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The SNMMI and EANM will periodically define new guidelines for nuclear medicine practice to help advance the science of nuclear medicine and to improve the quality of service to patients throughout the world. Existing practice guidelines will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice guideline, representing a policy statement by the SNMMI/EANM, has undergone a thorough consensus process in which it has been subjected to extensive review. The SNMMI and EANM recognize that the safe and effective use of diagnostic nuclear medicine imaging requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice guideline by those entities not providing these services is not authorized.

Revised 2013

SNMMI and EANM Practice Guideline for Meckel’s Diverticulum Scintigraphy V2.0

Authors

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate 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, both the SNMMI and the EANM caution against the use of these guidelines in litigation in which the clinical decisions of a practitioner are called into question.

The physician or medical physicist in light of all the circumstances presented must make the ultimate judgment regarding the propriety of any specific procedure or course of action. Thus, there is no implication that an approach differing from the 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 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 guidelines.

The practice of medicine includes both the art and the science of 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 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 guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

Gastrointestinal bleeding (GI) is common in children, and is often self-limited and benign; however, bleeding may have severe consequences if left untreated, and should therefore be investigated [1]. A complete history and physical examination can usually identify a presumptive bleeding source in children and facilitate the diagnosis and treatment [1]. A guaiac test should be performed for stool content, which may become black-colored after ingestion of iron, grape juice, spinach, and blueberry. It should be noted that a positive test result does not always indicate the presence of human blood because many foods, such as undercooked meat, raw fruits, and vegetables, can cause occult blood testing to be false-positive, especially in stool [1].

The clinical presentation in children with GI bleeding ranges from asymptomatic microcytic anemia to hypovolemic shock, depending on the rate and extent of bleeding, but very often clinical findings for gastrointestinal bleeding are unreliable and obscure [1]. Acute upper GI bleeding usually presents with hematemesis (vomiting of gross blood or coffee ground material) or melena, which can be dark maroon in color, or production of tarry stools that contain digested blood. Occasionally, hematochezia can occur even if the source of bleeding is proximal to the ligament of Treitz -- in the case of rapid transit of blood through the digestive tract. Bright red blood per rectum more commonly signifies bleeding distal to the ligament of Treitz [1].

Once the signs or symptoms of GI bleeding in children are recognized or suspected, careful evaluation of each child is imperative. This must also include assessment of the cardiorespiratory system, along with other diagnostic studies that could be useful for determining the cause of bleeding. The primary cause of GI bleeding varies with age, while the rate and extent of bleeding vary with cause. [2].

Meckel’s diverticulum is the most common cause of lower gastrointestinal hemorrhage in previously healthy infants. More than 50% of these patients present with bleeding by the age of two years [3].

Meckel’s diverticulum is the vestigial remnant of the omphalomesenteric duct and represents the most common congenital anomaly of the gastrointestinal tract with an incidence of 1-3% in the general population [3]. It is normally located on the antimesenteric border of the terminal ileum within 80-100 cm of the ileocecal valve and is on average 2 cm in length.

Approximately 57% of Meckel’s diverticula contain ectopic gastric mucosa [4], which actively secretes the hydrochloric acid responsible for mucosal ulcerations within the diverticulum and unprotected wall of the adjacent ileum [4-7]. The most common sign of Meckel’s diverticulum is gross rectal bleeding, which may or may not be associated with abdominal symptoms. Almost all diverticula of children with symptoms of lower gastrointestinal bleeding contain ectopic gastric mucosa. [8]
$^{99m}$Tc-pertechnetate is taken up by the mucin-producing cells of gastric mucosa and is then secreted into the gut lumen. The excretion of $^{99m}$Tc-pertechnetate is not dependent on the presence of parietal (acid producing) cells [9,10, 11]. Avid accumulation of $^{99m}$Tc-pertechnetate in gastric mucosa makes scintigraphy with $^{99m}$Tc-pertechnetate the study of choice for identifying ectopic gastric mucosa in a Meckel's diverticulum. Properly performed pertechnetate scintigraphy in the appropriate clinical setting is an effective method for the detection of Meckel's diverticulum containing functioning gastric mucosa, with overall sensitivity of 85%, specificity of 95%, and accuracy of 90% [6].

II. GOALS

The purpose of this guideline is to provide basic information to assist the nuclear medicine technologist and physician in understanding, recommending, performing, interpreting, and reporting the results of Meckel’s diverticulum (ectopic gastric mucosa) scintigraphy, which could identify the site and etiology of gastrointestinal bleeding.

III. DEFINITIONS

See the SNMMI Guideline for General Imaging

IV. EXAMPLES OF COMMON CLINICAL INDICATIONS

The indication for Meckel’s scintigraphy 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.

Meckel’s scintigraphy should be used when the patient is not actively bleeding. Even in young children, active bleeding is best studied by radiolabeled RBC scintigraphy [2].

V. QUALIFICATIONS AND RESPONSIBILITES OF PERSONNEL (in the United States)

See the SNMMI Guideline for General Imaging

VI. PROCEDURE/SPECIFICATIONS OF THE EXAMINATION

See also the SNM Guideline for General Imaging

A. Patient Preparation

Pre-exam fasting of 3-4 hours may reduce the size of the gastric silhouette and improve sensitivity for the detection of ectopic gastric mucosa [1]. However, fasting is
not required for the examination, and may not always be possible. If possible, the use of all drugs or procedures that may irritate the GI tract should be stopped for 2-3 days prior to the study.

It is important to determine whether the patient has undergone recent in-vivo RBC labeling where all circulating RBC’s were treated with stannous ion via intravenous administration of a “cold” pyrophosphate kit. If so, the Meckel’s scan may be compromised, since intravenous $^{99m}$Tc-pertechnetate will label RBC’s rather than concentrates in ectopic gastric mucosa. This may occur for days after the administration of stannous pyrophosphate. This is not a problem with in-vitro labeling. Recent administration of perchlorate may reduce the sensitivity of the test by decreasing uptake of pertechnetate in normal and ectopic gastric mucosa.

Pretreatment options:

1. **Histamine H2 blockers** (cimetidine, ranitidine, famotidine) inhibit acid secretion by the parietal cells. This limits release of pertechnetate by the mucosal cells [12, 13, 14]] and thus improves the sensitivity of the Meckel’s scan [3, 4, 5]. (See Appendix 1 for dose recommendations.)

2. **Glucagon** relaxes the smooth muscles of the gastrointestinal tract, slightly suppressing peristalsis and transit of any secreted pertechnetate through the small bowel. This movement of tracer may decrease the sensitivity of the study and the localization of ectopic gastric mucosa [6,7,8,10, 15]

3. Glucagon should not be administered to diabetic patients. (See Appendix 1 for dose recommendations.)

4. **Pentagastrin** has been previously recommended to augment visualization of the ectopic gastric mucosa in Meckel’s diverticula [15, 16]. It 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 local collection of tracer activity. Pentagastrin is not currently available in the U.S. for clinical use.

Pharmacologic pre-treatment is not considered necessary for performing a high-quality Meckel’s scan. Any medication administered to children should be scaled according to weight and route of administration (see Appendix 1)

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B. Information Pertinent to Performing the Procedure

1. Are there signs of active bleeding?
   (If so, a GI bleeding scan may be more helpful.)
2. Is there history of past bleeding episodes?
3. What are the results of prior studies to localize the bleeding site?
4. Has in-vivo RBC labeling been recently done? Previous in-vivo labeled RBC scintigraphy with $^{99m}$Tc-pertechnetate and stannous pyrophosphate could give an indeterminate result.

C. Precautions

The vital signs of children suspected of acute GI bleeding should be constantly monitored upon their arrival at the nuclear medicine clinic. The patient should have a large bore IV catheter in place (if necessary), so that hypotension can be rapidly treated.

D. Radiopharmaceuticals

*See the SNMMI Guideline for the Use of Radiopharmaceuticals*

$^{99m}$Tc pertechnetate is eluted from a molybdenum-technetium parent-daughter generator with physiologic saline, and injected intravenously. Administered activity should be calculated according to the recommendation of the 2012 North American Consensus Guidelines for Pediatric Radiopharmaceutical Administered Doses [17], The New EANM Paediatric Dosage Card [18], and the EU directive 97/43 (1997): The European Directive on Health Protection of Individuals against the Dangers of Ionising Radiation in relation to Medical Exposures (97/43/EURATOM) [19].

Administered doses should be in the context of “good practice” of nuclear medicine and local regulations.

The recommended administered activity for children from the 2010 North American consensus guidelines [17] is 1.85 MBq/kg (0.05 mCi/kg) with a minimum of 9.25 MBq (0.25 mCi). The EANM Paediatric Dose Card (2007 Version) [18] may also be used. Please refer to the *Harmonization of the 2007 EANM Paediatric Dosage Card (Version 1.5.2008) and the 2010 North America Consensus Guideline*.

The usual administered activity for adults in the U.S. is 296-444 MBq (8 to 12 mCi) intravenously.

E. Image Acquisition

1. Equipment

Camera: Large field-of-view

Collimator: Low energy, high resolution parallel collimator

Photopeak: 20% window, centered on 140 keV
232 Computer: Planar: 128 x 128 matrix, single or 2-byte mode; zoom appropriate for patient size
233
234 SPECT: 3 degrees per step, 30 seconds per frame, 360 degree rotation, 64 x 64 or 128 x 128 matrix, zoom appropriate for patient size
235
236 2. Patient position: Supine
237 3. Imaging field: Abdomen and pelvis (to include stomach and bladder)
238
239 4. Acquisition Protocol
240
241 a. Anterior abdominal dynamic flow images (1–5 seconds/frame for up to 1 minute) to identify any focus of vascular blood pool that may be confused with ectopic gastric mucosa.
242
243 b. Anterior abdominal dynamic images at a frame rate of one image every 30–60 seconds for at least 30 minutes. Imaging up to 60 minutes may be performed.
244
245 c. Additional static images, anterior oblique projections, lateral and posterior projection views are recommended at the end of the dynamic acquisition. Lateral views may be useful to localize renal pelvic activity. Post-void images may be helpful to detect activity in a Meckel’s diverticulum obscured by the urinary bladder.
246
247 d. When the study appears normal in children highly suspected of having a bleeding Meckel’s diverticulum, several delayed 5 minute static images may be performed up to 2 hours post-injection.
248
249 e. Single photon emission computed tomography (SPECT) imaging may improve the detection of a small diverticulum, or a diverticulum obscured by the urinary bladder, when the clinical suspicion for a Meckel’s diverticulum is high and the planar images are negative or equivocal.
250
251 f. SPECT imaging co-registered with a simultaneously acquired low dose CT scan on a hybrid system may be helpful for localization of a Meckel’s diverticulum [20, 21, 22].
252
253 g. SPECT/CT fusion adds a small amount of additional radiation exposure. The CT dose should be tailored for patient size and age. [23].
254
255 See SNM Procedure Guideline for General Imaging for SPECT
256
257
F. Interventions

A urinary catheter to drain the bladder of activity can be helpful if the Meckel’s diverticulum is adjacent to the bladder and if the patient is unable to voluntarily void. Alternatively, decubitus or upright views may be helpful to cause the Meckel’s diverticulum to fall away from the bladder.

G. Processing

SPECT:

See SNM Procedure Guideline for General Imaging

The FOV should be maximized for the patient’s size.

H. Interpretation Criteria

Normal structures seen on the flow phase following injection of 99mTc pertechnetate include the heart, lungs, major arteries and veins, as well as vascular organs such as the spleen, liver and kidneys. Stomach activity appears early on dynamic scintigraphy, and is the most prominent after 10-15 min. Radiopharmaceutical activity is often present in the kidneys, ureters and bladder.

Ectopic gastric mucosa is visible as a focal, localized area of uptake that appears at the same time as the activity in the normal gastric mucosa. As the stomach activity accumulates, so does that of the diverticulum. The intensity of the tracer accumulation may be less than that within the stomach, depending on the amount of mucosa present within the diverticulum and its secretory activity. Meckel’s diverticula are typically located in the right lower quadrant but may also be found elsewhere in the abdomen. It may change position during the study, especially after changing the body position. False positive studies can occur by mistaking excreted tracer activity in the proximal small bowel, the kidneys, ureter or bladder for ectopic gastric mucosa. Activity in the urinary tract usually appears after activity is seen in the normal gastric mucosa. A small Meckel’s diverticulum may appear slightly later than the stomach.

A lateral view at the end of the study usually allows activity in the kidney and ureters, which is in the posterior part of the abdomen, to be differentiated from the diverticulum, which is usually anterior [24].
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 loop on a computer display that also permits adjustment of image contrast is recommended to help distinguish small bowel or urinary tract activity from ectopic gastric mucosa.

I. Pitfalls

*False positive* radiopharmaceutical activity suggestive of Meckel’s diverticula can result from the following conditions:

- Duplication cyst with ectopic gastric mucosa
- Bowel inflammation [25]
- Intussusception, small bowel obstruction [26]
- Peptic ulcer [27]
- Vascular lesions with increased blood pool (e.g., hemangioma, AVM) [27]

*False negative* scans usually result from anatomic or physiologic causes (See: K. Sources of Errors). Other pathologic conditions which may result in a false negative scan include:

- GI bleeding unrelated to ectopic gastric mucosa (e.g., pancreatic mucosa) [28]

J. Reporting

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

1. Indication for the study
2. Procedure
   a. Radiopharmaceutical
      i. Dose
      ii. Route of administration (I.V.)
   b. Acquisition
      i. Duration of acquisition (e.g. 30 minutes vs 1 hour)
      ii. Frame rate (e.g. 60 seconds/frame)
      iii. Projections acquired (e.g. anterior, laterals)
      iv. Field of view (e.g. stomach to the bladder)
c. Display (e.g. static vs. cine)

d. Findings
  i. Time of appearance of gastric mucosa
  ii. Time of appearance of ectopic activity (e.g. early vs. late, correspondence with gastric activity)
  iii. Location of ectopic activity
  iv. Characteristics of ectopic activity
     a) Size and shape (e.g. focal, round, oblong, 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
      • Prior barium fluoroscopy exam [25]
      • Prior administration of perchlorate [29]

   b. False-Positive Result
      • Prior cleansing enema or laxatives causing bowel irritation [30]

2. Anatomic or physiologic causes of errors

   a. False-Positive Result
      • Focal pooling of tracer in the urinary tract
         ○ (hydronephrosis, extra-renal pelvis, ectopic kidney, hydroureter, VU reflux, bladder diverticulum)
      • Uterine blush [30]

   b. False-Negative Result
      • Obscuration by brisk GI bleeding during circulation of the tracer
      • Obscuration by urinary bladder or dilated ureter [25]
      • Small size of focus of ectopic mucosa (< 1.8 cm²) [31]
      • Movement of the diverticulum [25]
L. Issues Requiring Further Clarification

Role of pharmacologic interventions: Studies to determine if any of the specific H2 blockers, proton pump inhibitors, or any dose alterations of these agents have advantage over the others for pharmacologic augmentation

Role of SPECT and SPECT/CT to improve the accuracy of Meckel’s diverticulum scintigraphy

VII. DOCUMENTATION/REPORTING

See the SNM Guideline for General Imaging

VIII. EQUIPMENT SPECIFICATION

A large field-of-view gamma camera is recommended. A high resolution collimator is preferred. The photopeak is typically a 20% window, centered at 140 keV.

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

See the SNM Guideline for General Imaging

X. RADIATION DOSIMETRY

See also the SNM Guideline for General Imaging

It is the position of SNM that exposure to ionizing radiation should be at the minimum level consistent with obtaining a diagnostic examination. Radiation exposure reduction may be achieved by administering less radiopharmaceutical when the technique or equipment used for imaging can support such an action. Each procedure is unique and the methodology to achieve minimum exposure while maintaining diagnostic accuracy needs to be viewed in this light. Radiopharmaceutical dose ranges outlined in this document should be considered as a guide. Dose reduction techniques should be utilized when appropriate. The same principles should be applied when CT is used in a hybrid imaging procedure. CT acquisition protocols should be optimized to provide the information needed while minimizing radiation exposure. Minimizing radiation dose is especially important in children.
### Radiation Dosimetry: Adults

<table>
<thead>
<tr>
<th>Radiopharmaceutical</th>
<th>Administered activity MBq (mCi)</th>
<th>Organ receiving the largest radiation dose mGy/MBq (rad/mCi)</th>
<th>Effective dose mSv/MBq (rem/mCi)</th>
<th>Organ receiving the largest radiation dose mGy (rad)</th>
<th>Effective dose mSv (rem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{99m})Tc-pertechnetate</td>
<td>296-444 iv (8–12)</td>
<td>0.057 Upper large intestine (0.21)</td>
<td>0.013 (0.048)</td>
<td>17-25 Upper large intestine (1.7-2.5)</td>
<td>3.8-5.7 (0.38-0.57)</td>
</tr>
</tbody>
</table>

*per MBq (mCi) (ICRP 53 page 199, no blocking agent) [32]

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### Radiation Dosimetry: Children (5 Year Old)

<table>
<thead>
<tr>
<th>Radiopharmaceutical</th>
<th>Administered Activity* MBq (mCi)</th>
<th>Organ Receiving the Largest Radiation Dose mGy/MBq (rad/mCi)</th>
<th>Effective Dose mSv/MBq (rem/mCi)</th>
<th>Organ receiving the largest radiation dose mGy (rad)</th>
<th>Effective dose mSv (rem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(^{99m})Tc-pertechnetate</td>
<td>1.85 MBq/kg iv (0.05 mCi/kg) 37 MBq (1 mCi)</td>
<td>0.20 Upper large intestine (0.74)</td>
<td>0.040 (0.16)</td>
<td>7.4 Upper large intestine (0.74)</td>
<td>1.6 (0.16)</td>
</tr>
</tbody>
</table>

*20 kg body mass assumed (ICRP 80 page 73, no blocking agent) [33]

---


The EANM Paediatric Dose Card (2007 Version) may also be used [18]
Radiation Dosimetry in Fetus/Embryo: $^{99m}$Tc-pertechnetate

Dose estimates to the fetus are provided by Russell et al. [34]. Information about possible placental crossover of this compound was available and was used in estimating fetal doses.

<table>
<thead>
<tr>
<th>Stage of Gestation</th>
<th>Fetal Dose mGy/MBq (rad/mCi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early</td>
<td>0.011 (0.041)</td>
</tr>
<tr>
<td>3 months</td>
<td>0.022 (0.081)</td>
</tr>
<tr>
<td>6 months</td>
<td>0.014 (0.052)</td>
</tr>
<tr>
<td>9 months</td>
<td>0.0093 (0.034)</td>
</tr>
</tbody>
</table>

The Breastfeeding Patient


XI. ACKNOWLEDGEMENTS

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XIII. BOARD OF DIRECTORS APPROVAL DATES

Version 1.0 February 7, 1999
Version 2.0

Appendix 1

Pharmacological pretreatment in children referred for Meckel’s scan.

1. Cimetidine
   Oral administration:
   • neonates: 10-20 mg/kg/day p.o.
   • infants and older children: 20mg/kg/day x 2 days p.o.
   • adults: 300 mg QID x 2 days p.o.
   Intravenous administration
   • 300mg in 100 ml Dextrose 5% i.v. over 20 min, with imaging starting 1 hour later

2. Ranitidine
   Oral administration:
   • children: 2mg/kg p.o.
• adults: 150 mg/kg p.o.

Intravenous administration
• infants, children, adults: 1 mg/kg i.v. (maximum 50 mg) over 20 min with imaging starting one hour later

3. Famotidine

Oral administration:
• children: 0.5 mg/kg/day p.o.
• adults: 20 mg p.o.

Intravenous administration:
• children: 0.5 mg/kg/day i.v.
• adults: 20 mg i.v.
or -
  • 0.25 mg/kg i.v. one hour before the scanning procedure.

4. Pentagastrin

Subcutaneous administration
• 6 µg/kg s.c. 20-30 min before the administration of pertechnetate

5. Glucagon

Intravenous administration
• 50 µg/kg i.v., to a maximum of 1 mg, diluted to a volume of 10 ml with sterile water, infused slowly over two minutes immediately prior to injection of the pertechnetate. Flush intravenously with sterile water immediately before and after the infusion of Glucagon.

*DO NOT give Glucagon to a diabetic patient.*

It is important to reconstitute the Glucagon with sterile water, not normal saline. The patient should be observed carefully for signs of nausea or vomiting. (This is the primary reason to administer the Glucagon prior to administration of the radiotracer: to reduce the likelihood of vomiting and possible aspiration during the study.)