Sequential Ten-Second Acquisitions For Detection of Gastroesophageal Reflux

Jonathan C. Seymour, Jeffrey H. West and Walter E. Drane

Division of Nuclear Medicine, Shands Hospital, and the University of Florida College of Medicine, Gainesville, Florida

We illustrate the importance of short imaging times during gastroesophageal (GE) scintigraphy to better image GE reflux while still obtaining clinically useful gastric emptying data. While most reflux scans are comprised of 30- or 60-sec sequential images, we advocate the use of 10-sec images to maximize the signal-to-noise ratio of any radionuclide present in the esophagus. In the current case, clinically documented reflux of significant magnitude was missed during a study inadvertently performed using 60-sec frames, but subsequently detected using a 10-sec imaging protocol.

J Nucl Med 1993; 34:658–660

Gastroesophageal (GE) scintigraphy has been widely accepted as a safe and effective means of demonstrating and quantifying GE reflux since its introduction in the late 1970s. In fact, the sensitivity of the technique as a screening test has been reported to be as high as 90% in comparison to pH-probe studies (*1*). Many clinicians feel its most important application is in the pediatric population for two major reasons. First, the significance of GE reflux in infants and children is now widely recognized. In addition to recurrent vomiting and potentially severe esophagitis, failure to thrive and grave respiratory conditions, such as aspiration pneumonia and apnea, perhaps leading to sudden infant death, have been linked to GE reflux (*2*). Second, in a pediatric scan positive for reflux, the information concurrently obtained regarding gastric emptying can prove critical in planning treatment for the reflux condition.

Various methods have been utilized to image GE reflux by scintigraphy. Some of these have included the use of external abdominal pressure to induce reflux episodes (*1–3*). This practice has been abandoned by many in order to keep the exam optimally "physiological," since this quality represents a major theoretical advantage of the nuclear scan over the barium swallow, manometry and the pH probe, although the latter remains the "gold standard." Both older and current methods described in the literature call for imaging every 30 or 60 sec for 30–60 min to evaluate activity above the GE junction (*1–5*). Our standard protocol has utilized a faster frame rate (10 sec) and we report a case illustrating the advantages of this fast frame rate for the detection of GE reflux.

Received Sept. 1, 1992; revision accepted Dec. 2, 1992.

For correspondence or reprints contact: Walter E. Drane, MD, Professor and Director, Division of Nuclear Medicine, Box J-374, JHMHC, Gainesville, FL 32610.

CASE REPORT

The patient was a 6-yr-old male with mental retardation, chronic progressive hydrocephalus and seizures. Over the past year he had been hospitalized ten times for persistent vomiting and dehydration associated with increased seizure activity. After pH studies showed a 14% reflux (a markedly abnormal result), the patient was referred to our department for further evaluation. On Day 1, a GE reflux and gastric emptying study was scheduled, but the imaging computer was erroneously set up for a standard gastric emptying study. At our institution, a standard gastric emptying study in adults represents 120 min of continuous acquisition at 1 min/frame, typically performed using radiolabeled whole egg. For this patient, the study was performed using 250 cc of formula containing 1 mCi of ^{99m}Tc-sulfur colloid. In infants, we use 60 cc of formula, but increase this dose to 250 cc in children and adults who cannot or do not eat solid food. This examination showed normal gastric emptying and no evidence of GE reflux, with the exception of one frame when displayed at high contrast (Fig. 1A–1B). On Day 2, the following procedure was used as follow-up.

Gastroesophageal scintigraphy was performed after a 4-hr fast. The patient was administered 250 ml of formula containing 1 mCi ^{99m}Tc-sulfur colloid. With the patient supine under a gamma camera equipped with a parallel-hole, high-resolution collimator, sequential 10-sec computer-acquired images were obtained for 120 min. Regions of interest (i.e., esophagus, background and stomach) were defined and esophageal time-activity curves produced.

The time-activity plot (Fig. 2) reflects the findings on the serial scintigrams: clear evidence of repeated esophageal reflux. In particular, our criterion of greater than five episodes of reflux between 5–60 min postingestion was met, establishing this as a case of significant GE reflux. We were thus able to corroborate clinical impressions and pH-probe results.

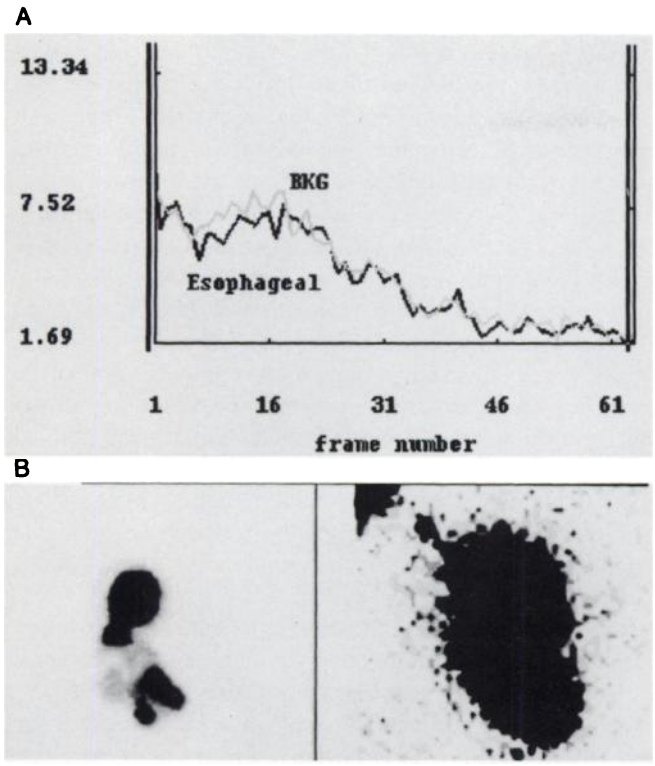

FIGURE 1. (A) Time-activity curve generated for the standard gastric emptying study supports the qualitative impression of no GE reflux. (B) One frame of the study, shown at normal intensity on the left and at maximal intensity on the right, demonstrates slight reflux on this single image.

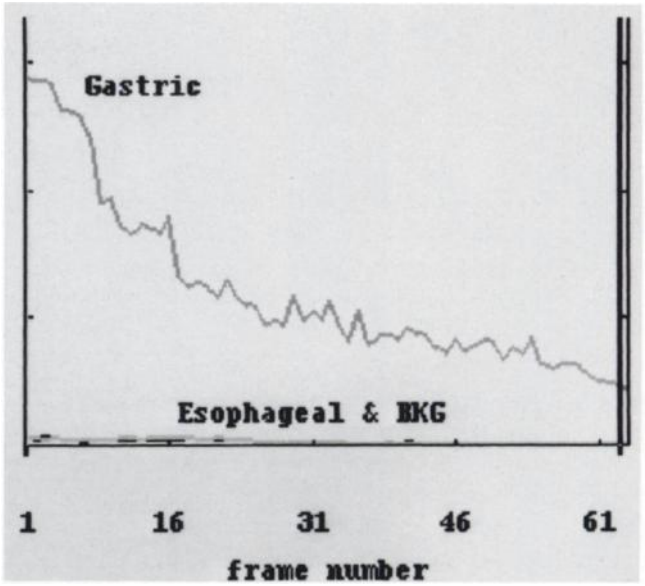

FIGURE 3. Study at 60-sec frame rate: esophageal counts are statistically outweighed by the stomach signal. Gastric emptying is normal.

DISCUSSION

Although the Day 1 gastric emptying study is not specifically designed to look for GE reflux, it is theoretically capable of detecting such activity. Based on the abnormal pH study and the patient's history and persistent symptomatology, we were highly suspicious that in this case the procedure had failed to detect the condition. This is possible because GE reflux detection depends on the ratio of counts seen in the esophageal region to counts seen in the gastric region. Since the majority of the radionuclide resides in the stomach for the duration of the study, over 60 sec the total activity in the stomach can be great enough to statistically outweigh the signal from the esophagus, thus rendering it "undetectable." Figure 3 illustrates the magnitude of the gastric signal relative to the esophageal activity in the Day 1 study. However, in our Day 2 scan designed to show reflux, imaging at 10-sec intervals detects one-sixth as many gastric counts while seeing an essentially similar amount of the transient esophageal activity.

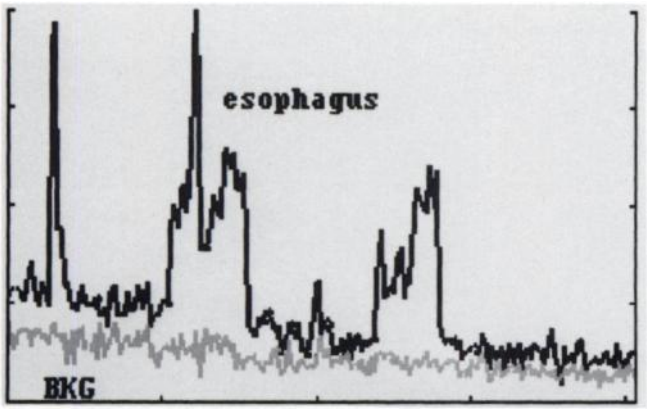

FIGURE 2. Time-activity curve generated for the study with 10-sec imaging displays at least seven discrete reflux events.

Consider the following hypothetical study involving a patient whose total radionuclide bolus emits 1000 cps. During the exam, the patient experiences 10% reflux for 4 sec. A 60-sec image thus records 400 counts in the esophagus (1000 cps × 4 sec × 10% in esophagus) or 0.67% of the 60,000 total counts (1000 cps × 60 sec). A 10-sec image records the same 400 counts in the esophagus, but this now accounts for 4% of the 10,000 total (1000 cps × 10 sec). It has been estimated that 3%–4% reflux is both the upper limit of normal and the minimum degree of reflux that can be visualized qualitatively (*1*). Thus, the technique has allowed us to diagnose the condition. To illustrate, Figure 4 displays six sequential 10-sec images from the presented case, each clearly showing reflux. Next to these images is a 60-sec composite image, which also detects the reflux. On the other hand, Figure 5 displays a different set of consecutive 10-sec images, only one of which shows reflux. Reflecting what we believe occurred on Day 1, the reflux is qualitatively absent on the composite 60-sec image. Clearly, while the 60-sec images, having more total counts, are visually more

FIGURE 4. (Left) Six sequential 10-sec images during a minute of constant GE reflux. (Right) Corresponding 60-sec composite image detects the reflux as well.

pleasing than the 10-sec images, they are much less sensitive for GE reflux.

We feel that 10-sec imaging is more practical than using 5- or even 1-sec frames, even though such methods may prove even more sensitive. First, the sheer number of images becomes overwhelming because more images are obtained, and since these scans must be acquired on a computer, demands on computer memory and storage become overwhelming as well. Additionally, one might hypothesize that episodes of reflux lasting significantly less than 10 sec have relatively little clinical significance.

Many investigators have used background regions of interest. We use them to increase the specificity of our GE reflux scan. In this study, there is actually little background activity to correct. However, the background region serves another purpose. If the esophageal and background curves have a similar contour—specifically, if any esophageal "spikes" are mimicked in the background plot—the "reflux" activity in the esophagus may well be due to patient motion. This provides a check for a common cause of pediatric false-positive examinations.

FIGURE 5. (Left) Six sequential 10-sec images show one transient episode of reflux. (Right) Corresponding 60-sec composite image does not qualitatively show GE reflux.

One could increase the signal-to-noise ratio for the detection of GE reflux by simply removing the gastric counts from the field of view and centering the camera over the chest. However, this change would prevent simultaneous determination of the gastric emptying rate. An important aspect of the fast frame rate protocol is that while the sensitivity of the test for GE reflux is increased, the value of the scan in the assessment of gastric emptying is uncompromised and there is no need to order a second study to obtain that information. This is beneficial for the clinician planning treatment after a positive reflux study. It has been shown that infants with GE reflux often have impaired gastric emptying, implying a motor disorder underlying the reflux (*6*). In such situations, medical management with prokinetic agents might be the treatment of choice. On the other hand, patients whose gastric emptying is normal, suggesting a lower esophageal sphincter abnormality, may respond better to a fundoplication procedure.

Our inadvertent case illustrates the value of fast frame rate imaging for GE reflux and simultaneous gastric emptying evaluation. Does this single case report "prove" this point? No. The "imaging statistics" discussed in the hypothetical case are the rationale for our use of the fast frame rate technique and the reported case graphically illustrates its advantages. We do not plan a prospective study of 10-sec versus 60-sec frame rates for GE reflux detection because the counting statistics foretell the outcome. We recommend the use of fast frame rate imaging ($\leq$10 sec) for GE reflux evaluation.

REFERENCES

1. Malmud LS, Fisher RS. Radionuclide studies of esophageal transit and gastroesophageal reflux. *Semin Nucl Med* 1982;12:104–115.
2. Blumhagen JD, Rudd TE, Christie DL. Gastroesophageal reflux in children: radionuclide gastroesophagography. *AJR* 1980;135:1001–1004.
3. Rudd TG, Christie DL. Demonstration of gastroesophageal reflux in children by radionuclide gastroesophagography. *Radiology* 1979;131:483–486.
4. Gonzalez FF, Arguelles MF, Rodriguez de quesada B, et al. Gastroesophageal scintigraphy: a useful screening test for GE reflux. *J Pediat Gastroenterol Nutrition* 1987;6:217–219.
5. Heyman S, Kirkpatrick JA, Winter HS, Treves S. An improved method for the diagnosis of gastroesophageal reflux and aspiration in children (milk scan). *Radiology* 1979;131:479–482.
6. Hillemeier AC, Lange R, McCallum R, Seashore J, Gryboski J. Delayed gastric emptying in infants with gastroesophageal reflux. *J Pediatr* 1981; 98:190–193.