

Why is the Tc-99m RBC for detecting GI bleeding more sensitive than the Tc-99m SC?

- Delayed images can be performed up to 24 hours with RBC labeling

What are the criteria needed to diagnose confidently the site of bleeding on a radionuclide study?

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- a. Hot spot appears where there was none and conforms to bowel activity
- b. Activity increases over time
- c. Activity moves antegrade and retrograde

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What other gastric abnormalities may contain gastric mucosa?

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What other gastric abnormalities may contain gastric mucosa?

- Duplication of GI tract
- Barrett's esophagus

What is the origin of Meckel's diverticulum?

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- Failure of closure of the omphalomesenteric duct of the embryo, which connects the yolk sac to the primitive foregut via the umbilical cord

Concerning Meckel's diverticulum

- A. Ectopic gastric mucosa in a Meckel's diverticulum can be reliably distinguished from ectopic mucosa elsewhere in the small intestine
- B. Cimetidine given before the scan to blocks the secretion of pertechnetate from gastric mucosa
- C. Children are more likely to have a positive test than adults
- D. Diverticulitis is a common cause of false positive result
- E. A false negative result may be obtained if there has been a recent barium study

Concerning Meckel's diverticulum

- FTTFT

Concerning GI bleeding studies

- A. Hepatic hemangioma is a recognised cause of false positive Tc-99m RBS study
- B. A rejecting transplanted kidney is a recognised cause of a false positive Tc-99m tin colloid study
- C. Anemia is a cause of visualization of the GB in labeled RBC study
- D. Diffuse colonic activity in a labeled RBC study indicates colonic bleeding
- E. When reporting a study. It is not necessary to view the dynamic images that provide all information

Concerning GI bleeding studies

- TTTF

GI bleeding studies

- A. Tin colloid studies are better at detecting bleeding sites proximal to the ligament of Treitz than distal to it
- B. Delayed images on a tin colloid scan may be of value in separating liver and spleen activity from bowel activity
- C. In vitro labeling of RBC gives fewer false positive tests than in vivo
- D. Bleeding must be continuous to be detected on a labeled RBC study
- E. ^{51}Cr -chromate labeled RBC can detect bleeding down to 1-2 mls per day

GI bleeding studies

- FFTFT

Concerning cholescintigraphy

- A. Failure to visualize the GB by 4 hr with normal activity appearing in the bowel is highly suggestive of GB disease
- B. Chronic Cholecystitis can be distinguished from acalculous cholecystitis
- C. Giving CCK before isotope is more likely to demonstrate the GB than giving morphine
- D. Common duct obstruction should be excluded if visualization of bowel activity is delayed beyond 1 hour
- E. GB emphysema has a typical rim sign appearance

Concerning cholescintigraphy

- TFTTT

Concerning cholescintigraphy

- A. Cholescintigraphy has greater specificity than ultrasound at detecting bile duct obstruction
- B. Following cholecystectomy, an abnormal accumulation of HIDA outside biliary tree likely due to bile leak
- C. US is more sensitive than cholescintigraphy at detecting bile leak
- D. Cholescintigraphy can diagnose afferent loop obstruction after gastroenterostomy
- E. Ascites can be detected

Concerning cholescintigraphy

- TTFTT

In pediatric cholescintigraphy

- A. Phenobarbitone is used to maximise hepatic of tracer
- B. Neonate hepatitis can be distinguished from Rotor syndrome
- C. Choledocal cyst can be distinguished from pancreatic cyst
- D. Cholescintigraphy is more accurate in diagnosing biliary atresia in children > 3 months than in neonates
- E. Dilated intrahepatic ducts are often seen in patients with biliary atresia

In pediatric cholescintigraphy

- TTTF

Concerning GI transit studies

- A. It is easier to detect abnormalities of gastric emptying for solids than for liquids
- B. DM is a common cause of delayed gastric emptying
- C. Hyperthyroidism is the commonest of rapid gastric emptying
- D. Scleroderma affects esophageal transit through the whole esophagus
- E. Achalasia has a specific appearance on a radionuclide esophageal transit time

Concerning GI transit studies

- TTFFF

Concerning Milk Studies

- A. Reflux is more likely to be detected if the infant is placed prone
- B. The longer the test the more sensitive it becomes
- C. Labeled milk studies are better at detecting post-prandial reflux than 24 hour pH monitoring
- D. A normal study excludes significant lung aspiration
- E. Reflux detected by scintigraphy is more likely to be significant

Concerning Milk Studies

- FTTF

1. Tc sulfur colloid for GI haemorrhage

- A. Bleeding must be active at the time of examination
- B. Present in blood for 30 minutes
- C. Very useful for upper GI bleed
- D. Study terminated if no abnormality is seen in 2 hours
- E. Flow study is performed for one minute

1. Tc sulfur colloid for GI haemorrhage

- TFFFT

2. Nuclear medicine in biliary atresia

- A. Phenobarbitone should be given for 2 days before the procedure
- B. Presence of tracer in bowel excludes diagnosis
- C. Hepatic activity seen in 5 minutes
- D. Images are sequential in the first one hour
- E. Severe neonatal hepatitis cannot be distinguished from biliary atresia

2. Nuclear medicine in biliary atresia

- FTTTF

3. False positive for Tc RBC

- A. Hemangioma
- B. Renal pelvis uptake
- C. Physiological uptake in intestine
- D. Intussusception
- E. Enteric duplication

3. False positive for Tc-99m RBC

- TTTF

4. False positive Meckel's scan

- A. Malrotation of ileum
- B. Zollinger Ellison syndrome
- C. Irritable bowel syndrome
- D. Tuberculosis
- E. Pancreatitis

4. False positive Meckel's scan

- FFFFFF

6. Tc HIDA scan

- A. Activity is seen in bile duct and duodenum in 30-60 minutes
- B. Detect bile leaks better than US or CT
- C. Best to image at 5 – 10 minutes for liver SOLs
- D. Negative uptake in gallbladder with acute cholecystitis
- E. GB uptake in chronic cholecystitis is seen in 30-60 minutes

6. Tc-99m HIDA

- TTTTF

7. Indication of Tc sulphur colloid scan

- A. Acute rejection of renal transplant
- B. Lower GI bleed
- C. Accessory spleen
- D. Gastric emptying
- E. Localizing abscess

7. Indication of Tc sulphur colloid scan

- TTTT

8. Sulphur colloid scan

- A. 55% localises in spleen
- B. Used to find the sites of erythropoiesis
- C. 10% localises to bone marrow
- D. Decreased splenic activity in hypersplenism
- E. Gelatin is added during preparation to prevent growth of particles

8. Sulphur colloid scan

- FFFFT

9. Colloid shift is seen in

- A. Cirrhosis
- B. Congestive cardiac failure
- C. Steroids
- D. Hepatitis
- E. Hepatic tumors

9. Colloid shift is seen in

- TTTTF

10. Causes of focal hot liver lesion in sulfur colloid scan

- A. In caudate lobe in IVC obstruction
- B. Quadrate lobe in SVC obstruction
- C. Caudate lobe in Budd-Chiari syndrome
- D. Hepatocellular carcinoma
- E. Focal nodal hyperplasia

10. Causes of focal hot liver lesion in sulfur colloid scan

- FTTFT

11. Mottle uptake in liver is seen in

- A. Lymphomas
- B. Hepatitis
- C. Radiation
- D. Hepatocellular carcinomas
- E. Amyloidosis

11. Mottle uptake in liver is seen in

- TTTFT

12. Focal defect in sulfur colloid scan is seen in

- A. Metastasis
- B. Focal nodular hyperplasia
- C. Pseudotumor
- D. Abscess
- E. trauma

12. Focal defect in sulphur colloid scan is seen in

- TTTT

What physiologic molecules does
Tc-99m IDA most closely mimic?

What physiologic molecules does Tc-99m IDA most closely mimic?

- Bilirubin

What is the main difference between
Tc-99m IDA and bilirubin?

What is the main difference between Tc-99m IDA and bilirubin?

- Tc-99m IDA is not conjugated

What level of bilirubin is required to interfere with the quality of HIDA scan?

What level of bilirubin is required to interfere with the quality of HIDA scan?

- > than **20 to 30 mg/dl**

How does prior CCK administration
affect the biliary to bowel transit time?

How does prior CCK administration affect the biliary to bowel transit time?

- CCK delays biliary to bowel transit time

How can one distinguish acute from chronic cholecystitis as a cause of non visualization of the GB at 1 hour ?

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- Obtain delayed image and perform morphine augmentation

What 2 findings on scan increased likelihood that nonvisualisation of GB is caused by acute cholecystitis ?

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1. Hyperemia in GB fossa on early images
2. Rim sign on later images

What is the prognostic implication of
rim sign in scan?

What is the prognostic implication of rim sign in scan?

- It is associated with GB gangrene and perforation

How does morphine augmented
cholescintigraphy work?

How does morphine augmented cholescintigraphy work?

- Morphine increases the tone of sphincter of oddi
- Raising common bile duct pressure
- Facilitating GB filling if cystic duct is patent

How does one perform morphine
augmented cholescintigraphy?

How does one perform morphine augmented cholescintigraphy?

- If GB does not fill by 60 minutes
- Give 0.04 mg/kg IV morphine
- If GB does not fill by 30 minutes means the patient has cystic duct obstruction

What is the major cause of a false negative scan for acute cholecystitis in scan ?

What is the major cause of a false negative scan for acute cholecystitis in scan ?

- Acute acalculous cholecystitis

How does one perform GB ejection fraction?

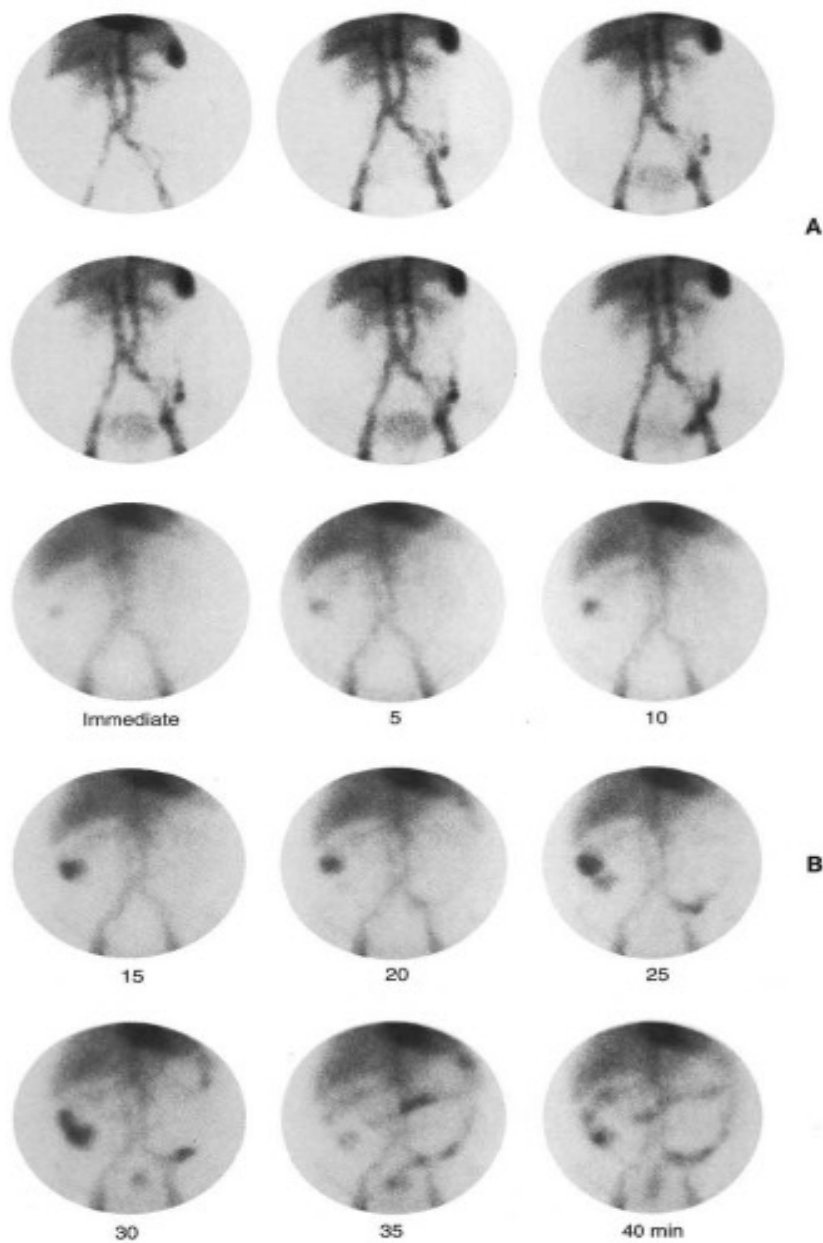
How does one perform GB ejection fraction?

- Administer IV sincilide $0.02 \mu\text{g/kg}$
- Normal GB ejection fraction = 35%

What patient preparation is required before scan for biliary atresia?

What patient preparation is required before scan for biliary atresia?

- Phenobarbital 5 mg/kg for 5 days

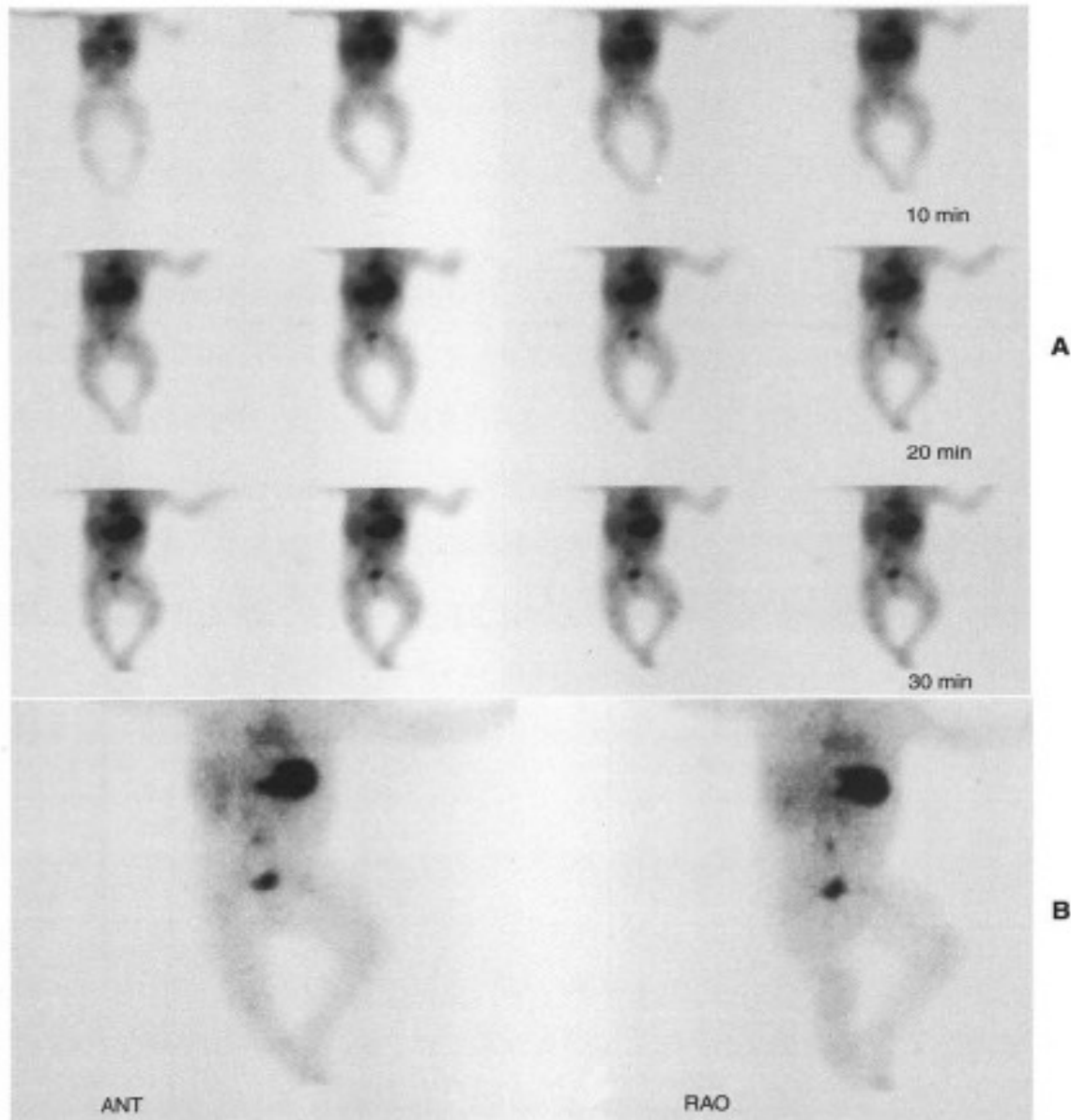


Two patients undergo studies for gastrointestinal bleeding.

1. What radiopharmaceutical is used?
2. Determine the site of bleeding in study *A*.
3. Determine the site of bleeding in study *B*.
4. What is the slowest rate of bleeding that can be detected with scintigraphy and with contrast angiography?

Tc-99m colonic bleeding

1. Tc-99m labeled RBCs.
2. A. left colon, rectosigmoid region
3. B. Right colon, hepatic flexure. It moves rapidly to the left colon.
4. RBC scintigraphy, 0.1 ml/min; contrast angiography 1 ml/min.

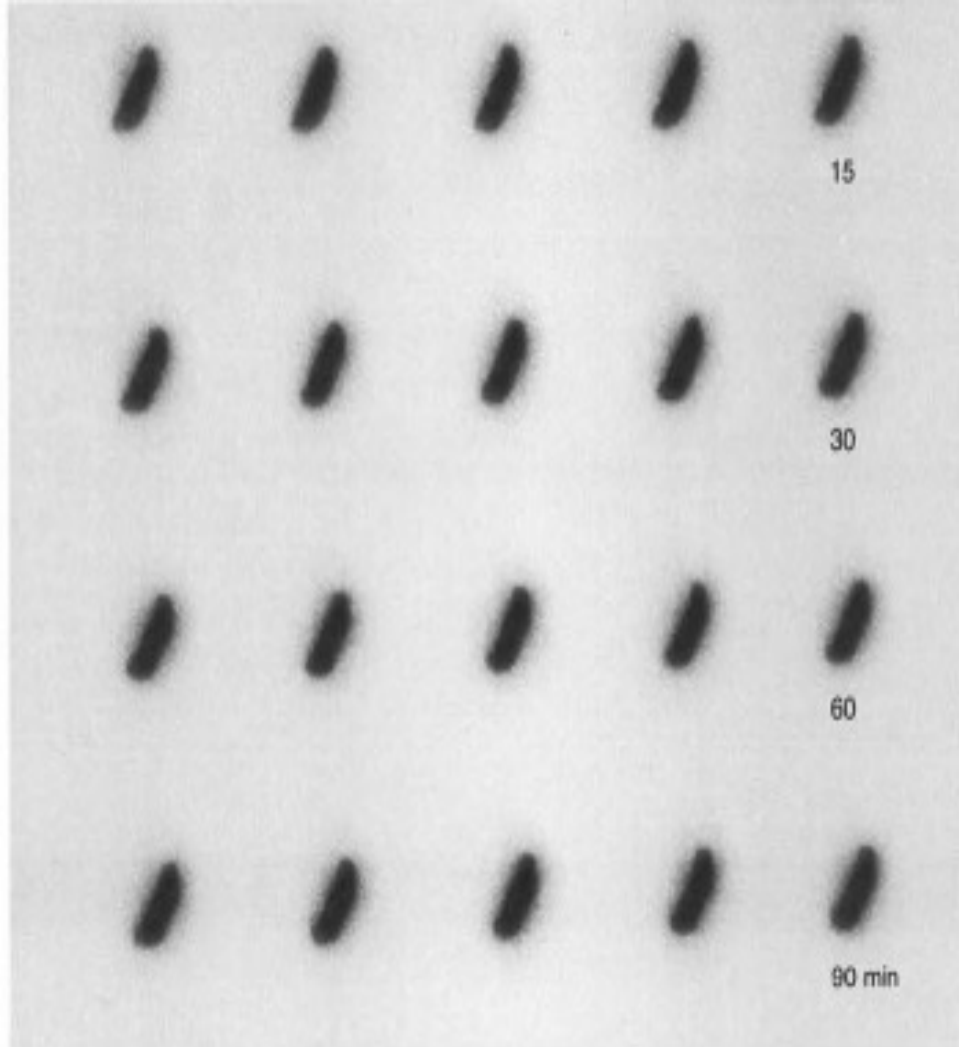


A 5-year-old girl is referred after passage of a bloody stool.

1. What is the radiopharmaceutical, its mechanism of uptake, and study type?
2. Which pharmacological drugs can be used to enhance detectability? What is their mechanism?
3. Provide an interpretation.
4. Why is bleeding a common complication of this disease entity?

Meckel's Diverticulum

1. Meckel's can. The radiopharmaceutical is taken up and secreted by gastric mucosa.
2. Pentagastrin increases rapidity, intensity and duration of uptake. It is used with glucagon, which is antiparistaltic that inhibits rapid dispersion effect of pentagastrin. Cimetidine, a histamine antagonist, increases and prolonged uptake because of inhibition of Tc-99m pertechnetate secretion from gastric mucosal cells.
3. Increasing focal uptake in the mid abdomen suspicious for Meckel's diverticulum, however, atypical timing of uptake lessens the certainty. The uptake should be coincident with gastric uptake in cases of Meckel's diverticulum. This may be false positive scan.
4. Acid and pepsin secretion by the gastric mucosa produces inflammation and ulceration of adjacent bowel mucosa.

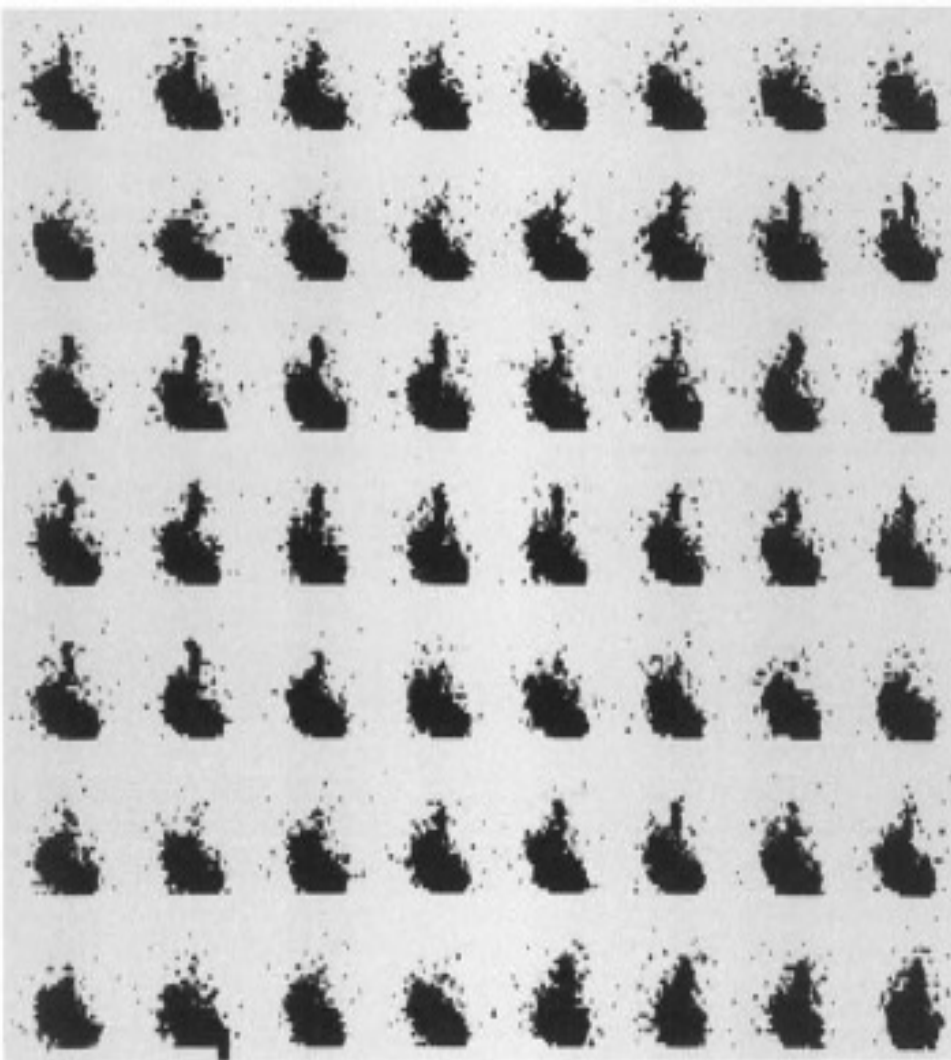


A patient with insulin-dependent diabetes has chronic symptoms of early satiety, postprandial bloating, and abdominal discomfort. A gastric emptying study is conducted 90 minutes after a solid meal.

1. What is the diagnosis?
2. What are normal values for solid meal gastric emptying?
3. What is the advantage of a solid radiolabeled meal over a liquid meal?
4. Why is attenuation correction recommended for accurate quantification of gastric emptying?

Diabetic gastroparesis

1. Consistent with severe diabetic gastroparesis. Obstruction cannot be ruled out.
2. Normal values are meal specific and depend on its volume/composition, the method of acquisition, attenuation correction, processing and quantification. Normal values must be determined in each clinic or results of a published method should be followed closely.
3. Solid or semisolid gastric emptying meals are more sensitive for detection of mild to moderate delay in emptying than studies conducted after a liquid meal.
4. Activity is detected with greatest efficiency close to the camera. The anterior view alone underestimates emptying and posterior view overestimates it because of variable attenuation as the meal moves through the stomach from the posterior gastric fundus to the more anterior gastric antrum.

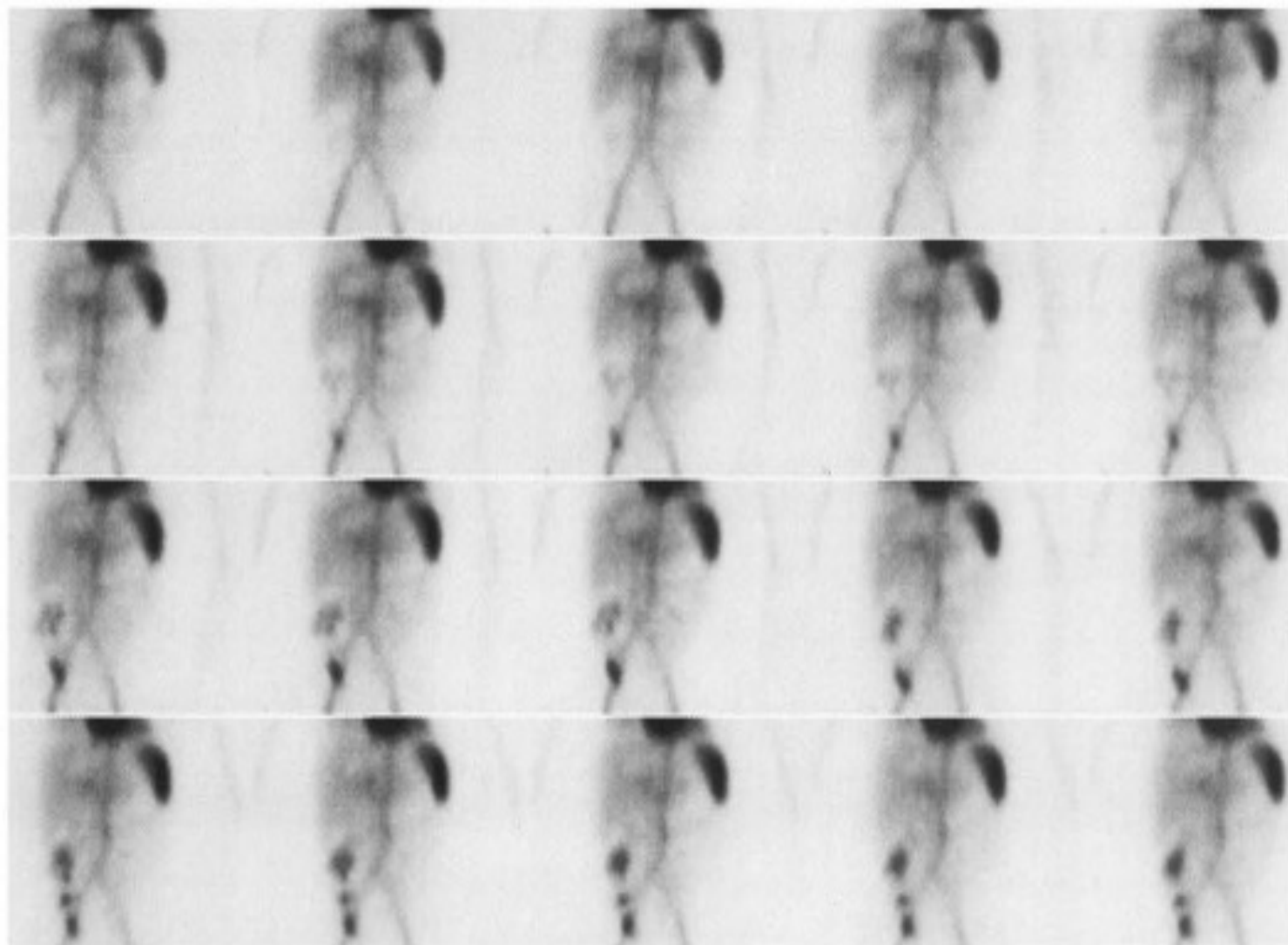


A 3-month-old infant was referred with symptoms of gastroesophageal reflux. A radionuclide gastroesophageal reflux study (milk study) was performed (posterior view).

1. What are common symptoms and problems in children associated with reflux?
2. What other method is used by pediatricians for detection of reflux?
3. What radiolabel and what meal is used for this study?
4. How frequently should images be acquired to maximize sensitivity of this test?

Gastroesophageal reflux

1. Vomiting, pulmonary symptoms, asthma, pneumonia, sudden death, failure to thrive and anemia.
2. 24 hours pH monitoring.
3. Tc-99m sulfur colloid 1 mCi in the child's usual feeding, formula or milk
4. 5 to 10 second/frame.

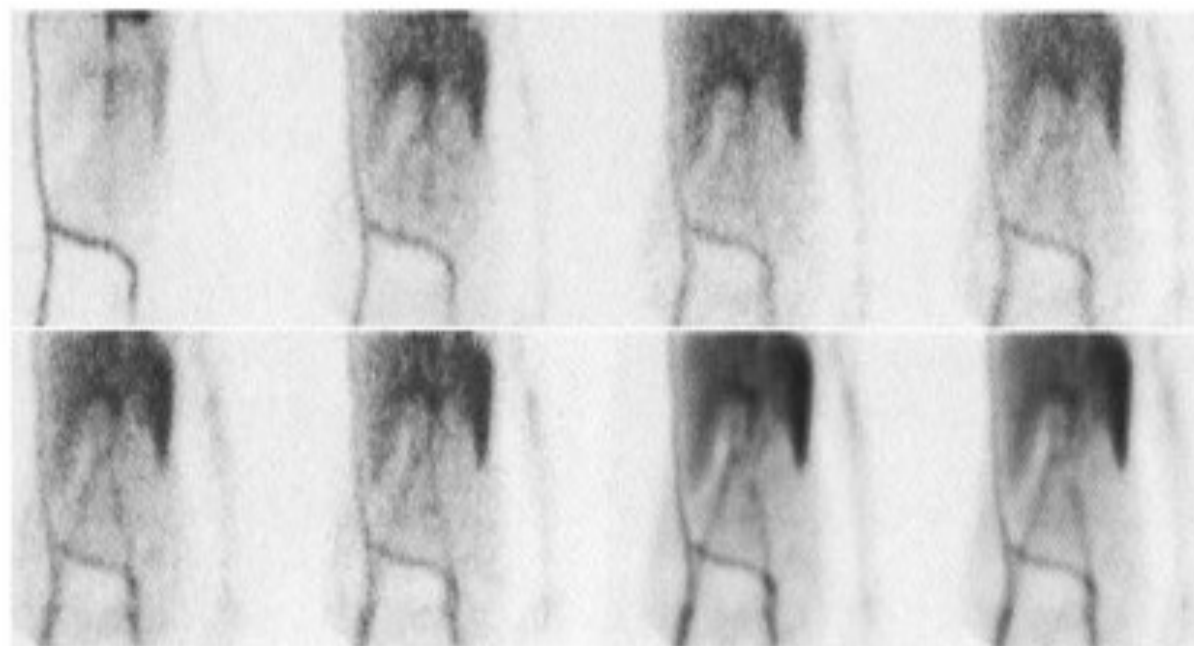


Bright red blood per rectum. No prior history.

1. What radionuclide study is this? Describe the scintigraphic findings.
2. Provide an accurate location for the findings.
3. Name another method of image review that should be used.
4. Provide the differential diagnosis.

Gastrointestinal bleeding

1. Tc-99m labeled RBC study. Abnormal focal uptake appearing simultaneously at two sites in the right abdomen, increasing in intensity and changing in pattern with time.
2. Caecum and ascending colon.
3. Review images on a computer in cinematic mode.
4. Acute bleeding due to angiodysplasia, diverticula, neoplasm, IBD and ischemia.

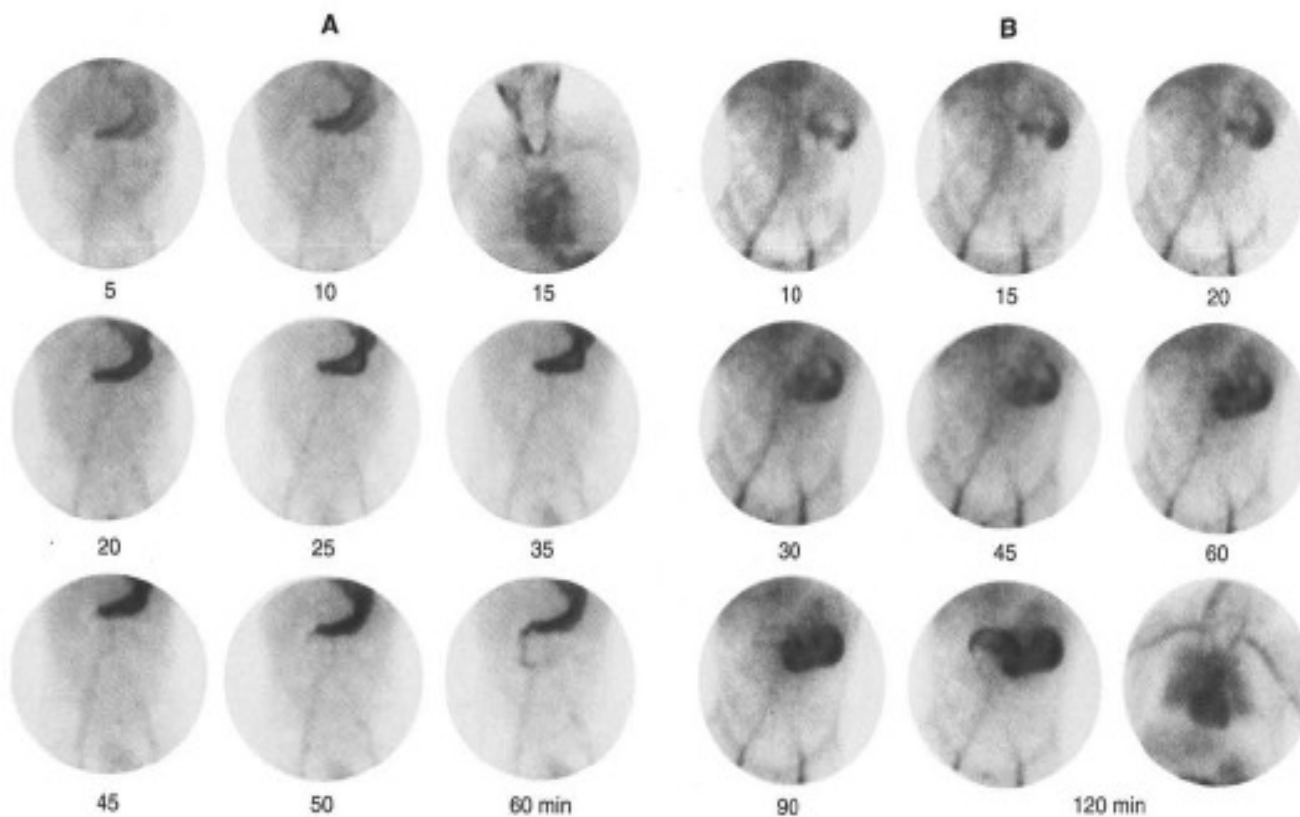


Recent bright red blood per rectum and low hematocrit.

1. Based on the history, what nuclear scans would be appropriate?
2. What information from the history is critical to determine the appropriate time to perform the examination?
3. Name the radiopharmaceutical used for this examination.
4. Describe the scintigraphic findings (first six images are blood flow, last two are delayed statics).

Axillobifemoral bypass graft

1. Tc-99m labeled RBC or sulfur colloid
2. Evidence of current or recent bleeding
3. Tc-99m RBCs
4. The vascular flow and delayed static images show no active bleeding seen. Labeled RBCs are shown in a tubular shape in the right abdomen that connects after a Y bifurcation to the two iliac vessels as a result of an axillobifemoral vascular bypass graft. The patient has prominent splenomegaly.

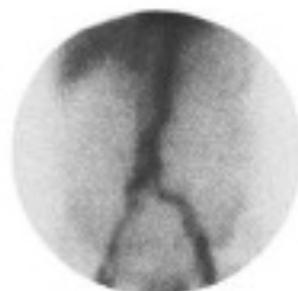


Two patients (*A* and *B*) were referred for a radionuclide gastrointestinal bleeding study.

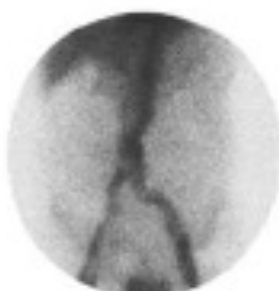
1. What is the radiopharmaceutical used in these studies?
2. Describe the image findings in both studies.
3. Interpret the two studies.
4. Which method of radiolabeling of RBCs has the highest labeling efficiency?

Free pertechnetate vs gastric bleeding

1. Tc-99m RBC
2. In both studies the stomach visualizes promptly. The chest and neck image shows thyroid and salivary gland uptake in study A but not in study B
3. A. Free pertechnetate. Negative for gastrointestinal bleeding. B. Active bleeding originating from the stomach
4. In vitro



Immediate



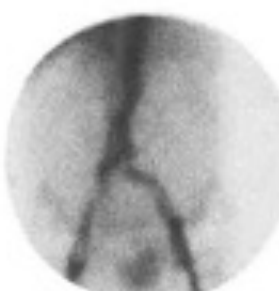
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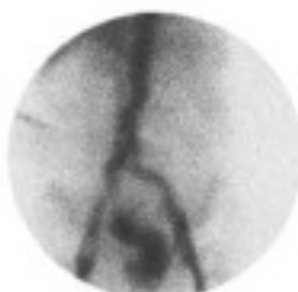
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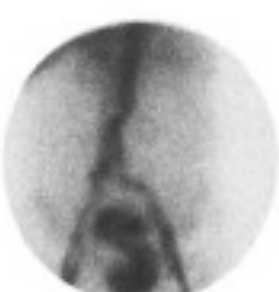
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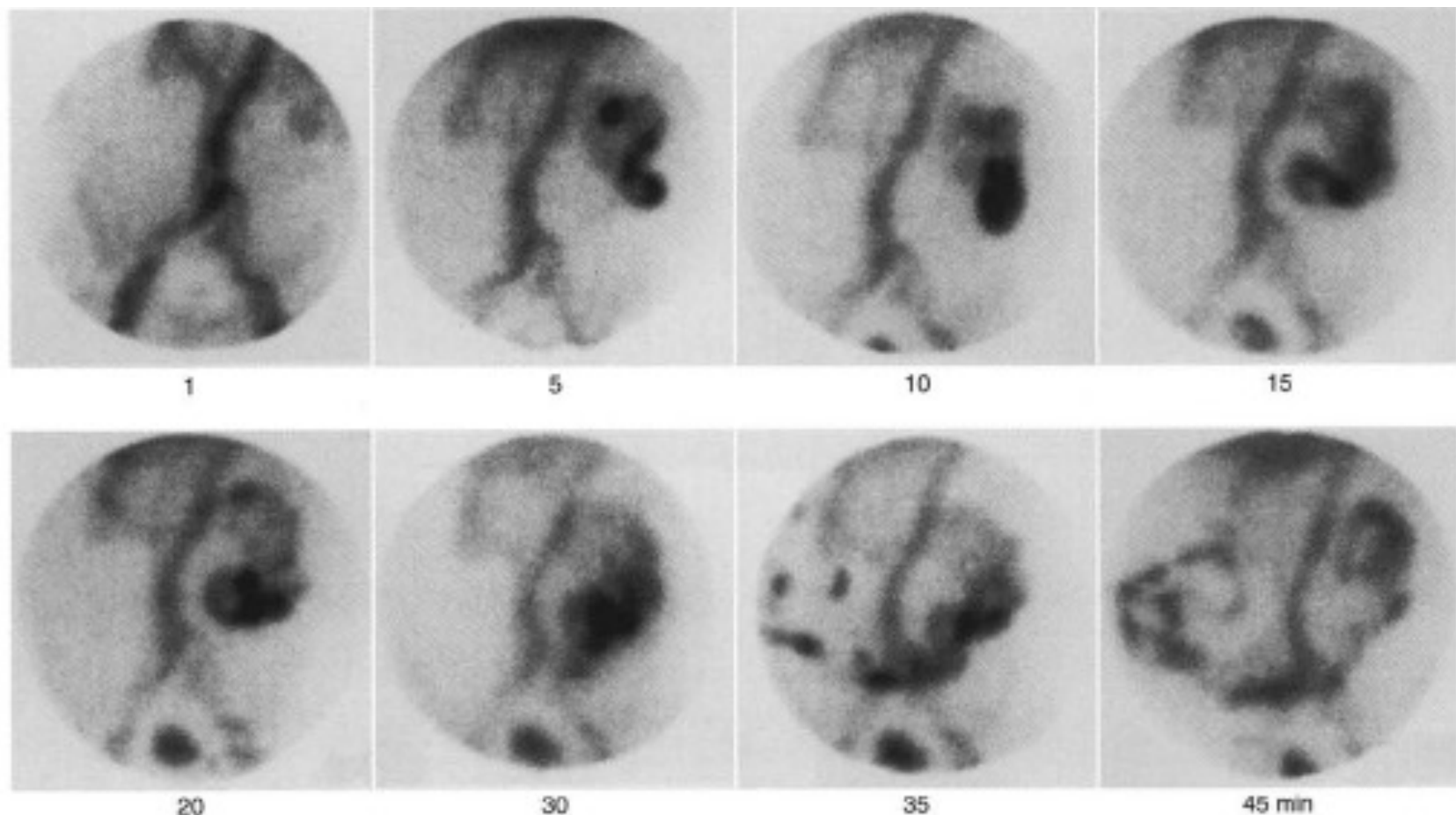
90 min

A 65-year-old man had had intermittent rectal bleeding for 2 days.

1. Describe the scintigraphic findings during this 90-minute study.
2. What is the purpose of the oblique/lateral pelvic view (last image) in this case?
3. What is your interpretation of the study?
4. What are the criteria for diagnosing and localizing a bleeding site?

Rectal bleeding

1. Abnormal activity accumulate early in the lower midline pelvis. The appearance is changing over time and seems to decrease and then increase again.
2. To differentiate activity in the rectum from bladder and penis, in this patient the activity is seen in the rectum.
3. Positive for gastrointestinal bleeding is not the answer. Localization is critical. The 90 minute lateral view confirms that this is rectal bleeding.
4. New activity, increases in amount over time and moves intraluminally.

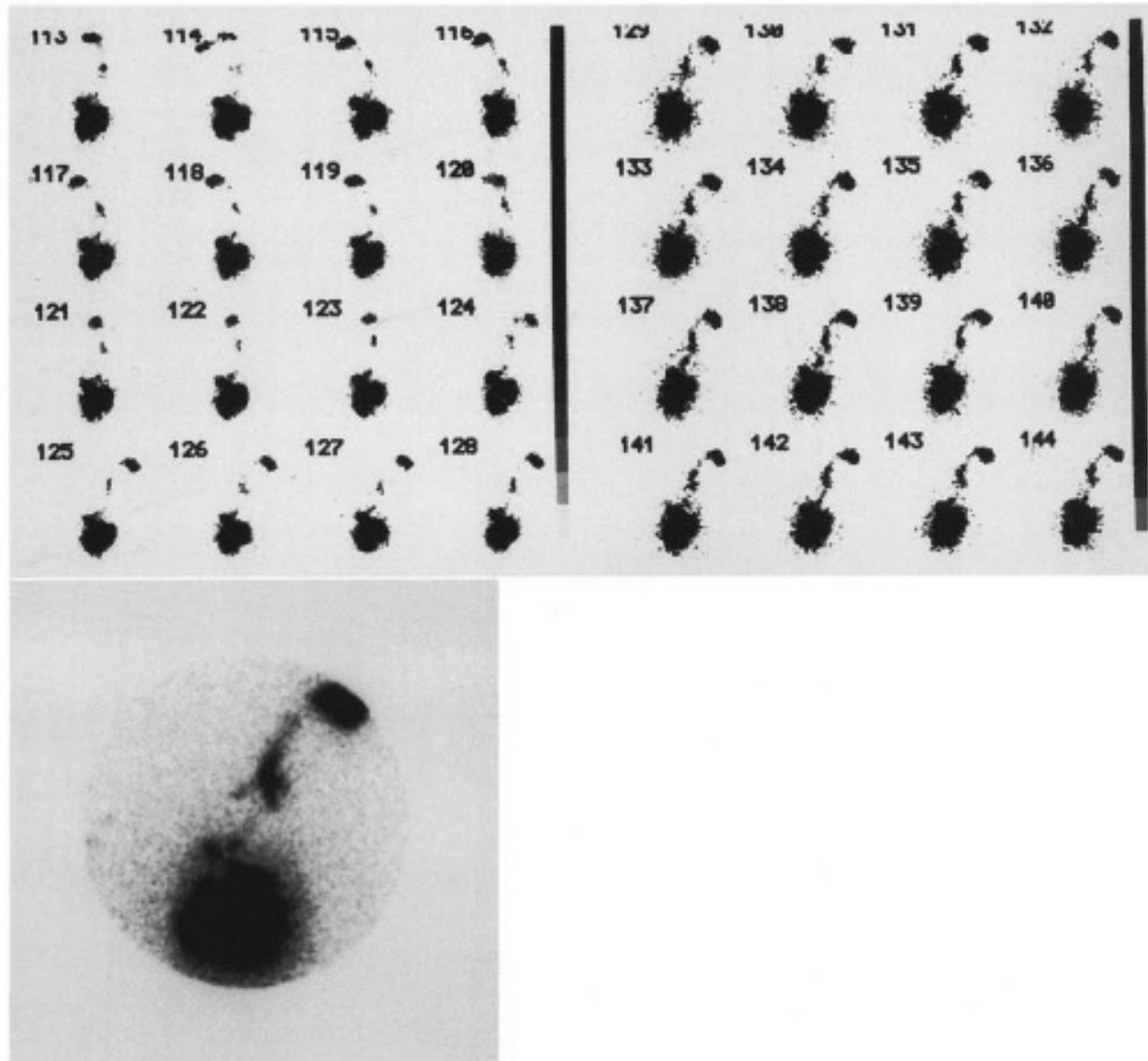


A 46-year-old man has a second episode of rectal bleeding.

1. What is the radiopharmaceutical, and what method of labeling was likely used?
2. Describe the scintigraphic bleeding study findings.
3. Provide a diagnosis.
4. List common causes for bleeding from this portion of the gastrointestinal tract.

Small bowel bleeding

1. Tc-99m RBCs. The in vitro method of labeling was used.
2. Evidence of active bleeding, first seen at 5 minutes, starting in the left upper abdomen and moving across the mid to lower abdomen to the right lower and then right mid abdomen.
3. Small bowel bleeding originating from the region of the jejunum.
4. Arteriovenous malformation or tumors

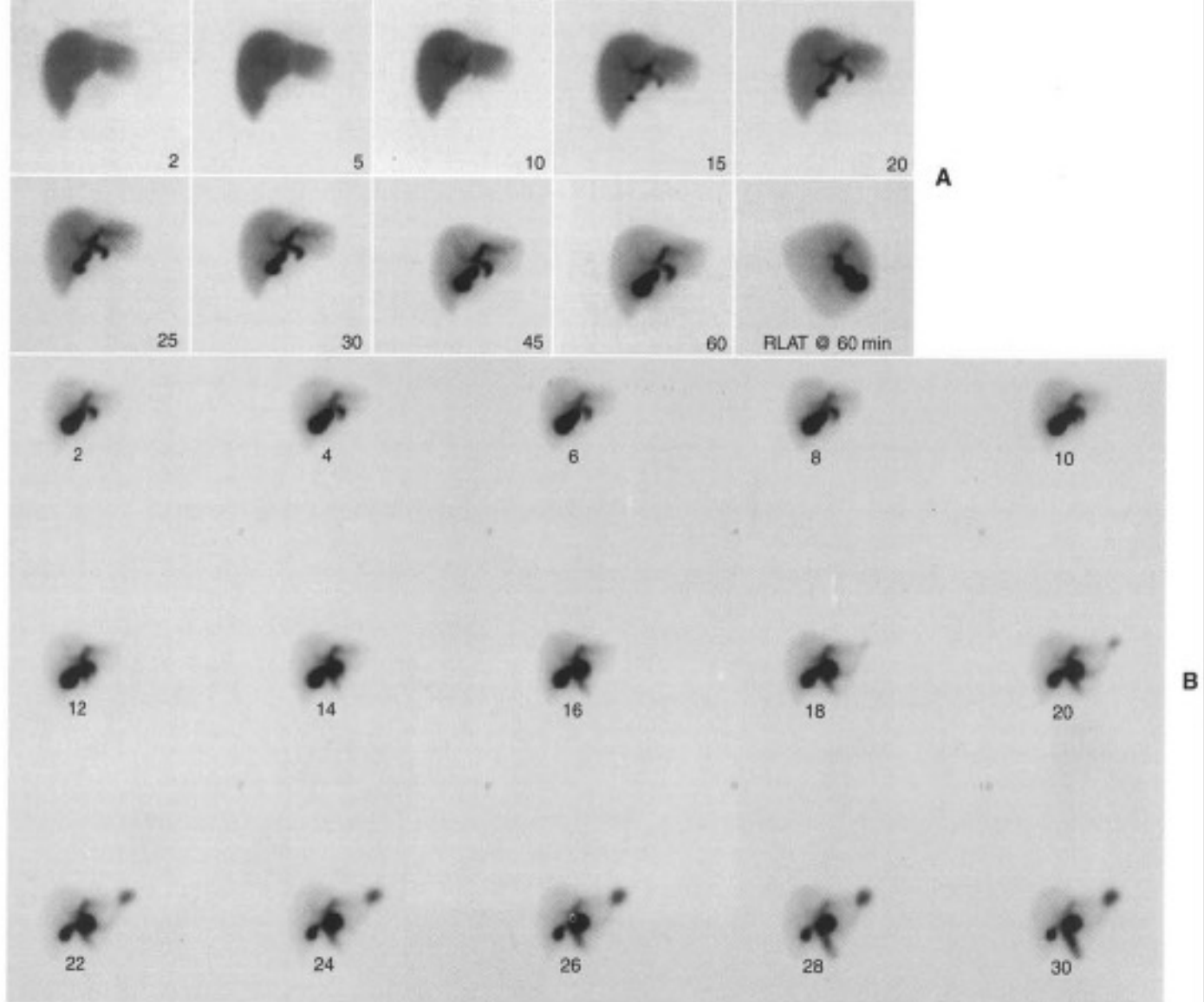


A 2-year-old was referred for "salivagram" (esophageal transit study) to diagnose suspected aspiration (anterior imaging). The result of a gastroesophageal reflux ("milk") study was positive for reflux but negative for aspiration.

1. What are the clinical symptoms of pulmonary aspiration?
2. What radiopharmaceutical is used for the salivagram, and what is the method of administration?
3. What are the scintigraphic findings in this case?
4. What is the advantage of the salivagram over the milk study?

Pulmonary aspiration

1. Recurrent pneumonia, cough, asthma, apnea or sudden infant death.
2. Tc-99m sulfur colloid in a small volume of fluid placed on the tongue and allowed to mix with oral secretion and swallowed.
3. Poor bolus progression noted in the dynamic esophageal swallow study with entrance into the main bronchi bilaterally and then into the right lower lobe.
4. The milk study is very sensitive for reflux, however it is insensitive for aspiration. The salivagram is sensitive for small amounts of pulmonary aspiration.

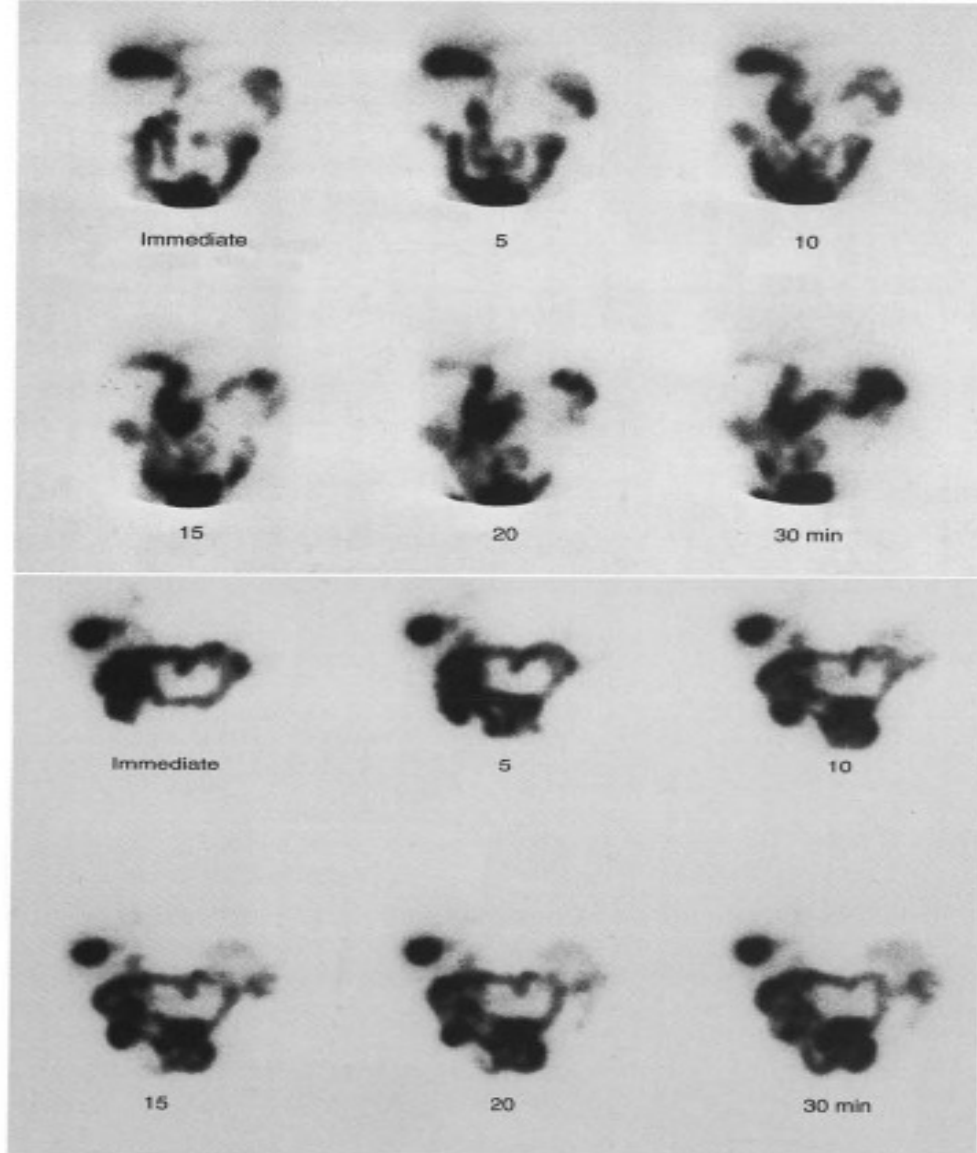


A 10-year-old girl has acute abdominal pain. A cholescintigraphy scan taken at 60 minutes (*A*) was followed by 30-minute cholecystikinin (CCK; sinicalide) infusion (*B*).

1. Describe the cholescintigraphic findings.
2. What is the likely diagnosis?
3. What other clinical presentations are common in patients with this problem?
4. What is the cause, pathological condition, and appropriate therapy for this entity?

Choledocal cyst

1. A. Good hepatic uptake and clearance into the gallbladder, common hepatic and proximal common bile duct at 60 minutes. No biliary to bowel transit. B. the gallbladder contracts with sincalide infusion, however focal increasing accumulation of radiotracer occurs just medial to the proximal portion of the common bile. The proximal common duct activity empties into the duodenum.
2. Likely choledocal cyst. Partial biliary obstruction also would cause radiotracer retention within the more proximal biliary duct.
3. Cholangitis, sepsis, pancreatitis or obstruction.
4. Congenital anomaly. Localize dilatation of the biliary tract, either fusiform or diverticular outpouching. Surgery is the appropriate therapy.



A

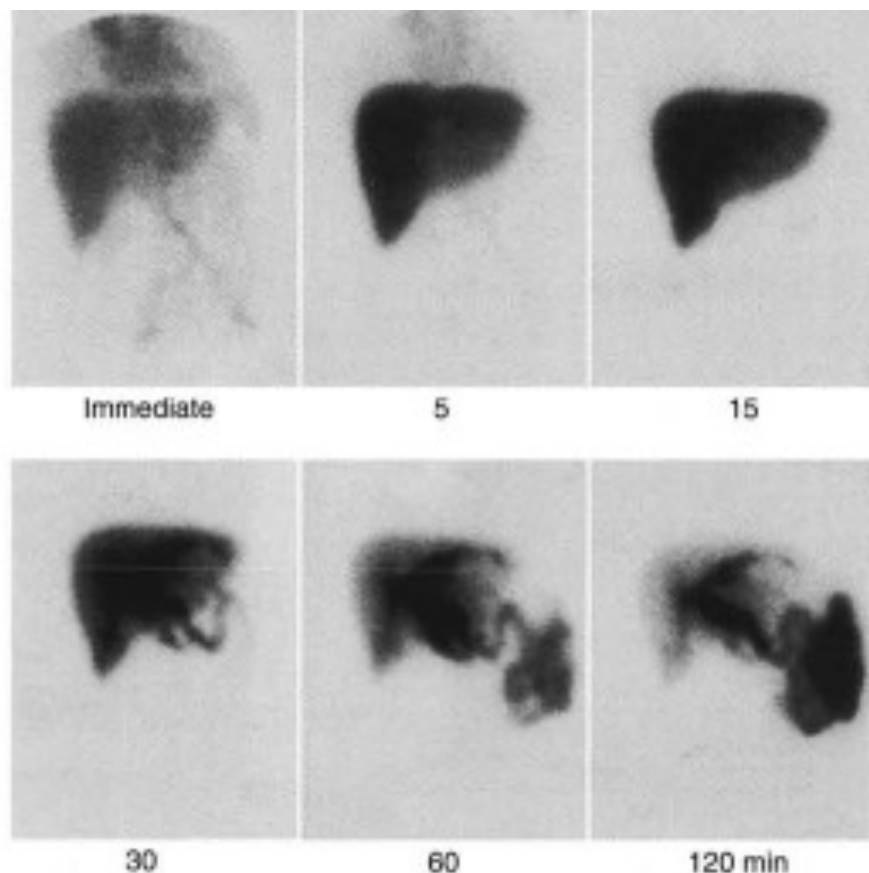
B

Two patients (*A* and *B*) have a similar history of recurrent, colicky upper abdominal pain and negative test results. They were referred for CCK cholecystigraphy to confirm the clinical diagnosis of chronic acalculous cholecystitis (CAC). Images were acquired during sincalide infusion.

1. What is CAC, and how does it differ from chronic calculous cholecystitis?
2. Why is sincalide cholecystigraphy required to make the diagnosis of CAC?
3. The calculated gallbladder ejection fraction (GBEF) was greater than 80% for patient *A* and 10% for patient *B*. What are their diagnoses?
4. What is the accuracy of CCK cholecystigraphy for confirming the diagnosis of CAC?

Chronic acalculous cholecystitis

1. CAC is clinically and pathologically identical to chronic calculous cholecystitis, except for absence of gallstone.
2. Anatomical imaging diagnosis depends heavily on visualization of gallstones. CCK cholescintigraphy allows quantification of gallbladder contraction. Diseased gallbladders do not contract.
3. Findings consistent with chronic acalculous cholecystitis in patient B but not A.
4. A low GBEF has a positive predictive value of more than 90% that cholecystectomy will cure the patient's symptoms and that diagnosis will be confirmed by pathological gallbladder examination.

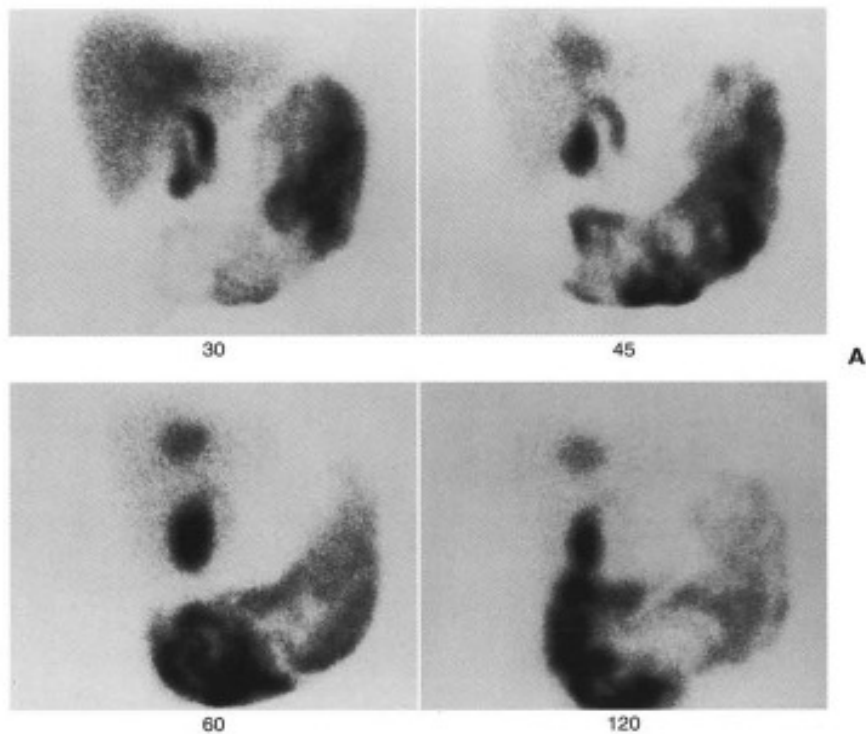


A 46-year-old woman 8 months after cholecystectomy and removal of common bile duct stone has recurrent upper abdominal pain.

1. Describe the cholescintigraphic findings.
2. Provide a differential diagnosis at 60 minutes. What is the likely diagnosis at 2 hours?
3. Give the differential diagnosis for the postcholecystectomy syndrome.
4. What is sphincter of Oddi dysfunction?

Post cholecystectomy syndrome

1. Prompt hepatic uptake, clearance into biliary ducts by 15 to 30 minutes, retention of activity in ducts, apparently dilated proximal hepatic and common ducts, biliary to bowel clearance but prominent retention in common duct with apparent cutoff distally.
2. 60 minutes: partial common duct obstruction versus post biliary duct obstruction surgery with nonobstructed persistent bile duct dilatation. 120 minutes: suspected partial obstruction.
3. Common duct stone, inflammatory stricture of the common duct, sphincter of Oddi dysfunction, inflamed cystic duct remnant.
4. Sphincter of Oddi dysfunction is a partial biliary obstruction at the level of the sphincter of Oddi not caused by atones or stricture.



A



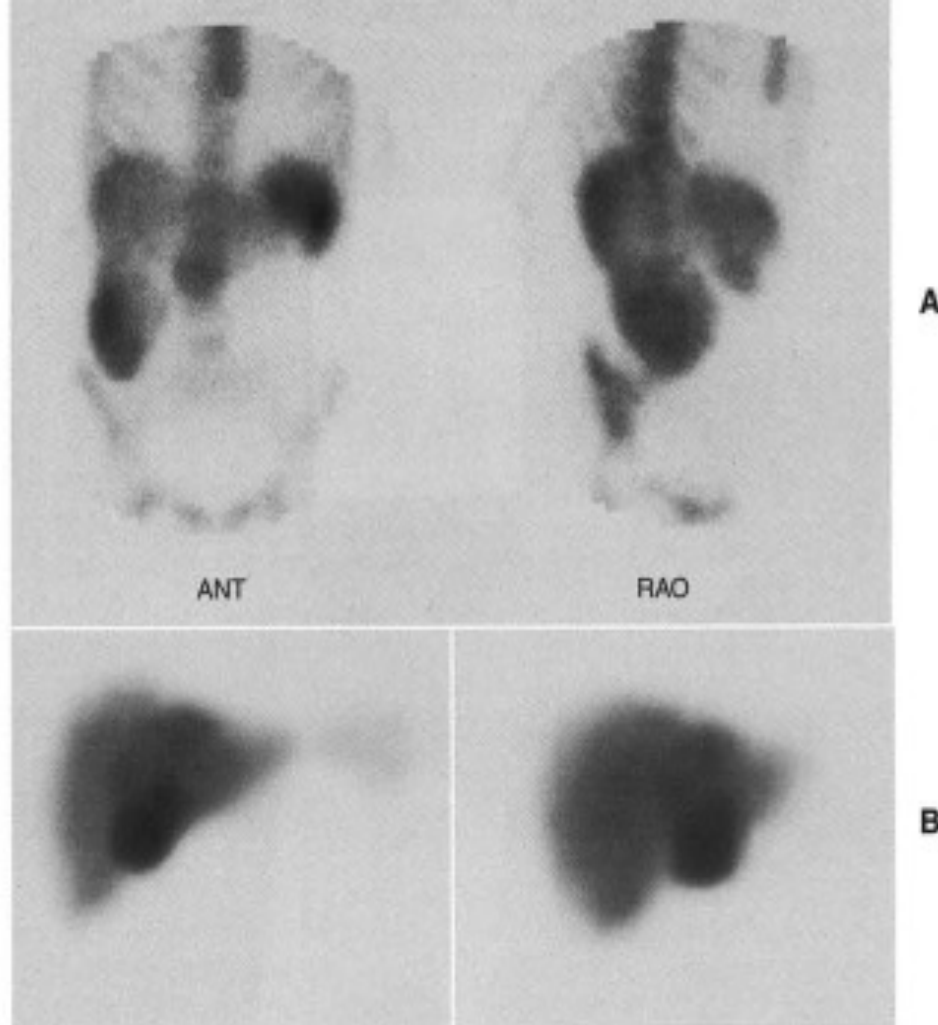
B

A 35-year-old woman has abdominal pain. Cholescintigraphy (A) images at 30 to 120 minutes. The CT scan (B) shows a large, circumscribed lesion at the juncture of the right and left lobes.

1. Describe the cholescintigraphic findings.
2. What is the differential diagnosis? What is the diagnosis in this case?
3. What is the appropriate therapy for each of these diagnoses?
4. What other radiopharmaceutical could confirm the diagnosis in this case?

Focal nodular hyperplasia

1. Increased uptake that corresponds to the lesion seen on CT. The uptake is retained after liver washout.
2. Benign and malignant tumors that have hepatocytes e.g., hepatic adenoma, hepatoma and FNH. The latter is the correct diagnosis.
3. FNH usually requires no specific therapy. Hepatic adenoma requires discontinuation of oral contraceptives and surgical removal and hepatoma requires resection.
4. Tc-99m sulfur colloid.

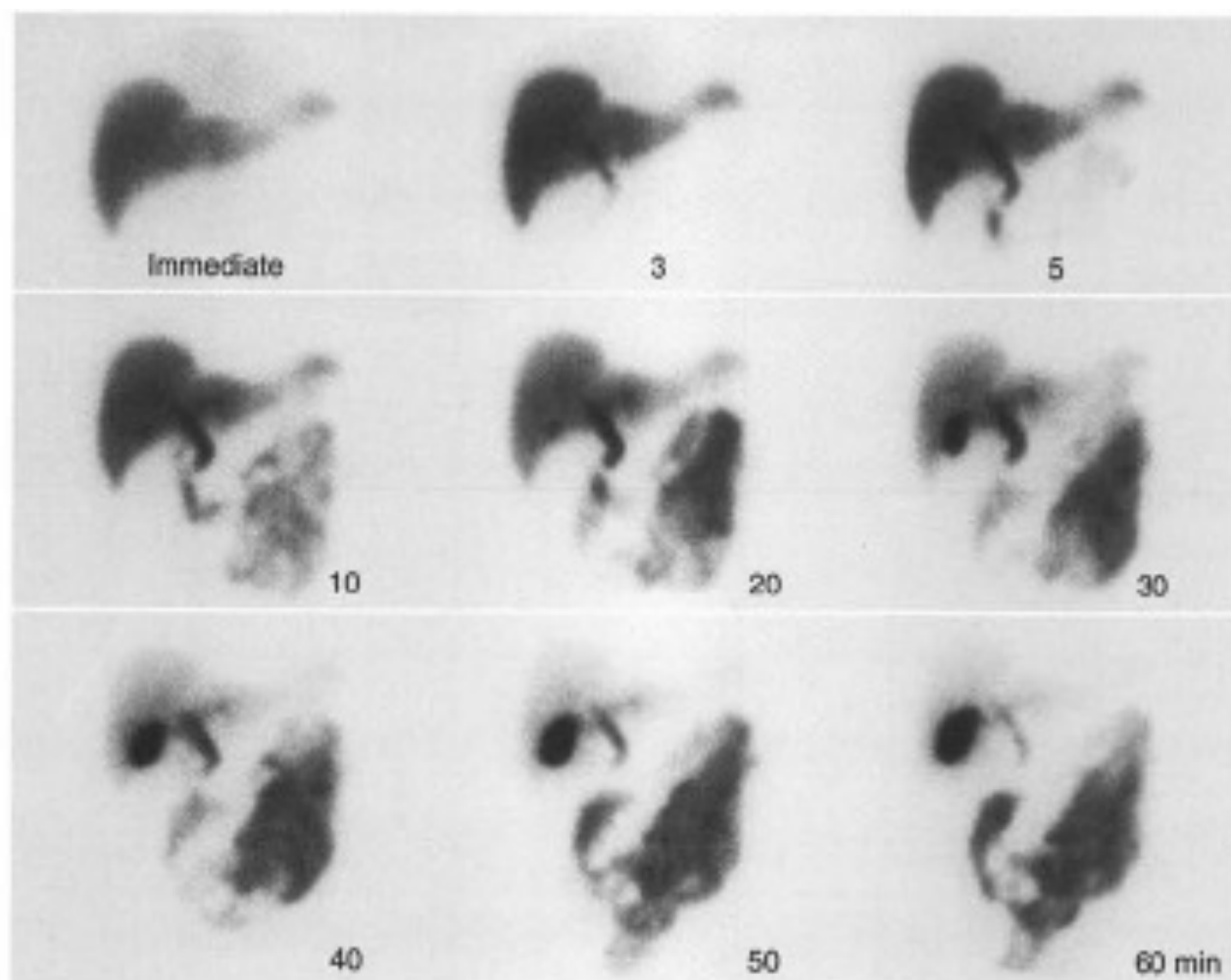


^{99m}Tc sulfur colloid liver-spleen scans in two patients. *A*, A 50-year old with abnormal liver function and hepatosplenomegaly. *B*, A 59-year-old with a liver mass on CT in the quadrate lobe. Anterior (*left*) and right anterior oblique views (*right*) in both studies.

1. What is the mechanism of ^{99m}Tc sulfur colloid uptake?
2. What is the normal distribution of this radiopharmaceutical?
3. What are the image findings and diagnoses in these two patients?
4. List three other causes for hot spots ^{99m}Tc sulfur colloid spleen scans.

Hot spot Tc-99m sulfur colloid imaging

1. Uptake by reticuloendothelial system.
2. 85% by Kupffer cells, 10% by the spleen and 5% by the bone marrow.
3. A. the central large cold region may be caused by an intrahepatic mass but the pattern has been stable and CT shows cirrhosis. B. increased uptake in the region of the quadrate lobe, consistent with FNH.
4. Superior vena cava syndrome, inferior vena cava obstruction, Budd-Chiari syndrome.

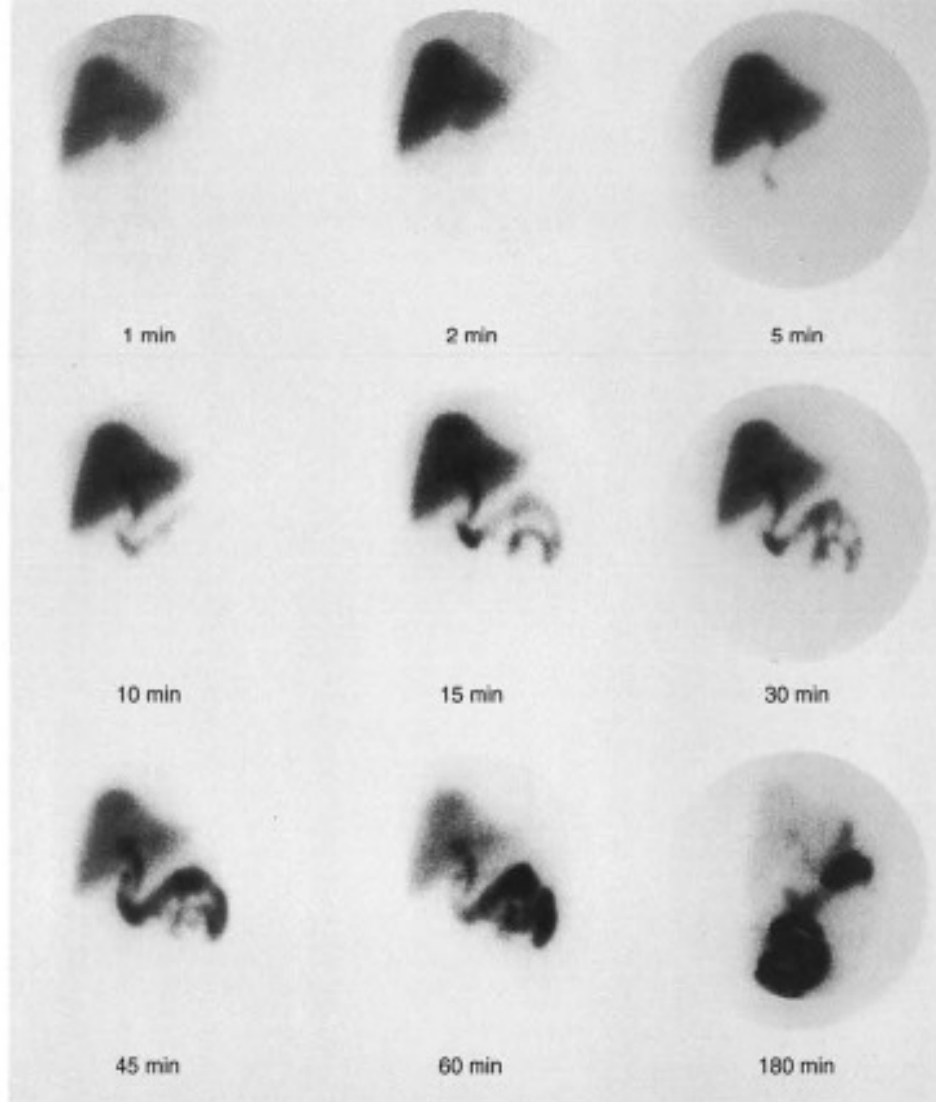


A 39-year-old woman had acute upper abdominal pain. Cholescintigraphy was requested.

1. What patient preparation is required before cholescintigraphy?
2. Which hepatobiliary radiopharmaceuticals are available in the United States?
3. What are the radiopharmaceuticals mechanisms of uptake and their differences?
4. Has acute cholecystitis been ruled out? With what degree of certainty?

Cholescintigraphy – normal study

1. No oral intake for 3 to 4 hours before injection.
2. Tc-99m disofenin or Tc-99m brida.
3. Both are iminodiacetic acid analogues, extracted and excreted by hepatocytes into biliary system. Mebrofenin has higher hepatocyte extraction (98%)
4. Yes. Acute cholecystitis is ruled out with a high degree of certainty.

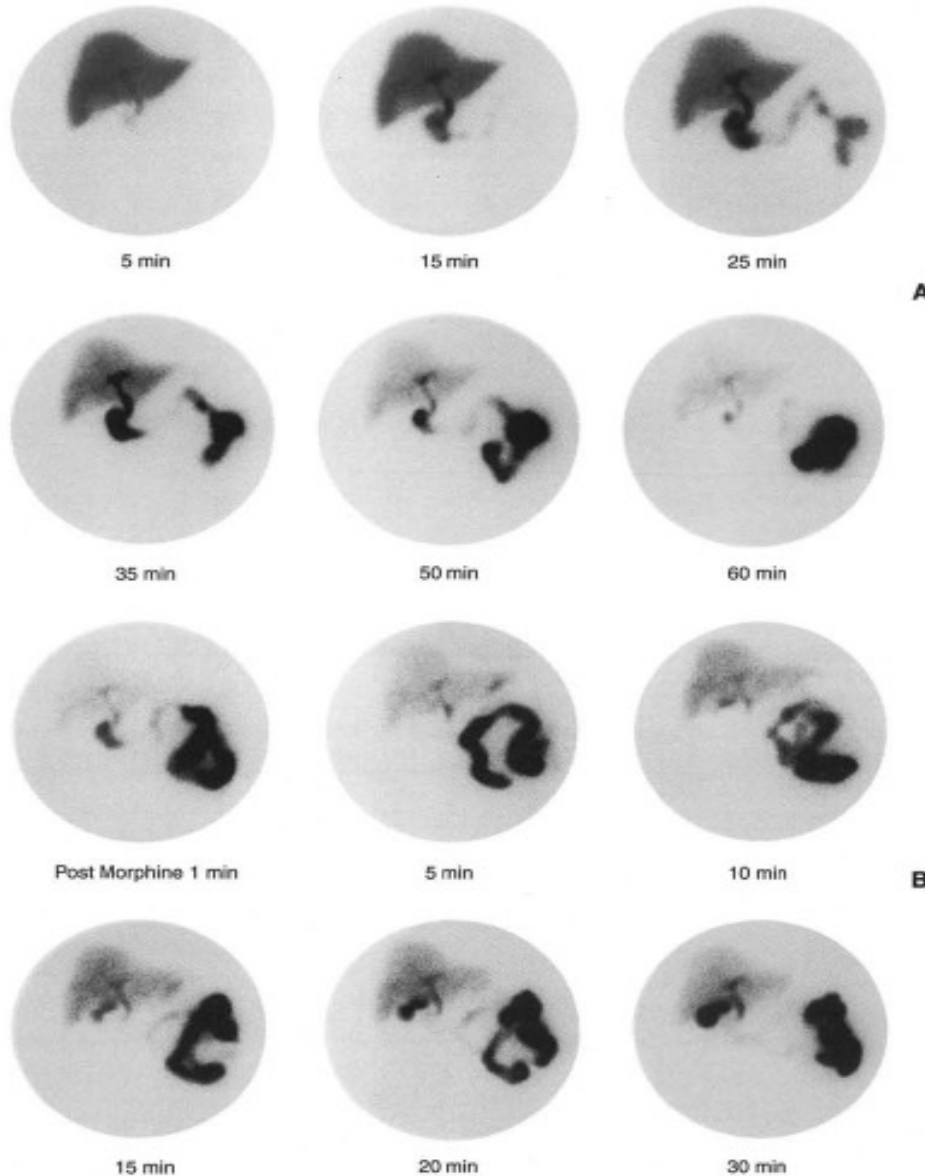


A 45-year-old woman with clinically suspected acute cholecystitis.

1. A, Is the study normal or abnormal at 60 minutes? B, Is it diagnostic of acute cholecystitis at 60 minutes? C, Is it diagnostic of acute cholecystitis at 180 minutes?
2. A, What is the diagnostic accuracy of cholescintigraphy for acute calculous cholecystitis? B, What is the diagnostic accuracy of cholescintigraphy for acute acalculous cholecystitis?
3. What is the relative accuracy of cholescintigraphy versus ultrasonography?
4. What are the most common causes for false-positive cholescintigraphy results in the evaluation of acute cholecystitis?

Acute cholecystitis

1. A. Abnormal. B. No. C, yes
2. A. Sensitivity 98%, specificity 95%, B greater than 90%.
3. The few direct comparisons published have shown cholescintigraphy superior to US.
4. Prolonged fasting, hyperalimentation, chronic cholecystitis and hepatic insufficiency.

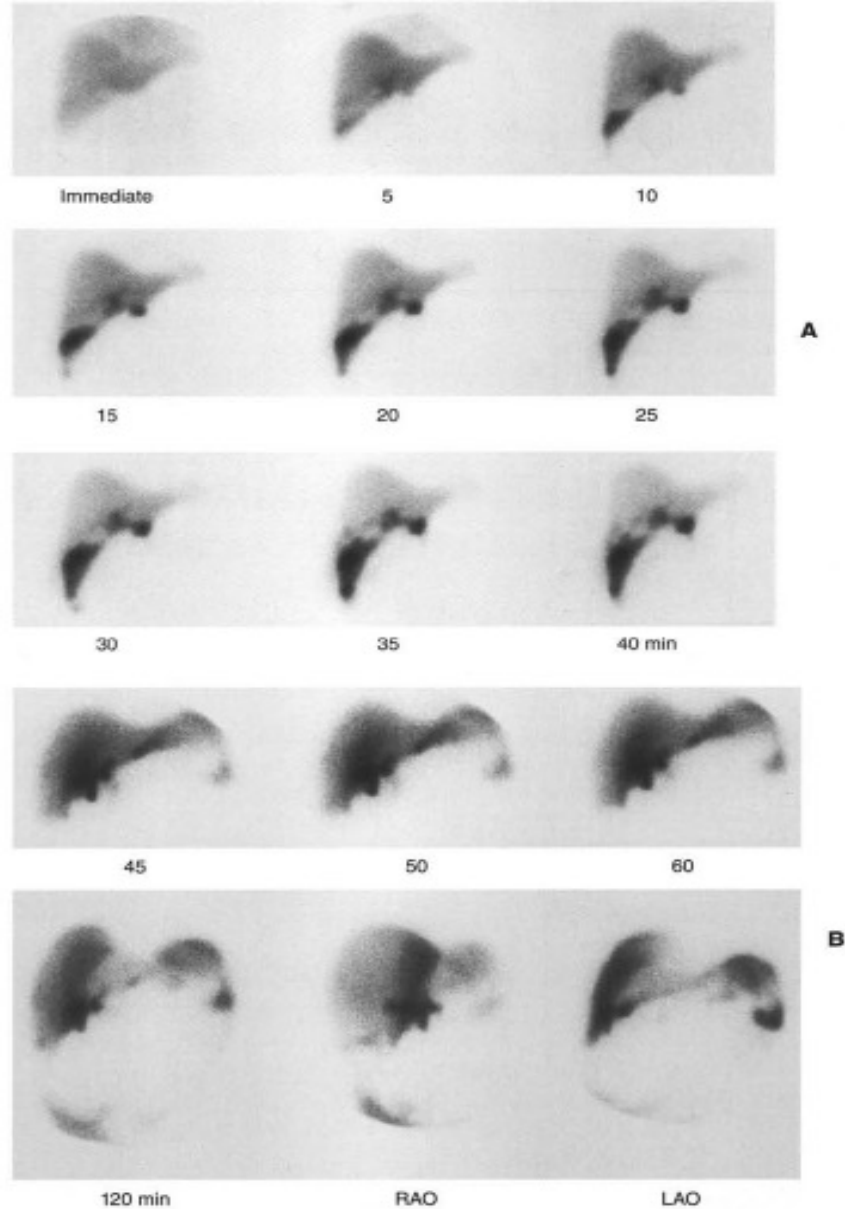


A 53 year-old woman has recent onset of right upper quadrant pain and suspected acute cholecystitis. *A*, 60-minute cholescintigraphy. *B*, 30-minute postmorphine acquisition.

1. Why is morphine used as an alternative to 3- to 4-hour delayed imaging?
2. In a patient with nonvisualization of the gallbladder at 60 minutes, what must be determined before morphine is administered?
3. What is the accuracy of morphine cholescintigraphy?
4. What is the dose of morphine, and how long after injection is the image obtained?

Morphine augmented cholescintigraphy

1. Morphine produces contraction of the sphincter of Oddi, which increases intraluminal common bile duct pressure. Bile and excreted radiotracer then preferentially flow through the cystic duct into the GB if the cystic duct is patent.
2. Exclude drug allergy. Do not give if evidence of common duct obstruction.
3. The accuracy is at least as good, if not better than the delayed imaging method.
4. IV 0.04 mg/kg morphine. Images are acquired for an additional 30 minutes.



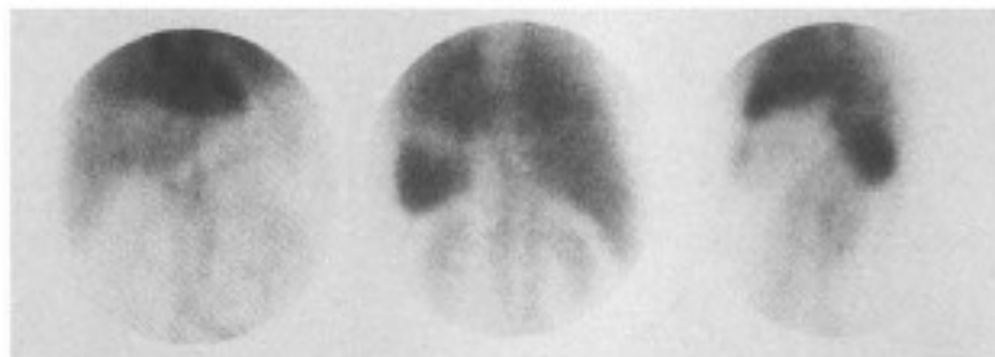
A 43-year-old woman has a low-grade fever and abdominal discomfort 2 days after cholecystectomy.

1. Describe the cholecystigraphic findings.
2. Interpret the study.
3. What are possible causes for this problem?
4. What unique information does cholecystigraphy provide that is not obtainable from other diagnostic imaging procedures?

Biliary leak

1. Rapid bile leakage probably originating from the region of the ligated cystic duct and extending toward the right colonic gutter with time, over the dome of the liver.
2. Rapid biliary leak.
3. Cystic duct ligature after cholecystectomy, surgical anastomosis, trauma and inflammatory processes.
4. Confirm that fluid collection seen by anatomical imaging modalities are biliary in nature.

Immediate



Delayed



ANT

POST

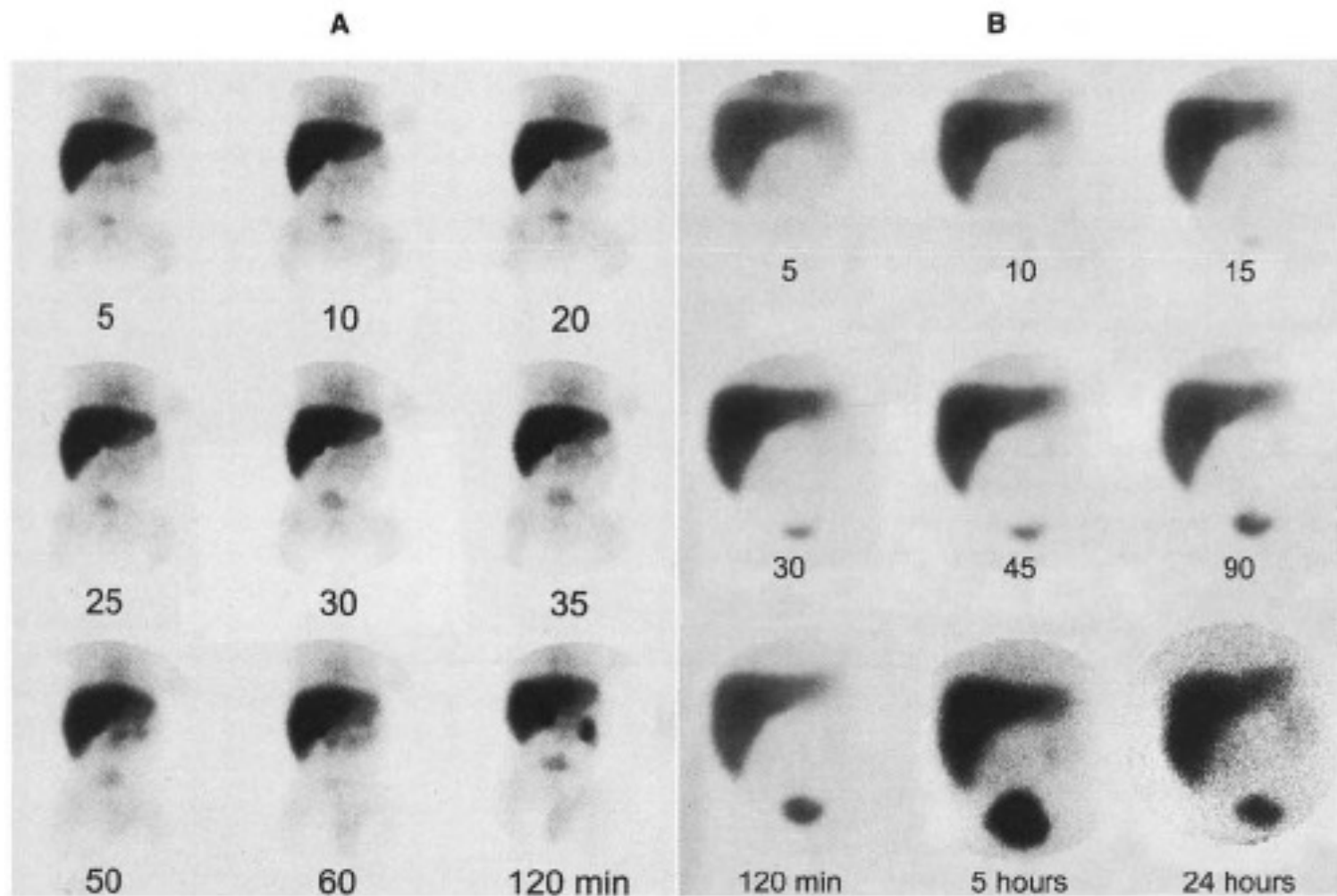
LLAT

A 59-year-old man is referred with abdominal pain. CT reportedly showed a lesion of uncertain origin in the left lobe of the liver.

1. What is the radiopharmaceutical? What is the study?
2. What are the findings and the likely diagnosis?
3. How large must this lesion be to be seen on planar scintigraphy?
4. What are the advantages/disadvantages and accuracy of the radionuclide study?

Cavernous hemangioma of the liver

1. Tc-99m RBCs
2. Immediate images show no definite abnormality. Delayed images show increased focal uptake in the left lobe consistent with cavernous hemangioma.
3. At least 2 cm
4. Very specific (>99%) for hemangioma. Poor sensitivity for small lesions.

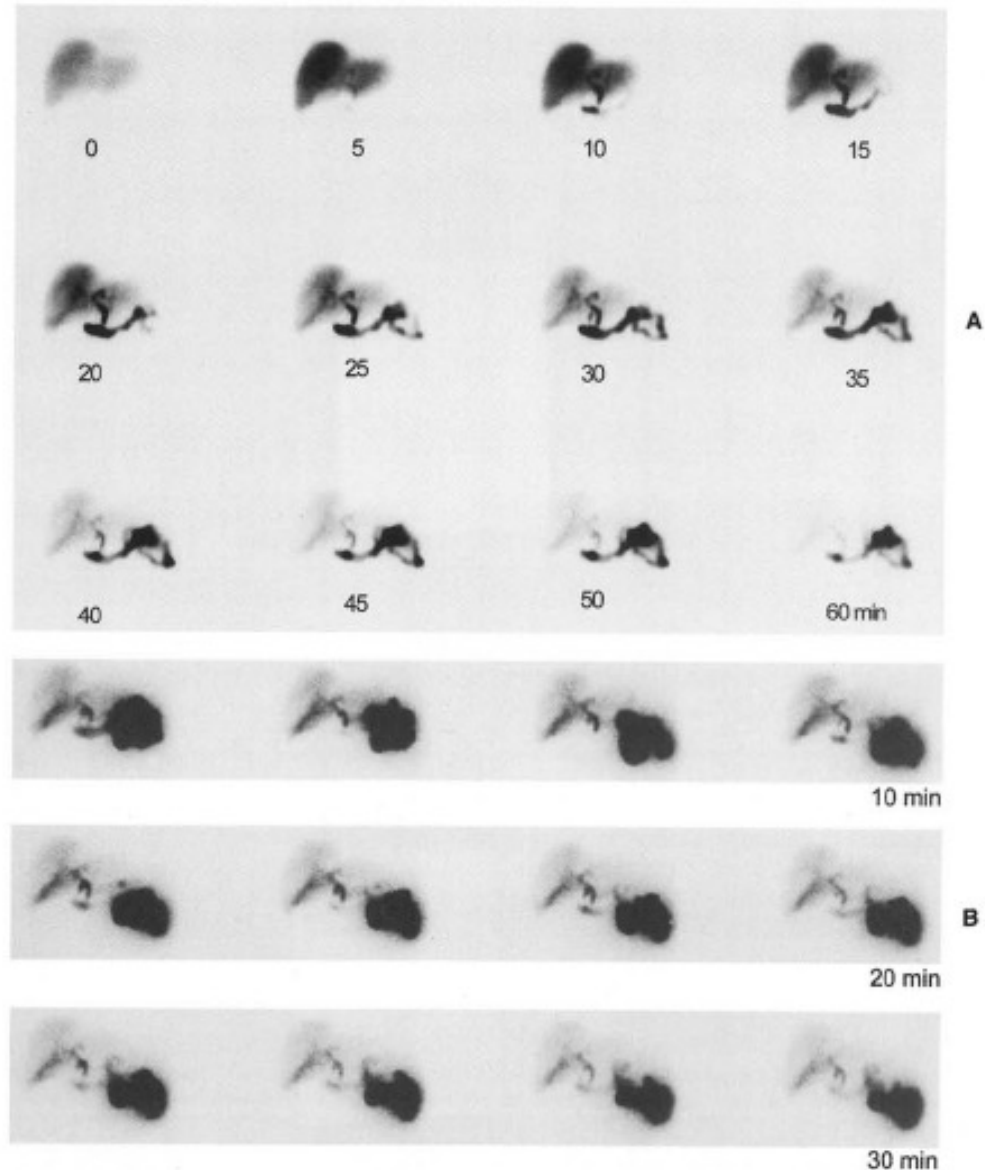


Both patients are 4 weeks old (*A* and *B*). They have hyperbilirubinemia and were referred to rule out biliary atresia.

1. What patient preparation is required before the cholescintigraphic study?
2. What is the differential diagnosis of hyperbilirubinemia in this age group?
3. What are the scintigraphic findings on these studies and your interpretations?
4. What is the accuracy of cholescintigraphy to diagnose biliary atresia?

Biliary atresia

1. Phenobarbital, 5mg/kg/day for 3 to 5 days before study.
2. Inflammatory, infections and metabolic causes for neonatal hepatitis and biliary atresia.
3. A. delayed blood pool clearance as the result of hepatic insufficiency. Biliary clearance at 50 minutes and increasing through 120 minutes. B. good liver function. No secretion into biliary duct during the initial 120 minutes or at 5 and 24 hours. Case B consistent with biliary atresia. Case A with neonatal hepatitis.
4. Sensitivity 97% and specificity 82%.



A 63-year-old woman has been hospitalized for 9 days with multiple serious medical problems and is receiving hyperalimentation. Now acute abdominal pain has developed. She has been referred for cholecystigraphy to rule out acute cholecystitis. *A*, 60-minute cholecystigraphy. *B*, Additional 30-minute images after administration of morphine.

1. What is the relative accuracy of cholecystigraphy in this patient's clinical setting?
2. Describe the cholecystigraphic findings.
3. What is the clinical significance of these findings?
4. What pathological condition is likely?

RIM sign

1. Increased incidence of false positive in patients who have been fasting more than 24 hours
2. Nonvisualization of GB after 60 minutes. After morphine, no filling of the GB occurs. Increased uptake is seen in the region of the GB fossa, which persists after most of the liver has washout (RIM sign)
3. Nonvisualization of the GB after morphine is consistent with acute cholecystitis. The RIM sign is very specific for acute cholecystitis and confirms diagnosis.
4. The RIM sign indicates severe acute cholecystitis which is associated with an increased incidence of GB gangrene and perforation.

Genitourinary scan

Pearls & Pitfalls

General

- The common indications for radionuclide scan for kidneys include allergy to iodinated contrast material, assessment of possible renal artery stenosis and differentiation of obstruction from collecting system. In children cortical scanning agents are used for evaluation of pyelonephritis.

Pearls & Pitfalls

General

- Tc-99m DTPA reflects glomerular filtration, Tc-99m MAG3 is essential a tubular agent.
- Tc-99m DMSA is renal cortical agent.
- Tc-99m glucoheptonate is used to evaluate both renal cortical and collecting system.
- Maximum parenchymal activity is seen at about 3 to 5 minutes and bladder activity is seen by 4 to 8 minutes.

Pearls & Pitfalls

General

- Half of the renal activity should be cleared in about 8 to 12 minutes.
- On a postcaptopril renogram using Tc-99m MAG3 , the kidney that has delayed clearance with significant renal cortical retention should be the one with the renal artery stenosis.
- Bilateral delayed clearance can be caused by bilateral stenosis, obstruction, renal disease, dehydration or hypotension.

Pearls & Pitfalls

General

- ATN perfusion is usually normal with bilaterally increased renal cortical activity and rising renogram curves when Tc-99m MAG3 is used.
- When faced with abnormal time activity curves, look at the images to see if the problem is parenchymal or related to the collecting system.

Pearls & Pitfalls

- Common indications are to differentiate rejection from ATN.
- Renal transplant • ATN is usually seen within the first week after transplantation. It usually has preserved renal perfusion with progressive accumulation of tubular agents (Tc-99m MAG3) in the renal parenchyma. It should improve with time.

Pearls & Pitfalls

Renal transplant

- Severe ATN can present with enough edema immediately after surgery to have reduced perfusion and therefore look similar to acute rejection.
- Cyclosporin toxicity can look like ATN but is usually not seen in the immediate postoperative period.
- Rejection usually has poor perfusion and poor tubular excretion.

Pearls & Pitfalls

Renal transplant

- Look for photopenic defects around the transplant on the blood pool image that may be caused by urinomas, hematomas and lymphoceles.

Pearls & Pitfalls

Testicular imaging

- Common indications are to differentiate between epididymitis and acute or delayed torsion.
- The initial problem is to determine whether blood flow is increased or decreased.
- The best way to determine which side is abnormal is to obtain a patient history.

Pearls & Pitfalls

Testicular imaging

- Epididymitis should be diffusely hot on all images and frequently focal hot in the region of the epididymitis.
- Increased flow to one hemiscrotum and a rim of testicular activity with a cold center (halo sign) can be a delayed torsion but also can be testicular abscess, hematoma or tumor

Radiopharmaceuticals

- **Tc-99m labeled Compounds:**

- **Glomerular Agents:**

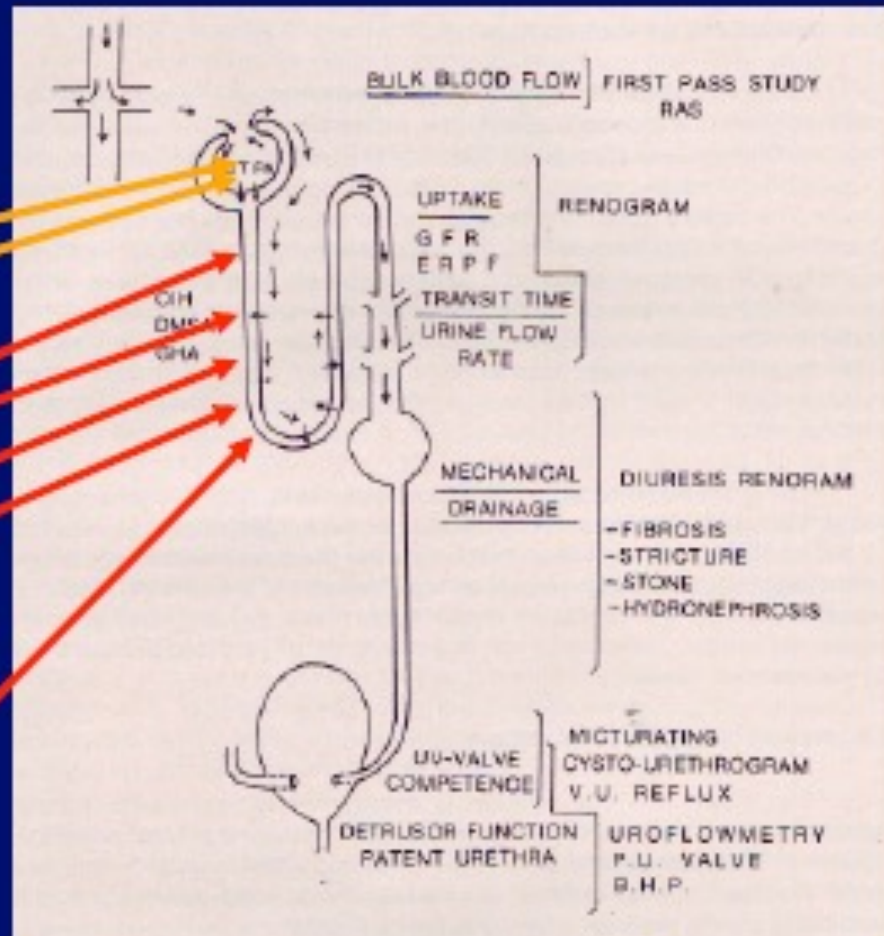
- Tc-99m DTPA
 - Tc-99m GHA

- **Tubular Agents:**

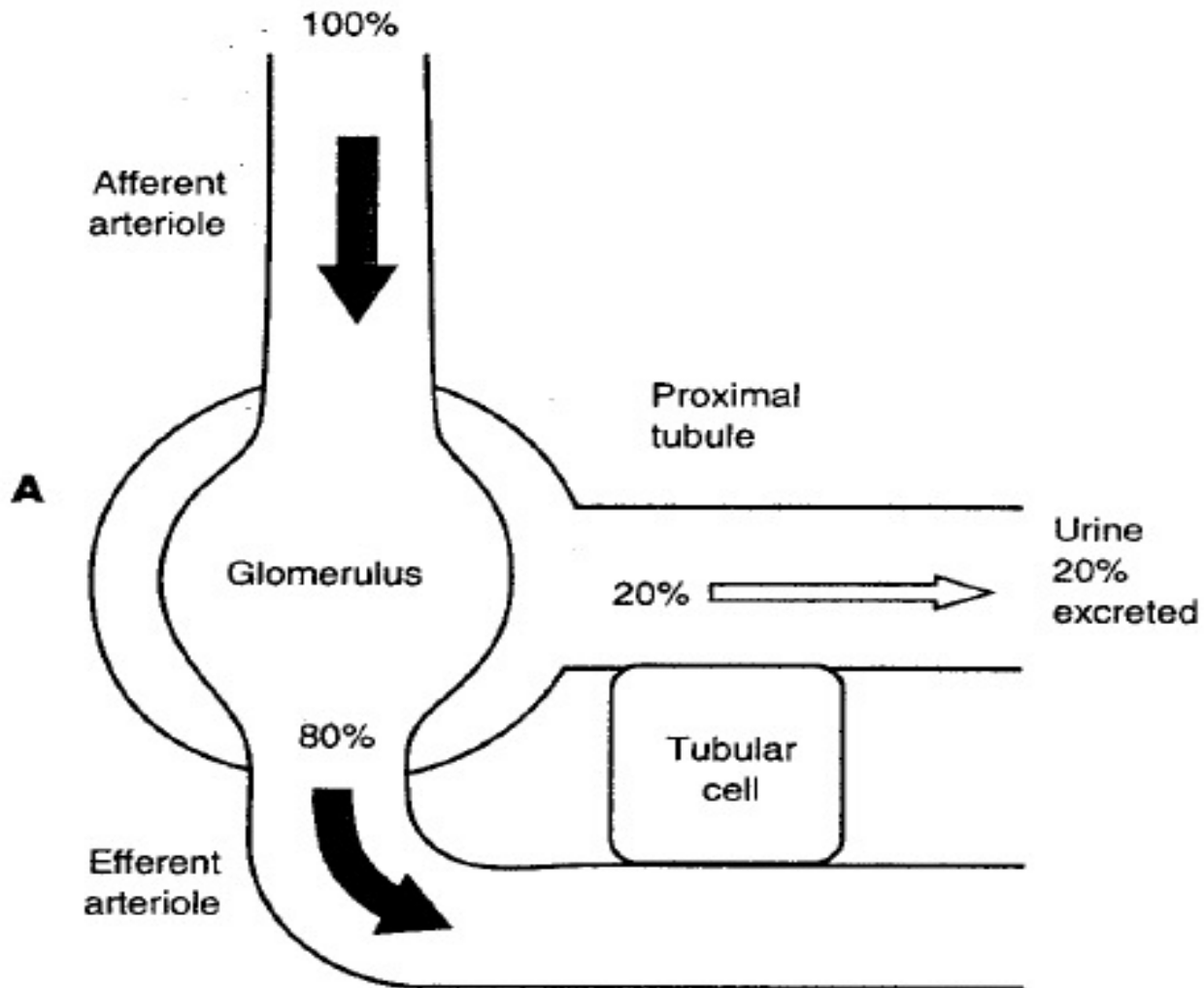
- Tc-99m MAG-3
 - Tc-99m EC
 - Tc-99m DACH
 - Tc-99m DMSA

- **Iodine labeled compounds:**

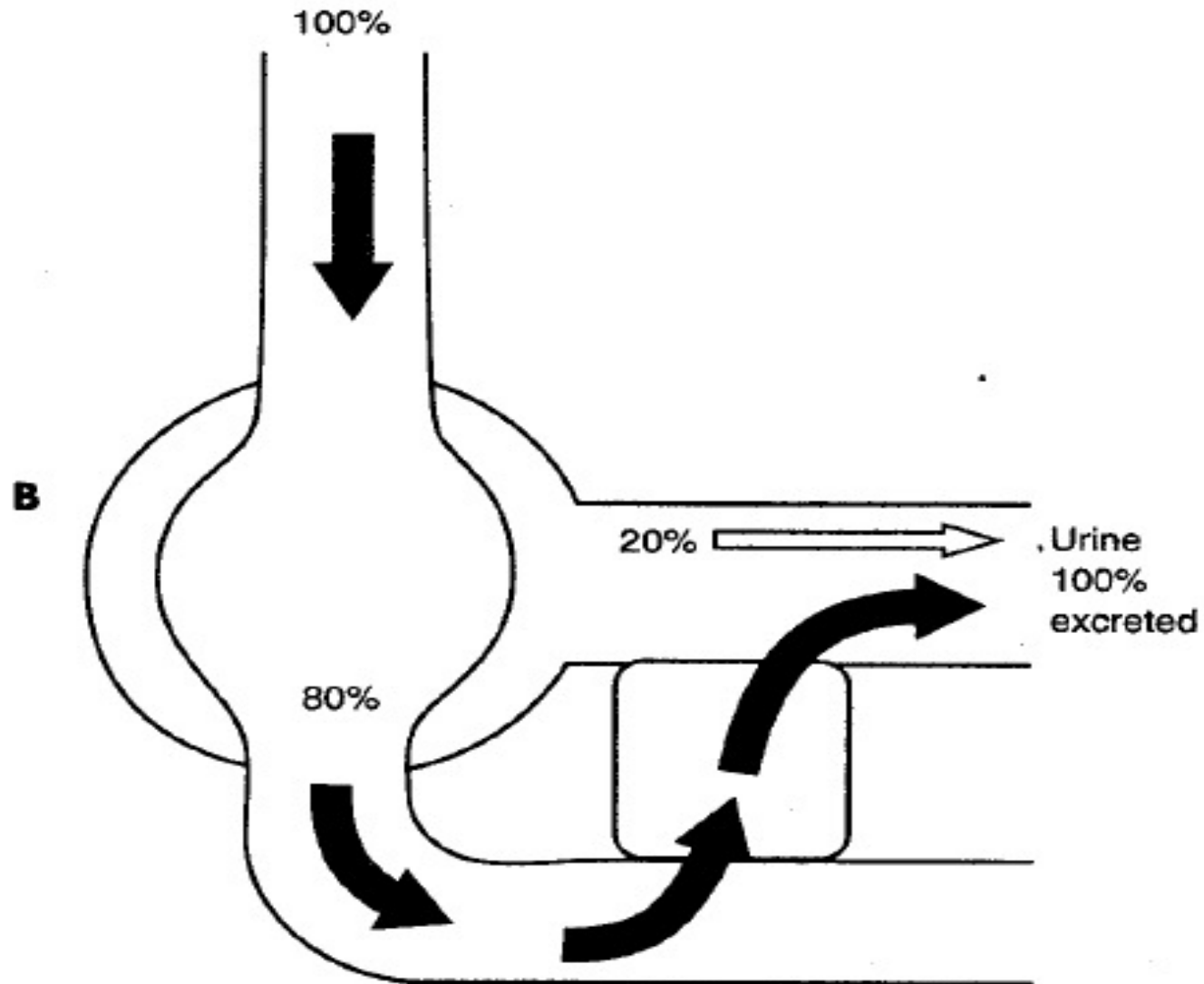
- I-131/125/123 Hippuran



GLOMERULAR FILTRATION



TUBULAR SECRETION



Choosing Renal Radiotracers

CLINICAL QUESTIONS	RADIOTRACERS
Perfusion	MAG-3, DTPA
Morphology	DMSA
Obstruction	MAG-3, DTPA, OIH
Relative function	All
GFR quantitation	Cr-51 EDTA, DTPA

Glomerular filtration 100 %	DTPA
Tubular secretion 100%	MAG 3
Tubular secretion 80% Glomerular filtration 20%	HIPPURAN
Cortical binding 40%	DMSA
Glomerular filtration 80% Cortical binding 15%	GLUCOHEPTONATE

	Tc-99m DTPA	Tc-99m MAG 3
Glomerular filtration	100%	-
Tubular secretion	-	100%
Extraction fraction	20%	40 – 50%
Target to back ground ratio	Poor	Good
Protein bound	No	Yes
Time for imaging	Immediate	Immediate
Heating for labeling	No	Yes

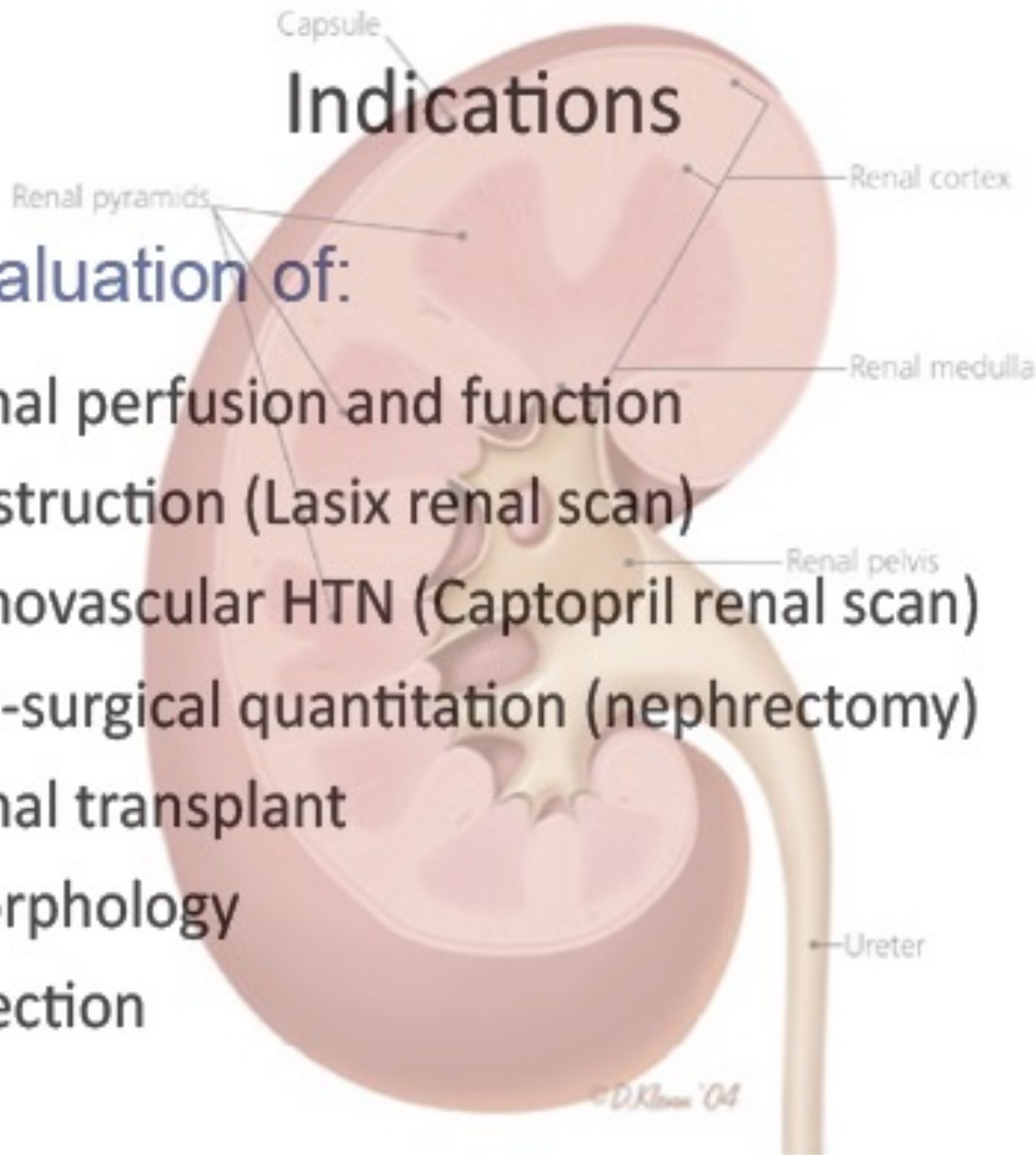
NUCLEAR NEPHRO-UROLOGY

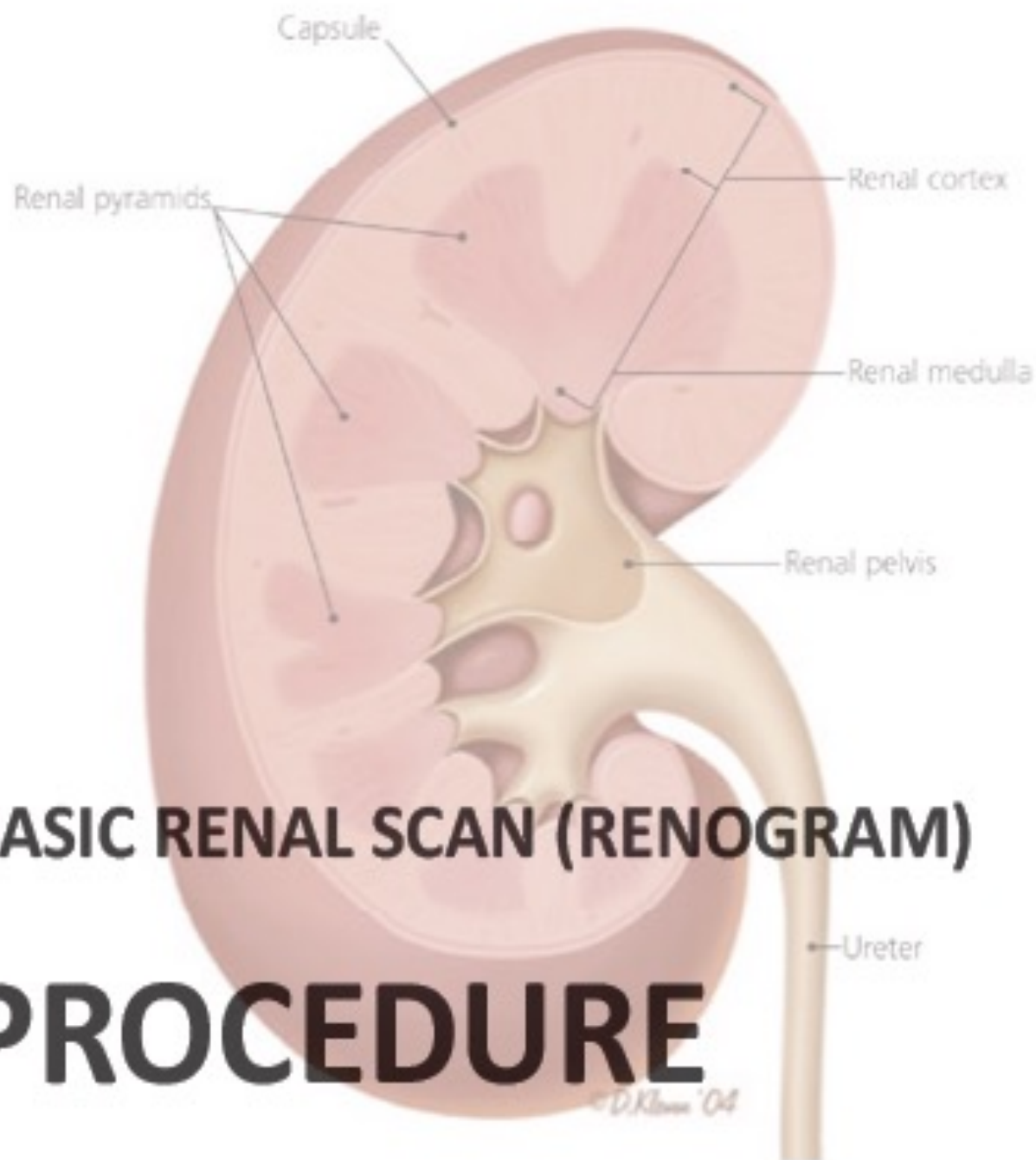
- Renogram
- Renal scan (DMSA Renal scan)
- Renal Dynamic Study
- Renal clearance studies (GFR, ERPF)
- Voiding cystography
- Renal transplant evaluation

Indications

Evaluation of:

- Renal perfusion and function
- Obstruction (Lasix renal scan)
- Renovascular HTN (Captopril renal scan)
- Pre-surgical quantitation (nephrectomy)
- Renal transplant
- Morphology
- Infection





BASIC RENAL SCAN (RENOGRAM)

PROCEDURE

© D. Klein '04

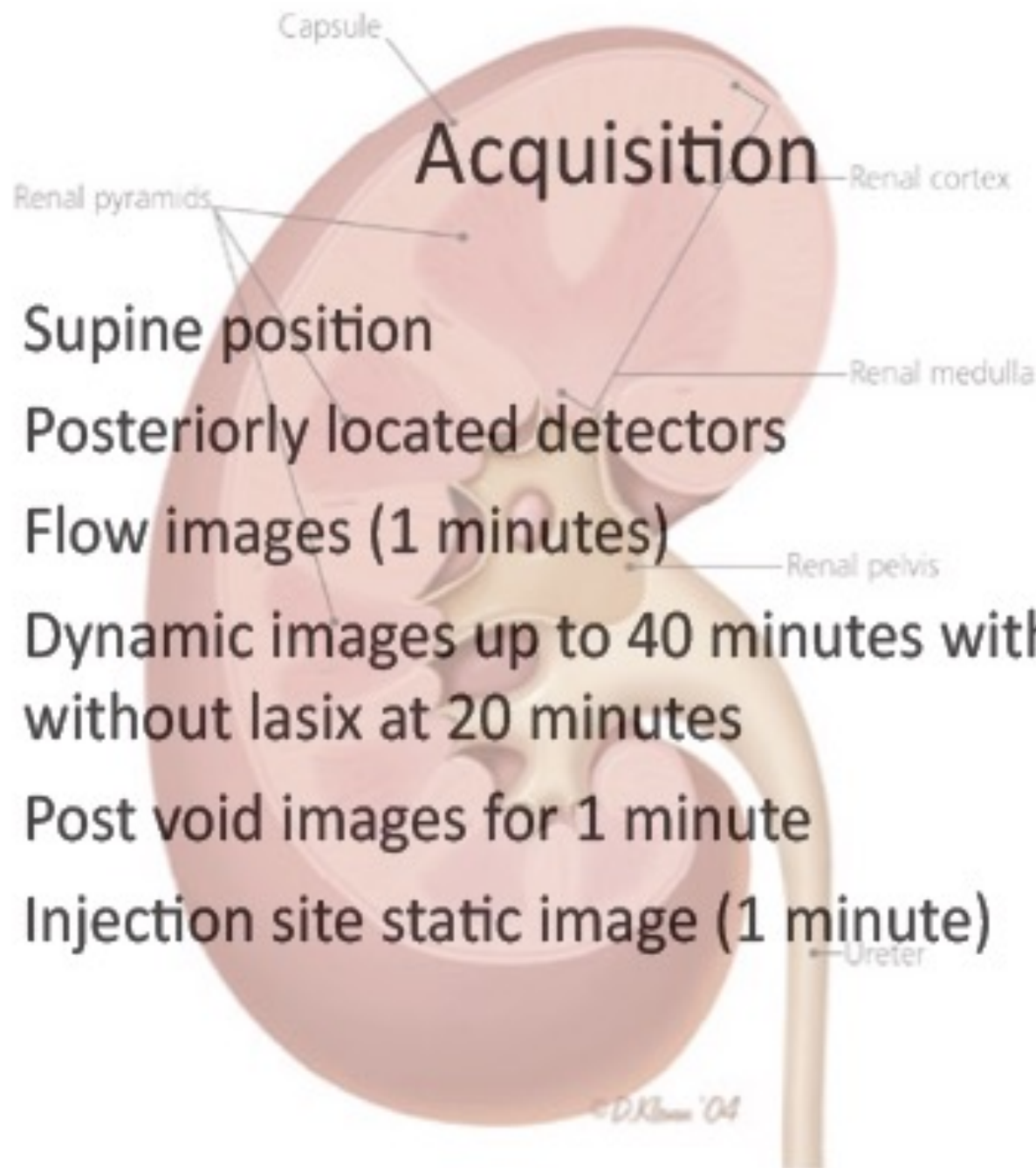
DTPA/MAG-3 :Patient Preparation

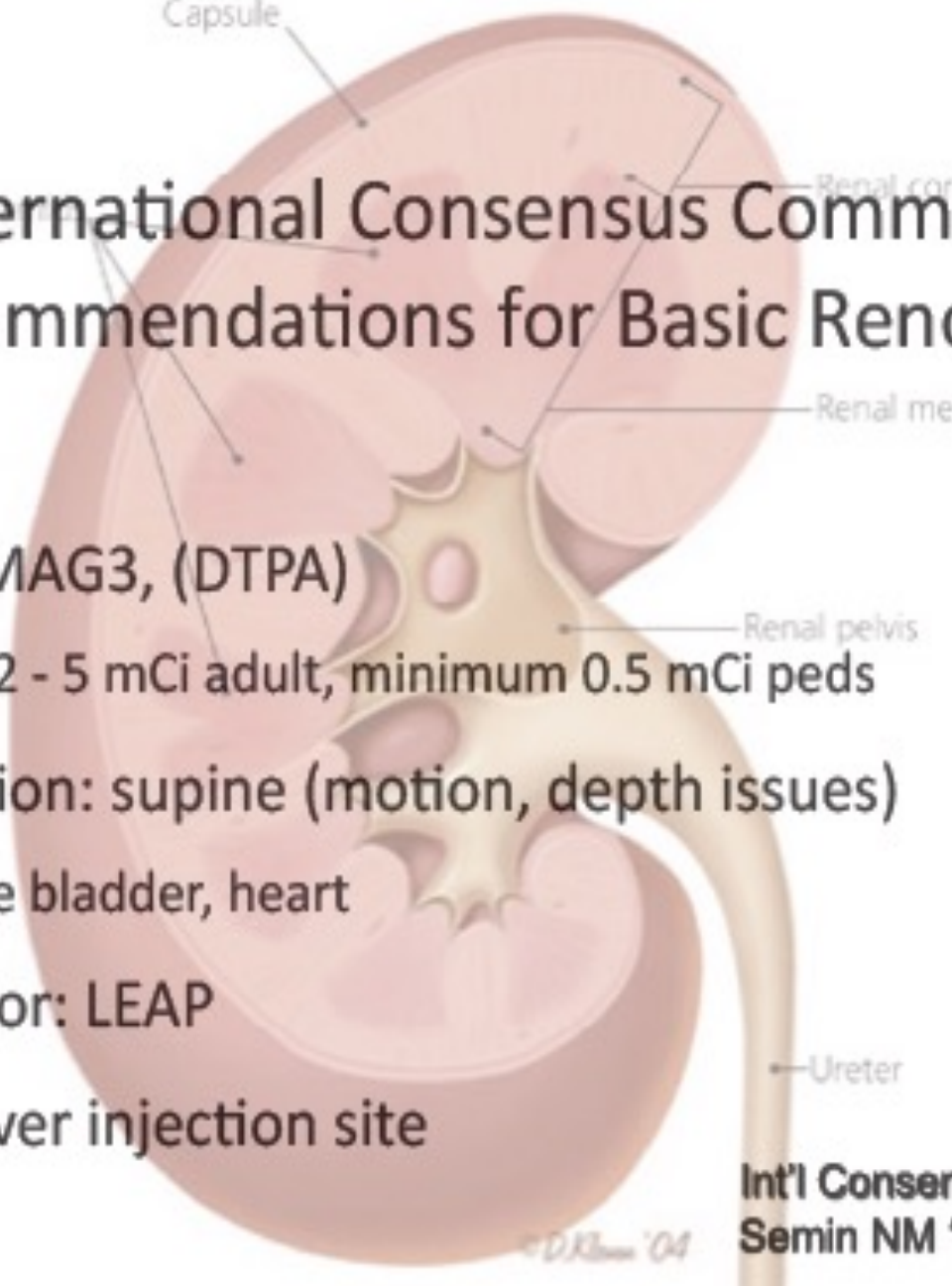
- Patient must be well hydrated
 - Give 5-10 ml/kg water (2-4 cups) 30-60 min. pre-injection
 - Can measure U - specific gravity (<1.015)
- Void before injection
- Void @ end of study

Int'l Consens. Comm.
Semin NM '99:146-159

Acquisition

- Supine position
- Posteriorly located detectors
- Flow images (1 minutes)
- Dynamic images up to 40 minutes with/without lasix at 20 minutes
- Post void images for 1 minute
- Injection site static image (1 minute)





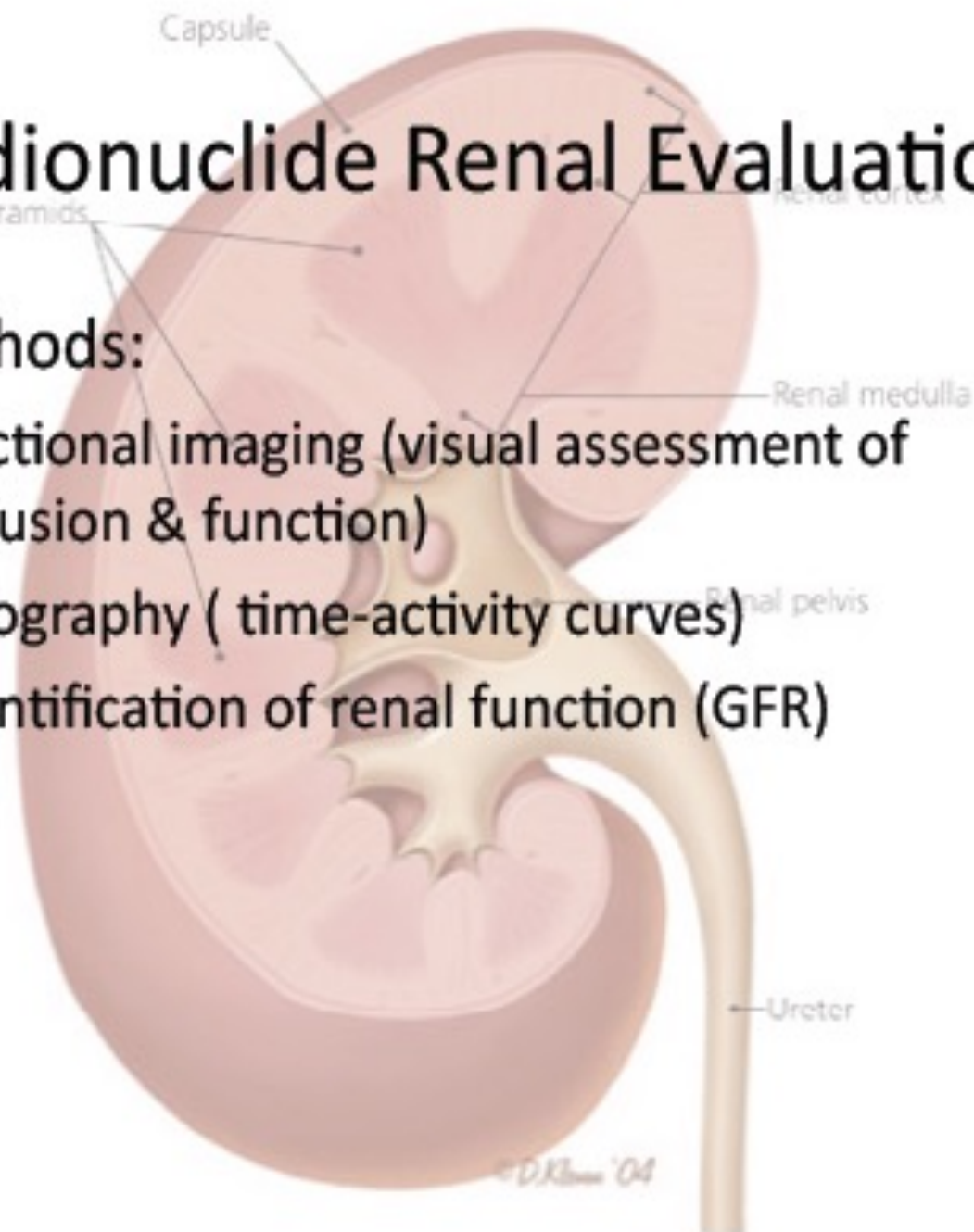
International Consensus Committee Recommendations for Basic Renogram

- **Tracer: MAG3, (DTPA)**
 - Dose: 2 - 5 mCi adult, minimum 0.5 mCi peds
- **Pt. position: supine (motion, depth issues)**
 - Include bladder, heart
- **Collimator: LEAP**
- **Image over injection site**

Int'l Consens. Comm.
Semin NM '99:146-159

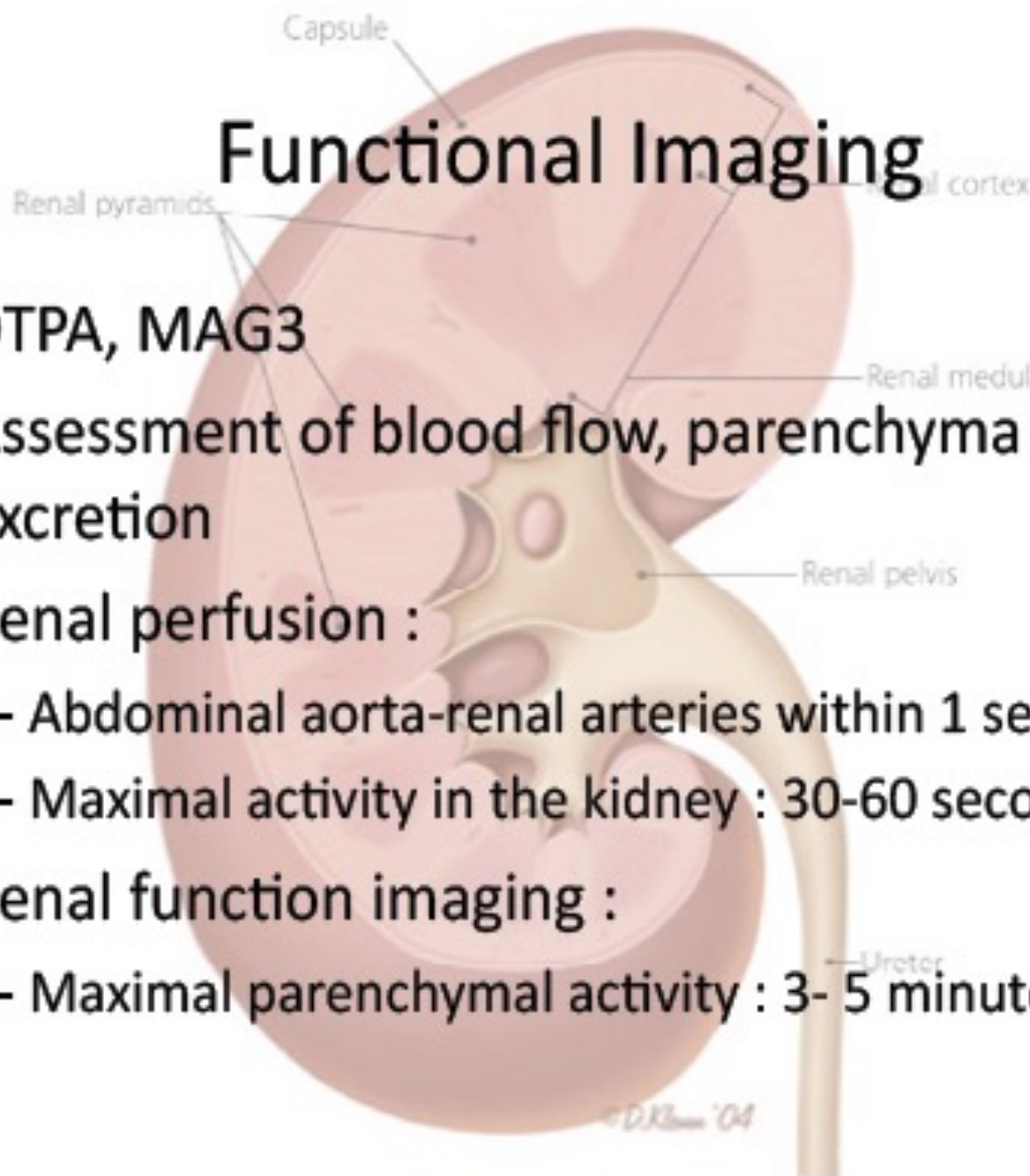
Radionuclide Renal Evaluation

- 3 methods:
 - Functional imaging (visual assessment of perfusion & function)
 - Renography (time-activity curves)
 - Quantification of renal function (GFR)



Functional Imaging

- DTPA, MAG3
- Assessment of blood flow, parenchyma and excretion
- Renal perfusion :
 - Abdominal aorta-renal arteries within 1 second
 - Maximal activity in the kidney : 30-60 seconds
- Renal function imaging :
 - Maximal parenchymal activity : 3- 5 minutes

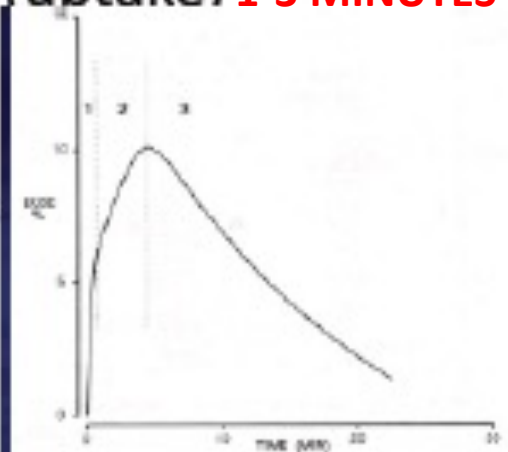


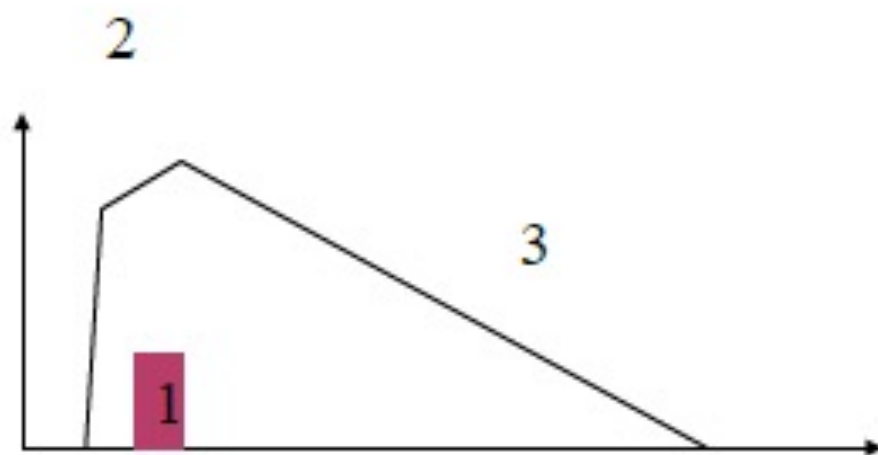
Renography

- time activity curve
- Graphic presentation of the uptake and excretion of a radiopharmaceutical by the kidney
- Phases:
 - Vascular transit time (perfusion) **30 – 60 SECONDS**
 - Cortical/tubular concentration phase (uptake) **1-3 MINUTES**
 - Clearance/excretion

COLLECTING
SYSTEM

CORTICAL



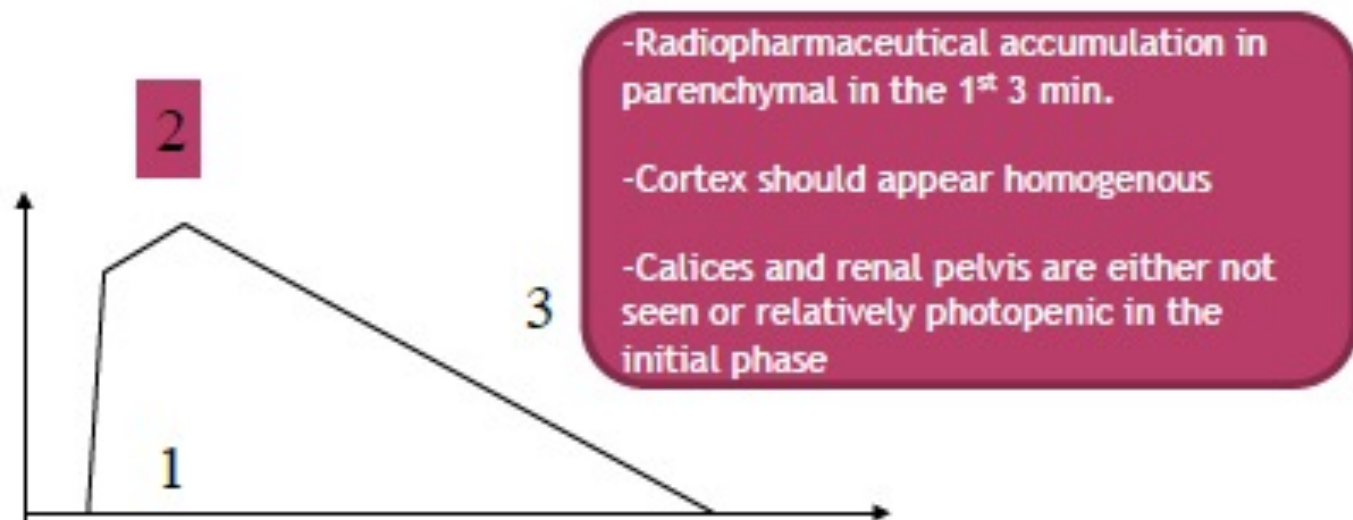


- 1 Blood flow phase (30-60sec)
- 2 Cortical uptake (1-3 mins)
- 3 Clearance phase (calyces & pelvis usually filling by 3 mins)- over next 10-15 mins, act in the kidney & collecting reduce

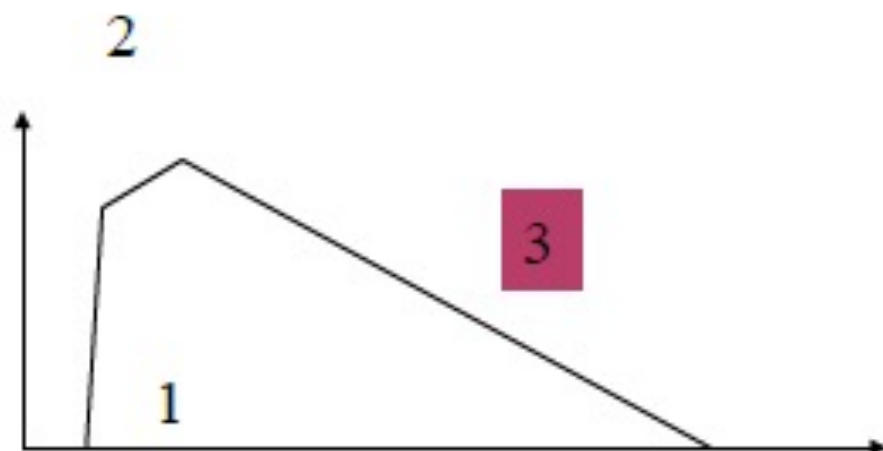
INTERPRETATION

◎ *Flow Phase*

- Blood flow is seen within 2-5sec of abdominal aorta visualization
- Assess quality of injection (delayed visualization may be due to suboptimal injection)
- Asymmetry in tracer activity suggest abnormal perfusion or delayed/decrease activity
- Smaller/scarred kidney-less flow due decrease parenchymal tissue volume



2 Cortical uptake (1-3 mins)



- 3 Clearance phase (calyces & pelvis usually filling by 3 mins)- over next 10-15 mins, activity in the kidney & collecting reduce

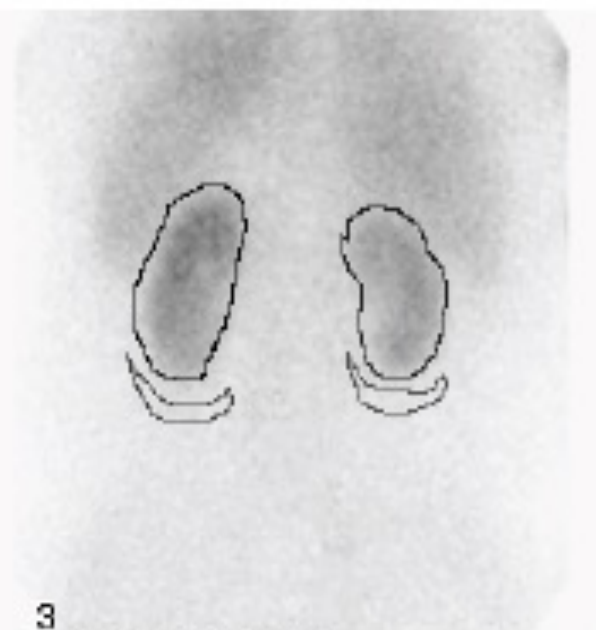
⊙ *Clearance phase*

- Filling of calyces and pelvis by 3 min
- Over 10-15 min, activity in the kidney and collecting system decreases.
- With good function, most radiotracer clears into the bladder by the end of study
- Hydronephrosis- lack of clearance / overlap of pelvocalyceal structures on the cortex
- Normal ureter-may/not be seen
- Prolong, unchanging or increase activity suggest dilatation.
- Reflux-ureteral activity persists after the kidneys have cleared (VCUG) -Bladder normally well seen
- Distension can cause an obstructed pattern
- Neurogenic bladder-catheter

Quantitation of renal function



2
1-2 MINUTE
LEFT=57% RIGHT=43%



3
2-3 MINUTE
LEFT=59% RIGHT=41%

Relative uptake

❖ Contribution of each kidney to the total fct

$$\% \text{ Lt kid} = \frac{\text{net cts in Lt ROI}}{\text{net cts Lt} + \text{net cts Rt ROI}} \times 100\%$$

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

Evaluation of Hydronephrosis

Diuretic (Lasix) Renal Scan

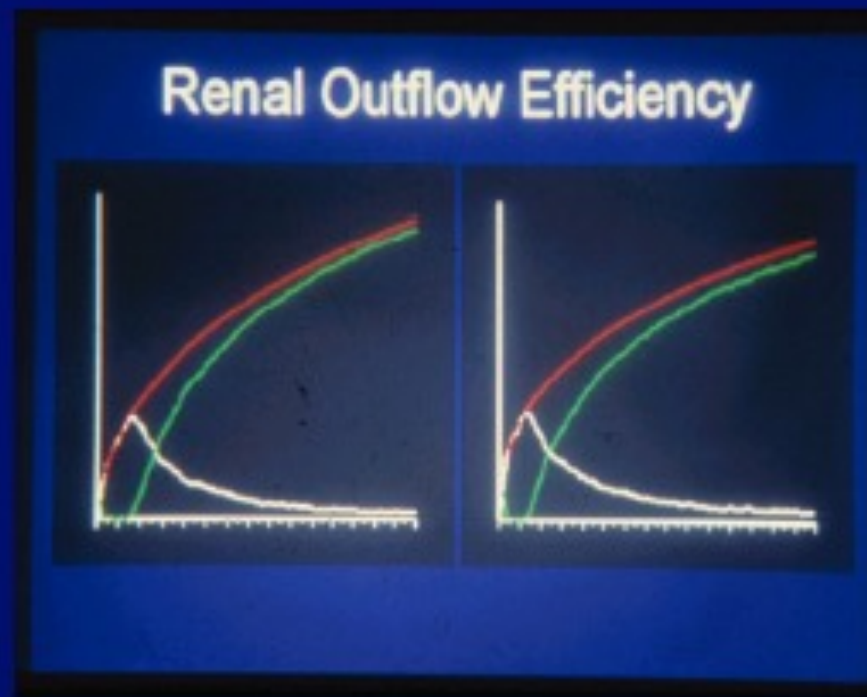
Obstruction

Obstruction to urine outflow leads to
obstructive uropathy
(hydronephrosis, hydroureter)
and

may lead to **obstructive nephropathy**
(loss of renal function)

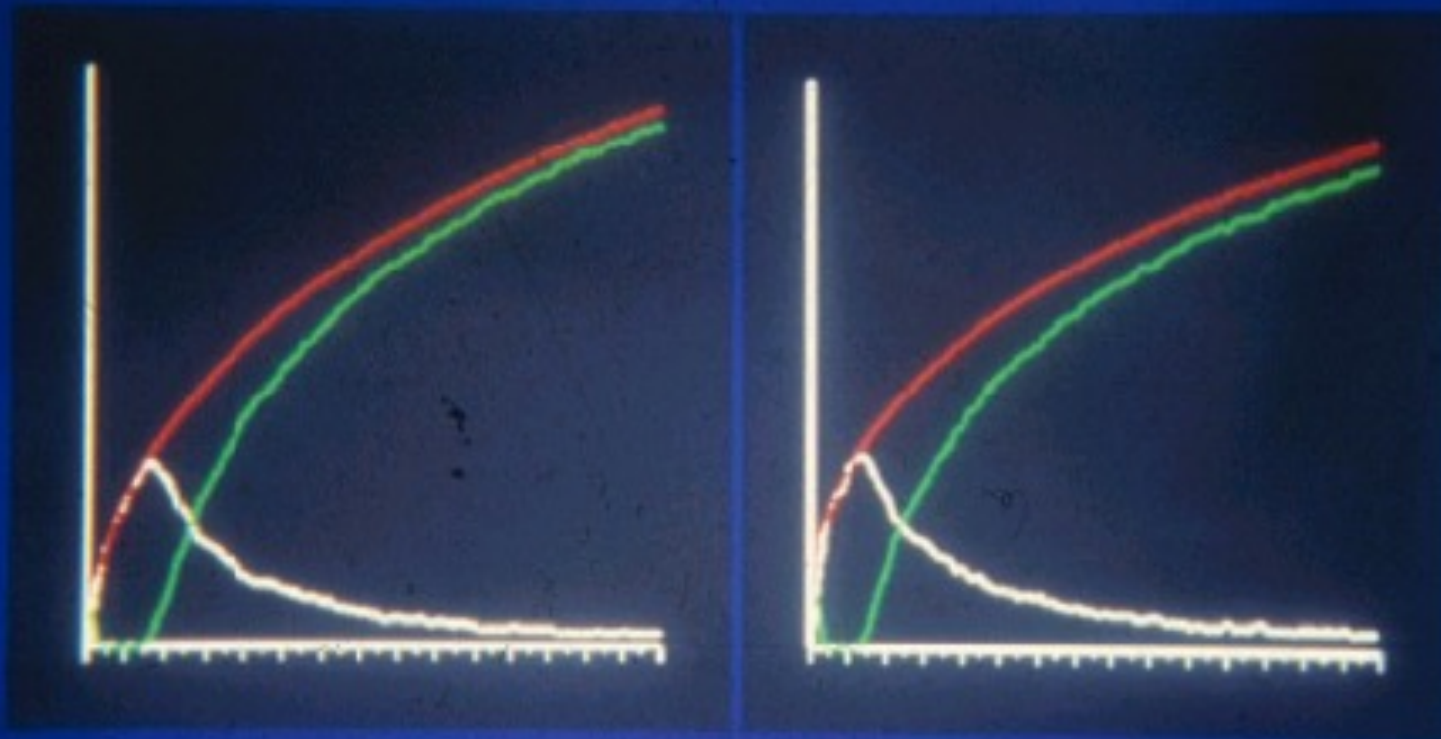
Renal Outflow Efficiency (ROE)

- The effect of a resistance to outflow:
 - comparing the cumulative input to the kidney with the cumulative output after Frusemide intervention.
- The cumulative input represents the situation that would be seen if the kidney's outflow had been completely obstructed, as the kidney acts as an integrator of each package of activity delivered by the blood stream.
- It is determined by fitting the integral of the blood clearance curve to the second phase of the renogram.
- The cumulative output is determined by subtracting the actual renogram from the cumulative input.
- The cumulative output is then taken as a percentage of the cumulative input to give the Output or Outflow Efficiency.



NORMAL:
ROE >78%

Renal Outflow Efficiency



Chaiwatsarat T, Padhy AK, Bomanji J, Nimmann CC, Sonmezoglu K and Britton KE. Validation of Renal Output Efficiency (ROE) as an objective quantitative parameter in the evaluation of Upper Urinary Tract Obstruction. J Nucl Med 34: 845-848, 1993

Diuretic Renal Scan

Principle

- ❖ Hydronephrosis - tracer pooling in dilated renal pelvis
- ❖ Lasix induces increased urine flow
- ❖ If obstructed >>> will not wash out
- ❖ If dilated, non-obstructed >>> will wash out
- ❖ Can quantitate rate of washout ($T_{1/2}$)

Diuretic Renal Scan

Indications

- ❖ Evaluate functional significance of hydronephrosis
- ❖ Determine need for surgery
 - obstructive hydronephrosis - surgical Rx
 - non-obstructive hydronephrosis - medical Rx
- ❖ Monitor effect of therapy

Diuretic Renal Scan

Requirements

- ❖ Rapidly cleared tracer
- ❖ Well hydrated patient
- ❖ Good renal function

Diuretic Renal Scan Procedure

❖ Pt. preparation:

➤ prehydration

adults - oral or 360ml/m² iv over 30'

peds - 10-15 ml/kg D5 0.3-0.45%NS

➤ void before injection

➤ bladder catheterization ?

Diuretic Renal Scan

Procedure (cont'd)

- ❖ Tracers: Tc-99m MAG3 5-10 mCi
(preferred over DTPA)
- ❖ Acquisition: supine until pelvis full
(can switch to sitting post- Lasix)
- ❖ Flow (angiogram) : 2-3 sec / fr x 1 min
- ❖ Dynamic: 15-30 sec / frame x 20-30 min

Diuretic Renal Scan Procedure (cont'd)

- ❖ Void before Lasix
- ❖ Lasix: 40mg adult, 1mg/kg child iv
@ ~10-20 min (when pelvis full)
or @ -15min ("F-15" method)
- ❖ Acquisition for 30 min post Lasix
- ❖ Assess adequacy of diuresis
 - Measure voided volume
 - Adults produce ~200-300 ml urine post-Lasix

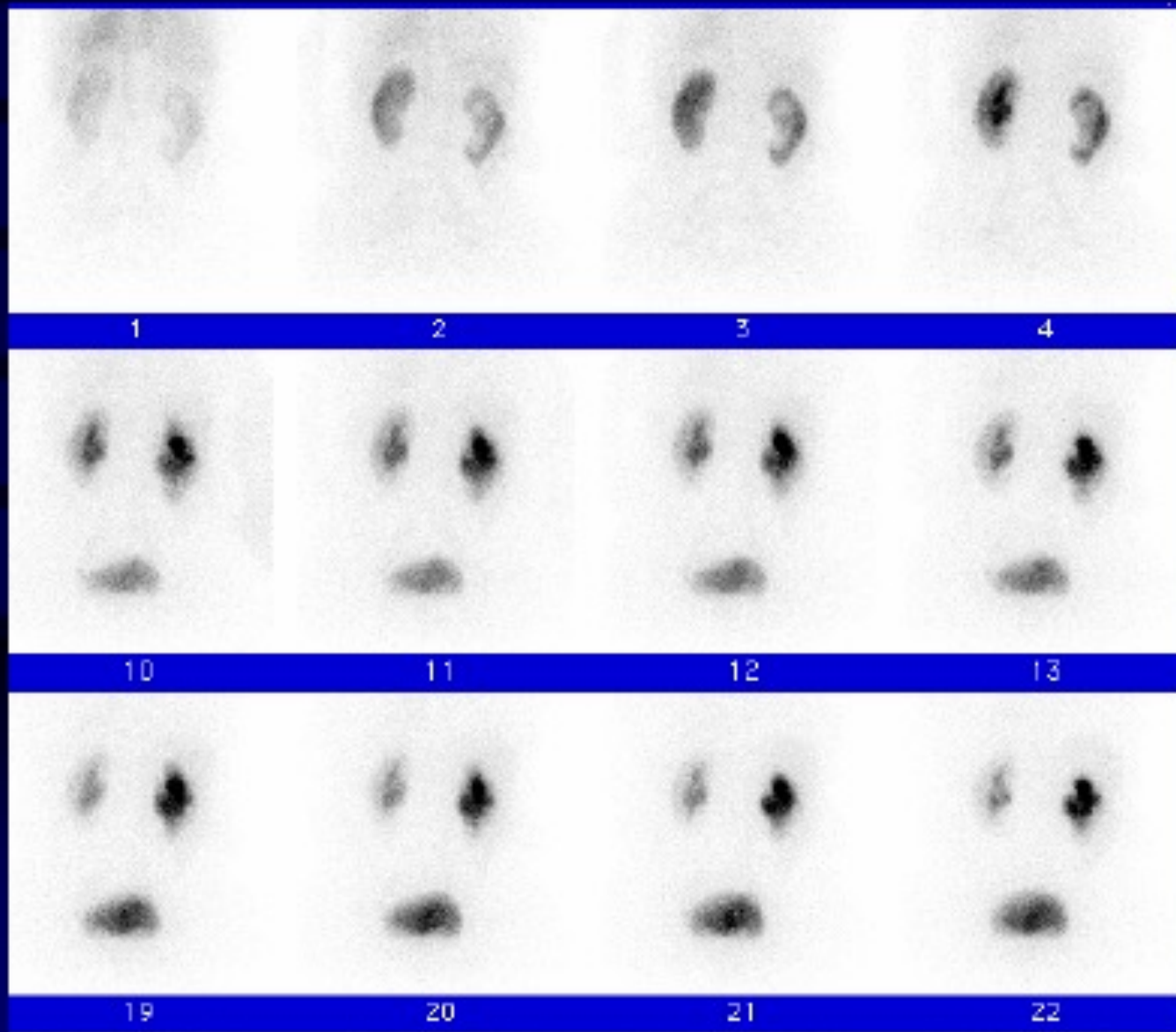
Diuretic Renal Scan

Procedure (cont'd)

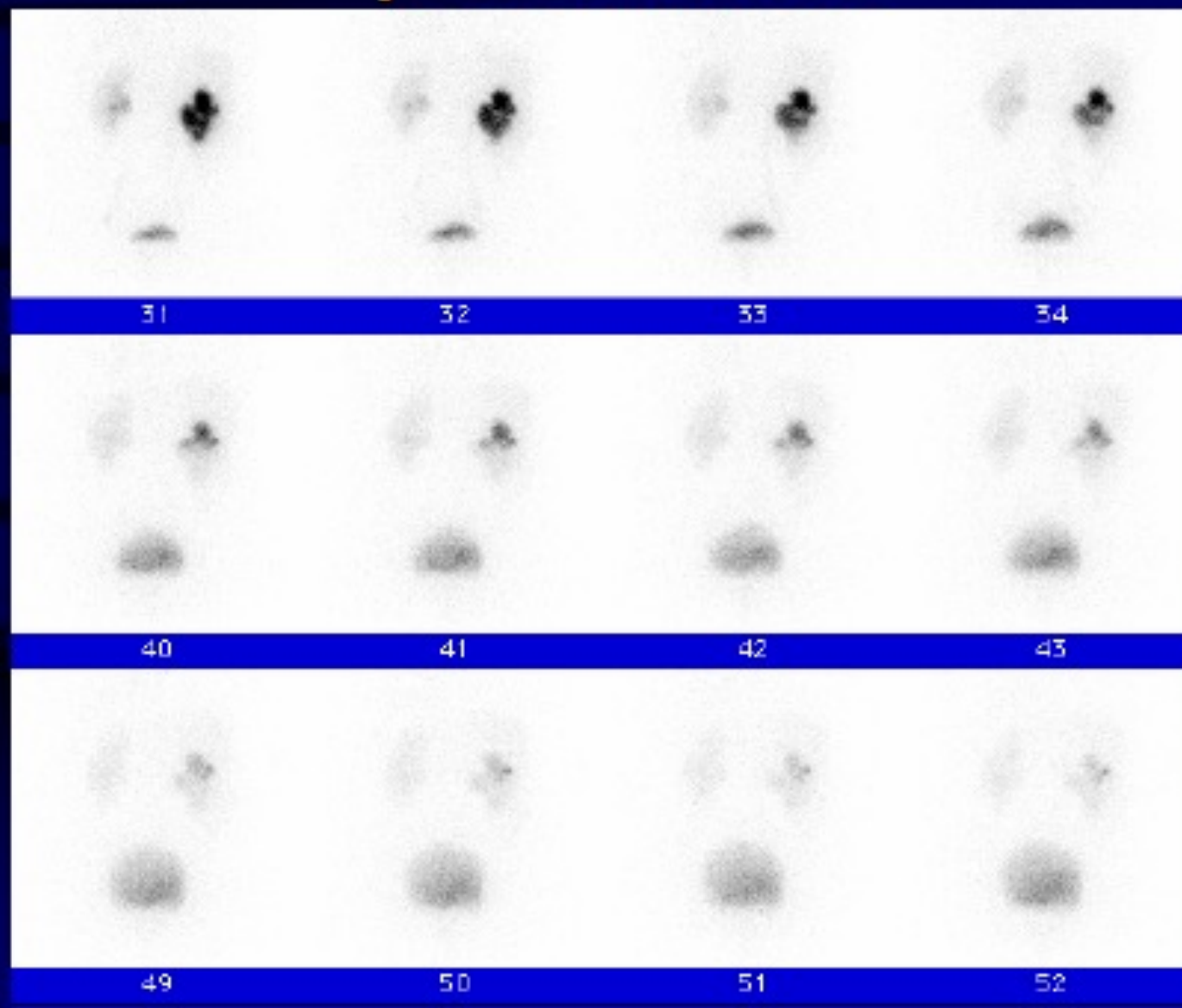
❖ Don't give Lasix if

- Collecting system still filling
- Collecting system not full by 60 min
- Collecting system drains spontaneously
- Poor ipsilateral fct ($< 20\%$)

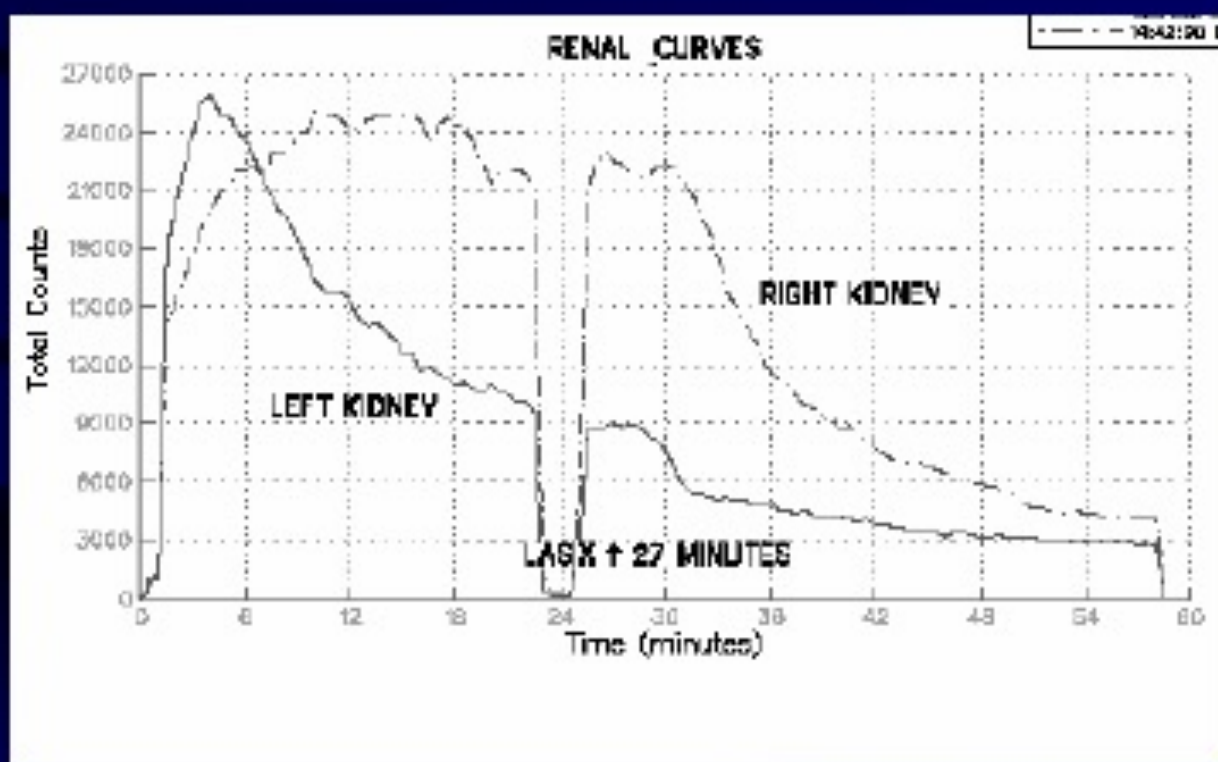
pre-Lasix



post-Lasix

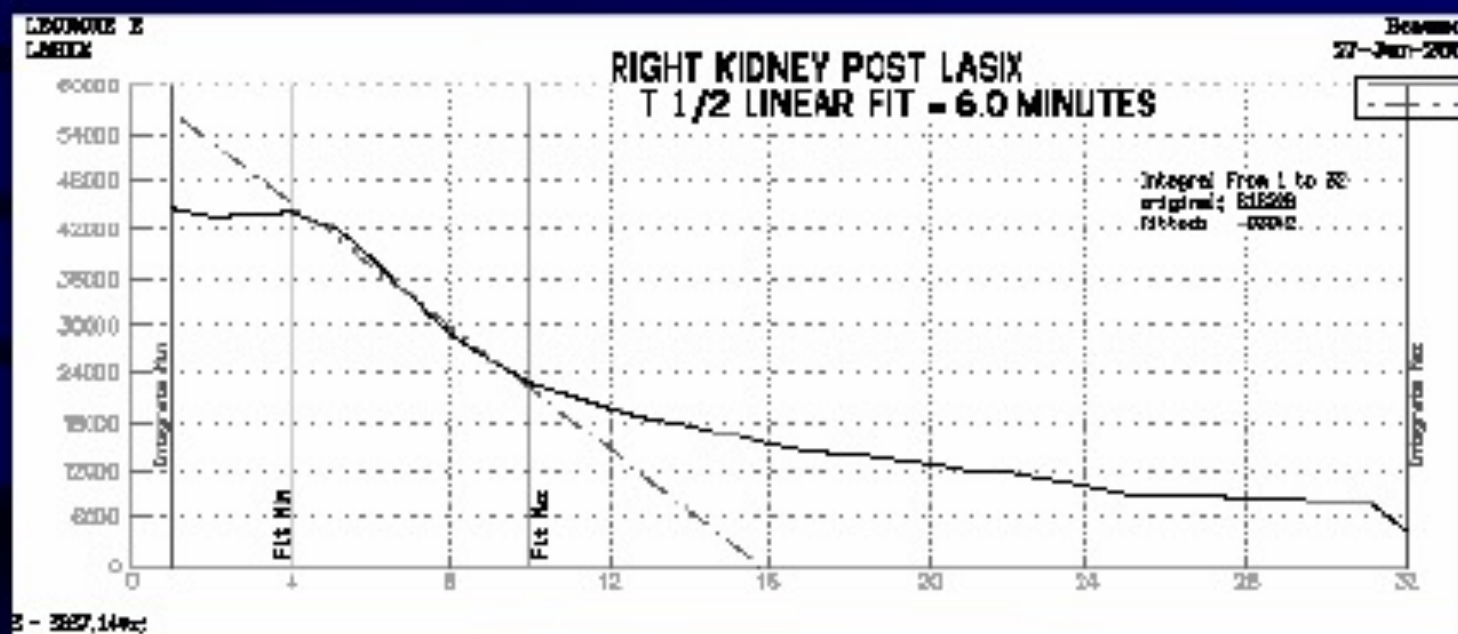


No UPJ obstruction



$T_{1/2}$
R = 6'
L = 2'

Post-Lasix curve



Diuretic Renal Scan Processing

❖ ROI placement

- around whole kidney *or*
- around dilated renal collecting system

❖ T/A curve

❖ $T_{1/2}$

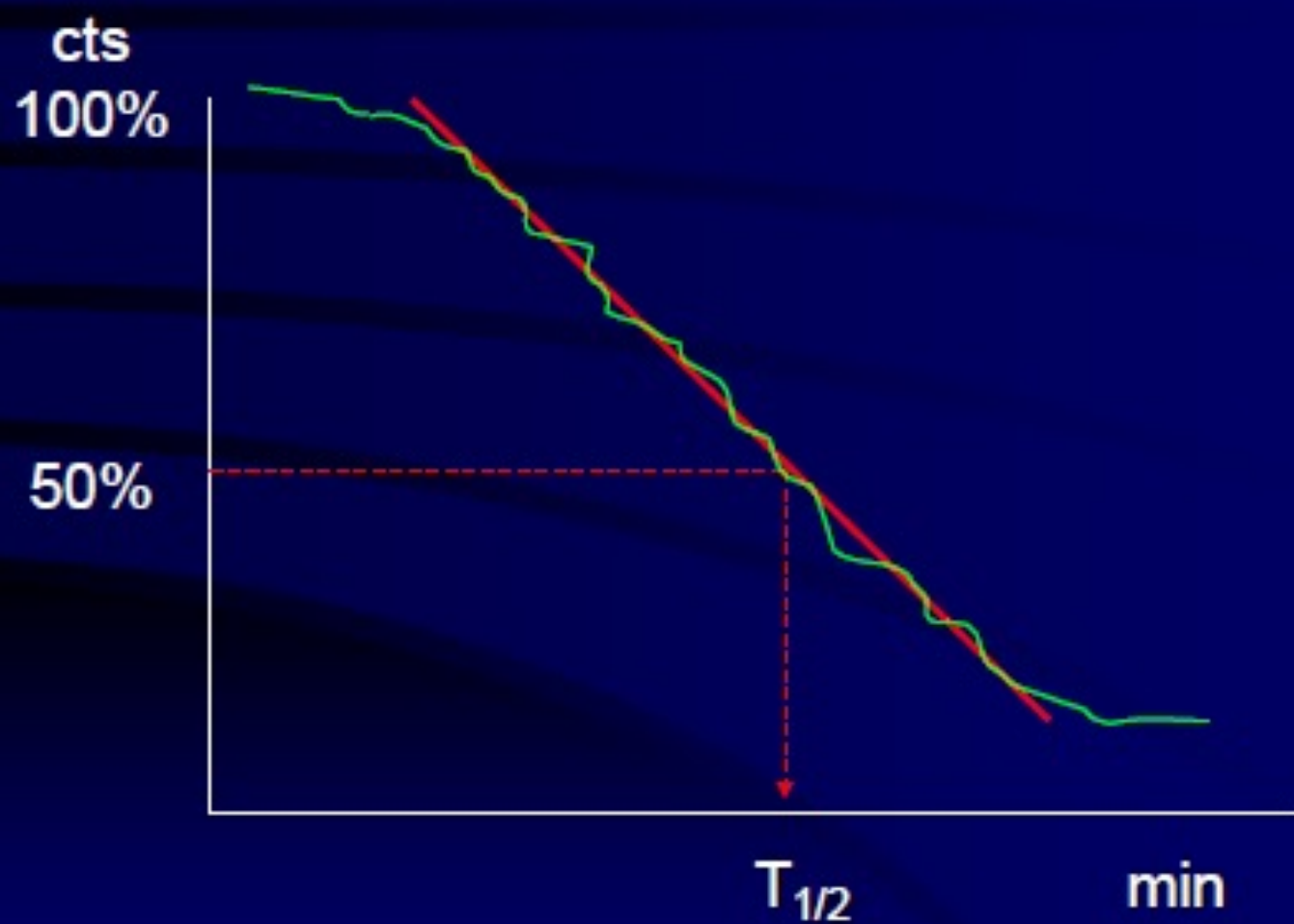
- from Lasix injection vs. from diuretic response
- linear vs. exponential fit of washout curve

Diuretic Renal Scan
Washout
(diuretic response)

$$T_{1/2}$$

time required for 50% tracer to leave
the dilated unit
i.e. time required for activity to fall
to 50% of peak

$T_{1/2}$ washout



$T_{1/2}$ value

❖ Variables influencing $T_{1/2}$ value:

- Tracer
- State of hydration
- Volume of dilated pelvis
- Bladder catheterization
- Dose of Lasix
- Renal function (response to Lasix)
- ROI (kidney vs. pelvis)
- $T_{1/2}$ calculation (from inj. vs. response, curve fit)

$T_{1/2}$

- | | |
|-----------------|-------------|
| ❖ Normal | < 10 min |
| ❖ Obstructed | > 20 min |
| ❖ Indeterminate | 10 - 20 min |
-
- ❖ Best to obtain own normals for each institution, depending on protocol used

Diuretic Renal Scan

Interpretation

- ❖ Interpret whole study, not $T_{1/2}$ alone
- ❖ Visual (dynamic images)
- ❖ Washout curve shape (concave vs. convex)
- ❖ $T_{1/2}$

Diuretic Renal Scan

Pitfalls

❖ False positive for obstruction

- Distended bladder
- Gross hydronephrosis

$$T(\text{transit time}) = V(\text{volume}) \div F(\text{flow})$$

- Poorly functioning / immature kidney
- Dehydration

❖ False negative

- Low grade obstruction
- Poorly functioning / immature kidney

“F minus 15” Diuretic Renogram

- ❖ Furosemide (Lasix) injected 15 min *before* radiopharmaceutical
- ❖ Rationale: kidney in maximal diuresis, under maximal stress
- ❖ Some equivocal results will become clearly positive, some clearly negative

Diagnosis of Urinary Tract Obstruction: Techniques and Limitations

$^{99m}\text{Tc-DTPA}$

$^{123}\text{I-OIH}$



- Renography (RNG) F0:
 - definitely established
- RNG: +++ Parameters
 - excretory
 - post-gravitatory

$^{99m}\text{Tc-DMSA}$

$^{99m}\text{Tc-GH}$

$^{99m}\text{Tc-MAG}_3$

$^{99m}\text{Tc-EC}$

$^{123}\text{I-OIH}$



Accepted Indications

- RNG F0
 - Prenatal hydronephrosis
- DMSA
 - Acute pyelonephritis
 - Scars
- CYSTOSCINTIGRAPHY
- RNG TX
- RNG + CAPTOPRIL

The diuretic renogram in the clinical management of neonatal hydronephrosis

Diuretic radionuclide renography easily detects whether a partial or total obstruction is present

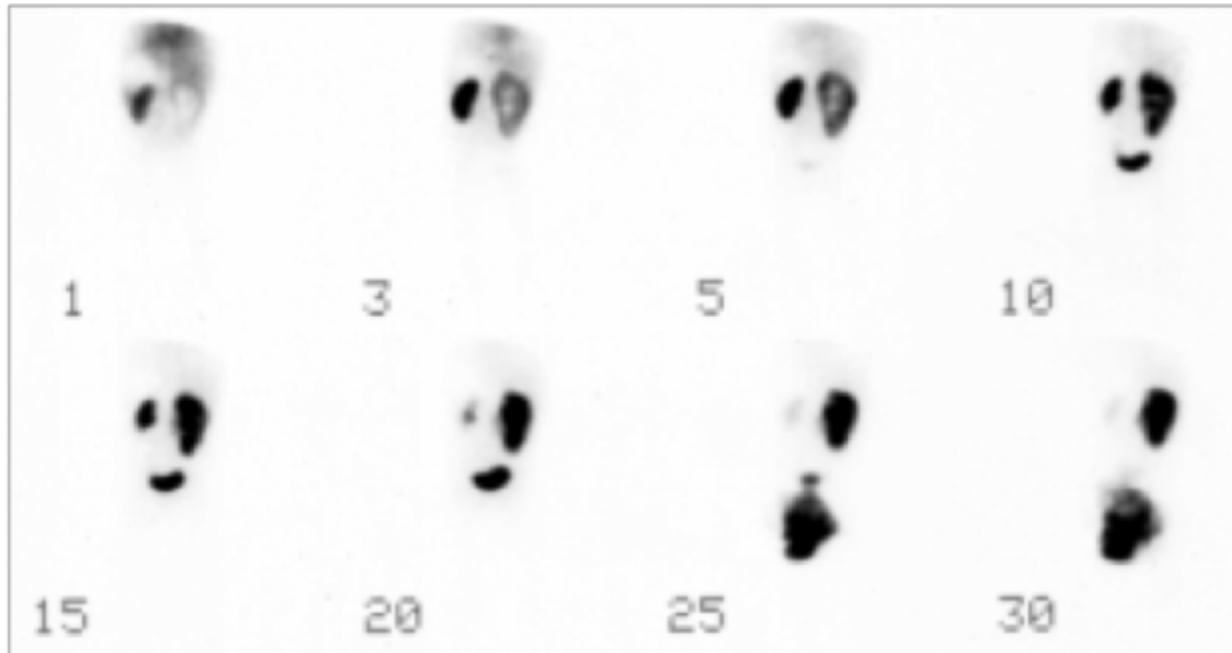


- preserved bilateral renal function
- moderate dilation of urinary tract



NO OBSTRUCTION

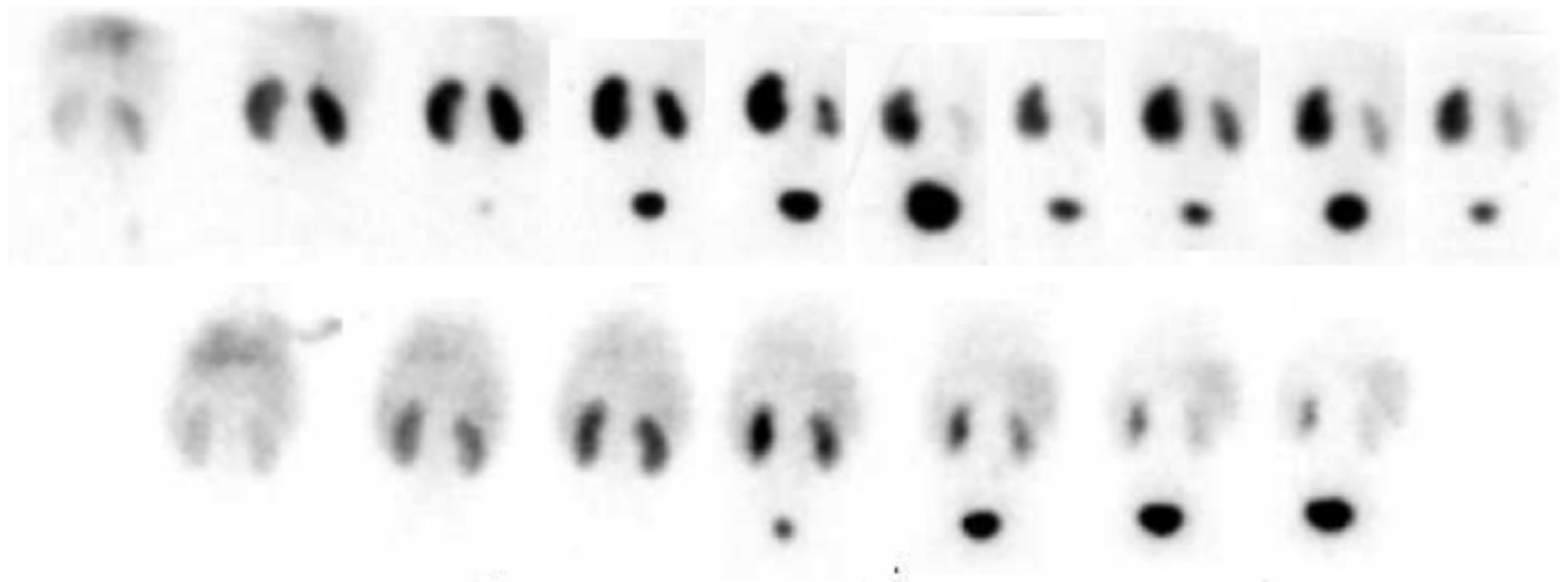
- asymmetric renal function
- urinary tract dilation



OBSTRUCTIVE PROFILE

When the pediatrician orders a diuretic renogram, what does he/she wants to know?

SURGERY?? **yes** / **no**



When the pediatrician orders a diuretic renogram, what does he/she wants to know?

SURGERY **yes** or **no??**

Can we answer the question?

NO

Can we help decide?

YES

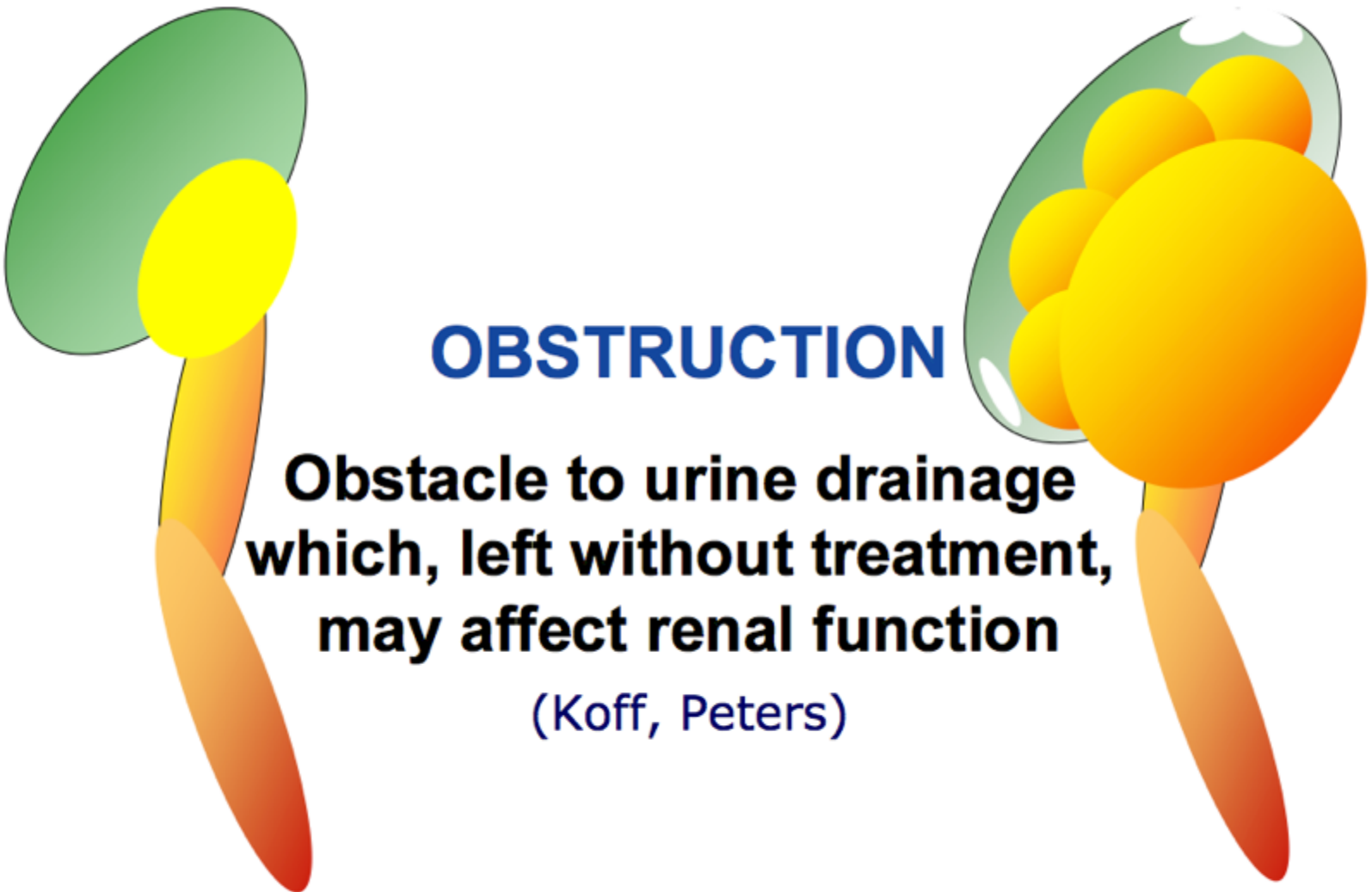
HOW?

HOW

Can we help the pediatrician evaluate
a patient with hydronephrosis?

Providing information about:

- renal function
- excretory pattern

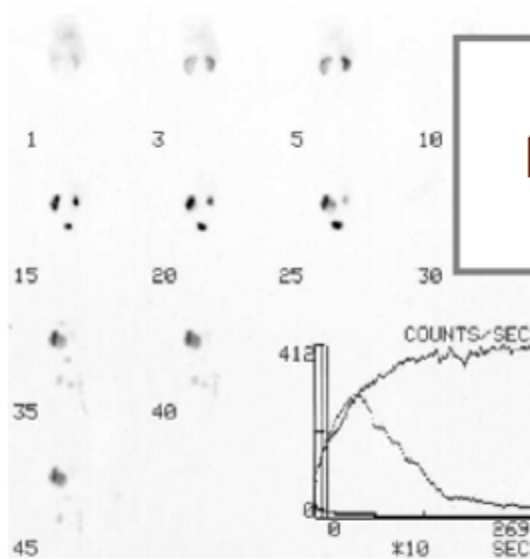
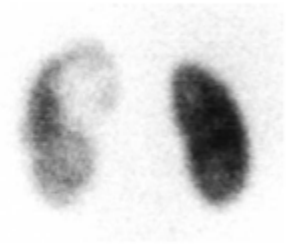


OBSTRUCTION

**Obstacle to urine drainage
which, left without treatment,
may affect renal function**

(Koff, Peters)

INTERPRETATION OF DIURETIC RENOGRAM IN CHILDREN



PROCEDURE:

- Technique
- Patient preparation

INTERPRETATION:

- Images
- Curves
- Quantitative parameters

OBSTRUCTIVE PROFILE ???



→ **Diuretic renogram**

There are as many protocols as NM services !

A comprehensive, complete software package is lacking

→ **Europe**

Oral hydration

For a baby, best possible hydration is lactation

→ **USA**

"Well tempered renography"

→ **F-15 F0 F+15 F+20 ??**

Probably all options are valid and clinically useful

- difficulties: centers with different protocols, controversies in interpretation

Published GUIDELINES:

Gordon I, Colarinha P, Fettich J *et al.*

Guidelines for standard and diuretic renography in children.

Eur J Nucl Med 2001; 28 : BP21–BP30

EANM

O'Reilly P, Aurell M, Britton K, Kletter K, Rosenthal L, Testa T.

Consensus on diuresis renography for investigating the dilated upper urinary tract. Radionuclides in Nephrourology Group. Consensus Committee on Diuresis Renography.

J Nucl Med 1996; 37 : 1872–6

BJU 2003; 91:239–243

ISCORN

Conway JJ, Maizels M.

The 'well tempered' diuretic renogram: a standard method to examine the asymptomatic neonate with hydronephrosis or hydroureteronephrosis. A report from combined meetings of The Society for Fetal Urology and members of The Pediatric Nuclear Medicine Council – The Society of Nuclear Medicine.

J Nucl Med 1992; 33 : 2047–51

SNM

Conway JJ, Maizels M.

The 'well tempered' diuretic renogram: a standard method to examine the asymptomatic neonate with hydronephrosis or hydroureteronephrosis. A report from combined meetings of The Society for Fetal Urology and members of The Pediatric Nuclear Medicine Council – The Society of Nuclear Medicine.

J Nucl Med 1992; 33 : 2047–51

- recommends a more invasive technique
- evaluation of drainage does not account for influence of gravity, renal function, pelvis size.

Gordon I, Colarinha P, Fettich J *et al.*

Guidelines for standard and diuretic renography in children.

Eur J Nucl Med 2001; 28 : BP21–BP30

- recommends a physiologic procedure
- evaluation of drainage takes into account renal function, and contemplates urinary excretion including gravity and micturation

Guidelines for standard and diuretic renography in children

Age of the child

MAG-3 diuresis renography has been shown to be useful even in children aged 1 month or less and this technique should be available to them

Guidelines for standard and diuretic renography in children

Bladder catheterization

- **Routine use of bladder catheter is not indicated.**
 - **Most children will void spontaneously, especially as a diuretic has been given.**
 - **Recommend the acquisition of a post-micturition image obtained after gravity assisted drainage.**
-

0-5min

5-10min

10-15min

15-20min



RENOGRAM F0



**post.mict.
post-gravity**

Guidelines for standard and diuretic renography in children

Hydration of the child

**Encourage oral fluid intake for
adequate hydration rather than
intravenous fluid administration**

Guidelines for standard and diuretic renography in children

Time of diuretic administration

- **F+20, F-15, F0: No evidence of any one of these timings being better than the others.**
- **If venous access is difficult, a single injection is recommended (F0).**

Guidelines for standard and diuretic renography in children

Parameters used

- **Renal function**
- **Drainage assessment**



➡ *Previous hydration*

- ➡ Neonates: start acquisition just after routine lactation.
- ➡ Offer water / orange juice.
- ➡ IV fluids only if necessary.

➡ *No bladder catheterization, only if:*

- ➡ Vesico-urethral reflux present +++
- ➡ Pelvic ectopic kidney.

➡ *Diuretic*

- ➡ Variable timing.

➡ *Gravity effect*

- ➡ Vertical position just before post-micturing image.

➡ *Previous micturation whenever possible.*



HYDRATION

IMMOBILIZATION

sand bags, Velcro strips

DIURETIC

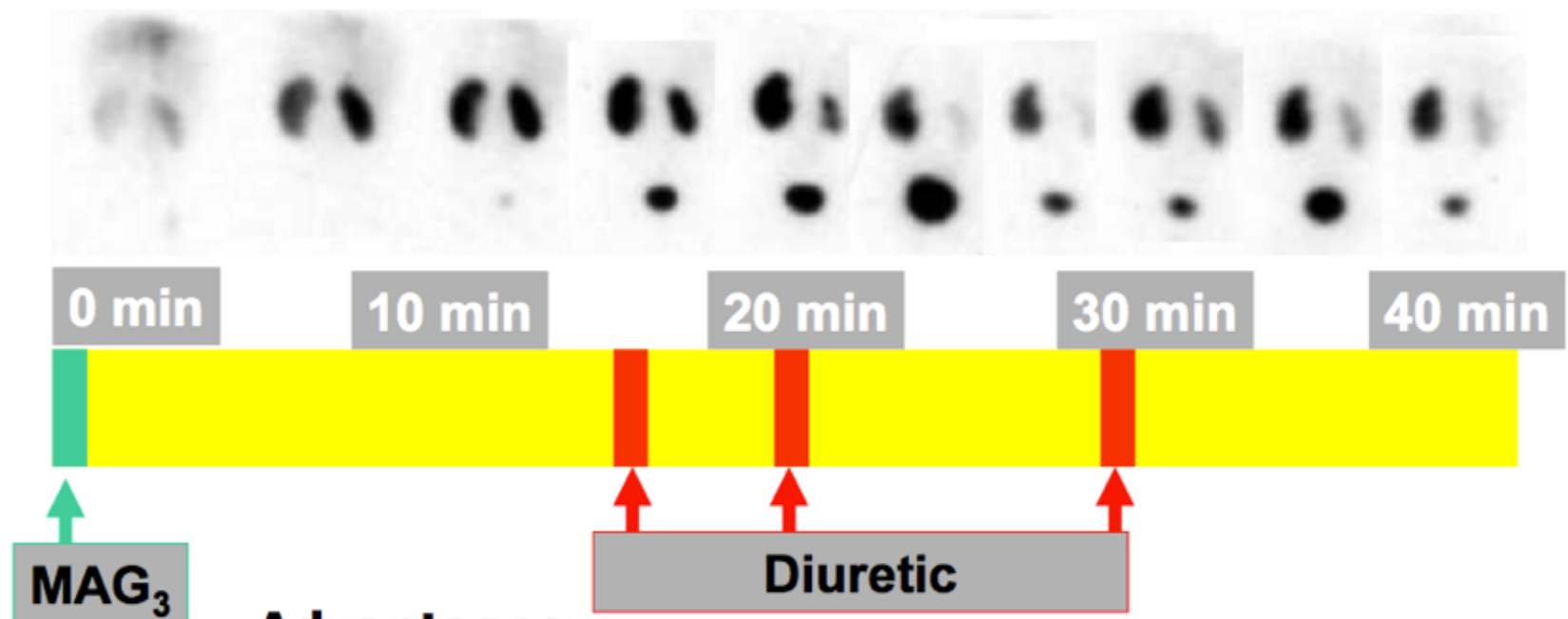
GRAVITY

POST-MICTURING IMAGE

→ **FUROSEMIDE: 0.5-1 mg/kg**

• **F+15 F+20 F+30**

Inject diuretic when maximum activity is detected in dilated structures just above the stenosis.

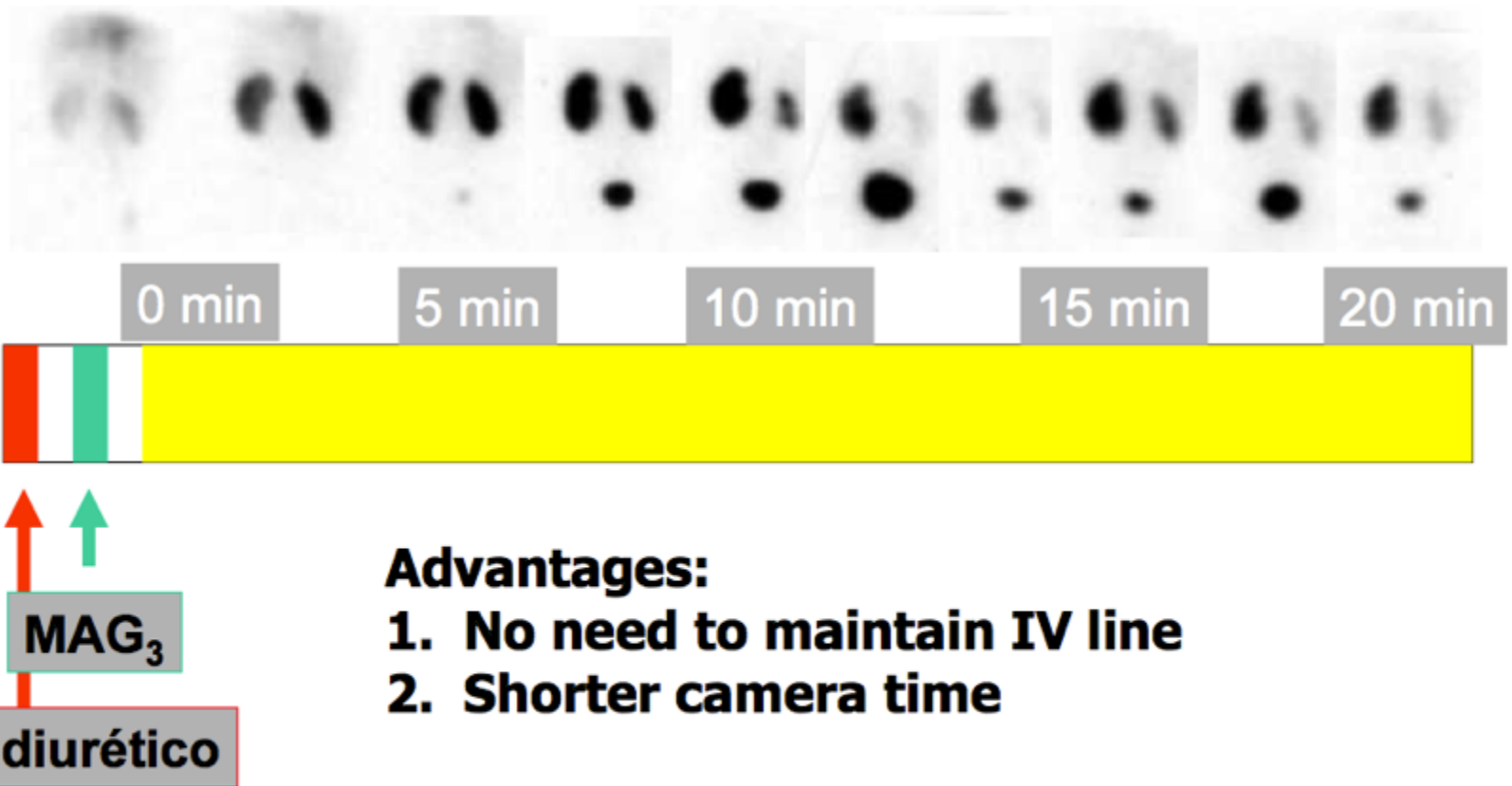


Advantages:

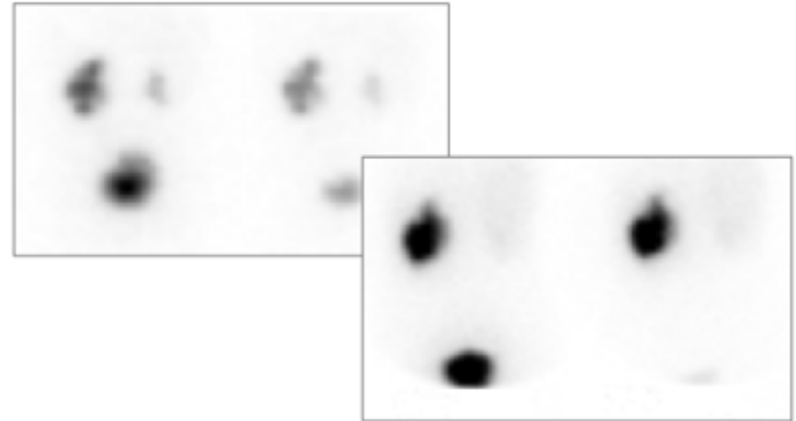
- 1. Interactive renogram**
- 2. Optimal functional information**

→ **FUROSEMIDE: 0.5-1 mg/kg**

• **F-15 or F0**



- **Bladder catheter:**
- Post-micturing image AVOIDS the use of catheter.

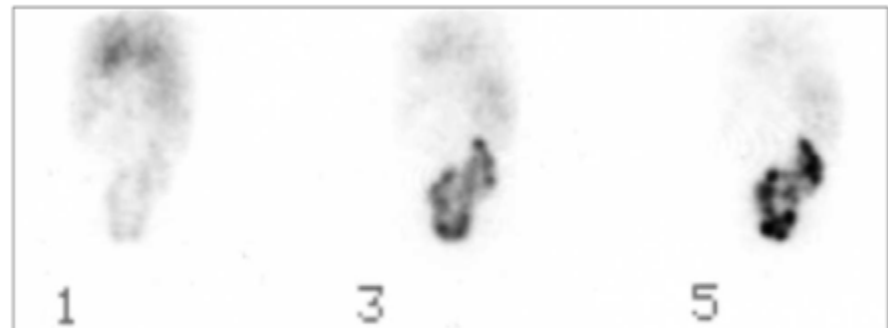


- **Catheter only necessary if:**

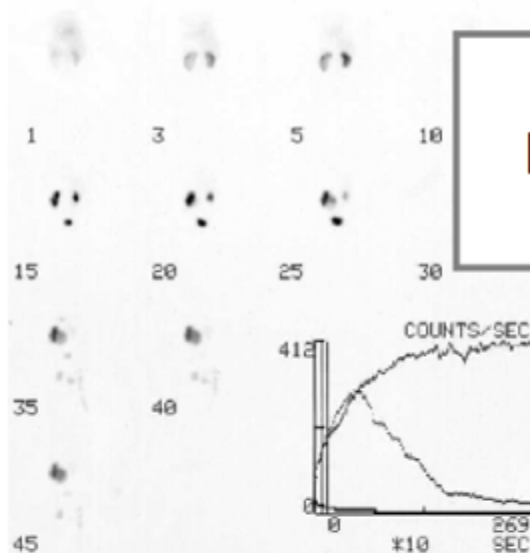
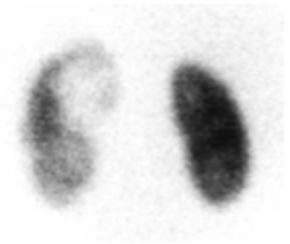
- **VUR +++++**



- **Ectopic kidney**



INTERPRETATION OF DIURETIC RENOGRAM IN CHILDREN



PROCEDURE:

- Technique
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INTERPRETATION:

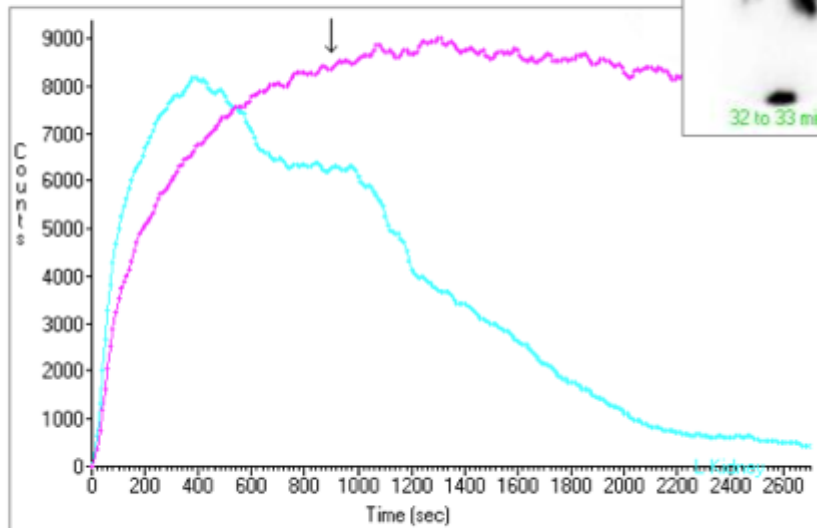
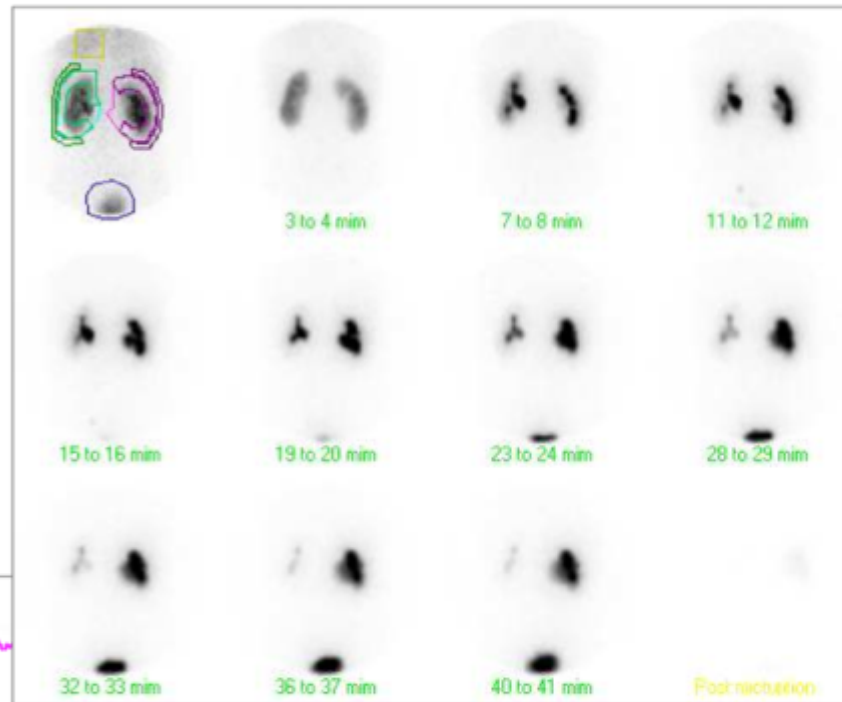
- Images
- Curves
- Quantitative parameters

OBSTRUCTIVE PROFILE ???



INTERPRETATION

- Images
- Curves
- Quantitative parameters



COMPARISON:

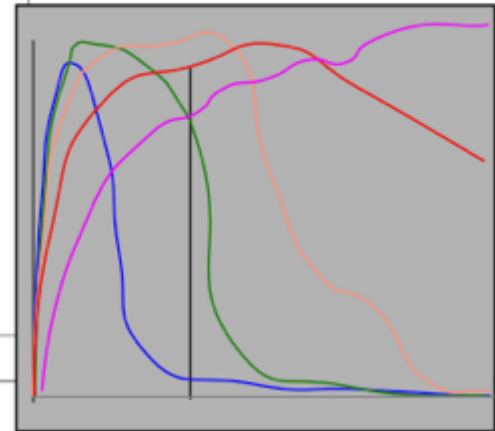
- IMAGES
- CURVES

Renogram classification

DEGREE OF UPTAKE: % DRF

Ransley et al (1990) classified patients according to % of differential renal function (DRF):

Poor uptake	: < 20%
Moderate uptake	: 20-39%
Good uptake	: > 40%



EXCRETION PATTERN

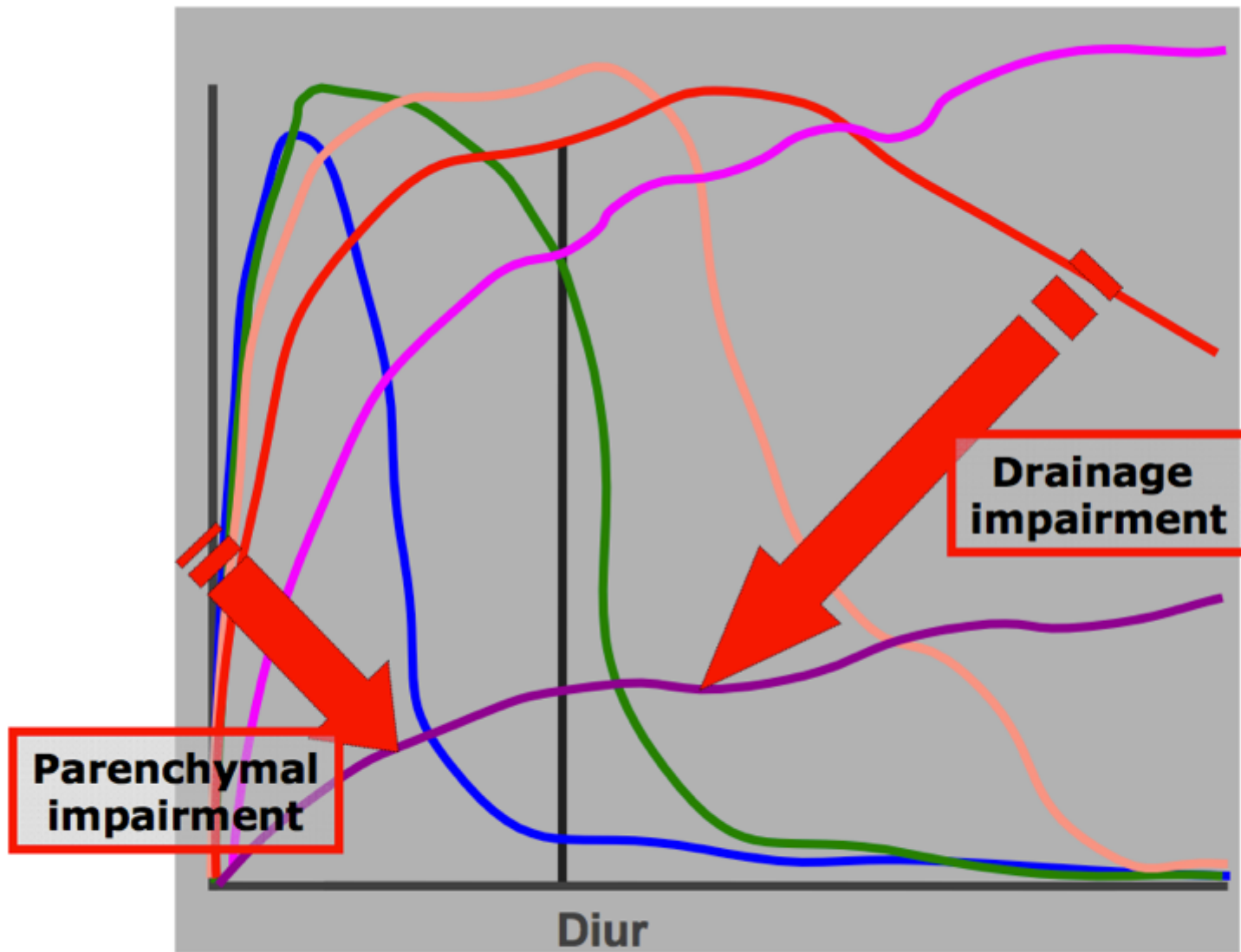
O' Reilly et al (1979) classified patients according to diuretic response:

Response I : Normal initial renography with no change after diuretic.

Response II : Obstructive initial renography with no change after diuretic.

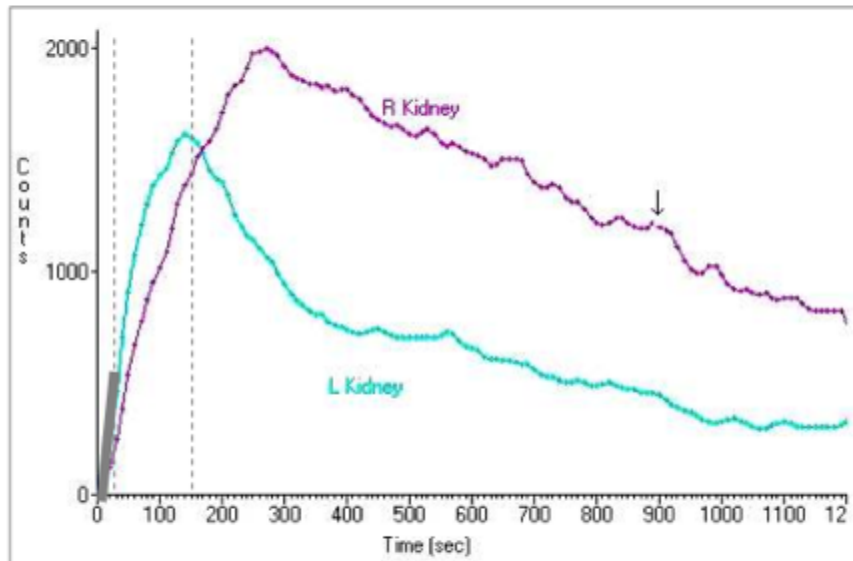
Response IIIa: Obstructive initial renography with rapid clearance after diuretic.

Response IIIb: Obstructive initial renography with mild/partial clearance after diuretic.



RENOGRAM

3 phases



Phase 1:

- Initial seconds
 - Fast $\uparrow$ activity
 - Injection
- = renal perfusion**

Phase 2:

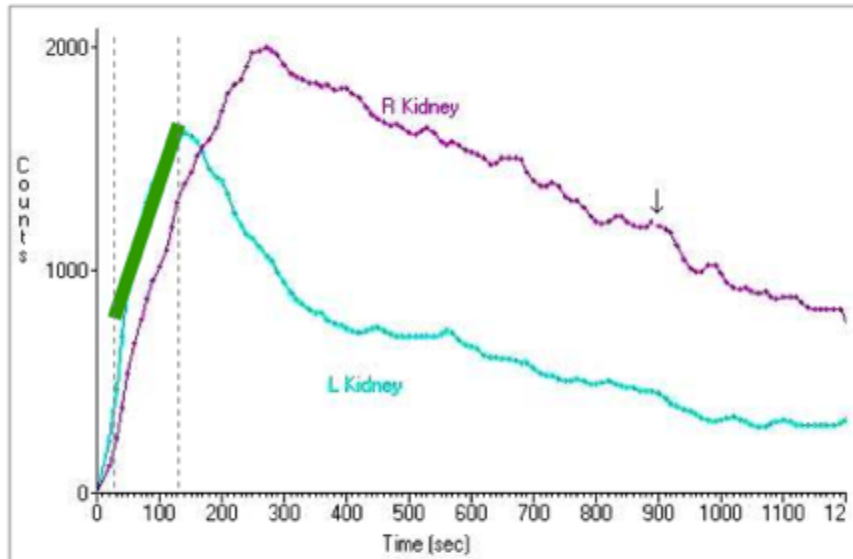
- 2–3 min post injection
 - Tracer accumulates in kidney
 - no excretion
- = renal uptake**

Phase 3:

- Tracer starts clearing
- = renal drainage**

RENOGRAM

3 phases



Phase 1:

- Initial seconds
 - Fast $\uparrow$ activity
 - Injection
- = renal perfusion**

Phase 2:

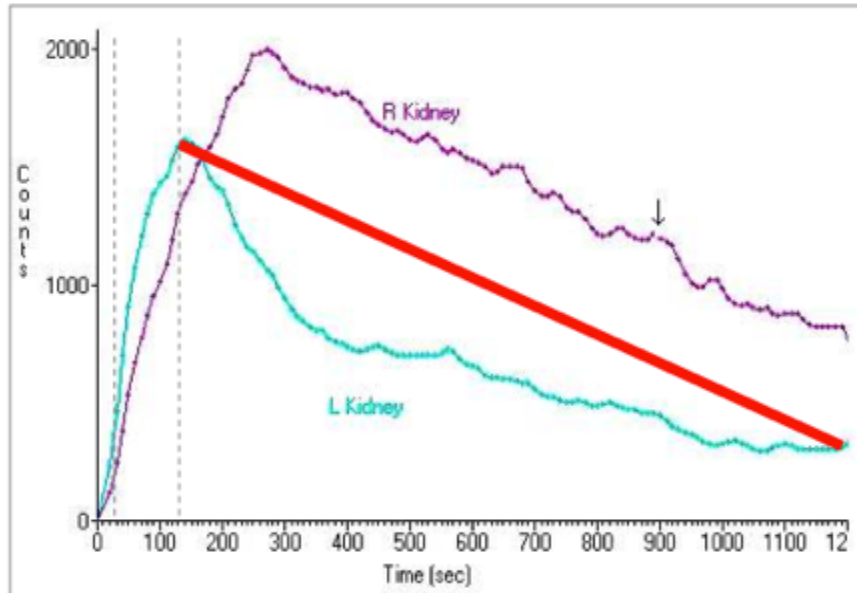
- 2–3 min post injection
 - Tracer accumulates in kidney
 - no excretion
- = renal uptake**

Phase 3:

- Tracer starts clearing
- = renal drainage**

RENOGRAM

3 phases



Phase 1:

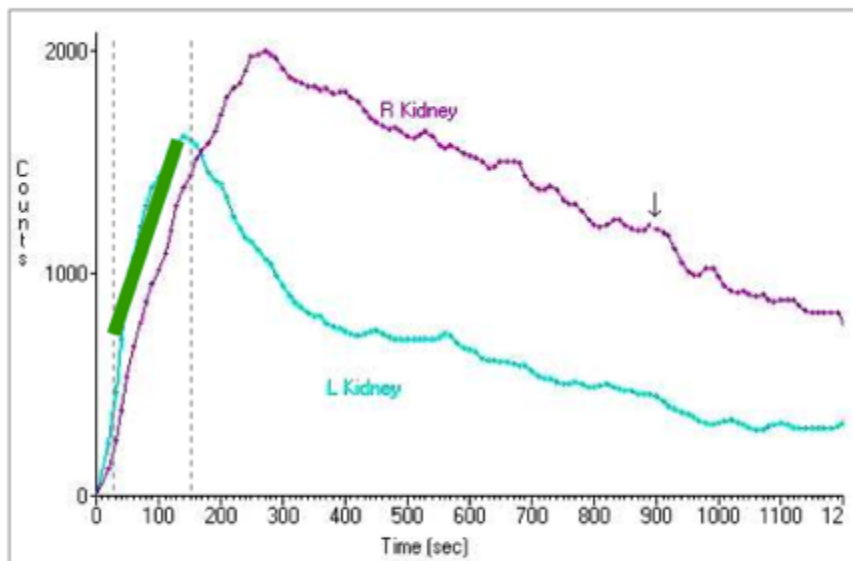
- Initial seconds
 - Fast $\uparrow$ activity
 - Injection
- = renal perfusion**

Phase 2:

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

Phase 3:

- Tracer starts clearing
- = renal drainage**



Phase 2:

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

- increment of renal activity $\approx$ differential renal function DRF
 - curve upslope
 - integral counts under the curve
- DRF should be calculated for the initial 2 minutes.

PITFALL

Late calculation of DRF:

- normal kidney: underestimation of relative function because part of the tracer is already leaving the kidney.
- Hydronephrosis: overestimation of relative function because of delay in clearance.