Pediatric GI Tract Imaging
An Overview

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Pediatric GI Tract Imaging
Common studies

- Aspiration/Swallowing Function
- Esophageal Motility/Clearance
- Gastroesophageal Reflux
- Gastric Emptying
- Meckel’s Imaging
- Inflammatory Bowel Disease
Aspiration

- Sources of aspiration include
  - Oropharyngeal secretions
  - Refluxed gastric contents
- The “standard” GE reflux study does not adequately evaluate aspirated oropharyngeal secretions
- Sidney Heyman developed a technique for studying the aspiration of oropharyngeal secretions – the Radionuclide Salivagram.
Salivagram Technique

- **Radiopharmaceutical:** Tc-99m Sulfur Colloid 200 uCi to 300 uCi per drop
- One or two drops of Tc-99m sulfur colloid are placed on the tongue of the patient to be studied
- The oral cavity becomes coated with radiolabeled colloid
- Dynamic images are obtained over the chest for 60 minutes to 90 minutes
- Further delayed images can be obtained if there is still colloid in the mouth at the end of the initial dynamic sequence
Salivagram

- Detection of aspiration has a low incidence in a standard GE reflux study
- Aspiration can occur as a result of swallowing dysfunction in the absence of GE reflux
- In Heyman’s study, the Salivagram detected aspiration in 29% of patients with recurrent pneumonia
- Higher concentration of radioactivity per volume aspirated is the likely reason for better detection
Salivagram

Image Courtesy of Sydney Heyman, M.D.
Esophageal Motility
Single Swallow

![Graph showing esophageal transit over time for different conditions.](attachment:image.png)
Multiple Swallow

![Graph showing esophageal transit percentage over the number of swallows for normal subjects, achalasia, diffuse spasm, and scleroderma.](image)
Achalasia: Pathophysiology

- Loss of ganglion cells in the smooth muscle of the distal esophagus
- Increased Lower Esophageal Sphincter (LES) pressure
- Decreased to absent peristalsis in the distal esophagus
- Absence of coordinated LES relaxation in response to swallowing
- Dilation of the esophagus, especially distally
Clinical Presentation

- Low Incidence < 10 cases per million
- Age: infant to adult with peak age 20-40
- Sex Male = Female
- Not Familial

Clinical Symptoms
- Difficulty swallowing solid foods
- Regurgitation of undigested food (80% to 90%)
- Retrosternal chest pain (25% to 50%)
- Cough at night/aspiration (30%)
- Weight loss
Diagnosis

- Barium Swallow
- Esophageal Manometry
- Scintigraphy
Scintigraphic Technique

- Radiopharmaceutical: 1 mCi Technetium-99m Sulfur Colloid
- Mixed in 4 to 6 oz milk and poured over a single serving size package of cereal
- Patient sits upright in front of the camera and consumes meal with the camera running
- 15 second dynamic images obtained for 30 minutes
- ROI drawn over esophagus and stomach.
- Results are expressed as percent of total meal at peak activity in esophagus and percent retained every five minutes
Esophageal Motility
### Clearance Data Normal Patient

#### Esophageal Clearance

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<th>Time (min)</th>
<th>Activity</th>
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<tr>
<td>10</td>
<td>2.08</td>
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<td>15</td>
<td>2.69</td>
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<tr>
<td>20</td>
<td>1.50</td>
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<tr>
<td>25</td>
<td>1.86</td>
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<tr>
<td>30</td>
<td>1.99</td>
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Peak Activity of 20.1% occurred @ 1.5 min
Achalasia

- Esophageal Clearance

- Peak Activity of 96.9% occurred at 2.7 min

<table>
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<tr>
<th>Time (min)</th>
<th>5</th>
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<th>15</th>
<th>20</th>
<th>25</th>
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<tr>
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<td>42.6</td>
<td>39.7</td>
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Treatment

- **Drugs**
  - Calcium channel blockers
  - Anticholinergic agents
  - Nitrates
  - Opioids
- **Botox**
- **Balloon Dilation**
- **Esophageal Myotomy**
Following Balloon Dilation
Curves Post Dilation

**Esophageal Clearance**

<table>
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<td>25</td>
<td>2.11</td>
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<tr>
<td>30</td>
<td>1.92</td>
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</table>

Peak Activity of 26.7% occurred at 2.0 min.
GE Reflux In Children

- Most studies are performed on infants and small children.
- Reflux may normally occur in children under six months of age.
- Lower Esophageal Sphincter matures by six months of age.
- It is important to distinguish between rapidly cycling reflux and delayed esophageal clearance.
GE Reflux Technique

- **Radiopharmaceutical:** Tc-99m Sulfur Colloid, 1 mCi administered in a milk meal
- **Dynamic images are obtained at 3 to 5 second intervals over 60 minutes**
  - Short cycling reflux events can “disappear” in frames as short as 10 seconds
- **Images are obtained in posterior projection so that the patient can be adequately monitored**
- **Dynamic images are obtained again for 15 minutes at 2 hours to look for late reflux**
  - Some patients reflux only after the meal becomes acidified
- **Images to calculate gastric emptying and to look for aspiration can also be obtained as part of the GE reflux study**
Low level reflux events in the first 15 minutes after feeding are not considered to be pathologic.

When esophageal motility is normal reflux events clear within 20 seconds:
- Distention of the distal esophagus initiates a secondary stripping wave.

Reflux to the level of the oropharynx places the patient at risk for aspiration.

Report frequency, level, and duration.
Low Level Reflux
Mid-Level GE Reflux
Short Cycle GE Reflux
Normal Clearance
Slow Clearance
(5 Seconds per Frame)
Reflux to Oropharynx
10 Second Composite
(Reflux Disappears)
Aspiration Secondary to T-E Fistula
Chronic Cough/Recurring Pneumonia
Reflux Study
Quantitative Evaluation of Reflux
Reflux Curves
Quantitation

Graph showing the G-E reflux index (%) for reflux patients and normal controls. The data points are distributed across the graph, with some points highlighted at specific reflux indices: 45.6, 33.3, and 27.5.
GE Reflux Scintigraphy vs pH Probe

- **pH probe cannot evaluate the volume or level of reflux**
  - pH probe cannot tell the difference between 0.1 cc of reflux and 100 cc of reflux
  - pH probe cannot tell whether reflux is just across the LES or to the level of the cricopharyngeus

- **pH probe poorly characterizes reflux**
  - pH probe cannot tell the difference between rapidly cycling reflux and delayed esophageal clearance
  - This is a major determinant of therapy

- **pH probe can study the patient over a longer period of time**

- **pH probe can detect smaller volume infrequent reflux**

- **pH probe should be used to screen patients with a negative GE reflux scintigraphic study**
Scintigraphy vs pH Probe
Gastric Emptying

- Standard composition meal is more difficult to obtain in small children
- Minimum meal in a newborn is 4 ounces of infant formula.
- Age specific normals have been published for small children, however at least 50% emptying at one hour and 75% emptying at 2 hours are approximately the normal range.
- Greater than 20% emptying at T₀ qualifies for dumping
  – Caveat: If the patient is fed by tube or via gastrostomy and the tube tip is close to the pylorus, artificial dumping can occur.
- Once a child’s GI tract is mature enough for a standard gastric emptying meal, we use our standard solid emptying meal.
- If GE reflux is part of the clinical question, we will continue to use a milk meal.
Technique

- Add 1 mCi of Tc-99m sulfur colloid to 2/3 of the volume of a milk meal. The final 1/3 is administered as a “cold chaser” to clear radioactivity from the mouth and esophagus.
- The meal is administered within a 15 minute time interval.
- Images can be obtained dynamically as part of a GE reflux study or as static images immediately post feeding and every 15 minutes for 2 hours.
Determinants of Gastric Emptying

- Volume
- Calories
- Fat content
- Osmolality
- Rate of administration
  - Meal should be consumed within 15 minutes (before any emptying can start)
Milk Meal

- The meal volume administered for a milk meal is proportional to the patient size
  - Since volume is a determinant of gastric emptying, for any size patient the meal should be similar in volume
  - Very small volumes or very slow administration rates will produce invalid results

- Once the meal becomes acidified, milk empties like a solid

- You must have a normal range for the meal you are using

- Most of the Tc-99m sulfur colloid empties with the solid phase of the meal
Meckel’s Diverticulum

- Omphalomesenteric duct remnant containing mucosa from throughout the GI tract
- Occur at the insertion point of the vitelline duct on the antimesenteric surface of the small bowel (approximately 2 ft from the ileocecal valve)
- Incidence: 2% of the population
- Only about 25% of Meckel’s diverticula contain gastric mucosa
  - Virtually all bleeding Meckels contain gastric mucosa
  - Remainder present as lead points for small bowel obstruction
- 4% to 6% lifetime risk of complication
- Treatment is surgical resection
Patient Prep

- NPO for four to six hours (depending on patient’s age)
- Meckel’s scan should be done before other diagnostic studies to avoid potential artifacts
- Patient should have had none of the following for at least 5 days:
  - Laxatives
  - Aspirin or NSAIDs
  - Endoscopies
  - Barium
Meckel’s Scintigraphy

- Inject 100 uCi/kg body weight Tc-99m pertechnetate IV (min dose 1 mCi/max dose 10 mCi)
- Image dynamically for 45 minutes (one minute per frame, 128 matrix) with patient in the LPO position relative to the table and the camera anterior to the patient
  - This helps to keep secreted Tc-99m pertechnetate in the stomach
- Obtain static images in Anterior, LAO, RAO, post void and Trendelenberg positions at the end of the dynamic sequence
Pharmacologic Intervention

- Cimetadine – blocks release of accumulated activity from the mucosal production site (holds the activity in place)

- Pentagastrin – increases gastric secretion
  - May dilute the secreted activity
  - May increase gastric motility
  - Subcutaneous injections are painful

- Glucagon – paralyzes bowel

- Value is largely anecdotal (case reports), but widely employed.

- In a study of a dog model several years ago, it took computer analysis of counts in the lesion to show a benefit for intervention.
Normal Meckel’s Scan
Meckel’s Diverticulum

Immediate  
5 Minutes  
10 Minutes

20 Minutes  
LAO  
Trendelenberg
Intraluminal Pertechnetate
Jejunal Inflammation Due to Aspirin
Appendicitis
Meckel’s Diverticulum
Small Bowel Duplication

Case Courtesy of Michael Gelfand, M.D.
Inflammatory Bowel Disease

- Labeled White Blood Cells
  - In-111 labeled WBCs
  - Tc-99m HMPAO labeled WBCs

- Technetium labeled WBCs are preferred in children because of lower radiation dose
  - Tc-99m HMPAO WBC: Spleen 1.8 rad/mCi, WB 0.2 rem/mCi
  - In-111 WBC: Spleen 63 rad/mCi, WB 6.7 rem/mCi

- Sensitivity ranges from 90% to 97%
- Specificity ranges from 97% at 1 hour to 83% at 3 hours
  - Specificity decreases because of physiologic excretion
Inflammatory Bowel Disease

- **Crohn’s Disease**
  - “Skip” Lesions in colon
  - Involves small bowel as well as colon
  - Involves the full thickness of the bowel wall
  - Incidence 7 per 100,000

- **Ulcerative Colitis**
  - Continuous involvement of colon
  - Starts at the rectum and progresses proximally
  - Involvement limited to the mucosa
  - Does not involve small bowel
  - Incidence 10 to 15 per 100,000
Signs and Symptoms

- Similar for both Crohn’s and Ulcerative Colitis
- Chronic diarrhea
- Abdominal pain and cramping
- Blood in stools
- Loss of appetite
- Weight loss
- Fever
Tc-99m HMPAO WBC Imaging

- Inject 5mCi to 10 mCi Tc-HMPAO labeled WBCs, based on weight
  - Approximately 100 uCi/kg

- Obtain early static images with high resolution collimator 30 to 60 minutes post injection
  - Supine, standing upright, and TOD images for 10 min/image
  - Upright images drop transverse colon away from liver
  - TOD separates bladder from rectum

- Obtain delayed images 2 to 3 hours post injection

- Physiologic activity in bowel may appear by 3 hours
  - Usually appears first in the right lower quadrant and then moves distally
Normal WBC Imaging

1 Hour

3 Hours

Charron: Radiology 1999: 212:507-513
HMPAO WBCs at 4 Hours
Crohn’s Disease

Crohn’s Disease
Crohn’s Disease In-111 WBCs
Ulcerative Colitis

Charron: Radiology 1999; 212:507-513

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Ulcerative Colitis

Charron: Radiology 1999; 212:507-513

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Advantages of WBC Scintigraphy

- More accurate than colonoscopy (90% vs 80%)
- No false positives in controls
- Noninvasive
- Reflects the intensity and distribution of the inflammatory process
- Radiation dose is 1/3 to 1/2 of barium studies
- Positive result within 30 minutes in 88%
- No bowel prep is required
Limitations of WBC Scintigraphy

- Requires in vitro WBC labeling
- Does not define anatomic details (strictures)
- Distinction between colon and small bowel may be difficult due to paucity of anatomic landmarks when inflammation is focal
- Concurrent GI bleeding complicates interpretation.
- Although sensitivity increases with time, specificity decreases
  - Normal bowel activity can confuse interpretation after 3 hours
Pediatric GI Tract Scintigraphy

- Aspiration/Swallowing Function
- Esophageal Motility/Clearance
- Gastroesophageal Reflux
- Gastric Emptying
- Meckel’s Imaging
- Inflammatory Bowel Disease