

Small-Bowel and Colon Transit

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RATIONALE

Intestinal chyme and indigestible solids move through the small and large bowels via complex gastrointestinal contractions. Identifying the location of a motility disorder causing gastrointestinal symptoms can be difficult because the symptoms may be due to upper or lower gastrointestinal tract dysfunction. Thus, it is often helpful to evaluate motility throughout the entire gastrointestinal tract to aid in selection of the appropriate treatment.

Whole-gut transit scintigraphy refers to a combined gastric emptying, small-bowel transit, and colon transit study. This practical protocol tip focuses on small-bowel and colon transit using single-isotope liquid gastric emptying with small-bowel and colon follow-through. An unlabeled standardized meal is an important component of the protocol, affecting the validity of the reference values given. As described in a procedure guideline by the Society of Nuclear Medicine and Molecular Imaging and the European Association of Nuclear Medicine, a dual-isotope study combining a solid meal (^{99m}Tc-labeled egg) and a liquid (¹¹¹In-diethylenetriaminepentaacetic acid [DTPA] water) may be performed.

CLINICAL INDICATIONS

The study is performed to evaluate gastrointestinal transit abnormalities in symptomatic patients with known or suspected gastroparesis, dyspepsia, irritable bowel syndrome, chronic constipation, chronic diarrhea, chronic idiopathic intestinal pseudoobstruction, scleroderma, celiac disease, or malabsorption syndrome. It may also be performed to demonstrate a motility disorder or slow colon transit or to provide evidence of a defecation disorder or functional rectosigmoid obstruction in patients with constipation.

CONTRAINDICATIONS

- Pregnancy or breastfeeding: pregnancy must be excluded in accordance with local institutional policy. If the patient is breastfeeding, appropriate radiation safety instructions should be provided.
- Allergy to eggs or any component of the meal.
- Hypoglycemia with a blood glucose level of less than 40 mg/dL.
- Hyperglycemia with a blood glucose level of more than 200–250 mg/dL.

- A recent nuclear medicine study (radiopharmaceutical-dependent).

PATIENT PREPARATION/EDUCATION

- The patient preparation mirrors the standard gastric-emptying study (5). Patients should ...
 - Fast overnight or for a minimum of 8 h before the scan.
 - For 48–72 h before the test and on the 4 d of testing, discontinue medications that may affect gastrointestinal motility unless the test is being performed to assess motility while on these medications, which include opiate analgesics, anticholinergic medications, and prokinetic agents (metoclopramide, domperidone, erythromycin).
 - Withhold laxatives.
 - Eat a normal diet for 2 d before the exam and for the 4 d of imaging.
 - Avoid diagnostic studies that require altered eating patterns or ingestion of contrast agents (e.g., bowel contrast) during the 4 d of testing.
- Diabetic patients should ...
 - Bring insulin and a glucometer on the day of the procedure.
 - Measure their blood glucose before the exam (if >250 mg/dL, the bowel motility study should be rescheduled because hyperglycemia may delay gastric emptying and impact small-bowel transit accuracy).
 - Administer a scheduled insulin dose just before ingesting the test meal (consult the supervising physician to determine whether the insulin dose should be modified).
- A focused history should be obtained, including ...
 - Detailed gastrointestinal symptoms, such as frequency of bowel movements and routine use of laxatives.

TABLE 1

Radiopharmaceutical Identity, Dose, and Route of Administration

Identity	Dose	Route of administration
¹¹¹ In-DTPA	3.7–37 MBq (0.1–1 mCi)	Oral

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TABLE 2
Acquisition Parameters

Parameter	Characteristics	Standard/preferred/optional
Camera type	Large field of view, dual head	Preferred
	Large field of view, single head	Standard
Energy peak	172 and 247 keV	Standard
Energy window	20%	Standard
Collimator	Medium energy	Standard
Patient position	Standing or supine	Standard
Camera position	Total abdomen from gastric fundus to pelvis	Standard
Injection-to-imaging time	Immediately on meal completion	Standard
Acquisition type	Planar	Standard
Views	Anterior and posterior	Standard
	Initial (0 h) and 1, 2, 3, 4, 5, and 6 h	
Additional views	Anterior and posterior	Not applicable
	24, 48, and 72 h	
Matrix	128 × 128	Standard
Number of views	2 views at each time point	Standard
Time per view	60 s	Standard
Additional images: time per view	4 min	Standard

- Presence of other systemic illnesses, such as diabetes, celiac sprue, and scleroderma.
- Pertinent test results, such as other radiographic studies and endoscopy.
- Prior surgical procedures.
- Current medications.

RADIOPHARMACEUTICAL IDENTITY, DOSE, AND ROUTE OF ADMINISTRATION

Table 1 presents the radiopharmaceutical identity, dose, and route of administration. ^{99m}Tc-sulfur colloid is the only radiopharmaceutical that has received Food and Drug Administration approval for oral administration. ¹¹¹In-DTPA is not approved for oral administration. Its use, however, for a study such as this one is typically permitted at sites with a broad license with local approval.

ACQUISITION PARAMETERS

Table 2 presents the acquisition parameters.

ACQUISITION INSTRUCTIONS

- Prepare an unlabeled solid meal using standardized meal ingredients: 4 oz (118 mL) of liquid egg white (e.g., Eggbeaters; Bob Evans Farms, LLC), 2 slices of toasted white bread, 30 g of jam or jelly, and 300 mL of water.
- Prepare the unlabeled meal: cook the egg white in a microwave oven or on a stove, stirring once or twice, until it

has the consistency of an omelet. Toast the bread and spread the jelly on it. The egg and toast may be eaten separately or, to decrease the time required for ingestion, as a sandwich.

- Prepare the labeled water: mix the ¹¹¹In-DTPA in the water. For whole-gut transit, 300 mL of water are used; for a gastric-emptying study, 120 mL are used.
- Instruct the patient to ingest the meal and the liquid within 10 min.
- Acquire the images with the patient either standing or supine.
- Place a ⁵⁷Co position marker on the iliac crest for every image over the 4-d exam.

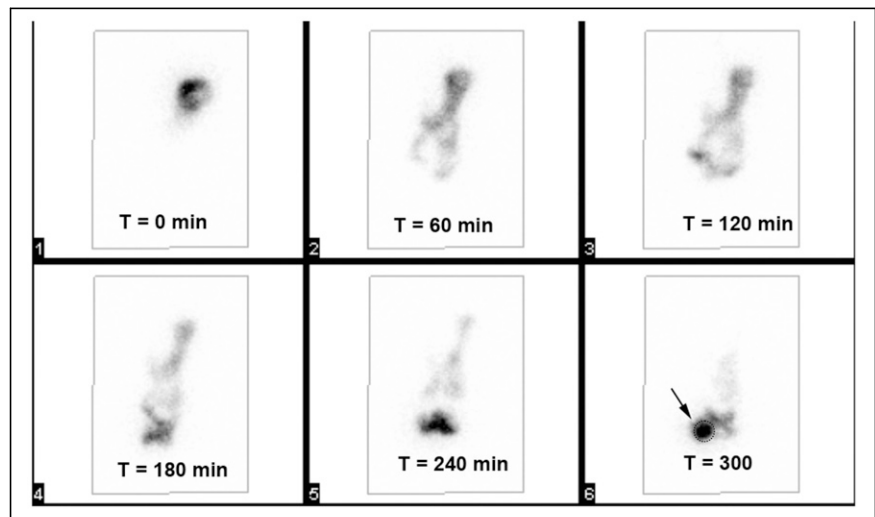


FIGURE 1. Total abdominal and terminal ileum (arrow and circle) regions of interest. (Reprinted from (4).)

- Obtain 60-s anterior and posterior images from the gastric fundus to the pelvis immediately after ingestion of the meal.
- Obtain repeat images (same position and views) hourly for 6 h on the same camera.
- Instruct the patient to resume a normal diet and activity.
- Obtain repeat images at 24, 48, and 72 h.
- Correct all images for radioisotope decay and time per image. Thus, the 24-, 48-, and 72-h colon images must be divided by 4 for comparison to the 1-min images on the first day.

COMMON OPTIONS

For certain patients who will not or cannot ingest the standard egg meal, facilities may need to establish an alternative meal. This will need to have similar nutritional content but without eggs or gluten for patients with allergies or intolerance to the standard meal.

PROCESSING INSTRUCTIONS

Small-Bowel Transit (Terminal Ileum Filling Method)

- Draw a large region of interest on the anterior and posterior images to include the entire abdomen for the 2-, 3-, 4-, and 5-h images (Fig. 1).
- Calculate the geometric mean ($\sqrt{[\text{anterior counts} \times \text{posterior counts}]}$).
- Decay-correct each view.
- Calculate the average total abdominal counts using the 2-, 3-, 4-, and 5-h views. The mean total abdominal counts are used to determine the counts available to fill the terminal ileum at 6 h (small-bowel transit) and to enter the colon (geometric center analysis).
- Draw a region of interest around the terminal ileum at 6 h. Include any activity in the region of interest that has passed through the terminal ileum and into the cecum or colon at 6 h, as this activity has passed through the small bowel.
- Calculate the percentage of activity transited through the small bowel as in the following equation, where counts are the geometric mean and decay-corrected counts for 1 min:

$$\% \text{ activity transited through the small bowel} = \frac{\text{total counts in the terminal ileum} + \text{colon at 6 h}}{\text{mean total abdominal counts (2 to 5 h after meal)}}$$

- Be aware that normal small-bowel transit is greater than 40% of the total abdominal ^{111}In counts in the terminal ileum or any counts that have passed from the terminal ileum into the colon.

Colon Transit (Geometric Center Method)

Colon transit is determined by calculating the geometric center of the ^{111}In as it moves through the colon. Colon

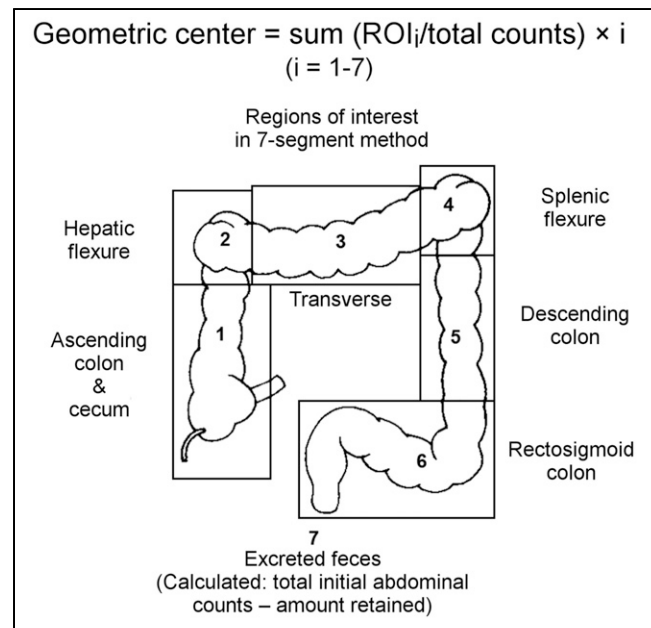


FIGURE 2. Six regions of interest and calculated counts in excreted feces used to calculate geometric center. (Reprinted from (3).)

transit is a measure of the progression of radiotracer through the colon. The geometric center is determined from average weighted counts in specific segments of the colon. The 24-, 48-, and 72-h images are used.

- Calculate the geometric center by dividing the colon into 7 anatomic regions. Each region has a numeric value: 1, cecum–ascending colon; 2, hepatic flexure; 3, transverse colon; 4, splenic flexure; 5, descending colon; 6, rectosigmoid colon; and 7, excreted stool (Fig. 2).
- Draw the 6 regions of interest as shown in Figure 2. To calculate the amount of activity that has been defecated and left the body (region 7), subtract the amount retained from the total available counts on day 1, obtained from the average of total abdominal counts between 2 and 5 h (as described for the terminal ileum filling method).

TABLE 3
Normal Mean Values for Geometric Center

Imaging time from meal ingestion (h)	Mean \pm SD
24	4.6 \pm 1.5
48	6.1 \pm 1.0
72	6.6 \pm 0.19

- Calculate the geometric center (the sum of the weighted counts in each region) using the following equation, where $i = 1-7$:

$$\text{Geometric center} = \text{sum (region of interest}_i/\text{total counts)} \times i.$$

In this equation, counts are geometric mean counts corrected for decay and for time per image. For example, the colon images (4 min/frame) need to be divided by 4 for comparison with 1-min images of total abdominal counts on the first day. The reference mean values for the geometric center are shown in Table 3.

SUGGESTED READING

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