Esophageal Transit Scintigraphy
New Concepts On An Old Test

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Goals

• Define the clinical problem of dysphagia
• Review diagnostic tests for dysphagia
• Define the spectrum of esophageal motility disorders
• Present historical review of methods used for esophageal transit scintigraphy(ETS)
• Present one consolidated method for performing ETS
  – Combines ETS and GER study
  – Emphasis on personal (Temple) experience
• Example case studies
  – Primary esophageal motility disorders
  – Gastroesophageal reflux

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Dysphagia

• Definition
  – Sensation of difficulty swallowing

• Etiology
  – Usually caused by an esophageal motility disorder
    » Must exclude an anatomic/obstructing lesion

• Prevalence
  – 2-15% (Mid to Elderly aged population)
Diagnostic Tests for Dysphagia

• **Esophageal manometry**
  - Gastroenterologists’ “gold standard”
    » Disadvantages:
      • Invasive
      • Not routinely available
        – specialized expertise

• **Barium Esophagography (Video Esophagram)**
  - Widely available
  - Anatomic and physiologic information
  - Disadvantage
    » Qualitative (Non-quantitative)
      • Difficult to compare pre/post therapy studies

• **Esophageal Transit Scintigraphy**
  - Non-invasive, physiologic
  - Quantitative (Pre/Post Therapy)
  - Disadvantage
    » Lack of standardization
    » Mixed results
    » Poor acceptance
Normal Manometry/Ba Swallow

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Primary Esophageal Motility Disorders (Spectrum)

Non-Specific Esophageal Motility Disorders (NEMD)
- Acid/Reflux Induced

Diffuse Esophageal Spasm (DES)
- Nutcracker Esophagus
- Hypertensive LES
- Vigorous Achalasia

Scleroderma Achalasia
Manometric Criteria: Achalasia

- Hypertensive lower esophageal sphincter (> 30 mm Hg)
- Incomplete sphincter relaxation
- Absent peristalsis
- Elevated intraesophageal pressure (> gastric)
Manometric Criteria : Scleroderma

- Low - to - absent LES pressures
- Weak - to - absent peristaltic contractions in the distal 1/3 rd of esophagus
- Normal peristalsis and sphincters in the upper 2/3 rds of esophagus
Manometric Criteria: Diffuse Esophageal Spasm

- Repetitive, nonperistaltic (simultaneous) contractions
- Increased duration of contractions (> 7.5 sec)
- Spontaneous motor activity
- Intermittent normal peristalsis
- Increased amplitude contractions ( >200 mm Hg)
- LES abnormality in 1/3rd of patients
Esophageal Transit Scintigraphy
Historical Background

• 1980’s - Initial Studies
  – High sensitivity
  – Limited data on specificity

• Early 1990’s - Further Studies
  – Lower sensitivity (42-56%)
    » Especially for disorders with high amplitude contractions (DES), NEMD, or isolated elevation of LES pressure

• 1995
  – “Esophageal transit scintigraphy was introduced over 20 years ago, but its exact role in the evaluation of patients with suspected esophageal motility disorders till remains controversial” Klein HA, Sem Nucl Med. 25, 1995, pp 306-317

• 1996

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What is the number of swallows required to detect an abnormality?

- Up to 5 swallows (95% confidence interval)

What is best bolus composition?

- Water
- Semi-solid (cereal)
- Gelatin
Methods and Components for ETS (Currently No One Method Widely Accepted)

- **Total ("Global") Esophageal Transit/Clearance**
  - Single swallow esophageal transit time
  - Global clearance over many swallows (up to 10 minutes)

- **Regional Transit Analysis**
  - Upper, Middle, Lower thirds analysis
    - Cine Display visual review of bolus transit
    - Condensed images

- **Combination of both above**
Processing and Display
Normal Esophageal Transit - Initial Single Swallow

Cine

Upper

Middle

Lower

NI ETT < 14 sec
Single Swallow Analysis
- Esophageal Transit Time

- **Kazem** *(AJR 115:681–688, 1972)*  
  - ETT < 8 sec, LES relaxation < 5 secs
- **Russell** *(Gastroenterology 80:887–892, 1981)*  
  - 7.2 ± 1.7 sec
- **Blackwell** *(Gut 24:421–426, 1983)*  
  - 7.3 ± 2.3 sec
- **Holloway** *(Dig Dis Sci 34:905–912, 1989)*  
  - 9.6 sec (range 6-15 sec)
- **Parkman** *(Dig Dis & Sci 41:1355-1368, 1996)*  
  - < 12 sec (includes LES relaxation time)

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Processing and Display
Normal Global Clearance - Multiple Swallows

Cine

Region of Interest
Entire Esophagus

15 sec  30 sec  60 sec
2 min   3 min   4 min
6 min   8 min   10 min

Normal < 18% at 10 min

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Global Clearance: Normal vs Abnormals

Tolin et al: Gastroenterolgy 1402-8, 1979

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Formation of Esophageal Condensed Images


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Condensed Images

Mouth

Mouth

Mouth

Stomach

Stomach

Stomach

GER

DES

Achalsia


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Klein Residual Fractions (Multiswallow Study)

RF1 = 25%
RF2 = 10%
RF4 = 5%

Esophageal Transit Scintigraphy (ETS)

Temple University Hospital Method

- ETS - performed two parts - first supine and then upright imaging after a practice swallow; 64x64 byte mode
  - Initial single swallow
    » 150µCi (5.55MBq) of Tc99m sulfur colloid in 15 mL of water
    » Dynamic cine acquired @ 0.25 sec/image for 30 sec to record esophageal transit through upper, middle, lower 1/3rds of the esophagus
      - Cinematic visual inspection regional transit
      - Regional analysis and esophageal transit time(sec)
  
- Multiple sequential swallows
  » Serial dry swallows @ 30 second intervals for 10 minutes to record esophageal clearance of any remaining activity (15 sec/image
    - Cinematic visual inspection ? GER
    - Global clearance curve compared to primary motility disorders

- Always performed with a gastroesophageal reflux study
  » Additional 300 cc water/OJ
  » Abdominal binder pressures, 20/40/60/80/100 mmHg
GER Method - TUH

- 300 µCi (11.1 MBq) Tc99m sulfur colloid in 150 mL orange juice ingested
- Additional H₂O to bring total volume to 300 mL
- Imaging with abdominal binder at incremental pressures up to 100 mm Hg
- All images 128x128 byte matrix, 30 sec each
Normal GER Study

Cine

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1996 Study

Optimal Evaluation of Patients with Nonobstructive Esophageal Dysphagia Manometry, Scintigraphy, or Videoesophagography?

HENRY P. PARKMAN, MD, ALAN H. MAURER, MD, DINA F. CAROLINE, MD, DONALD L. MILLER, MD, BENJAMIN KREVSKY, MD, and ROBERT S. FISHER, MD

Digestive Diseases and Sciences, Vol. 41, No. 7 (July 1996), pp. 1355-1368
## Diagnostic Criteria for Interpreting ETS

<table>
<thead>
<tr>
<th>Condition</th>
<th>Single Swallow ETT (sec)</th>
<th>Esophageal Retention at 10 min (%)</th>
<th>Visual Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>≤14</td>
<td>≤18</td>
<td>normal progression bolus rapid clearance no GER</td>
</tr>
<tr>
<td>Achalasia</td>
<td>&gt;30</td>
<td>&gt;50</td>
<td>severe delay transit mid-distal 1/3 no change upright typical bird’s beak</td>
</tr>
<tr>
<td>Scleroderma</td>
<td>&gt;30</td>
<td>18≥E10≤30</td>
<td>delayed transit mid-distal 1/3 improvement with upright GER +/-</td>
</tr>
<tr>
<td>DES</td>
<td>&gt;14</td>
<td>18≥E10≥30</td>
<td>antegrade/retrograde transit mild retention +/-</td>
</tr>
<tr>
<td>Reflux Esophagitis</td>
<td>&gt;20</td>
<td>≤30</td>
<td>mild delay distal 1/3 mild retention distal 1/3 GER + single swallow GER + multi swallow localized antegrade/retrograde distal 1/3</td>
</tr>
</tbody>
</table>

*(Parkman et al: Dig Dis Sci. 41: #7, 1996)*
Optimal Evaluation of Patients with Nonobstructive Esophageal Dysphagia
Manometry, Scintigraphy, or Videoesophagography?

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<tr>
<th>TABLE 7.1. Sensitivity and Specificity of Esophageal Transit Scintigraphy and Videoesophagography Based on Manometric Diagnoses*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>------------------------------------</td>
</tr>
<tr>
<td>Esophageal transit scintigraphy</td>
</tr>
<tr>
<td>Achalasia</td>
</tr>
<tr>
<td>DES</td>
</tr>
<tr>
<td>Scleroderma</td>
</tr>
<tr>
<td>LES dysfunction</td>
</tr>
<tr>
<td>NSEMD</td>
</tr>
<tr>
<td>Videoesophagography</td>
</tr>
<tr>
<td>Achalasia</td>
</tr>
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<td>DES</td>
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<tr>
<td>LES dysfunction</td>
</tr>
<tr>
<td>NSEMD</td>
</tr>
</tbody>
</table>

*Adapted from Parkman et al.\(^5\)

DES, diffuse esophageal spasm; LES, lower esophageal sphincter; NSEMD, nonspecific esophageal motility disorder.
Esophageal Transit Scintigraphy (ETS) Conclusions 1996 Temple Study

- Limited value as screening test
  - Barium swallow most cost effective
- Helpful with conflicting or equivocal other tests
- Valid for quantification of response to therapy (mechanical or drug)
  - Quantification needs broader standardization
Our Experience Post 1996

• ETS ordered when manometry or barium swallow:
  – Not tolerated
  – Equivocal
  – Negative with a strong clinical suspicion especially of reflux
Clinical Role of Esophageal and Gastroesophageal Reflux Scintigraphy

P Kochan, AH Maurer, H P Parkman, J Guo, K V Panganamamula, L Cone, LC Knight, RS Fisher
Temple University School of Medicine
Philadelphia, PA

Results

- ETS ordered when other studies non diagnostic
- Of the patients referred for ETS/GERS
  - the most common referring symptom was GER
  - with a smaller number of pts with dysphagia and chest pain
- ETS/GERS led to
  - A change in diagnosis in 57%
  - A change in therapy in 69%
- The most common scintigraphic findings were:
  - GER 54%
  - Normal 31%
  - Other 15%
- To detect GER with max sensitivity a combined approach (ETS&GERS) should be done
Normal-Variants Single Swallow

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Regional Transit Curves

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Normal Multiswallow

Global Clearance Curve

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Achalasia (supine)

Regional Transit Curves
Achalasia (Supine)

Global Clearance Curve

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Scleroderma (Supine)

Regional Transit Curves

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Scleroderma (Erect)

Regional Transit Curves

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Scleroderma Multiswallow (Supine)

Supine Global Clearance Curve

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Scleroderma
Multiswallow Detection of GER

Global Clearance Curve

GER Binder Study

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Regional Curves

Erect

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Supine

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Global Clearance Curve

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Hypertensive LES

Global Clearance Curve

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HLES

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Erect

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Supine

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NEMD from Reflux

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NEMD from Reflux

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Gastroesophageal Reflux Scintigraphy (Performed with ETS)

- Limited Applications
- 24 hour pH probe “gold standard”
GER Seen Single Swallow

0 sec 2 sec 5 sec
8 sec 10 sec 15 sec
20 sec 25 sec 30 sec

Counts

Time in Milliseconds

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GER + Initial Swallow only

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GER + GER study only

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Cine

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GER+ Multiswallow Only

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GER positive all studies
Summary - ETS Current Indications

- Esophageal transit scintigraphy (ETS) and Gastroesophageal reflux scintigraphy (GERS) appear most useful to evaluate patients with reflux symptoms who are referred after nondiagnostic conventional studies (Manometry, pH probe, endoscopy, xray studies).

- Of additional value when quantitative measurement of response to therapy is needed.
  - Achalasia
Cases
Case #1

Upright

Supine

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QuickTime™ and a Cinepak decompressor are needed to see this picture.

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CXR Hiatal Hernia
Case #2

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Case #2 - Gastric Emptying

[

Graph showing gastric emptying with images and data points.]

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Case #2

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Case #3

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Upright  Supine

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Case 4

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Upright

Supine

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Case 4

Supine Multiswallow

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Case 5

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Case 5.2
Case 6

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Case 6

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Other Indications

- Oropharyngeal dysfunction
- Odynophagia
- Heartburn (GE Reflux)
- Chest pain
- Globus sensation
- Cough
- Aspiration
- Hoarseness
Achalasis Pre/Post Dilatation
Response to Therapy
Timed Barium Swallow

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Achalasia Pre/Post Rx

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Esophageal Regions of Interest

Upper
Middle
Lower

Summed Image