Gastric Emptying: Beyond the Basics and Recent Consensus Recommendations

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Philadelphia, PA
Goals

• Review basic anatomic and functional aspects of gastric emptying and how they relate to measurement of gastric emptying
• Describe advances in gastric emptying scintigraphy which can more fully characterize gastric emptying
• Demonstrate how small bowel and colon transit studies can augment gastric emptying scintigraphy
• Explain the recent consensus recommendations which standardize GE scintigraphy
Importance of Functional GI Disorders

- Incidence ≈ 25% of general population
- Common diagnoses in general practice
  - Functional (Nonulcer) dyspepsia
  - GERD (15% population)
  - IBS (irritable bowel syndrome)
  - Constipation (15-20% population)
- Cost estimates high
  - UK 1992-94 job related study = 500 million £
Goals of Diagnosing GI Motility Disorders

• Confirm or exclude a diagnosis
  – Reduce anxiety, explain symptoms
  – Educate about natural course of disease

• Initiate proper treatment
  – Prokinetic agent
  – Antispasmodic, anticholinergic
  – Invasive: surgical or endoscopic
When to Order GI Scintigraphy?

- After an anatomic cause for symptoms has been excluded by:
  - Endoscopy
  - Radiologic or other anatomic study
- When functional GI symptoms persist
- Equivocal other studies
  - Manometry
  - Endoscopy
  - pH probe
  - Radiologic/anatomic
Basic Concepts: GI Nuclear Medicine

#1 Physiologic Markers Used (Not Barium)

- Solid foods for Gastric Emptying
- Liquids for Reflux Studies
- Bile like compounds for bile transit
Manometric/Myometric “Gold Standards?”

- Using catheters, amplitude, duration, and location of pressure changes measured

- Gives an *indication of* but does not measure bulk transit
Basic Concepts: GI Nuclear Medicine

#2 Combines Imaging and Quantification

No geometric assumptions to calculate volumes

(Counts proportional to volume)
Organization of the Stomach
Structural and Myoelectric

Fundus:
- Upper third, tonic reservoir which undergoes receptive relaxation
- No peristalsis, constant pressure gradient
- Controls liquid emptying

Antrum:
- Phasic contractions, grinds solid food particles
- Controls emptying of solids
Other Factors Which Control Gastric Emptying

- Physical and chemical composition of the meal
- Nervous innervation
- Circulating endocrine transmitters
New Concepts

Two Compartments

Fundo-Antral Coordination

Antro-pyloro-duodenal Coordination

Visceral Perception

Neurotransmitter/Receptors
  • Serotonin
  • 5 HT
Summary: Role of the Stomach in Solid Food Digestion

- Storage and reception
  - **Fundus** - receptive relaxation for solids and transfer to antrum
- Trituration (grinding and sieving)
  - **Antral** contractions
- Delivery to small bowel to maximize absorption
  - **Antroduodenal** contractions and coordination
Gastric Emptying Scintigraphy

**Indications**

- **Gastroparesis** (Nausea, early satiety, postprandial fullness, abdominal pain/discomfort)
  - Diabetic
  - Idiopathic
  - Surgical, Post transplantation

- **Dyspepsia**
  - Post prandial fullness, nausea, vomiting, distention, easy satiety, weight loss, pain

- **Symptoms of rapid emptying** (Mimic slow emptying)
  - Post gastrectomy (dumping)
  - Cyclic vomiting syndrome

- **GER with poor response to therapy**

- **Assess response to therapy**

- **Unexplained GI symptoms** (? Organic Cause)
What is Normal Gastric Emptying?

• Depends on:
  – Patient preparation (Glucose control, fasting, medications…)
  – Meal
  – Acquisition
  – Data analysis
Gastric Emptying Studies

*Items Needing Standardization*

- Radiolabeled meal
  - Normal values
  - Solids vs Liquids
    - Eggs, chicken liver, others...

- Acquisition protocol
  - Static images (90 min, 2 hr, 4 hr)
  - Dynamic

- Processing & Analysis
  - Attenuation correction
    - Single view vs two views
  - T 1/2, % retention, lag phase
Gastric Emptying
The Radiolabeled Meal

• Must be standardized for:
  – Volume (solids + liquids)
  – Nature of solids
  – Caloric content
  – Amounts of CHO, Fat, and Protein

• Must be stable in gastric juice
  – Compare to "gold standard" (In vivo labeled chicken liver)

• Solid phase- most clinically relevant

• Liquid phase
  – Used to record small bowel and colon transit (Whole gut studies)
  – May be abnormal in early diabetic gastropathy
## Radiolabel Meal Stability

<table>
<thead>
<tr>
<th></th>
<th>% Bound at 4 Hr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1 N HCl</td>
</tr>
<tr>
<td><strong>Liver</strong></td>
<td></td>
</tr>
<tr>
<td>Surface labeled</td>
<td>90%</td>
</tr>
<tr>
<td>In-vivo labeled</td>
<td>94%</td>
</tr>
<tr>
<td><strong>Eggs</strong></td>
<td></td>
</tr>
<tr>
<td>Two large natural</td>
<td>97%</td>
</tr>
<tr>
<td>Synthetic (Egg Beater)</td>
<td>97%</td>
</tr>
</tbody>
</table>
**Popular Standardized Meals**

**Whole Egg(Temple) Dual Isotope**

- **Solid Phase**
  - 500 µCi Tc-99m sulfur colloid
  - Two large eggs
  - Two pieces white toast

  Total = 282 kcal

- **Liquid Phase**
  - (125 µCi In-111 DTPA)
  - 300 cc water

**Tougas Meal**

- **Solid Phase**
  - 500 µCi Tc-99m sulfur colloid
  - 120 gm Egg Beater (equiv vol = 2 large eggs)
  - Two pieces white bread
  - 30 gm strawberry jam

  Total = 255 kcal

- **Liquid Phase**
  - 120 cc water
Meal Preparation
Microwave vs Skillet
Cooking - Microwave vs Skillet

Egg Labeling Methods for Gastric Emptying Scintigraphy Are Not Equivalent in Producing a Stable Solid Meal

Linda C. Knight\textsuperscript{1}, Steven Kantor\textsuperscript{1,2}, Siva Doma\textsuperscript{2}, Henry P. Parkman\textsuperscript{2}, and Alan H. Maurer\textsuperscript{1}

\textsuperscript{1}Division of Nuclear Medicine, Department of Radiology, Temple University School of Medicine and Hospital, Philadelphia, Pennsylvania; and \textsuperscript{2}Section of Gastroenterology, Department of Medicine, Temple University School of Medicine and Hospital, Philadelphia, Pennsylvania


\begin{table}
\centering
\begin{tabular}{llll}
\hline
Egg type & Method of cooking & \% Solids at 2 h & \% Solids at 4 h \\
\hline
Egg substitute & Griddle & 95.7 ± 1.1 & 96.4 ± 0.8 \\
Whole eggs & Griddle & 86.8 ± 5.3 & 80.7 ± 19.0 \\
Egg substitute & Microwave & 95.4 ± 1.6 & 96.2 ± 1.1 \\
Whole eggs & Microwave & 73.1 ± 12.4 & 42.5 ± 2.3 \\
\hline
& Incubation in human gastric fluid, pH 1.5 & & \\
Egg substitute & Griddle & 96.0 ± 3.0 & 95.5 ± 1.7 \\
Whole eggs & Griddle & 97.4 ± 0.3 & 97.9 ± 0.5 \\
Egg substitute & Microwave & 96.0 ± 2.9 & 95.2 ± 1.2 \\
Whole eggs & Microwave & 96.9 ± 0.6 & 97.3 ± 0.7 \\
\hline
& Incubation in HCl, pH 1.5 & & \\
\end{tabular}
\caption{Percentage of $^{99m}$Tc Remaining with Solid Egg}
\end{table}

\*P < 0.05 (by unpaired \textit{t} test).
\dagger P < 0.00005 (by unpaired \textit{t} test).
Generic Liquid Egg Substitutes - Jam
Gastric Emptying

Parameters

• Commonly in use
  – T 1/2
  – % Remaining at fixed time: 90 min, 2 hr, 3 hr, … 4 hr (95% conf interval)

• Other
  – Curve Fitting
    » Lag phase and rate of emptying
  – Dynamic antral contraction studies
    » Frequency of contractions
    » Amplitude of contractions
  – Two compartment: fundal/antral emptying
  – Fundal accomodation studies
  – Whole abdomen analysis
Need for 4 Hr Gastric Emptying

Extending Gastric Emptying Scintigraphy from Two to Four Hours Detects More Patients with Gastroparesis

JIN-PING GUO, ALAN H. MAURER, ROBERT S. FISHER, and HENRY P. PARKMAN, MD

Assessment of Gastric Emptying Using a Low Fat Meal
Establishment of International Control Values

Camera Acquisition - A-P(LAO), Upright, Positioning
Geometric Mean Attenuation Correction

Gastric Emptying Curves
Geometric Mean* vs Single View LAO

*GM = \sqrt{\text{Ant Cts} \times \text{Post Cts}}
Less Controversial
ROIs and Processing

1. Manual, irregular computer regions of interest drawn to obtain gastric counts (volume remaining)
2. Correction for physical decay (scatter, if dual isotope)
3. Attenuation Correction
   a. Geometric Mean (Ant X Post)$^{1/2}$
   b. LAO view
4. Plot % retention normalized to 100% at t=0
Manual ROIs: Global, Fundus, Antrum
Can Automated Edge Detection Be Developed?
Gastric Emptying

**Results**

- Plot % remaining as function of time
- Report 2 hr(< 50%), and 4 hr(< 10%) values
  - May be discordant results Abn early vs Abn late
- Rapid GE = <35% at 1 hr
## Analysis - TUH Excel Spreadsheet

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time</td>
<td>Anterior</td>
<td>Posterior</td>
<td>Geom Mean</td>
<td>Decay Corrected</td>
<td>% Remaining</td>
<td></td>
<td></td>
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<tr>
<td>0</td>
<td>43,581</td>
<td>13,111</td>
<td>23,904</td>
<td>23,904</td>
<td>94</td>
<td></td>
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<tr>
<td>15</td>
<td>48,326</td>
<td>12,517</td>
<td>24,595</td>
<td>25,308</td>
<td>100</td>
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<tr>
<td>30</td>
<td>43,686</td>
<td>10,551</td>
<td>21,469</td>
<td>22,733</td>
<td>90</td>
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<td>45</td>
<td>47,069</td>
<td>9,791</td>
<td>21,467</td>
<td>23,390</td>
<td>92</td>
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<tr>
<td>60</td>
<td>38,415</td>
<td>6,604</td>
<td>15,928</td>
<td>17,857</td>
<td>71</td>
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<tr>
<td>75</td>
<td>30,954</td>
<td>5,663</td>
<td>13,240</td>
<td>15,274</td>
<td>60</td>
<td></td>
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<td></td>
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<tr>
<td>90</td>
<td>25,992</td>
<td>4,282</td>
<td>10,550</td>
<td>12,524</td>
<td>49</td>
<td></td>
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<tr>
<td>105</td>
<td>16,043</td>
<td>2,704</td>
<td>6,586</td>
<td>8,046</td>
<td>32</td>
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<tr>
<td>120</td>
<td>7,290</td>
<td>1,574</td>
<td>3,387</td>
<td>4,258</td>
<td>17</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**DATE**

### % Remaining

**Graph 1:**
- X-axis: Time (min)
- Y-axis: % Remaining

**Graph 2:**
- X-axis: Time (min)
- Y-axis: % Remaining

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Commercial Analysis (GE)
Data Analysis: Curve Fitting

Geometric mean counts fit to a modified power exponential function:

\[ \% \text{Retention} = 100(1-(1-e^{-\kappa t})\beta) \]

![Graph showing the fit of data to the modified power exponential function.](image)
Normal Dual Isotope Gastric Emptying

Tc-99m Solid Phase

In-111 Liquid Phase

Solid Phase

Liquid Phase

% Gastric Retention

Time (min)

0 60 120 180 240

0 25 50 75 100

T = 0 min

T = 30 min

T = 60 min

T = 120 min

T = 240 min
Diabetic Gastroparesis
Antral retention
Normal at 2 hr - Abn at 3,4 hr
Fundal Retention Pattern

![Graph showing gastric retention over time](image)
Transplant: Must Rule Out Obstruction
Rapid Gastric Emptying
“Dumping Syndrome”
Limitations of Current Gastric Emptying Scintigraphy

• Not Sufficient Test To Explain All Upper GI Dyspepsia
  – Less than 50% patients with typical symptoms have abnormal gastric emptying

• Limited to physiology of “emptying” need to evaluate other factors:
  – Gastric accommodation response (40% abn in dyspepsia)
  – Fundal antral coordination
  – Antropyloric coordination
  – Gastric arrhythmias

• Need to address rapid emptying
SPECT Gastric Volumes
Prolonged Accomodation Response

Pre Meal Ingestion
20 min Post Meal Ingestion
2 Hr Post Meal Ingestion
Gastric Accomodation Studies

<table>
<thead>
<tr>
<th></th>
<th>Erthyromycin</th>
<th>Control</th>
<th>Isosorbide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasting</td>
<td>180 cm³</td>
<td>165 cm³</td>
<td>225 cm³</td>
</tr>
<tr>
<td>Postprandial</td>
<td>575 cm³</td>
<td>734 cm³</td>
<td>753 cm³</td>
</tr>
</tbody>
</table>

300 ml 300 Kcal Ensure 3 min
Gastric Accommodation Response

![Images showing the gastric response at different times: T = 0 min, T = 20 min, T = 60 min.]

![Graph showing the percentage of baseline for total and gastric retention over time.]

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Loss of Fundal Accomodation
Using this, we found that diabetic gastroparetic patients have delayed proximal gastric emptying in addition to antral hypomotility. More recently, we correlated regional GE with symptoms. An initially delayed proximal gastric emptying is seen in GERD. In contrast, an initially rapid proximal gastric emptying is seen in the dyspeptic symptoms of upper abdominal fullness, nausea, and vomiting. These results suggest that excessive fundic relaxation with impaired contraction is present in GERD. Proximal gastric accommodation appears impaired in functional dyspepsia.
Regional GE - Better Correlation with Symptoms

Table 5B. Odd Ratios for the chance of delay total, proximal, and distal gastric emptying in patients with each of the upper GI symptom*

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Odd Ratio</th>
<th>95 % CI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nausea</td>
<td>Total GE</td>
<td>2.51</td>
<td>0.72-8.73</td>
</tr>
<tr>
<td></td>
<td>Prox GE</td>
<td>4.5</td>
<td>1.26-16.11</td>
</tr>
<tr>
<td></td>
<td>Dist GE</td>
<td>2.8</td>
<td>0.50-15.87</td>
</tr>
<tr>
<td></td>
<td>Total GE</td>
<td>5.19</td>
<td>1.43-18.89</td>
</tr>
<tr>
<td>Vomiting</td>
<td>Prox GE</td>
<td>5.54</td>
<td>1.46-21.08</td>
</tr>
<tr>
<td></td>
<td>Dist GE</td>
<td>5.11</td>
<td>1.22-21.37</td>
</tr>
<tr>
<td>Heartburn</td>
<td>Total GE</td>
<td>2.16</td>
<td>0.57-8.20</td>
</tr>
<tr>
<td></td>
<td>Prox GE</td>
<td>1.83</td>
<td>0.55-6.13</td>
</tr>
<tr>
<td></td>
<td>Dist GE</td>
<td>1.04</td>
<td>0.22-4.93</td>
</tr>
<tr>
<td></td>
<td>Total GE</td>
<td>2.51</td>
<td>0.70-9.01</td>
</tr>
<tr>
<td>Acid regurg</td>
<td>Prox GE</td>
<td>3.72</td>
<td>1.04-13.31</td>
</tr>
<tr>
<td></td>
<td>Dist GE</td>
<td>3.16</td>
<td>0.56-17.87</td>
</tr>
<tr>
<td></td>
<td>Total GE</td>
<td>2.08</td>
<td>0.51-8.4</td>
</tr>
<tr>
<td></td>
<td>Dist GE</td>
<td>2.08</td>
<td>0.34-12.54</td>
</tr>
<tr>
<td></td>
<td>Total GE</td>
<td>0.52</td>
<td>0.13-2.05</td>
</tr>
<tr>
<td>Anorexia</td>
<td>Prox GE</td>
<td>0.81</td>
<td>0.24-2.76</td>
</tr>
<tr>
<td></td>
<td>Dist GE</td>
<td>0.43</td>
<td>0.08-2.42</td>
</tr>
</tbody>
</table>

* Mantel-Haenszel test adjusted for sex
Antral Contraction Studies
Antral Contraction Studies
Dynamic Antral Contraction Scintigraphy (DACS)

Dynamic acquisition every 1 second allows gastric antral contractions to be characterized noninvasively with scintigraphy; both the frequency and an estimate of the contractions can be obtained.

With a region of interest drawn around the mid antrum, the time activity curves show the counts oscillate at about 3 contractions per minute. The amplitude of the FFT analysis gives an approximation of the ejection fraction (contraction strength).
Fourier Analysis

MALE SUBJECT

Frequency (cycles/min)

3.0 cycles/min

FEMALE SUBJECT

Frequency (cycles/min)

3.6 cycles/min
Gastric Emptying Parameters

<table>
<thead>
<tr>
<th></th>
<th>MALE</th>
<th>FEMALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>T 1/2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>0.01</td>
<td>0.03</td>
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</table>

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Future?
Direct New Therapies
Pre/post Gastric pacing
Whole Gut Transit Scintigraphy (Gastroenterocolonic)

Gastric Emptying

Small Bowel Transit

Colon Transit

T=0

T=90

T=48 Hrs
Rational for Whole Gut Transit

Symptom Overlap*

- **Esophageal**
  - Dysphagia, heartburn, chest pain, regurgitation

- **Gastric***
  - Early satiety, distention, bloating, nausea/vomiting, postprandial pain/discomfort

- **Gastroesophageal Reflux**
  - Chest pain

- **Small intestinal***
  - Abdominal distention, bloating, nausea/vomiting, postprandial pain/discomfort

- **Colon**
  - Constipation, diarrhea, fecal incontinence, abdominal pain

- **Gallbladder**
  - Right upper quadrant, back pain
Value of Whole Gut Transit Study

- Symptom overlap

- Only up to 50% patients with upper GI dyspepsia thought to have gastroparesis will have abnormal gastric emptying
Anatomy: Distal Small Bowel and Colon
Normal: Liquid DTPA Study
Percent Filling of TI+CAC

Cecum/Ascending

TI Reservoir

Total TI+CAC

Mean ± 2 S.D. @ 6h

% TI-CAC Mean

0 10 20 30 40 50 60 70 80 90 100

HOURS

Mean- 2 S.D.@ 6h
Normal
Colonic Inertia

48 Hr GC = 1.42

72 Hr GC = 1.63

24 Hr GC = 1.83

72 Hr GC = 2.61

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48 Hr GC = 4.58
72 Hr GC = 5.29
24 Hr
48 Hr=5.38
72 Hr=5.82
Generalized Slow Transit

48 Hr GC = 2.81

72 Hr GC = 5.08

24 Hr

48 Hr = 3.19

72 Hr = 5.63
Colon Transit - Geometric Center Analysis and Diagnostic Subtypes

Colonic Inertia

Generalized Slow Transit

Functional Outlet Obstr

GC<4.1@48hr and 72hr

GC<4.1@48hr and (4.1-6.2)@ 72hr

GC>4.1@48hr and < 6.2@72hr

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Why A Gastric Emptying Consensus?

- Better Patient Care - requires standardization
- Preserving a scintigraphic “Gold standard”
- Prepare for “Pay for Performance”
  – Combined effort multiple professional societies
The Issues

• Gastroenterologists unhappy

• New modalities threaten future utilization of scintigraphy for gastric emptying studies

• Patients unhappy
The Issues (cont)

- Gastroenterologists unhappy
  - GE results vary from site to site, comparisons not possible
  - Standards already being established
    » NIH Gastroparesis Research Consortium
    » $15 million, study 1000 patients, began Dec 2006
    » Established a standardized GE test

Gastroparesis Registry

This study is currently recruiting patients.

Sponsored by: National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK)
Information provided by: National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK)
ClinicalTrials.gov Identifier: NCT00398801

Purpose

The Gastroparesis Registry (GpR) is an observational study to clarify the epidemiology, natural history, clinical course, and other outcomes of gastroparesis.
The Issues (cont.)

• New modalities threaten utilization of scintigraphic gastric emptying studies
  – Office Based
  – Non “nuclear” (no radiation exposure)
    » Breath testing
    » Smart Pill
The Issues (cont.)

- Patients unhappy - Feedback from GPDA
  - Need for repeat studies
    » Different doctors
    » Different test protocols/meals
    » Insurance issues
Consensus: Methodology

- Joint project of the Society of Nuclear Medicine (SNM) and the American Neurogastroenterology and Motility Society (ANMS)
- Contributors
  - Academic
  - Private Practice
- Proposed to SNM Procedure Guidelines Committee (Nov 2005)
- Conjoint meetings
  - Philadelphia (April 2006)
  - San Diego (SNM) (June 2006)
  - Boston (ANMS) (Sept. 2006)
  - Final draft (March 2007)
- Final draft manuscript approval (May/June 2007)
  - SNM GI Council
  - SNM Procedure Guidelines Committee and SNM Board
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  – Paul Shreve, MD; Advanced Radiology, P.C. and Spectrum Health
  – Harvey A. Ziessman, MD; Johns Hopkins University School of Medicine
Consensus Recommendations for Gastric Emptying Scintigraphy: A Joint Report of the American Neurogastroenterology and Motility Society and the Society of Nuclear Medicine


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Limitations - Current SNM Guideline

• SNM Guidelines and Communications Committee (GCC) was established 1998

• Guiding Principles:
  – “After much discussion”, it was felt that the guidelines should not describe optimal cutting edge technology
    » but should describe the current “best practice”
  – Should include “all acceptable variations” in practice
    » Often dictated by the resources and expertise at a particular facility
    » Assuming a panel of experts found those practices to be acceptable

Courtesy Kevin Donahoe, MD
Goals - ANM/ANMS GE Consensus

• Provide a single, standardized protocol
  – Based on large number of normals and well documented normative data

• Meet the needs of clinicians
  – Clinical results meaningful (site to site)

• Meet the needs of imaging specialists
  – Cost/time/scheduling and equipment needs vs current reimbursement

• Meet the needs of patients
  – Diagnostic results which direct management
  – Consistent results pre/post therapy

• **Address those items in most immediate need of standardization**
  – The meal
  – The frequency of imaging
  – Duration of the test
  – Normative data
Items - Not Addressed

• Technical factors
  – Already covered in current SNM Procedure Guideline

• Unresolved Questions
  – Many questions raised that need to be addressed in the future are delineated
Consensus - Summary

• ANMS and SNM recommend a standardized method for measuring gastric emptying by scintigraphy (GES)
• Protocol uses a low-fat, egg white meal with imaging at 0, 1, 2, 4 hours after meal ingestion
• Normal data from multicenter study (Tougas et al)
  – Provides information about normal and abnormal gastric emptying
    » rapid
    » delayed
• Promote standardization by providing
  – Sample patient instructions, sample questionnaires and report content
• Adoption of this standardized protocol will:
  – Resolve the lack of uniformity of testing
  – Add reliability and credibility to the results
  – Improves the clinical utility of the gastric emptying test.
Consensus Elements

• **Patient preparation**
  – Sample patient instruction sheet
  – Symptom questionnaire

• **Meal, preparation, and ingestion**
  – 4 oz liquid egg white, bread, jam, water
  – Eggs cooked skillet or microwave
  – Ingested within 10 minutes

• **Image Acquisition**
  – Minimum 1hr/2hr/4hr Ant/Post images
  – Dynamic imaging not excluded

• **Image Analysis**
  – Manual ROI, total gastric counts
  – Geometric mean, decay corrected total gastric counts

• **Report elements**
  – % retained (1hr/2hr/4hr); (graph & dynamic optional)
  – **Fasting blood glucose if diabetic**
  – Medications at time of study
  – Total % meal ingested
  – Other findings: reflux, hiatal hernia…
Patient Prep and Instructions

- Fasting (overnight or min 6 hrs)
- Medications (Listing those to stop, no tobacco day of study)
- Diabetics (Insulin(1/2), glucose < 275)
- Female patients
  - Pregnancy
  - Menstrual cycle (early cycle)
- Description of test procedure
  - Meal
  - Duration of testing
  - Activity between images
Sample Patient Info Questionnaire

• Main symptom(s)

• Concurrent medications
  – Pain, promotility
  – Other

• Prior GI tract surgery
Report Content

- Medications at time of study
- Pre meal serum glucose (if known diabetic)
  - Treat if > 275 mg/dL
- Amount of meal ingested
  - Time to ingest meal
- Evidence of rapid GE:
  - 1 hour % retained
- Evidence of delayed GE:
  - 2 and 4 hour % retained
- Other findings
The Tougas EggBeaters® Meal

- Low fat egg whites
- Radiolabeled with 0.5 -1 mCi Tc 99m
- Served with toast, jam, water
- Imaging at 0, 1, 2 and 4 hr
Tougas - Normal Subject Results

- 123 Normal volunteers
- 11 International centers
- Median retention values
  - 1 hr = 64%
  - 2 hr = 24%
  - 4 hr = 1%
- Abnormal values (95% confidence intervals)
  - > 60% at 2 hr
  - > 10% at 4 hrs
Male vs Female Normal Values

![Diagram showing comparison of gastric retention between males and females at different time points (1 hr, 2 hr, 4 hr). The chart indicates statistically significant differences between the genders with p-values P < 0.002, P < 0.0001, and P < 0.2 for 1 hr, 2 hr, and 4 hr respectively.]

Tougas Dig Dis Sci: 46, 24-29 2001

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Gastric Emptying vs Age

Tougas Dig Dis Sci: 46, 24-29 2001
### Table 2: Future Issues

1. Interpretation of discordant results for delayed gastric emptying (2 vs 4 hour)
2. Optimization of the specific time points used for imaging
   - A. Use of 0.5 or 1 hour result for detection of rapid gastric emptying.
   - B. Use of 3 hour result vs 2/4 hour results for detection of delayed GE.
3. Better define patient-related factors: Age, Gender (Menstrual cycle), Weight and BMI
4. Need for a larger database for normal early values at 30 vs 60 min of gastric emptying
5. Evaluation of alternative meals
   - A. For patients allergic to eggs
   - B. For patients with gluten sensitive enteropathy
   - C. Use of different meals with different caloric/fat challenges.
6. Management of diabetic patients
   - A. Assessment of glucose in diabetic patients prior to the test: glucose and Hgb-A1c.
   - B. Management of hyperglycemic patients on day of test
   - C. Administration of insulin and oral hypoglycemic agents
   - D. Need for monitoring postprandial glucose
7. Need for data base of “normal” values for post surgery patients
8. Clinical value of additional characterization of gastric emptying
   - A. Regional analysis of gastric emptying (antral and fundal measurements)
   - B. Lag phase analysis
   - C. Use of curve fitting techniques to analyze the time activity points
   - D. Dynamic antral contraction studies
   - E. Fundal accommodation studies with SPECT
9. Clinical value of liquid phase gastric emptying
Clinical Applications of GI Scintigraphy

- **Oropharyngeal function**
- **Esophageal motility and GERD**
  - Not primary screen
  - Equivocal findings from manometry, barium studies
- **Gastric Motor Function**
  - Gold standard for diagnosis of gastroparesis
  - Evaluation of “Nonulcer dyspepsia”
    - Fundal accommodation, DACs (antral contraction)
  - Postgastrectomy syndromes- rapid emptying (“dumping”)
- **Whole gut transit studies: GE + Small Bowel + Colon Transit**
  - Chronic constipation - colon transit
  - Diagnose Diffuse GI Dysmotility/symptoms overlap - whole gut
- **Hepatobiliary Studies**
  - Calculous/achalcalculous disease
  - Biliary dyskinesia
- **GI Bleeding**
  - Methods: Cine scintigraphy, Labeled RBCs vs Colloid
  - Meckles diverticuli
Causes of Delayed Gastric Emptying

- **Anatomic obstruction**
  - Peptic ulcer, tumor, pyloric hypertrophy
- **Drugs**
  - Anticholinergics, opioids
- **Electrical disorder**
  - Tachygastric
- **Metabolic**
  - Electrolyte, diabetic acidosis, uremia
- **Neurologic**
  - Diabetic gastroparesis
  - Vagotomy
    » Cardiac, pulmonary transplantation
- **Systemic Diseases**
  - Scleroderma, amyloidosis