Gastrointestinal Tract scintigraphy
and Localization of Active Abdominal Bleeding

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GI TRACT AND LIVER/SPLEEN SCINTIGRAPHY

GASTROINTESTINAL TRACT STUDIES

Salivary Glands
Esophageal Motility
Gastro-Esophageal Reflux
Gastric Emptying and Bowel Motility
Bleeding Ectopic Gastric Mucosa

LOCALIZATION of ACTIVE ABDOMINAL BLEEDING

LIVER AND SPLEEN SCAN (Anatomy and Function)

(\textsuperscript{99m}Tc -Sulfur-Colloid)
Reticulo-Endothelial Cell Phagocytosis

HEPATOBILIARY SCINTIGRAPHY (Biliary Disorders)

(\textsuperscript{99m}Tc-Imino-Di-Acetic-Acid Derivatives)
Hepatocyte Uptake and Bile Excretion (no conjugation)

EVALUATION of TUMORS and INFECTIONS
SCINTIGRAPHY OF THE GI TRACT
Radiopharmaceuticals and Indications

• EVALUATION OF FUNCTION OF SALIVARY GLANDS
  $^{99m}$Tc-Pertechnetate iv for tumors or functional disorders

• ESOPHAGEAL MOTILITY STUDIES
  $^{99m}$TcSC-labeled milk (or other liquid), or solid food

• GASTRIC EMPTYING AND BOWEL MOTILITY STUDIES
  $^{99m}$TcSC-labeled standard meal for failure to thrive in infancy and
  for diagnosis of diabetic gastro-paresis in the adult

• GASTRO-ESOPHAGEAL REFLUX
  $^{99m}$TcSC-labeled orange juice for quantification of GER

• DIAGNOSIS OF BLEEDING ECTOPIC GASTRIC MUCOSA
  $^{99m}$Tc-Pertechnetate to visualize ectopic gastric mucus cells

• LOCALIZATION OF ACTIVE ABDOMINAL BLEEDING
  $^{99m}$Tc-labeled-RBC to localize $>0.1\text{ml/min}$ bleeding over 3hr
EVALUATION OF FUNCTION OF SALIVARY GLANDS

For tumors or functional disorders

$^{99m}$Tc-Pertechnetate ($^{99m}$Tc$\text{O}_4^-$) iv 10 mCi
Imaging Anterior and Lateral
Lemon juice in mouth to check emptying
SALIVARY GLAND STUDY

Salivary Gland Study

1. RT SIDE 1
2. LF SIDE 2
3. RT AFTER LEMON JUI 4
4. LF AFTER LEMON JUI 5
RADIOTRACER STUDIES
OF THE GASTROESOPHAGEAL MOTILITY
Indications

a) Functional Abnormalities
   - Achalasia
   - Chalasia
   - Diffuse Esophageal Spasm

b) Anatomical Abnormalities
   - Assess function
   - Assess results of therapy
STUDIES OF ESOPHAGEAL MOTILITY

Technique

Fasting more than 4 hours.

200 µCi of $^{99m}$Tc-Sulfur Colloid in 15 ml of milk (water, juice)
The patient sitting swallows the drink

Dynamic Posterior Imaging
1 image/sec for 2 min and if activity persists
1 image/30 sec for 15 min

Histograms of the upper, middle, and lower 1/3 of the esophagus
ESOPHAGEAL TRANSIT TIME

The study of the esophagus is divided into three parts:
ESOPHAGEAL TRANSIT TIME

Normal
ESOPHAGEAL TRANSIT TIME

NORMAL STUDY

a) SINGLE SWALLOWING (in children and adults)
ESOPHAGEAL TRANSIT TIME

Normal
ESOPHAGEAL TRANSIT TIME

NORMAL STUDY

b) MULTIPLE SWALLOWING (usually in infants)
ACHALASIA
A baby had failure to thrive. He was evaluated by a Nuclear Motility Study then he was treated and re-evaluated.
ACHALASIA

BEFORE THERAPY

AFTER BOUGIENAGE

SUBSTANTIAL IMPROVEMENT
DIFFUSE ESOPHAGEAL SPASM
ESOPHAGEAL TRANSIT TIME QUANTIFICATION

- Normal Subjects
- Diffuse Spasm
- Scleroderma
- Achalasia

Graph showing esophageal transit time in seconds after the initial swallow for different conditions.
SCINTI-SIELOGRAM

**Indications**
Clinical suspicion of aspiration (pneumonias)

**Method**
Deposit one drop of high specific activity $^{99m}$Tc –SC (200$\mu$Ci) on each side of oral cavity.

Image head-chest until disappearance (20 min)

**Findings**
Normal: Esophagus and stomach are visualized
Abnormal: Bronchial tree is seen
SCINTISIELOGRAM

Normal

Aspiration
GASTRO-ESOPHAGEAL REFLUX STUDY

Indications

a) Vomiting, Failure to thrive, Bleeding
b) Aspiration Pneumonias or “Asthma,” Apneic Spells,
   Near Miss Syndrome (SIDS)
c) Pyrosis, Pain, Posture (Sandifer’s syndrome).

$^{99m}$Tc-Sulfur Colloid - labeled Milk Scan

200-500 µCi $^{99m}$Tc-Sulfur Colloid in 150-500ml milk (juice)

Evaluate for 1hr in Supine, Trendelenburg and with increased pressure
Images are taking every 10sec continuously

Delayed image at 4-5hr to check for Pulmonary Aspiration
GASTRO-ESOPHAGEAL REFLUX STUDY
GASTRO-ESOPHAGEAL REFLUX STUDY

LEG S RAISED

CIRCLING 60°
Quantification

Reading computer data with contrast enhancement
Histogram generation of esophagus and stomach

\[
\text{Reflux Index (RI)} = \frac{\text{counts from the esophagus}}{\text{counts from the stomach}} \times 100
\]

Remark: Background activity should be carefully calculated and subtracted from the esophageal activity
GASTROESOPHAGEAL REFLUX QUANTIFICATION

- (45.6)
- (33.3)
- (27.5)

G-E REFUX INDEX (%)

REFLUX PATIENTS  NORMAL CONTROLS

10 mmHg  15 mmHg  20 mmHg

25 mmHg  30 mmHg  35 mmHg

10 mmHg  15  20

25  30  35
PULMONARY ASPIRATION

Delayed Imaging after GER study
Infants are evaluated for VUR and Aspiration
PULMONARY ASPIRATION

Is there Aspiration?

Negative Study

Positive Study
PULMONARY ASPIRATION

Is there Aspiration?

Positive Study
GASTRIC EMPTYING TIME for CHILDREN

Indications
Vomiting, Failure to thrive, Pain, Diabetes in adults

Method
Fasting overnight,
200-500 $^{99m}$Tc-Sulfur Colloid in 150-00ml milk
The patient drinks regular feed amount
Imaging in Anterior and Posterior, 1 min images
0, 1 hr, 2, 3, 4, (5, 6) hours
Decay corrected Geometric Mean Ant and Post counts

Interpretation
4 hr post prandially < 25% of the original activity remains in the stomach
Delayed images may depict aspiration
QUANTIFICATION OF GASTRIC EMPTYING

ROI selection

Graph Generation
GASTRIC EMPTYING TIME for ADULTS

Indications
Pain, Diabetes

Method
Fasting overnight
The meal: Two eggs labeled with 1 mCi $^{99mTc}$Sulfur Colloid
Two slices of bread and a glass of orange juice
Imaging in Anterior and Posterior, 1 min images
0 time and at every 30 min till 2 hr and 30 min
Decay corrected Geometric Mean of the Ant and Post counts

Interpretation
Using a standard curve produced in the population studied

Delayed images may depict aspiration
**GASTRIC EMPTYING STUDY**

**Reporting Results**

The Normal Mean

1 SD above and bellow
A 1 yo boy is studied because of hematochesia
HEMATOCHEZIA = FRESH BLOOD IN STOOL

The usual work up is not diagnostic
ECTOPIC GASTRIC MUCOSA IN A MECKELS DIVERTICULUM:

Activity in Ectopic Gastric Mucosa

The stomach

Gastro-Esophageal Reflux

Right Kidney

5min

10min

30min

30min Lat

40min

50min Lat

1hr

$^{99m}Tc$-PerTechnetate Abdominal Scintigraphy
BLEEDING ECTOPIC GASTRIC MUCOSA IN A MECKELS DIVERTICULUM
THE GASTRIC MUCOSA

THE BLEEDING ULCER
BLEEDING ECTOPIC GASTRIC MUCOSA

Clinical Presentation
Hematochesia, Anemia, Abdominal Pain, from ulceration

Patient Preparation
Avoid contrast studies, No medications and overnight NPO

$^{99m}$Tc-Pertechnetate (Tc-PT) Scintigraphy (1-10mCi)
Imaging every 5min for 1 hr Ant, with Lat at 30 min and 1 hr

Mucous producing cells (not the parietal) accumulate Tc- PT
the Ectopic Mucosa is visualized like the stomach

Sensitivity > 90%, and is enhanced by glucagon injection
99mTc-Pertechnetate (Tc-PT) Scintigraphy

This method detects ECTOPIC GASTRIC MUCOSA in

a) Meckel’s Diverticulum
b) Esophagus (Barrett’s esophagus)
c) Intestine (Islets of ectopic gastric mucosa)
d) Enteric or gastric duplication (or cysts)
Meckel’s Diverticulum
Evolution of the Omphalo-Mesenteric Duct

NORMALLY the duct is absorbed

ABDNORMAL DEVELOPMENT
1) Persistent Omphalomesenteric Duct
2) Fibrous cord remnant
3) Umbilical Sinus
4) Meckel’s Diverticulum (1-3%)
Ectopic Gastric Mucosa is present in approximately 50% of all Meckel’s Diverticula, in 20-30% of Enteric Duplications, in Bowel Duplications, Barrett’s Esophagus, or occasionally in the walls of normal bowel.

Due to acid-peptic secretion (in 25% of all Diverticula) ulceration of the adjacent normal unprocted mucosa may occur, which may produce most commonly bleeding and severe anemia.

In addition and due to ulcer penetration of muscularis with local inflammatory reaction pain may occur.
TECHNETIUM-99m PERTECHNETATE
ABDOMINAL IMAGING
FOR ECTOPIC GASTRIC MUCOSA

IMAGING TECHNIQUE
Inject 100 μCi/kg Tc-99m-Pertechnetate intravenously.
Acquire Flow Study at injection
   (to diagnose Arteriovenous malformations).
Perform Sequential Imaging (anterior) every 10 min for 60 min.
   – Right lateral images at 30 min and 60 min (kidney)
   – Upright images to differentiate duodenum from right upper quadrant abnormalities.

Some investigators proposed continuous suction or left decubitus position.
The following patients were studied because of Hematochesia
$^{99m}$Tc-Pertechnetate (Tc-PT) Scintigraphy

Normal Study
$^{99m}\text{Tc-Pertechnetate (Tc-PT) Scintigraphy}$

Study Positive for Ectopic Gastric Mucosa
No evidence of Ectopic Gastric Accumulation
The following patients were studied because of Hematochesia
99mTc-Pertechnetate (Tc-PT) Scintigraphy

Watch for the right kidney

Ectopic Gastric Mucosa

The right kidney
$^{99m}$Tc-Pertechnetate (Tc-PT) Scintigraphy

Bladder interference

A full bladder may cover a lesion

Ectopic Gastric Mucosa
The following patient was studied because of Anemia (Ht=8)
$^{99m}$Tc-Pertechnetate (Tc-PT) Scintigraphy

Ectopic Gastric Mucosa
### 99mTc-Pertechnetate (Tc-PT) Scintigraphy

#### OSU/Children's Hospital and UM Experience

<table>
<thead>
<tr>
<th>Patients with Surgically Proven Diagnosis</th>
</tr>
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<tbody>
<tr>
<td>Total Number of Studies</td>
</tr>
<tr>
<td>For Ectopic Gastric Mucosa</td>
</tr>
<tr>
<td>True Positive</td>
</tr>
<tr>
<td>True Negative</td>
</tr>
<tr>
<td>False Positive</td>
</tr>
<tr>
<td>False Negative</td>
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</tbody>
</table>
Experiments in dogs with Ectopic Gastric Wall Transplantation

**Scintigraphic Studies**

- Control
- Pentagastrin 6 µG/Kg @ - 15 MIN.
- Glucagon .05 Mg/Kg Iv @ +10 Min
- Pentagastrin + Glucagon (above dose)
Experiments in dogs with Ectopic Gastric Wall Transplantation

Hormonal Enhancement

Glucagon gave the best pictures For the ectopic mucosa
STOMACH LOCALIZATION

INDICATIONS
To evaluate suspected lesions in the left upper abdomen during liver/spleen, kidney, bone and Ga-67 images (J Nucl Med Techn 2:146-149, 74)

METHOD
An oral dose of 500µCi of Tc-99m Sulfur Colloid in water, juice or milk will visualize the stomach.
STOMACH LOCALIZATION

RENAL SCAN

RENAL SCAN + STOMACH LOCALIZATION

DIAGNOSIS: L. MULTICYSTIC KIDNEY
INTESTINAL NECROSIS

INDICATIONS
Desirable to detect bowel infarction in Neonatal Necrotizing Enterocolitis prior to perforation

COMPLICATIONS
Intestinal Infarction — Gangrene

HYPOTHESIS
radionuclide scanning can demonstrate intestinal necrosis

METHOD
Tc99m - Pyrophosphate 100 µCi/kg IV
Anterior, Posterior, Lateral abdominal images (overexposed)
At 4 hours after injection
Radiolabeled Leukocytes (experimental studies)
INTESTINAL NECROSIS

COMMENTS

NEC a positive scan does not necessarily mean transmural necrosis of bowel.
Recoveries following a positive scan have been observed.
Small lesion, even with perforation, may have negative scans (insufficient tissue).
NECROTIZING ENTEROCOLITIS

RABBIT EXPERIMENTS
(44 ANIMALS)

LESIONS WITHOUT NECROSIS
- SHAM OPERATION
- INCOMPLETE DEvascularization
- REDUCED INTOSSUSCEPTION
- LUMINAL OBSTRUCTION

LESIONS WITH NECROSIS
- LOOP STRANGULATION
- MESENTERIC VESSEL LIGATION
NECROTIZING ENTEROCOLITIS

PRELIMINARY CLINICAL EXPERIENCE

NORMAL INFANT

LATERAL

ANTERIOR

LESIONS WITH NECROSIS

NEONATAL NECROTISING ENTEROCOLITIS

GANGRENOUS APPENDICITIS
NECROTIZING ENTEROCOLITIS
INFLAMMATORY BOWEL DISEASE

Regional Enteritis and Ulcerative Colitis may produce positive Ga-67 images.
Perforation and abscess formation can be excluded if the study is negative (*J Nucl Med* 20:215-8, 79)
REGIONAL ENTERITIS

1. Scintigraphy with Gallium-67
   A sensitive but non specific method because of normal visualization of bowel

2. Scintigraphy with autologous WBCs, labeled with $^{111}$In or $^{99m}$Tc
   A very sensitive and specific method for the diagnosis, evaluation of severity and for follow-up of regional enteritis
REGIONAL ENTERITIS: GALLIUM

24hr

72hr
Imaging of Inflammation with *Indium-111 Tropolonate* Labeled Leukocytes

A. Michael Peters, Sethna H. Saverymuttu, Helen J. Reavy, Heather J. Danpure, Safiye Osman, and J. Peter Lavender

*Hammersmith Hospital, London W12 OHS UK*

Fig. 8. Ischemic bowel disease proven at surgery.
A 12 yo child with abdominal pain and diarrhea
REGIONAL ENTERITIS

Liver

Spleen

Abnormal Activity in the Bowel

Bone Marrow

Labeled WBC study: Anterior Abdomen
REGIONAL ENTERITIS: $^{111}\text{In-WBC}$

Four Patient with increasing degree of severity
LOCALIZATION OF ACTIVE ABDOMINAL BLEEDING

It is important to localize the location of the beginning of abdominal bleeding for intervention.
LOCALIZATION OF ACTIVE ABDOMINAL BLEEDING

a) $^{99m}$Tc-Sulfur Colloid 5-10 mCi IV
Imaging of the abdomen for 30 min
Bleeding is localized only if it occurs during the 0-10 min after injection of the radiopharmaceutical

b) $^{99m}$Tc-labeled-RBCs
Imaging of the abdomen for 3 hr
May localize >0.1ml/min bleeding volume
1/3 of bleedings happen between 2-3 hr
ACTIVE BLEEDING RLQ  TcSC
LOCALIZATION OF ACTIVE ABDOMINAL BLEEDING

$^{99m}$Tc-labeled-RBCs may localize >0.1ml/min bleeding volume

Bleeding is localized if it occurs over 1-3 hr post injection and during continuous imaging (not spotty imaging)

METHOD

50-60 ml of blood are drawn in anticoagulant

Sn-PYP or SnCloride is added and incubated for 20 min

The labeled RBCs are injected and imaging begins:

a. First Pass Flow 1-3 sec/frame (for vascular anomalies)

b. Continuous imaging in 1 min/frame x 1-3 hr

(for active bleeding localization)
BLEEDING LOCALIZATION NEGATIVE

0-60min


60-120min


120-180min

Cases of bleeding localization
ACTIVE BLEEDING LLQ BLOOD POOL STUDY

2 min                         4                        6
12 min                       14                        16
ACTIVE BLEEDING LLQ in patient with renal transplant
Cases of bleeding localization
The left kidney. No Active Bleeding
Cases of bleeding localization
GI BLEED TRANSVERSE COLON, LEFT SIDE
GI BLEEDING: Descending Colon
Cases of bleeding localization
PROFOUND BLEEDING LARGE BOWEL

FOCAL  SPREADS OUT  FILLS THE BOWEL
Cases of bleeding localization

Patient with Lymphoma and Hematochesia
MASSIVE BLEEDING SMALL BOWEL

Patient with Lymphoma and Hematochesia
Cases of bleeding localization
BLEEDING ASCENDING COLON