Society of Nuclear Medicine Procedure Guideline for Gastric Emptying and Motility

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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 gastric emptying/motility studies.

II. Background Information and Definitions

Radionuclide studies of gastric emptying and motility are the most physiologic studies available for studying gastric motor function. The study is noninvasive, uses a physiologic meal (solids with/without liquids), and is quantitative. Serial testing can determine the effectiveness of therapy.

III. Examples of Clinical or Research Applications

A. Postprandial:
   1. Nausea, vomiting
   2. Upper abdominal discomfort, bloating
   3. Chronic aspiration

B. Suspected gastroparesis

C. Poor diabetic control

D. Gastroesophageal reflux

E. Following response to therapy for previously documented motility disturbances

IV. Procedure

A. Patient Preparation

1. NPO for a minimum of 8 h before imaging. It is preferable to be NPO after midnight, then administer radiolabeled meal in the morning.
2. The patient should be advised of the logistical demands of the procedure (e.g., the meal to be used, the time required for eating the meal [<10 min] and for imaging, and the position patient will be required to maintain throughout the study). Diabetics should be instructed to bring insulin with them. The dose of insulin is to be adjusted when meal is given. If the patient cannot tolerate standard solid or liquid meal study, the procedure should not be done.
3. Premenopausal women should be studied on days 1–10 of their menstrual cycle, if possible, to avoid the effects of hormonal variation on gastrointestinal motility.

B. Information Pertinent to Performing the Procedure

1. Related diseases
   a. Hiatal hernia
   b. Gastroesophageal reflux
2. Previous interventions
   a. Medications (e.g., cisapride, metoclopra-

mide, domperidone, and erythromycin)
b. Surgery

C. Precautions/Contraindications

1. Allergy to the meal
2. Fasting in diabetic patients resulting in hypoglycemia

D. Radiopharmaceuticals

The composition of radiolabeled meals varies widely. An important consideration in selection of a specific radiolabeled meal is that normal emptying rates must be established for the specific meal, patient position, imaging protocol, and environment. The radiolabel stability in gastric juice for any solid meal must be established.

Meals are most often labeled with ^{99m}Tc-sulfur colloid and may include:

1. Solids (radiotracer is added before cooking)
   a. Eggs
      i. Scrambled
         (a) Whole eggs
         (b) Egg whites
         (c) Commercial egg substitute
      ii. Hard-boiled eggs
   b. Beef stew
   c. Liver surface labeled with isotope
2. Liquids: Almost any liquid can be used, but liquid emptying alone is not as sensitive for delayed emptying as solid or semisolid meals.
   a. Orange juice
   b. Water
   c. Milk

E. Image Acquisition

Ingestion of the radiolabeled test meal should be completed as quickly as possible, optimally within 10 min. The technologist should record how long it took to ingest the meal and whether any portion of the meal was not eaten. The method should be standardized as to patient positioning and environmental conditions, such as ambient noise, lighting, or other factors affecting patient comfort. The normal values should be based on this standard methodology.

1. Images are obtained in a format of at least 64 × 64 pixels using a general-purpose collimator or low-energy high-resolution collimator. Recommended photopeak settings are 20% at 140 keV for 99mTc. For 111In, 20% energy windows should be established around both the 172 and 246 keV photopeaks. If 111In is used, a medium-energy collimator must be used for image acquisition.
2. Planar images with the distal esophagus, stomach, and proximal small bowel in the field of view should be obtained immediately after ingestion of the meal.
3. Images are optimally obtained for at least 90 min, longer (2–3 h) for meals with larger volume, or higher calorie, fat, carbohydrate, or

Radiation Dosimetry: Adults*

Radiopharmaceuticals	Administered Activity MBq (mCi)	Organ Receiving the Largest Radiation Dose mGy/MBq (rad/mCi)	Effective Dose mSv/MBq (rem/mCi))
Nonabsorbable liquid labeleled with ^{99m}Tc	7.4 – 18.5 (0.2 – 0.5)	0.13 Upper large intestine (0.48)	0.024 (0.089)
Nonabsorbable solid labeled with ^{99m}Tc	7.4 – 18.5 (0.2 – 0.5)	0.11 Upper large intestine (0.41)	0.024 (0.089)
Nonabsorbable liquid labeled with ^{111}In	3.7 – 11.1 (0.1 – 0.3)	2.1 Lower large intestine (7.8)	0.3 (1.1)
Nonabsorbable solid labeled with ^{111}In	3.7 – 11.1 (0.1 – 0.3)	2.0 Lower large intestine (7.4)	0.31 (1.1)

* International Commission on Radiological Protection. *Radiation Dose to Patients from Radiopharmaceuticals.*. ICRP Publication 53. London, UK: ICRP; 1988:226 (for ^{99m}Tc); 250 (for ^{111}In).

protein content. Recent literature cites the need to obtain images for up to 4 h, suggesting that retention of >10% of the meal in the stomach at 4 h is abnormal. Anterior and posterior views allow calculation of a geometric mean (the geometric mean is the square root of the product of counts in the anterior and posterior regions of interest [ROIs]), which more consistently represents the amount of tracer in ROI independent of anterior–posterior movement between the fundus and antrum. The geometric mean can be calculated using sequential anterior and posterior images from a single-head camera or, preferably, simultaneously with a 2-head camera. Alternatively, the study can be acquired in the left anterior oblique (LAO) view with a single-head camera. In this case, no mathematical attenuation correction is required.

4. Continuous data collection with a framing rate of 30–60 sec is recommended. If data are collected only every 15 min, emptying half-time is not as accurately determined and lag phase information may be unavailable. Intermittent data acquisition may be more suitable than continuous data acquisition for imaging patients in an upright position.
5. Images may be obtained standing, sitting, or supine, but position should not change during the study. Normal values must be established in the position used (must have separate normal values for upright, supine).
6. Follow-up studies should always be done under the same conditions as the first study (i.e., same meal, collimator, analysis program, etc.)

F. Interventions

Metoclopramide or other prokinetic drugs can be used diagnostically in conjunction with gastric emptying studies to evaluate the effectiveness of a particular therapy.

G. Processing

1. An ROI is drawn around the tracer activity in the stomach in anterior and posterior views (and/or LAO view, if acquired). Cine display may be helpful to confirm the stomach outline and to determine the extent of patient motion so that the ROI may be appropriately adjusted. Alternatively, if continuous imaging is used, the stomach contour may be identified with initial images combined with images from later in the study, after the radiolabeled meal has had an opportunity to distribute itself within the stomach. Using initial or later images exclusively may under-represent the extent of the fundus and antrum.
2. Data points must be corrected for radioactive decay.
3. A time–activity curve obtained from the geometric mean or attenuation corrected counts of ROI activity should then be displayed.
4. Measurements of gastric emptying may be derived and reported in several ways. Normal values should be available for the specific analysis protocol being used. The value reported as the half-emptying time should be accompanied by a brief description of what the value represents or how the value was obtained. Values may be obtained by:
   a. Determination of the time it takes to reach half the peak counts.
   b. Least squares fit of the emptying data is used to derive a half-emptying time to reach 50% of the peak counts.
   c. The percentage retained at specific times after meal ingestion (e.g., at 2, 3, or 4 h).
5. In addition to rate of emptying, the percentage of emptying at the end of the study, and the percentage retained at specific time points after meal ingestion, other information may be obtained from gastric motility studies, including:
   a. Regional motility (e.g., antral contraction frequency and amplitude)
   b. Response to medical interventions
   c. Effect of varying meal composition on emptying

H. Interpretation Criteria

1. Normal values for the specific meal and environment used should be established before results can be reported.
2. Display of images in a cine format should be done to better demonstrate gastric anatomy and findings such as esophageal reflux, overlap of small bowel with gastric ROI, and possible movement of gastric contents outside the drawn ROI.
3. The emptying curve generated from the ROI should be interpreted in light of the manner in which images were collected. For example, if only anterior imaging was done, a “plateau phase” may represent gastric emptying at the same time posterior-to-anterior movement of tracer is occurring within the stomach.
4. A careful history addressing possible prior surgical procedures and current medications should be obtained before the study and considered during interpretation of findings.

I. Reporting

1. The meal, imaging protocol, and techniques for data analysis should be outlined in the report.

2. The gastric emptying data reported should be compared with normal values.
3. The study should be compared with previous studies, if available. If the previous study protocol differed from the current study (type of meal, position patient during imaging), the differences should be reported.
4. Any medications currently being taken that may alter gastric emptying should be documented.

J. Quality Control

The meal ingested must be controlled for caloric content (amount of carbohydrate, fat, and protein) and volume.

K. Sources of Error

1. Before a liquid phase meal is administered to an infant or through a feeding tube to a patient with severe neurologic impairment, an abdominal radiograph should be obtained to ensure that the meal is placed in the stomach, not the lung or small bowel.
2. Poor labeling
3. Nonstandard meal
4. Marked variation in the environment, such as noise, lighting, or temperature during imaging
5. Emotional fluctuations, such as fear of the medical environment, anxiety about results, anger after a long wait for the study to begin
6. Nausea caused by a meal that may be unfamiliar to the patient
7. Patient has eaten just before the study
8. Slow movement of the ingested meal from the mouth or esophagus into the stomach
9. Gastroesophageal reflux
10. Overlap of small bowel activity with the stomach ROI
11. Prolonged length of time for patient to ingest the meal
12. Lack of attenuation correction, particularly in obese patients
13. Failure to recognize that patient has not eaten entire meal

V. Issues Requiring Further Clarification

A. Intrasubject variability
B. Effect of environmental conditions on emptying rate
C. Effect of meal volume, composition, texture, etc., on emptying rate
D. Range of normal values for various meals in selected populations (specific age ranges, hormonal and emotional states)
E. Effect of hormonal variation on emptying/motility
F. Gender differences in emptying/motility
G. Age differences in emptying/motility

VI. Concise Bibliography

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