

## Gastroesophageal scintigraphy in children: a comparison of posterior and anterior imaging

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The purpose of this study was to compare the posterior dynamic imaging with the anterior imaging in the evaluation of children with gastroesophageal reflux (GER). Sixty-eight children (26 female, 42 male; age range 4 months to 7 years, median 21 months) were studied. After 4-hour fasting, all the subjects underwent gastroesophageal scintigraphy. Synchronous dynamic imaging in the anterior and posterior projections was performed with the subject in the supine position with a dual-head gamma camera equipped with low-energy general-purpose collimators at a rate of 30 s/frame for 40 min. The anterior and posterior images were visually evaluated for the presence of gastroesophageal reflux by two nuclear medicine physicians. The anterior and posterior images were correlated by Pearson correlation analysis, and inter-observer variability was evaluated by paired t-test and kappa value. There was a good correlation between the two projections with r-values of 0.906–0.990. The inter-observer agreement for interpretation of the anterior and posterior imaging was excellent (k: 0.83). In conclusion, anterior and posterior dynamic imaging showed excellent correlation in detection of GER in children. Posterior imaging is superior to anterior imaging in that it is more comfortable, and it reduces motion artifacts, especially for infants and anxious children; thus, it may be preferred over anterior imaging.

**Key words:** gastroesophageal reflux, gastroesophageal scintigraphy, posterior imaging, pediatrics

### INTRODUCTION

SCINTIGRAPHY is a widely accepted method for the detection and evaluation of gastroesophageal reflux (GER) in infants and children.<sup>1–4</sup> The most recommended application involves a long-term imaging through anterior projection with the patient in the supine position and under physiological conditions (with no pressure exertion).<sup>1</sup> However, throughout anterior imaging, lying under a camera for a considerable amount of time may cause anxiety in some children. Therefore, this study was designed to compare posterior imaging, which is considered more comfortable for children and parents, with routinely used anterior imaging, to determine their correlation and inter-observer variability, and to investigate whether posterior imaging can be used routinely.

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### METHOD

In the study 75 patients were considered primarily but 7 of them discarded due to inefficient imaging quality. Sixty-eight children (26 female, 42 male; age range: 4 months to 7 years, mean age:  $41 \pm 34$  months, and median age: 21 months) were studied. After 4-hour fasting, all the subjects underwent gastroesophageal scintigraphy through administration of 100–300 ml milk or orange juice with 100–500  $\mu\text{Ci}$  (3.7–18.5 MBq) of  $^{99\text{m}}\text{Tc}$ -sulfur colloid. The patient was placed in the supine position between the two detectors, covering both the stomach and thorax in the field of view. Synchronous dynamic imaging in anterior and posterior projections was performed with a dual-head gamma camera (E-cam, Siemens, USA) equipped with low-energy general-purpose collimators at 30 seconds/frame for 40 minutes.

*Image interpretation:* The anterior and posterior images were visually evaluated for the presence of gastroesophageal reflux, number of episodes and frames, and grades of GER. Grading scores were based on the Blumhagen grading system and were as follows<sup>2</sup>: Grade

**Table 1** Comparisons of the anterior and posterior images for number of episodes, frames, and grades

	Anterior/posterior		
	Episode	Frame	Grade
Observer 1	101/101	159/159	82/82
Observer 2	94/97	154/158	78/81
Total	195/198	313/317	160/163

**Table 2** Number of patients with GER detected from anterior and/or posterior images by observers

	anterior	posterior	only anterior	only posterior
Observer 1	35	35	1	1
Observer 2	33	34	—	1
Both	33	34	—	1

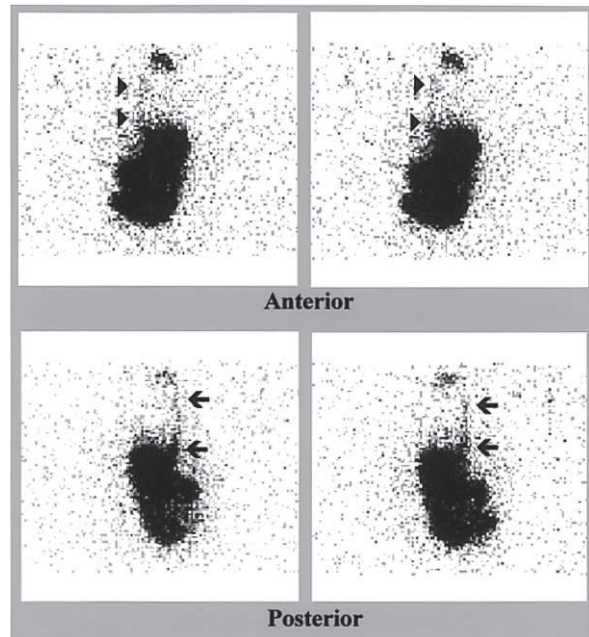
0: no reflux; Grade 1: two or fewer episodes in the first 5 minutes; Grade 2: three or four episodes; Grade 3: five or more episodes. All the studies were independently conducted by two nuclear medicine specialists blinded to each other. The evaluations of the anterior-posterior images were performed on a gray scale via adjusted intensity and cinematic display. Then, both specialists re-evaluated the disagreements on the images of some patients at the same time, and a common consensus was obtained.

**Quantitative analysis:** The anterior and posterior reflux index (Ri) of all the patients with reflux was calculated with the formula of  $Ri = (Et - Eb)/Go \times 100$ .<sup>5</sup> Ri refers to reflux index; Et, esophagus activity at the time of reflux detection; Eb, the beginning of basal esophagus activity; and Go, beginning of gastric activity count. Rectangular areas of the same size were drawn for esophagus, while free areas of interest were drawn for the stomach; thus, counts were obtained and used in the formula. The conformity between the anterior and posterior Ri was then evaluated.

**Statistical analysis:** Anterior and posterior images were correlated by Pearson correlation analysis, and inter-observer variability was evaluated by paired t-test and kappa value.

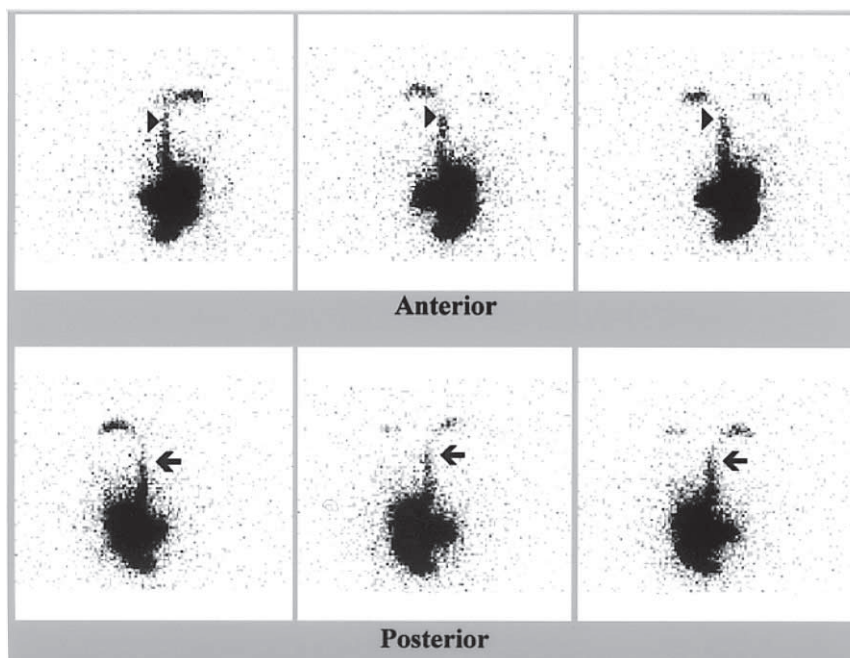
## RESULTS

Reflux was detected on both the anterior and posterior images of 33 of 68 patients by the two observers. The values obtained in the comparisons of the anterior and posterior images for episodes, numbers of frames, and grades were provided in Table 1. The total line summarized that there was not a major difference in the anterior and posterior readings between the two observers although the number of positive readings was slightly higher and favors the posterior images over the anterior



**Fig. 1** A sample of a prominent posterior image. Two 30 second/frame anterior and posterior images obtained at 16 minutes; the esophageal activity is seen at the upper third and is more prominent on the posterior images (arrows) than the anterior ones (arrowheads).

images. In the evaluation of the anterior images, reflux was detected in 35 patients by the first observer and in 33 patients by the second observer, while in the evaluation of the posterior images, it was detected in 35 patients by the first observer and in 34 patients by the second observer. The inter-observer variability was lower for posterior image evaluations. The first observer detected reflux in the 2 episodes of only the anterior image of one patient, and both observers detected reflux in 1 episode of only the posterior image of a same patient (Table 2). The disagreements between either the anterior/posterior images or both observers on 3 patients were re-evaluated together by both observers. Then, it was determined that there was reflux in all of these patients based on both the anterior and posterior images. However, the presence of reflux was more prominent on the anterior image of one patient and on the posterior image of another patient (Fig. 1). In the third patient, on the other hand, reflux was at a minimal level on both projections. The anterior and posterior reflux indexes had lower density but reflected the visual differences on the anterior and posterior images ( $Ri\text{-ant}/Ri\text{-post}$ : 0.7/1.4, 0.9/0.4, 0.5/0.5, respectively). In addition to these findings, in some patients with multiple episodes of reflux, the first observer evaluated one episode of the posterior image for 3 patients and one episode of the anterior image for 2 patients as positive. Similarly, the second observer evaluated one episode of the posterior image of 2 patients and one episode of the anterior image of 1 patient as positive.



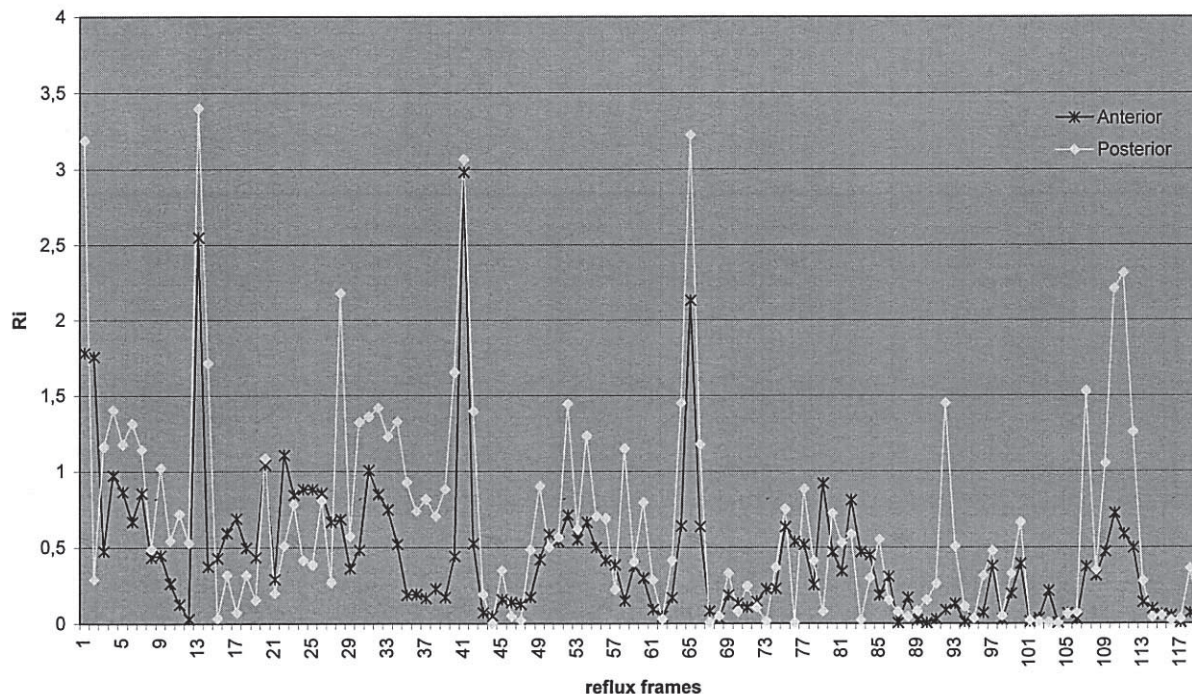
**Fig. 2** Three 30 second/frame anterior and posterior images obtained at 8, 17, and 34 minutes with marked esophageal activities at the upper third were noted both at the anterior (*arrowheads*) and the posterior images (*arrows*) of the same patient.

These results caused a grade increase to grade 3 on the posterior image of one patient, while they did not change the grades of the other patients. On re-evaluation, these episodes in both projections were found to have reflux of minimal density. The reflux indexes of all the other patients with reflux were parallel. There was a good correlation between the two projections with r-values of 0.906–0.990. Analysis of the inter-observer variability was based on the percentage of agreement. The inter-observer agreement for interpretation of the anterior and posterior images was excellent ( $k: 0.8$ ), and paired t-test showed no statistical difference between interpretations of observers ( $p > 0.05$ ,  $r: 0.945$ – $0.989$ ).

## DISCUSSION

The presence of pathological GER is defined endoscopically, histologically, by pH probe, radiographically, or scintigraphically. Scintigraphy is established as a screening test for gastroesophageal reflux in children.<sup>4</sup> It is more physiological and noninvasive than other methods in that no sedation is required and no provocative maneuvers are needed to induce reflux. Anterior imaging while the patient is in the supine position is recommended for gastroesophageal reflux evaluation. If gastric emptying evaluation is also planned within the same study, dual-head camera use has been suggested to be optimal for anterior and posterior imaging.<sup>6</sup> Heyman et al. conducted a dynamic anterior and posterior imaging procedure with a dual-head gamma camera on children and evaluated

gastric emptying and reflux simultaneously.<sup>7</sup> They found the anterior images of 25 patients in conformity with the conjugated images for the evaluation of gastric emptying and recommended the routine use of anterior imaging. In the same study, a marked reflux was detected in the gastroesophageal reflux evaluations of both projections for 14 patients, and in 3 patients, minimal reflux episodes were observed on only the anterior images. Based on these findings, they reported that minimal episodes with insignificant clinical value could remain unnoticed on posterior images. In our study, there was a significant correlation between the number of reflux episodes and reflux grades on both the anterior and posterior images. Marked reflux episodes were detected on the anterior and posterior images of 33 patients by both observers (Fig. 2). Nevertheless, a few minimal episodes were unnoticed on either the anterior or posterior images. With respect to grades, the posterior images of 2 patients and the anterior image of 1 patient were superior to the other one. One of the observers identified reflux on only the anterior image of 1 patient and both observers identified reflux on only the posterior image in 1 patient. When the results of the patients with different interpretations were re-evaluated together by both observers, it was concluded that these patients had reflux in both projections, but it was observed more clearly in the aforementioned projections. Among these, the reflux observed only on the anterior images was found in two episodes and two frames, whereas the reflux detected on only the posterior image was seen in one episode and one frame. In the analysis based on frame and



**Fig. 3** The anterior and posterior indexes are parallel. In both projections, there are episodes of slightly higher indexes compared to the other one. (Ri: Reflux index)

episode count, posterior images provided better correlation between the observers with regard to reflux detection than did the anterior images; however, the difference was not statistically significant.

*Attenuation effect:* For the anterior imaging, the distance and the soft tissue; for the posterior imaging, vertebral colon and the patient's bed lead to attenuation. Among these, anterior soft tissue and posterior vertebral colon are constant factors. The patient beds used with the new cameras are designed with special materials to attain minimal attenuation. In our study, the interpretations based on the visual and reflux indexes showed no significant differences between the anterior and posterior projections, which was suggestive of the insignificance of the vertebral and bed related attenuation in infants and children. The effect of distance factor can be reduced by placement of the detector as close as possible to the patient with a mean of 10–15 cm. However, the distance is compellingly greater with restless children, which constitutes a disadvantage in anterior imaging.

In our clinic, visual analysis is the routine method of reflux evaluation. Despite the reports of errors related to scattered activity from the stomach and geometric problems due to differences among patients, in this study, the reflux index was employed to analyze the effects of attenuation on the anterior and posterior images and to show the presence of minimal reflux in the episodes with conflicting visual evaluations. The anterior and posterior indexes were parallel, and in both projections, there were episodes of slightly higher indexes compared to the other

one (Fig. 3). These differences may be attributable to lower gastric counts on the posterior than on the anterior, as a result of which lesser scatter effect, geometric variations, and good-observation of reflux up to the mouth on the anterior images are expected.

During anterior imaging, the supine position of the child with closely positioned detector and long periods of positional stability are reasons for restlessness in many patients. This often leads to intolerance, worried parents, and sedation requests by parents. Clinically, however, it has been observed that infants and children better tolerate posterior imaging only, thus, there are fewer motion-associated artifacts.

In conclusion, a significant correlation was found between dynamic anterior and posterior imaging for gastroesophageal reflux detection. Posterior imaging should be preferred over anterior imaging in routine use particularly since it is more convenient for younger and restless children and their parents. Furthermore, due to these advantages, posterior imaging enables clinicians to better evaluate the test results.

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