Procedure Guideline for Adult Solid-Meal Gastric-Emptying Study 3.0*

Kevin J. Donohoe[1], Alan H. Maurer[2], Harvey A. Ziessman[3], Jean-Luc C. Urbain[4], Henry D. Royal[5], and J. Martin-Comin[6]

[1]Beth Israel Deaconess Medical Center, Boston, Massachusetts; [2]Temple University Hospital, Philadelphia, Pennsylvania; [3]Johns Hopkins University Hospital, Baltimore, Maryland; [4]University of Western Ontario, Ontario, Canada; [5]Mallinckrodt Institute of Radiology, St. Louis, Missouri; and [6]University Hospital of Bellvitge, Barcelona, Spain

I. PURPOSE

The purpose of this guideline is to assist nuclear medicine practitioners in recommending, performing, interpreting, and reporting the results of gastric-emptying and motility studies in adults.

II. BACKGROUND INFORMATION AND DEFINITIONS

Radionuclide studies of gastric emptying and motility are the most comprehensive and physiologic studies of gastric motor function available. The studies are noninvasive, use a physiologic meal (solids with or without liquids), and are quantitative. Serial testing can determine the effectiveness of therapy. The Society of Nuclear Medicine (SNM) and the American Neurogastroenterological and Motility Society have recently agreed on a standard meal and a standard imaging protocol for measurement of gastric emptying. The recommended meal is intended to simplify and standardize the methodology and reference values based on a large, multiinstitutional investigation of 123 healthy subjects. This standardization will alleviate the problem of comparing results between institutions that did not use the same meal or imaging protocol. The detailed recommendations for the recommended meal and the imaging protocol can be found in the paper by Abell et al. listed in the bibliography of this guideline.

III. PROCEDURES

A. Patient Preparation

The following summarizes the key recommendations from the recent consensus guideline (a sample patient instruction sheet is included in the paper by Abell et al.).

1. The patient should take nothing by mouth for a minimum of 4 h before initiation of the study. It is preferable for the patient to take nothing by mouth starting at midnight and then to be given the 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, the number of images required, and what the patient is allowed to do between images).
3. Instructions for diabetic patients:
   a. Insulin-dependent diabetic patients should bring their glucose monitors and insulin with them. The serum glucose level at the time of meal ingestion should be recorded and included in the final report.
   b. Diabetic patients should have their diabetes under good control, with the blood sugar ideally less than 200 mg/dL. Diabetic patients should monitor their glucose level and adjust their morning dose of insulin as needed for the prescribed meal.
4. Premenopausal women should ideally be studied on days 1–10 of their menstrual cycle, if possible, to avoid the effects of hormonal variation on gastrointestinal motility.
5. Prokinetic agents such as metoclopramide, tegaserod, domperidone, and erythromycin are generally stopped 2 d before the test unless the test is done to assess the efficacy of these drugs.
6. Medications that delay gastric emptying, such as opiates or antispasmodic agents, should generally also be stopped 2 d before testing. Some other medications that may have an effect on the rate of gastric emptying include atropine, nifedipine, progesterone, octreotide, theophylline, benzodiazepine, and phentolamine.

B. Medical History Pertinent to Performing the Procedure

A sample patient information form is in the paper by Abell et al. The information to be gathered includes...

Received Jul. 1, 2009; revision accepted Jul. 1, 2009.
For correspondence or reprints contact: Kevin Donohoe, Beth Israel Deaconess Medical Center, 330 Brookline Ave., Boston, MA 02215.
E-mail: kdonohoe@caregroup.harvard.edu
*YOU CAN ACCESS THIS ACTIVITY THROUGH THE SNM WEB SITE (http://www.snm.org/guidelines).

DOI: 10.2967/jnmt.109.067843

1. Related diseases
   a. Hiatal hernia
   b. Gastroesophageal reflux
   c. Esophageal motility disorders (e.g., achalasia, scleroderma, diffuse esophageal spasm, or stricture)
2. Previous interventions
   a. Medications (e.g., cisapride, metoclopramide, domperidone, or erythromycin)
   b. Surgery

C. Precautions/Contraindications

1. Some patients may be allergic to the meal.
2. Fasting in diabetic patients may result in hypoglycemia.

D. Radiopharmaceuticals

The following standardized meal is recommended by the American Neurogastroenterology and Motility Society and the SNM. Reference values have been obtained through a multicenter trial. Use of a standardized meal will allow referring physicians to compare results between institutions more easily and with less need to repeat the study when a patient is referred from an outside institution. If another meal is used, the reference values cited for this standardized meal do not apply.

1. Recommended meal:
   a. 118 mL (4 oz.) of liquid egg whites (e.g., Eggbeaters [ConAgra Foods, Inc.] or an equivalent generic liquid egg white)
   b. Two slices of toasted white bread
   c. 30 g of jam or jelly
   d. 120 mL of water
2. Meal preparation:
   a. Mix 18.5–37 MBq (0.5–1 mCi) of ^{99m}Tc-sulfur colloid into the liquid egg whites.
   b. Cook the eggs in a microwave or on a hot nonstick skillet (as described by Ziessman et al. [2007]).
   c. Stir the eggs once or twice during cooking and cook until firm—to the consistency of an omelet.
   d. Toast the bread and spread the jelly on the toasted bread.
3. The meal may be eaten as a sandwich to decrease the time required for ingestion; if preferred, the eggs and toast may be eaten separately.

Radiation dosimetry for a nonabsorbable solid labeled with ^{99m}Tc is presented in Table 1.

E. Image Acquisition

The radiolabeled test meal should be ingested as quickly as possible, optimally within 10 min. The technologist should record how long it took the patient to ingest the meal and whether any portion of the meal was not eaten. The method should be standardized as to environmental conditions, such as ambient noise, lighting, or other factors affecting patient comfort. The reference values are based on this standard imaging methodology endorsed by the SNM and the American Neurogastroenterology and Motility Society.

1. Images are obtained in a format of at least 64 × 64 pixels using a general-purpose collimator or a low-energy high-resolution collimator. A 128 × 128 word-mode image matrix is recommended. The photopeak settings are 20% at the 140-keV peak for ^{99m}Tc.
2. Anterior and posterior planar images (or a single left anterior oblique image) with the distal esophagus, stomach, and proximal small bowel in the field of view should be obtained for 1 min immediately after ingestion of the meal.
3. Repeated images are obtained in the same projection(s) for 1 min at hourly intervals up to 4 h on the same camera as was used for the initial images. If imaging shows that more than 10% of the tracer remains in the stomach at 1, 2, or 3 h, recent literature cites the need to obtain images for up to 4 h, suggesting that retention of more than 10% of the meal in the stomach at 4 h is abnormal and is also the best discriminator between normal and abnormal results. 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 the ROI, independent of anterior–posterior movement between the fundus and antrum. The geometric mean is preferably calculated from anterior–posterior data obtained simultaneously with a dual-head γ-camera; however, sequential anterior and posterior images from a single-head

TABLE 1
Radiation Dosimetry: Adults

Radiopharmaceutical	Administered activity		Upper large intestine (organ receiving the largest radiation dose)		Effective dose	
	MBq	mCi	mGy/MBq	rad/mCi	mSv/MBq	rem/mCi
Nonabsorbable solid labeled with ^{99m}Tc	18.5–37	0.5–1.0	0.11	0.41	0.024	0.089

Data are from *Radiation Dose to Patients from Radiopharmaceuticals*. London, U.K.: ICRP;1988:226. ICRP Publication 53.

camera may also be used. Although some institutions acquire images in the left anterior oblique view with a single-head camera, this method is less reliable in compensating for attenuation than is the geometric mean method.
4. Follow-up studies should always be done under the same conditions as the first study (e.g., same meal, collimator, and analysis program)

F. Interventions

A repeat of the gastric-emptying study after a change in symptoms or therapy may be helpful for monitoring changes in motility.

G. Processing

1. An ROI is drawn around the activity in the entire stomach in anterior and posterior views (or the left anterior oblique view, if acquired). The ROI should include any visualized activity in the fundic (proximal) and antral (distal) regions of the stomach, with care to adjust the ROI to avoid activity from adjacent small bowel, if possible. A marker placed on the patient in a fixed position such as the iliac crest may be helpful for ensuring reproducibility in gastric positioning and ROI placement.
2. All data must be corrected for radioactive decay.
3. The final measurement of gastric emptying is based on the percentage of gastric retention at specific times after meal ingestion (e.g., at 2, 3, and 4 h). A time–activity curve obtained from the geometric mean of gastric counts displayed for all time points may be helpful.

H. Interpretation Criteria

1. Reference values for the specific meal recommended in this guideline are presented in Table 2.
2. If continuous data are collected for a portion of the study, display of images in a cine format may better demonstrate gastric anatomy and findings such as esophageal reflux, overlap of small bowel with the gastric ROI, and possible movement of gastric contents outside the drawn ROI. Although continuous data collection is not part of the standardized imaging protocol, some institutions may continue to use it for a portion of the study. Static images should also be carefully evaluated for esophageal reflux.
3. A history of possible prior surgical procedures and current medications should be obtained before the study and considered during interpretation of findings. The reference values do not apply to patients who have had gastric surgery.

I. Reporting

1. Any medications currently being taken that may alter gastric emptying should be documented, as well as any symptoms the patient experienced during the study, and those symptoms should be compared with the symptoms typically experienced by the patient.
2. The meal, imaging protocol, and techniques for data analysis should be outlined in the report. These include any difficulties with ingesting the meal or other variations from the standardized protocol.
3. Reporting should include the percentage of tracer retained at specific times after meal ingestion (at 1, 2, 3, and 4 h). This is the preferred method recommended for the standardized meal and imaging procedure described.
4. The gastric-emptying data reported should be compared with the reference values.
5. A description of the pattern of emptying may also be helpful (e.g., tracer remains in the fundus or antrum throughout the study).
6. The study should be compared with previous studies, if available. If the previous study protocol differed from the current study protocol (type of meal, position of patient during imaging), the differences should be reported.

TABLE 2
Normal Limits for Gastric Retention

Time point	Lower limit (a lower value suggests abnormally rapid gastric emptying)	Upper limit (a greater value suggests abnormally delayed gastric emptying)
0.5 h	70%	
1.0 h	30%	90%
2.0 h		60%
3.0 h		30%
4.0 h		10%

Data are from *Am J Gastroenterol.* 2007;102:1–11.

J. Quality Control

To achieve standardization, only the liquid egg meal recommended in the recent consensus report is to be used for adult solid gastric-emptying studies. Any deviation from this standard meal, such as ingestion of only a small portion of the meal or the use of another nonstandard meal, should be indicated in the final report.

K. Sources of Error

1. Vomiting after meal ingestion
2. Poor labeling
3. A nonstandard meal
4. A marked variation in the environment, such as noise, lighting, or temperature, during imaging
5. Emotional fluctuations, such as fear of the medical environment, anxieties 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. A patient who 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. A prolonged time for the patient to ingest the meal
12. Lack of attenuation correction, particularly in obese patients
13. Failure to recognize that the patient has not eaten the entire meal
14. Lack of decay correction for the tracer used
15. Failure of the patient to ingest the entire meal

IV. Issues Requiring Further Clarification

A. Intrasubject variability
B. Effect of environmental conditions on emptying rate
C. Effect of such factors as meal volume, composition, and texture on emptying rate
D. Range of reference values for various meals in selected populations (specific age ranges, hormonal and emotional states)
E. Effect of hormonal variation on emptying and motility
F. Pediatric gastric emptying (standardized meals, imaging protocols, and reference study values have yet to be established)
G. Importance of other aspects of gastric motility such as fundal–antral coordination, antropyloric coordination, gastric accommodation, and regional muscular contraction patterns within the stomach
H. Other important information on gastric motility that may be obtained from gastric-emptying studies, including. . .
    1. Antral motility (antral contraction frequency and amplitude)
    2. Fundal accommodation response
    3. Separate fundal and antral emptying curves
    4. Effect of varying meal composition on emptying

Tests to obtain this information, however, are not yet well standardized and are not generally performed as a part of a routine clinical solid-meal gastric-emptying study.

V. CONCISE BIBLIOGRAPHY

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VI. DISCLAIMER

The SNM has written and approved this Procedure Guideline as an educational tool designed to promote the cost-effective use of high-quality nuclear medicine procedures in medical practice or in the conduct of research and to assist practitioners in providing appropriate care for patients. The Procedure Guideline should not be deemed inclusive of all proper procedures or exclusive of other procedures reasonably directed to obtaining the same results. The guidelines are neither inflexible rules nor requirements of practice and are not intended nor should they be used to establish a legal standard of care. For these reasons, the SNM cautions against the use of this Procedure Guideline in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment about the propriety of any specific procedure or course of action must be made by the physician when considering the circumstances presented. Therefore, an approach that differs from the Procedure Guideline is not necessarily below the standard of care. A conscientious practitioner may responsibly adopt a course

of action different from that set forth in the Procedure Guideline when, in his or her reasonable judgment, that course of action is indicated by the condition of the patient, limitations on available resources, or advances in knowledge or technology subsequent to publication of the Procedure Guideline.

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 this Procedure Guideline is to assist practitioners in achieving this objective.

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

VII. APPROVAL

This Procedure Guideline was approved by the Board of Directors of the SNM on February 8, 2009.