

Radionuclide Studies of the Upper Gastrointestinal Tract in Children with Feeding Disorders

Sydney Heyman, Peggy S. Eicher and Abass Alavi

From the case records of Children's Hospital of Philadelphia and Children's Seashore House, Philadelphia, Pennsylvania

The case of a female infant with a feeding disorder and with inadequate growth is described. In her workup, there was no evidence of an organic disorder. Barium studies of the upper GI tract showed normal anatomy and function. A radionuclide milk scan was helpful in demonstrating mild reflux and significantly delayed gastric emptying. There was a good response to therapy.

Key Words: feeding disorder; reflux; gastric emptying; scintigraphy

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CASE PRESENTATION

Our patient is a 30-mo-old female referred for the evaluation of food refusal and inadequate growth. She was delivered 20 wk prematurely because of placenta previa. Ventilatory support was required for the first 4 wk of life. The neonatal period was further complicated by an intraventricular hemorrhage and retinopathy related to premature delivery. These both resolved and she was discharged at 2.5 mo of age on bottle feedings.

At 10 mo of age, she presented with a urinary tract infection at another institution. A voiding cystoureterogram and a sonogram were normal. Inadequate growth was noted and screening tests to exclude organic disease were obtained. These included electrolytes, complete blood count, thyroid function tests, liver function tests, serum amino acids and urinary organic acids. All were within normal limits and no recommendations were made.

At 16 mo, she was re-evaluated because of developmental delay, with growth parameters at 50th percentile for a 3-5-mo-old. She was receiving formula by bottle with small amounts of rice, beans or mashed potatoes two to three times a day. The child's mother was instructed to introduce a high calorie formula and nutritionally balanced spoon feedings.

She did not return for further assessment until the age of 29 mo. She had been switched to whole-milk and starchy table foods, but her growth parameters had remained at the 50th percentile for a 10-16-mo-old. She was admitted for re-evaluation of her inadequate growth. The child underwent testing for organic disorders

not excluded by medical history or physical examination. These included chest x-ray, urinalysis, electrolytes, complete blood count, thyroid function tests, liver function tests, serum amino acids and urinary organic acids. All results were within the normal range. Bone age assessment by x-ray was consistent with her chronological age. HIV testing was negative. During observation of several meals, our patient demonstrated normal oral motor skills but early satiety. At each meal she was initially interested and fed herself several bites, but she then stopped abruptly and could not be urged to take even her favorite foods. Because this pattern of food refusal had been seen in other children who also had gastroesophageal reflux, an evaluation for gastroesophageal reflux was recommended. Barium studies of the upper gastrointestinal tract showed normal anatomy and function. A milk scan was performed by the oral administration of 120 ml of milk containing 37 MBq (1 mCi) of ^{99m}Tc sulfur colloid.

The initial phase of the study with swallowed boluses, while the patient was in a semi-recumbent position, showed normal esophageal transit (Fig. 1). Sequential 30-sec images over the next 60 min, with the patient supine, revealed two significant episodes of reflux (Fig. 2). Simultaneous computer images were obtained at 5-sec intervals. Time-activity curves from regions of interest (ROIs) placed over the entire esophagus and over the upper half of the esophagus only, confirmed the reflux which reached to the upper esophagus (Fig. 3). Gastric emptying was delayed with 85% of the initial activity retained in the stomach at 60 min, and 61% at 120 min (Fig. 4A). These values are shown plotted on a semilogarithmic coordinates curve with the normal range also displayed (Fig. 4B). There was no evidence of pulmonary aspiration in images obtained over the lung fields, in both anterior and posterior projections, at the end of 1 and 2 hr following the initiation of the study.

Based on findings on the milk scan of mild, though significant, gastroesophageal reflux, and delayed gastric emptying, she was started on an antacid and a prokinetic agent. Without other therapy, her desire to select only certain edibles decreased and her intake of food increased. Subsequently, she was noted to have an optimal rate of weight gain.

DISCUSSION

Patient Selection

Certain clinical findings are frequently observed in patients with inadequate growth which may lead the pediatrician to initiate an evaluation for gastro-esophageal reflux and/or delayed gastric emptying. Patients with reflux tend

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For correspondence or reprints contact: Sydney Heyman, MD, Division of Nuclear Medicine, Children's Hospital of Philadelphia, 34th & Civic Center Blvd., Philadelphia, PA 19104.

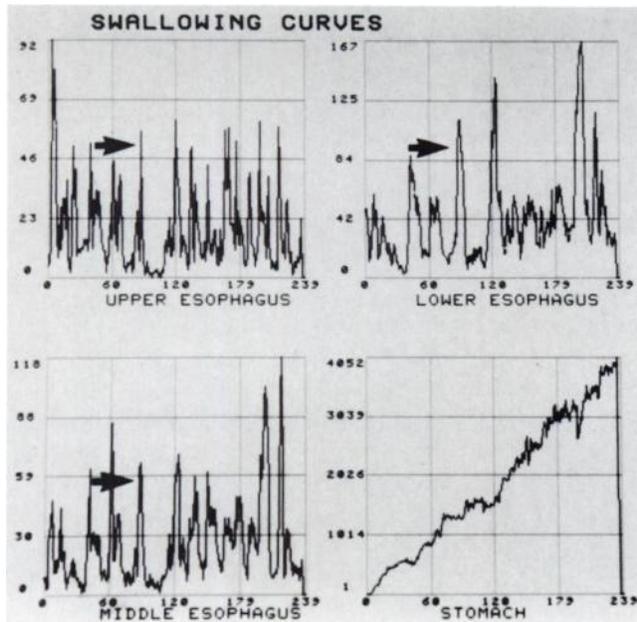


FIGURE 1. Curves from equal ROIs placed over the upper, middle and lower esophagus show normal transit of swallowed boluses with early entry into the stomach (progress of single bolus showed by arrows).

to be irritable while being fed and show early satiety. There is also increased holding of food. Typically, breakfast provokes this type of behavior more often than other meals. Recurrent emesis is frequently associated with reflux. Many children with reflux, however, choose to restrict their per meal intake to a level below that at which they start to feel uncomfortable. As a result, these children will not have a history of recurrent emesis. It is not yet clear what contributes to their perceived discomfort: nausea, gastric distension, irritation from reflux; or what the mechanism is that triggers the satiety signal. In the presence of delayed gastric emptying, the patients never seem hungry and long time intervals are necessary between meals. With the latter disorder, dinners are poorly tolerated. Delayed gastric emptying is often associated with chronic constipation.

This case report demonstrates the value of radionuclide scintigraphy in the evaluation of infants with feeding disorders. These studies are more sensitive than barium radi-

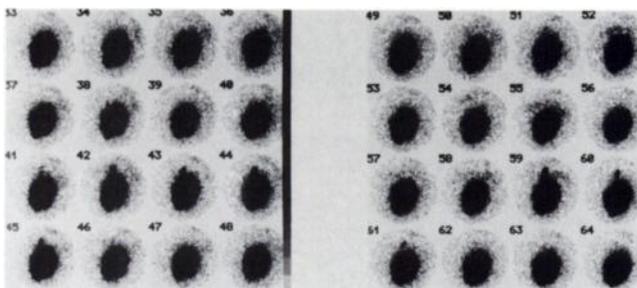


FIGURE 2. The 30-sec sequential images reveal two episodes of reflux.

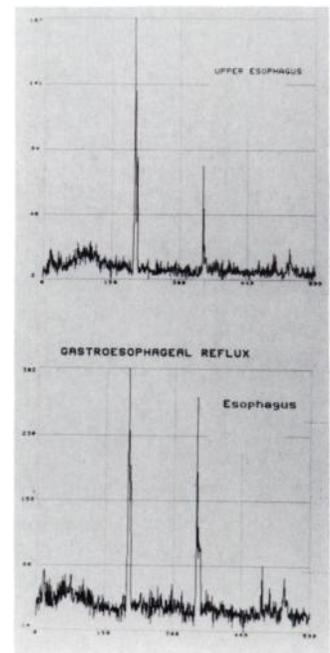


FIGURE 3. Curves derived from the 5 sec/frame computer images demonstrate the reflux, which reach to the upper esophagus.

ography for detecting gastroesophageal reflux and the data obtained from them can be quantitated. Radiography continues to be necessary, however, for excluding anatomical abnormalities. Our experience in treating many patients on the basis of the scintigraphic findings has been rewarding.

Technique and Interpretation

Technetium-99m sulfur colloid is the radiopharmaceutical used for the evaluation of the upper gastrointestinal tract because it remains chemically stable and is not absorbed, thus background activity does not increase with time. It is mixed with the milk or formula feeding. The dose of ^{99m}Tc-sulfur colloid added ranges between 7.4 and 37 MBq (200 to 1000 μ Ci). Our aim is to have concentration of about 0.185 MBq/ml (5 μ Ci/ml). One-third of the feeding is kept unlabeled.

The study is performed at the time of a usual feeding. The swallowing phase is initiated with the back positioned on the surface of a high-sensitivity collimator, which is inclined at 45°. The mouth and the stomach are included in the field of view. The bottle is shielded to reduce the scattered radiation. Computer acquisition is set at 0.5 sec/frame for 240 frames. Time-activity curves are obtained from equal ROIs drawn over the upper, middle and lower esophagus, with a fourth ROI over the stomach. These show a progression of the swallowed boluses down the esophagus with early entry of activity into the stomach. Though quantitation of the transit times is possible, we have relied on pattern recognition. Abnormal transit has been observed with achalasia, esophagitis, after surgery for esophageal atresia, scleroderma, esophageal stricture, neurodegenerative disorders and Down's syndrome (1,2). Krypton-81m-labeled glucose has also been used to examine esophageal transit with quantitation of transit times. Glucose in water (5%) infused through a 555-MBq (15 mCi)

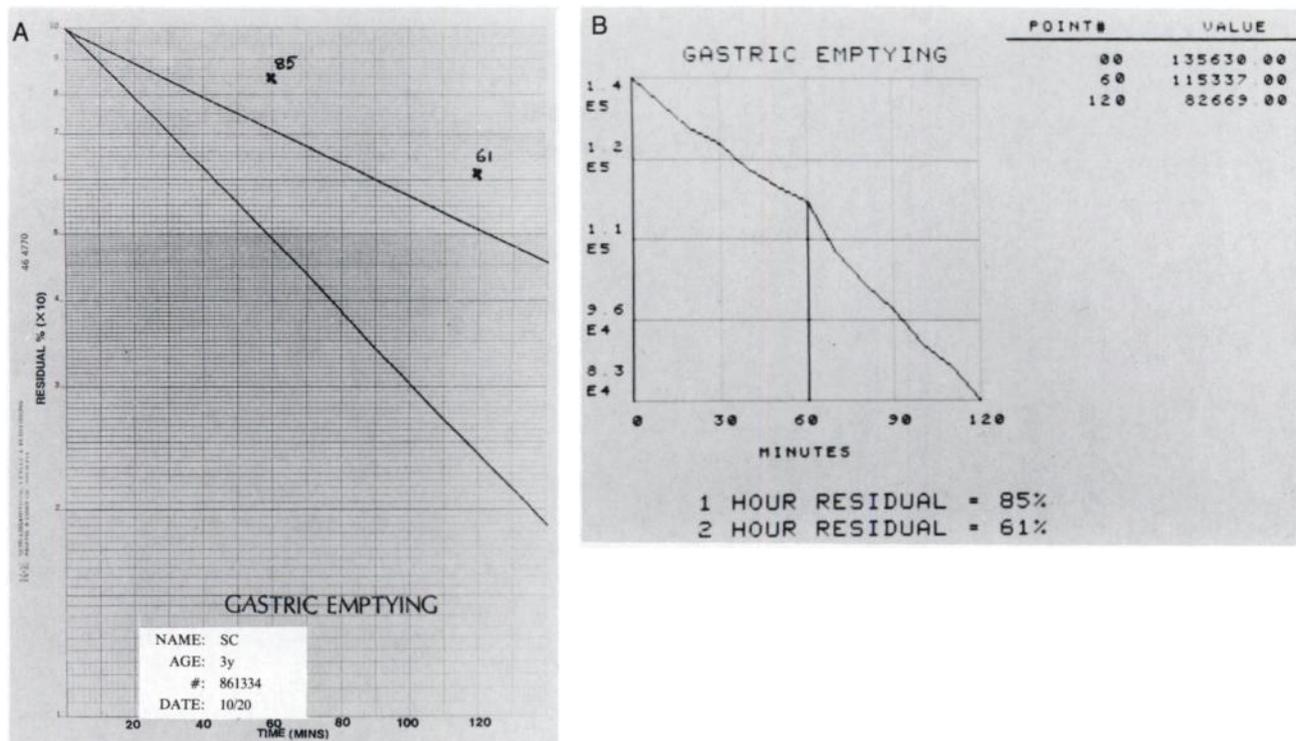


FIGURE 4. (A) The curve of gastric activity over 2 hr shows delayed emptying. (B) The gastric residuals at 1 and 2 hr are plotted on semi-logarithmic paper, with the normal range superimposed.

^{81}Rb - $^{81\text{m}}\text{Kr}$ generator elutes several megabecquerels of $^{81\text{m}}\text{Kr}$ as a solution. In children, 2 ml of this eluate is delivered into the mouth by a syringe (3).

After the swallowing phase, the remaining labeled feeding is ingested. The unlabeled portion is then given to wash out any activity from the mouth and esophagus positioned in the field of view. While slower framing rates may be used, usually (30 sec/frame), the fast acquisition allows a clear visualization of the frequency of reflux and the clearance from the esophagus. Using the concentration of the radioactivity in feeding as suggested, we feel that reflux episodes are readily detected. In fact, it appears that brief episodes of reflux are more clearly visualized with rapid framing (4). If analogue images are acquired along with computer acquisition, these can be obtained at 30-sec intervals. At the end of 60 min, the computer images, with suitable contrast enhancement, are reviewed for reflux. Curves from ROIs drawn over the entire esophagus and over the upper half will demonstrate the frequency of reflux, and the number of episodes reaching the upper esophagus. Various indices have been described to quantitate the reflux severity (5). We reframe the data to 30-sec frames, then integrate the background corrected esophageal curves and express the integral as a percentage of the initial gastric activity. This is used as an index expressing the severity of reflux into the esophagus. The sensitivity for detecting reflux with radionuclide imaging compared to pH monitoring is at least 75% provided that image enhancement is used. This is superior to that reported with barium radiography (5).

Time-activity curves from a stomach ROI, corrected for decay, allow the measurement of gastric emptying. Normal values for gastric emptying for children are generally not available, but a study in normal infants several years ago, using milk feedings, suggested a residual of 48%–70% of the original activity at 1 hr (6). This is supported by a study in which infants were judged to have normal emptying retrospectively. The residual at 1 hr ranged between 36% and 68% (7). Milk usually empties in a monoexponential manner, though not always. We have extrapolated the curves to 2 hr, giving a range which serves as a guide to normal emptying.

Delayed images of the chest in both anterior and posterior projections are taken at 1, 2 and 24 hr. Pulmonary aspiration may be detected during the swallowing phase or



FIGURE 5. Bilateral pulmonary aspiration detected after an episode of reflux.

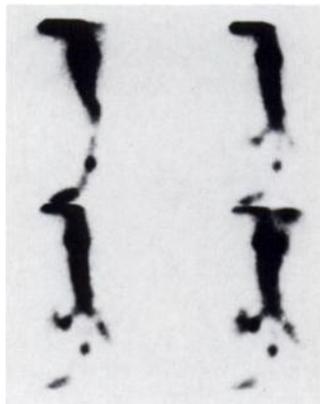


FIGURE 6. Sequential images from a salivagram demonstrating bilateral pulmonary aspiration.

after reflux (Fig. 5), however, it is demonstrated less frequently than expected based on a history of recurrent pneumonia. This may be due to rapid clearance of activity from the upper airway by ciliary action or coughing (8), but may also be due to a low concentration of radioactivity in the aspirated material.

To demonstrate the aspiration of oral secretions in patients with neuromuscular incoordination a salivagram may be employed. A small drop (100 μ l) of ^{99m}Tc -sulfur colloid containing 11.1 MBq (300 μ Ci) of activity is placed on the tongue. Images at 30–60-sec intervals are obtained in the posterior projection (9). Pulmonary aspiration, if present, is clearly delineated (Fig. 6) on these images.

CONCLUSION

The radionuclide evaluation of infants and children with feeding problems has proved to be a very useful clinical

adjunct. These tests offer physiological information about these disorders not attainable with other studies, while providing an objective assessment of esophageal transit, gastroesophageal reflux and gastric emptying. These data significantly influence patient management as illustrated in the case presented in this report. In the appropriate clinical settings, pulmonary aspiration may also be demonstrated. As discussed above, however, the sensitivity for the latter may be compromised by the low concentration of the radioactivity in the aspirate, or the residence time in the lungs. In selected patients, the salivagram is of value in documenting the aspiration of oral contents when there is clinical evidence of neuromuscular incoordination.

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