Archives of Disease in Childhood 1992; 67: 146–148

PERSONAL PRACTICE

Lower oesophageal pH monitoring—a useful clinical tool

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Early diagnosis and prompt treatment of gastro-oesophageal reflux (GOR) can halt unnecessary investigations and prevent medical complications, such as failure to thrive,[1] severe oesophagitis,[2] and aspiration syndromes.[3] The standard investigation for GOR is the upper gastrointestinal barium contrast series. However, because of poor sensitivity and specificity the role of this test in clinical practice has been questioned.[4] Several other methods of investigation are available and to some extent the choice of investigation depends on the clinical problem.[5] Over the last 10 years, 24 hour lower oesophageal pH monitoring has increasingly become established as the 'gold standard' for documenting 'acid' GOR.[3 5] The ability to monitor over prolonged time intervals and the avoidance of any radiation are particularly attractive features of this test. However, until recently, the use of the technique has largely been confined to clinical research studies. At the Royal Hospital for Sick Children (RHSC), Glasgow, over the last four years an open clinical pH monitoring service has been available and has proved valuable in diagnosing and managing GOR. We describe here the development of this service, our experience with the technique, and our current practice.

Setting up the service

We first used pH monitoring as a research tool between 1984 and 1986 at the RHSC. The test was increasingly used for diagnostic purposes and in 1986 we established a clinical service. This service was routinely available to all consultants in the hospital and any paediatricians referring children from district paediatric facilities in the west of Scotland. Initially, the clinical studies were performed by medical staff (JYP) but by 1988 the senior NHS technician (CK) in the respiratory laboratory had been trained in the technique. Since then she has been responsible for all technical aspects of the monitoring.

Equipment

All pH studies are performed using a Synectics Digitrapper System for ambulatory pH recording (Synectics Medical Ltd). pH measurements from a 3 mm antimony probe sited in the lower oesophagus are measured every four seconds and stored electronically in the Digitrapper memory. After the completion of a study readings are downloaded from the digitrapper to an IBM AT computer, using dedicated software, for analysis and storage on disc.

Lower oesophageal pH measurement

Each study is performed in hospital by one experienced technician (CK). Initially, the pH probes were passed by ward nurses but latterly, this too has been performed by the technician. Currently, in a large paediatric teaching hospital we perform between three and six studies per week. Each study takes approximately 30 minutes to set up and 15 minutes at the end to analyse. Reporting is performed by one paediatrician (JYP).

Performing the study

No premedication is used so that the 24 hour recording can include as much normal activity as possible. If children are admitted specifically for the investigation it is commenced in the afternoon and they are discharged the next evening. During the 24 hours of the study the children are allowed normal diet and unrestricted activity. The child's carer is asked to note the time of events such as the beginning and end of feeds on a chart and to activate an electronic marker by pressing a button on the recorder. In a busy ward setting it has not proved practical to note accurately either the child's position or state of arousal from minute to minute.

Before use and between studies, the probes are sterilised by immersion in 70% methylated spirit for four hours. Then the probe is calibrated in vitro using standard buffer solutions (pH 7·0 and 1·01, Synectics Medical) at 23°C.

At the start the procedure is explained to parents and child. Each child's height is measured and the distance from the tip of the nose to the lower oesophageal sphincter calculated using the nomogram of Strobel *et al*,[6] which relates oesophageal length to height. A distance, equal to 87% of the total, is calculated and marked on the pH probe which is then passed to this mark. This places the probe above the lower oesophageal sphincter. As there is no fixed radiographic landmark for the lower oesophageal sphincter we have not routinely confirmed the position of the probe by radiography. However, a number of children have had chest radiographs while the probe was in place and in each case the probe has been situated in the lower oesophagus above the diaphragm as expected.

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Once fixed in position the probe is then connected to the recorder (Digitrapper). This is small, battery operated, and portable allowing unrestricted activity. When the study is completed the data in the electronic recorder is transferred to a computer and the recording reviewed; if technically satisfactory, the child is discharged home.

Analysis of pH studies

The study is initially reviewed on computer screen by the technician. The timing of any periods of artefact during the study are noted and can then be disregarded in the subsequent analysis. The duration of the study and the following indices of GOR are then calculated automatically by the computer software and are used to describe the study: (i) the number of episodes of reflux, (ii) the number of episodes of reflux lasting greater than five minutes; (iii) duration of the longest episode, and (iv) percentage of the total time where the pH was less than 4 (reflux index). All indices are normalised to a 24 hour baseline to compensate for differences in study lengths between subjects. A printout of each study with the results and a 24 hour graph is produced for the child's notes.

Costs

One pH probe costs £35 and can be reused on a limited basis. On average we have been able to perform seven studies with each probe. When a probe fails to calibrate at the beginning of a study it is replaced.

The current capital cost of a system including the Digitrapper, accessories to perform 30 studies, and computer software (running on an IBM compatible computer) is £4500. The digitrapper recorders very occasionally need repair reflecting the heavy use they receive.

Clinical experience with pH monitoring

To audit the service we performed a retrospective analysis of consecutive studies performed between April 1985 and March 1989. The children studied could be divided into two broad categories reflecting the medical and surgical situations where GOR is commonly suspected: normal infants with vomiting and children with underlying neurological problems where GOR is common but the diagnosis often difficult (table).

In the four year period 229 studies were performed on 152 children referred by physicians and surgeons in RHSC. Fifty one children had underlying neurological disease while 101 were neurologically normal. Twice as many boys as girls were studied in all groups. Children with underlying neurological disorders were generally older than the other normal children.

Indications for pH monitoring

The clinical problems prompting a request for a pH study are listed in the table. Gastrointestinal symptoms, particularly vomiting, dominated. Within the group of normal children the second main reason for requesting a study was failure to thrive. In contrast, among children with neurological problems the second commonest indication was unusual neurological presentations, such as seizure-like episodes which have been reported to be related to GOR.[7] Respiratory problems possibly related to recurrent pulmonary aspiration, secondary to GOR, were another common indication in both groups.

Symptoms in children suspected of GOR referred for pH study

	Neurological (n=51)	*Non-neurological (n=101)*
Gastro-intestinal:		
Vomiting	21	60
Haematemesis	7	10
Abdominal/chest pain	3	5
Anaemia	1	2
Dysphagia	0	2
Failure to thrive	1	21
Respiratory:		
Lower respiratory tract	6	8
Wheeze	5	8
Apnoea	2	6
Choking	2	11
Neurological:		
Irritability	4	1
Seizures	13	0
Others	3	3

Acid reflux

In the studies we defined an episode of reflux as occurring when the oesophageal pH fell below pH 4. This is the level most commonly used to define 'acid' GOR since Tuttle and Ruffin showed that adult volunteers experienced epigastric pain from infused acid solutions below pH 4.[8] Also in vitro work shows pepsin to be inactive in solution above pH 4. However, there is no directly similar data available for children. pH 4 may not always be the most appropriate level to use particularly in young children. For example, Mason showed that the pH of gastric contents took some time to fall below pH 4 in breast fed neonates.[9] When using pH 4, therefore, to indicate reflux it is important to remember that non-acid reflux may occur and will not be detected. It is, therefore, useful to look for short episodes of brief physiological reflux at some point during a study as confirmation that sufficient acid is being produced.

Reporting

In reporting we used the normal values of Vandenplas and Sacre-Smits[10] and Biox-Ochoa *et al.*[11] The series of Vandenplas and Sacre-Smits of lower oesophageal pH studies in 285 asymptomatic siblings of children dying of sudden infant death syndrome represents the largest series of 'normal' data available for children. Clearly some caution must be exercised in viewing such a group as 'normal'.

Vandeplas and Sacre-Smits found between 0 and 15 months of age normal values for reflux index of up to 11·5% and up to eight episodes of reflux lasting more than five minutes during a 24 hour study (mean+2SD). For older children normal values were: a reflux index up to 6% and

up to six episodes of reflux lasting more than five minutes (mean+2SD).

In reporting the studies, we initially focused on the reflux index and the number of pH drops longer than five minutes over a 24 hour period. These are the two indices identified by Euler and Byrne as providing the best discrimination between normal and abnormal 24 hour pH studies.[12] In practice, however, we have found little gain in using the combination of parameters. The percentage time pH is less than 4 in the lower oesophagus (reflux index) has provided a convenient single summary of the study for clinical purposes. Hampton *et al* have also recently reported no apparent advantage in using variables other than the reflux index.[13]

Results

Using the data from Vandeplas and Sacre-Smits for classifying the studies, 82 children (56%) were judged to have 'significant' GOR.[10]

Oesophageal pH monitoring proved particularly useful in children with underlying neurological problems where more than half the children studied had pathological GOR. In these children the presence of GOR is often difficult to establish by barium studies; some may not even be able to swallow reliably for the study to be performed. In contrast, many are used to having nasogastric tubes in place and the presence of a pH probe causes little additional distress. Without pH monitoring, confirming the diagnosis of GOR in these children would often have been difficult.

Repeat studies

One advantage of pH monitoring is the opportunity to repeat studies on a number of occasions. In the period reviewed we repeated studies for four main reasons: to confirm an unexpected or important result, to evaluate the response to treatment, to assess if natural resolution of GOR had occurred with time, or because of technical failure on the initial study (usually disconnection of the probe from the recorder). We did not attempt to investigate systematically the question of reproducibility of pH monitoring, an area recently addressed by Hampton *et al*.[13] In our clinical experience the investigation has been reproducible and changes in pH mirror changes in symptomatology. For example, in 14 children where GOR was diagnosed, a second study was performed after medical or surgical treatment. In seven a clinical improvement was noted and in six of these there was improvement of greater than 6% in the reflux index. In the other seven there was no improvement in either the clinical symptoms or the pH indices of GOR.

We have found lower oesophageal pH monitoring particularly useful in demonstrating the effectiveness of treatment in children with neurological problems where changes in symptoms may not be immediately obvious.

Problems

(A) FAILURES

In 31 studies the procedure failed (14%). In 16 this was due to accidental disconnection of the probes from the recorder, in five to a broken probe, and in four to malposition of the probe. In the remaining six the reasons for the failure were not recorded. Technical failures were readily identifiable allowing the study to be immediately repeated. Hence, despite the fact that the studies are being performed on active and unrestrained children we have found the equipment and technique remarkably robust in routine use.

(B) COMPLICATIONS

No serious complications occurred. In one subject persistent coughing developed at the start of the study. A chest radiograph showed the probe lodged in the right main bronchus. The probe was removed with resolution of the symptom and the study repeated successfully without further morbidity. Other groups have described complications including aspiration of stomach contents and perforation if a stricture is present in the oesophagus. We have not had problems with aspiration and feel perforation is very unlikely when an experienced technician performs the procedure.

Conclusion

We have found lower oesophageal pH monitoring to be a simple and useful tool in the clinical investigation and management of children with suspected GOR. In general, we have found the equipment and technique for pH monitoring surprisingly robust even when used in active or handicapped children.

In this hospital, ambulatory lower oesophageal pH monitoring is increasingly becoming the technique of choice for the initial investigation of suspected GOR in children, particularly when there are associated neurological problems. We feel it is a technique that should now be more widely available and more readily used in clinical paediatric practice.

1 Ferry GD, Selby M, Pietro TJ. Clinical response to short-term naso-gastric feeding in infants with gastro-oesophageal reflux and growth failure. *J Pediatr Gastroenterol Nutr* 1983;**2**: 57–61.
2 Shub MO, Ulshen MH, Hargrove CB, *et al*. Esophagitis. A frequent consequence of gastro-esophageal reflux in infancy. *J Pediatr* 1985;**107**:881–4.
3 Orenstein SR, Orenstein DM. Gastroesophageal reflux and respiratory disease in children. *J Pediatr* 1988;**112**:847–58.
4 Leonidas JC. Gastroesophageal reflux in infants: role of the upper gastro-intestinal series. *Am J Roentgenol* 1984;**143**: 350–1.
5 Boyle JT. Gastro-oesophageal reflux in the paediatric patient. *Gastroenterol Clin North Am* 1989;**18**:315–37.
6 Strobel CT, Byrne WJ, Ament ME, Euler AR. Correlation of esophageal length in children with height: application to the Tuttle test without prior esophageal manometry. *J Pediatr* 1979;**94**:81–4.
7 Nanayakkara CS, Paton JY. Sandifer syndrome: an overlooked diagnosis. *Dev Med Child Neurol* 1985;**27**:814–21.
8 Tuttle SG, Ruffin F. The physiology of heartburn. *Ann Intern Med* 1961;**55**:292–300.
9 Mason S. Some aspects of gastric function in the newborn. *Arch Dis Child* 1962;**37**:381–91.
10 Vandenplas Y, Sacre-Smits L. Continuous 24-hour esophageal pH monitoring in 285 asymptomatic infants 0–15 months old. *J Pediatr Gastroenterol Nutr* 1987;**6**:220–4.
11 Boix-Ochoa J, Lafuenta JM, Gil-Vernet. Twenty-four hour esophageal pH monitoring in gastro-oesophageal reflux. *J Pediatr Surg* 1980;**15**:74–8.
12 Euler AR, Byrne WJ. Twenty-four hour esophageal intraluminal pH probe testing: a comparative analysis. *Gastroenterology* 1981;**80**:957–61.
13 Hampton FJ, MacFadyen UM, Simpson HS. The reproducibility of 24 hour pH studies in infants. *Arch Dis Child* 1990; **65**:1249–54.

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Arch Dis Child 1992 67: 146-148
doi: 10.1136/adc.67.1.146

Notes