Who Should Request a Breath Hydrogen Test? A Six-Year Feasibility, Sensitivity of Clinical Suspicion and Cost-Effectiveness Analysis

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ABSTRACT

Objectives: To assess the feasibility of using an at home breath-sampling technique in patients referred for breath hydrogen testing, and to determine the likelihood for a positive breath hydrogen test (BHT) based on whether the ordering physician is a gastroenterologist or general practitioner.

Methods: Breath samples were collected via a nasal prong technique and stored in a collection kit. The breath samples were then analyzed using the Quintron microlyzer. A positive BHT was defined as a rise in hydrogen gas concentration of more than 10 ppm above baseline.

Results: Over a six-year period (1996 to 2002), 372 consecutive BHTs were performed, 40 in patients younger than 5 years, 201 in patients aged 5 to 18 years, and 131 in patients older than 18 years. Overall, 45 breath samples (12%) were considered unsatisfactory. Patients younger than 5 years (38%) had a significantly higher ($P<0.001$) number of unsatisfactory breath samples than the other 2 age groups (5-18 years old [10%], > 18 years old [7%]). Of the 328 satisfactory BHTs, 162 (49%) were positive for either lactose intolerance (90%) or small bowel bacterial overgrowth (10%). The likelihood in obtaining a positive BHT was significantly ($P<0.001$) higher if the referring physician was a gastroenterologist. Our analysis also suggests a potential cost savings in having gastroenterologists screen patients for suspected lactose intolerance or bacterial overgrowth prior to ordering breath hydrogen testing.

Conclusions: The nasal prong technique is a feasible method of performing the BHT at home in children younger than 5 years of age. In the very young (<5

Table 1. BHT Results According to Age Groups and Requesting Physician*

	Patients tested	Positive BHT	% Positive BHT
All patient	328	162	49 (M51/F48)
< 5 years old	25	12	48 (M47/F50)
5-18 years old	181	96	53 (M53/F53)
> 18 years old	122	54	44 (M46/F44)
Requested by a gastroenterologist	187	111	59 (M58/F61)†
Requested by a general practitioner	141	51	36 (M41/F33)

*M indicates male, and F, female.

†$P < 0.001$ compared to general practitioner group.

Table 2. Cost Analysis of BHT According to Requesting Physician

	General Practitioner	Gastroenterologist
Positive test rate	36%	59%
BHT requests	100	61*
Kit ($40/kit)	$4,000	$2,440
Test & interpretation ($165/test)	$16,500	$10,065
Gastroenterologist consultation ($73.6/patient)	0	$7,360
Total costs	$20,500	$19,865

years of age), new and innovative breath sampling techniques are needed to make home testing practical. Since gastroenterologists are more selective than general practitioners in requesting BHTs, the potential cost savings may offset the added cost of a patient referral.

INTRODUCTION

Breath hydrogen testing is a simple and noninvasive technique that is used in diagnosing lactose intolerance (LI) and small bowel bacterial overgrowth.[1-5] The intraluminal fermentation of unabsorbed carbohydrate produces hydrogen, and methane gases that readily diffuse into the portal circulation and are eventually exhaled. Various methods have been developed to collect breath samples either at home by using a breath collection kit or in the presence of a specialized nurse practitioner.[5-8] Although the availability of home collection kits has lead to the widespread use of this diagnostic tool by both general practitioners and community gastroenterologists, the feasibility of performing these tests at home is unknown. Moreover, the practicality of performing breath collection at home given the present sampling strategies available in pediatrics has yet to be investigated. The objectives of the present study are to assess the feasibility of performing the home collection of breath samples in the different pediatric age groups, and to measure the sensitivity of breath hydrogen testing based on the clinical suspicion of either the ordering gastroenterologist or the general practitioner.

METHODS

Patients

In total, 131 consecutive adults (38 male, 93 female) with a mean (±SD) age of 51.1 ± 16.1 years, and 241 children (138 male, 103 female) with a mean (±SD) age of 9.1 ± 4.3 years, were referred to the breath hydrogen test (BHT) laboratory for evaluation from 1996 to 2002. There were 198 patients (145 male, 153 female) referred for suspected LI, and 74 patients (31 male, 43 female) referred for suspected small bowel bacterial overgrowth. All patients were required to fill in a questionnaire of possibly presenting clinical symptoms, including

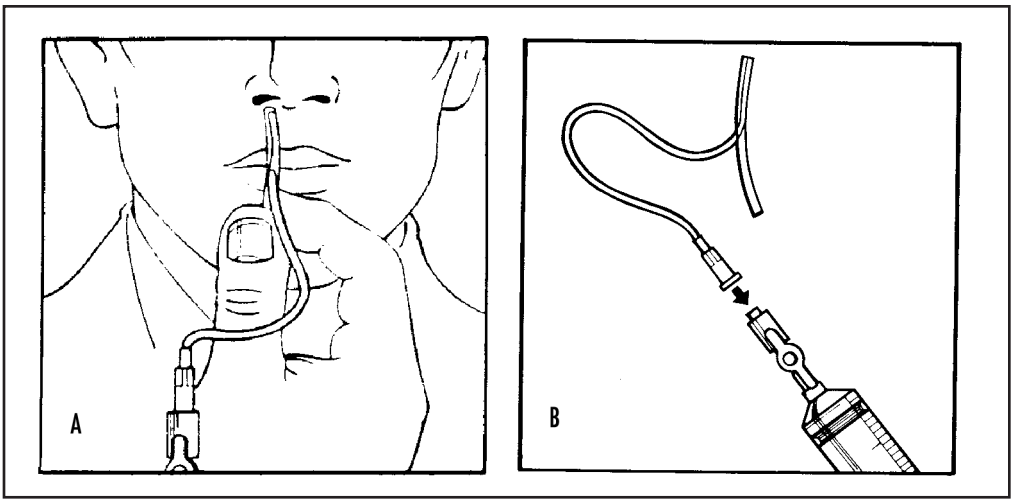

Figure 1. Breath sample collection. (A) A nasal prong is placed in the anterior nostril and exhaled air is pulled back into the syringe. (B) The nasal prong is constructed using a 16 cm length of tubing connected to a syringe with stopcock.

abdominal pain, diarrhea, flatulence, nausea, and vomiting. The questionnaire received approval by the Joint Committee of Clinical Investigation at The Johns Hopkins Hospital. Patients who were on antibiotic therapy, and underwent either endoscopic or radiological investigations within 4 weeks of testing were excluded from the study.

Sample Collection

All patients with suspected lactase deficiency underwent a lactose breath test after an overnight fast. A low fiber diet was prescribed the day before the investigation. The patients consumed 2 grams of lactose per kilogram bodyweight to a maximum 50 grams in 250 mL of water. Patients with suspected small bowel bacterial overgrowth were given glucose in place of lactose sugar.

Exhaled breath samples were collected before and then at 30-minute intervals up to 3 hours after the ingestion of the aqueous carbohydrate solution. In those patients who used the home sample collection kit, breath samples were obtained via a nasal prong technique, as demonstrated in Figure 1A. Expired gas was collected (Figure 1B) in non-sterile 20 mL collection tubes, and transported to The Johns Hopkins Hospital BHT laboratory for analysis.

Breath-Hydrogen Analysis

Breath samples were analyzed with a Quintron microlyzer (Quintron Instrument Co., Milwaukee, Wis) as previously described.[9] Samples with carbon dioxide gas less than 10% were considered unsatisfactory. A positive BHT was defined as a rise in hydrogen gas concentration of more than 10 parts per million above the baseline.

Statistical Analysis

χ^2 analysis was used to determine the likelihood of obtaining adequate breath samples, based on the patient's age, and the likelihood of a positive BHT based on whether the referring physician was a gastroenterologist or general practitioner. A P value of less than 0.05 was considered statistically significant.

RESULTS

Patients

Over the 6-year observation period, 372 consecutive patients were referred for breath hydrogen testing. Among these, 40 were patients younger than 5 years (27 male, 13 female), 201 were patients

aged 5 to 18 years (111 male, 90 female), and 131 were patients aged 18 years or older (38 male, 93 female). There were 209 tests referred by a gastroenterologist and 163 by a general practitioner. Overall, 44 (12%) breath samples were considered inadequate for breath hydrogen testing. Among these, 15 (38%) were in patients younger than 5 years, significantly higher (P<0.001) than the 2 other age groups (5-18 years old: 20 [10%]; > 18 years old: 9 [7%)]).

BHT

Of the 328 satisfactory BHTs, 162 (49%) were positive. The percentage of positive BHTs did not vary with either patient sex or among the different age groups. However, the likelihood of a positive BHT was significantly higher (P<0.001) if the referring physician was a gastroenterologist (Table 1).

Among the 162 patients with a positive BHT, 146 (90%) were diagnosed with LI, and 16 (10%) with small bowel bacterial overgrowth. The common presenting symptoms were abdominal pain and diarrhea in patients with a positive BHT. Interestingly, there was no significant difference in presenting complaints between patients with and without a positive BHT. However, patients with LI were more likely to present with abdominal pain (P<0.01) than patients with small bowel bacterial overgrowth. Conversely, patients with small bowel bacterial overgrowth were more likely to present with complaints of diarrhea (P< 0.01) than patients with LI.

Cost Analysis

The cost analysis was based on the likelihood of obtaining a positive BHT by either a referring gastroenterologist (59%) or general practitioner (36%). In order to achieve the same number of positive BHTs as a general practitioner, a gastroenterologist would need to request 61 tests among the 100 patients referred for consultation. The added cost of a gastroenterologist consultation is offset by the potential savings in the reduced number of patients referred for breath hydrogen testing (Table1). The analysis does not take into consideration the number of patients with a negative BHT that would ultimately be referred to a gastroenterologist for evaluation.

DISCUSSION

Our study is the first to have evaluated the feasibility of performing breath hydrogen testing at home using the nasal prong technique. Home breath sampling in older (>5 years) children and adults was shown to be a practical and cost-effective means of performing breath hydrogen testing. In comparison, children younger than 5 years had a significantly higher rate of unsatisfactory breath sampling when compared to the older age groups, thereby indicating that the home collection method may not be feasible in this pediatric age group. This study would also suggest that innovative breath sampling techniques need to be developed in the very young in order to facilitate home testing. Otherwise, these children should have breath hydrogen testing done in the presence of trained pediatric nurse practitioners.

Breath hydrogen testing is a safe and practical way for general practitioners and gastroenterologists to evaluate patients with suspected carbohydrate malabsorption.[2,3,5,9,10] Despite the known association of symptoms of abdominal pain, diarrhea, flatulence, nausea, and vomiting in patients with either LI or small bowel bacterial overgrowth,3,11-13 our study would suggest that these symptoms have limited specificity and sensitivity in predicting a positive BHT. Although our study would suggest that gastroenterologists are more likely to obtain a positive BHT than general practitioners, it may be due to the simple fact that gastroenterologist have

received the specialized training to differentiate among a variety of gastrointestinal diseases, including inflammatory bowel disease, and irritable bowel syndrome that are known to manifest similar symptomatology. Our cost analysis would also support the notion of a gastroenterologist referral prior to ordering a BHT. The potential savings in ordering less BHTs would offset the added cost of a gastroenterologist consultation.

In conclusion, our study clearly shows that out-patient breath hydrogen testing is a practical and inexpensive method to evaluate patients with suspected LI and small bowel bacterial overgrowth. The nasal prong technique is a feasible technique for performing breath hydrogen testing in older children (>5 years) and adults. In the very young (<5 years), new and innovative breath sampling techniques are needed to make home testing practical. The fact that gastroenterologists are more selective in requesting breath hydrogen testing may require that general practitioners consider a consultation with a gastrointestinal specialist prior to testing.

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