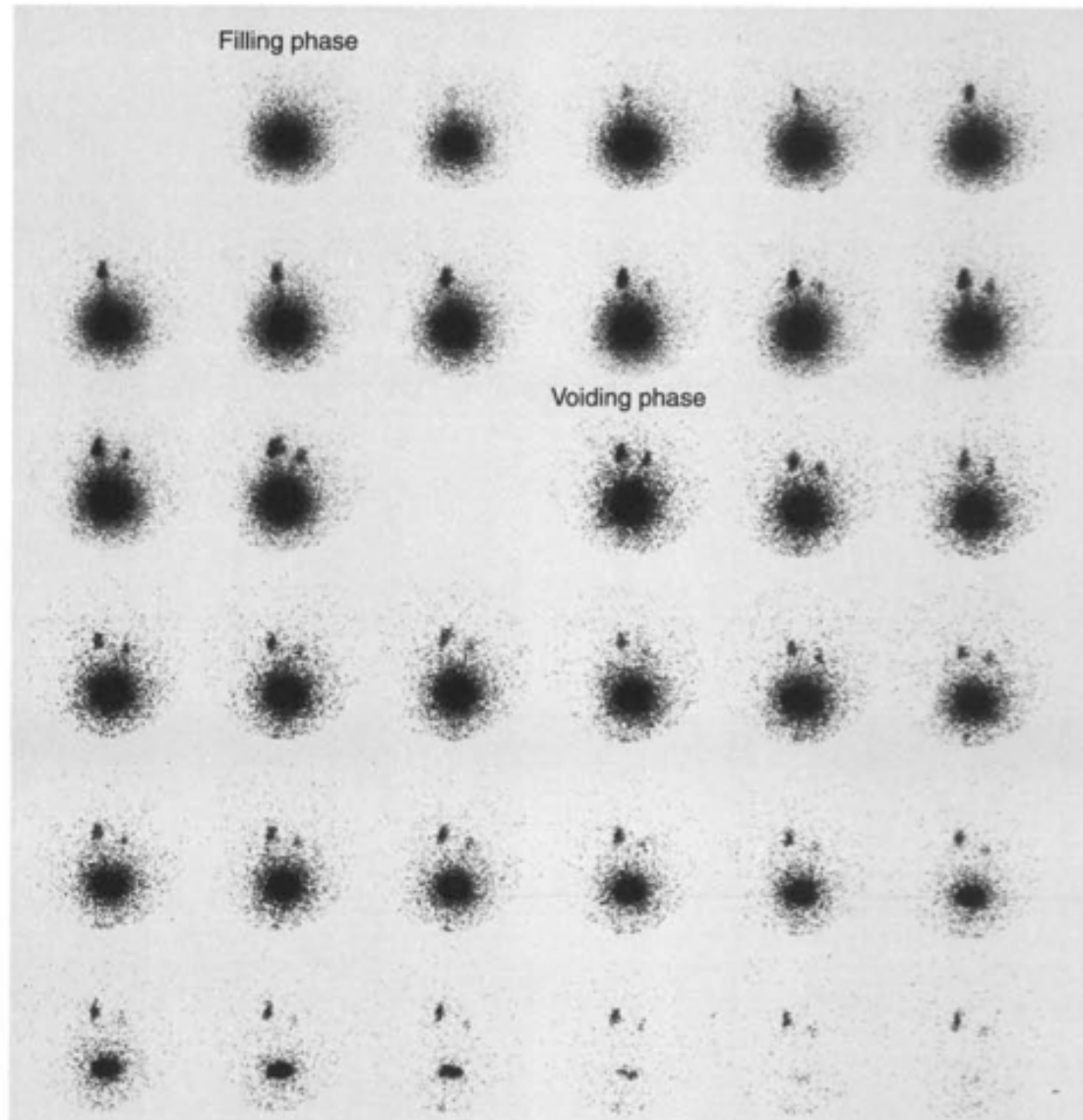


Three patients (*A*, *B*, and *C*) present with acute scrotal pain. All had testicular scans with blood flow (*left*) and post-flow static images (*right*).

1. What are the scintigraphic findings in each case?
2. What is the most likely diagnosis in each patient?
3. What is the pathophysiological condition for patients *A*, *B*, and *C*?
4. What is the incidence of the most frequent final diagnoses in patients referred for acute scrotal pain?

Torsion of testicular appendage

1. A, Mildly increased flow and mild focal left upper scrotal uptake on the static image. B, Increased flow and increased distribution on the left hemiscrotum. C, Increased flow and delayed halo sign of the right hemiscrotum.
2. A, Torsion of a testicular appendage. B, Acute epididymitis/orchitis. D, Delayed testicular torsion.
3. A, Loss of blood supply to the appendage of the testicle. B, Infection, viral or bacterial. C, Infarction of the testicle caused by torsion more than 24 hours duration.
4. Testicular torsion, 35%; torsion of the appendix testis, 35%; acute epididymitis, 25%.

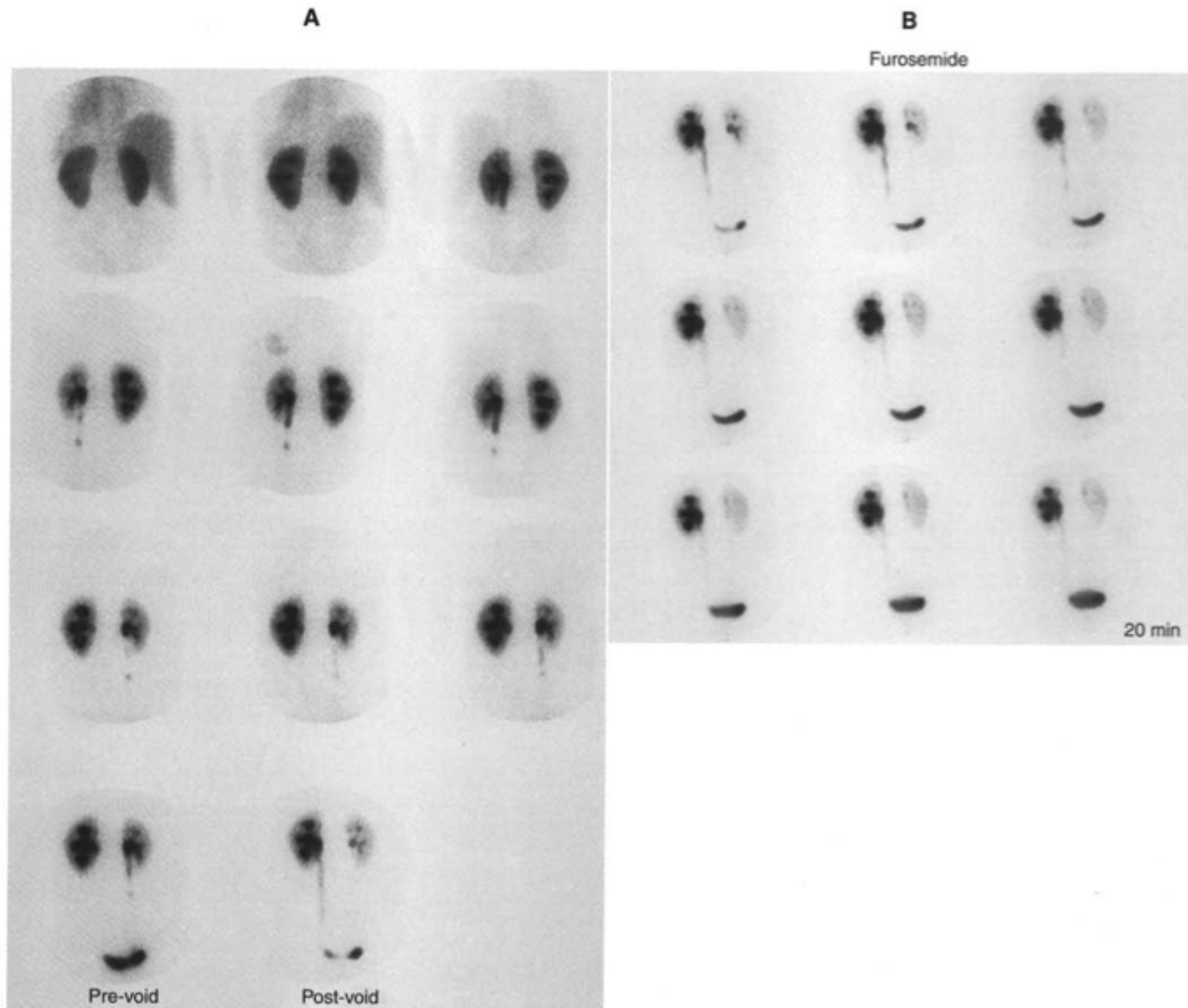


A 5-year-old girl has had two urinary tract infections in the past 6 months.

1. Which radiopharmaceuticals commonly are used for cystography?
2. What is the advantage of radionuclide cystography over the contrast study?
3. What is the difference between indirect and direct radionuclide cystography?
4. How is reflux graded with radionuclide cystography?

Radionuclide cystography

1. Tc-99m DTPA and Tc-99m SC
2. Radionuclide cystography is more sensitive in detection of VUR and results in 50 to 200 times less radiation exposure to gonads compared with the contrast study.
3. The direct method is commonly used and requires urinary catheterization and installation of radiotracer into the bladder through catheter. The indirect method is performed after routine DTPA/MAG3. when the bladder is full, a prevoiding image is obtained, followed by dynamic images during and after voiding.
4. Grading criteria are similar to those used with contrast cystography, however the radionuclide study's limited resolution does not permit assessment of calyceal morphology. Mild reflux; confined to the ureter. Moderate; reaches the pelvicalyceal system. Severe; distorted collecting system and dilated tortuous ureter.

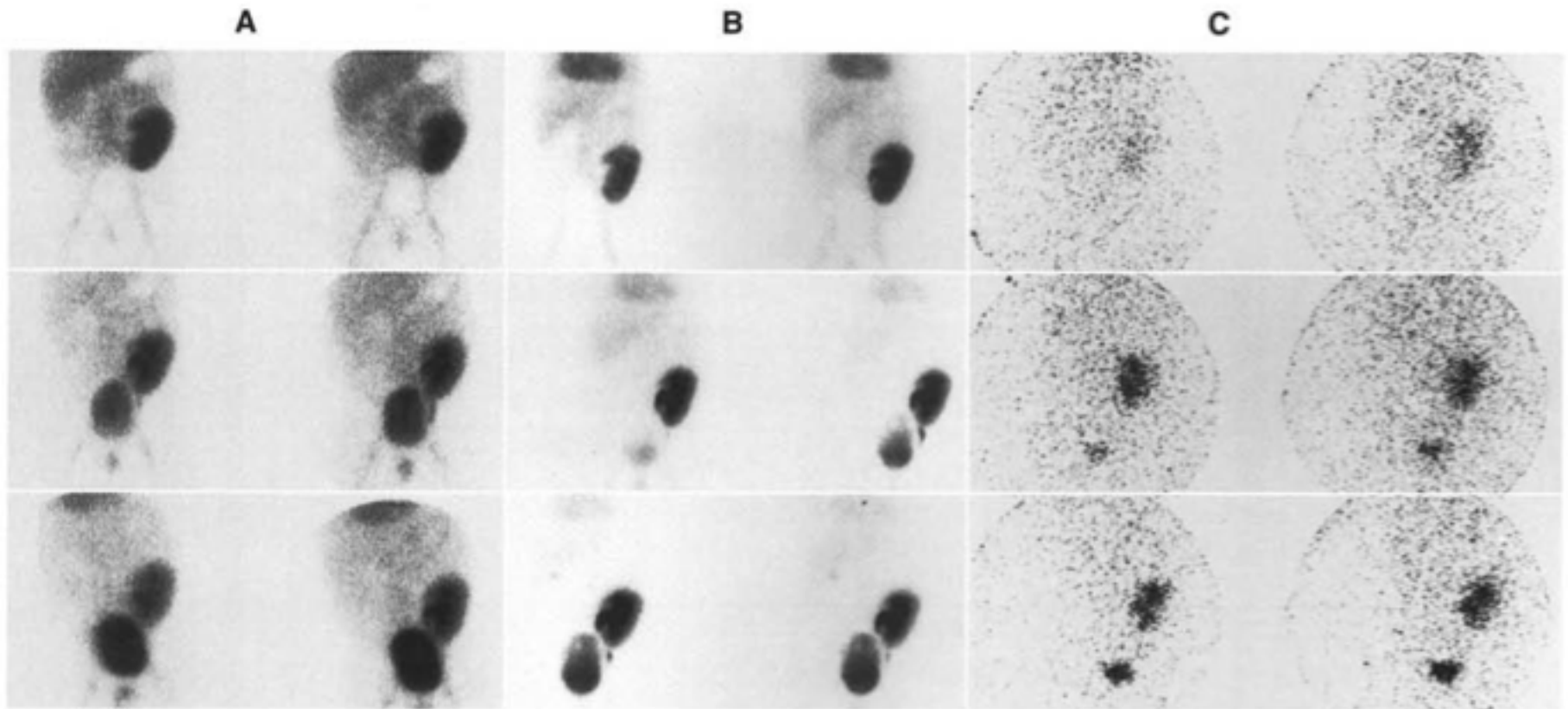


A 45-year-old woman with cervical carcinoma has new bilateral hydronephrosis demonstrated on CT scanning.

1. Describe the scintigraphic findings before and after furosemide administration.
2. Interpret the study before laser administration.
3. Interpret the study after laser administration.
4. List some limitations of diuretic renography.

Unilateral obstruction

1. Good symmetrical cortical uptake and prompt excretion into collecting systems bilaterally. Retention of activity in left renal collecting system, apparent cutoff in the upper ureter and very poor response of furosemide. The right side shows a prominent collecting system but washes out spontaneously before furosemide.
2. HN of the left kidney. TRO obstruction.
3. Consistent with significant obstruction of the left kidney.
4. Dehydration, renal insufficiency, inadequate diuretic dose, full bladder and large collecting system.

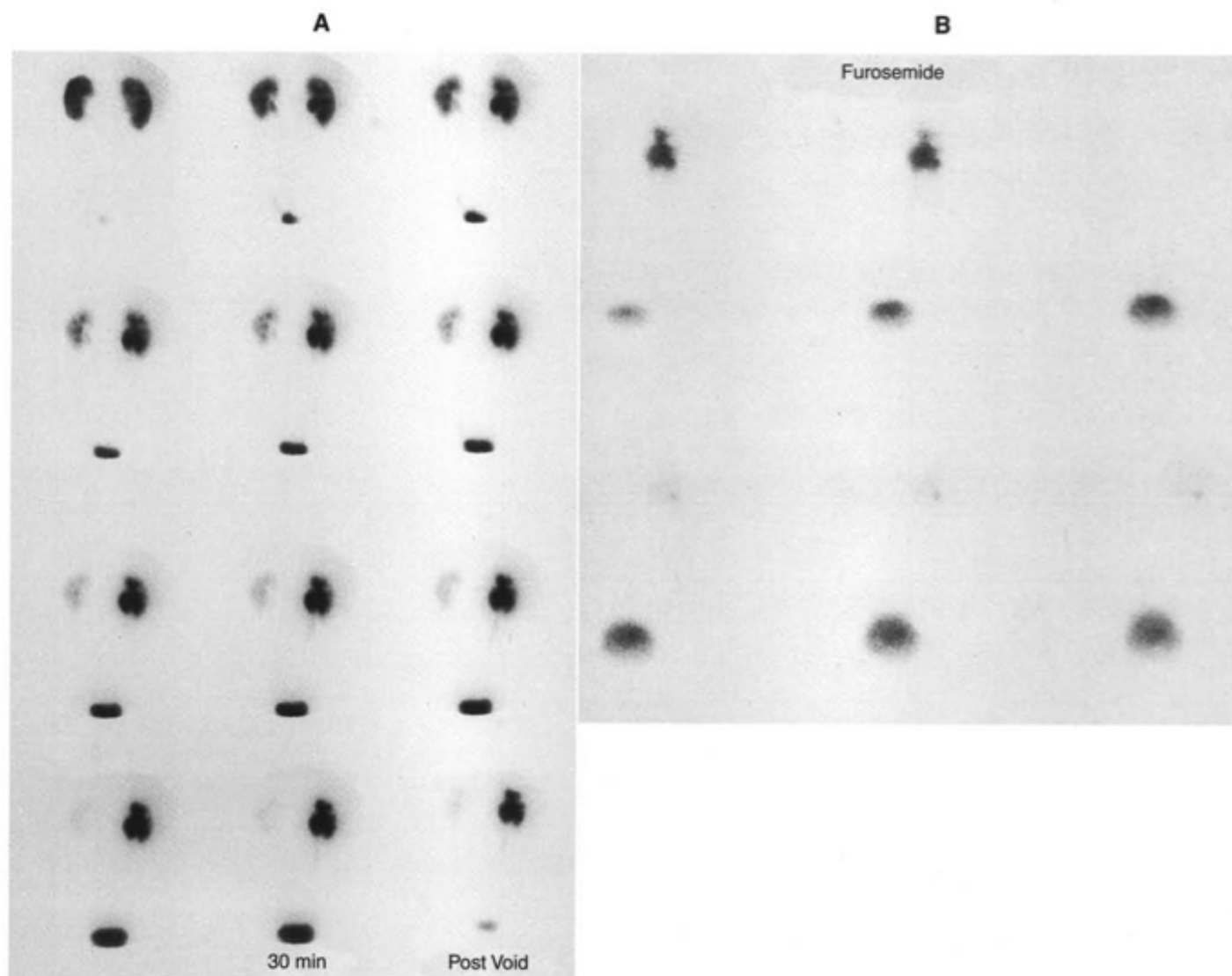


A 35-year-old renal transplant patient has three renal studies (sequential images over 30 minutes) using ^{99m}Tc DTPA on one day and ^{99m}Tc MAG3 and ^{131}I hippuran 1 week later.

1. Which renal radiopharmaceutical is used for each study: *A*, *B*, and *C*?
2. What is the mechanism of uptake of the three radiopharmaceuticals?
3. What are the advantages and disadvantages of each radiopharmaceutical?
4. Can a blood flow (radionuclide angiogram) study be done with all three agents? Why?

Renal scan

1. Tc-99m DTPA, Tc-99m MAG3 and I-131 hippuran.
2. DTPA; glomerular filtration, MAG3; tubular secretion and hippuran; 20% glomerular and 80% tubular.
3. DTPA is inexpensive, provides a good image quality but has low extraction efficiency (10-20%) and poor poor quality images with renal insufficiency. MAG 3 has a high extraction rate (60%), good target to background and good quality images with renal insufficiency. Hippuran has good extraction efficiency, high target to background, poor image quality, poor cortical/collecting system differentiation and delivers a high radiation dose in renal insufficiency.
4. No . A dose of 5 mCi is needed for good blood flow images.

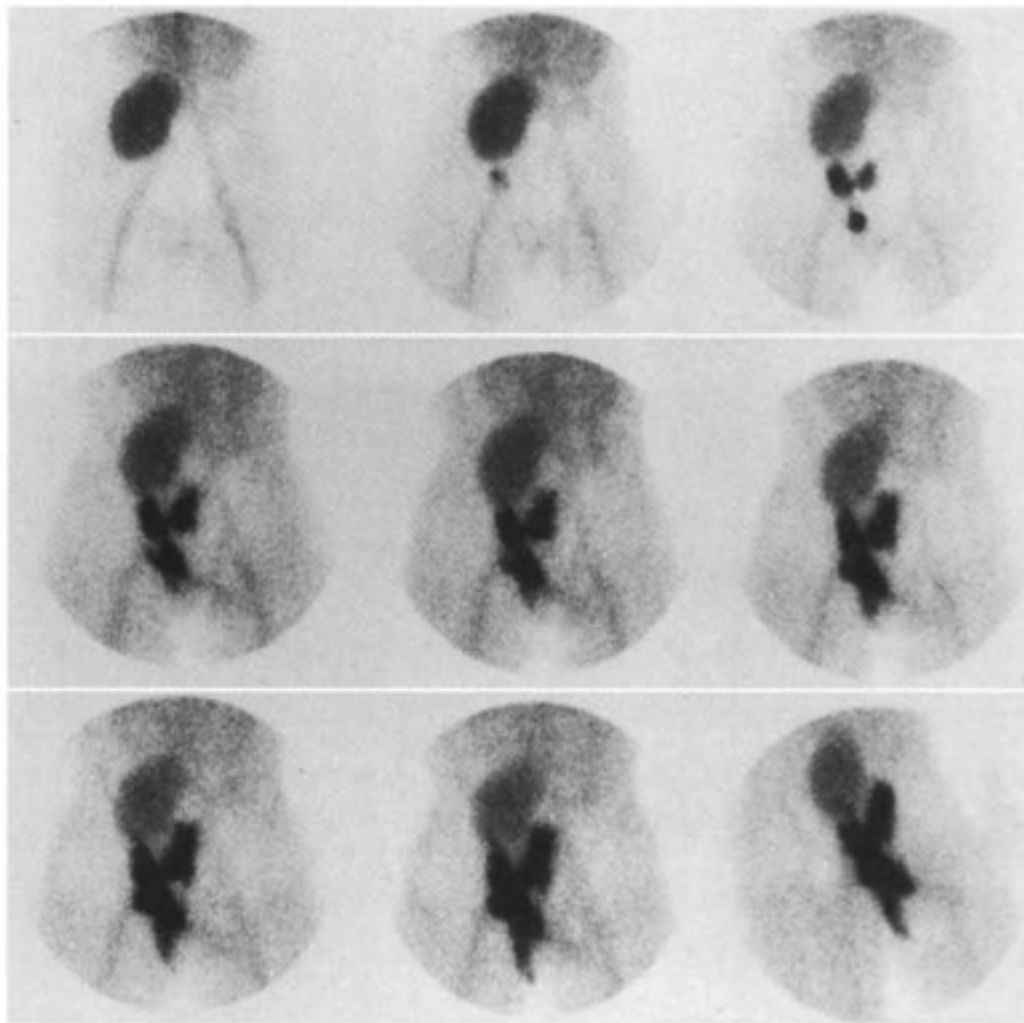


A 31-year-old man with a history of congenital ureteropelvic junction obstruction had surgical correction several years ago. The most recent diuretic renogram was interpreted as right renal obstruction. This scan was obtained after the second surgical correction.

1. Describe the scintigraphic imaging findings before and after administration of furosemide.
2. What is your interpretation of the study?
3. Can ureteropelvic vs. ureterovesical obstruction be distinguished from this study?
4. What is the Whittaker test?

Diuretic renography

1. Bilateral cortical uptake and excretion into collecting systems. Retention in the right collecting system at 30 minutes with good post furosemide washout.
2. Good response to surgical correction with no obstruction.
3. Not with certainty. Ureteral nonvisualization is not diagnostic of ureteropelvic junction obstruction because a standing column of ureteral urine can prevent radiotracer entry.
4. It measures pressure flow relationships and requires fluoroscopically guided trocar or spinal needle insertion into the renal pelvis. Basal and pressure measurements during infusion of a contrast solution at a rate are recorded. Obstruction pressure is defined as greater than 15cm water, no obstruction as less than 10 to 12 cm water.

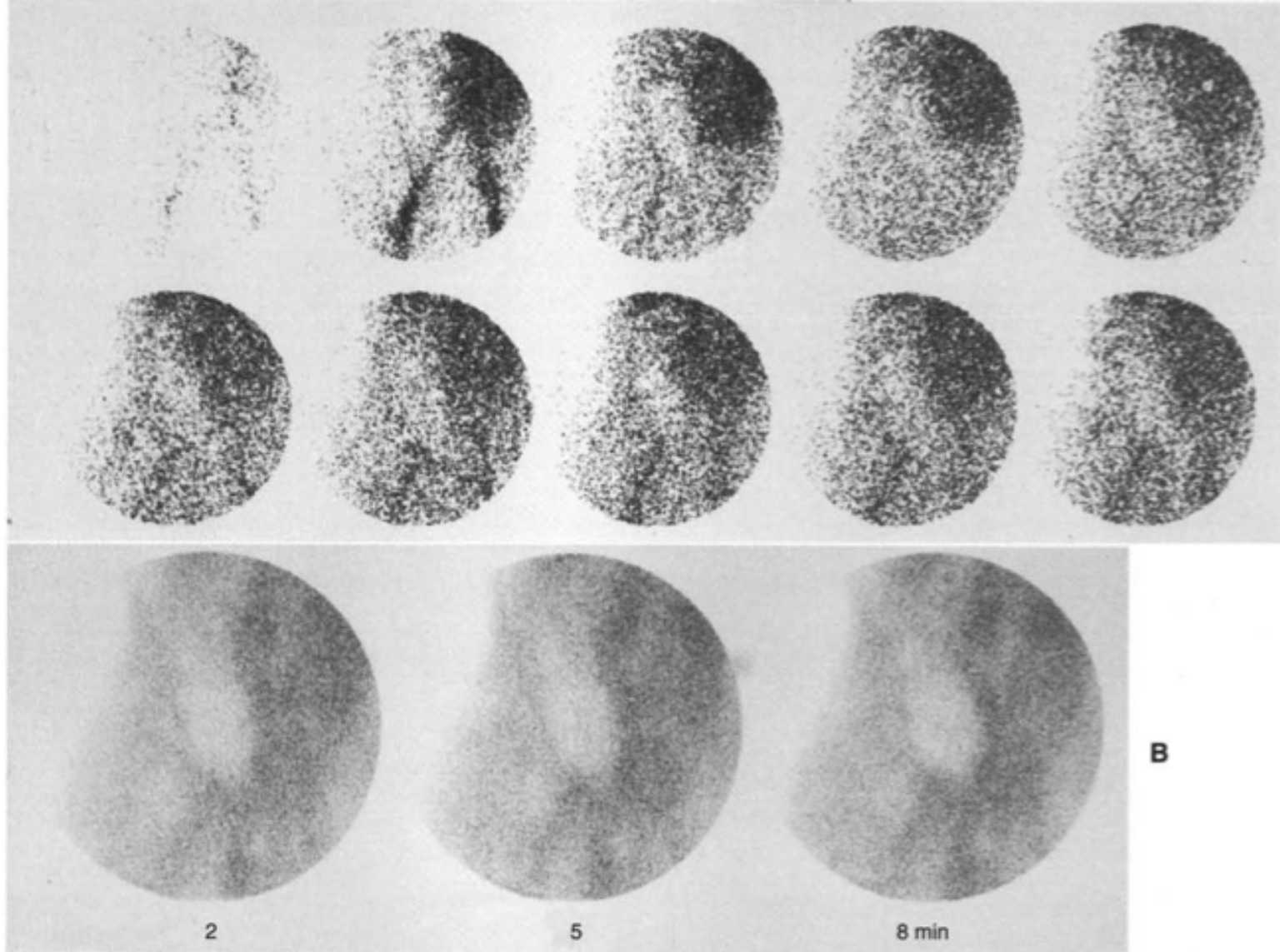


A 30-year-old kidney transplant recipient has decreasing postoperative urine output, fullness and tenderness around the graft, and scrotal swelling 24 hours after surgery.

1. Describe the findings on the 25-minute dynamic renal scintigraphy.
2. What is the diagnosis?
3. What are other causes of postoperative fluid collections adjacent to the graft?
4. What are other common complications during the first weeks after transplantation?

Transplanted kidney

1. Rapid leakage of urine just inferior to the transplanted kidney and extravasating into the scrotum.
2. Urinary leak caused by disruption of surgical anastomosis.
3. Hematomas and abscess occur in the early postoperative course, whereas lymphoceles generally are noted 4 to 8 weeks after surgery.
4. ATN, acute rejection or obstruction. Cyclosporin toxicity usually occurs months after transplant.

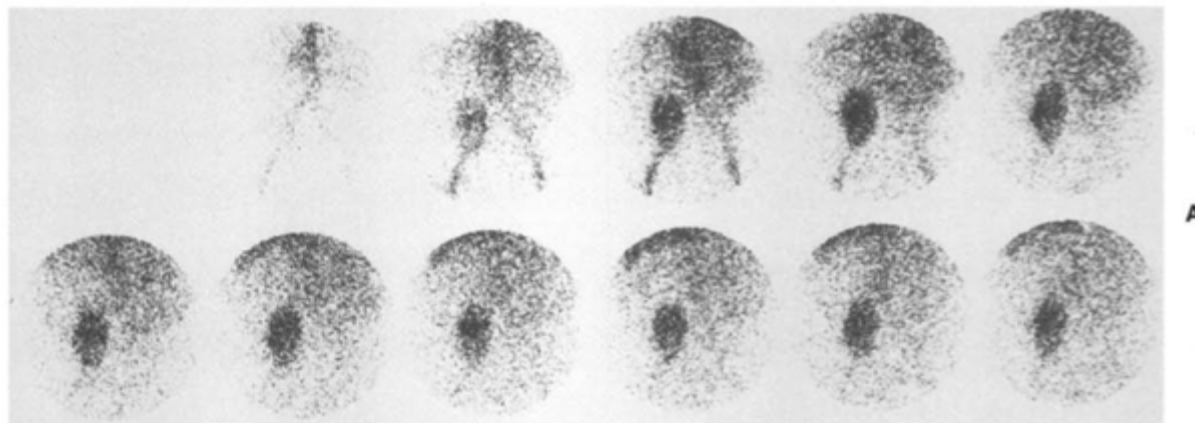


Radionuclide blood flow and early dynamic images at 24 hours after transplantation.

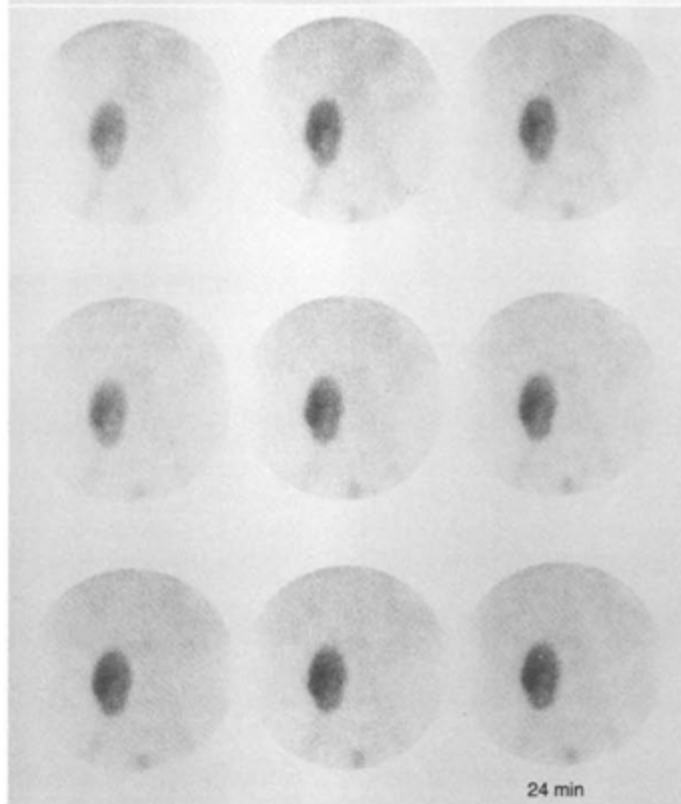
1. What are the scintigraphic findings?
2. What is your physiologic interpretation?
3. What is the differential diagnosis?
4. What therapy would be appropriate?

Non viable kidney after transplantation

1. No blood flow to the transplanted kidney. No renal uptake. A photopenic region in the shape of the transplanted kidney.
2. Nonviable kidney
3. Arterial or venous thrombosis, severe irreversible rejection and acute cortical necrosis.
4. Removal of nonviable transplanted kidney



A



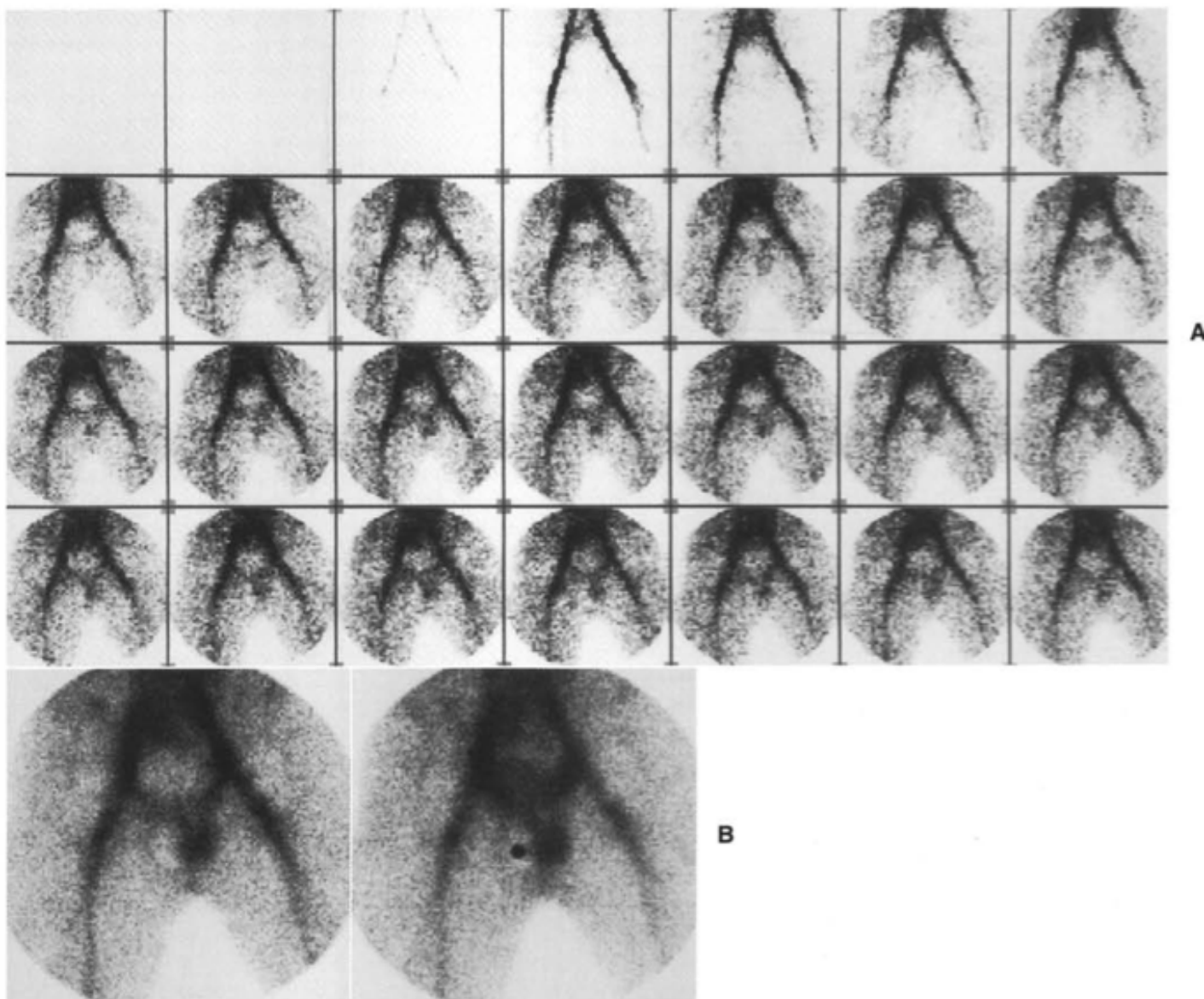
B

A 25-year-old man undergoes imaging 3 days after a renal cadaver transplant.

1. Which postoperative complications occur in the first week of renal transplantation?
2. During which postoperative period does acute rejection typically occur?
3. What are the scintigraphic findings in this case?
4. What is the diagnosis?

ATN

1. ATN, accelerated acute rejection, urinary leak and urinary obstruction.
2. The second postoperative week. Accelerated rejection may occur during the first week in patients who have had previous transplants or received multiple transfusion.
3. Normal blood flow, very poor function, no excretion. Base of penis seen inferiorly.
4. The pattern of normal blood flow but poor function during the first week after transplantation is typical of ATN

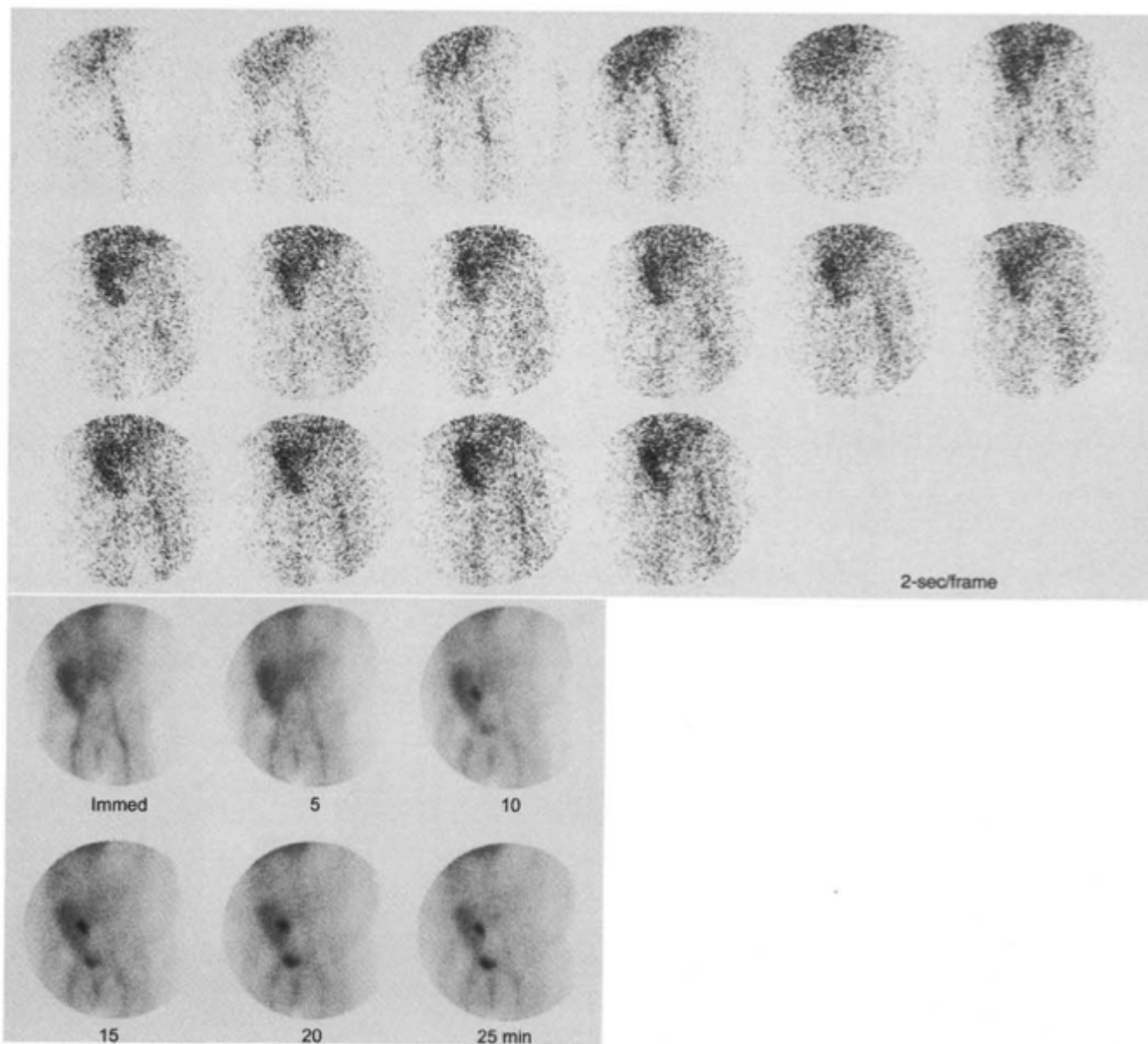


An 8-year-old boy has acute onset of right testicular pain.

1. What is the radiopharmaceutical and mechanism of distribution?
2. What are the most common causes of acute testicular pain?
3. What is the mechanism of testicular torsion?
4. What are the imaging findings, and what is the diagnosis in the case?

Testicular torsion

1. Tc-99m pertechnetate, initial blood flow and then tracer distributes in the extracellular fluid space.
2. Acute epididymitis, testicular torsion or torsion of the testicular appendage.
3. Developmental abnormality of testicular descent and attachment predisposes to spermatic cord torsion. The most common anatomical abnormality is “bell clapper” testis.
4. Decreased blood flow to the right testicle and a photopenic right testicle consistent with acute testicular torsion.

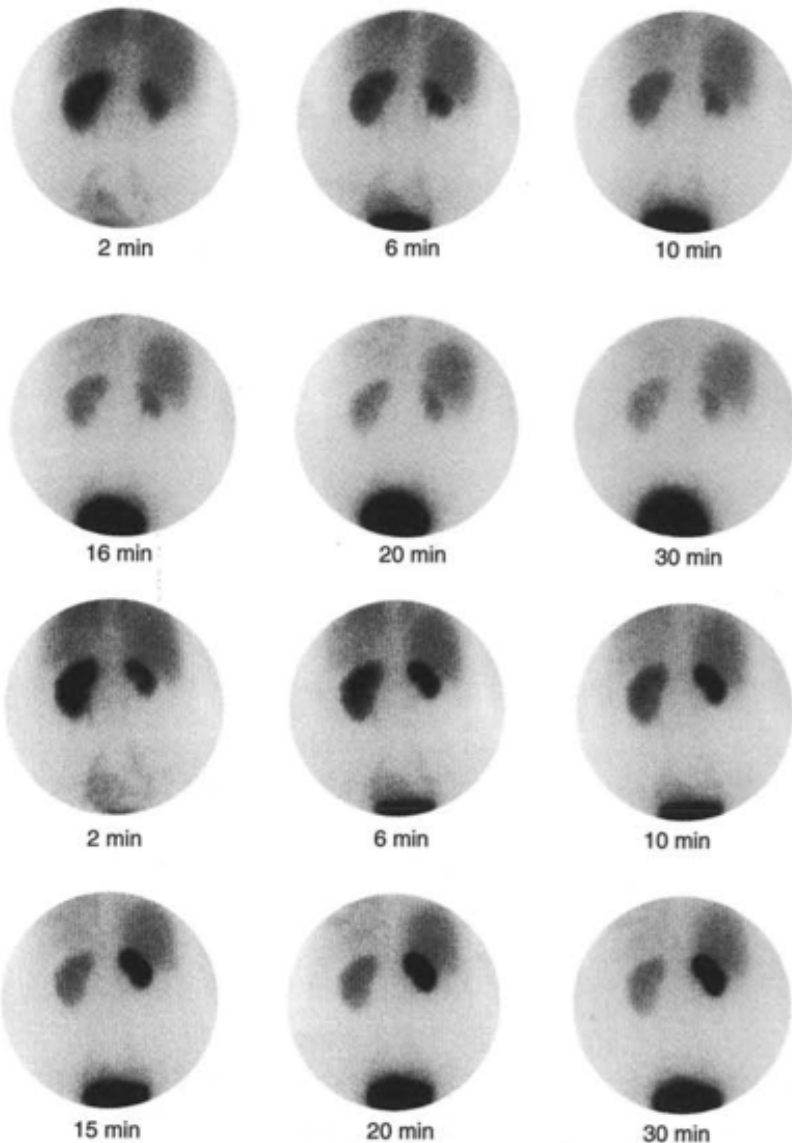
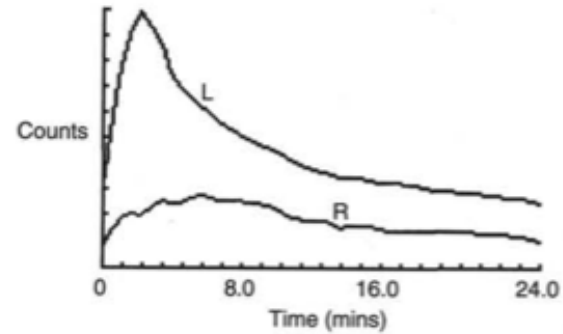


A 25-year-old woman had a kidney transplant 7 days earlier.

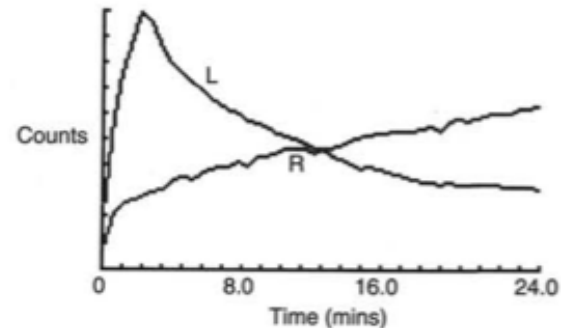
1. What are the scintigraphic findings of this ^{99m}Tc MAG3 study?
2. What is the most likely diagnosis?
3. What are the usual associated clinical symptoms and findings?
4. How is the final diagnosis established?

Acute renal transplant rejection

1. Very decreased and delayed blood flow and poor transplant function.
2. Acute rejection.
3. Fever, transplant tenderness and enlargement, decreased urinary output and rising serum creatinine level.
4. Biopsy.



A



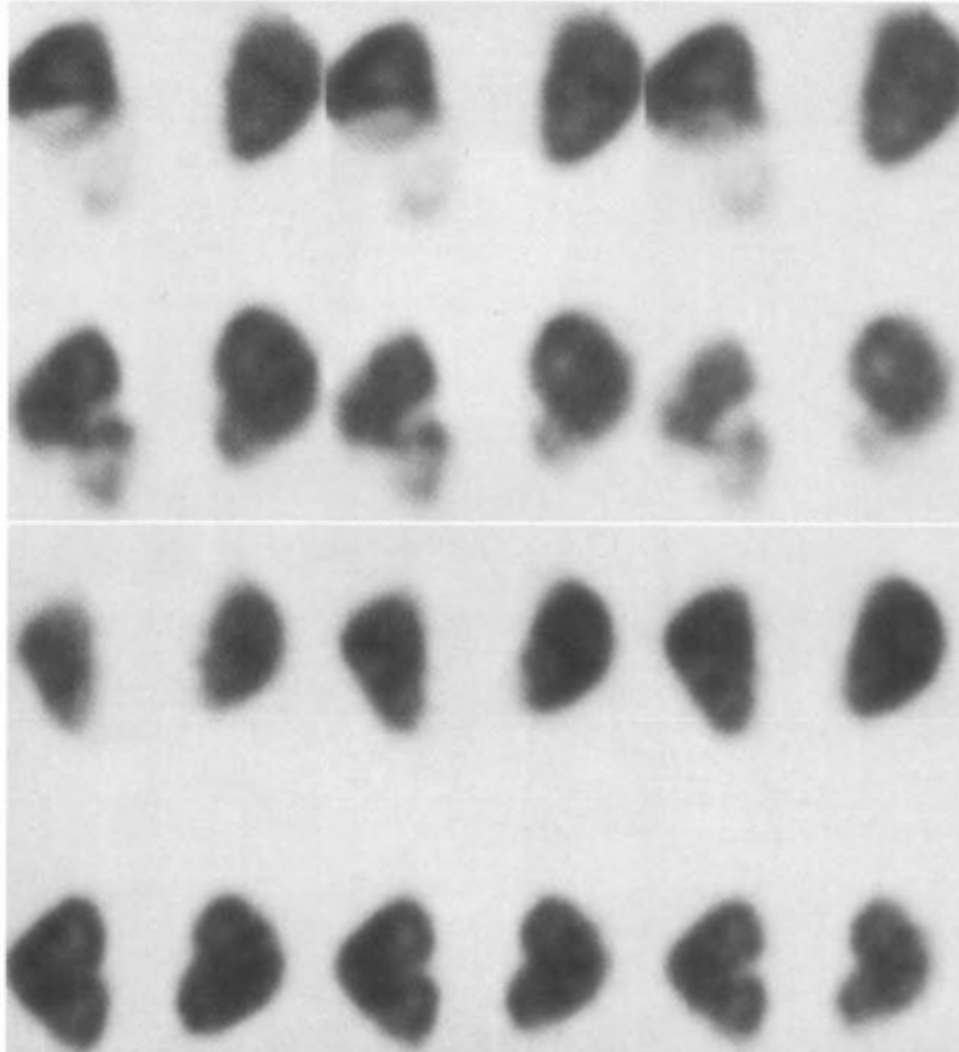
B

A 30-year-old man has poorly controlled and accelerating hypertension. Baseline study without captopril (A) and ^{99m}Tc MAG3 renal studies with captopril (B) are shown.

1. What is the rationale and physiological mechanism for the captopril renal study?
2. What are the scintigraphic and time-activity curve findings and diagnosis?
3. Could ^{131}I hippuran or ^{99m}Tc DPTA have been used instead?
4. What is the accuracy of captopril renography?

Captopril renography

1. With renal artery stenosis, glomerular filtration decreases and GFR drops. Renin released from juxtaglomerular convert angiotensin I to angiotensin II. Angiotensin II causes vasoconstriction of the glomerular efferent arterioles, rising filtration and maintaining GFR. ACE inhibitor blocks conversion of angiotensin I to II resulting in decreased in a decrease GFR.
2. The right kidney is small but with good function. With captopril cortical retention persists, consistent with renin dependent renovascular HPT of the right kidney. This is confirmed by the renal cortical time activity curves.
3. Yes. The accuracy of I-131 hippuran, Tc-99m DTPA and Tc-99m MAG 3 are similar.
4. Sensitivity 90% and specificity 95%. Sensitivity is less for detection of renin dependent HPT if the patient has been taking an ACE inhibitor chronically or renal insufficiency.



A

B

A 6-year-old girl has recurrent and recent urinary tract infections. *A*, ^{99m}Tc DMSA SPECT renal study. *B*, A repeat study 6 months later (comparable coronal slices).

1. What is the mechanism of uptake of ^{99m}Tc DMSA?
2. What are the most common indications for a ^{99m}Tc DMSA study?
3. What are the scintigraphic SPECT findings and what is the diagnosis? What would have been the diagnosis if the second study (*B*) looked similar to the first study (*A*)?
4. What is the clinical importance of differentiating upper and lower tract infection?

Pyelonephritis

1. 40% of DMSA binds and fixes to functioning proximal cortical renal tubules.
2. Diagnosis of pyelonephritis or renal scarring.
3. Decreased uptake in the lower half of the right kidney on initial imaging (A). Repeat SPECT show normalization of uptake. A, Pyelonephritis. B, Renal scarring
4. DMSA in the early stages of infection is the best predictor of renal sequelae. Identification of pyelonephritis will increase the duration of antibiotic therapy.

Lung scintigraphy

Pearls & Pitfalls

Lungs perfusion

- Unless it is completely and absolutely normal, never interpret a V/P scan without a recent chest radiograph.
- A normal perfusion lung scan essentially excludes clinically significant PE.
- An abnormal ventilation scan or chest radiograph will not change this assessment.

Pearls & Pitfalls

Lungs perfusion

- Other causes of perfusion defects are COPD, asthma, tumor, mediastinitis, mucous plug, fat emboli and vasculitis.
- Most perfusion defects caused by PE are wedge shaped and extend to the periphery, usually bilateral and multiple.
- An unmatched defects refers to one that is seen on the perfusion scan without ventilation abnormality.

Pearls & Pitfalls

Lungs perfusion

- Even a low probability scan has a 15% to 20% probability of PE.
- A very low probability scan has a positive predictive value of less than 10%.
- Asthma, mucous plugs and COPD can cause segmental defects, but they should not have normal ventilation scans.

Pearls & Pitfalls

Lungs perfusion

- A stripe sign of peripheral activity around a perfusion defect is frequently seen with COPD and indicates a very low probability defect.
- When there is an infiltrate on the CXR and a small perfusion defect, pneumonia is a common cause.
- When there is a small infiltrate and a relatively larger perfusion defect, PE should be considered.

Pearls & Pitfalls

Lungs perfusion

- If there is ventilation of one whole lung but no perfusion, the differential diagnosis includes congenital absence of the pulmonary artery, massive central PE, mediastinal fibrosis or hilar neoplasm.
- A focal hot spot in the lung is due to an injected labeled clot that was either formed in the syringe or dislodged from the end of the central line through which Tc-99m MAA was injected.

Pearls & Pitfalls

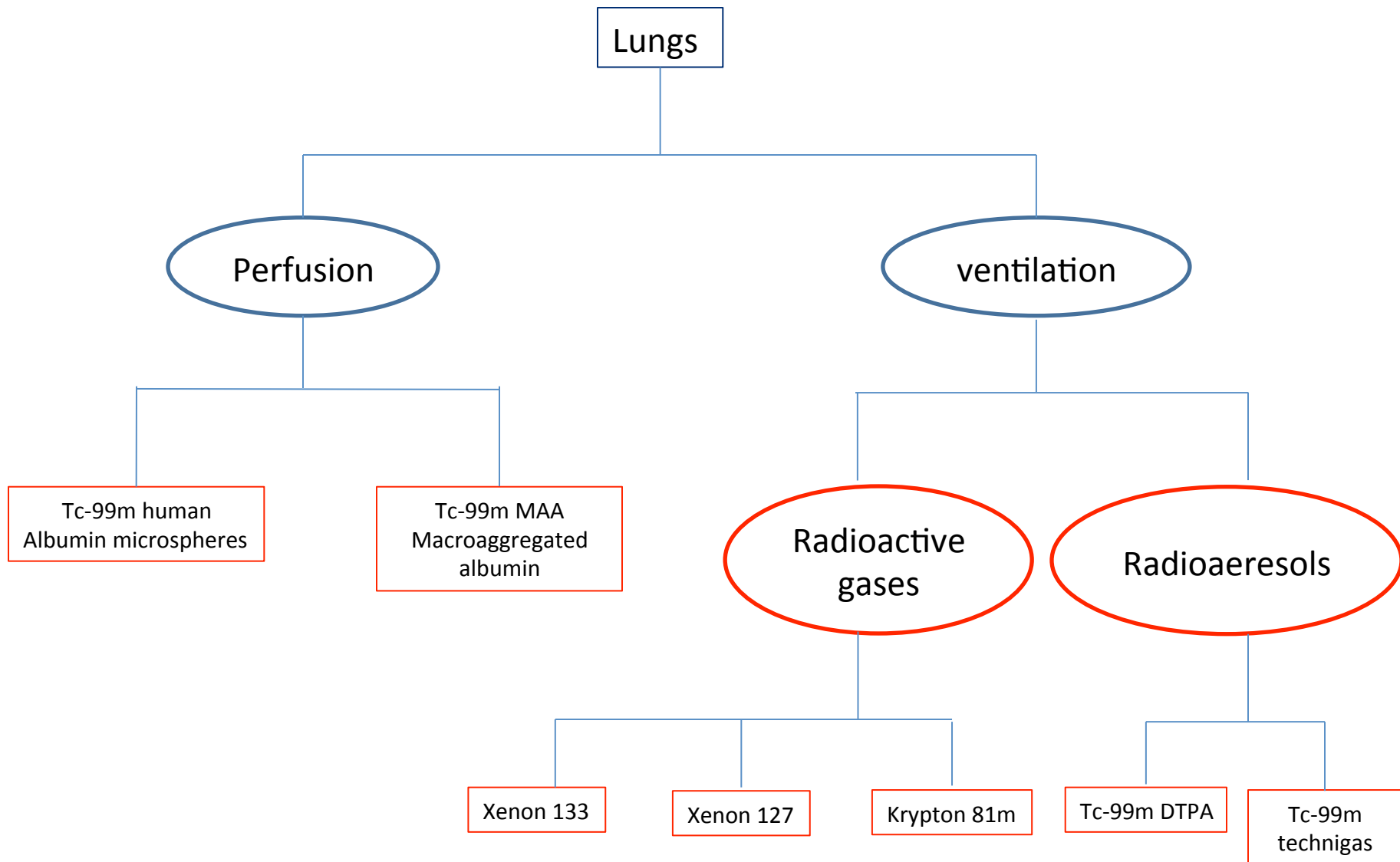
Lungs perfusion

- On an aerosol ventilation scan, collection of activity in the central bronchi is an indication of COPD.
- Poor perfusion to the lung apices may be normal after lung transplantation.
- Large segmental V/Q mismatches are more likely to represent PE than the small ones.
- Multiple irregular tiny perfusion defects can be due to COPD, fat emboli and vasculitis.

Pearls & Pitfalls

Lung perfusion

- Parenchymal renal activity on a Tc-99m MAA scan indicates a possible right to left shunt.
- This can be confirmed by noting activity in the brain.
- V/Q scans remain useful for renal failure patients and contrast allergies.



Some facts about PE

- estimated to be in the region of 100 cases per 100,000 person years
- rare in children under 15 years of age (<5 per 100,000).
- increases dramatically after the age of 60 years
- PE developed in 44% of patients with proximal DVT.
 - DVT developed in 30% of 132 patients undergoing surgery without prophylaxis (Kakkar et al, 1969)

- May be asymptomatic or cause sudden death
- not possible to confirm a diagnosis of PE on clinical features alone
 - diagnosis proven in only 30% of cases
- One-third of untreated patients with PE will die, compared with less than 10% of treated patients
- Diagnostic imaging important to ensure that anticoagulant therapy is given only to those patients who require treatment bec of inherent risks of a 1% fatal bleeding rate and a 4–16% serious haemorrhage rate per 100 treatment-yrs

Diagnosis of PE

Imaging Investigations

- Lung Ventilation/ Perfusion (V/Q) study
 - Planar
 - SPECT
- Pulmonary Angiography
- MDCT
- MRI

Lung perfusion study

Indications

- Evaluation for pulmonary embolism (PE),
- Evaluation of pulmonary perfusion.
 - Evaluation of lungs for pre- and post-lung surgery
 - Evaluation of lung transplantation
- Detection of right to left cardiac shunt. Primarily for pediatrics patients
- Evaluation of chest pain.
- Evaluation of shortness of breath.
- Evaluation of low blood oxygen saturation.
- Evaluation and management of carcinoma of the bronchus.
- Evaluation of perfusion affected by emphysema, chronic bronchitis, asthma, inflammatory disease, and cardiac disease.

Lung ventilation study

Indications

- Evaluation and detection of pulmonary embolism (PE) in conjunction with lung perfusion (mismatching defects).
- Evaluation of chronic obstructive pulmonary disease (COPD) in conjunction with lung perfusion (matching defects).
- Evaluation of obstructed or constricted airways, alveolar spaces, and air distribution, resulting in shortness of breath.
- Evaluation of pulmonary retention.
- Evaluation of chest pain.
- Evaluation of low blood oxygen saturation.
- Evaluation of adult respiratory distress syndrome (ARDS), emphysema, inflammation, chronic bronchitis, or pneumonia.
- Evaluation of tracheobronchial epithelium function (aerosol).
- Evaluation and staging of patients with COPD, lung carcinoma, and bronchial obstruction (aerosol).
- Evaluation of pulmonary permeability in restrictive lung disease or pulmonary edema by observing clearance rates using submicrometer aerosols (DTPA).

Lung Perfusion

Physiological basis of study

- Tracer particles distributed into the pulmonary vascular bed and are trapped in the capillaries of the pulmonary arteries (microembolization).
- In general, $<0.1\%$ of the capillaries are blocked from a typical injection.

Radiopharmaceutical

- MAA (macroaggregated albumin) or HAM (human albumin microspheres) tagged to ^{99m}Tc
- Particle size, 10–90 μm , 75,000–700,000 particles/injection

Adult Dose Range

- 2–6 mCi (74–222 MBq)

- Slow injection with the patient supine. To assist in distribution to lungs, patient is asked to take in several deep breaths during injection.
- flush heavily with saline only (MAA and heparin do not mix, flush well).
- No reblush of blood in the hub of the needle (it may clot and cause a hot spot or false-positive).
- Lift injected arm momentarily to assist in circulation of radiotracer.
- Avoid injecting through any indwelling catheter that contains a filter, e.g., Swan-Ganz or chemotherapy line.