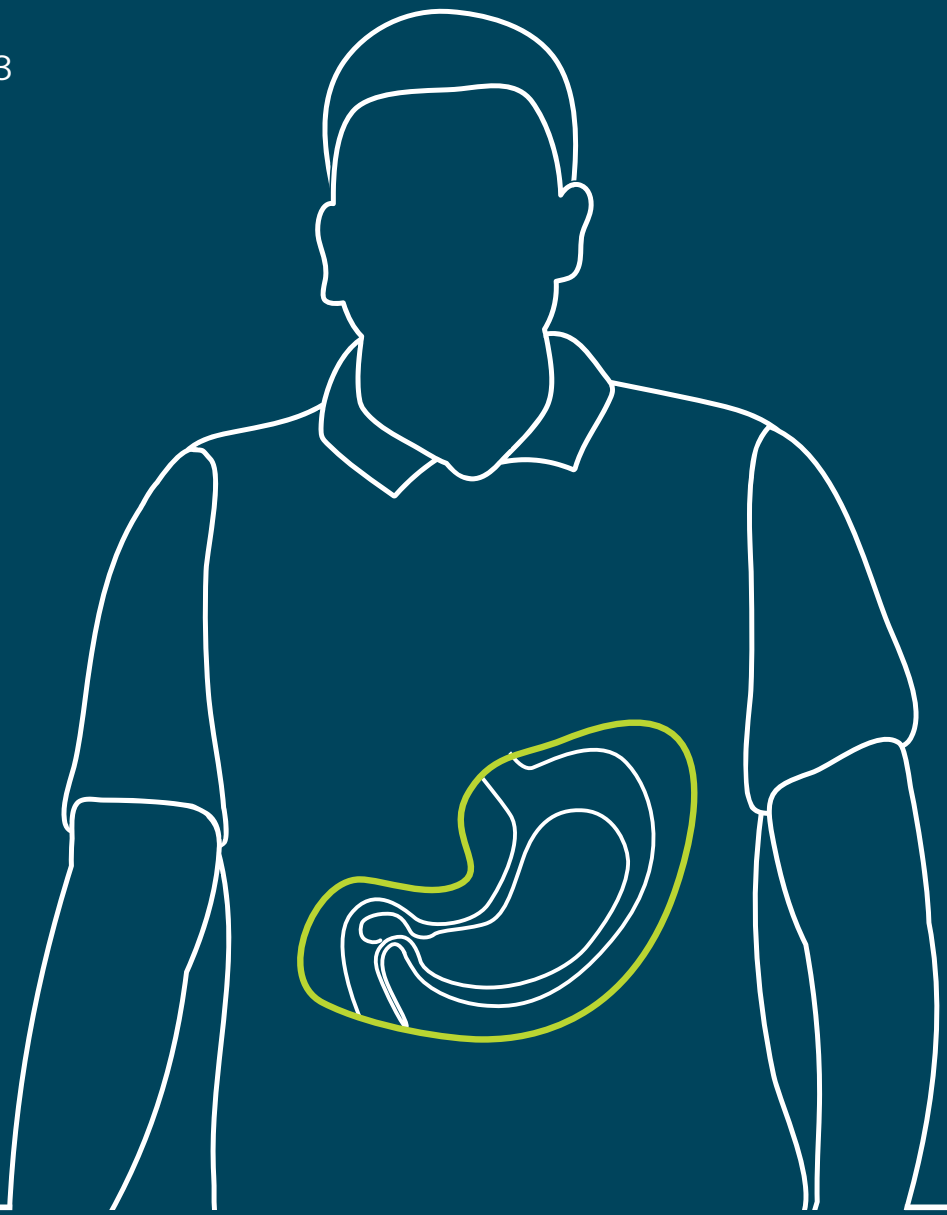
CLINICAL PRACTICE GUIDE

Gastric emptying scintigraphy

MARCH 2023



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Preferred citation: *NSW Agency for Clinical Innovation. Gastric emptying scintigraphy: Clinical Practice Guide.* Sydney: ACI; 2023.

SHPN (ACI) 230050
ISBN 978-1-76023-431-7

Version: V1 ACI_7201 [2/23]

Published: March 2023
Review date: March 2028

Cover image credit: Shutterstock.com

TRIM ACI/D21/813

At a glance

Gastric emptying scintigraphy is the ‘gold standard’ measurement for assessing the rate of stomach emptying. It is the primary test for the diagnosis of abnormal gastric emptying. This guide aims to standardise the technique used for gastric emptying scintigraphy; optimise clinical practice; and reduce clinical variation across nuclear medicine departments in NSW.

Gastric emptying scintigraphy

Contents

Summary

Gastric emptying scintigraphy is the ‘gold standard’ measurement for assessing the rate of stomach emptying. It is the primary test for the diagnosis of abnormal gastric emptying.

This guide aims to standardise the technique used for gastric emptying scintigraphy; optimise clinical practice; and reduce clinical variation across nuclear medicine departments in NSW. Below is a summary of the requirements for optimal gastric emptying scintigraphy."

Radiopharmaceutical

^{99m}Tc sulphur colloid: 20-40 MBq is recommended, mixed into either a standard (eggwhite) or alternative (rice idli) solid meal, or equivalent liquid meal (weight-based dose).

Meals and preparation

Solid meal

For all patients as per current international standards, the standard meal is eggwhite, bread and jam with unlabelled water. Rice idli can be used as an alternative meal for all patients with the following dietary requirements:

- Allergic to eggs
- Vegetarian
- Ggluten intolerant
- Vegan or cultural (religious) requirements

Other validated alternative meals can be used if they have medical reasons outside of this list, e.g. an oatmeal alternative.

Liquid meal

Liquid meals are chosen to identify rapid (not delayed) emptying. Liquid gastric emptying (GE) studies are also recommended for children 0-5 years, and for adults and children with suspected gastroparesis and with an unsafe swallow who are mainly gastrostomy fed, e.g. patients in the intensive care unit (ICU).

Liquid tests may be conducted using water, orange juice and other high-nutrient liquids such as glucose or a liquid nutritional supplement. Water is recommended as the most consistent test liquid with no calories.

Paediatric meal

For infants and children 0-5 years who are not yet on solids, patient-supplied milk or formula is recommended. The feed should be given orally and/or by nasogastric tube. Administration via percutaneous gastrostomy tube can be considered if required.

For children over 5 years or who are on solids, the test meal of eggwhite, bread, jam and water is recommended.

Patient preparation

- Check the effects of drugs on GE.
- Patient to be nil by mouth from midnight the night before the study.
- Smoking should be ceased from the night before the test.
- Medications that delay GE should also be discontinued for 2 days before the exam. Metformin may be ceased 48 hours prior to GE measurement, as per site protocols. Ondansetron may be used to control intolerable symptoms in this period.
- Provide an information sheet to the patient at the time of booking, including the above stated requirements and logistical demands for the procedure, such as the meal to be used, the time required for eating the meal (as quickly as possible in 5-10 minutes) and the examination time (approximately 4.5 hours, depending on the test meal).
- Patients with diabetes should have their diabetes under good control with the blood sugar less than 11.1mmol/L. Type 1 (insulin-dependent) diabetic patients are to bring their glucose monitors and insulin with them. For type 2 diabetes patients, check drug interactions as above.

Equipment and energy windows

- Collimators: low energy, high resolution, parallel hole.
- Energy windows: 140 keV and a 20% window.

Patient position and imaging field

- Patient posture will be upright (erect) for solid meals and lying down (supine) for liquid meals. If patients are unable to sit/stand, then the procedure can be performed supine. It is important to keep the patient posture consistent throughout the study. Active movement between scans should be minimised.
- Imaging field: Anterior and posterior, stomach in the upper/centre of the field of view (FOV).

Reporting requirements

- It is critical for the requesting clinician that the nuclear medicine (NM) technologist provides all relevant information observed or gleaned at the time of the test to the reporting physician, e.g. type of meal for emptying, vomiting, patient refusing meal, fasting blood glucose measurement in patients with diabetes.
- The exact composition of the meal and radioisotopic label should be provided. For infants and children using a milk or formula feed, the number of calories consumed in the milk/formula feed may be useful and can be stated in the worksheet to assist with the reporting of remaining meal in the stomach after a certain period.
- It is essential to document:
  - medications
  - the time taken to ingest the meal
  - the presence of postprandial vomiting
  - blood glucose concentration just prior to study commencement for diabetics
  - the amount of the meal consumed by the patient
  - any symptoms experienced; and standardised imaging labelling.

Introduction

Purpose

There is wide variation in nuclear medicine (NM) scanning protocols in NSW and in the international literature[1] regarding the types of food labelled, radioisotopes used, normal ranges for gastric emptying (GE) and the reporting of results. The purpose of this guide is to reduce clinical variation in GE protocols among NM departments, by standardising the technique and optimising clinical practice.

Background

Normal GE relies on coordination of the contractile activity of the proximal and distal stomach, pylorus and upper small intestine; the release of gut peptides; and small intestinal feedback. There are several conditions that lead to abnormal GE. Gastroparesis, or so-called 'paralysis of the stomach', is a digestive condition where there is a delay in the emptying of solids in the absence of mechanical obstruction.[2] In contrast, GE may also be abnormally rapid, as is the case in dumping syndrome.[3]

There are several methods used to assess GE; however, scintigraphy is regarded as the gold standard measurement.[4-6] Hence, it is the primary test for the diagnosis of abnormal GE. This NM functional scan is a non-invasive method for assessing the rate of stomach emptying and has been used clinically for many years.

The rate of GE is dependent on several factors including meal composition, meal temperature, body posture and in particular, the caloric content of the test meal used in the GE study. The normal rate of GE in health is wide, approximating 1-4kcal/min.[7] The normal ranges of GE are, therefore, specific to their respective test meals and established by measurement in a cohort of normal volunteers. Both solid and liquid meals for the measurement of GE are outlined in this guide.

Overview

This clinical guide outlines GE scintigraphy protocols in NM for several variations of radiolabelled ^{99m}Tc sulphur colloid meals:

Solid GE is recommended as it challenges the grinding function of the stomach. Where patient limitations exist, e.g. patients with an inability to tolerate solids or those with a gastrostomy tube, a single liquid meal protocol can be used.[8,9]

While it is traditionally believed that liquid GE is of less importance, several studies have shown that emptying of liquids can be abnormal in the presence of normal solid emptying.[6, 10-12] Most information is derived from simultaneous measurement of both solids and liquids in a dual isotope GE study.[6, 10-12]

While the measurement of discretely labelled solid and liquid meal components is a more sensitive test for disordered GE than a single component, the dual isotope technique is more challenging and may require the input of a physicist to assist in performing correction factors for down-scatter from the higher energy isotope into the lower energy window.[13] The dual isotope technique is, therefore, unlikely to be practical for the majority of NM departments.

Methodology

In 2019, a survey of NM technologists and gastroenterologists in NSW was conducted to determine the range of current services and procedures available, including GE scintigraphy Picture Archive and Communication System (PACS) and Radiology Information System (RIS) activity.

In 2019–2020, the Agency for Clinical Innovation (ACI) Chief Nuclear Medicine Technologists (NMTs) Group provided analysis of exisiting site-based protocols. (Note: an 18-month project hibernation period occurred during the COVID-19 pandemic.)

The GE Steering Group was formed in October 2020 to examine the key literature and seek advice from lead university academics. This group comprised ACI Chief NMTs; the lead gastroenterologist from the Gastric Intestinal Disorders Unit, Western Sydney University, Dr Vincent Ho; and lead academic at the University of Adelaide, Professor Karen Jones, School of Medicine, Medical Sciences, NHMRC CRE in Translating Nutritional Science to Good Health. The Steering Group with external membership can be found in Acknowledgements.

Literature Review

An initial literature review was conducted by the GE Steering Group Chair (for the period 1985–2019) with further additions provided by the ACI Nuclear Medicine Chief Technologists Group, Professor Karen Jones and Dr Vincent Ho. Peer-reviewed articles were further identified through PubMed for 2002–-2022 (May 27, 2022) and returned 252 hits. Search string:

(("Gastric Emptying"[MeSH Terms] OR "gastric empty*"[Title] OR "Gastroparesis"[MeSH Terms] OR "Gastroparesis"[Title] OR "Delayed gastric emptying"[Title] OR "DGE"[Title])) AND ("guideline*"[Title/Abstract] OR "approach*"[Title/Abstract] OR "recommend*"[Title/Abstract] OR "measure*"[Title/Abstract] OR "regulat*"[Title/Abstract] OR "evaluat*"[Title/Abstract] OR "diagnos*"[Title/Abstract] OR "administrat*"[Title/Abstract] OR "standard*"[Title/Abstract] OR "protocol*"[Title/Abstract] OR "reference*"[Title/Abstract] OR "compar*"[Title/Abstract] OR "assess*"[Title/Abstract]) AND (english[Filter]) AND (2002:2022[pdat]) AND "meal"[All Fields] AND "scintigraphy"[All Fields]

A cross-check of this search was performed with the Steering Group references and found that many articles provided by the Steering Group were outside of PubMed, e.g textbooks, grey literature or historic in nature. Some articles in the Journal of Nuclear Medicine were not online in 2007, therefore not available via any search engines. Hence the criteria for the review of this search were as follows:

Inclusion criteria

- English language
- High quality papers with NM best practice
- All international articles relevant to Australian diet
- All articles relevant to vegan protocols (gastric emptying scintigraphy vegan or gluten-free gastric emptying study)
- Historic GE protocols (for imaging protocols and physiology)

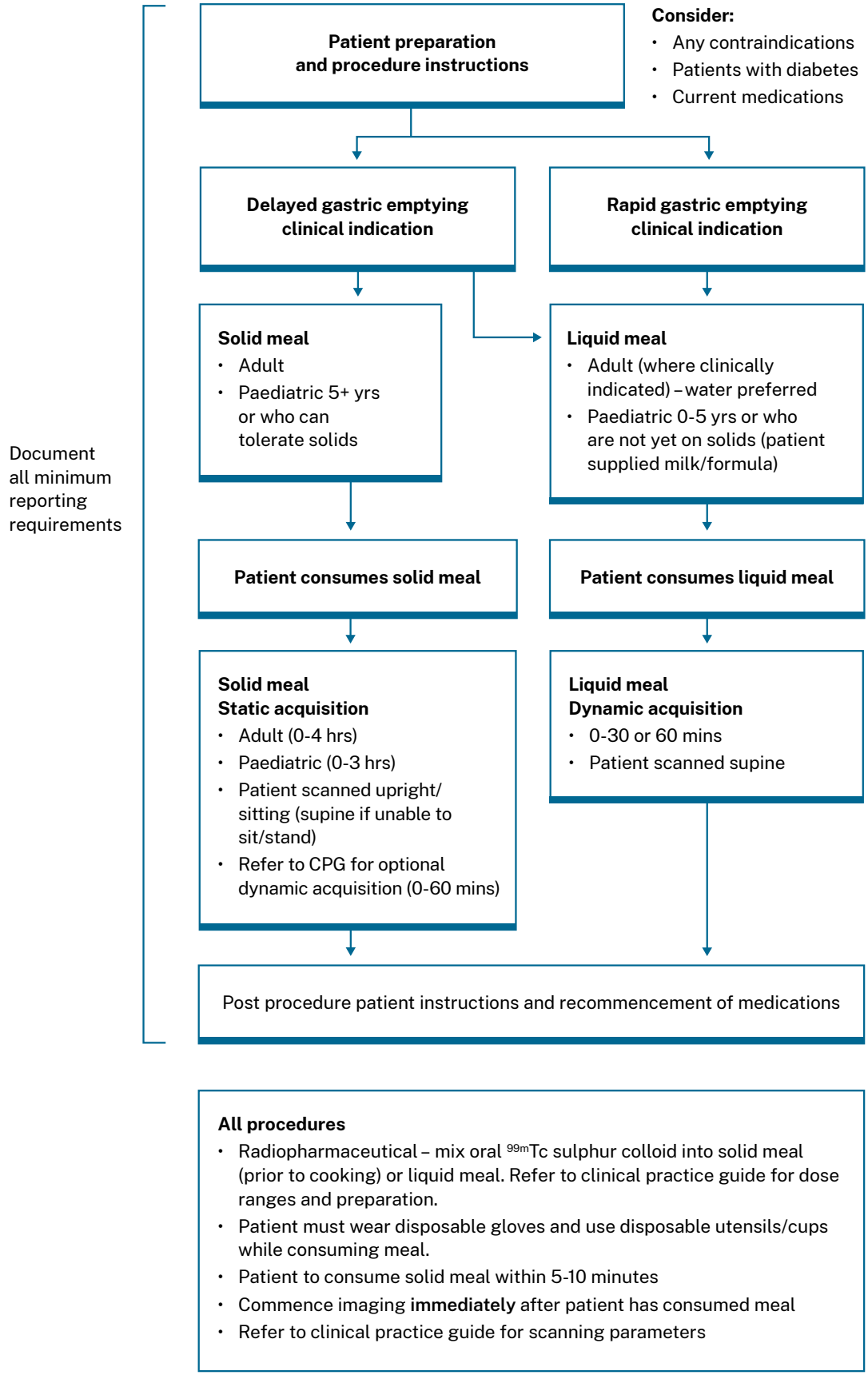
Exclusion criteria

- Duplicate articles
- Trials
- New protocols that were plausible but not widely accepted
- International meals not relevant to Australia

Standardisation and consultation

- The GE Steering Group together and the Chief NMT Group obtained consensus on the most consistent and effective GE protocols for a statewide guide.
- Usability studies were performed at Bankstown Hospital. (Patient surveys on the new alternative meal (rice idli) were conducted by the Chief Investigator.)
- During Phase 1 consultation in October 2020, feedback on the initial draft of this clinical practice guide was sought from the NSW Gastroenterology Network and Chief NMTs. The document was reviewed for suggested revisions.
- Phase 2 consultation, from December 2020 to January 2021, took place via the ACI's Nuclear Medicine Network, which involved the Chief NMT Group and Directors of NM across NSW Health. The document was reviewed for suggested revisions.
- During Phase 3 consultation, between May and June 2021, the draft was circulated for statewide consultation (via Local Health District (LHD) chief executives) and was sent to all NSW LHDs and specialty health networks (SHNs). Responses were incorporated into the final draft by the GE Steering Group.

Figure 1: Gastric emptying scintigraphy protocols



Common referrals for gastric emptying studies

Referral indications

The referring gastroenterologist may have one or more considerations and suspicions regarding a patient's presenting symptoms and possible causes. The following list includes examples of clinical histories commonly referred for GE studies:

- Silent reflux
- Post stomach surgery
- Determination of GE and quantification of the rate of GE rate/extent of altered function
- Evaluation of mechanical or anatomical obstruction
- Possible gastroparesis or dumping syndrome
- Evaluation of nausea, vomiting and early satiety (also postprandial fullness and bloating)
- Evaluation of response to therapy for previously documented motility disturbances
- Diabetic patients with or without upper gastrointestinal (GI) symptoms[14]
- Possible gastric reflux
- Endoscopy-negative dyspepsia[15]
- Persistent symptoms after gastric surgery
- Follow-up scans to assess response to therapy
- Unexplained hypoglycaemia.

The interdependent relationship between the rate of GE and glycaemia is an important consideration in the diagnosis and management of gastroparesis, as both hyper- and hypoglycaemia influence GE.[2]

Contraindications

The British Nuclear Medicine Society has published absolute and relative contraindications to GE studies.[5]

Absolute contraindications

- Allergy to the food stuff, e.g. eggs, nuts, lactose, gluten, depending on the meal provided.

Relative contraindications

- Diabetes: diabetic patients require caution when fasting.
- Pregnancy and breastfeeding: if ^{99m}Tc sulphur colloid is used, there is no need to interrupt breastfeeding when undertaking scintigraphy on a breastfeeding mother. However, as studies of GE do not relate to life-threatening conditions, consideration should be given to delaying the investigation until after breastfeeding has ceased. **Note:** While no radioactivity is transferred into breast milk, the proximity of the infant to the breastfeeding mother remains a consideration, despite radiation dose being a minor/negligible risk. The ALARA (As Low As Reasonably Achievable) principle for radiation exposure is always considered, as per the ARPANSA RPS G-2 Radiation protection principles.

Radiopharmaceuticals and dosimetry

The following radiopharmaceuticals and dosimetry are recommended as standard for GE studies.

Radiopharmaceuticals

- Oral ^{99m}Tc sulphur colloid: 20-40 MBq mixed into either a standard (eggwhite) or alternative (rice idli) solid meal, or equivalent liquid meal (weight-based dose).
- Dual isotope protocols exist using ^{67}Ga EDTA (liquid) and ^{99m}Tc sulphur colloid (solid) for concurrent measurement of GE of solids and liquids. However, variable ^{67}Ga supplies, down-scatter correction capabilities and increased radiation dose limit this technique.

Gastric emptying dosimetry

Refer to the following guidelines from the International Commission for Radiological Protection for the recommended dosimetry for GE studies (with dose ranges):

- Adult: Radiation dose to patients from radiopharmaceuticals; ICRP Publication 53[16]
- Paediatric: Radiation Dose to Patients from Radiopharmaceuticals (addendum to ICRP Publication 53; ICRP Publication 128.[1]

Also refer to Lassman et al's Paediatric radiopharmaceutical administration: harmonization of the 2007 EANM paediatric dosage card (version 1.5.2008) and the 2010 North American consensus guidelines from the EANM/SNMMI Paediatric Dosage Harmonization Working Group.[17]

Standardisation of meals

Solid gastric emptying studies

There are many techniques for solid meals in the literature; however, the international standard is outlined in Consensus recommendations for gastric emptying scintigraphy: a joint report of the American Neurogastroenterology and Motility Society and the Society of Nuclear Medicine.[4]

Standard meal (eggwhite, bread and jam)

For details of the preparation method, see Experience with a simplified, standardized 4-hour gastric-emptying protocol by Ziessman et al.[18]

Ingredients

- Two large eggwhites (118mL packaged liquid eggwhites)
- Two slices toasted white bread
- 30g strawberry jam (do not substitute other items, e.g. butter, as the total calories must be retained)
- 120mL unlabelled water

Preparation

- Mix 20-40MBq (0.5-1 mCi) of ^{99m}Tc sulphur colloid into the liquid eggwhites.
- Cook in a microwave or in a non-stick frypan.
- Stir the eggs once or twice during cooking and cook until firm to the consistency of an omelette. Do not use oil in the pan as it can add calories which increases variables.
- Toast the bread and spread with the jam.
- The meal may be eaten as a sandwich to decrease the time required for ingestion. Alternatively, if preferred, the eggs and toast may be eaten separately.

Alternative meal (rice idli) for patients with dietary restrictions or allergies

Rice idli is recommended for the diagnosis of gastric motility disorders.[8] Rice Idli is an Indian savoury rice pancake, usually eaten at breakfast, which originates from Southern India. It can be used as an alternative meal for all patients with the following dietary requirements:

- Allergic to eggs
- Vegetarian
- Gluten intolerant
- Vegan
- Cultural (religious) requirements

Rice idli is an established standard meal for GE studies with validated normal ranges that are similar to the standard Society of Nuclear Medicine (SNM) normal ranges for eggwhite meals.[8] Rice idli GE rates are similar to the standard eggwhite meal when the imaging parameters are similar, i.e. gamma camera time is similar; see Table 1.

The rice idli can be served with sugar-free maple-flavoured syrup if desired to create a more 'Westernised' meal, as it does not add extra calories. For further information on ingredients and preparation of the rice idli meal, refer to Somasundaram et al's A Gluten-Free Vegan Meal for Gastric Emptying Scintigraphy.[8]

Other validated alternative meals can be used if the patient has medical reasons outside of those listed above, e.g. an oatmeal alternative has been described in literature by Klingensmith.[19]

Liquid gastric emptying studies

Liquid studies have been recommended for:

- identifying rapid (not delayed) GE
- children (see **Paediatric gastric emptying studies**)
- suspected gastroparesis in adults and children – for the detection of gastroparesis, liquid GE has considerable added diagnostic value over a study of solid emptying alone[10-12]
- for adults and children with an unsafe swallow who are mainly gastrostomy fed, e.g. ICU patients.[20]
- Liquid tests with water, orange juice[5] and other high-nutrient liquids such as glucose[14, 21-22] or a liquid nutritional supplement[20, 23] are all noted in the literature. Given there is decreased consistency in the number of calories when varying the test drink, water is recommended as the most consistent test liquid with no calories.

Paediatric gastric emptying studies

Children 5+ years or who are on solids

Children older than 5 years or who are on solids should be given the standard solid meal (eggwhite, bread and jam) described above, or the rice idli alternative as required. The adult normative standards for GE scintigraphy are applicable for use in the paediatric population.[9]

Infants and children 0-5 years who are not on solids

GE studies should be performed using a milk or formula feed as provided by the parent(s). The number of calories consumed in the milk/formula feed may be useful and can be noted in the worksheet to assist with reporting of the remaining meal in the stomach after a certain period. The feed should be given orally and/or by nasogastric (NG) tube. Administration via percutaneous gastrostomy tube can be considered if required. Refer to Paediatric acquisition times and reference levels.

Patient preparation

Patient questionnaire

Provide a patient questionnaire at the time of the appointment booking to obtain a history regarding their symptoms, diabetic status, current medications and any surgery to the GI tract. For a suggested patient questionnaire template, see Appendix 1.

The NM physician should check the effects on GE of drugs, including:

- GLP-1 receptor agonists (long- and short-acting drugs/agonists)[6, 21, 24] – these drugs are being used increasingly in patients with type 2 diabetes to lower blood glucose and have significant effects on GE, particularly the short-acting drugs, e.g. lixisenatide, exenatide twice daily (BID).[6, 21] Lixisenatide is short-acting,[21] exenatide once weekly (QW) is long-acting.[24]
- anticholinergics
- cannabinoids that can delay GE
- antispasmodic agents with anticholinergic effects that delay GE are bethanechol, baclofen, prucalopride, tricyclics/antidepressants
- prokinetic agents that increase the rate of GE, such as tegaserod, erythromycin, azithromycin, domperidone and metoclopramide.

Metformin may be ceased 48 hours prior to GE measurement as per site protocols. There is recent evidence that metformin slows GE,[25, 26] although to date this has only been assessed using a breath test technique.

Ondansetron may be used to control intolerable symptoms in this period, as it has little impact on GE.[27] This can be administered intravenously to control symptoms during the GE study if the patient has severe vomiting.

It is recommended that any of the drugs mentioned above should be ceased 48 hours prior to the study, unless the test is being performed to assess the efficacy of these drugs.

If the patient is taking a long-acting GLP-1 receptor agonist, 48 hours is not sufficient, i.e. if the medication is taken daily (liraglutide) or once weekly (exenatide QW, dulaglutide, semaglutide). It is best to document the medication and comment on it in the report, e.g. noting that any delay in GE may be due to the long-acting GLP-1 receptor agonist.

Patient information sheet

Provide an information sheet to the patient at the time of the appointment booking, including the following information:

- The patient is to be nil by mouth from 12am the night before the study and then given the radiolabelled meal, preferably in the morning. Morning bookings are recommended.
- A sip of water in the morning when the patient brushes their teeth is acceptable.
- Smoking should be ceased from the night before the test.
- Examination time is approximately 4.5 hours, depending on the test meal.
- Patient posture during the test will be erect/upright for solid meals and lying down (supine) for liquid meals.
- The logistical demands of the procedure, e.g. which meal is to be used for their procedure, the time required for eating the meal. The patient should be instructed to eat the whole solid meal as quickly as possible (in 5-10 minutes).[28]
- Information on the imaging procedure, the number of images required, and what the patient can do in between imaging.

Information for patients with diabetes[1, 14, 26]

- Patients with diabetes should have their diabetes under good control with the blood sugar less than 11.1mmol/L.
- Diabetic patients should monitor their glucose level and adjust their morning dose of insulin as needed for the prescribed meal. The NM physician will discuss these conditions and consider rebooking if required.
- Type 1 (insulin-dependent) patients with diabetes are to bring their glucose monitors and insulin with them.
- Type 2 patients require drug interactions to be checked as recommended under Patient questionnaire.
- Record the blood glucose level immediately prior to meal ingestion and include in the final report.

Imaging protocols

The following GE imaging protocols apply to all meal types and the single isotope test.

Equipment and energy windows

- Collimators: low energy, high resolution, parallel hole.
- Energy windows: 140keV and a 20% window.

Patient position and imaging field

Patient position

- For solid meals, upright/sitting posture is preferred for the study to be physiological. The effect of gravity will affect GE of a low nutrient liquid. While the preferred posture is erect, if patients are unable to sit/stand, then the procedure can be performed supine.
- It is important to keep the patient posture consistent throughout the study. Active movement between scans should be minimised.

Imaging field

- Anterior and posterior, stomach in the upper/centre of the FOV.

Solid and liquid meal scanning parameters

Table 1. Solid and liquid meal scanning parameters

Parameter	Solid Meal	Liquid Meal
Static acquisition	0 minutes, 30 minutes, 1 hour, 2 hours, 4 hours. Time = 0 minutes represents the time immediately after meal ingestion. *Can cease imaging earlier if the stomach is sensitive or the normal clearance has been achieved.* **Note:** 3 hours for paediatrics rather than 4 hours	Dynamic for 30-60 minutes
Matrix	128 or 256	128
Zoom	Zoom (as required)	No zoom
Frame rates/time	1-3 minutes per static	60 seconds per frame

An optional dynamic 0-60 minutes (60-second frames 128 x128, same zoom as statics) can be performed, and a time activity curve (TAC) generated to comment on lag periods.

- If the request has a clinical indication of "?dumping", dynamic imaging should be performed. In the case of dumping, 4-hour imaging is unlikely to be required and imaging can cease once the stomach has emptied.
- Recent studies concluded that the GE studies T½ correlates more strongly with retention at 2 hours than at 4 hours. T½ alone may misclassify patients, particularly those with late-phase (4-hour only) delays, reducing its utility for diagnosing gastroparesis.[15]

- If the patient has had surgery to the stomach or has an unusual looking stomach at the 0-minute static, acquire a dynamic immediately after for approximately 5 minutes.
- If the patient vomits at any time post meal, the doctor on duty should reassess to determine whether to continue with the study or cease scanning. If scanning ceases, the study then becomes qualitative.
- The patient must wear gloves while eating the meal to reduce radioactive contamination. Gloves may be removed after the meal is completed.
- Disposable plates and cutlery are recommended for ease of waste disposal by NM staff in a sealed bag following radiation safety protocols.
- The patient should eat the whole solid meal as quickly as possible in 5-10 minutes.
- Nothing other than the test meal should be eaten for the duration of the study.
- Staff should avoid eating at the same time as the patient or have visual triggers of eating and smell in front of the patient, which can activate the patient's gastric motility.
- Once the patient meal is completed, imaging must start immediately.
- At least 50% of each component of the standard meal must be consumed for a valid test. This occurrence must be recorded in the report, together with the amount ingested. If less than 100% of the meal is ingested, the procedure becomes qualitative rather than a quantitative examination as the normal ranges are no longer valid for this study.

Post processing

Post processing is performed to determine the geometric mean of the image and to calculate the rate of GE for the patient. The geometric mean image is the gold standard for the correction of attenuation. Other techniques can also be used, such as a left anterior oblique acquisition[29] or correction factors applied that are derived from a left lateral image[13].

A region-of interest is drawn around the stomach, excluding the proximal small intestine, where possible. Data is corrected for patient movement, radioactive decay and gamma ray attenuation (using the geometric mean technique or correction factors derived from a left lateral image). For static imaging, the % retention at 1 hour, 2 hours, 3 hours and 4 hours are calculated, where time = 0 minutes represents the end of meal ingestion.[4]

Where dynamic imaging was employed, TACs can be generated and the % retention at 1 hour, 2 hours, 3 hours and 4 hours derived. The lag phase, determined as the time preceding that in which activity is observed in the proximal small intestine, may be recorded for reporting purposes.[13]

The 4-hour solid GE time should be considered the primary measure in the diagnosis of delayed GE. For rapid GE, the 1-hour values are likely to be more relevant.

Acquisition protocols and reference levels

Adult acquisition times and reference levels

Adult acquisition times are recommended by Abell et al[4] and Somasundaram et al.[8]

Note that the GE normal range for the rice idli meal has been based on an Indian population.[8] It should be recognised that GE varies based on ethnicity, e.g. people of both Hispanic[30] and Han Chinese[31] origin have more rapid GE.

Changes in blood glucose have reversible effects on GE. Hyperglycaemia (~15mmol/L) has been shown to slow GE,[32] while hypoglycaemia (~2.6mmol/L) increases GE.[33] Even changes within the normal physiological range (~8mmol/L) will also affect GE. For example, in normal subjects and patients with Type 1 diabetes, emptying of solids and liquids is slower at a blood glucose concentration of 8mmol/L when compared with 4mmol/L.[34] Hence, in patients with diabetes with a blood glucose concentration >8mmol/L, this should be discussed and documented when reporting GE results.

Paediatric acquisition times and reference levels

In 2016, Malik et al[35] evaluated GE in 30 healthy children following a standardised vegetarian meal, providing normal gastric retention values at 30 minutes (90%), 1 hour (77%), 2 hours (33%), 3 hours (16%) and 4 hours (7%).

Paediatric study normal values following ingestion of 200mL strawberry flavoured milk (112 kcal) have been reported by Sachdeva et al.[23] More recently, normal ranges for liquid GE of milk in paediatric patients less than 5 years of age have been defined by Kwatra et al.[36]

In summary, if emptying is not 80% or more in up to 3 hours, the study is considered abnormal (delayed).

Kwatra et al retrospectively reviewed 5,136 GE studies on children 5 years and under. The conclusion of this article is below.[36]

Gastric emptying in infants and children is related to age, feeding volume and route of administration. There appears to be no correlation between gastroesophageal reflux and gastric emptying. The tabulated age-specific gastric emptying range in this large series may serve as a reasonable surrogate for normal values of gastric emptying of milk/formula. We suggest ≥80% as a cutoff value for normal 3-hour gastric emptying with milk in infants and children up to 5 years of age. One-hour emptying measurements may not be reliable for detecting delayed gastric emptying.

Reference range for the solid meal in children older than 5 years is the same as for adults.[8]

Minimum reporting requirements

It is critical for the requesting clinician that the NM technologist provides all relevant information observed or gleaned at the time of the test to the reporting physician, including:

- the exact composition of the meal and radio-isotopic label
- any of the medications listed in the Patient preparation section taken within 48 hours of the study (e.g. a long-acting GLP-1 agonist taken a week before may influence GE)
- time taken to ingest the meal
- for diabetics, blood glucose concentration just prior to study commencement
- a record of the amount of the meal consumed by the patient and any symptoms experienced (particularly if the patient vomits, and the timing of this event)
- presence of postprandial vomiting
- appropriately displayed and labelled GE images, including the term 'solid'
- all images processed as per local data analysis programming, and reviewed by the doctor on duty
- if a study is delayed at 3 hours but normal at 4 hours, this can be reported as equivocal or borderline.

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Appendix: Gastric emptying study patient questionnaire and worksheet templates

These examples of gastric emptying study patient questionnaire and worksheet templates (see overleaf) are provided for use at sites without formal questionnaires or worksheets. Once completed, the questionnaire or worksheet should be scanned into the local Radiology Information System (RIS) and Picture Archive and Communication System (PACS).

These can also be found online at:

Gastric emptying study patient questionnaire

Gastric emptying study worksheet template

Gastric emptying study

Patient questionnaire

Name: DOB:

Date of Study:

1. **What is your main symptom that has led to undergoing the test today?** (Please tick):

☐ heartburn ☐ chest pain ☐ nausea ☐ vomiting ☐ abdominal pain

☐ bloating/distension ☐ constipation ☐ diarrhoea ☐ unexplained hypoglycaemia

Other:

2. **Do you have diabetes?** (Please tick) ☐ No ☐ Yes

If yes, Type: How long have you had diabetes?

What medication do you take? (Please tick) ☐ Insulin ☐ Tablets ☐ Subcutaneous injection

Did you measure your glucose this morning before the test? (Please tick) ☐ No ☐ Yes

If yes, what was the value?

3. **Do you take any pain medication?** (Please tick) ☐ No ☐ Yes

If yes, which one(s) and how often?

When did you last take this type of medicine?

4. **Do you take any medications to speed up your gastrointestinal tract (stomach or colon)?** (Please tick)

☐ No ☐ Yes If yes, which one(s)?

When did you last take this type of medicine?

5. **List any other medications you currently take:**

6. **Have you had surgery on your gastrointestinal tract (the oesophagus, stomach or colon)?** (Please tick)

☐ No ☐ Yes If yes, please describe:

Name of clinician completing form with patient:

Signed: Date:

Gastric emptying

Worksheet template

Name of patient: DOB:

MRN: Date of Study:

Patient height: Patient Weight:

Preparation

Patient last ate: BSL pre-meal (if diabetic): Time:

Medication/s stopped:

Note: The amount of calories in a milk/formula liquid meal should be reported here:

Start Eating (hh:mm): Finish Eating (hh:mm):

Image	Expected start time (hh:mm)	Actual start time (hh:mm)	% Retention
0 min			
60 min			
120 min			
240 min			

Did the patient eat the whole meal? (Please tick) ☐ No ☐ Yes

Did the patient experience any symptoms?

Name of clinician completing form:

Signed: Date:

DOSE STICKER

Acknowledgements

GE Steering Group

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The ACI Medical Imaging Network

Chief Nuclear Medicine Technologist (NMT) Group

Nuclear Medicine teams

Bankstown-Lidcombe Hospital

Gosford Hospital

Royal North Shore Hospital

Sydney Children’s Hospitals Network/Children’s Hospital at Westmead

Central Coast LHD (templates in Appendix 1)

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We bring consumers, clinicians and healthcare managers together to support the design, assessment and implementation of clinical innovations across the NSW public health system to change the way that care is delivered.

The ACI's clinical networks, institutes and taskforces are chaired by senior clinicians and consumers who have a keen interest and track record in innovative clinical care.

We also work closely with the Ministry of Health and the four other pillars of NSW Health to pilot, scale and spread solutions to healthcare system-wide challenges. We seek to improve the care and outcomes for patients by re-designing and transforming the NSW public health system.

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