NEW TECHNIQUES

Alternative method of positioning the pH probe for oesophageal pH monitoring

A Anggiansah, N Bright, M McCullagh, K Sumboonnanonda, W J Owen

Oesophageal Investigation Unit, Department of Surgery, Guy's Hospital, London
A Anggiansah
N Bright
M McCullagh
K Sumboonnanonda
W J Owen

Correspondence to:
Mrs A Anggiansah, Department of Surgery, Guy's Hospital, St Thomas Street, London SE1 9RT.

Accepted for publication 18 March 1991

Abstract
The most reliable method of positioning a pH probe for oesophageal pH monitoring is to use manometry to determine the upper margin of the lower oesophageal sphincter and to place the probe 5 cm above this point. Manometry is expensive, however, requires special equipment and training, and is not widely available. An alternative cheaper way of determining the site of the lower oesophageal sphincter has been evaluated. A fine bore nasogastric tube with a latex balloon at its tip was inserted transnasally into the stomach. The balloon was inflated with 10 ml of water and the tube withdrawn until resistance was met. The distance from the nose (in cm) was noted and compared with the upper margin of the lower oesophageal sphincter as determined by oesophageal manometry. The manometric distance agreed closely with the balloon distance minus 1 cm (bias 0·29 cm; 95% CI of bias, 0·03 to 0·55 cm; 2 SD, limits of agreement, 1·58 cm). We conclude that where oesophageal manometry is not available, balloon localisation is a suitably accurate way of identifying the lower oesophageal sphincter.

Oesophageal pH monitoring is the most reliable method of demonstrating gastro-oesophageal acid reflux.[1 2] Miniaturisation of the recording devices[3] has led to the development of outpatient ambulatory pH recording. In addition to the benefit of avoiding hospital admission, Branicki *et al*[3] have shown that more physiological and pathological reflux occurs when the patient is freely ambulant at home and engaged in normal daily activities.

With the advance of computer technology, the laborious manual calculation of the recorded pH data has been replaced by computerised data analysis programmes that are readily obtainable commercially (Synectics, Aspen Medical, Oxford Instruments). Furthermore, the high fidelity of the present recording systems and the ease with which the pH probe can be introduced have led to the test being performed more frequently. These factors, combined with the proved benefit of pH recording in the diagnosis of gastro-oesophageal reflux,[5–8] have led to an increasing number of gastroenterological units being equipped with a pH recording system over the past decade.

It is generally agreed that the pH sensor should be positioned 5 cm above the upper margin of the lower oesophageal sphincter and that the lower oesophageal sphincter position should be determined by prior oesophageal manometry.[4 6 9] Where this is not available, however, there are other methods of locating the upper margin of the lower oesophageal sphincter: (a) measurement from the incisors to the gastro-oesophageal junction obtained at endoscopy, adding 4 to 5 cm[5 10] to allow for the fact that the nasal route is longer; and (b) estimation of the distance from the nose to the position where the pH changes from a low gastric to a high oesophageal pH.[11] The measurements based on pH changes or gastroscopy, however, may not be accurate enough to enable localisation of the upper margin of the lower oesophageal sphincter.[12] An early method,[13] using radiological control to position the pH probe for prolonged pH monitoring, has been abandoned in adult patients. In infants, however, a formula relating oesophageal length to the child's height is widely used to calculate the distance from the nose.[14] After placement of the probe, the patient is screened under radiological control to confirm the position of pH sensor.

The aim of this study was to compare manometry with the balloon method in localising the lower oesophageal sphincter.

Methods
Thirty five patients (20 men, 15 women; mean (SD) age 49·97 (11·8) years; range 25–71 years)

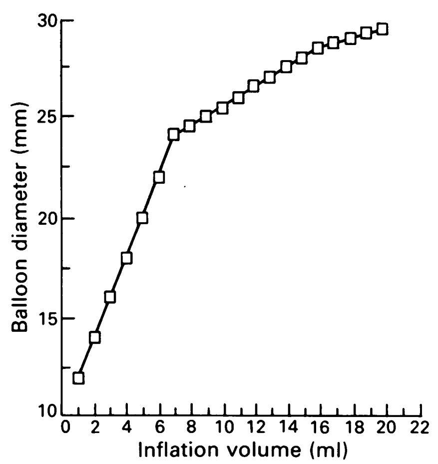

Figure 1: The distension volumes with increments of 1 ml up to 20 ml is plotted against the mean outer balloon diameters.

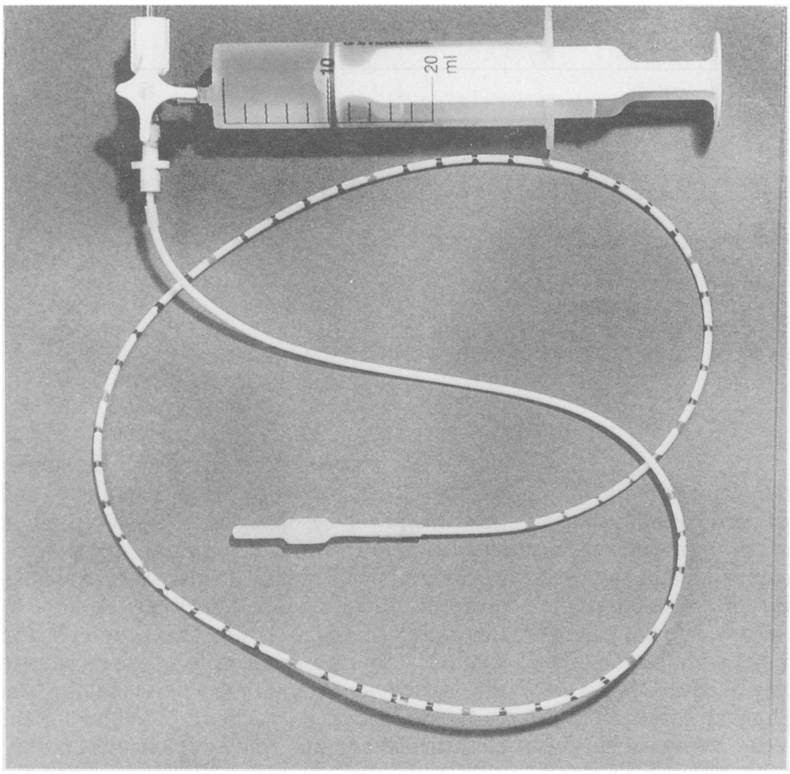

Figure 2: A fine bore nasogastric tube incorporating a latex balloon at its tip is connected to a 20 ml syringe through a three way stop cock.

complaining of chest pain, heartburn, regurgitation, and dysphagia were studied.

A fine bore nasogastric tube (Cassenne Ltd) was prepared by tying a latex balloon (7 mm diameter, 1 cm long) (Dipped Latex Products) to its tip. The tube was marked at 1 cm intervals from the proximal end of the balloon to 60 cm to allow easy measurement of the distance to the balloon. The diameter of the balloon had been tested three times before the study and a graph of distension volumes with increments of 1 ml up to 20 ml was plotted against the mean outer balloon diameters (Fig 1). The inflated balloon diameters were found to be reproducible and linear up to inflation volumes of approximately 10 ml. A standard inflation volume of 10 ml was therefore chosen for this study.

To recognise the sensation produced when the inflated balloon impinged on the gastro-oesophageal junction from below, a glass tube 1·5 cm in diameter was used as a substitute for the oesophagus. The inflated balloon was withdrawn until it was in contact with the end of the glass tube. Further traction was exerted to familiarise the operator with the effects on the balloon and the elastic sensation generated by tension on the finebore nasogastric tube. Hence the operator was able to detect from the tension on the nasogastric tube that the gastro-oesophageal junction had been reached. Slight recoil (approximately 1 cm) was allowed before measurements of the distance from the proximal edge of the balloon to the edge of the nares were taken.

A guidewire was inserted into the nasogastric tube before intubation to prevent the probe curling and to aid intubation. The tube was inserted transnasally into the stomach to a distance 60 cm from the nose. The guidewire was then removed. The proximal end of the fine bore nasogastric tube was connected to a three way stop cock attached to a 20 ml syringe (Fig 2). Once the balloon was positioned in the stomach it was inflated, then slowly withdrawn, until resistance was met as described previously. The distance from the nose (in cm) was noted. The procedure was repeated three times to test the reproducibility of the distances measured.

To determine whether the distances measured were to the diaphragmatic hiatus or to the lower oesophageal sphincter, seven patients known to have small hiatus hernias (ranging from 2–3 cm) and three patients with large hiatus hernias (5–7 cm) were studied. Although a very slight degree of resistance was occasionally felt, probably when the inflated balloon was passing through the diaphragmatic hiatus, the operator was able to continue withdrawing the balloon until lower oesophageal sphincter resistance was met.

At the end of the study, the catheter and balloon were removed. As the cost was about £2 per balloon and £2.50 for the finebore nasogastric tube, they were soaked in Cidex for 10 minutes and then rinsed in sterile water and allowed to dry before being used again.

Location of the lower oesophageal sphincter was then determined manometrically by the station pull through technique,[15] using a catheter with six surface mounted miniature pressure transducers (Gaeltec) positioned at 5 cm intervals. Manometry was performed in the sitting position with transnasal intubation after a four hour fast. The distance (in cm) from the nose to the upper margin of lower oesophageal sphincter was noted. Both tests were performed on the same day by different operators who were blind to the findings of other methods.

STATISTICAL ANALYSIS

To assess agreement between two methods of clinical measurement, the difference in values was plotted against the average, as recommended by Bland and Altman.[16] The bias was the mean difference in distances measured by the two methods. Two SD about the bias showed the limits of agreement. The 95% confidence intervals (CI) of the bias showed the precision of the estimate. One way analysis of variance was used to investigate whether bias varied according to certain subgroups of patients.

Results

The difference between the manometric and balloon measurements was calculated for each of the 35 subjects to derive the mean (SD) values of the differences. The mean difference of 0·29 cm was shown to be closest to zero for balloon distance minus 1 cm. The residual random variability of the differences had an SD of 0·79 cm; thus 95% of the differences between the manometric and the adjusted balloon measurements would fall below 1·58 cm after adjusting for the 0·29 cm bias. Therefore, the balloon distance minus 1 cm (adjusted balloon distance) was chosen and the difference between the manometric distance was plotted against the average distance (Fig 3).

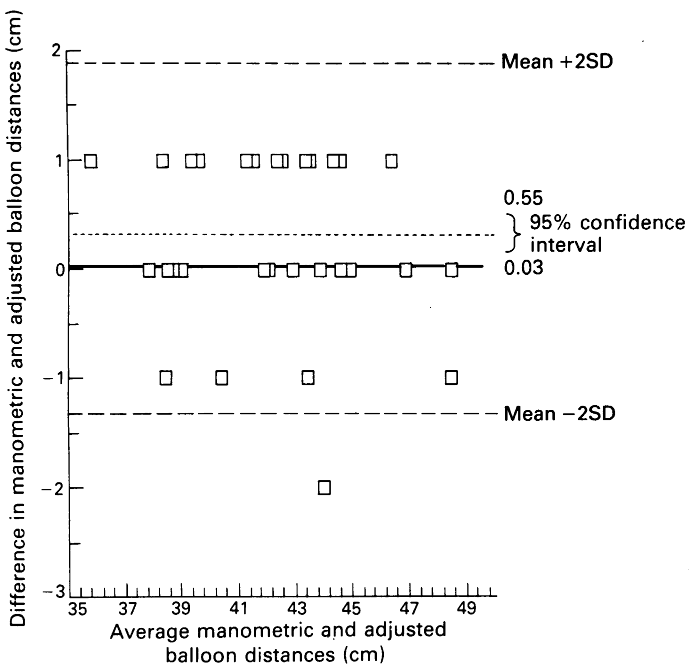

Figure 3: Agreement between the manometric and the adjusted balloon distances (cm). The x axis shows the average value by the manometric and adjusted balloon distance and the y axis the difference between the two distances.

The agreement between the two methods (Fig 3) shows that the bias over the range of 36 to 49 cm is 0·29 cm and the 95% CI is 0·03 to 0·55 cm. The limits of agreement value of 1·58 cm is small compared with the differences observed between patients.

Data on sex, age, hiatus hernia, lower oesophageal sphincter pressure, and manometric and adjusted balloon distances for all patients are given in the Table. Of the 35 patients, 10 presented with hiatal hernia, one with oesophagitis, two had undergone Nissen fundoplication for gastro-oesophageal reflux, and another two had had Heller's myotomy for achalasia.

Individual data on sex, age, hiatus hernia (HH), lower oesophageal sphincter (LOS) pressure, manometric distance (M), balloon distance – 1 cm (B), and the difference between M and B (D)

					Distance (cm)		
No	*Sex*	*Age (yrs)*	*HH*	*LOS pressure (mm Hg)*	*M*	*B*	*D*
1	M	65	No	5	44	44	0
2	M	47	No	20	42	41	1
3	M	31	No	9	45	44	1
4	M	46	No	6	47	46	1
5	M	26	No	5	42	42	0
6	F	61	No(Oes)	5	38	39	−1
7	M	66	No	8	48	49	−1
8	F	52	No	30	42	41	1
9	F	25	No	16	42	42	0
10	F	40	No	7	40	39	1
11	M	52	No	6	43	42	1
12	M	53	No	2	40	41	−1
13	F	71	Yes	8	38	38	0
14	F	40	No	30	47	47	0
15	M	55	Yes	7	45	45	0
16	M	42	Yes	2	40	39	1
17	M	51	Yes	16	44	43	1
18	M	56	PN	13	42	42	0
19	M	51	PN	18	43	44	−1
20	F	59	No	28	43	45	−2
21	M	46	No	15	43	43	0
22	M	63	No	9	45	44	1
23	F	65	Yes	12	39	39	0
24	F	55	No	10	39	38	1
25	F	52	No	10	43	42	1
26	M	38	PH	4	42	41	1
27	F	45	PH	5	44	43	1
28	M	62	No	10	45	44	1
29	M	42	No	7	43	43	0
30	F	45	No	10	40	39	1
31	F	70	Yes	5	39	40	0
32	F	51	Yes	10	38	39	0
33	M	32	Yes	9	48	49	0
34	M	54	Yes	5	36	36	1
35	F	40	Yes	9	44	45	0

PN=post Nissen fundoplication, PH=post Heller's myotomy, Oes=oesophagitis.

The difference between the manometric and adjusted balloon distance was not statistically significant when the 10 patients presenting with hiatus hernia were compared with the 25 remaining patients ($p=0·84$) (one way analysis of variance).

There were 25 patients with a lower oesophageal sphincter pressure of 2–10 mm Hg, seven were in the range 12–20 mm Hg, and three within the 28–30 mm Hg range. The differences between the manometric and adjusted balloon distances for those with a lower oesophageal sphincter pressure ranging between 2 and 10 mm Hg, 12 and 20 mm Hg, and 28 and 30 mm Hg were not statistically significant ($p=0·28$) (one way analysis of variance).

The distance to the upper margin of the lower oesophageal sphincter, measured by manometry, varied from 36 cm to 48 cm with a mean (SD) of 42·4 (3·03) cm. The adjusted balloon distance varied from 35 cm to 49 cm with a mean (SD) of 42·1 (3·1) cm. In 14 patients, both measurements were identical, in 20 patients the difference was 1 cm, and in the remaining one patient the difference was 2 cm.

Discussion

The most accurate method of positioning the pH sensor 5 cm above the upper margin of lower oesophageal sphincter is to determine the site by prior oesophageal manometry.[1–4 9] Lack of precision in positioning the sensor may lead to inaccurate estimation of acid reflux and change the results of oesophageal pH monitoring,[17 18] although one report[19] disputed this and stated that there was no significant difference between the results of oesophageal pH monitoring at 5 and 10 cm above lower oesophageal sphincter.

In the early stages of prolonged nonambulatory pH monitoring, Spencer[13] used radiological control to position the pH sensor at the junction of the lower and middle third of oesophagus. It was realised, however, that the length of the oesophagus varies considerably,[20] so other methods were sought to position the pH sensor more precisely.

In the same year, Kantrowitz *et al*,[9] attempted to localise the gastro-oesophageal junction by noting the position at which the low gastric pH changed to high oesophageal pH and compared this with the manometric measurements. In 22 of their 29 patients there was a good correlation, but in the remaining seven there was a gradual pH gradient continuing for some centimetres above the lower oesophageal sphincter. They concluded that manometry was required for optimal localisation of the lower oesophageal sphincter and for accurate pH monitoring. In an earlier study,[11] we found an abrupt change from the low gastric pH to the higher oesophageal pH in all our patients enabling us to define the position where pH transition occurs. A difference in the speed of withdrawal of the pH probe in these two studies may account for the differing results. In 1987, however, Marples *et al*,[6] showed that in asymptomatic controls with no acid load before pH pull through, the results obtained by this method were well below the lower oesophageal sphincter, while in reflux patients the result was well above the lower oesophageal sphincter. In the case of asymptomatic controls, the change in pH occurred up to 16 cm below the lower oesophageal sphincter. The pH probe (microelectrode MI-506) used in this study was very flexible and can easily curl inside the oesophagus. Indeed, we have had the same experience when using this type of catheter. On one occasion on removing the catheter, it was found to have knotted itself within the oesophagus so invalidating the result of recording. Marples *et al*[6] concluded again that locating the lower oesophageal sphincter should be done by prior oesophageal manometry and that pH pull through is an inaccurate method of positioning oesophageal pH electrodes.

When endoscopy is used to identify the gastro-oesophageal junction, some difficulty may be encountered when the patient presents with hiatus hernia, as the transition from tubular oesophagus to saccular stomach may be gradual rather than abrupt. Care must be taken not to confuse the squamocolumnar junction with the gastro-oesophageal junction as the former may be much more proximal in the cases of oesophagitis and Barrett's oesophagus.[7] The correction factor of 4 or 5 cm to compensate for the nasal route also varies between centres.[5,10] In addition to that, there are interobserver variations in the distance measured to the gastro-oesophageal junction during routine flexible upper oesophagoscopy. McCullagh and Owen[21] reported exact agreement of only 74% in the gastro-oesophageal junction distance measured by two trained endoscopists.

A distance of 5 cm above the upper margin of lower oesophageal sphincter determined before manometry is currently the agreed value for standard oesophageal pH monitoring,[1,22] although others may position the pH tip 5 cm above the lower border of the lower oesophageal sphincter[8] or 3 cm above its upper margin.[23] However, existing studies describing data from normal control subjects, and used in the diagnosis of gastro-oesophageal reflux[24,25] by automated programmes, are based on a large number of controls with the pH recording at 5 cm above the upper margin of the lower oesophageal sphincter. These two studies[24,25] showed unexpectedly consistent results in control subjects aged under 45 years. Therefore, to use the available control data[24] to separate health from disease or for valid comparison, it is crucial to be able to position the pH tip accurately 5 cm above the upper margin of the lower oesophageal sphincter.

In this study on the 10 patients with known hiatis hernias, the distances measurement by the balloon localised method agreed closely with the manometric distances.

In our study, a stiff guidewire was inserted into the fine bore nasogastric tube to prevent the curling of the catheter that Marples *et al*[6] had experienced. The method of withdrawing the balloon inflated with 10 ml water (25 mm diameter) will identify the lower oesophageal sphincter regardless of whether the patient has reflux disease, oesophagitis, or a hiatus hernia. We believe that the lower oesophageal sphincter can be accurately determined using this method. The pH sensor can then be placed 6 cm above this level to achieve satisfactory pH recording.

We thank Richard Morris for his statistical assistance.

1 Johnson JF, DeMeester TR. Twenty-four-hour pH monitoring of the distal esophagus – a quantitative measure of gastroesophageal reflux. *Am J Gastroenterol* 1974; **63:** 325–32.
2 Skinner DB. Pathophysiology of gastroesophageal reflux. *Ann Surg* 1985; **202:** 546–56.
3 Branicki FS, Evans DF, Ogilvie AL, Atkinson M, Hardcastle JD. Ambulatory monitoring of oesophageal pH in reflux oesophagitis using a portable radiotelemetry system. *Gut* 1982; **23:** 992–8.
4 DeMeester TR, Wang CJ, Wernly JA, Pellegrini CA, Little AG, Klementschitsch P, *et al.* Technique, indication and clinical use of 24 hour esophageal pH monitoring. *J Thorac Cardiovasc Surg* 1980; **79:** 656–70.
5 Donald IP, Ford GA, Wilkinson SP. Is 24h ambulatory oesophageal pH monitoring useful in district general hospital? *Lancet* 1987; **10:** 89–92.
6 Marples MI, Mughal M, Bancewicz J. Can an oesophageal pH electrode be accurately positioned without manometry? In: Siewert JR, Holscher AH, eds. *Diseases of the esophagus.* Berlin: Springer-Verlag, 1987: 789–91.
7 Blackstone MD. *Endoscopic interpretation. Normal and pathological appearances of gastro-intestinal tract.* 1st ed. New York: Raven Press, 1984.
8 De Caestecker JS, Blackwell JN, Pryde A, Heading RC. Daytime gastro-oesophageal is important in oesophagitis. *Gut* 1987; **28:** 519–626.
9 Kantrowitz PA, Corson JG, Fleischli DJ, Skinner DB. Measurement of gastroesophageal reflux. *Gastroenterology* 1969; **56:** 666–74.
10 Owen WJ. The role of the oesophageal laboratory. *Gastroenterol Practice* 1988; Feb/Mar: 20–6.
11 Rokkas TH, Anggiansah A, Dorrington L, Owen WJ, Sladen GE. Accurate positioning of the pH-probe in the oesophagus without manometry. *Italy J Gastroenterol* 1987; **19:** 176–8.
12 Walther B, DeMeester TR. Placement of the esophageal pH electrode for 24-hour esophageal pH monitoring. In: DeMeester TR, Skinner BD, eds. *Esophageal disorders: pathophysiology and therapy.* New York: Raven Press, 1985: 539–41.
13 Spencer J. Prolonged pH recording in the study of gastro-oesophageal reflux. *Br J Surg* 1969; **56:** 912–4.
14 Rode H, Stunden RJ, Millar AJW, Cywes S. Esophageal pH assessment of gastroesophageal reflux in 18 patients and the effect of two prokinetic agents: cisapride and metoclopramide. *J Pediatr Surg* 1987; **22:** 931–4.
15 Welch RW, Drake ST. Normal lower oesophageal sphincter pressure: a comparison of rapid Vs slow pull-through techniques. *Gastroenterology* 1980; **78:** 1446–51.
16 Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986; i: 307–10.
17 Shaker R, Dodds WJ, Helm JF, Hogan WJ, Arndorfer RC. Regional esophageal distribution and clearance of refluxed acid. *Gastroenterology* 1987; **92:** 1635.
18 Johansson KE, Tibbling L. Evaluation of the 24-hour pH test at two different levels of the esophagus. In: DeMeester TR, Skinner DB, eds. *Esophageal disorders. Pathophysiology and therapy.* New York: Raven Press, 1985: 579–82.
19 Walker SJ, Holt S, Sanderson CJ, Stoddard CJ, Shields R. Does the position of the probe affect the results of oesophageal pH monitoring? *Gut* 1986; **27:** A1242.
20 Kalloor GJ, Deshpande AH, Collis JL. Observation on oesophageal length. *Thorax* 1976; **31:** 284–8.
21 McCullagh M, Owen WJ. Interobserver variations on routine flexible oesophagoscopy. *Gut* 1989; **30:** A1490.
22 Emde C, Garner A, Blum A. Technical aspects of intraluminal pH-metry in man: current status and recommendations. *Gut* 1987; **23:** 1177–88.
23 Kaye MD. Postprandial gastro-oesophageal reflux in healthy people. *Gut* 1977; **18:** 709–12.
24 DeMeester TR. Prolonged oesophageal pH monitoring. In: Read NW, ed. *Gastrointestinal motility. Which test?* London: Wrightson Biomedical, 1989: 41–52.
25 Smout AJPM, Breedijk M, Roelofs JMM, Akkermans LMA. What is normal 24-hour esophageal pH-metry? *Gastroenterology* 1988; **94:** A433.