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The SNMMI Procedure Standard/ACNM Practice Guideline for Gastrointestinal Bleeding Scintigraphy 3.0

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PREAMBLE

The Society of Nuclear Medicine and Molecular Imaging (SNMMI) is an international scientific and professional organization founded in 1954 to promote the science, technology, and practical application of nuclear medicine. Its 18,000 members are physicians, technologists, and scientists specializing in the research and practice of nuclear medicine. In addition to publishing journals, newsletters, and books, the SNMMI also sponsors international meetings and workshops designed to increase the competencies of nuclear medicine practitioners and to promote new advances in the science of nuclear medicine.

SNMMI collaborated with the American College of Nuclear Medicine (ACNM) to develop this guideline. ACNM is comprised of physicians and other nuclear medicine professionals dedicated to enhancing the practice of nuclear medicine through study, education, and improvement of clinical practice. The SNMMI will periodically define new standards/guidelines for nuclear medicine practice to help advance the science of nuclear medicine and to improve the quality of service to patients. Existing standards/guidelines will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated. As of February 2014, the SNMMI guidelines will now be referred to as procedure standards. Any previous practice guideline or procedure guideline that describes how to perform a procedure is now considered an SNMMI procedure standard.

Each standard/guideline, representing a policy statement by SNMMI, has undergone a thorough consensus process in which it has been subjected to extensive review. The SNMMI recognizes that the safe and effective use of diagnostic nuclear medicine imaging requires specific training, skills, and techniques, as described in each document. The SNMMI has written and approved these standards/guidelines to promote the use of nuclear medicine procedures with high quality. These standards/guidelines are intended to assist practitioners in providing appropriate nuclear medicine care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the SNMMI cautions against the use of these standards/guidelines in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by medical professionals taking into account the unique circumstances of each case. Thus, there is no implication that an approach differing from the standards/guidelines, standing alone, is below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the standards/guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the standards/guidelines.

The practice of medicine involves not only the science but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to these standards/guidelines will not ensure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of these standards/guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

Gastrointestinal bleeding scintigraphy (GIBS) is a noninvasive study that is performed on patients with suspected

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gastrointestinal bleeding to determine whether the bleeding is active, to localize the bleeding site, and to approximate the bleeding volume for prognostic purposes. These characteristics can be challenging to identify but are important for initiation of prompt and effective therapy. The clinical signs and symptoms and laboratory indicators of gastrointestinal hemorrhage are often unreliable and misleading regarding the presence of active bleeding. There is frequently a marked lag between the onset of bleeding and the clinical findings. Melena is a sequela of earlier bleeding that could have stopped, and blood may remain in the bowel for hours before being evacuated. Orthostatic hypotension and tachycardia may be detected more acutely but are insensitive and nonspecific. A decrease in hematocrit and an elevation in serum blood urea nitrogen generally lag behind a bleeding episode, which may have ended hours earlier.

GIBS enables continuous monitoring of the entire gastrointestinal tract for up to approximately 24 h (*1*,*2*). The ability to perform continuous imaging increases the likelihood of detection of intermittent bleeding over other techniques that are limited to only a single time point or periodic sampling (*3*–*7*). Furthermore, GIBS is a procedure that does not require any patient preparation, can be performed with standard nuclear medicine instrumentation, and is well tolerated even in patients who are acutely ill.

Gastrointestinal bleeding may be classified as upper gastrointestinal bleeding (above the ampulla of Vater and within reach of esophagogastroduodenoscopy), mid gastrointestinal bleeding (small bowel from the ampulla of Vater to the terminal ileum, which can be evaluated by capsule endoscopy or double-balloon enteroscopy), or lower gastrointestinal bleeding in the colon, which can be evaluated by colonoscopy (*8*). Common causes of upper gastrointestinal bleeding include esophageal varices, gastric and duodenal ulcers, gastritis, esophagitis, Mallory–Weiss tears, and neoplasms. The most common causes of mid gastrointestinal bleeding are angiodysplasia, neoplasms, Crohn disease, diverticula, and Meckel diverticulum. Common causes of lower gastrointestinal bleeding include angiodysplasia, diverticulosis, benign and malignant bowel neoplasms, adenomatous polyps, inflammatory bowel disease, and infectious bowel disease.

Although this standard/guideline is focused on the use of ^{99m}Tc-labeled autologous red blood cells (^{99m}Tc-RBCs) for detection of sites of gastrointestinal bleeding, the methods described in this standard/guideline may be applicable to localizing occult bleeding elsewhere in the body.

II. GOALS

The purpose of this standard/guideline is to assist nuclear medicine practitioners in recommending, performing, interpreting, and reporting the results of GIBS in adults and children. The goals of GIBS are to determine whether the patient is actively bleeding, to localize the bleeding bowel segment, and to estimate the rate of blood loss, which allows for treatment planning and risk stratification.

III. DEFINITIONS

GIBS is a diagnostic radionuclide imaging study performed with ^{99m}Tc-RBCs that detects active bleeding into the gastrointestinal lumen. Gastrointestinal bleeding can be either occult (detected only on guaiac fecal occult blood testing) or overt (with clinical signs and symptoms such as melena or hematochezia). Obscure gastrointestinal bleeding can be either overt or occult and is defined as persistent or recurrent gastrointestinal bleeding from an unknown source despite an exhaustive work-up including esophagogastroduodenoscopy, colonoscopy, or other initial studies (*9*).

IV. COMMON CLINICAL INDICATIONS

GIBS is commonly indicated for identifying an active gastrointestinal bleeding site in patients with overt gastrointestinal bleeding. GIBS should not be performed on patients with chronic occult gastrointestinal bleeding because the guaiac fecal occult blood test may detect bleeding at rates well below those necessary to be identified on GIBS.

GIBS is indicated primarily for overt mid or lower gastrointestinal bleeding, specifically when an upper gastrointestinal bleed has been excluded by nasogastric lavage (*10*). In this scenario, GIBS can be used as an early diagnostic study for gastrointestinal bleeding especially for hospitalized patients or patients in the emergency department (*10*–*12*). GIBS can be beneficial when other studies require lengthy patient preparation or are contraindicated. Although GIBS can also identify overt upper gastrointestinal bleeding, usually the first procedure performed to confirm upper gastrointestinal bleeding is nasogastric lavage, followed by esophagogastroduodenoscopy to identify and treat suspected overt upper gastrointestinal bleeding.

GIBS is also indicated to help identify the source of obscure overt gastrointestinal bleeding. However, most studies have shown that GIBS can help localize the obscure overt bleeding site in these patients (*13*–*20*). Among some of the other common clinical indications for GIBS are stratifying risk in patients with gastrointestinal bleeding (*21*–*27*), directing timely diagnostic angiography, and assisting in plans for surgical or other interventional procedures (*7*,*12*,*28*–*31*).

V. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL (IN THE UNITED STATES)

Refer to the SNMMI Procedure Standard for General Imaging.

VI. PROCEDURE/SPECIFICATIONS OF THE EXAMINATION

A. Request

At the time of the request, it is important for the referring clinician to have a management plan in place before GIBS. Through early coordination of clinical services (such as

interventional radiology, gastroenterology, or surgery), the patient can be directed promptly to the next diagnostic or therapeutic procedure if GIBS has positive results (*32*). Any unnecessary delay increases the likelihood of negative angiography findings, as bleeding often stops spontaneously (*30*).

All pertinent clinical information should be reviewed before the study is started. Information specifically related to GIBS may include the following.

1. Clinical signs of gastrointestinal bleeding (frequency, volume, and character [hematochezia, melena, or hematemesis]; current and recent hemoglobin, hematocrit, and blood urea nitrogen findings; number of recent transfusions; current blood pressure and heart rate; presence of orthostatic vital signs)
2. History of prior abdominal or pelvic surgeries
3. Diagnostic studies (nasogastric tube aspiration, esophagogastroduodenoscopy, capsule endoscopy, double-balloon enteroscopy, sigmoidoscopy or colonoscopy, prior GIBS, angiography, CT enterography/angiography)
4. Therapeutic interventions (endoscopic epinephrine injection, coagulation [by cautery, heater probe, laser, or argon plasma coagulator] or mechanical therapy [clips, bands, or detachable loops], angiographic embolization, selective arterial infusion of vasoconstrictors such as vasopressin)
5. Current medications
6. Factors that may decrease RBC radiolabeling efficiency including drug interactions and medical conditions are listed in Table 1 (*4*,*33*–*35*)
7. Oral contrast agents such as barium used for other gastrointestinal imaging studies ([can cause photopenic artifacts (*36*) but are not an absolute contraindication for GIBS (*37*)])

TABLE 1
Causes of Reduced RBC Labeling Efficiency

Cause	Drug or process
Complex formation with ^{99m}Tc	Dextrose
Decreased RBC labeling	Digoxin
	Prazosin
	Propranolol
Formation of RBC antibodies	Immune disorders
	Leukemia and lymphoma
	Methyldopa
	Penicillin
	Prior transfusion or transplantation
Prior transfusion or transplantation	Excess stannous chloride
	Insufficient stannous chloride
Oxidation or reduction of availability of stannous ion	Cyclosporin
	Decreased hematocrit
	Heparin
	Hydralazine
Mechanism unknown	Calcium channel blockers
	Dipyridamole
	Doxorubicin
	Iodinated contrast
	Metronidazole
	Quinidine
	Ranitidine
	Sickle-cell disease
	Thalassemia

B. Patient Preparation and Precautions

Patients with gastrointestinal bleeding who are considered hemodynamically unstable should be monitored by a physician, advanced practice provider, or nurse while in the nuclear medicine department.

Reinjection of radiolabeled blood taken from one patient poses the risk of incorrect administration of the blood to a different patient than the patient who originally provided the blood. Written policies must be in place, with special safeguards regarding the handling and administration of blood to eliminate any possibility of administration to the wrong patient, particularly when two or more RBC labeling studies are performed simultaneously. Universal precautions must be followed to avoid staff exposure to blood products. Refer to the SNMMI Procedure Standard for Use of Radiopharmaceuticals.

Fasting is not required for GIBS. However, fasting may be required for subsequent procedures such as angiography or surgery.

Patients should be instructed to void immediately before imaging so they are comfortable during a potentially long scan and to facilitate scan interpretation.

C. Radiopharmaceuticals

Historically, two radiopharmaceuticals have been used for GIBS: ^{99m}Tc-RBCs and ^{99m}Tc-sulfur colloid. ^{99m}Tc-RBCs are the radiopharmaceutical of choice for performing GIBS because of an intravascular half-life that allows continuous imaging of the gastrointestinal tract over many hours (*38*–*40*). The superior clinical utility of ^{99m}Tc-RBCs over early studies using ^{99m}Tc-sulfur colloid has been demonstrated in comparison studies (*38*–*40*). ^{99m}Tc-labeled human serum albumin results in suboptimal image quality, when compared with labeled RBCs, due to breakdown of the albumin, and as such its use is not recommended.

^{99m}Tc-RBCs can detect gastrointestinal bleeding at a rate of as low as 0.04 mL/min in experimental animal models and 0.1 mL/min in clinical studies (*27*,*41*). High efficiency of RBC labeling with minimal unbound ^{99m}Tc is critical to producing optimal images.

Three methods are available to label RBCs: in vitro, modified in vivo, and in vivo. The in vitro method using a commercially available kit yields the highest labeling efficiency (≥95%) and is the method of choice (*42*,*43*). A further advantage of the in vitro method is that a sample can be evaluated for radiolabeling efficiency with a centrifuge method as described in the manufacturer's package insert. Additionally, if radiolabeling is substandard because of a drug interaction, low hematocrit level, or other factor (section VI.A.6), or because of a procedural deviation, a salvage technique may be attempted (*44*). This procedure involves transferring the in vitro ^{99m}Tc-RBCs into a sterile 15-mL polypropylene centrifuge tube and centrifuging at 400 *g* for

5 min. The supernatant is then removed with a sterile pipette, and the ^{99m}Tc-RBCs are resuspended in 2 mL of 0.9% sodium chloride. If the radiochemical purity of the ^{99m}Tc-RBCs is then more than 95% and adequate radioactivity remains, the salvage is deemed successful.

The modified in vivo label (90% labeling efficiency) can serve as an alternative when the in vitro method is not available (*45*–*47*). The in vivo method is not recommended because of suboptimal labeling and a higher likelihood of free ^{99m}Tc-pertechnetate. However, the in vivo method may be needed for patients who, because of religious convictions or other reasons, will not accept re-injection of blood.

The recommended administered activity of ^{99m}Tc-RBCs is 555–1,110 MBq (15–30 mCi) in adults. In children under 18 y old, the recommended administered activity based on the North American Consensus Guidelines for Pediatric Administered Radiopharmaceutical Activities is 11.8 MBq/kg (0.32 mCi/kg) with a minimum administered activity of 74 MBq (2.0 mCi) and a maximum administered activity of 740 MBq (20.0 mCi) (*47*,*48*). Alternatively, the European Association Nuclear Medicine Pediatric Dosage Card uses a baseline activity of 56 MBq (1.51 mCi) multiplied by a weight-based multiple (*49*). The resulting minimum administered activity is 80 MBq (2.16 mCi) for a 3-kg patient and the maximum administered activity is 784 MBq (21.19 mCi) for a 68-kg patient.

D. Protocol/Image Acquisition

1. Image Acquisition. In the supine position, anterior images of the abdomen and pelvis are acquired (section VIII specifies equipment). A minimum image matrix of 128 × 128 is recommended for planar imaging. Any items on the patient that may produce imaging artifacts should be removed or moved out of the field of view. Care should be taken to keep patients' upper extremities from overlying the abdomen and pelvis during imaging as the upper extremities can obscure findings and their movement can cause artifacts.

After the injection of ^{99m}Tc-RBCs through an intravenous line, rapid dynamic image acquisition at a rate of 1 frame per 1–3 s for 60 s (nuclear angiography) can be performed to visualize vascular structures and may help differentiate between blood pool activity and bleeding on later images. However, these angiographic images seldom add to the overall study result and are considered optional.

Immediately after the angiographic study, dynamic imaging should be performed. Serial intermittent static images are not recommended. The maximum recommended frame rate should not exceed 1 frame per 60 s. As the frame duration becomes longer, the temporal resolution of the scan decreases, possibly leading to inaccurate localizing of the bleeding source.

Since intraluminal blood promotes rapid bowel peristalsis and movement of blood antegrade or retrograde from the bleeding site, faster frame rates such as 1 frame per 10–20 s allow for higher temporal resolution to better localize the gastrointestinal bleeding site (*50*). On the other hand, a small volume of intraluminal blood or slow gastrointestinal bleeding may be more difficult to detect when fast frame rates are used because of lower count densities (*50*). This shortcoming can be compensated by reformatting/summing the acquired study into longer frames (*50*,*51*). Therefore, reformatting/summing is recommended when using fast frame rates. However, the optimal dynamic frame rate for GIBS has not been established because there are no published clinical studies that have compared these various acquisition techniques. Acquiring the dynamic images in 10- to 20-min sequences may facilitate review of these images by the physician because one series can be reviewed while subsequent sequences are still being acquired. However, this method results in fragmented imaging clips so adding all of the images together into one continuous imaging sequence at the conclusion of the scan is beneficial for interpretation. Since gastrointestinal bleeding occurs intermittently, the patient should be imaged continuously for as long as practical to identify the bleeding source (*11*,*31*,*52*–*54*). Initial imaging for a minimum of 60 min is recommended if no gastrointestinal bleeding is detected (*13*,*18*,*40*,*51*,*55*). If abnormal focal RBC activity is detected, image acquisition should continue for a sufficient time to confidently identify the bleeding site. Accurate localization of the bleeding site is dependent on identification of the initial location of extravasated blood and movement of blood from that site within the bowel lumen. Increased imaging time may be particularly needed to differentiate a small-bowel bleed from a large bowel bleed. Single Photon Emission Computed Tomography/Computed Tomography (SPECT/CT) may also be helpful in this context (*56*).

SPECT/CT may be a valuable method for more precise interpretation and to facilitate specific anatomical information of the bleeding site (*57*–*62*). If applied, a typical SPECT acquisition uses a 128 × 128 matrix over a 360° arc, using a body-contoured elliptic orbit, optimally obtaining 120 (minimum of 60) projections at 20–30 s per projection (every 3–6 degrees), depending on the number of projections and sensitivity of the detector (*57*,*58*,*61*,*62*). An equivalent total number of counts should be acquired if continuous acquisition is used. Three-dimensional iterative ordered-subsets expectation maximization is the usual reconstruction algorithm.

The optimal CT parameters (mAs and kVp), acquisition time and slice thickness should be determined based on the manufacturer or laboratory guidelines to maximize imaging quality and minimize radiation exposure to the patient. Typical CT parameters include a tube current ranging from 100–200 mAs, voltage of 120 kVp (ranging from 100–140 kVp), pitch 1.0, rotation time 0.6 s, and a slice thickness of 2.5–5 mm (*57*,*58*,*61*,*62*). Fused 3-dimensional SPECT/CT images are usually displayed as 2-dimensional orthogonal (axial, coronal, and sagittal) and maximum-intensity projections.

Urine activity in a full bladder may obscure sigmoid or rectal bleeding on a standard anterior view. Lateral, posterior, or subpubic views may help in identifying activity in

the rectum that would otherwise not be detected because of bladder activity or soft-tissue attenuation. The entire abdomen and pelvis must be examined before one can conclude that no gastrointestinal bleeding is detected. When a dual-head camera is used, simultaneous imaging in the anterior and posterior views may improve the sensitivity for detecting rectal bleeding. Furthermore, lateral views are helpful in differentiating anterior vascular penile activity (which can move or change in intensity during imaging) from bleeding in the more posteriorly located rectosigmoid colon (*32*).

If gastric activity is visualized, an anterior image of the head and neck should be obtained to evaluate for possible thyroid and salivary gland activity. Activity at these sites suggests the presence of free ^{99m}Tc-pertechnetate as the cause of the gastric activity rather than gastric bleeding. Although some centers have advocated imaging stool if the patient has had a bowel movement, the presence of radioactivity in the stool would only confirm that the patient has bled in the past and does not localize the origin of the bleeding.

If no bleeding site is identified on the initial images, delayed images can be acquired by rescanning the patient for up to 24 h, especially if there is clinical evidence of recurrent gastrointestinal bleeding (section F). All delayed images should be acquired using the same dynamic method as the initial images. If available, the same camera as used for the initial images should also be used for the delayed images.

2. Processing. If motion correction software is available, it can minimize the effects of patient movement. Computer subtraction of background activity of early images from later frames in the imaging sequence has the following limitations: the patient must remain still during the examination or motion correction software must be applied, and the biodistribution of the ^{99m}Tc-RBCs should be similar between the early frames and any image to be subtracted (*50*,*63*–*67*). Failure to control these factors can cause false-positive findings.

E. Interpretation

Accurate interpretation of GIBS requires knowledge of normal and abnormal anatomic variations in the abdomen and pelvis. Comparison with anatomic imaging studies (CT, MR imaging, or radiographs) of the abdomen and pelvis is useful in establishing gastrointestinal tract and vascular anatomy. Review of the dynamic images in cinematic display is essential to detect subtle gastrointestinal bleeding and avoid inaccurate localization of the bleeding site (*1*,*3*,*51*,*68*,*69*). Proper adjustment of gray-scale levels on the interpreting physician's computer display also facilitates the detection of subtle abnormalities.

^{99m}Tc-RBCs are rapidly distributed within the vascular space, including the heart, liver, spleen, and great vessels. Some excreted radioactivity may be seen in the urinary tract because of small amounts of free ^{99m}Tc-pertechnetate and other ^{99m}Tc moieties even when in vitro labeling is used (*70*). The initial angiographic-phase images rarely reveal the site of rapid gastrointestinal bleeding and may be confounded by the presence of vascular blush in neoplasms, arteriovenous malformations, or angiodysplasia (*51*,*71*,*72*).

The key diagnostic criteria for scintigraphic gastrointestinal bleeding are the appearance of activity outside the expected anatomic blood pool structures, a change in the intensity of activity on consecutive images, and movement of activity in a pattern consistent with bowel. All 3 of these criteria must be satisfied to diagnose a site of active gastrointestinal bleeding. Small bowel bleeding usually can be distinguished from large bowel bleeding by its rapid curvilinear movement and usual central location in the abdomen or pelvis. In comparison, large bowel bleeding has a more linear pattern and typically occurs in the periphery of the abdomen or pelvis. Large bowel bleeding can also be visualized as an S-shaped pattern in the central pelvis conforming to the distribution of the rectosigmoid colon. The origin of the site of gastrointestinal bleeding should be reported as the location of the initial site of detected activity rather than the most intense, largest, or most proximal site of activity. GIBS may be used to estimate the severity of the bleeding. Factors associated with a low bleeding rate include visualization of blood after 1 h, activity less intense than that in the liver, and shorter bleeding durations (*27*). Higher bleeding rates are associated with the early appearance of blood in the bowel, intense activity equal to or greater than that in the liver, and a longer duration of bleeding (*27*). As soon as bleeding site can be confirmed, notification of the referring clinician, interventional radiology, and/or gastrointestinal team may help expedite patient management.

F. Sources of Error

Delayed imaging after a period of non-imaging can be problematic because bowel activity seen immediately on the first frame of delayed images indicates merely that bleeding originating elsewhere in the gastrointestinal tract has occurred during the interim; the activity should not be misinterpreted as the bleeding site. Therefore, the location of bowel activity on delayed images should be reported as the bleeding site only when an actual episode of RBC extravasation on dynamic imaging is observed. Digital subtraction may be helpful for identification of the actual site of active bleeding when delayed images have been obtained (section D.2).

The benefits of delayed imaging, including its effect on patient management such as transfusion requirements, referrals to angiography or surgery, and clinical outcomes, are controversial (*73*,*74*). Many investigators have shown that delayed images are not as accurate as early images in localizing the site of gastrointestinal bleeding (*12*,*31*,*55*,*73*,*75*–*77*). Some authors advocate imaging patients for as long as possible during the initial phase rather than performing routine delayed imaging at arbitrary intervals after injection (*11*,*55*). Other investigators have demonstrated usefulness for delayed imaging in detecting a site of intermittent gastrointestinal bleeding not seen on the initial phase (*1*,*38*,*52*,*54*,*66*,*77*–*79*). Therefore, delayed imaging is considered optional.

There are some pitfalls to the interpretation of GIBS images.

1. Free ^{99m}Tc-Pertechnetate. Free ^{99m}Tc-pertechnetate can be visualized in the upper gastrointestinal tract secondary to swallowed salivary gland activity or excreted gastric mucosal activity. Since free ^{99m}Tc-pertechnetate can move from the stomach into the small bowel over time, it can be mistaken for upper gastrointestinal bleeding. Images of the neck to detect thyroid and salivary gland activity should be obtained to confirm the presence of free ^{99m}Tc-pertechnetate as a source of an artifact. Urinary tract activity due to free ^{99m}Tc-pertechnetate may be seen in the abdomen or pelvis.

2. Increased RBC Activity Due to Other Causes. In the reproductive system, penile blood pool can be mistaken for rectal bleeding (*80*). Obtaining lateral images or changing the position of the penis can distinguish penile activity from rectal bleeding (*32*). In addition, variable uterine activity during the ovulatory cycle causes fixed increased perfusion due to endometrial proliferation (*81*). Finally, a uterine leiomyoma may show transient, fixed activity due to hypervascularity (*82*,*83*).

Renal activity is usually fixed but can confuse interpretation when the activity arises from an unexpected location such as a pelvic or ectopic kidney (*84*,*85*), a horseshoe kidney (*86*), or a renal transplant. Movement or pooling of urine activity can mimic gastrointestinal bleeding located in the ureter, bladder, or bladder diverticulum (*4*) or can be caused by urinary diversion surgery.

Vascular causes of abnormal RBC distribution can include aneurysms of the abdominal aorta, gastroduodenal artery, iliac artery, and other arterial vessels. Vascular grafts can also alter the normal blood pool anatomy. There are several reports of arterial leaks mimicking gastrointestinal bleeding (*87–92*). In addition, the literature reports a number of case reports demonstrating aortoduodenal fistula rupture (*93*), hemangiomas in the liver or small bowel (*94*,*95*), and abdominal varices (*96*,*97*). Varices are most commonly seen as static blood pool structures, but they can also rupture and cause bleeding (*98–100*). The literature also contains a report of visualization of an abnormal ovarian vein (*101*).

Splenic variants and pathology can cause fixed activity in the form of accessory spleens and splenosis. They can mimic gastrointestinal bleeding if they rupture (*102–104*).

Activity may be seen in the gallbladder in patients with renal failure or prior transfusions from hepatobiliary excretion of radiolabeled heme. Less commonly, gallbladder activity can be seen with hemobilia (*105–110*). There are several other possible causes of increased RBC activity. Bleeding can occur from a pancreatic pseudocyst through the papilla of Vater and into the duodenum (*111*). A catheter site can cause static activity in the abdominal wall (*112*). A blush of activity in the bowel may occur because of hyperemia after surgical resection or in Crohn disease (*88*). Nonenteric bleeding activity can move and accumulate and confuse interpretation, including intraperitoneal hemorrhage (*113*,*114*), mesenteric bleeding (*115*), and soft-tissue hematoma/hemorrhage (*116–121*). Both benign and malignant neoplasms and metastatic disease can cause hyperemia and bleeding when ulcerated or necrotic (*122–131*). Retroperitoneal bleeding can show focal uptake that grows in intensity but is not expected to move in a luminal pattern (*132*).

G. Issues Requiring Further Clarification

1. SPECT. Using planar technique, GIBS may only be able to approximate the site of bleeding. The inherent 3-dimensional nature of SPECT with multiplane reconstruction may yield more accurate localization of a gastrointestinal bleeding site. Comparison of SPECT results to anatomic cross-sectional imaging such as CT and MR imaging can also help to identify the source of bleeding.

2. SPECT/CT. Software-fused SPECT and CT images acquired as separate studies can be beneficial but are limited by the potential interval change in bowel location between the 2 modalities (*133*). The use of dedicated SPECT/CT hybrid cameras can help overcome these shortcomings. Several early studies have suggested that SPECT/CT scanning is able to better pinpoint the site of bleeding that is not well localized or is equivocal on planar images or to differentiate physiologic uptake from pathologic activity (*57–59*,*134*). In one study in which abnormal activity on standard planar scans was evaluated by SPECT/CT, SPECT/CT was required in 37% of the patients either to precisely localize the site of gastrointestinal bleeding or to exclude gastrointestinal bleeding (*58*). Although the authors used a 30-min acquisition for the SPECT images, a shorter acquisition (approximately 15 min) may be adequate.

Similarly, a different group of authors demonstrated that SPECT/CT correctly localized the source of bleeding in 44% patients who had incorrect localization on planar images (*59*). Other studies showed that SPECT/CT had a higher accuracy in determining the bleeding site (92.3-93%) compared to planar scans (73.8-83%) (*59*,*60*). When SPECT/CT was used in conjunction with planar scans, the combination had the highest ability to correctly localize the GI bleeding site compared to planar only and combination of planar and SPECT only techniques (*61*).

SPECT/CT can be particularly helpful in the case of slow gastrointestinal bleeding, for which one may have to wait a long time to see the bowel activity conform into a more specific pattern (*56*). SPECT/CT can also estimate the length of the gastrointestinal tract leading to the bleeding site and therefore help decide which endoscopic approach to use for further evaluation (*55*). Furthermore, SPECT/CT helps clarify and avoid the pitfalls that can mimic gastrointestinal bleeding (*32*,*62*). In patients with prior bowel surgery and altered anatomy, SPECT/CT can be especially useful in identifying the bleeding site in relation to the location of previous surgery (*62*). In addition, SPECT/CT can also reveal unsuspected bleeding outside of the GI tract (*62*). More studies are needed to validate these results. No data exist on the use of SPECT/CT when planar GIBS shows no evidence of gastrointestinal bleeding. There has been no direct comparison of SPECT/CT to Computed Tomography Angiography (CTA) for detecting gastrointestinal bleeding.

No data exists for the use of oral/IV contrast for the acquisition of the low dose CT component of the SPECT/CT scan.

VII. DOCUMENTATION/REPORTING

A. Goals of the Report

Refer to the SNMMI Procedure Standard for General Imaging.

B. Direct Communication

Refer to the SNMMI Procedure Standard for General Imaging.

C. Written Communication

Refer to the SNMMI Procedure Standard for General Imaging.

D. Contents of the Report

The first part of the report should identify the study; provide patient demographics, clinical information (indication for the study), and comparison/correlative imaging data; describe the procedure (radiopharmaceutical, administered activity, route of administration, radiolabeling method for RBCs [in vitro, in vivo, or modified in vivo], duration of the acquisition, frame rate, projections acquired, and whether delayed or special images were obtained); and mention the quality and any limitations of the study.

Next, the report should describe the findings.

1. Presence of any baseline vascular, gastrointestinal tract, or solid-organ variants.
2. Characteristics of any abnormal activity (time of onset in relation to injection, shape, intensity in relationship to background liver activity, extent, subjective volume [small, medium, or large], focal or diffuse, stationary activity or movement of activity in gastrointestinal tract [and, if the latter, whether it is curvilinear (small bowel) or linear (large bowel), rapid or slow, and antegrade or retrograde]).
3. Location of any abnormal activity (quadrant of abdomen and pelvis, gastric, small bowel [duodenum, jejunum, or ileum], or large bowel [cecum, ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, sigmoid colon, or rectum]).

If the bleeding site cannot be definitively localized, then giving an approximate site based on the imaging characteristics is appropriate. If SPECT/CT is used to further localize small bowel activity, an attempt should be made to approximate the distance from the ampulla of Vater to the bleeding site to help determine which endoscopic technique can be used should gastroenterology be consulted. The ampulla of Vater is located in the medial aspect of the second (descending) portion of the duodenum at the confluence of the common bile duct and pancreatic duct. Any significant CT findings on the low dose CT should be reported. For instance, GI hemorrhage can occasionally be seen as increased attenuation within bowel on the low dose CT. Refer to the SNMMI SPECT/CT Guidelines for further information.

Finally, the report should give the impression (whether the study was positive or negative for active gastrointestinal bleeding and, for a positive scan, the originating site of gastrointestinal bleeding, if known).

VIII. EQUIPMENT SPECIFICATION

A large field-of-view gamma camera equipped with a low-energy high-resolution collimator is preferred, although a low-energy general-purpose collimator may also be used. When the study must be performed at the bedside, a diverging collimator (if available) is useful to visualize the maximum abdominal and pelvic areas, particularly in large patients. A SPECT or SPECT/CT camera can be used to assist further localization of the gastrointestinal bleeding site.

Refer also to the SNMMI Procedure Standard for SPECT/CT Imaging.

IX. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION CONCERNS

Refer to the SNMMI Procedure Standard for General Imaging.

X. RADIATION SAFETY IN IMAGING

Refer also to the SNMMI Procedure Standard for General Imaging. Radiation dosimetry in adults, a 5 y-old child, and the fetus are presented in Tables 2–4.

Administration of radiopharmaceuticals to pregnant, potentially pregnant, or lactating patients is addressed in the SNMMI Procedure Standard for General Imaging. International Commission on Radiological Protection publication 106, appendix D, suggests that lactating patients who receive in vivo ^{99m}Tc-RBCs require a 12-h interruption of breast feeding. No cessation of breast feeding is required for patients receiving in vitro ^{99m}Tc-RBCs. The physician must consider the indication for the test, the potential benefit the information may provide, and the potential radiation risk to the mother and fetus.

TABLE 2
Radiation Dosimetry in Adults for ^{99m}Tc-RBCs (*135*)

Administered activity (intravenous)		Organ receiving largest radiation dose (urinary bladder)		Effective dose	
MBq	mCi	mGy/MBq	rad/mCi	mSv/MBq	rem/mCi
555–1,100	15–30	0.012	0.044	0.0047	0.017

TABLE 3
Radiation Dosimetry in Children (5 Years Old) for ^{99m}Tc-RBCs (*135*)

Administered activity (intravenous)		Organ receiving largest radiation dose (urinary bladder)		Effective dose	
MBq/kg	mCi/kg	mGy/MBq	rad/mCi	mSv/MBq	rem/mCi
11.39–26.67	0.31–0.72	0.027	0.099	0.01121	0.042

TABLE 4
Dose Estimates to Fetus for ^{99m}Tc-RBCs (*136*)

Stage of gestation	Fetal dose	
	mGy/MBq	rad/mCi
Early	0.0070	0.030
3 mo	0.0055	0.020
6 mo	0.0040	0.015
9 mo	0.0033	0.012

Dose estimates for in vivo or in vitro labeling are only slightly different. The slightly higher values for in vitro labeling are presented here.

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