

Society of Nuclear Medicine Procedure Guideline for Gastrointestinal Bleeding and Meckel's Diverticulum Scintigraphy

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I. Purpose

The purpose of this guideline is to assist nuclear medicine practitioners in recommending, performing, interpreting, and reporting the results of gastrointestinal bleeding and Meckel's diverticulum scintigraphy.

II. Background Information and Definitions

Gastrointestinal bleeding scintigraphy is performed in patients suspected of active gastrointestinal bleeding using Tc-99m labeled red blood cells (RBCs). Sites of active bleeding are identified by the accumulation and movement of labeled Red Blood Cells within the bowel lumen. Since activity within the lumen of the bowel can move antegrade and retrograde, frequent images (1 image every 10–60 sec) will increase the accuracy of localizing the bleeding site. Tc-99m sulfur colloid (SC) is rarely used today because of the short residence time within the blood. Tc-99m SC is cleared from the blood by the reticuloendothelial system with a half-time as short as 2 to 3 min while radiolabeled RBCs last for hours.

Gastrointestinal bleeding (GI) is either upper, originating above the ligament of Treitz, or lower, distal to the ligament of Treitz. Frequent causes of upper GI bleeding include esophageal varices, gastric and duodenal ulcers, gastritis, esophagitis, Mallory-Weiss tear or neoplasm. Causes of lower GI hemorrhage include angiodysplasia, diverticula, neoplasms and inflammation, and, in children, Meckel's diverticulum. Endoscopy and angiography provide accurate localization of bleeding sites and potentially therapeutic control. Scintigraphy with labeled RBCs is complementary to endoscopy and angiography because it permits continuous monitoring over hours. This is a major advantage

over intermittent sampling since most GI bleeds are intermittent and therefore frequently missed.

The clinical findings for active gastrointestinal hemorrhage are often unreliable and misleading. There is frequently a marked temporal lag between the onset of bleeding and the clinical findings. While it may be clinically apparent that the patient has bled from the presence of melena or hematochezia, the blood may pool in the colon for hours before being evacuated. A drop in the hematocrit and elevated serum blood urea nitrogen (BUN) also lack the temporal resolution needed to indicate active bleeding. Orthostatic hypotension and tachycardia occur more acutely but are insensitive and non-specific.

In cases where there is only occult bleeding detected by guaiac positive stools, gastrointestinal bleeding scintigraphy is unlikely to be useful. Gastrointestinal bleeding scintigraphy can detect bleeding rates as low as 0.1 to 0.35 ml per min. The guaiac test detects bleeds at rates well below the level necessary to be seen on gastrointestinal bleeding scintigraphy.

Meckel's Diverticulum Scintigraphy

A **Meckel's diverticulum** is a vestigial remnant of the omphalomesenteric duct located on the ileum about 50 to 80 cm from the ileocecal valve. About half of Meckel's diverticuli have gastric mucosa. Bleeding may result from ileal mucosal ulceration from acid secretion. Tc-99m pertechnetate avidly accumulates in gastric mucosa and is the study of choice for identifying ectopic gastric mucosa in a Meckel's diverticulum.

III. Common Indications

Gastrointestinal Bleeding Scintigraphy

The goals of gastrointestinal bleeding scintigraphy are to locate the bleeding site and to determine who

requires aggressive treatment versus those who can be medically managed. It is usually in those patients that require urgent care that the bleeding site is identified. In some patients, the bleeding site is identified with sufficient confidence for specific surgical intervention (e.g. right hemicolectomy in the case of a bleeding site in the ascending colon). If bleeding is detected, the site is usually localized well enough to direct the next diagnostic test (e.g. endoscopy or arteriography). Gastrointestinal scintigraphy should be done as soon as possible after the patient presents for medical care, since active bleeding is more likely at early times and is needed for correct localization.

Meckel's Diverticulum Scintigraphy

The indication for a Meckel's scintiscan is to localize ectopic gastric mucosa in a Meckel's diverticulum as the source of unexplained gastrointestinal bleeding. Bleeding Meckel's diverticula usually occur in young children. The Meckel's scintiscan should be used when the patient is not actively bleeding. Even in young children, active bleeding is best studied by radiolabeled RBC scintigraphy.

IV. Procedures

Gastrointestinal Bleeding Scintigraphy

A. Patient Preparation

See Precautions (IV.C.) below

B. Information Pertinent to Performing the Procedure

1. History of past bleeding episodes
 - a. Number of transfusions in the past
 - b. Results of prior studies to localize the bleeding site
 - c. Prior therapeutic interventions
 - d. History of factors that affect RBC radiolabeling efficiency (e.g. thalassemia, chemotherapy)
2. Current blood pressure and pulse
3. Clinical signs of active bleeding
 - a. Presence of orthostatic hypotension

- b. Change in resting pulse rate from supine to erect position
 - c. Frequency and volume of bleeding
 - d. Current hemoglobin and hematocrit
 - e. Recent hemoglobins and hematocrits
 - f. Number of recent transfusions
4. Suspected location of bleeding
 - a. Results of nasogastric aspirate and/or upper gastrointestinal endoscopy
 - b. Results of sigmoidoscopy or colonoscopy

C. Precautions

1. Patients suspected of acute gastrointestinal bleeding should have a blood pressure and pulse measured upon their arrival in the nuclear medicine department to confirm that they are not hypotensive. The vital signs should be monitored periodically while the patient is being imaged. The patient should have a large bore IV catheter in place so that hypotension can be rapidly treated with replacement fluids or blood.
2. The removal of blood for radiolabeling and reinjection poses the risk of misadministration to the wrong patient. The handling and administration of blood products must be subject to special safeguards and procedures, the goals of which are to eliminate any possibility of administration to the wrong patient or contamination of workers. See "Special Considerations for Labeled Blood Products" in the *Society of Nuclear Medicine Procedure Guideline for Use of Radiopharmaceuticals*.

D. Radiopharmaceuticals

The in-vitro method for labeling red blood cells is preferred due to its higher labeling efficiency. The in-vivo/in-vitro method can be used. The in-vivo method is not recommended. See the *Society of Nuclear Medicine Procedure Guideline for Use of Radiopharmaceuticals*.

E. Image Acquisition

Continuous acquisition of images at a frame rate of one image every 10–60 sec is important in order to accurately localize the bleeding site.

Radiation Dosimetry in Adults

Radiopharmaceutical	Administered Activity MBq (mCi)	Organ Receiving the Largest Radiation Dose* mGy (rad)	Effective Dose* mSv (rem)
Tc-99m labeled RBCs	750 – 1100 i.v. (20 – 30)	0.023 heart (0.085)	0.0085 (0.031)

*per MBq (mCi)
(ICRP 53 page 210)

1. Equipment

- Camera: Large field-of-view
- Collimator: A low energy, all-purpose, parallel hole collimator is preferred. When the study must be performed at the bedside, a diverging collimator is useful to see the maximum abdominal area.
- Photopeak: Typically 20% window at 140 keV.
- Computer: 128 x 128 matrix, single or 2-byte mode. (One byte has been called byte-mode and 2-bytes, word-mode.)

2. Patient position: Supine

3. Imaging field: Abdomen and pelvis

4. Acquisition Protocol

a. Abdominal Flow Study

Anterior abdominal flow images (1–5 secs/frame x 1 min) are recommended.

b. Dynamic Abdominal Imaging

i. Dynamic anterior abdominal images are acquired at a frame rate of 10–60 sec per frame over a 60 to 90 min period. Acquiring these images in multiple sets of 10–15 min each may facilitate review of these images by the physician as the images are being acquired.

ii. If computer acquisition is not possible: Sequential static images 1 million counts per image at least every 5 min for 60–90 min. Localization might be aided by obtaining images at a shorter interval, every 2–3 min.

c. Delayed Imaging

For Tc-99m RBCs, if no bleeding site is identified on the initial 60–90 min dynamic images, delayed images may be acquired.

These images are optional. Typically delayed images are done from 2–6 hr and/or at 18–24 hr after the injection of the radiopharmaceutical. Delayed images are useful in showing subsequent bleeding and categorizing the severity, but may result in incorrect localization when identifying a bleeding site. Initiating a new dynamic study may give useful localizing information if the patient is actively bleeding at the time of imaging. This may be done while initiating a new study by radiolabeling a new RBC kit.

d. Additional Views

Due to overlying bladder activity, activity in the rectum can be difficult to appreciate. Lateral views may be needed to see rectal bleeding. Anterior oblique and posterior views are frequently helpful in deciding if activity is located anteriorly versus posteriorly.

e. Region of interest counts over extravasated blood in the bowel may be used to estimate blood loss when normalized to counts obtained from a blood sample drawn simultaneously from the patient and corrected for attenuation. The precision and accuracy of such estimates should be determined by each institution making such estimates.

f. In cases where extravasated blood is seen but does not move sufficiently to determine the location or where the movement is unusual, the following may be useful: review of prior barium studies; oral Tc-99m SC to outline the upper GI and small bowel anatomy; or Tc-99m SC enema to outline the colon.

F. Interventions

Pharmacologic (pharmacologic intervention is controversial and is not widely used).

**Radiation Dosimetry in Children
(5 year old)**

Radiopharmaceutical	Administered Activity MBq (mCi)	Organ Receiving the Largest Radiation Dose* mGy (rad)	Effective Dose* mSv (rem)
Tc-99m labeled RBCs	10 – 15 i.v. (0.3 – 0.4)	0.062 heart (0.23)	0.025 (0.093)

*per MBq (mCi)
(ICRP 53 page 210)

Glucagon has been suggested as an adjunct to GI bleeding studies. Glucagon decreases intestinal peristalsis and increases vasodilatation. Glucagon is not widely used.

Heparin also has been suggested as an adjunct to GI bleeding studies in selected patients with recurrent significant bleeding from a site that has not been localized using standard diagnostic tests. Standard procedure is to administer IV 6,000 units heparin as a loading dose, followed by 1,000 units IV heparin per hr. The patient's baseline coagulation status should be evaluated before giving heparin. Heparin provocation is not widely used. Surgical coverage should be immediately available as a precautionary measure. Close monitoring of the patient is necessary and protamine sulfate should be immediately available to reverse the effects of heparin.

G. Processing

Other than optional subtraction/contrast enhancement or blood loss estimation, there is no routine processing. If the software is available, motion correction may be used to minimize the effects of patient movement.

Subtraction Cine

The first frame or normalized summed set of data can be subtracted from the latter images to improve contrast. When using this technique, the patient must remain still during the exam or have appropriate motion correction software.

H. Interpretation Criteria

Accurate interpretation of GI bleeding scintigraphy requires knowledge of the normal and abnormal variations in the abdominal vascular space.

Labeled red blood cells rapidly reach equilibrium within the vascular space of the liver, spleen and great vessels. It is normal for some radioactivity to be excreted in the urine and the urinary tract to be seen even when in vitro labeling is used.

Extravasated radiolabeled RBCs within the lumen of the bowel are identified as an area of activity that increases in intensity with time, and/or as a focus of activity that moves in a pattern corresponding to the lumen of the large or small bowel. Small bowel bleeding usually can be distinguished from large bowel bleeding by its rapid serpiginous movement.

GI bleeding scintigraphy may be used to estimate the severity of the bleeding. Factors associated with a low bleeding rate are visualization of blood after one hour and activity less intense than the liver. Higher bleeding rates are associ-

ated with early appearance of blood in the bowel and intense activity equal to or greater than the liver.

I. Reporting

Aside from patient demographics, the report should include the following information:

1. Indication for the study
2. Procedure
 - a. Radiopharmaceutical
 - i. Dose
 - ii. Radiolabeling method for RBCs (e.g., in-vivo)
 - iii. Method of administration (i.v.)
 - b. Acquisition
 - i. Duration of acquisition (e.g., 1 hr)
 - ii. Frame rate (e.g., 10 sec/frame)
 - iii. Projections acquired (e.g., anterior, laterals)
 - c. Display (e.g., static vs. cine)
 - d. Findings
 - i. Onset
 - ii. Location
 - iii. Characteristics
 - (a) Size and Shape (e.g., focal, diffuse)
 - (b) Pattern of movement (e.g. moves vs. stationary, serpentine small bowel pattern vs. colonic, antegrade or retrograde)
 - (c) Severity (e.g., waxing or waning intensity, qualitative intensity compared to the liver, qualitative volume—large/small)
 - e. Study limitations, confounding factors
 - f. Interpretation (e.g., positive, negative, indeterminate) and state location of bleeding site

J. Quality Control

Quality control for the gamma camera, computer system and image display are as described by the *Society of Nuclear Medicine Procedure Guideline for General Imaging*.

K. Sources of Error

1. Delay in implementing the procedure since bleeding may have stopped.
2. Failure to use a computer to display dynamic images as a movie. Subtle areas of bleeding may go undetected or the location of the bleeding may be inaccurately identified if images are not reviewed as a movie. Use of windowing levels and different color schemes on a computer display also facilitates the detection of subtle abnormalities.
3. It is important to continue to acquire images after abnormal activity is detected. Accurate localization of the bleeding site is dependent

upon identification of the focus of initial blood collection, and upon the movement of the blood away from the bleeding focus.

4. The entire abdomen must be examined before concluding that no bleeding was detected. A lateral, posterior and/or sub-pubic view is best to help in identifying activity in the rectum that would otherwise not be detected due to overlying bladder activity or soft tissue attenuation.
5. Inexperienced readers may mistake mesenteric varices or penile blood pool for areas of bleeding. A full urinary bladder may obscure sigmoid or rectal bleeding. Radioactive urine in the renal pelvis of a transplanted kidney, in either the right or left lower quadrant of the abdomen, may look like colonic activity.
6. Gastric mucosal and renal activity is seen when free Tc-99m pertechnetate is present. This potential source of error can be avoided by using in vitro RBC labeling method and performing QC for free pertechnetate, and by recognizing that intraluminal blood moves in a distinct pattern. Images of the thyroid and salivary glands can confirm the presence of free Tc-99m pertechnetate as a source of artifact.

Meckel's Diverticulum Scintigraphy

A. Patient Preparation

Pretreatment with pentagastrin, Histamine H₂ blockers or glucagon is reported to enhance the sensitivity of the Meckel's scan. Pentagastrin is a potent stimulator of gastric secretions and increases gastric mucosa uptake of pertechnetate. It also stimulates secretion of pertechnetate and GI motility, potentially reducing ectopic site activity. Pentagastrin is administered subcutaneously, 6 micrograms/kg 15 to 20 min prior to injecting the Tc-99m pertechnetate. Histamine H₂ blockers (cimetidine, ranitidine) block secretion from the cells and increase gastric mucosa uptake. Oral cimetidine should be administered, 300 mg QID x 2 days in adults, 20 mg/kg/day x 2 days in children, or 10–20 mg/kg/day in neonates prior to starting. Intravenous cimetidine should be administered at a rate of 300 mg in 100 ml of D5W over 20 min with imaging starting 1 hr later. Ranitidine may be substituted for cimetidine. Ranitidine dosage is 1 mg/kg i.v. for infants, children and adults, up to a maximum of 50 mg, infused over 20 min and imaging starting one hr later, or 2 mg/kg/dose p.o. for children

and 150 mg/dose for adults. Glucagon relaxes the smooth muscles of the gastrointestinal tract, decreasing peristalsis. The dose for glucagon is 50 micrograms/kg i.v. 10 min after the Tc-99m pertechnetate.

It is not recommended that an H₂ blocker and pentagastrin be combined since H₂ blockers antagonize pentagastrin.

Pharmacologic pre-treatment is not considered necessary for performing a high-quality Meckel's scan.

Determine whether the patient has had recent in-vivo RBC labeling where all circulating RBC were treated with stannous ion via i.v. administration of a "cold" pyrophosphate kit. If so, the Meckel's scan may be compromised, since i.v. Tc-99m pertechnetate will label RBC rather than concentrate in ectopic gastric mucosa. This may occur for days after the administration of stannous pyrophosphate. This is not a problem with in-vitro labeling.

Patients may also be placed in a left lateral decubitus position to decrease small bowel activity arising from the stomach. Nasogastric tube suction has also been used for this purpose.

- B. Information Pertinent to Performing the Procedure
 1. History of past bleeding episodes
 2. Results of prior studies to localize the bleeding site
 3. Has in-vivo RBC labeling been done?
 4. Clinical signs of active bleeding
- C. Precautions

None
- D. Radiopharmaceuticals (see Tables)
- E. Image Acquisition
 1. Equipment
 - Camera: Large field-of-view
 - Collimator: A low energy, all-purpose, parallel hole collimator is preferred.
 - Photopeak: Typically 20% window at 140 keV.
 - Computer: 128 x 128 matrix, single or 2-byte mode.
 2. Patient position: Supine (optional: left lateral decubitus)
 3. Imaging field: Abdomen and pelvis
 4. Acquisition Protocol
 - a. Optional acquisition of anterior abdominal flow images (1–5 sec/frame x 1 min).
 - b. Anterior abdominal images at a frame rate of one image every 30–60 sec for at least 30 min (some favor 60 min).
 - c. Additional static images, anterior oblique projections, laterals and posterior projec-

Radiation Dosimetry in Adults

Radiopharmaceutical	Administered Activity MBq (mCi)	Organ Receiving the Largest Radiation Dose*	Effective Dose*
		mGy (rad)	mSv (rem)
Tc-99m pertechnetate	300 – 450 i.v.	0.062	0.013
	(8 – 12)	ULI# (0.23)	(0.048)

*per MBq (mCi)

Upper Large Intestine

(ICRP 53 page 199, no blocking agent)

tion views are recommended at the end of the dynamic acquisition. Stopping the dynamic acquisition to obtain these images when abnormal activity is first seen can be helpful to distinguish activity in a Meckel's diverticulum from activity in the kidney, ureter or bladder. Post-void images can also be helpful to detect activity in a Meckel's diverticulum observed by the urinary bladder.

F. Interventions

See Patient Preparation (IV.A) above.

A urinary catheter to drain the bladder of activity can be helpful if the Meckel's diverticulum is adjacent to the bladder.

Alternatively, decubitus or upright views can sometimes cause the Meckel's diverticulum to fall away from the bladder.

G. Processing

None

H. Interpretation Criteria

Activity in the ectopic gastric mucosa should appear at the same time as the activity in the normal gastric mucosa. A Meckel's diverticulum may appear anywhere within the abdomen, al-

though classically it is seen in the right lower quadrant. The activity that is most often confused for a Meckel's diverticulum is activity in the kidneys, ureter or bladder. Activity in the urinary tract usually first appears after activity is seen in the normal gastric mucosa. Small Meckel's diverticulum may seem to appear at a later time than the stomach.

Pertechnetate that is secreted by the gastric mucosa will gradually accumulate in the small bowel. This activity can be distinguished from a Meckel's diverticulum by its delayed appearance and by its appearance as an area of mildly, ill-defined increased activity.

Viewing the dynamic image as a cine on a computer display that also permits adjustment of image contrast is helpful.

I. Reporting

Aside from patient demographics, the report should include the following information:

1. Indication for the study
2. Procedure
 - a. Radiopharmaceutical
 - i. Dose
 - ii. Method of administration (i.v.)

Radiation Dosimetry in Children (5 year old)

Radiopharmaceutical	Administered Activity MBq (mCi)	Organ Receiving the Largest Radiation Dose*	Effective Dose*
		mGy (rad)	mSv (rem)
Tc-99m pertechnetate	4.0 – 6.0 i.v.	0.21	0.040
	(0.11 – 0.16)	ULI# (0.78)	(0.15)

*per MBq (mCi)

#Upper Large Intestine

(ICRP 53 page 199, no blocking agent)

- b. Acquisition
 - i. Duration of acquisition (e.g., 1 hr)
 - ii. Frame rate (e.g., 60 sec/frame)
 - iii. Projections acquired (e.g. anterior, laterals)
- c. Display (e.g., static vs. cine)
- d. Findings
 - i. Onset (e.g. early vs. late, correspondence with gastric activity)
 - ii. Location
 - iii. Characteristics
 - (a) Size and Shape (e.g., focal, diffuse)
 - (b) Movement (if any)
 - e. Study limitations, confounding factors
 - f. Interpretation (e.g., positive, negative, indeterminate)
- J. Quality Control

Quality controls for the gamma camera, computer system and image display are as enumerated by the *Society of Nuclear Medicine Procedure Guideline for General Imaging*.
- K. Sources of Errors
 - 1. Procedures that may cause interference:
 - a. False-Negative Result

Barium enema, upper GI exam, perchlorate, recent in-vivo RBC labeling
 - b. False-Positive Result

Laxatives or endoscopy causing bowel irritation
 - 2. Anatomic causes of errors
 - a. False-Negative Result

Small amount of gastric mucosa in the Meckel's diverticulum, ischemia or necrosis, obscured by urinary tract activity, e.g. bladder
 - b. False-Positive Result

Urinary tract activity, lesions with increased blood pool, ulceration, inflammation, irritation, tumor, intussusception.

V. Issues Requiring Further Clarification

Gastrointestinal Bleeding Scintigraphy

- A. How to optimize the sequencing of examinations including angiography, endoscopy and scintigraphy
- B. How to best select patients who will benefit from this study
- C. Role of pharmacologic interventions

Meckel's Diverticulum Scintigraphy

Role of pharmacologic interventions

VI. Concise Bibliography

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VIII. Disclaimer

The Society of Nuclear Medicine has written and approved guidelines to promote the cost-effective use of high quality nuclear medicine procedures. These generic recommendations cannot be applied to all patients in all practice settings. The guidelines should not be deemed inclusive of all proper procedures or exclusive of other procedures reasonably directed to obtaining the same results. The spectrum of patients seen in a specialized practice setting may be quite different than the spectrum of patients seen in a more general practice setting. The appropriateness of a procedure will depend in part on the prevalence of disease in the patient population. In addition, the resources available to care for patients may vary greatly from one medical facility to another. For these reasons, guidelines cannot be rigidly applied.

Advances in medicine occur at a rapid rate. The date of a guideline should always be considered in determining its current applicability.