



## Diagnosis of Gastroesophageal Reflux Disease in Children: Comparing Barium Studies with 24-hour Esophageal pH Monitoring

Ratanaporn Pornkul, MD.<sup>1</sup>, Warattha Wachirapanone, MD.<sup>1</sup>,  
Kaimuk Petsrikun, RN<sup>2</sup>, Suporn Treepongkaruna, MD.<sup>3</sup>

<sup>1</sup> Department of Radiology, <sup>2</sup> Department of Nursing, <sup>3</sup> Department of Pediatrics,

Faculty of Medicine, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand

### Abstract

**Background:** Twenty-four-hour esophageal pH monitoring is a useful investigation for diagnosis of gastroesophageal reflux disease (GERD), however, it is not widely available in developing countries including Thailand. Barium studies are widely available in our country. The objective of this study was to compare the sensitivity and specificity of the modified barium studies in our hospital with the 24-h esophageal pH monitoring for diagnosis of GERD in children.

**Subjects and methods:** All children suspected of GERD who underwent barium studies and 24-h esophageal pH monitoring within 14 days, during the 7 consecutive-years period, were retrospectively reviewed. Criteria for diagnosis of GERD by 24-h pH monitoring were having fraction time with pH below 4.0 more than 10% in infants and 5% in older children.

**Results:** Total 159 children met the criteria; 7 cases were excluded due to incomplete data. Comparing to 24-h pH monitoring, barium studies showed a sensitivity, specificity and accuracy of 61.2%, 37.7% and 47.4%, respectively.

**Conclusion:** Comparing with 24-h esophageal pH monitoring, modified barium examination still has a rather low sensitivity, specificity and accuracy for diagnosis of pediatric GERD. Barium studies may be useful for evaluation of children with clinical suspected of GERD but a limitation for diagnosis of GERD should be aware.

**Key words:** gastroesophageal reflux disease, 24-hour esophageal pH monitoring, barium studies

## Introduction

Gastroesophageal reflux (GER) is defined as regurgitation of gastric contents backwardly into the esophagus and is considered a physiologic condition.<sup>1,2</sup> In contrast to physiologic GER, gastroesophageal reflux disease (GERD) is a condition in which reflux is pathologic, causing troublesome symptoms and/or complications which include erosive esophagitis, esophageal stricture, Barrett's esophagus and respiratory disorders (chronic cough, recurrent pneumonia, recurrent wheezing) and apparent life threatening event.<sup>1-5</sup> Complications of GERD can be severe, early diagnosis and treatment of GERD is therefore essential to prevent potential serious complications.<sup>2,6</sup> There are many diagnostic modalities to diagnose GERD which include upper endoscopy, 24-h esophageal pH monitoring (epHm), combined multichannel intraluminal impedance (MII)-pH monitoring, barium studies, and gastroesophageal scintigraphy (milk scan).<sup>7,8</sup> Each modality has advantages and limitations and there is no absolute gold standard for diagnosing GERD.<sup>9,10</sup> Single diagnostic test is insufficiently accurate, and therefore the diagnosis and evaluation of GERD may require two or more studies.

Among these investigations, only barium studies are widely available in Thailand since they are easy to perform, tolerable, less invasive and inexpensive. Moreover, they can demonstrate the anatomic details of esophagus and upper gastrointestinal (GI) tract as well as the anatomic level of the refluxate. Some studies suggested that the sensitivity and specificity of barium studies can be improved with additional techniques.<sup>11-13</sup> In our hospital, barium study techniques are modified for improvement of diagnostic yield for GERD. The purpose of this study was to compare the sensitivity

and specificity of modified barium studies with 24-hr esophageal pH monitoring for diagnosis of GERD in pediatric patients.

## Subjects and Methods

The study was approved by the Ethic Committee of Ramathibodi Hospital. All pediatric patients with suspected of GERD who underwent 24-h epHm and barium studies (barium swallow study or upper gastrointestinal series) within 14 days at Ramathibodi Hospital, during the 7 consecutive-years period, were retrospectively reviewed. The patients who underwent 24-h epHm but no barium examinations were excluded from this study. The results of barium studies were compared with 24-h epHm.

### Barium Studies

All patients were fasting for 3-4 hours before studies. The patients were fed with a mixture of one part of 58 percent wt/wt barium sulfate to four part of milk (100-180 ml for infants, 190-250 ml for children over 1 year of age) by feeding bottle or cup according to age. Feeding via nasogastric tube was given in those who were unable to drink by mouth. Effervescent granules were not used. The barium studies were performed under the digital subtraction fluoroscopy by one of the two pediatric radiologists following the same technical instruction. The patients lied supine in order to place the esophagogastric junctions in dependent position, while the fundus and body of the stomachs filled with barium sulfate. The patients were observed for GER throughout the barium studies and at the end of the examination. Intermittent fluoroscopy was performed every 10 seconds for a maximum of 5 minutes to look for GER. Additional procedures such

as water-siphon test and provocative maneuvers such as cough, valsalva maneuver, or abdominal compression were not performed. We routinely executed spot films of the esophagus, stomach, duodenum, and duodeno-jejunal junction in several views to assess the anatomical abnormalities. Additional spot films were taken if GER was detected during the examination. Radiographs of the esophagogastric junction which includes the whole thorax while the patients in supine position were obtained in every case for interpretation of GER. The patients were diagnosed as having GER when barium sulfate moving up from the gastric fundus to the esophagus was detected, regardless the level and amount of refluxed barium. Esophagitis was diagnosed when edematous mucosal folds or irregularity of esophageal mucosa was seen.

#### 24-h esophageal pH monitoring

EpHm was performed by pediatric gastroenterologists using a digitrapper MK III (Synectics Liberty System, Sweden). The antimony crystal pH catheter with electrode (Synectics Medical, Sweden) was calibrated before each study in buffer of pH 1.07 and pH 7.01. The pH catheter was placed transnasally and located above the lower esophageal sphincter (LES), at the distance about 87% of the total esophageal length, measured from the external nares. The position of LES was determined by calculating from the child length as previously described by Strobel et al.<sup>14</sup> The position of pH electrode was re-checked by chest radiograph.<sup>15</sup> Regular feedings were given during the study period but continuous feeding via nasogastric tube was not allowed. Esophageal pH was continuously recorded for 24 hour and the recorded data were transferred to the computer for analysis (EsopHogram

Version 5, Gastrosoft Inc, Sweden). Criteria for diagnosis of GERD by 24-h epHm were having fraction time with pH below 4.00 more than 10% in infants and 5% in older children, respectively.<sup>2,15</sup>

## Results

Total 159 pediatric patients (98 males, 61 females), aged 2-60 months, met the inclusion criteria. The most common presenting symptom was recurrent pneumonia in 111 of 159 (69.8%). Seven patients were excluded because of incomplete data, resulted in 152 patients included in this study. By reviewing the reports as well as the recorded images, GER was detected by barium studies in 94 of 152 patients (61.8%) and detected as GERD by 24-h epHm in 62 of 152 (40.8%). The sensitivity, specificity and accuracy of barium studies for detection of GERD compared with 24-h epHm were 61.2%, 37.7%, and 47.3%, respectively. (Table 1). Malrotation was detected by barium studies in 3 patients without midgut volvulus. None had esophagitis detected by barium studies.

## Discussion

The manifestations of GERD in children involve both esophageal and extra-esophageal symptoms. Because of the diverse clinical manifestations, the diagnostic evaluation of GERD can be difficult. Although there are many diagnostic modalities for GERD in children, none of them is considered as a gold standard test. Barium studies are useful for evaluation of anatomical abnormality of the esophagus and upper GI tract such as hiatal hernia, esophageal stricture, gastric outlet obstruction and intestinal malrotation. It is also useful to evaluate swallowing dysfunction and detect the H-type tracheo-esophageal (TE) fistula in children who have

**Table 1** Comparison of barium studies with 24-hour pH monitoring for diagnosis of GERD in 152 patients

| Study                      | 24-hour pH monitoring |                    | Sensitivity<br>% | Specificity<br>% | Accuracy<br>% |
|----------------------------|-----------------------|--------------------|------------------|------------------|---------------|
|                            | Positive<br>(n=62)    | Negative<br>(n=90) |                  |                  |               |
| Barium GER Positive (n=94) | 38 (25%)              | 56 (36%)           | 61.2             | 37.7             | 47.4          |
| Barium GER Negative (n=58) | 24 (15.7%)            | 34 (23.3%)         |                  |                  |               |

recurrent pneumonia or chronic respiratory symptoms. In addition, barium studies can demonstrate the height of refluxate and may demonstrate an aspiration of gastric contents into upper airways or lungs. However, barium studies can give a false positive result in diagnosis of GERD since a GER episode detected during the study could be physiologic reflux. In addition, the short duration of the study can give a false negative result.<sup>2</sup>

In the last decade, 24-h epHm was considered as a gold standard test for diagnosing GERD [15]. However, recent studies have not proven this. It is reliable for a quantitative measurement of acid reflux into the esophagus but has a limitation in detecting non-acid reflux.<sup>2,16</sup> This is a particular problem in the postprandial period when stomach contents are typically neutralized for up to 2 hours after meals. In pediatric patients, particularly infants, who feed every 2-3 hours, the pH probe might significantly underestimate the amount of reflux.<sup>17</sup> Other possible technical problems contributing to a false negative result of the 24-h epHm include a high probe location in the esophagus, insufficient contact between the probe and esophageal fluid because of adherent food or mucus, and impaction of electrode tip against the esophageal wall.

Combined MII and pH monitoring is superior to pH monitoring alone for diagnosis of GERD since

it can detect both acid and non-acid reflux episodes as well as the height of refluxed material.<sup>18</sup> Many studies using combined MII and pH monitoring have demonstrated that non-acid refluxes are common and account for 40-50% of reflux episodes in children with persistent respiratory symptoms<sup>16</sup> and neurological impairment.<sup>19</sup> However, the use of MII in general practice has been limited due to the lack of well established normal values in children.<sup>17</sup>

Upper endoscopy is useful for detection of erosive esophagitis, and a normal upper endoscopic study does not exclude GERD. Endoscopy has a sensitivity of only 30-50% in adult patients who present with heartburn.<sup>9</sup> Gastroesophageal nuclear scintigraphy is not recommended for the routine evaluation of pediatric patients suspected of GERD since the standard of this test are poorly established and the sensitivity for diagnosis of GERD is low.<sup>2</sup> Proton pump inhibitor (PPI) test has been shown in adults to have a sensitivity and specificity of 74% and 54%, respectively, comparing to endoscopy or 24-h epHm<sup>20</sup>, but the test has not been validated for pediatric patients. Improvement following treatment does not always confirm a diagnosis of GERD since symptoms may improve spontaneously or as a placebo effect.

The majority of the patients in our study presented with extra-esophageal GERD and the most

common manifestation was recurrent pneumonia because both barium studies and 24-h epHm are commonly performed if the patients had these symptoms. The patients who underwent 24-h epHm only for evaluation of GERD may have other symptoms in majority but is not in scope of this study. Upper endoscopy is performed only in patients suspected of reflux esophagitis or those who did not respond to treatment.

Detection rate of GERD by barium studies and pH monitoring were 43% and 83% by Al-Khawari et al<sup>21</sup>, 18% and 60% by Thompson et al<sup>13</sup>, 38% and 68% by Sellar et al<sup>22</sup>, and 25% and 66% by Johnston et al<sup>12</sup>. The higher detection rate of GER by barium studies (61.8%) than pH monitoring (40.7%) in our studies is contrary to others, and could be due to the technique used in our study. In similar to ours, the study by Al-Khawari et al<sup>21</sup> included small children with nearly half of the patients were below one year of age. They performed intermittent fluoroscopy every 3-4 seconds for a maximum of 5 minutes for observation of GER but the position of the patients during studies was not mentioned. We let the patients lie in supine position with barium sulfate filling fundus and body of the stomach while performing intermittent fluoroscopy every 10 seconds for a maximum of 5 minutes. We believed this is the best technique to elicit barium reflux with less radiation to the patients. Barium sulfate had to fill the gastric fundus and was around the area of esophago-gastric junction to be seen moving up into the esophagus. Gastric fundus is the most posterior part of the stomach, so only supine position is suitable for barium sulfate to perfectly fill it. It was possible that our technique can increase the sensitivity for detection of barium reflux.

In comparison with 24-h epHm, Al-Khawari et al<sup>21</sup> reported the sensitivity, specificity and accuracy of barium studies for diagnosis of GERD as 42%, 57% and 45%, respectively. Thompson et al<sup>13</sup> compared barium studies with pH proved GERD and found that the sensitivity of fluoroscopic detection of GER rose from 26% to 70% when provocative maneuvers such as coughing, Valsalva maneuver, rolling from supine to right lateral position and water-siphon test, which let the patient drink water while lying supine for observing GER, were used to elicit reflux. However, the same authors reported that with increasing of sensitivity, the specificity of barium studies was decreased from 94% to 74% with provocative maneuvers. Blumhagen et al<sup>11</sup> addressed a high false positive result of the water-siphon test as 29%, while Johnston et al<sup>12</sup> experienced sensitivity of such test to be 92% but the specificity was zero. We decided not to use these provocative maneuvers because of such evidences, along with the difficulty to perform them in small pediatric patients, and to probably decrease a false positive result. In our study, we found false positive result of 36%.

In GERD related respiratory symptoms, pathophysiologic mechanisms include microaspiration and acid-induced vagal reflex.<sup>4</sup> The height of refluxate could be contributed in pulmonary aspiration despite of the small quantitative amount of acid refluxes. Although the sensitivity, specificity and accuracy for the diagnosis of GERD is not high when compared with 24-h epHm, barium study can provide the height of refluxate. In addition, due to the patients with GERD may present with diverse clinical manifestations, barium studies, on the other hand, will help diagnose the diseases causing symptoms resemble GERD.

The limitation of this study is that 24-h pHm is not a true gold standard test<sup>17</sup>, although it would result in a difficulty for interpretation, it was the best standard we had at the time of study. Further study comparing barium studies with the absolute gold standard test should be performed. Combined MII-pH study is supposed to be a gold standard test for diagnosis of GERD if normal values in children can be established.<sup>17</sup>

## Conclusion

Comparing to 24-hour esophageal pH monitoring; the sensitivity, specificity and accuracy of barium studies is not quite promising for the diagnosis of GERD, and certain limitations are still existed. Due to the limitation of availability of the other tests for diagnosis of GERD in children in developing countries including Thailand, barium studies which are widely available may be useful for evaluation of children with clinical suspected of GERD but a limitation for diagnosis of GERD should be aware.

## References

1. Vakil N, van Zanten SV, Kahrilas P, Dent J, Jones R. The Montreal definition and classification of gastroesophageal reflux disease: a global evidence-based consensus. *Am J Gastroenterol* 2006;101:1900-20.
2. Rudolph CD, Mazur LJ, Liptak GS, Baker RD, Boyle JT, Colletti RB, et al. Guidelines for evaluation and treatment of gastroesophageal reflux in infants and children: recommendations of the North American Society for Pediatric Gastroenterology and Nutrition. *J Pediatr Gastroenterol Nutr* 2001;32 Suppl 2:S1-31.
3. Treepongkaruna S, Phuapradit P, Assadamongkol K, Chantarojanasiri T, Preutthipan A, Suwanjutha S, et al. Gastroesophageal reflux in children with recurrent pneumonia. *Rama Med J* 1996;19:92-8.
4. Gold BD. Asthma and gastroesophageal reflux disease in children: exploring the relationship. *J Pediatr* 2005;146: S13-20.
5. Gupta SK, Hassall E, Chiu YL, Amer F, Heyman MB. Presenting symptoms of nonerosive and erosive esophagitis in pediatric patients. *Dig Dis Sci* 2006;51:858-63.
6. Cohen S, Parkman HP. Heartburn--a serious symptom. *N Engl J Med* 1999;340:878-9.
7. Dranove JE. Focus on diagnosis: new technologies for the diagnosis of gastroesophageal reflux disease. *Pediatr Rev* 2008;29:317-20.
8. Hirano I. Review article: modern technology in the diagnosis of gastro-oesophageal reflux disease--Bilitec, intraluminal impedance and Bravo capsule pH monitoring. *Aliment Pharmacol Ther* 2006;23 Suppl 1:12-24.
9. Madan K, Ahuja V, Gupta SD, Bal C, Kapoor A, Sharma MP. Impact of 24-h esophageal pH monitoring on the diagnosis of gastroesophageal reflux disease: defining the gold standard. *J Gastroenterol Hepatol* 2005;20:30-7.
10. van Os E, De Schryver J, Houwen RH, Ten WE. Gastroesophageal reflux disease in children: how reliable is the gold standard? *J Pediatr (Rio J)* 2009;85:84-6.
11. Blumhagen JD, Christie DL. Gastroesophageal reflux in children: evaluation of the water siphon test. *Radiology* 1979;131:345-9.
12. Johnston BT, Troshinsky MB, Castell JA, Castell DO. Comparison of barium radiology with esophageal pH monitoring in the diagnosis of gastroesophageal reflux disease. *Am J Gastroenterol* 1996;91:1181-5.
13. Thompson JK, Koehler RE, Richter JE. Detection of gastroesophageal reflux: value of barium studies compared with 24-hr pH monitoring. *AJR Am J Roentgenol* 1994; 162:621-6.
14. Strobel CT, Byrne WJ, Ament ME, Euler AR. Correlation of esophageal lengths in children with height: application to the Tuttle test without prior esophageal manometry. *J Pediatr* 1979;94:81-4.
15. Vandenplas Y, Sacre-Smits L. Gastro-oesophageal reflux in infants. Evaluation of treatment by pH monitoring. *Eur J Pediatr* 1987;146:504-7.
16. Rosen R, Nurko S. The importance of multichannel intraluminal impedance in the evaluation of children with persistent respiratory symptoms. *Am J Gastroenterol* 2004;99:2452-8.

17. Vandenplas Y, Salvatore S, Vieira MC, Hauser B. Will esophageal impedance replace pH monitoring? *Pediatrics* 2007;119:118-22.
18. Wenzl TG. Investigating esophageal reflux with the intraluminal impedance technique. *J Pediatr Gastroenterol Nutr* 2002;34:261-8.
19. Del Buono R, Wenzl TG, Rawat D, Thomson M. Acid and nonacid gastro-oesophageal reflux in neurologically impaired children: investigation with the multiple intraluminal impedance procedure. *J Pediatr Gastroenterol Nutr* 2006;43:331-5.
20. Numans ME, Lau J, de Wit NJ, Bonis PA. Short-term treatment with proton-pump inhibitors as a test for gastroesophageal reflux disease: a meta-analysis of diagnostic test characteristics. *Ann Internal Med* 2004;140:518-27.
21. Al-Khawari HA, Sinan TS, Seymour H. Diagnosis of gastro-oesophageal reflux in children. Comparison between oesophageal pH and barium examinations. *Pediatr Radiol* 2002;32:765-70.
22. Sellar RJ, De Caestecker JS, Heading RC. Barium radiology: a sensitive test for gastro-oesophageal reflux. *Clin Radiol* 1987;38:303-7.