

# The following are true

- A. About 25% of toxic nodules are palpable
- B. The scan appearances of Grave's disease may be confused with toxic MNG
- C. Thallium-201 may be used to demonstrate thyroid tissue in which uptake but not metabolic activity has been diminished
- D. Almost 10% of patients with Grave's disease will relapse following a prolonged course of antithyroid drugs
- E. RAI therapy for thyrotoxicosis is contraindicated in pregnancy

# The following are true

- FTTFT

# Concerning thyroid imaging in thyroiditis

- A. Thyroid uptake usually diffusely decreased in acute(suppurative) thyroiditis.
- B. Uptake in the early phase of subacute (de Quervian's)thyroiditis is usually increased
- C. Scan appearances in Hashimoto's thyroiditis may be difficult to distinguish from Grave's disease
- D. Radiation induced thyroiditis is commonly seen following external radiation therapy
- E. RAI uptake in Reidel's thyroiditis is increased

# Concerning thyroid imaging in thyroiditis

- FFTFF

# In the investigation of solitary thyroid nodules

- A. A single warm nodule is likely to be an adenoma
- B. The risk of carcinoma in a hot nodule is 10%
- C. The risk of carcinoma in a cold nodule is at least 10%
- D. The risk of carcinoma in the dominant nodule within MNG is approximately 1%
- E. A history of childhood of head and neck irradiation substantially increases the risk of malignant change in solitary thyroid nodule

# In the investigation of solitary thyroid nodules

- TFTFT

# The following are true

- A. The commonest site for ectopic thyroid tissue is the base of tongue
- B. I-123 is superior than Tc-99m in confirming the presence of a lingual thyroid gland
- C. Isotopes of Iodine are superior than Tc-99m for localizing retrosternal thyroid tissue
- D. Absence of activity below the sternal notch excludes an intrathoracic goitre
- E. Ectopic thyroid tissue may be found in up to 50% of cases of neonatal hypothyroidism

# The following are true

- TTTFT

# Concerning malignancy of the thyroid gland

- A. The majority of tumors are follicular type
- B. Most tumors are well differentiated
- C. Most thyroid tumors are detected following demonstration of an area of increased uptake relative to normal thyroid on Tc-99m scan
- D. Anaplastic carcinoma never takes up I-131
- E. Screening of relatives is mandatory in anaplastic carcinoma

# Concerning malignancy of the thyroid gland

- FTFTF

The following may cause a solitary cold nodule in thyroid scan

- A. Lymphoma
- B. Parathyroid adenoma
- C. TB
- D. Wegner's granulomatous
- E. Metastatic adenocarcinoma

# The following may cause a solitary cold nodule in thyroid scan

- TTTFT

# The following are true

- A. The patient with toxic MNG presenting with pressure symptoms should be treated with RAI first instance
- B. Patients receiving I-131 for thyrotoxicosis should take approximately 1 week off work following treatment
- C. The absolute of thyroid hormones and TSH before treatment with RAI is a useful predictor of the development of hypothyroidism in Grave's
- D. A rise of thyroglobulin level following complete ablation for thyroid carcinoma is indicative of recurrent malignant disease
- E. Uptake of RAI into thyroid carcinoma metastases has prognostic significance

# The following are true

- FTFTT

What is the origin of lingual and sublingual thyroid tissue?

# What is the origin of lingual and sublingual thyroid tissue?

- The main thyroid anlage begins as a downgrowth from the foramen cecum.
- Thyroid tissue may be seen anywhere along the tract of the thyroglossal duct from the foramen cecum to the usual location of the gland.
- However with lingual thyroid tissue, there is usually a failure of normal development and no tissue in the normal location of the thyroid

What is meant by the organification of iodine?

# What is meant by the organification of iodine?

- In thyroid metabolism, iodide is oxidized to iodine and incorporated into tyrosine to form either monoiodotyrosine or diiodotyrosine.
- A deficiency in peroxidase which catalyzes the reaction, is cause of congenital hypothyroidism.

What is the difference in mechanism of thyroid uptake between Tc-99m pertechnetate and radioiodine?

# What is the difference in mechanism of thyroid uptake between Tc-99m pertechnetate and radioiodine?

- Radioiodine is taken up or extracted (trapped) by the thyroid follicular cell and organified, binding to tyrosine residues on thyroglobulin and stored in colloid in the follicle.
- Tc-99m pertechnetate is trapped but not organified.

Which are common causes of falsely low thyroid uptake?

# Which are common causes of falsely low thyroid uptake?

- Thyroid hormone
- Iodine containing drugs
- Recent administration of IV iodine contrast.

What is the difference between thyroid scan and thyroid uptake?

# What is the difference between thyroid scan and thyroid uptake?

- A thyroid uptake is usually a nonimaging study using gamma detector probe.
- Thyroid scan results from gamma camera imaging.

How can a thyroid uptake test differentiate two most common causes of thyrotoxicosis, Grave's and subacute thyroiditis?

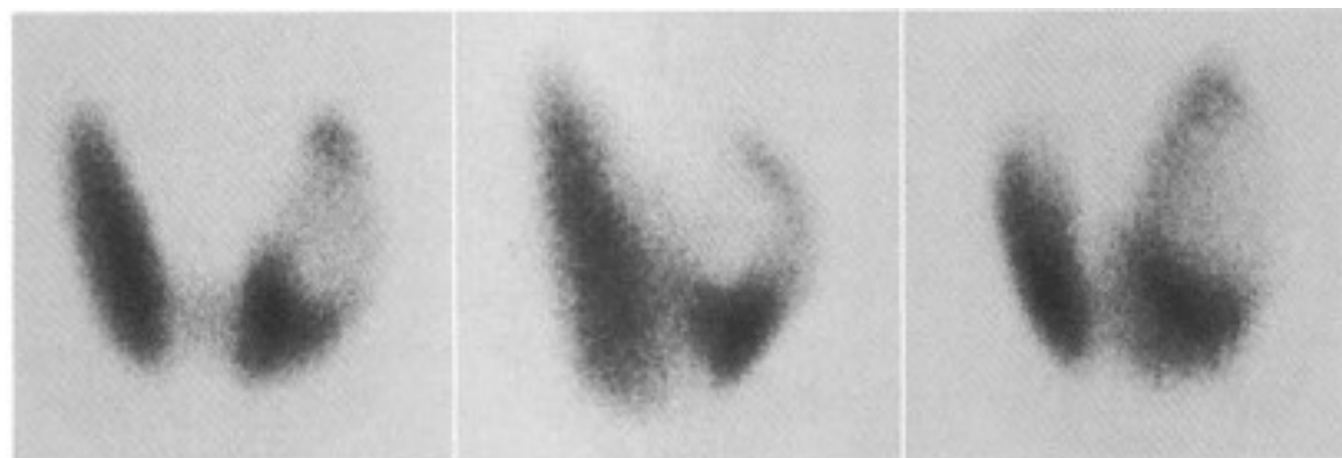
# How can a thyroid uptake test differentiate two most common causes of thyrotoxicosis, Grave's and subacute thyroiditis?

- In the initial phase of subacute thyroiditis, thyroid hormone are released from the inflamed gland causing thyrotoxicosis.
- Due to pituitary feedback, TSH is suppressed.
- Radioiodine or Tc-99m uptake requires TSH stimulation.
- Thus, the uptake of radioiodine or Tc-99m pertechnetate is low or suppressed.
- With Grave's disease, TSH is suppressed, however the gland is autonomous and the uptake is high.

What is the mechanism of action of antithyroid drugs PTU and CBZ?

# What is the mechanism of action of antithyroid drugs PTU and CBZ?

- Both PTU and CBZ are thiourea antithyroid drugs that block the organification of iodine

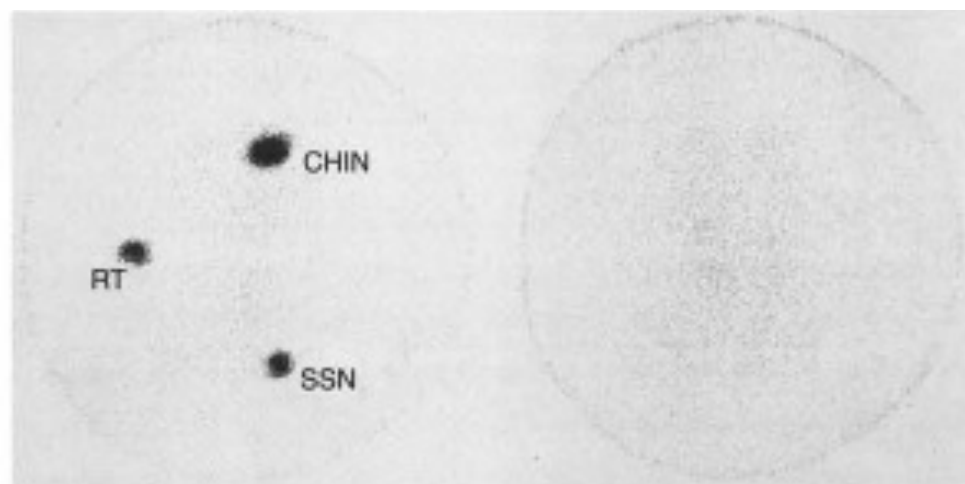


A 55-year-old woman is referred for a thyroid scan to evaluate a palpable thyroid nodule. Left to right views are anterior, right anterior oblique, and left anterior oblique.

1. What are the two radiopharmaceuticals used for thyroid scintigraphy, their photopeaks, and physical half-lives?
2. What is the likelihood of thyroid cancer in this patient?
3. What would you recommend as the next diagnostic or therapeutic procedure?
4. What imaging method is used here? What is its image resolution?

# Cold thyroid nodule

1. IV Tc-99m pertechnetate, 140 keV, 6 hours; oral sodium I-123, 159 keV and 8 hours.
2. A single cold nodule has a 15% to 20% chance of malignancy.
3. FNA
4. Pinhole collimator 4 to 6 mm

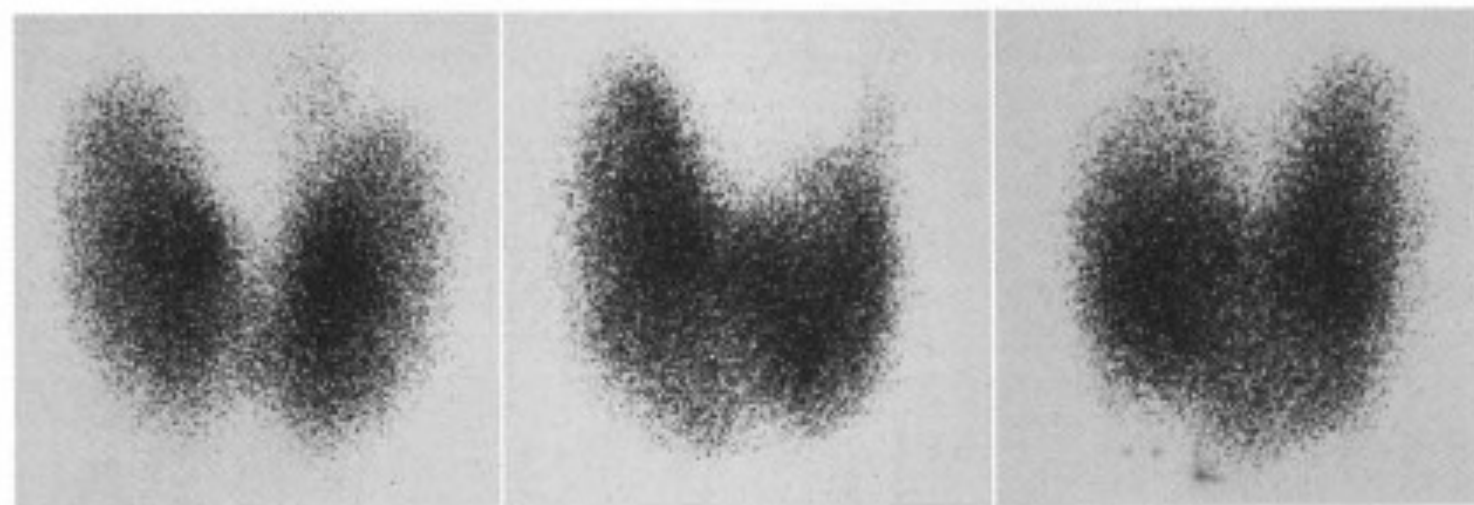


A 48-year-old woman has recent onset of neck tenderness and hyperthyroidism (thyroid-stimulating hormones [TSH]  $<0.05 \mu\text{U/ml}$ );  $^{123}\text{I}$  scan uptake (radioactive iodine uptake [RAIU])  $\leq 1\%$ . Right side (*R*); suprasternal notch (*SSN*).

1. What is the clinical differential diagnosis of hyperthyroidism?
2. What is the clinical purpose of the thyroid scan and RAIU tests in hyperthyroidism?
3. How is the RAIU calculated?
4. What is the likely diagnosis in this patient?

# Hyperthyroidism/ thyroiditis

1. Grave's disease, toxic nodules, thyroiditis, iatrogenic thyroid hormone ingestion, iodine induced, trophoblastic tumors, Hashitoxicosis and struma ovarii.
2. Aid in the DD of hyperthyroidism
3. A nonimaging gamma probe obtains counts/time from neck and a phantom counting activity equal to the orally administered dose to convert to gamma probe counts  $\mu\text{Ci}$  % RAIU = neck ( $\mu\text{Ci}$ ) divided by the total administered dose ( $\mu\text{Ci}$ ) after background correction.
4. Subacute thyroiditis based on the history of neck tenderness, laboratory finding and RAIU.

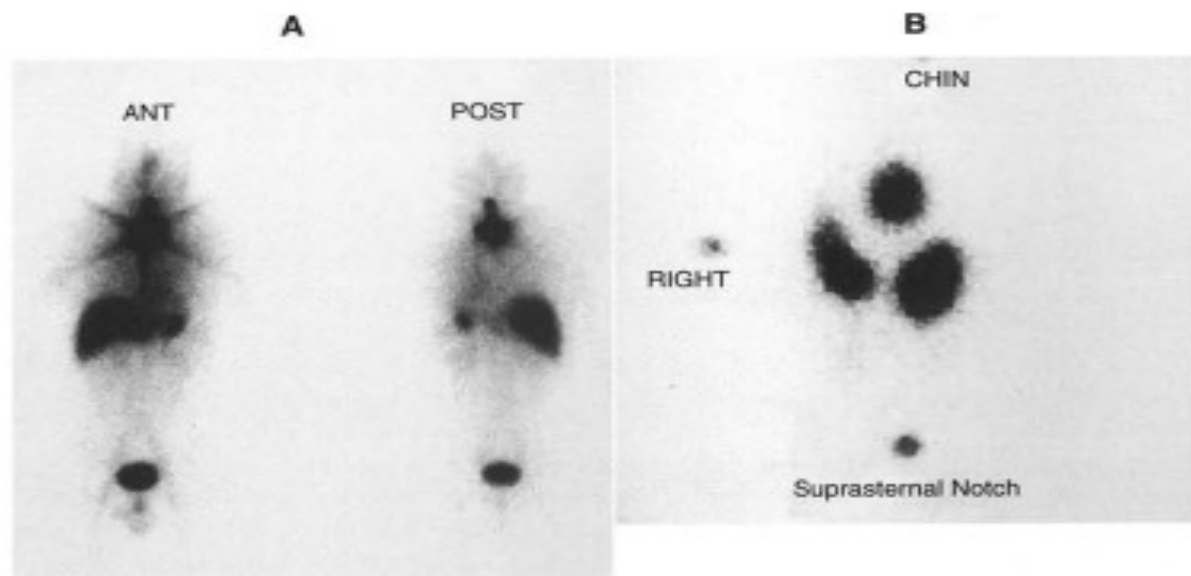


A 35-year-old woman with hyperthyroidism. Radioactive iodine uptake was 94% at 4 hours and 81% at 24 hours.

1. Describe the difference between Graves' disease and euthyroid scan appearance.
2. What is the appropriate therapy for Graves' disease?
3. What are the usual administered doses of radiotracer for  $^{131}\text{I}$  uptakes,  $^{123}\text{I}$  scans, and Graves' disease therapy?
4. What are the short-term and long-term side effects of  $^{131}\text{I}$  therapy for hyperthyroidism?

# Grave's disease

1. Scan appearance may be similar. With the large goiter the scan often has a plumper appearance with convex borders. The pyramidal lobe may be seen as in this case.
2. Surgery is seldom performed because of the high risk. PTU and CBZ sometimes are used initially who require cooling down most of the patients are treated with RAI after 6 to 12 months of antithyroid medication. Many patients are treated initially with I-131.
3. I-131 uptake (10  $\mu$ Ci), I-123 scan and uptake (300  $\mu$ Ci) and Grave's disease therapy; I-131 (5-15 mCi)
4. Short term; occasional exacerbation of hyperthyroidism and thyroid storm. Long term; hypothyroidism. There is no increased incidence of secondary cancers or reduction in fertility.

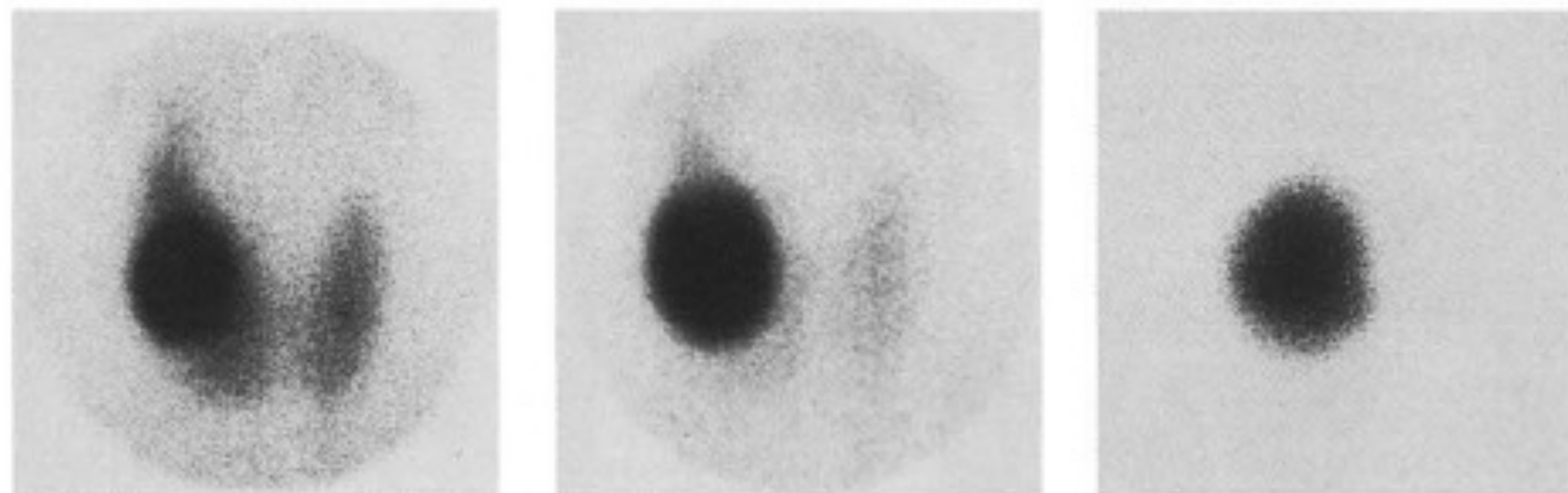


A 39-year-old woman 6 weeks previously underwent total thyroidectomy for thyroid cancer. Scanning was done 7 days after therapy for thyroid ablation with 75 mCi of  $^{131}\text{I}$ .

1. Describe and interpret the scintigraphic images.
2. What is the reason for the star artifact pattern in the neck in scan A?
3. What collimator was used for image B?
4. Why is the liver seen in image A?

# I-131 star artifact

1. A. Post therapy I-131 WBS shows intense uptake in the neck with a star effect, diffuse liver activity and bladder clearance. B, Pinhole image of the neck with three foci of uptake.
2. Septal penetration of high energy of I-131 gamma rays through the collimator septa.
3. Pinhole collimator centered on the thyroid.
4. Radiolabeled thyroid hormone is metabolized in the liver. This usually seen only on the post therapy scan.

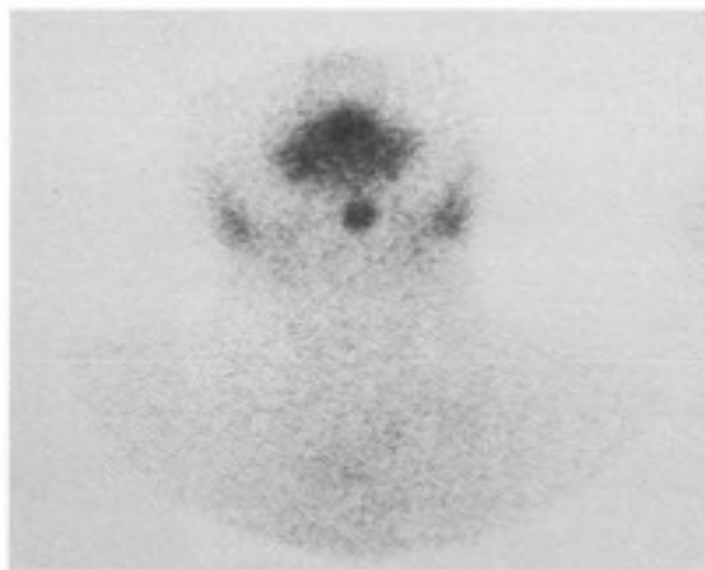


A 39-year-old woman has a 3-year history of hyperthyroidism. <sup>123</sup>I thyroid scans were performed each year, shown from left to right.

1. Describe the scintigraphic findings.
2. Give the diagnosis.
3. What treatment options are appropriate for this patient?
4. What would you expect the radioactive iodine thyroid uptake to be?

# Toxic autonomous thyroid nodule

1. Hot nodule in the mid right of the thyroid with increasing suppression of the remaining gland at each successive year
2. Toxic autonomous thyroid nodule
3. Surgery and RAI I-131
4. The iodine uptake may be moderately elevated, but it often is in the normal range. Normal 24 hour uptake is 10 to 30%

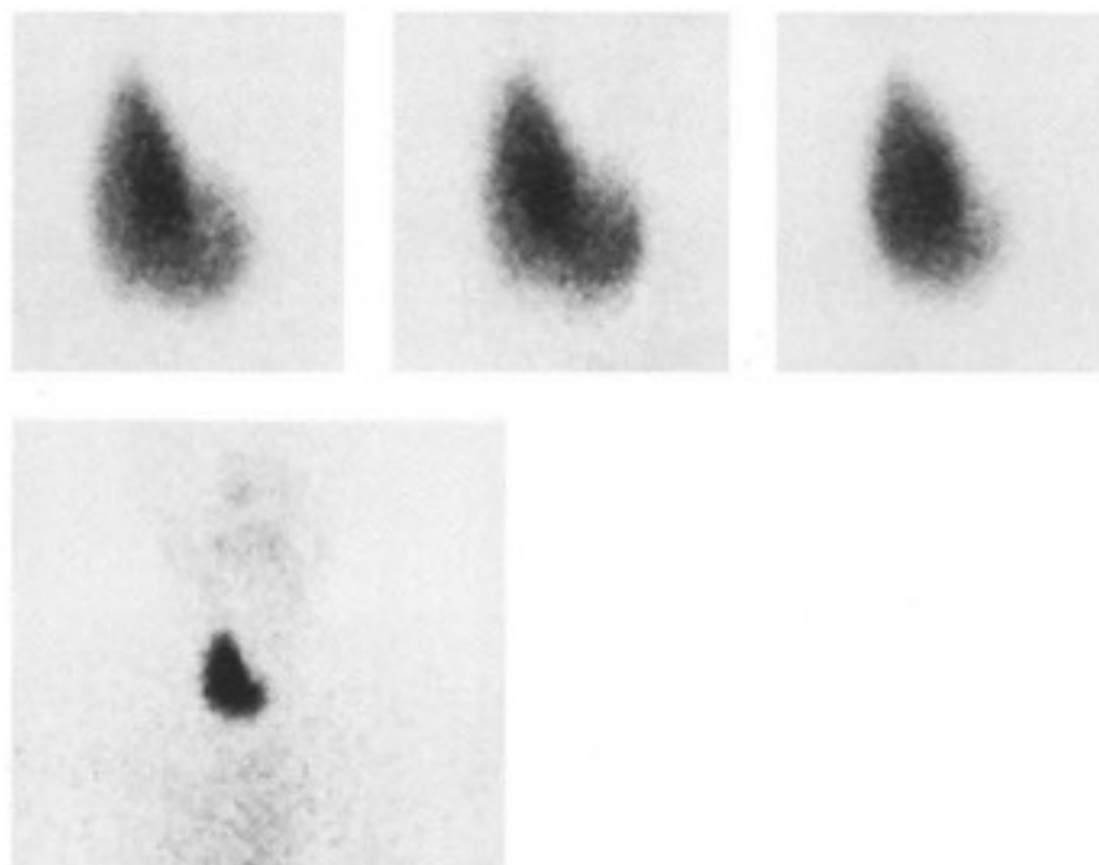


$^{99m}\text{Tc}$  pertechnetate scan in a 3-year-old child with a sublingual mass. Patient is euthyroid.

1. What is the mechanism of  $^{99m}\text{Tc}$  pertechnetate and  $^{123}\text{I}$  sodium iodide uptake?
2. What is the advantage of  $^{99m}\text{Tc}$  pertechnetate over  $^{123}\text{I}$  in this patient?
3. Describe the scintigraphic findings.
4. What is the diagnosis?

# Lingual thyroid

1. Tc-99m pertechnetate is taken up by thyroid follicular cells like iodine but not organified. I-123 taken up and organified.
2. Lower radiation exposure to the pediatric patient.
3. Focal uptake at the base of the tongue. Normal is submandibular glands and mouth. No thyroid in the neck.
4. Lingual thyroid.



$^{99m}\text{Tc}$  pertechnetate thyroid scan in a patient with clinical hyperthyroidism.

1. Describe the scintigraphic findings.
2. Describe the scan evidence that supports the reported hyperthyroidism.
3. What is the differential diagnosis regarding the left lobe?
4. The right lobe is two times normal size by examination. The left lobe is not palpable, no nodules are felt, and no scars are present. What is the most likely diagnosis?

# Left thyroid agenesis

1. Uniform uptake in the right lobe. No activity seen at the left lobe or elsewhere in the neck or upper chest.
2. The uniform activity in the right lobe is more intense than the salivary glands indirect evidence of an elevated uptake in the absence of intrinsic salivary gland disease.
3. Surgical excision, replacement by hypofunctioning adenoma or carcinoma or agenesis of the left lobe with Grave's disease of the solitary right lobe.
4. Grave's disease with agenesis of the left lobe.

# Gastrointestinal & Hepatobiliary

# Pearls & Pitfalls

## Gastric emptying studies

- The study usually are performed the rate of emptying of solids from stomach, they are most commonly performed by Tc-99m colloid mixed with scramble eggs before they are cooked.
- Half of the activity of a solid meal should be out of the stomach in about 90 minutes.
- Solids leave the stomach in a linear fashion, liquids exponentially.

# Pearls & Pitfalls

## Gastrointestinal bleeding studies

- Usually these are performed by Tc-99m labeled RBC, but Tc-99m sulfur colloid can also be used.
- A focus of bleeding should change shape and location on sequential images. If the activity does not move, it may represent a vascular abnormality such as aneurysm or intussusception.

# Pearls & Pitfalls

## Gastrointestinal bleeding studies

- The best way to pinpoint the bleeding site is to find an image in which there is a definite abnormality and then to look at the earlier images and find the first image in which the activity can be seen. This is necessary because activity seen as a result of bleeding can go anterograde or retrograde in the bowel.

# Pearls & Pitfalls

## Gastrointestinal bleeding studies

- Bladder activity from free Tc-99m pertechnetate can be confusing and sometimes it is necessary for the patients to void or catheterized.
- If bleeding is intermittent, use Tc-99m RBC. If the bleeding is active, either Tc-99m RBC or Tc-99m sulfur colloid can be used.

# Pearls & Pitfalls

Gastrointestinal  
bleeding studies

- **False positives:**
  - ❖ Free pertechnetate seen at stomach
  - ❖ Renal excretion of breakdown products
  - ❖ Penile blood pool, transplanted kidney and varices.

# Pearls & Pitfalls

## Gastrointestinal bleeding studies

- **False negatives:**
  - ❖ Small bowel bleeding
  - ❖ Rectal bleeding obscured by bladder activity
  - ❖ A stationary abnormal focus could represent clotted blood

# Salivary scintigraphy

## Salivary Scintigraphy Radiotracers

99m-Tc Pertechnitate

123-I

131-I

67-Ga

111-In WBC

## Three Major Pairs of Salivary Glands

1. Parotid
2. Submandibular
3. Sublingual

## Indications of Tc-99m pertechnitate

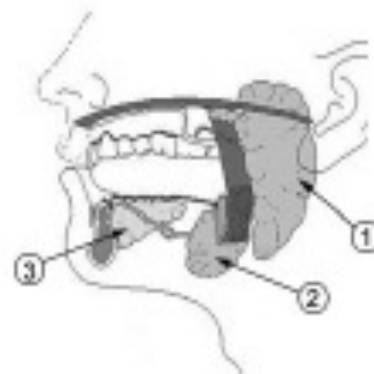
Salivary obstruction

Xerostomia

Sjögren syndrome

Inflammation of the salivary gland

Tumors eg Warthin's tumor



# Salivary scintigraphy

Patient lies supine in the Water's position (chin and nose touching collimator face)  
Tracer injected intravenously

## PRE-STIMULUS

Dynamic blood flow images immediately after injection for 3–5 s/frame for 1–2 min, followed by 20 min of dynamic imaging for 2–3 min/frame to assess function of the glands.

Trapping of the pertechnetate should occur within 1 min of intravenous injection in normal glands.

Peak activity occurs in the glands within 10 (22) to 21 min

Lateral images should be acquired

## POST-STIMULUS

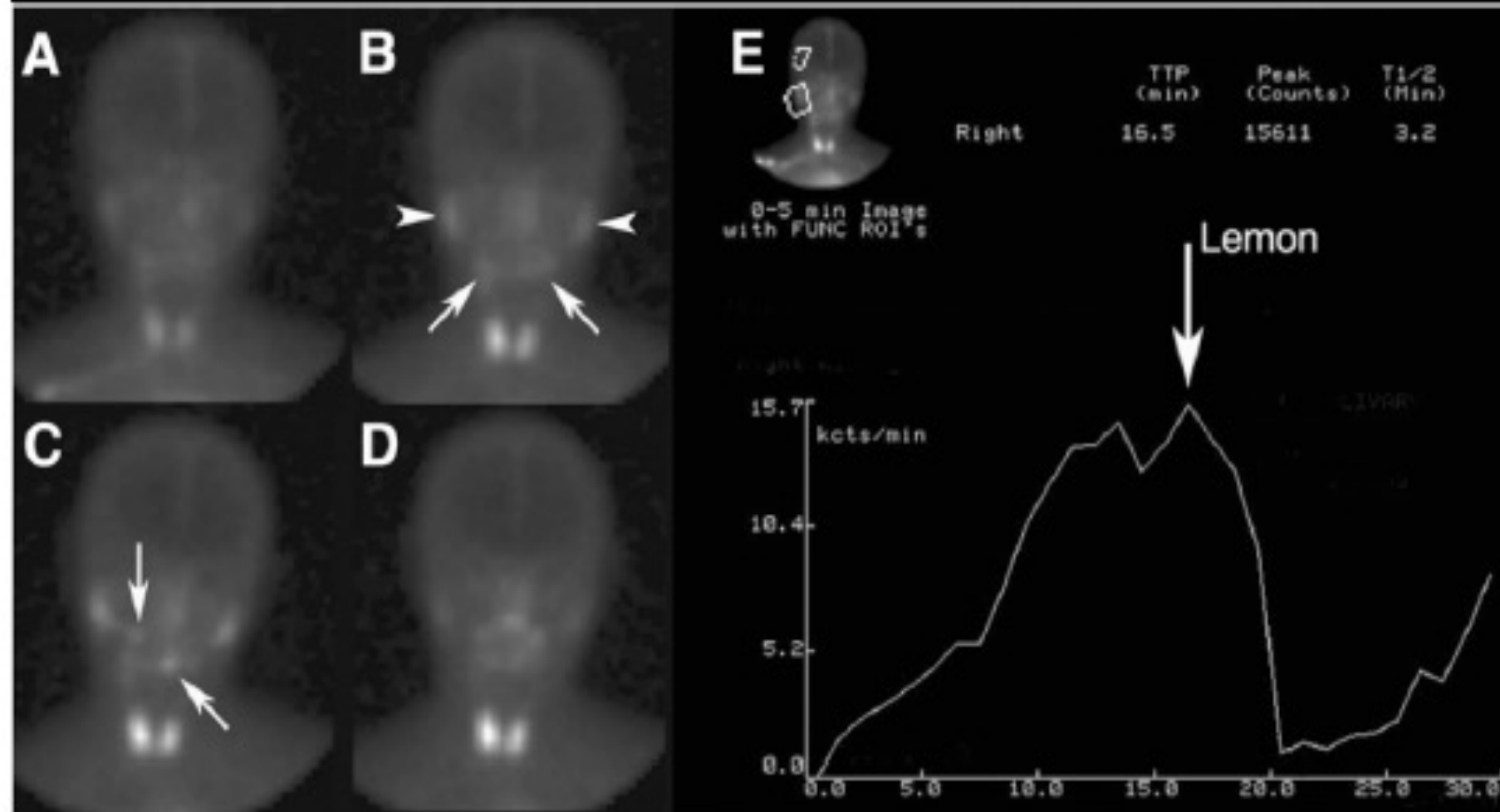
Then stimulate with lemon juice - drink a mouthful of lemon juice via a straw and hold this in the oral cavity for a few seconds before swallowing

A further 20 min of dynamic imaging for 2–3 min/frame

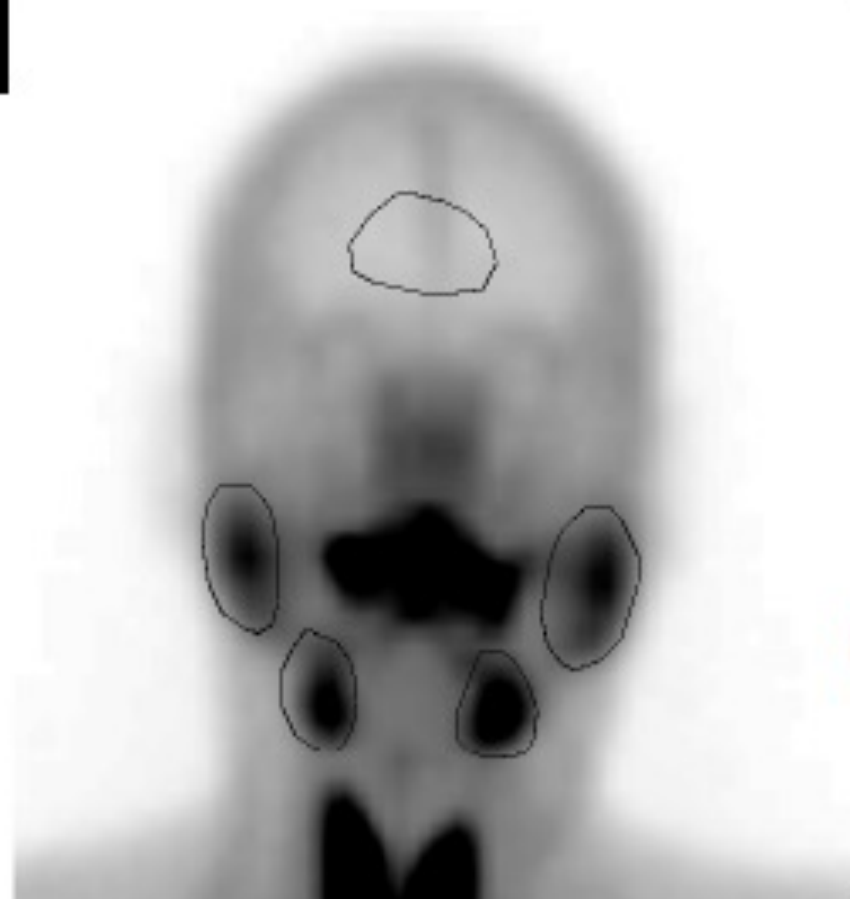
Draw ROI over glands to chart washout

## MARKERS

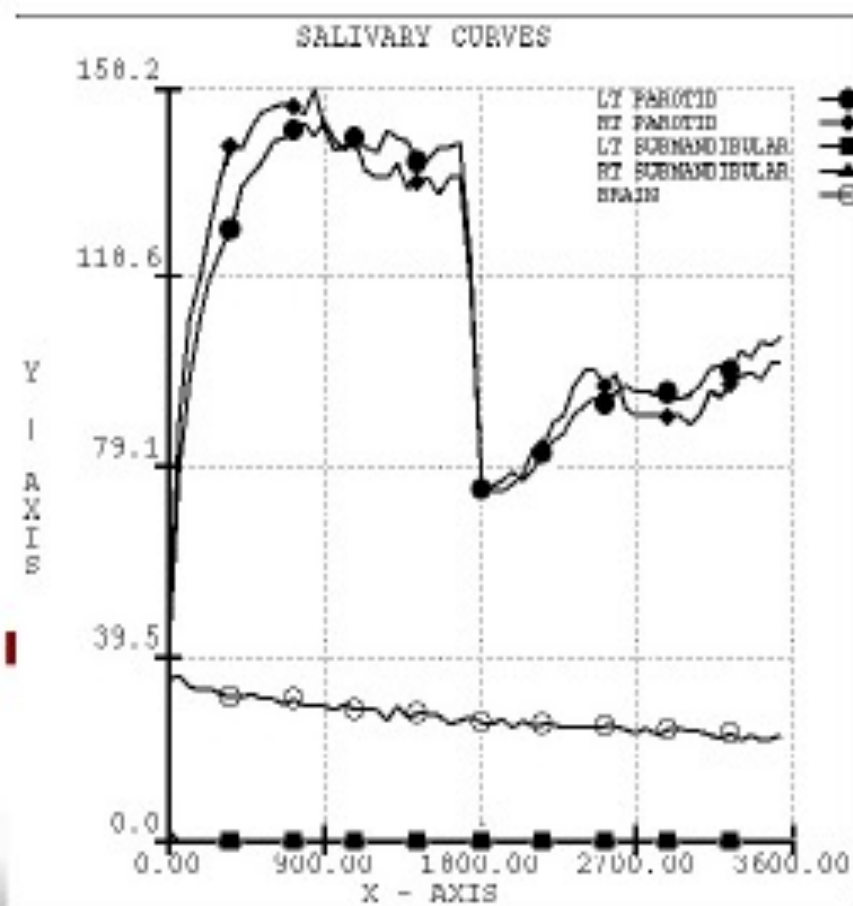
Used to localise abnormal distribution of radiotracer



Infrequently Performed Studies in Nuclear Medicine: Part 2  
 Anita MacDonald and Steven Burrell  
 J Nucl Med Technol 2009; 37:1-13



COMPOSITE



SALIVARY CURVES

# Salivary scintigraphy

## **<sup>99m</sup>Tc Pertechnetate interpretation**

### **INFECTION, ABSCESS AND INFLAMMATION**

Acute parotitis – Diffuse increased uptake, poor secretion on stimulation

Later stages show decreased or absent uptake

Sialolithiasis - Diffuse increased uptake, poor secretion on stimulation due to obstruction

Abscess or cyst – Photopenia. WBC scan may be helpful.

### **TUMORS**

Photopenic except for most Warthin's tumors

Warthin's tumor (papillary cystadenoma) are better seen on post stimulation as they retain tracer.

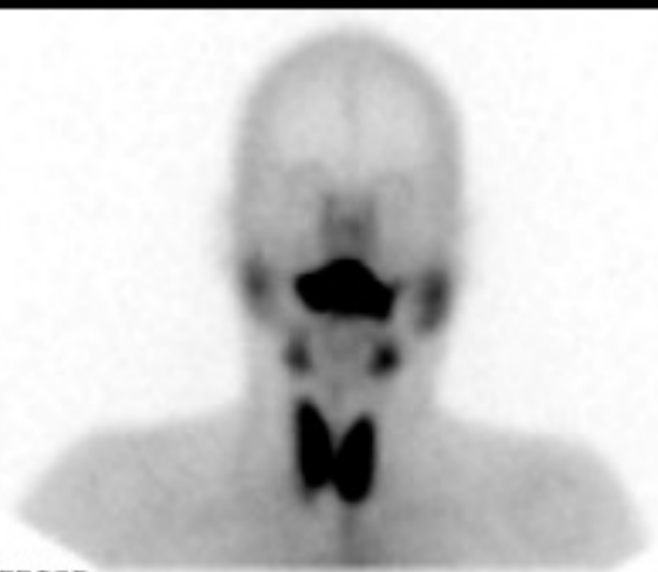
It can sometimes lie outside the salivary gland.

### **SJÖGREN SYNDROME**

Monitor disease response.

Submandibular gland to parotid gland on salivary SPECT (S/P ratio) – abnormal if >1

Ga-67 citrate can distinguish primary (avid) from secondary involvement.



ANTERIOR



POSTERIOR



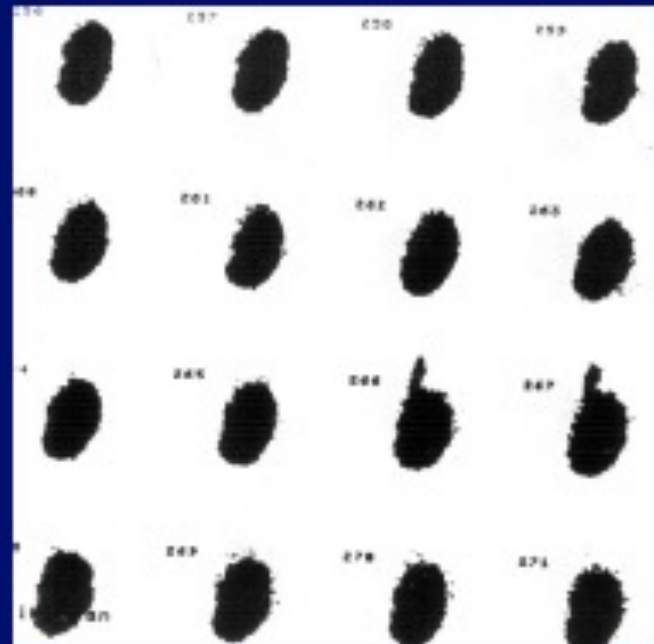
LT LAT



RT LAT

# Gastroesophageal reflux studies

- Normal and abnormal studies
  - The upper limit of GR is 3%
  - Between 3-4% is intermediate
  - >4% is abnormal
  - The sensitivity of the study is about 90%
  - The study can be used in the initial diagnosis of GR and in the evaluation of various therapeutic modalities



# Gastroesophageal reflux : Milk study

|                     |                                                                                                                                                                      |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Patient preparation | Overnight fasting                                                                                                                                                    |
| Radionuclide        | Tc-99m SC (0.2 – 1 mCi)                                                                                                                                              |
| Feeding meal        | The radionuclide is mixed with half of the meal and fed the child. The second “cold” half of the meal is then fed to the child. Orange juice for adults and children |
| Imaging             | After burping infant, place supine with gamma camera and radioactive marker at the mouth<br>Acquire delayed image of the chest                                       |

# Gastric Emptying

Performed after mechanical obstruction of the stomach and intestine are excluded by radiologic studies

Dual labelled solid – liquid can help distinguish gastroparesis from partial gastric outlet obstruction



1



6



3



4



5



6



7



8



9



10



11



12



13



14



15



16

ANTERIOR  
GASTRIC EMPTYING

4MINS/FRAME

gastroscopy



1



3



4



5



6



7



8



9



10



11



12



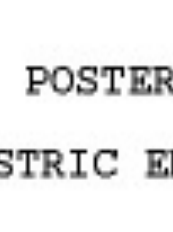
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14



15

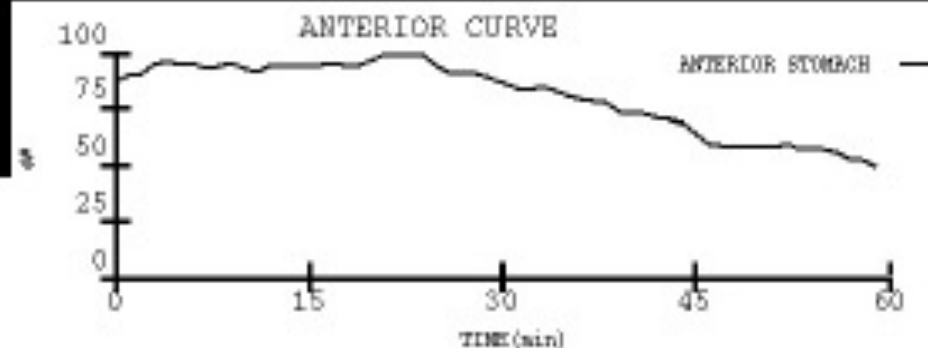
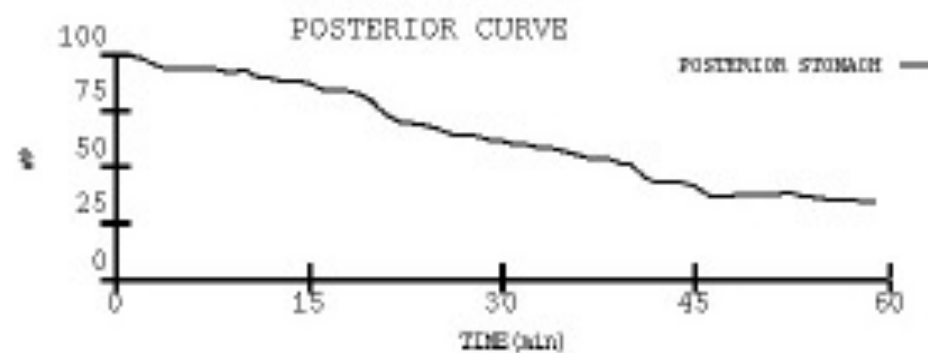
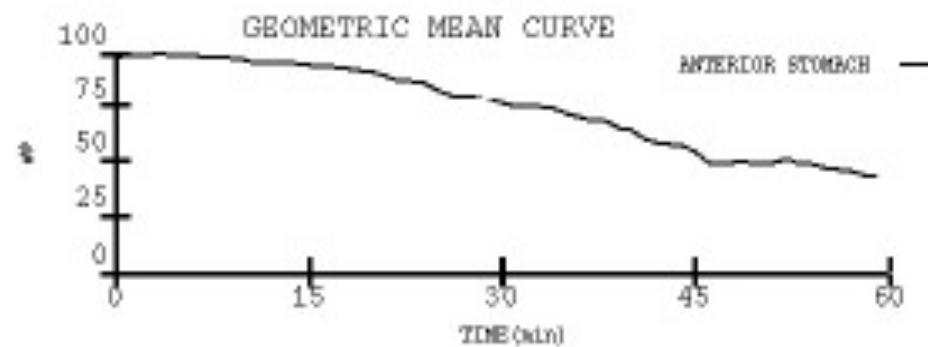


16

POSTERIOR  
GASTRIC EMPTYING

4MINS/FRAME

gastroscopy



|              | ANTERIOR | POSTERIOR | GEOMETRIC |
|--------------|----------|-----------|-----------|
| $T_{1/2}$ :  | 36.00    | 41.00     | 43.00     |
| % EMPTIED:   | 21.76    | 57.58     | 42.39     |
| % REMAINING: | 78.24    | 42.42     | 57.61     |

# Gastric Emptying

4 static images at 0, 1, 2 and 4 hours.  
No dynamic images.

1 hour imaging – rapid transit

4 hour imaging – delayed transit

Meal:

Egg white from two large eggs

Two slices of white bread (120 kcal)

Strawberry jam (30 g, 74 kcal)

Water (120 mL)

Technetium-99m sulfur colloid, 0.521 mCi.

Caloric value of 255 kcal

72% carbohydrate,

24% protein,

2% fat,

2% fiber.

An allergy to eggs is a contraindication to this meal.

**TABLE 1**  
Normal Values for Low-Fat, Egg-White  
Gastric Emptying Scintigraphy

| Time Point | Lower Normal Limit for Gastric Retention      | Upper Normal Limit for Gastric Retention          |
|------------|-----------------------------------------------|---------------------------------------------------|
| 0 min      | A lower value suggests rapid gastric emptying | A greater value suggests delayed gastric emptying |
| 0.5 h      | 70% <sup>†</sup>                              |                                                   |
| 1 h        | 30% <sup>‡</sup>                              | 90%*                                              |
| 2 h        |                                               | 60%*                                              |
| 3 h        |                                               | 30% <sup>‡</sup>                                  |
| 4 h        |                                               | 10%*                                              |

Values are the 95th percentile confidence interval.  
\*Tougas et al. (38).  
<sup>†</sup>Abell et al. (50).  
<sup>‡</sup>Lin et al. (51).

# Gastric Emptying

## GASTRIC EMPTYING SCINTIGRAPHY - SGH DNMP SPREADSHEET - 2009

Department of Nuclear Medicine and PET, Singapore General Hospital, Singapore



Singapore  
General Hospital  
SingHealth

Reference:

Consensus: Recommendations for Gastric Emptying Scintigraphy: A Joint Report of the American Neurogastroenterology and Motility Society and the Society of Nuclear Medicine;  
Abell et al; J Nucl Med Technol 2008; 29:44-54

| Time of day<br>(24-hour) | Time from meal<br>ingestion<br>(in minutes) | Anterior<br>Counts (A) | Posterior<br>Counts (B) | Anterior<br>counts<br>(corrected) | Posterior<br>counts<br>(corrected) | Geometric<br>Mean<br>( $\sqrt{A \times B}$ ) | Percentage<br>Remaining<br>% | Reference<br>Range | Normal<br>/<br>Abnormal |
|--------------------------|---------------------------------------------|------------------------|-------------------------|-----------------------------------|------------------------------------|----------------------------------------------|------------------------------|--------------------|-------------------------|
|                          | 0                                           |                        |                         | 0                                 | 0                                  | 0                                            | 100%                         | 100%               | baseline                |
|                          | 0                                           |                        |                         | 0                                 | 0                                  | 0                                            | 0%                           | 37-90%             | no counts               |
|                          | 0                                           |                        |                         | 0                                 | 0                                  | 0                                            | 0%                           | 30-60%             | no counts               |
|                          | 0                                           |                        |                         | 0                                 | 0                                  | 0                                            | 0%                           | <10%               | no counts               |

### Instructions - Enter data into the YELLOW cells ONLY please.

1. Please clear all the data from the yellow cells.
2. Enter time in 24 hour format (00:00) for the 0 hr, 1 hr, 2 hr and 4 hr counts
3. Enter the anterior and posterior counts into the YELLOW shaded cells ONLY
4. Note the results in the blue cells (automatically generated)
5. Report the final results in the orange cells.

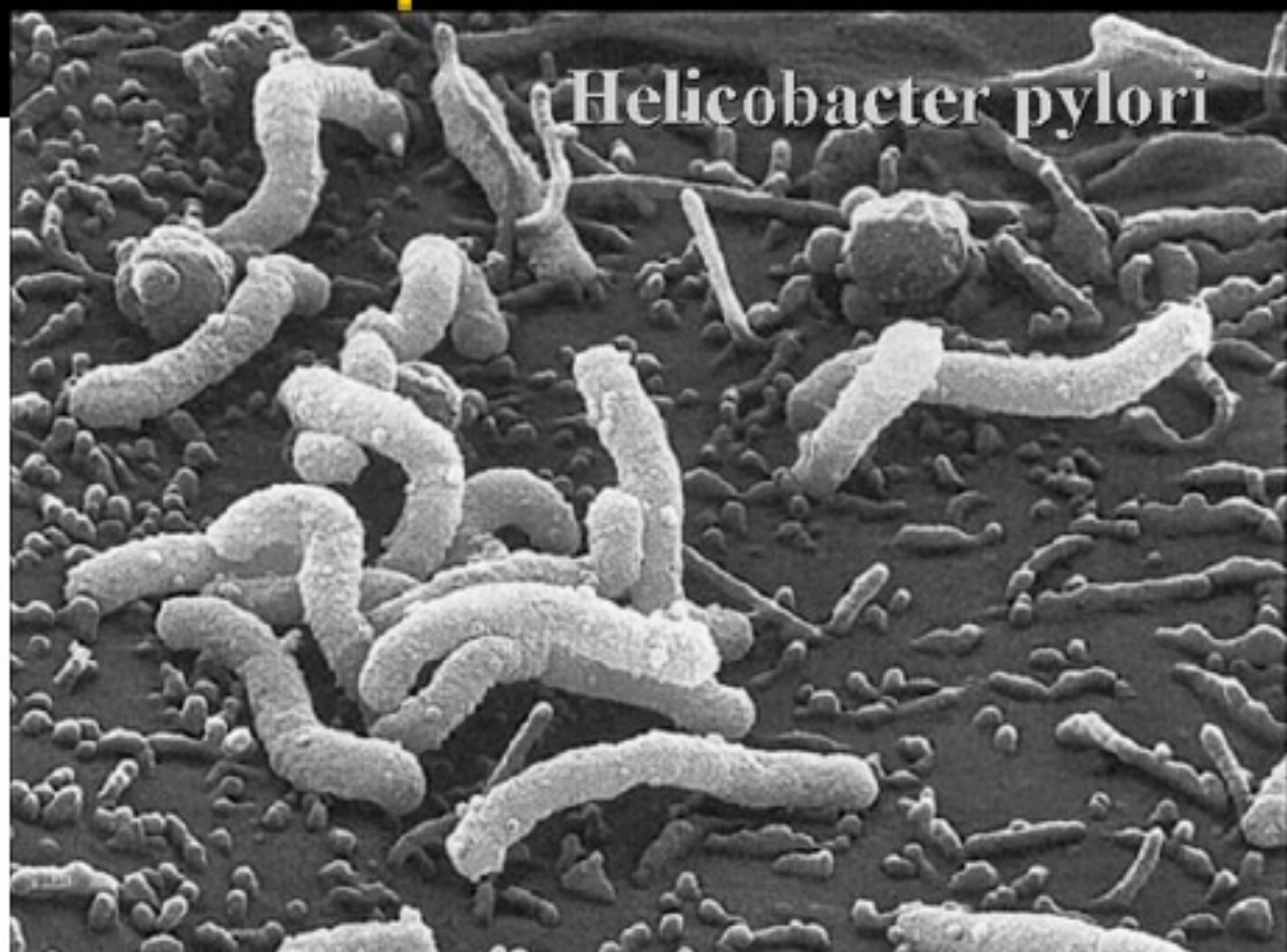
Patient name

NRIC

Date

**PLEASE DO NOT KEY IN ANY FIGURES INTO THE BLUE SHADED CELLS**

# Carbon-14 Urea Breath Test



# Carbon-14 Urea Breath Test



Noninvasive

80% of non-NSAID-induced gastric ulcers are infected with *H. pylori*.

Eradication reduces ulcer recurrence to <10% in 1 yr vs. 60-100% .

A 1- $\mu$ Ci capsule of C-14–labeled urea is administered and 10 minutes later a breath sample is collected.

*H. pylori* contains an enzyme, urease.

This hydrolyzes the urea into ammonia and C-14–labeled carbon dioxide which is absorbed in the blood and exhaled in the lungs.

The patient exhales until liquid is blue. The C-14–labeled carbon dioxide is detected in the breath sample using liquid scintillation techniques.

# Gastrointestinal Bleeding

Can detect bleeding at rates as low as 0.1 mL/min.

Angiography can detect 1.0 mL/min

## Radiotracer

Tc-99m labeled RBCs

Alternate Tc-99m SC (rarely used)

## Labeling Methods

In-vivo

Combined in-vivo and in-vitro

In-vitro

The radiopharmaceutical is injected intravenously.

Angiographic sequence of 1 frame/sec for 60 sec

Serial imaging of 1 frame/min for 60-90 mins

Delayed images as needed

Maximum time 4 hours vs 24 hours.

# Gastrointestinal Bleeding

Table 1 Basic Differences in Methodology of  $^{99m}\text{Tc}$ -Labeling of Erythrocytes (Red Blood Cells) and the Relative Advantages and Disadvantages of Each Technique

| In Vivo                                                                                                                                              | Modified in Vitro                                                                                                                                                                                   | In Vitro                                                                                                                                                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Technique</b><br>Intravenous stannous chloride.<br>10- to 20-minute interval.<br>Intravenous $^{99m}\text{Tc}$ pertechnetate<br>740 MBq (20 mCi). | Intravenous Stannous chloride.<br>10- to 15-minute interval.<br>Draw 3 mL of venous blood.<br>Add $^{99m}\text{Tc}$ pertechnetate 740 MBq<br>(20 mCi).<br>Readminister labeled blood to<br>patient. | Draw 1-3 mL of blood.<br>Label according to UltraTag <sup>®</sup> Red<br>Blood Cell kit instructions.*<br>Readminister $^{99m}\text{Tc}$ -labeled blood<br>to patient. |
| <b>Advantages</b><br>Rapid and simple to administer.                                                                                                 | Improved labeling efficiency.<br>Improved target to background ratio.                                                                                                                               | Excellent labeling efficiency.<br>Optimal target-to-background ratio.                                                                                                  |
| <b>Disadvantages</b><br>Free $^{99m}\text{Tc}$ pertechnetate may<br>degrade image quality.                                                           | Good-but-suboptimal image quality.                                                                                                                                                                  | More costly.                                                                                                                                                           |

\*Mallinckrodt Inc, St. Louis, MO.

The Role of Nuclear Medicine in the Detection of Acute Gastrointestinal Bleeding  
Douglas M. Howarth, FRACP  
Semin Nucl Med 36:133-146

# **$^{99m}\text{Tc}$ –RBC Labelling**

## **In vitro technique**

**Method of choice. RBC separated from a 10ml blood sample, incubated with stannous chloride then with  $^{99m}\text{TcO}_4$ , washed and reinjected**

## **In vivo technique** (MODIFIED IN VITRO)

**Stannous chloride injected i.v, 10 mls of blood drawn into a syringe containing  $^{99m}\text{TcO}_4$  & heparinised saline, mixed & reinjected.**

**Convenient but results in false +ve (free  $^{99m}\text{TcO}_4$ )**

## Comparison of Tc 99m Sulphur Colloids(SC) and Tc 99m Red Blood Cell for GIT bleed

|                             | Tc 99 m SC                                                                                              | Tc 99m RBC                                                          |
|-----------------------------|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| Dose                        | 10 mCi                                                                                                  | 25mCi                                                               |
| Minimal bleeding detectable | 0.1 mL/min                                                                                              | 0.05-0.4mL/min                                                      |
| Imaging duration            | 20-30 min(repeat once)                                                                                  | 60-90 min (repeat as needed for 24 H)                               |
| Advantages                  | Short imaging time<br>(High target to background ratio)                                                 | Repeated imaging up to 24 hours                                     |
| Disadvantages               | 1) Difficulty detecting hepatic and splenic flexure bleeding<br>2) Detect bleeding only over short time | False positive studies due to excretion of free Tc99m pertechnetate |

# Cimetidine

- Histamine H<sub>2</sub> receptor antagonis
- Increases uptake of Tc-99m pertechnitate
- Inhibit releasing of gastric mucosa
- Dose 20 mg/kg orally 2 days prior of the study

# Pentagastrin

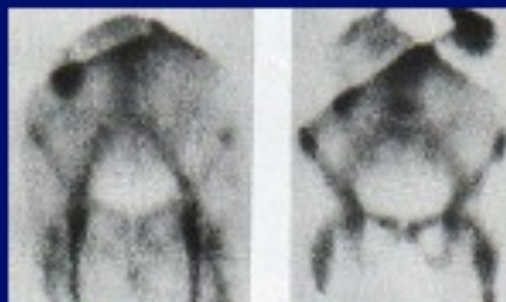
- Increases rapidity, duration and intensity of Tc-99m pertechnetate uptake
- Increased mucin producing cells
- Increases intestinal motility

# Glucagon

- Antiperistalsis
- Decreased bowel peristalsis
- Prevent tracer washout from diverticulum

# GI Bleeding

## $^{99m}\text{Tc}$ -Colloid

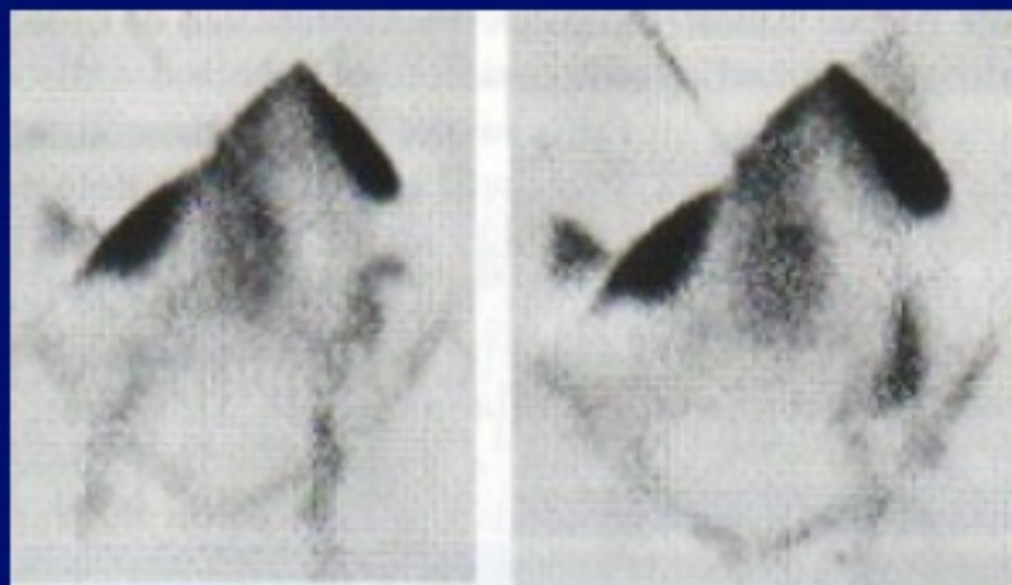


2 min 10 min

## Normal Appearance

# GI Bleeding

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



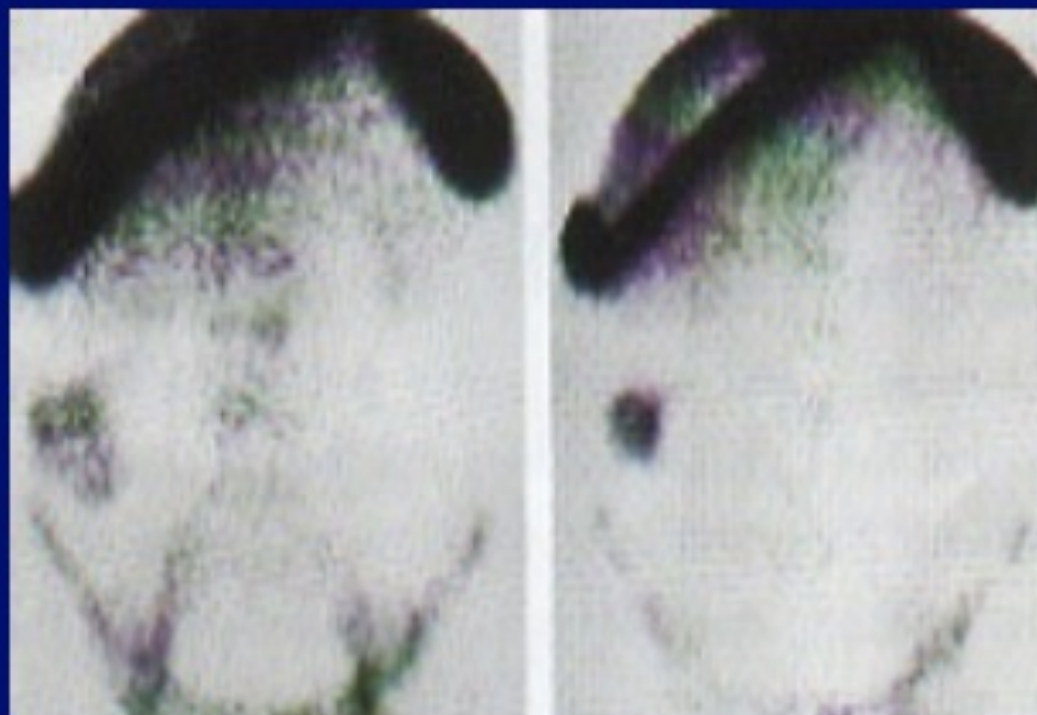
5 min

10 min

**Diverticular disease descending colon**

# GI Bleeding

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



2 min

10 min

**Bleeding and stasis in RIF**



**15 min**



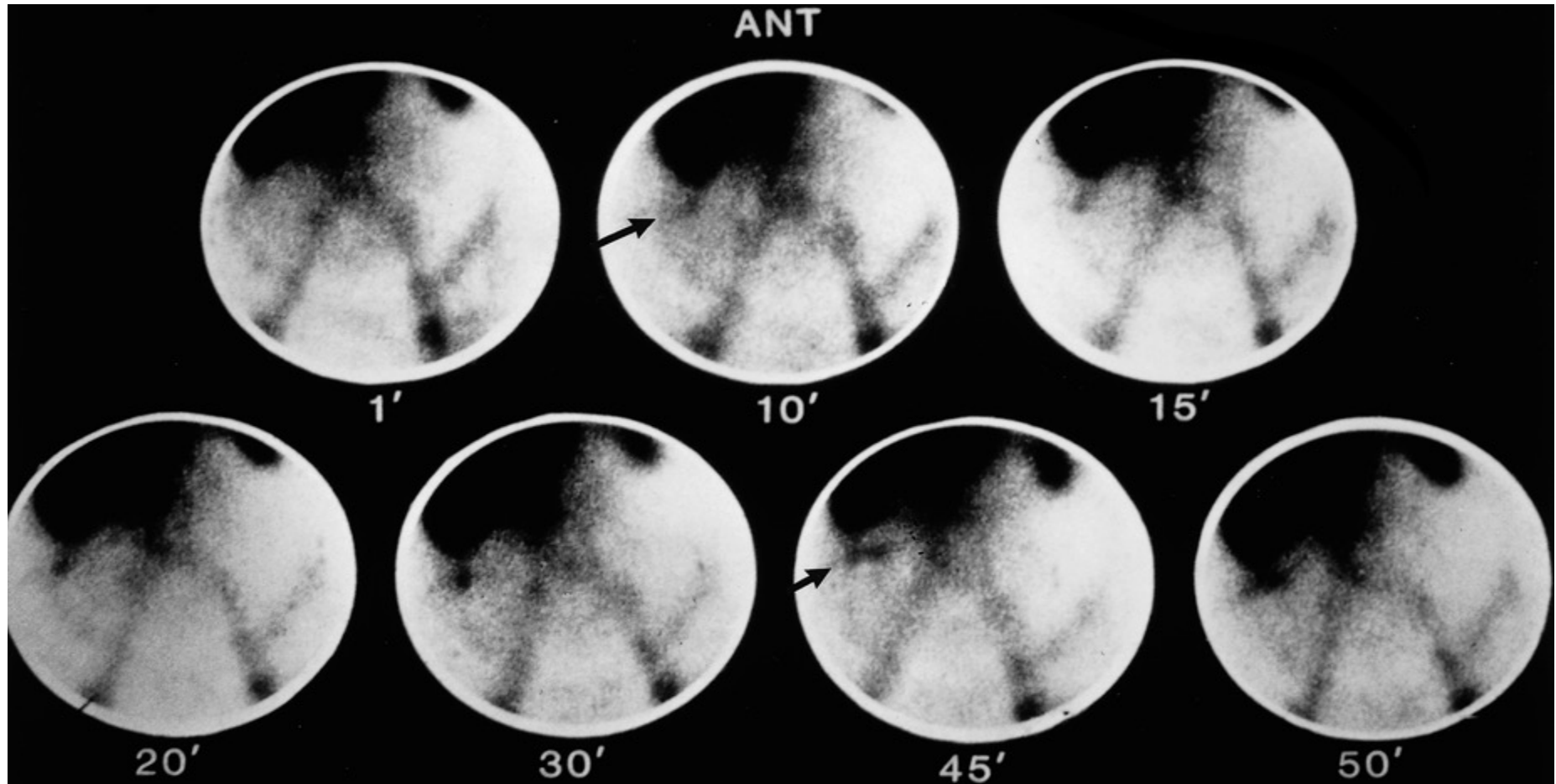
**30 min**



**60 min**

**A 55 year male c/o of GI Bleeding . Serial Tc99m-RBC' s  
Blood pool Scintigraphy showing GI Bleeding from  
ileocecal junction**

# Tc-99m RBC



**Criteria for  
diagnosis of  
bleeding site with  
Tc-99m RBC**

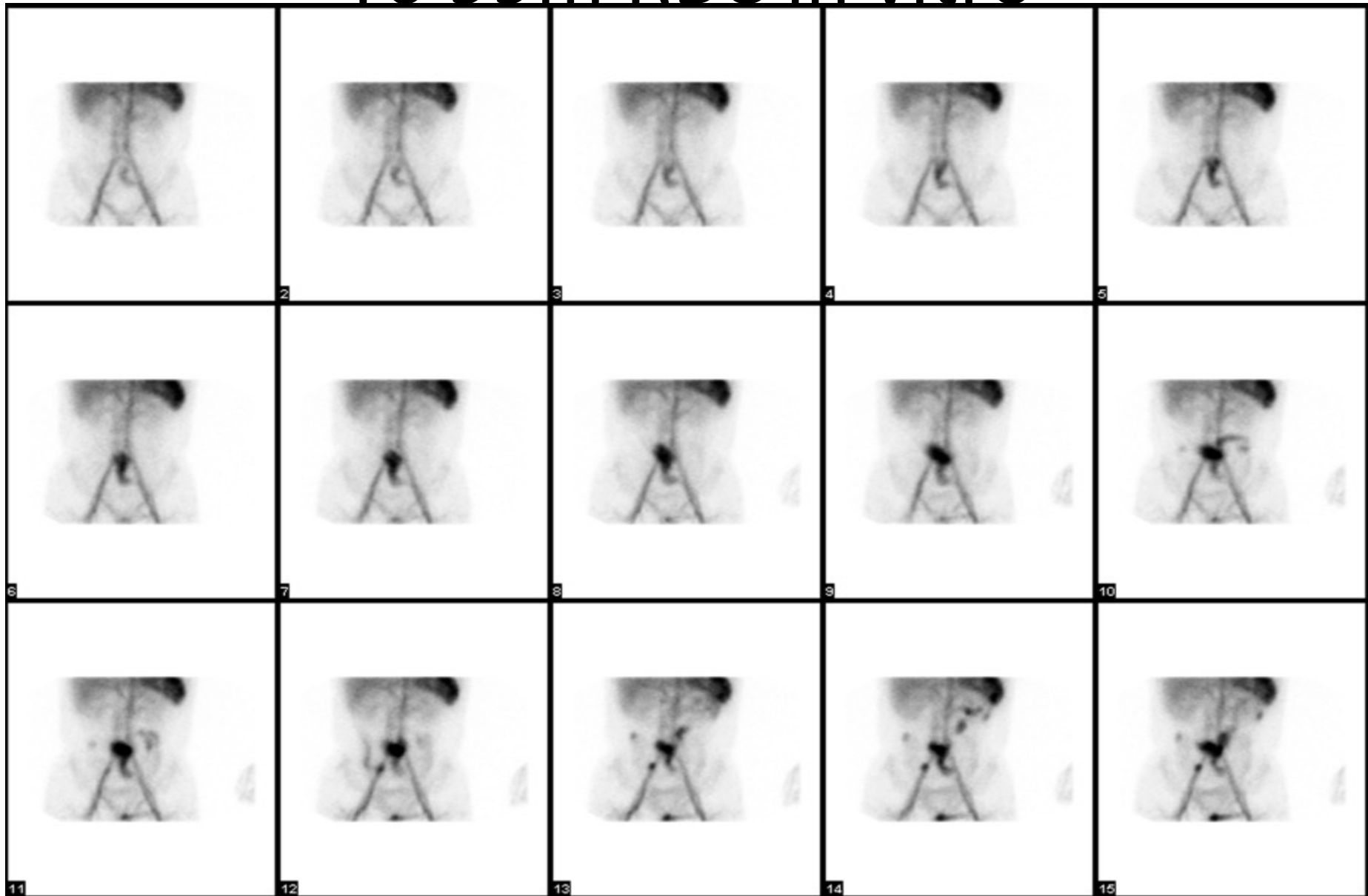
Focal activity appears

Activity increases over time

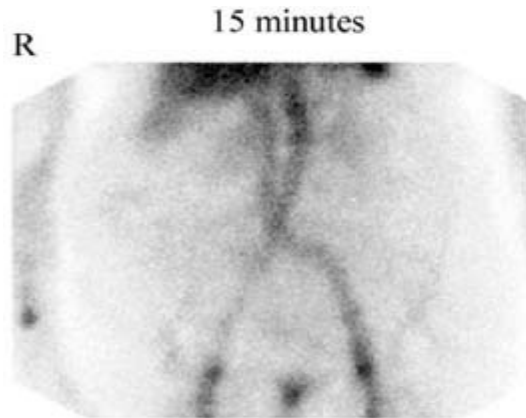
activity movement confirm  
to intestinal anatomy

Movement may be  
antegrade or retrograde

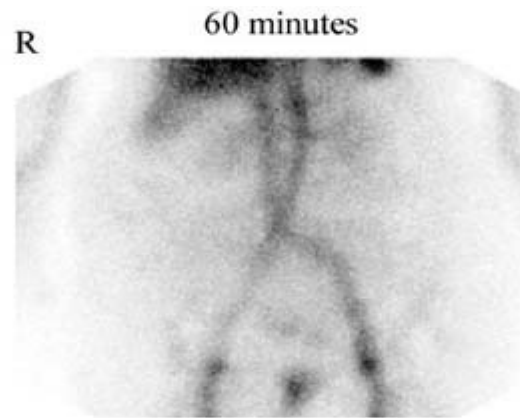
# Tc-99m RBC in vitro



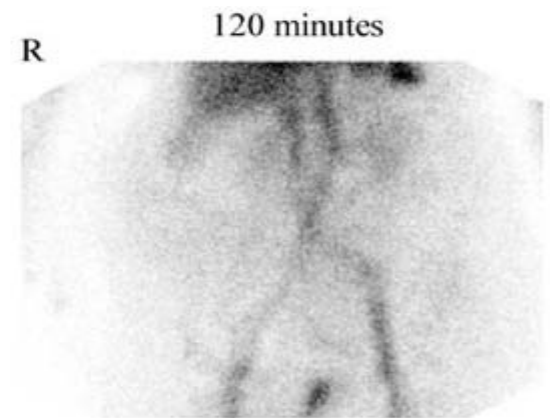
# Tc-99m RBC



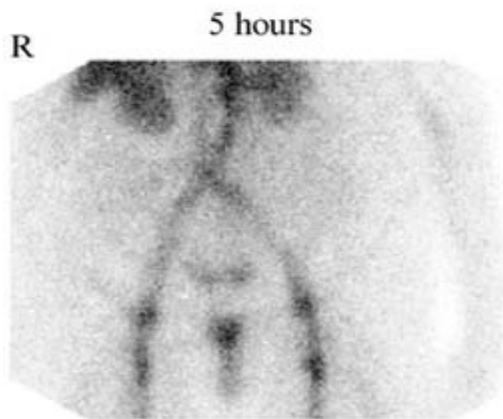
Anterior



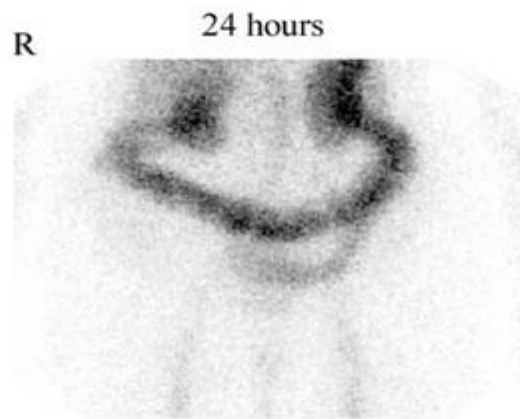
Anterior



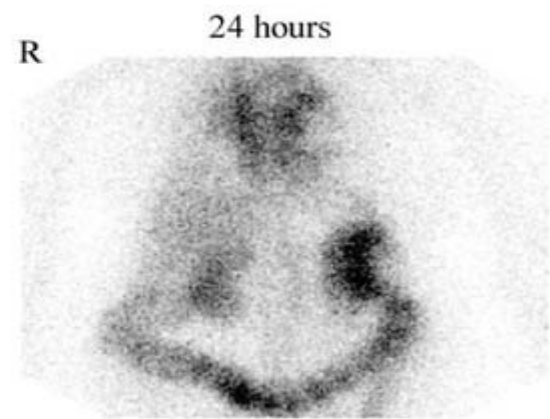
Anterior



Anterior



Anterior

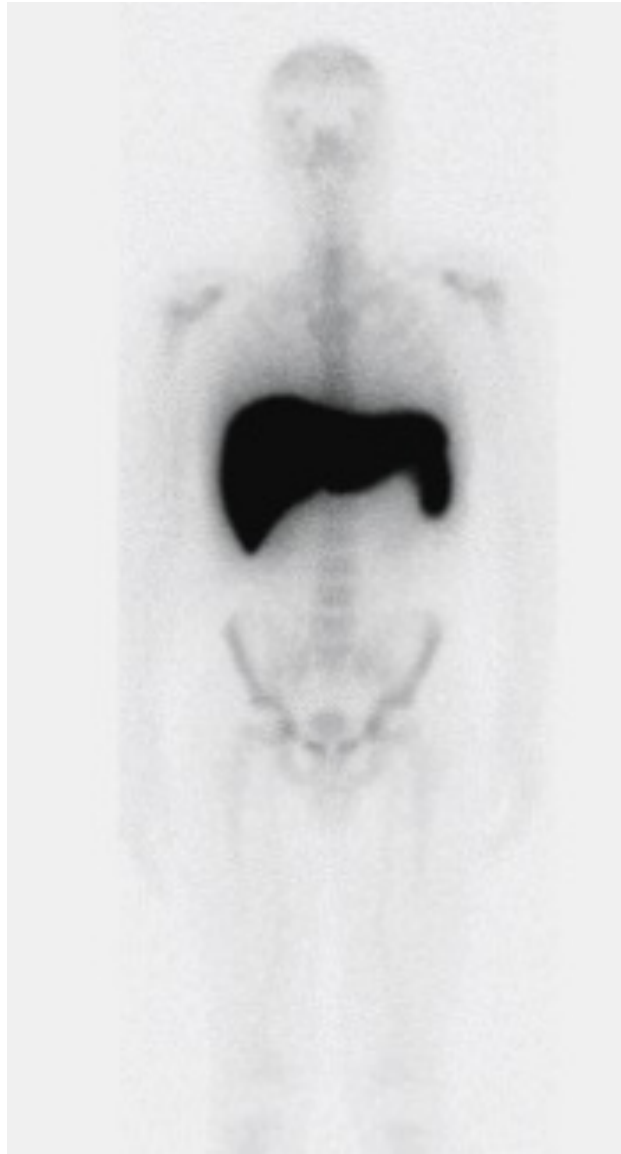


Anterior

# Tc-99m SC



# Tc-99m SC



# Meckel's Diverticulum

# Pearls & Pitfalls

## Meckel's diverticulum imaging

- These scan are performed with Tc-99m pertechnetate which concentrates in normal and ectopic gastric mucosa
- Most Meckel's diverticula do not contain ectopic gastric mucosa but the ones that bleed almost always do.
- A Meckel's diverticula should be seen anteriorly, lateral or oblique.

# Pearls & Pitfalls

## Meckel's diverticulum imaging

- Cimetidine can be used to fix the radiotracer and pentagastrin can increase uptake in the gastric mucosa, thus increasing the sensitivity of the study.
- Bladder activity from the Tc-99m pertechnetate is normal. The patient may need to void or be catheterized if there is a suspicious lesion nearby.

# Pearls & Pitfalls

Meckel's diverticulum  
imaging

- False positives:
  - ❖ Confounding urinary system activity, GI obstruction, tumor and inflammation.

# Pearls & Pitfalls

Meckel's diverticulum  
imaging

- False negatives:
  - ❖ Lack of sufficient gastric mucosa.
  - ❖ Recent barium study or bladder.

# HETEROTOPIC GASTRIC MUCOSA

- Heterotopic refers to a tissue at its site of origin
- Other manifestations of heterotopic gastric mucosa are in
  - gastrointestinal duplication
  - post operative retained gastric antrum
  - Barrett's oesophagus

# MECKEL'S DIVERTICULUM

## Epidemiology

A memory aid is the rule of 2's:

- **2%** (of the population) - **2** feet (from the ileocecal valve)
- **2%** are symptomatic,
- **2** inches (in length)
- **2** types of common ectopic tissue (gastric and pancreatic),
- the most common age at clinical presentation is **2**,
- males are **2 times** as likely to be affected.

- 10-31% have ectopic gastric mucosa
- 95-98% of patient with bleeding have ectopic gastric mucosa

## **Clinical Manifestation**

- ✓ bleeding (uncommon in patient >40y)
- ✓ peptic ulcer
- ✓ pain
- ✓ perforate
- 60% patient with complication <2 y
- Adult –intussusception, obstruction, infection, abnormal fixation

- ❖ result from failure of closure of the omphalomesenteric duct in the embryo
- ❖ the duct connect the yolk sac to the primitive foregut through the umbilical cord
- ❖ True diverticulum arises on the antimesenteric side of small bowel

- Treatment is surgical, consisting of a resection of the affected portion of the bowel.

# MECHANISM OF UPTAKE

- ❖ Gastric fundus contain
  - parietal cell (secrete HCL,intrincic factor)
  - chief cell (secrete pepsinogen)
- ❖ Antrum and pylorus
  - G cell ( secrete hormone gastrin)
  - Columnar mucin secreting epithelial cell (excrete alkaline juice)
- ❖ Tc-99m pertechnetate being secreted by mucin cell

## **PATIENT PREPARATION**

- ✓ 4-6 hours fasting before study to reduce size of stomach
- ✓ No barium studies should be performed within 3-4 days of scintigraphy
- ✓ Void before, during if possible, and after study

## Pharmacological Augmentation

### Cimetidine

- Histamine –H<sub>2</sub>receptor antagonist increases uptake of Tc-99m pertechnetate by inhibiting its release from the gastric mucosa
- Reserve its use for a patient with a suspected false negative scan.
- Usual dose 20mg/kg orally for 2 days prior to study

## *Pentagastrin and Glucagon*

- it increases rapidity, duration and intensity of Tc-99m pertechnetate uptake.
- mechanism: increase acid production leading to increase activity of mucin-producing cell
- .....use together with Glucagon ( antiperistalsis effect and can prevent tracer washout from a diverticulum)
- disadvantage: increase motility leading to rapid movement into small bowel and significant side effect

## FALSE NEGATIVE

- poor technique
- washout of secreted Tc-99m pertechnetate
- lack of sufficient gastric mucosa
- small diverticular  $<2\text{cm}^3$
- impair blood supply to diverticulum from intussusception, volvulus and infarction
- in adult appears to have poor sensitivity than in children

## FALSE POSITIVE

- Urinary tract (ectopic kidney, extrarenal pelvis, VUR)
- Vascular (AVM, angiodysplasia)
- Other area of ectopic gastric mucosa (duplication cyst, Barrett's oesophagus)
- Inflammatory (peptic ulcer, CD, UC)
- Small bowel obstruction
- Neoplasm (Ca sigmoid colon, lymphoma)

# Meckel's

15 minutes



20 minutes



30 minutes



40 minutes



Anterior

50 minutes



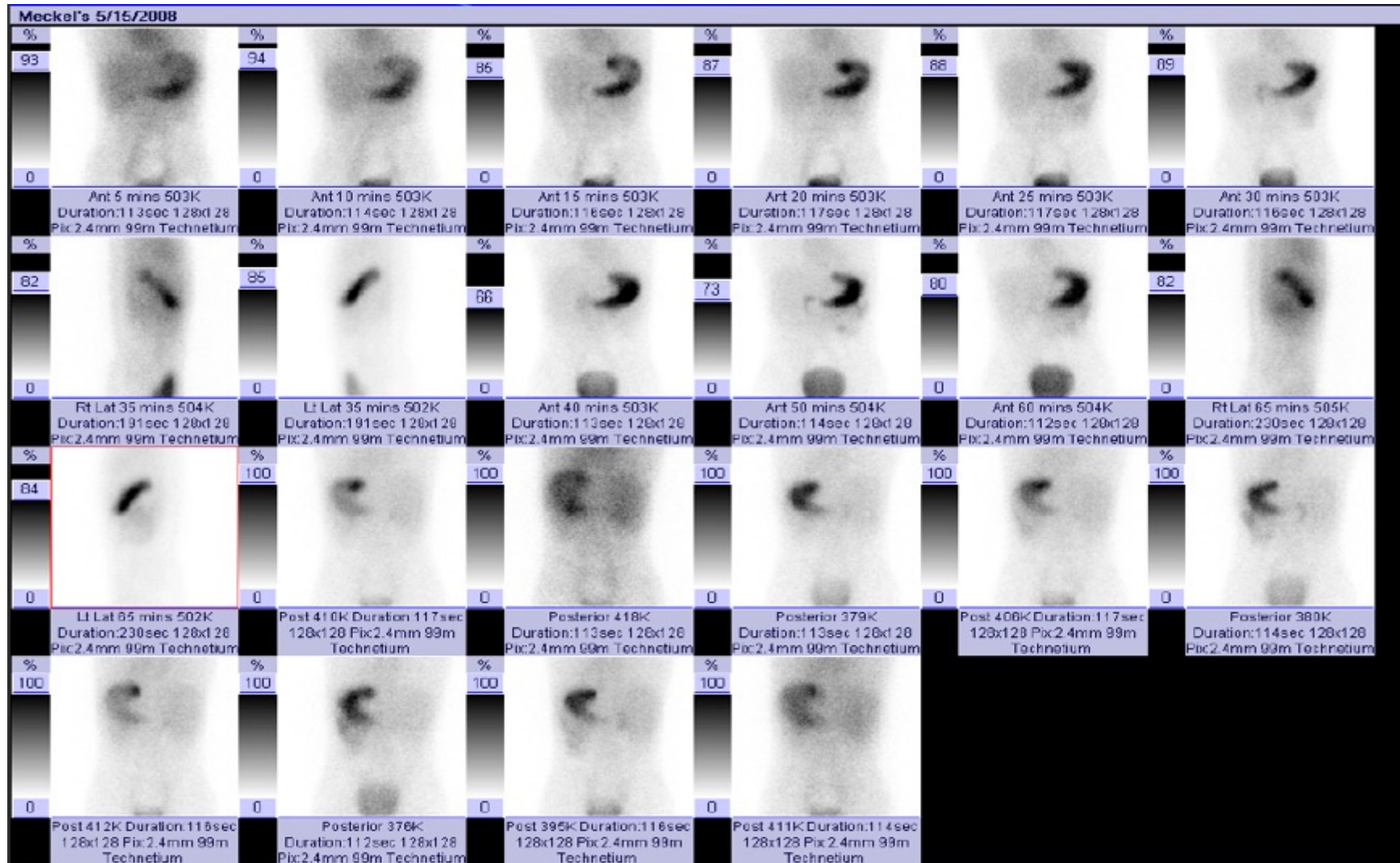
Anterior

60 minutes



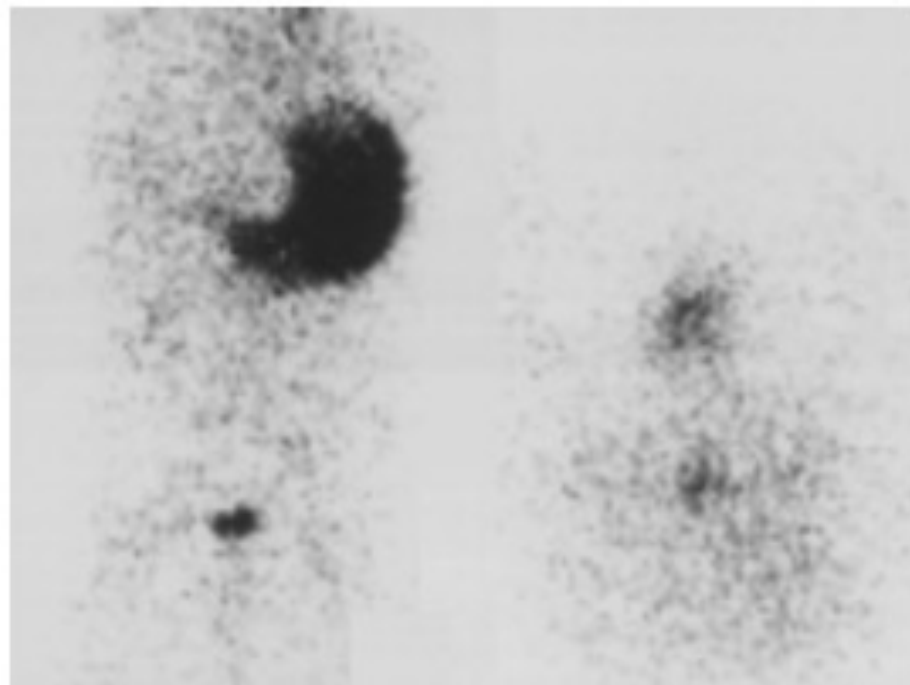
Rt Lateral

# Tc-99m pertechnetate (Meckel's)



# MECKEL SCAN

## UNFREQUENT LOCALIZATIONS OF THE MECKEL DIVERTICULUM



retrovesical



oesophageal

Hepatobiliary

# Pearls & Pitfalls

## Hepatobiliary

- The most common indications for hepatobiliary study are to differentiate between acute or chronic cholecystitis, to look for suspected bile leaks or biliary obstruction and in the setting of neonatal jaundice, to differentiate neonatal jaundice or biliary atresia.
- Tc-99m (IDA) agents are cleared and excreted by hepatocytes but not conjugated.

# Pearls & Pitfalls

## Hepatobiliary

- Cardiac blood pool activity should clear by 5 to 10 minutes. Lack of clearance indicates poorly functioning hepatocytes.
- If there is persistent cardiac blood pool activity and no biliary excretion, the DD includes hepatitis and biliary obstruction.
- Renal and bladder activity may be seen if the liver cannot efficiently excrete the radiotracer.

# Pearls & Pitfalls

## Hepatobiliary

- Bowel activity should be seen by 1 hour. Delayed biliary to bowel transit can be result of a number of entities, including common duct calculous, tumor, stricture, morphine, sphincter dyskinesia and chronic cholecystitis.
- For hepatobiliary scans performed to differentiate biliary atresia from neonatal hepatitis, delayed 24 hours images to look for evidence of excretion into bowel are often necessary.

# Pearls & Pitfalls

## Hepatobiliary

- The normal GB with patent cystic duct is usually seen by 30 minutes and should always be seen by 1 hour.
- Nonvisualization of the GB is most likely the result of acute or chronic cholecystitis.
- Nonvisualization of the GB at 4 hours or after given morphine at 1 hour is most likely due to acute cholecystitis.

# Pearls & Pitfalls

## Hepatobiliary

- Nonvisualization of the GB at 1 hour but visualization at 4 hours after morphine is most likely due to chronic cholecystitis.
- Look for either RIM sign or cystic duct sign of acute cholecystitis if the GB is not seen by 1 hour. A RIM sign increases the likelihood of complicated cholecystitis (gangrene, abscess or rupture)

# Pearls & Pitfalls

## Hepatobiliary

- Bile leaks often pool in the region of the porta hepatis, along right lateral aspect of the liver. If the GB was recently removed, the bile may pool in the GB fossa and mimic a GB.
- An unequivocally GBEF after CCK is more than 50%. Borderline 35 – 50% and abnormal < 35%.
- A recent meal may cause GB contraction and result in nonvisualisation of GB, simulating acute cholecystitis.

# Pearls & Pitfalls

## Hepatobiliary

- False positive
  - ❖ Fasting longer than 24 hours may cause GB distend with viscous bile. CCK can contract GB.
  - ❖ Severe illness, pancreatitis, chronic cholecystitis and rapid biliary to bowel transit.

# Pearls & Pitfalls

## Hepatobiliary

- False negatives:
  - ❖ Mistake with duodenum, renal pelvis and cystic or common bile duct

# Focal Liver Lesions

- Focal Liver Diseases:
  - Benign lesions:
    - Haemangiomas
    - Abscess (Amoebic, Pyogenic)
    - Cysts (Hydatid)
    - Trauma (haematomas etc)
    - Focal Nodular Hyperplasia
  - Malignant:
    - HCC
    - Metastatic liver disease
    - Lymphomas

## Diagnosis of Focal Liver Disease

- Tc-99m Colloid Liver Scan
- US/CT/MRI
- Radionuclide studies:
  - Tc-99m Colloid
  - Tc-99m RBC
  - Tc-99m Iminodiacetic acid derivatives
  - Tc-99m MAA
- Haemangioma
- Focal nodular hyperplasia
- Hepatocellular adenomas
- Hepatocellular carcinomas
- Metastatic liver disease.

# Focal Lesions of Liver

- Haemangioma
- Hepatocellular Adenoma
- Focal Nodular Hyperplasia
- Hepatocellular Carcinoma
- Liver Metastases

# HAEMANGIOMA

- **Cavernous haemangiomas** are the most common benign tumours of liver
- Second most common hepatic tumour, exceeding in incidence only by hepatic metastases
- Tc-99m labeled RBC scintigraphy has been found to be extremely useful for the diagnosis of cavernous haemangioma of the liver

## **HAEMANGIOMA: Tc-99m RBC Imaging**

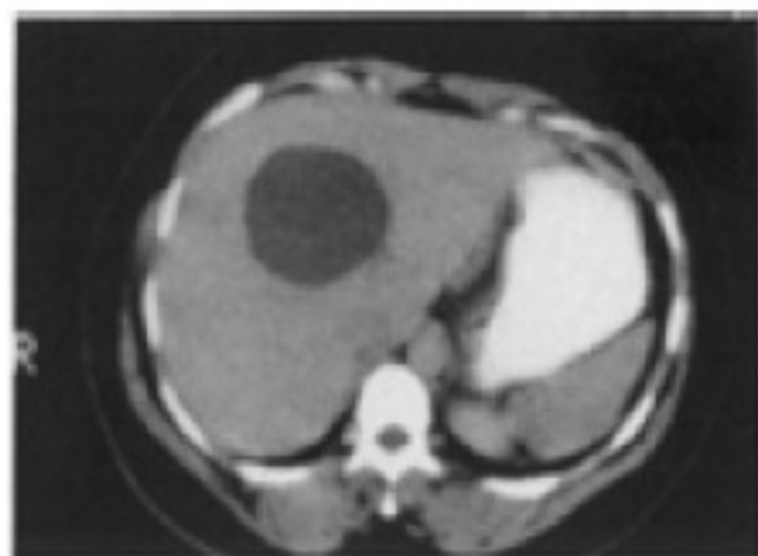
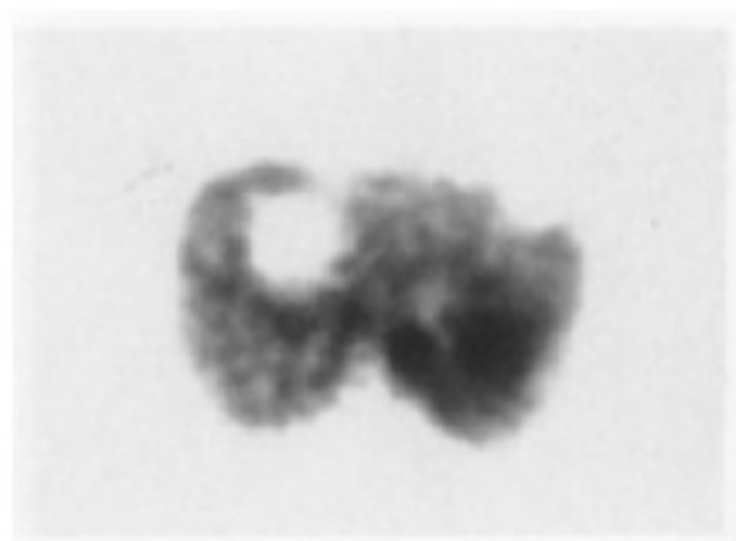
- Extremely accurate
- Highly specific
- Few direct comparisons of Tc-99m RBC SPECT and MRI have been performed to compare the sensitivity and specificity of scintigraphy and MRI.

## **HAEMANGIOMA: Tc-99m RBC Imaging**

- The present data however suggest that Tc-99m RBC liver scintigraphy is highly specific for the diagnosis of cavernous haemangiomas
- while the sensitivity of MRI is extremely high.
- Tc-99m RBC scintigraphy can usually obviate the need for invasive angiography or biopsy
- Unknowing biopsy of a cavernous haemangioma has resulted in serious haemorrhage and even death

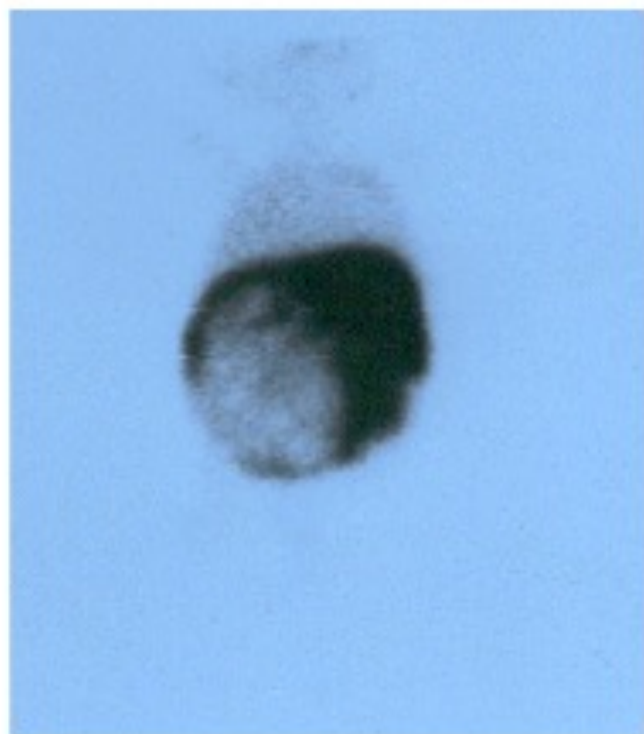
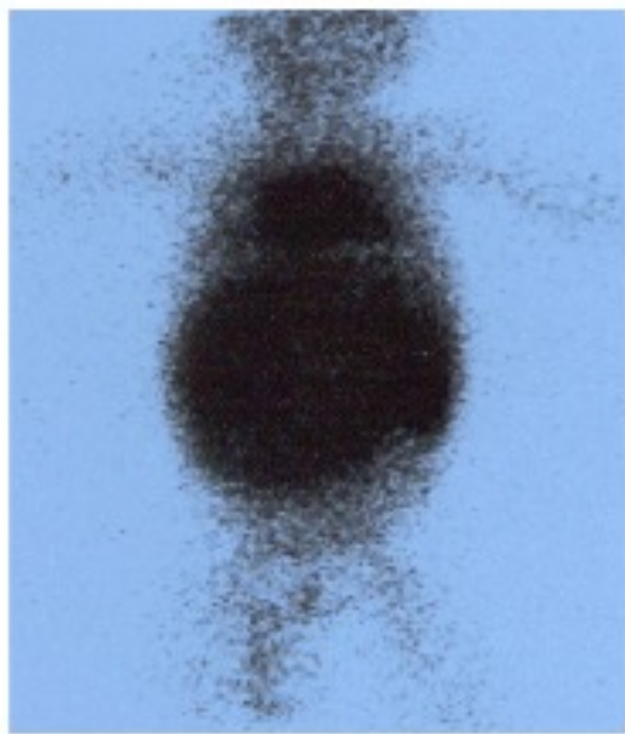
**scan interpretation:**  
**Benign cyst or**  
**Haemangioma**

**Tc-99m RBC Study:**  
**Rules out**  
**Haemangioma**



# Haemangioma in Infants & Children

- Capillary haemangioma and infantile haemangioendothelioma
- Present differently from cavernous haemangiomas in the adults
- They are rarely asymptomatic and typically present with hepatomegaly and congestive heart failure
- Frequently simulating a primary hepatic malignancy clinically
- They may simulate malignancy in CT, MRI as well as in Angiography
- But Tc-99m RBC scintigraphy is diagnostic



## ■ **HEPATOCELLULAR ADENOMA:**

- Related to estrogen-progesteron treatment can lead to two potentially fatal complications:
  - intratumor or intraperitoneal hemorrhage
  - degeneration to hepatocellular carcinoma
- Justifying systematic resection.

## ■ **FOCAL NODULAR HYPERPLASIA:**

- Ten times more frequent than adenoma
- Observed independently of hormone replacement therapy
- Does not lead to complications and
- Does not require treatment
- It is crucial to establish the diagnosis of non-invasive FNH in order to avoid unnecessary surgery

## **Benign Focal Lesions: Significance of Correlative Imaging**

- Correlative imaging is extremely important to decide management strategy in patients with focal benign lesions
- The philosophy of treatment remains abstention from surgery for confirmed diagnosis of angioma, biliary cyst or asymptomatic FNH, irrespective of the size
- For symptomatic patients, it is essential to establish positive diagnosis initially and determine the relationship between the signs and symptoms and the tumor before deciding on adapted surgery (fenestration, enucleation, hepatectomy)
- Surgery may be necessary for cystadenomas, adenomas or cases of doubtful diagnosis, keeping in mind the risk of morbidity and mortality associated with hepatic surgery for benign tumors

# Heat-Damaged Red Blood Cell Scan for Splenic Tissue

Tc-99m-labeled red blood cells that have been damaged by heating are preferentially extracted from circulation by splenic tissue.

## Indications

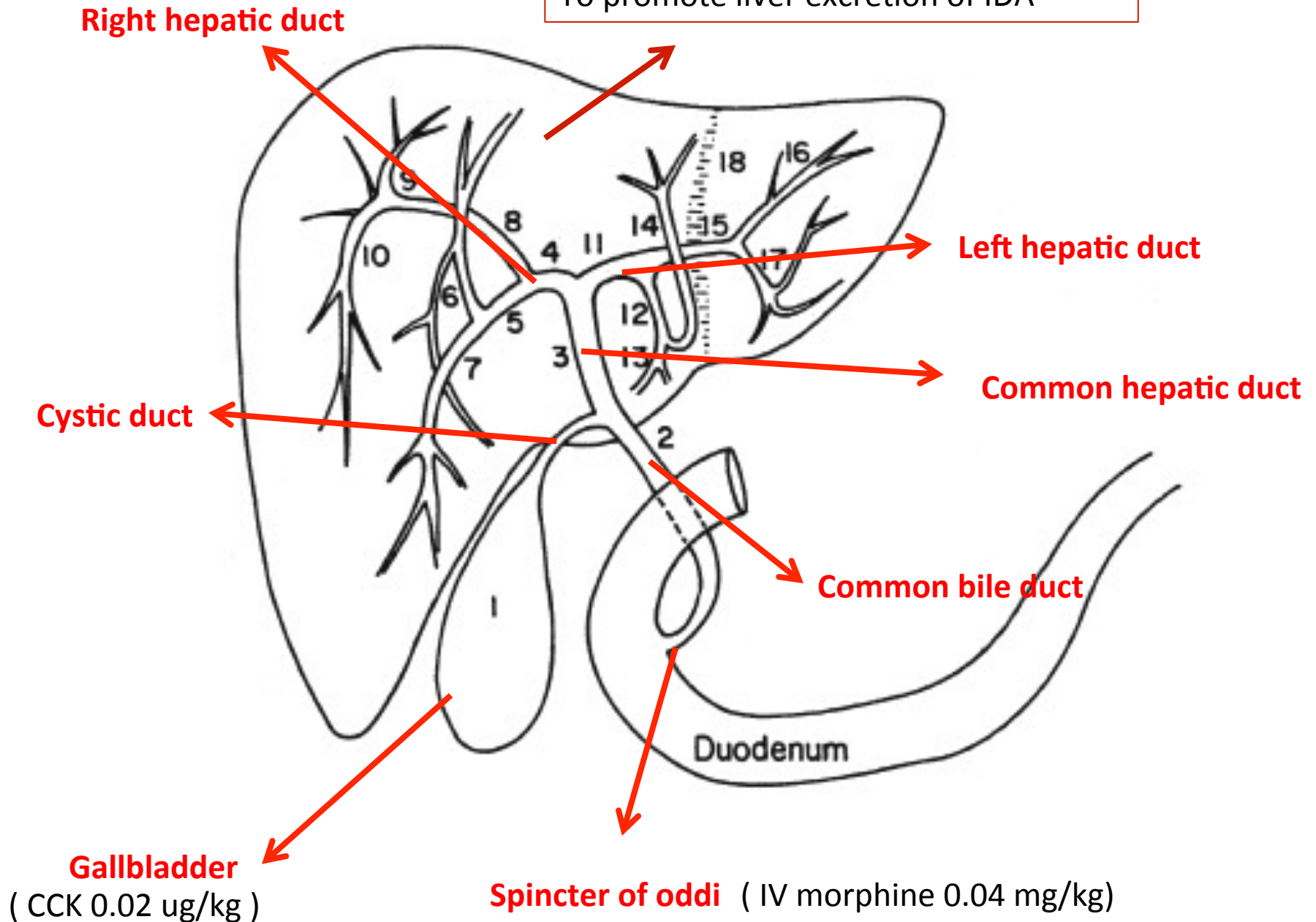
Diagnosis of polysplenia and splenosis  
Confirmation of accessory splenic tissue.

In trauma with splenic rupture in can assess for implants of splenic tissue. If the diaphragm may have been violated during the trauma, then the thorax must be imaged as well to assess for implants there.

## Vs 99mTc-sulfur colloid

The normal spleen takes up only about 10% of injected 99mTc-sulfur colloid, versus 90% of heat damaged RBCs.

(Phenobarbital 5 mg/d for 3-5 days PO)  
To promote liver excretion of IDA



# Hepatobiliary scintigraphy

Current practice uses Tc-99m–labeled iminodiacetic acid compounds.

Two are commercially available:

Tc-disofenin

Tc-mebrofenin.

Tc-HIDA (lidofenin) is no longer commercially available.

These tracers are excreted unchanged into the biliary system.

They work even in the presence of elevated serum bilirubin.

# Hepatobiliary scintigraphy

## PEDIATRIC INDICATIONS

Biliary atresia

Hepatitis

Biliary atresia versus neonatal hepatitis

Right upper quadrant pain/cholecystitis

Postoperative/Kasai operation

Choledochal cyst

Liver transplantation

Right upper quadrant mass

Trauma

Congenital malformations

# Hepatobiliary scintigraphy

## **Biliary atresia**

Twice as often in females.

If passage of tracer into the bowel cannot be demonstrated, scintigraphic distinction between biliary atresia and severe hepatocellular disease cannot be made with certainty. Repeat hepatobiliary scintigraphy after a few days may be helpful.

## **Choledocal cysts**

Choledochal cyst is a congenital dilatation of the extrahepatic biliary tree.

# Hepatobiliary scintigraphy

## Choledocal cysts

Three types:

1. Most common one is a dilatation of the common bile duct, +/- dilatation of the hepatic ducts. Cystic duct and the gallbladder are usually not dilated.  
15% of these patients also have biliary atresia.
2. Diverticulum of the common bile duct.  
Biliary tree otherwise normal.
3. Dilatation of the duodenal intramural portion of the common bile duct (choledochocele).

# Hepatobiliary scintigraphy

## TECHNIQUE

Serial 0.5-minute frames for 60 minutes

Delayed images at 2, 4, 6, and 24 hours or until radiotracer appears in the bowel.

If the gallbladder fails to empty significantly during the initial 60-minute period, an additional series of images (one frame per minute for 60 minutes) is obtained following the administration of a cholecystokin analogue or a standard fatty meal. If a biliary leak is suspected, additional images in various projections are obtained in order to identify any abnormal collection of tracer.

### **Phenobarbital**

Pretreatment in jaundiced neonates can increase bile secretion and, therefore, to help better differentiate neonatal hepatitis and biliary atresia.

5 mg/kg/day divided into two equal doses for 3 to 5 days prior to hepatobiliary scintigraphy.

*Pretreatment is a must before imaging.*

### **Cholecystokin analogue**

Sincalide (0.02µg/kg, 1.4µg/70 kg) intravenously over a 30 to 60-second interval

Causes prompt contraction of the gallbladder that becomes maximum in 5 to 15 minutes.

|                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Patient preparation | NBM for 4 hours before study<br>If fasting longer than 24 hours, infuse sincalide                                                                                                                                                                                                                                                                                                                                                                 |
| Radiopharmaceutical | Tc-99m HIDA/ mebrofenin/ disofenin IV<br>Adults bilirubin < 2mg/dl : 5 mCi<br>2-10 mg/dl : 7.5 mCi<br>>10 mg/dl : 10 mCi<br>Children 200 µCi/kg (no less than 1 mCi)                                                                                                                                                                                                                                                                              |
| Patient positioning | Supine                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Instrumentation     | Collimator: LEGP<br>Window : 15% 140 keV                                                                                                                                                                                                                                                                                                                                                                                                          |
| Imaging protocol    | Inject Tc-99m IDA IV<br>At 60 min, acquire right lateral and left anterior oblique<br>If GB not filled and acute cholecystitis suspected, inject IV morphine sulfate (0.04 mg/kg over 1 min)<br>Perform delayed imaging 2 to 4 hour if:<br><ol style="list-style-type: none"><li>1. Morphine sulfate is not administered and GB has not filled</li><li>2. Hepatic insufficient/ suspected biliary leak/ partial common duct obstruction</li></ol> |

# Hepatobiliary scintigraphy

Most commonly used to evaluate suspected acute cholecystitis in adults.

## Normal scan

The anterior dynamic images of normal hepatobiliary scans show prompt and homogeneous uptake of the radiopharmaceutical by the liver.

Liver activity decreases, the radiotracer is excreted into the biliary system and then drains into the small bowel.

The activity should be seen in the major extrahepatic ducts, gallbladder, and small bowel within 1 hour.

# Hepatobiliary scintigraphy– Pharmacologic Intervention

Small doses of IV morphine ( 0.04 mg/kg ) raise the pressure on the sphincter of Oddi. This helps push radiolabeled bile into the gallbladder.

Morphine administration can also help in patients who have stimulated their gallbladders to contract by eating before the scan.

Morphine is administered within 30-60 minutes of a study to evaluate for acute cholecystitis is suspected *after* the tracer is seen in the intestinal tract. This is followed by an additional imaging for 15-30 minutes.

Tracer must be present in the biliary tract at the time of morphine administration.

A second dose of radiopharmaceutical may be needed to have adequate amount of tracer in the bile ducts.

## **Absolute contraindications**

Increased intracranial pressure in children, severe respiratory depression (in nonventilated patients), and morphine allergy

## **Relative contraindication**

Acute pancreatitis

# Hepatobiliary scintigraphy

## Findings in acute cholecystitis

Nonvisualization of the gallbladder at both 1- and 4-hour intervals after IV injection of the biliary agent, or 30 minutes after morphine administration.

A small minority of patients, usually the chronically ill, have acalculous cholecystitis.

The gall bladder fills in 15% of acalculous cholecystitis.

# Hepatobiliary scintigraphy – Pharmacologic Intervention

## Cholecystokin analogues (sincalide)

Prolonged fasting (>24 hrs) can cause gallbladder distension and a false positive test. The radiopharmaceutical cannot enter the gallbladder as it is completely full and atonic.

Analogues of cholecystokin (CCK) cause prompt gallbladder contraction. After emptying, the gallbladder refills, allowing entry of the radiotracer.

## Gallbladder ejection fraction

For evaluating functional biliary pain syndromes using an intravenous infusion of 0.01-0.04  $\mu\text{g/kg}$  of sincalide (commonly used dose is 0.02  $\mu\text{g/kg}$ ) over 15 to 30 minutes.

An infusion over 15 to 30 minutes is preferred over shorter infusion times as it is usually effective with minimal side effects. The study requires activity in the gallbladder, but not in the gut. This infusion is usually done after 60 minutes of dynamic imaging. An ejection fraction of 35% or less is generally considered abnormal.

Also useful in acalculous cholecystitis.

# Cholescintigraphy – Meal Intervention

## Fatty meal

A fatty meal may cause emptying of the bile from the biliary system into the duodenum.

This should be done only after the gallbladder is seen.

This is used in where common duct patency needs to be determined in patients being evaluated for cholecystitis.

# Hepatobiliary scintigraphy - Acute Cholecystitis

Reported sensitivity and specificity of 98% and better than a 95% accuracy rate for the diagnosis of acute cholecystitis.

Increased blood flow on radionuclide angiograms of the gallbladder fossa can be seen in acute cholecystitis.

A “rim sign” on hepatobiliary scan images is seen as a band of increased activity around the gallbladder fossa, which represents poor excretion of radiotracer from inflamed hepatocytes.

The rim sign is usually associated with **gangrenous cholecystitis**.

False-positive diagnosis of acute cholecystitis may also occur with

- previous cholecystectomy
- tumor obstructing the cystic duct
- agenesis of the gallbladder.

# Hepatobiliary scintigraphy

Overall view of the transplant's functional parenchyma and of bile drainage.  
Sensitive for detecting leaks.

Baseline study within 24 hours of the transplant can detect  
Regional hepatic flow  
Global hepatic function  
Biliary drainage

Focal defects can be seen from vascular damage during harvesting.

It can be used at any time to evaluate complications.

# Hepatobiliary scintigraphy – Bile leaks

Postoperative complications and bile leaks in trauma.

The excretion phase of the scan is important in evaluating hepatic and common bile duct patency.

A delay of more than 1 hour in visualization of the bile ducts suggests obstruction.

Delays in biliary visualization can be seen with severe hepatocellular dysfunction as well as in obstruction.

| Drug              | Dose, route                                              | Mechanism                                                      | Use                                                                                                                                                                              |
|-------------------|----------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Cholecystokinin-8 | 10 – 20 ng/kg/<br>3 min, IV                              | Stimulates contraction of the GB and relaxes sphincter of Oddi | <ol style="list-style-type: none"> <li>1. Evacuation of sludge from GB prior to study</li> <li>2. Evaluation of percent GB emptying post-stimulus (ejection fraction)</li> </ol> |
| Morphine sulfate  | 40 – 100 µg/kg<br>slowly over<br>2 – 3 min, IV           | Constricts sphincter of Oddi                                   | Divert IDA from CBD into GB, thereby reducing period of biliary scintigraphy                                                                                                     |
| Phenobarbital     | 5 mg/kg daily in<br>two divided<br>doses × 5 days,<br>PO | Induces hepatic enzymes                                        | Used to promote liver excretion of IDA in differentiation of neonatal hepatitis from biliary atresia                                                                             |

| <b>Radiopharmaceutical</b> | <b>Mechanism of uptake</b>             | <b>Indication</b>          |
|----------------------------|----------------------------------------|----------------------------|
| Tc-99m sulfur colloid      | Kupffer cell uptake                    | Focal nodular hyperplasia  |
| Tc-99m HIDA                | Hepatocyte uptake                      | Cholescintigraphy          |
| Tc-99m RBC                 | Blood pool distribution                | Cavernous hemangioma       |
| Tc-99m MAA                 | Blood flow & capillary blockage        | Hepatic arterial perfusion |
| Xe-133                     | Lipid soluble                          | Focal fatty tumor uptake   |
| Gallium-67 citrate         | Lactoferrin transport and iron binding | Tumor/abscess              |
| F-18 FDG                   | Glucose metabolism                     | tumor                      |

# CCK

- 33- amino acid polypeptide
- Gallbladder contraction
- Relaxation of sphincter of oddi
- Sincalide = synthetic form of CCK

## **Gastrointestinal actions of CCK**

Contracts gallbladder

Relaxes sphincter of Oddi

Stimulates intestinal  
motility

Inhibits gastric emptying

Reduces gastrointestinal  
sphincter tone

Stimulates hepatic bile  
secretion

Stimulates pancreatic  
enzyme secretion

# Morphine sulphate

- Constricting sphincter of Oddi
- Increases intraluminal biliary pressure
- IV 0.04 mg/kg when GB not filled by 60 minutes
- Should not be given to :
  1. Poor clearance to the bowel
  2. Significant retention of radiotracer in biliary duct

**False positive of  
Acute  
Cholecystitis**

Fasting < 4 hour

Fasting > 4 hour

concurrent severe illness

Chronic cholecystitis

hepatic insufficient

hyperalimentation

Alcoholism/pancreatitis (?)

| <b>Drugs a/w poor GB contraction</b> | <b>Diseases a/w poor GB contraction</b> |
|--------------------------------------|-----------------------------------------|
| Morphine                             | DM                                      |
| Atropine                             | Sickle cells disease                    |
| Nifedipine (CCB)                     | IBS                                     |
| Indomethacin                         | Pancreatic insufficiency                |
| Progesterone                         | Crohn's disease                         |
| Oral contraception                   | Celiac disease                          |
| Octreotide                           | Achalasia                               |
| Theophylline                         | Obesity                                 |
| Benzodiazepine                       | Cirrhosis                               |
| Phentolamine                         | Pregnancy                               |
|                                      | Dyspeptic syndrome                      |
|                                      | Truncal vagotomy                        |

# Differential diagnosis of Primary Hepatic tumor with Tc-99m HIDA

| <b>Lesion</b>             | <b>Flow</b> | <b>Uptake</b> | <b>Clearance</b> |
|---------------------------|-------------|---------------|------------------|
| Focal nodular hyperplasia | Increased   | Immediate     | Delayed          |
| Hepatic adenoma           | Normal      | none          | -                |
| Hepatocellular carcinoma  | Increased   | Delayed       | Delayed          |

## **Causes of Focal Liver Defects**

Cyst

Benign and malignant  
tumor

Abscess

Hematoma

Laceration

Radiation therapy

Infarction

Cirrhosis

Fatty infiltration

Dilated bile duct

**Increased focal  
uptake in Tc-99m SC**

Arm injection

Leg injection

focal nodular hyperplasia

Budd-Chiari syndrome

Cirrhosis

# **Liver heterogeneity of Tc-99m SC**

Metastases

Lymphoma/leukemia

Hepatitis

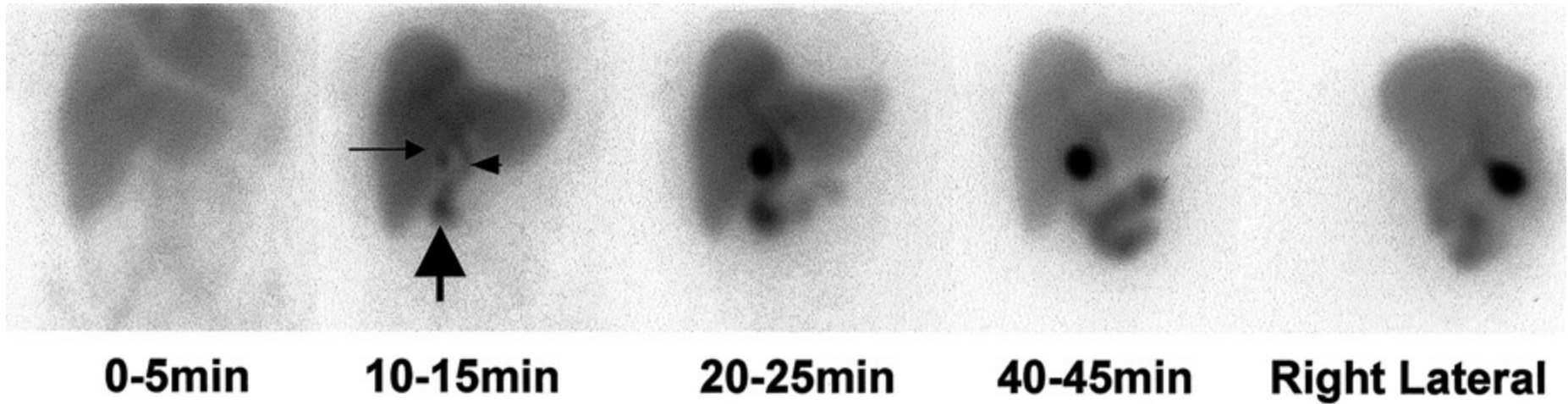
Chronic passive congestion

Cirrhosis

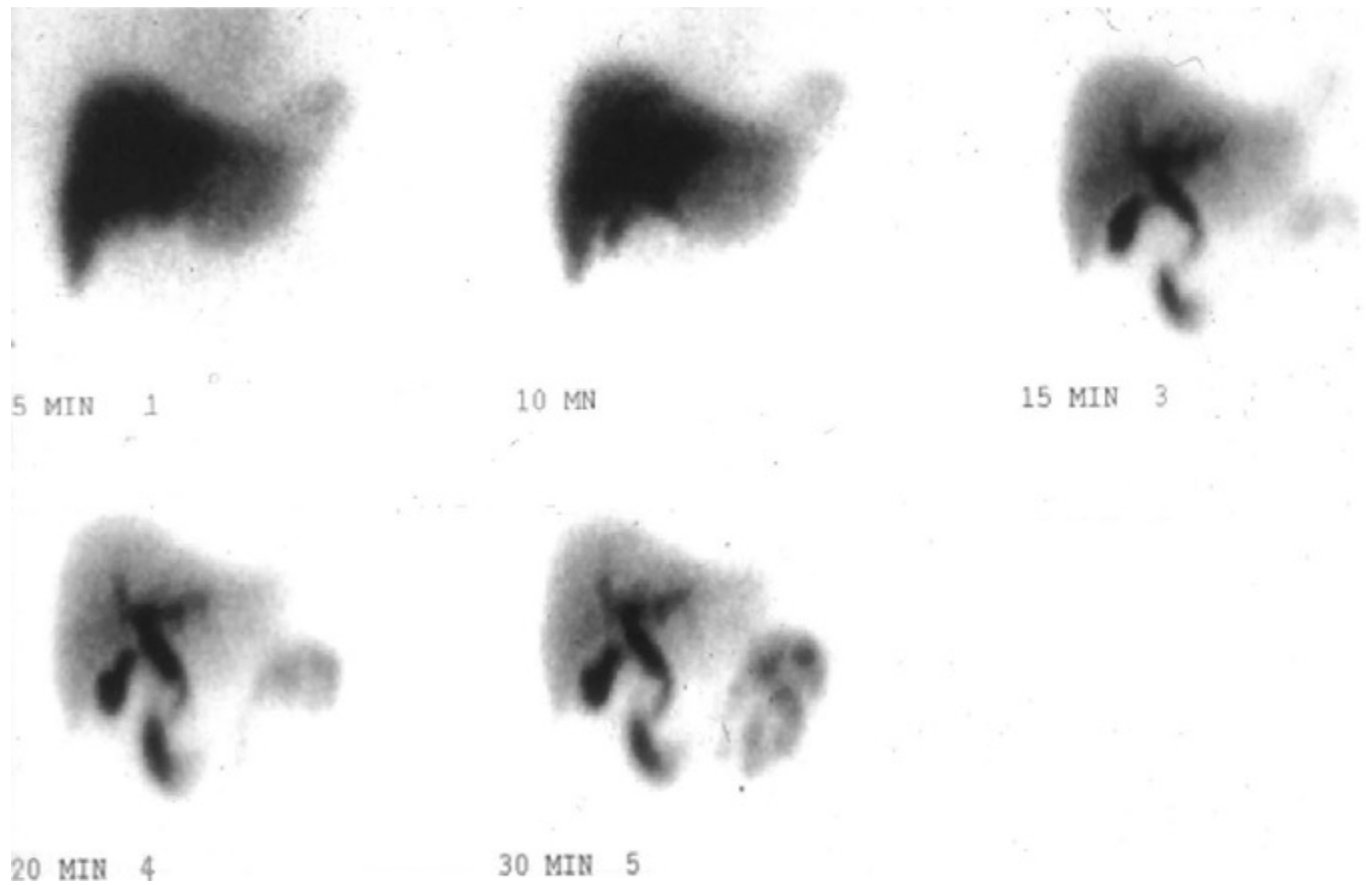
Parenchymal liver disease

Fatty metamorphosis

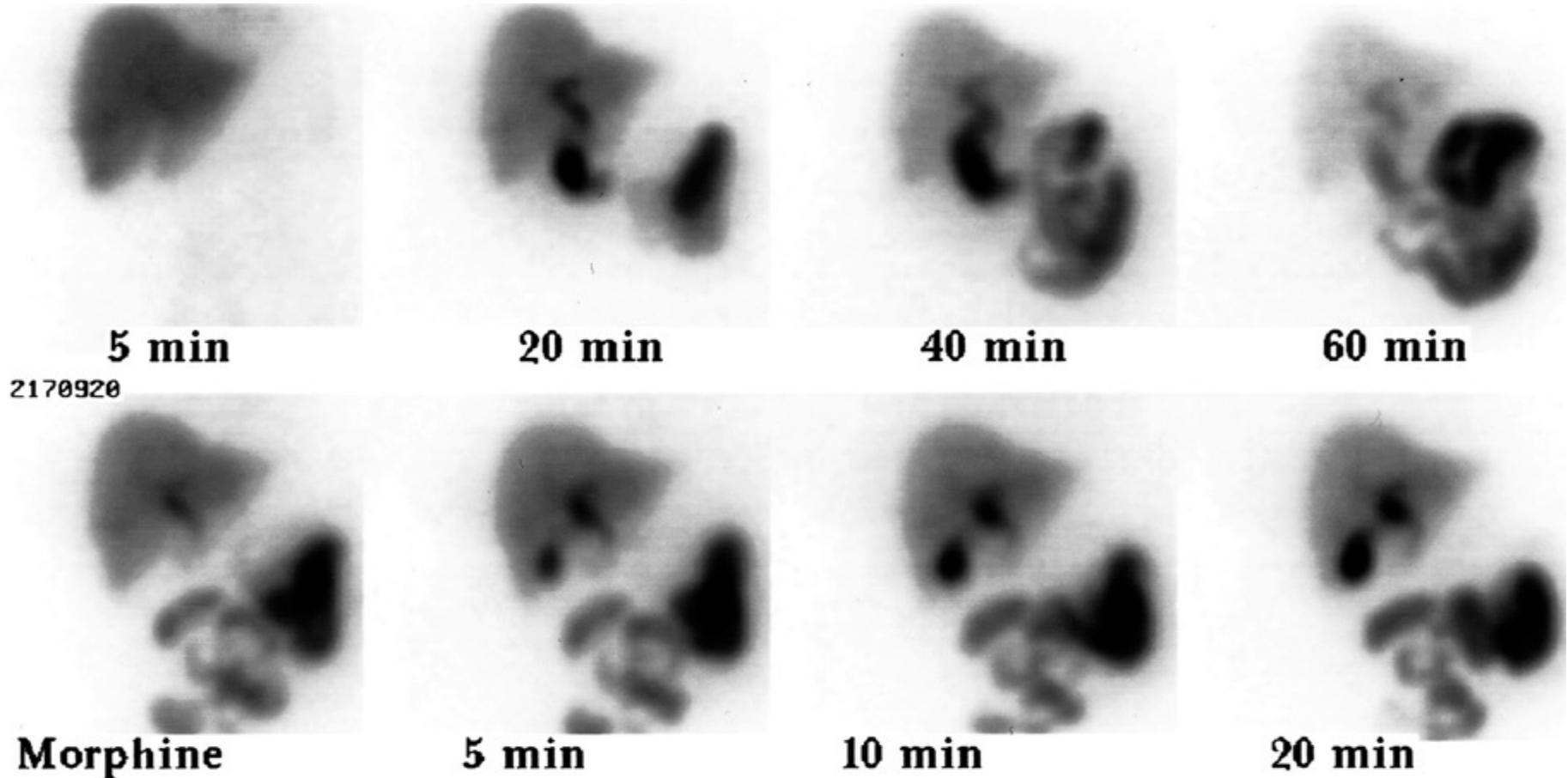
# Normal HIDA



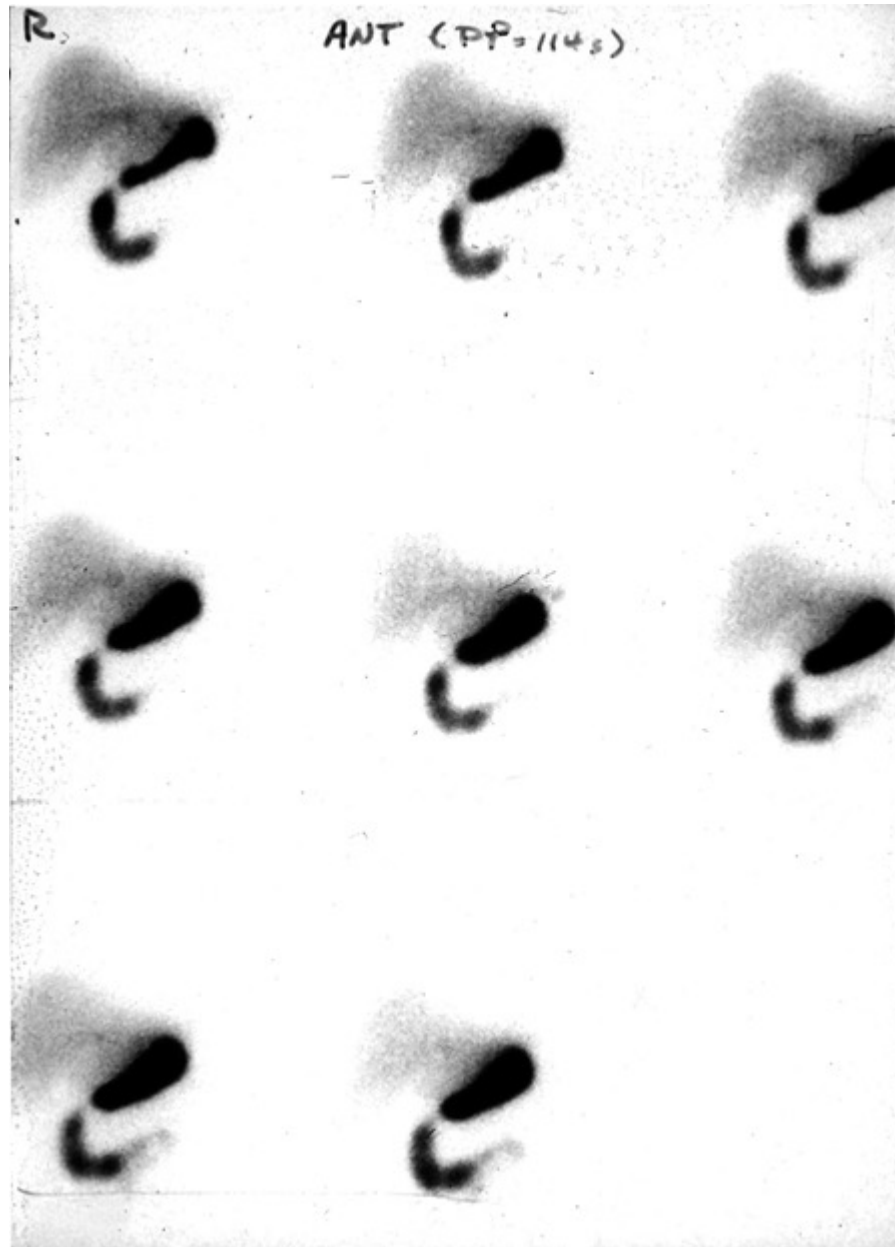
# Normal HIDA



# HIDA scan, GB visualized after morphine



# Acute cholecystitis



What are two FDA approved IDA in use and how are they different?

# What are two FDA approved IDA in use and how are they different?

- Tc-99m DISIDA and Tc-99m mebrofenin. Mebrofenin has better hepatic extraction 98% and renal excretion is 1 %. The higher extraction of mebrofenin is preferable in patients with hepatic insufficiency.

What is the most important Q to ask  
the patient before starting  
cholescintigraphy for suspected acute  
cholecystitis?

# What is the most important Q to ask the patient before starting cholescintigraphy for suspected acute cholecystitis?

- When did you last eat. If the patient has eaten in the last 4 hours, the GB may be contracted secondary to endogenous stimulation of CCK and therefore tracer cannot enter into GB.
- If the patient has not eaten > 24 hours, the GB may not have had the stimulus to contract and will be full of thick, concentrated bile which may prevent tracer entry.

What are 5 indication for CCK  
infusion?

# What are 5 indication for CCK infusion?

1. Empty GB in patient fasting longer than 24 hours
2. Differentiate common duct obstruction from normal hypertonic sphincter of Oddi
3. Exclude GB acalculous cholecystitis if GB fills.
4. Diagnose chronic acalculous cholecystitis. Confirm or exclude chronic calculous cholecystitis.
5. Assist in the diagnosis of sphincter of Oddi dysfunction.

In what clinical settings are false positive HIDA studies likely to occur when performed to rule out acute cholecystitis.

In what clinical settings are false positive HIDA studies likely to occur when performed to rule out acute cholecystitis.

- In patients who have fasted less than 4 hours or more than 24 hours, patient receiving hyperalimentation and those who have chronic cholecystitis, hepatic insufficiency or severe illness.

What is the rim sign sometimes seen with cholescintigraphy and what is its significance?

In what clinical settings are false positive HIDA studies likely to occur when performed to rule out acute cholecystitis.

- The rim sign is increased uptake and delayed clearance of activity in the hepatic parenchyma adjacent to the GB fossa. It has been associated with an increased incidence of complications e.g.. perforation and gangrene.

At what time after HIDA injection is nonfilling of the GB diagnostic of acute cholecystitis

# At what time after HIDA injection is nonfilling of the GB diagnostic of acute cholecystitis

- One hour is defined as abnormal. However, nonfilling of the GB is diagnostic of acute cholecystitis if delayed images show no filling by 2 to 4 hours or 30 minutes after morphine administration.

What is the mechanism of morphine augmented cholescintigraphy?

# What is the mechanism of morphine augmented cholescintigraphy?

- Morphine increases tone at the sphincter of Oddi, resulting in increased intraductal pressure. This results in bile flow through the cystic duct, if it is patent.

What is the most common scan finding  
in chronic cholecystitis?

# What is the most common scan finding in chronic cholecystitis?

- A normal study. < 5% of patients with chronic cholecystitis have delayed filling. Other associated findings include delayed biliary to bowel transit time and rarely nonvisualization of GB or intraluminal filling defects.

What is acute acalculous cholecystitis?

# What is acute acalculous cholecystitis?

- Cholecystitis without a stone occluding the cystic duct. The obstruction may be caused by debris or inflammatory changes or the cholecystitis may be limited to the GB wall because of infection, ischemia or toxins. It occurs in hospitalized patients who have sustained trauma, burns, sepsis or other serious illness.

What are the cholescintigraphic findings of high grade common duct obstruction?

# What are the cholescintigraphic findings of high grade common duct obstruction?

- Persistent hepatogram with no clearance into biliary ducts.

What are the cholescintigraphic findings of partial common duct obstruction?

# What are the cholescintigraphic findings of partial common duct obstruction?

- Prominent retention of activity in the common duct, delayed biliary to bowel clearance and most important, poor ductal clearance on delayed imaging or with CCK.

What is the difference in clinical presentation and clinical course of patients with FNH and hepatic adenoma

# What is the difference in clinical presentation and clinical course of patients with FNH and hepatic adenoma

- FNH is asymptomatic and found incidentally, whereas hepatic adenomas often present with hemorrhage and can be life threatening. Adenomas are closely associated with the use of OCP which must be discontinued.

What are the Tc-99m SC scan findings in FNH and hepatic adenoma?

# What are the Tc-99m SC scan findings in FNH and hepatic adenoma?

- Hepatic adenomas do not show Tc-99m SC uptake because they do not usually have Kupffer cells. FNH is associated with increased blood flow. Uptake may be increased, normal or nonexistent. Two thirds of cases of FNH show some Tc-99m SC uptake.

What are the characteristic  
scintigraphy findings in liver  
hemangioma?

# What are the characteristic scintigraphy findings in liver hemangioma?

- Blood flow is normal. Immediate images show a cold defect, whereas delayed images acquired 1 to 2 hours after tracer administration show increased uptake within the lesion compared with the normal liver, often equal to uptake in the spleen and heart.

Beside FNH, what are other causes of increased focal uptake on Tc-99m SC imaging?

Beside FNH, what are other causes of increased focal uptake on Tc-99m SC imaging?

- Superior vena cava syndrome (with arm injection), inferior vena cava syndrome (with leg injection), Budd-Chiari syndrome and cirrhosis with a regenerating nodule.

# What is functional asplenia?

# What is functional asplenia?

- Nonvisualization of the spleen on a Tc-99m SC when the spleen is anatomically present and when functions other than reticuloendothelial extraction are intact. Functional asplenia is caused by an acquired dysfunction of the reticuloendothelial system e.g.. sickle cell anemia or by a disruption of the blood supply (splenic artery occlusion).

What is achalasia and how can radionuclide studies help in making the diagnosis and following the patient's course?

# What is achalasia and how can radionuclide studies help in making the diagnosis and following the patient's course?

- Achalasia is characterized by absence of peristalsis in the distal two thirds of the esophagus, increased lower esophageal sphincter pressure and incomplete sphincter relaxation after swallowing. The diagnosis can be confirmed by esophageal manometry. Radionuclide esophageal transit studies have a high sensitivity for making the diagnosis and evaluate the effectiveness of esophageal dilatation.

# In regard to reflux and aspiration studies?

- A. The milk study is a sensitive method for diagnosing gastroesophageal reflux.
- B. The milk study is a sensitive method for diagnosing aspiration.
- C. Frequent image acquisition improves the sensitivity of milk study.
- D. The salivagram is a sensitive method for diagnosing aspiration.

# In regard to reflux and aspiration studies?

- TFFT

Which anatomical portion of the stomach are responsible for solid emptying and which for liquid emptying

# Which anatomical portion of the stomach are responsible for solid emptying and which for liquid emptying

- Liquid emptying is largely caused by the slow contractions of the proximal fundus whereas the distal stomach or antrum is responsible for the grinding and sieving solid food.

Which of these factors will affect the rate of gastric emptying?

- A. Meal content
- B. Time of day
- C. Gender
- D. Position
- E. Stress
- F. Exercise

# Which of these factors will affect the rate of gastric emptying?

- TTTTTT

# Regarding gastric emptying studies?

- A. Attenuation results in an underestimation of gastric emptying when performed in the anterior view
- B. A solid gastric emptying time activity curve shows a rise in activity after ingestion in the anterior view
- C. The geometric mean method of attenuation correction is considered the reference standard
- D. The left anterior oblique method of attenuation correction is superior to the geometric mean.

# Regarding gastric emptying studies?

- TTTF

When might the use of Tc-99m SC offer advantages over Tc-99m RBCs for the diagnosis of acute GI bleeding?

When might the use of Tc-99m SC offer advantages over Tc-99m RBCs for the diagnosis of acute GI bleeding?

- With very rapid GI bleeding and vascular instability, the radiotracer can be injected and the study completed in 15 to 20 minutes. It is likely to be positive with the rapid hemorrhage when transfusion cannot keep up with the bleeding rate. The patient can then go directly for angiography.

List in increasing order the labeling efficiency for method to label Tc-99m RBCs; in vivo, in vitro or in vivtro

List in increasing order the labeling efficiency for method to label Tc-99m RBCs; in vivo, in vitro or in vivtro

- In vivo 75%, in vivtro 85% and in vitro 98%

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