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Postprandial gastro-oesophageal reflux in healthy people[1]

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SUMMARY Distal oesophageal pH was monitored for three hours after a standard meal in 10 young healthy subjects without symptoms of gastro-oesophageal reflux. Episodes of reflux occurred in nine of these subjects; and, in five, oesophageal pH was less than 5 for between 11 and 75% of the first postprandial hour. Intermittent incompetence of the lower oesophageal sphincter after food must, therefore, be regarded as a normal phenomenon. The method described would be suitable for the evaluation of agents believed to weaken or to strengthen the lower oesophageal sphincter.

Repeated exposure of oesophageal mucosa to gastric contents may lead to reflux oesophagitis, especially if exposure is prolonged because of poor oesophageal emptying, or if gastric contents are unusually noxious. A prerequisite for the development of gastro-oesophageal reflux is incompetence of the lower oesophageal sphincter, the control of which remains poorly understood, despite intensive study. Though it is often tacitly assumed that the normal lower oesophageal sphincter provides an effective barrier to reflux at all times except during eructation and vomiting, this assumption has received little investigation. The aim of this study was to determine whether or not the normal lower oesophageal sphincter remains continuously competent under physiological conditions, and thereby to provide a more solid basis for the definition of incompetence of the lower oesophageal sphincter; and to devise a test applicable to the investigation of physiological and pharmacological influences upon its competence.

Methods

SUBJECTS

Ten normal subjects were studied. Specifically selected were subjects who had never experienced heartburn, and who denied symptoms of sour or bitter regurgitation, dysphagia, odynophagia, epigastric discomfort; or antacid consumption. None had undergone barium meal examination or any type of upper abdominal surgery. Of the 10 subjects, seven were male and three were female, aged between 20 and 27 years, with a mean of 24·3 years. Fully informed written consent was obtained from each subject before study.

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MANOMETRY

The location and characteristics of the lower oesophageal sphincter were determined by manometry. Subjects fasted overnight. A tube with six separate lumens, and with an overall diameter of 0·67 cm, was passed through the mouth into the stomach. Three of the lumens had side openings at the same axial level of the assembly, with equal spacing around its circumference. These sensors were used for assessment of the lower oesophageal sphincter. The remaining lumens had openings spaced at 5 cm intervals proximal to the latter sensors. Each lumen was continuously perfused with distilled water at a rate of 0·5 ml/minute by means of a pneumo-hydraulic capillary infusion system (Arndorfer Medical Specialties Co., Greenfield, Wisconsin; Dodds *et al.*, 1974); and was connected to an external transducer (Bell and Howell 4-327-1), the output from which was recorded on a multichannel recorder (Gilson Macropolygraph). Respiration was recorded by means of a flexible pneumatic cuff positioned around the chest and connected to a separate transducer, and swallowing was monitored by an electromyograph. During recording subjects lay supine on a couch. Lower oesophageal sphincter pressure profiles were obtained by both station withdrawal and continuous withdrawal techniques. For station withdrawal, recording openings were withdrawn, 0·5 cm at a time, from

stomach to distal oesophagus. The assembly was maintained at each point until stable baseline pressures had been recorded. Expiratory, inspiratory, and mid-respiratory lower oesophageal sphincter pressures were measured in relation to gastric fundic baseline pressures. For continuous withdrawal measurements, recording openings were withdrawn from stomach to oesophagus at a rate of 1 cm/s while subjects held their breath at the end of a tidal expiration. Subjects were instructed to avoid swallowing for 30 seconds before, and during withdrawal. If there was any evidence of swallowing, breathing, or Valsalva manoeuvre during withdrawal, the measurement was discarded. At least two withdrawals of each type were carried out in each subject. For a given withdrawal, the mean value from the simultaneous measurements registered by the three sensors with a common axial location was used.

PH MEASUREMENT

A small glass pH electrode (Radiometer GK 282C, Copenhagen, Denmark) was passed through the mouth of the fasting subject and positioned 3 cm above the upper margin of the lower oesophageal sphincter, as determined previously by manometry. The assembly was anchored by taping firmly to the cheek. Oesophageal pH was recorded continuously by pH meter (Radiometer PHM 62, Copenhagen. Denmark), the output of which was recorded on a multichannel recorder (Gilson Macropolygraph). Respiration was also recorded by means of a flexible pneumatic cuff placed around the chest and connected through an external transducer to the recorder. With the pH electrode in place, the subject ate a standard meal consisting of a glass of orange juice, two scrambled eggs, two slices of buttered toast, and a cup of coffee. After ingestion of the meal, he lay supine on a bed with one or two pillows for three hours, during which pH was recorded continuously. Smoking was not permitted.

For the purposes of this analysis, falls in oesophageal pH below 5 were considered to indicate gastro-oesophageal reflux. Periods of time during which oesophageal pH was between 5 and 4, 4 and 3, 3 and 2, and 2 and 1 were measured for each hour of recording, and for the total recording time. Each period at a given pH level was then expressed as a percentage of the recording time.

A crude scoring system was devised in order to approximate the amount of reflux in each subject. For periods between 5 and 4, 4 and 3, 3 and 2, and 2 and 1, multiplication factors of 1, 2, 3, and 4, respectively, were applied.

Table 1 *Oesophageal pH during first hour after meal. Figures represent percentage of time that pH was between values shown.*

Subject	% Time between			
	5 and 4	4 and 3	3 and 2	2 and 1
JB	5·6	3·4	2·5	0·3
GT	8·9	7·1	6·5	1·3
MP	9·4	4·8	5·1	2·7
JE	1·1	0·8	0	0
CR	0	0	0	0
JG	3·2	1·5	0·3	0
RS	1·2	2·6	1·7	0·1
SG	71·4	4·6	0	0
GF	13·4	15·7	4·7	0
MC	1·8	0·3	0	0
Mean	11·60	4·08	2·08	0·44

Table 2 *Individual fasting lower oesophageal sphincter pressures (mmHg) and reflux scores (derivation of score described in text).*

Subject	Lower oesophageal sphincter		Reflux score			
	Continuous withdrawal	Station withdrawal	1st h	2nd h	3rd h	3 h Total
JB	10·7	15·3	21·2	17·7	3·6	42·5
GT	12·3	16·8	47·9	47·7	21·7	117·3
MP	16·5	21·6	45·0	43·6	0	88·6
JE	16·7	20·1	2·7	0·7	0	3·4
CR	18·8	21·6	0	0	0	0
JG	19·3	24·8	7·0	0·7	1·0	8·7
RS	22·8	25·1	11·7	0	0	11·7
SG	23·5	17·5	80·6	0	0	80·6
GF	37·8	34·8	59·1	0·7	1·0	63·2
MC	40·7	34·7	2·4	0	0	2·4

Results

Resting lower oesophageal sphincter pressures, as measured by the continuous withdrawal method, ranged between 10·7 and 40·7 mmHg (mean 21·9). Pressures obtained by the station withdrawal method (mid-respiratory) ranged between 15·3 and 34·8 mmHg (mean 23·2).

Episodes of reflux occurred in nine of 10 subjects during the first hour after the meal, in five of 10 during the second, and in four of 10 during the third. The duration and especially frequency of reflux episodes was much greater during the first hour, values for which are given in Table 1. pH scores for each hour and for the total three-hour period are shown in Table 2, which includes also individual lower oesophageal sphincter pressures. It will be clear from this table that there was no correlation between the amount of postprandial reflux and fasting lower oesophageal sphincter pressure.

The Figure illustrates episodic gastro-oesophageal reflux as observed in one of the subjects studied.

Discussion

Gastro-oesophageal reflux is often assessed by the Tuttle test (Tuttle and Grossman, 1958) in which

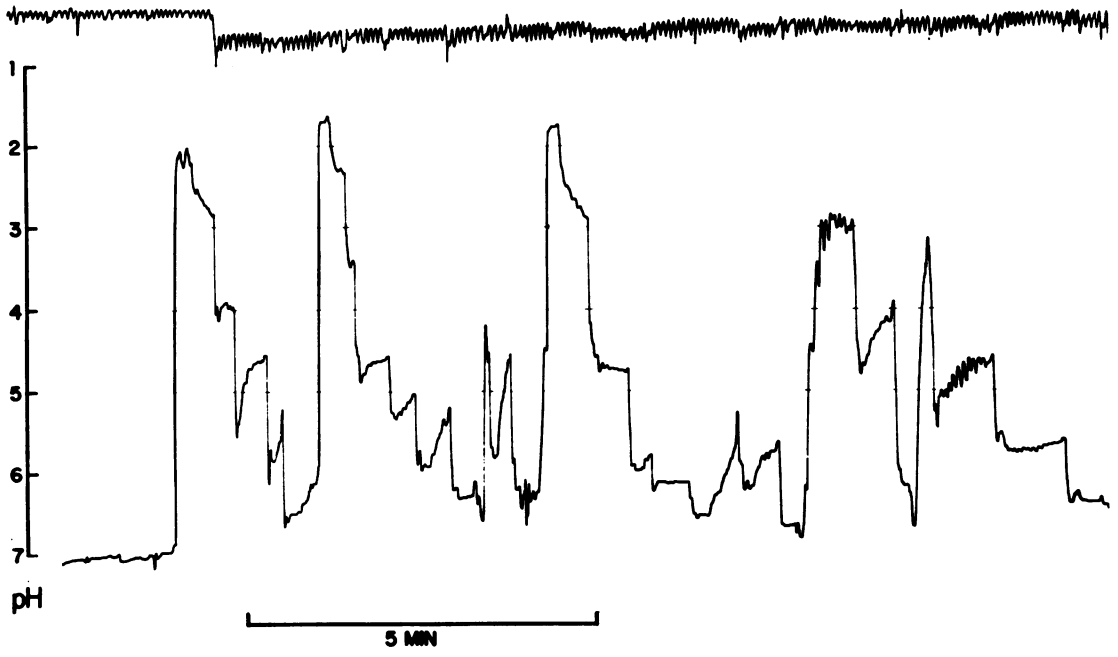

Figure *Portion of pH recording during first hour after meal in subject MP. The uppermost tracing is a pneumograph (inspiration downward). pH scale is shown on the left. There are repeated episodes of gastro-oesophageal reflux.*

distal oesophageal pH is measured by pH electrode after placing in the stomach 300 ml 0·1 N NCl, and during performance of a variety of manoeuvres designed to stress the lower oesophageal sphincter. Early reports (Tuttle *et al.*, 1960; Piccone *et al.*, 1965; Bombeck *et al.*, 1970; Skinner and Booth, 1970; Haddad, 1970; Ismail-Beigi *et al.*, 1970; Benz *et al.*, 1972) suggested that this test reliably distinguished between subjects with and without symptoms of gastro-oesophageal reflux and/or oesophagitis. In other reports, however, the incidence of false positive and false negative results has been sufficiently high to cast doubt upon the reliability of this test (Venkatachalam *et al.*, 1972; Johnson *et al.*, 1974; Behar *et al.*, 1976); and attention has turned recently to relatively prolonged monitoring of oesophageal pH under more physiological conditions of study. Using this approach, all investigators have reported episodes of oesophageal reflux in some of their control subjects. Controls studied by Spencer (1969) and by Pattrick (1970) were not normal in that the majority had duodenal ulcer or some other upper gastrointestinal disorder. Those who have studied entirely healthy individuals have reported reflux in 18 of 26 subjects supine for 12 hours (Boesby, 1975), in two of 10 supine for three hours after a steak meal (Behar and Biancani, 1976), and during 0·29% of a 24-hour recording period in 15 subjects (Johnson and DeMeester 1974).

The test described in this report uses a relatively short period of recording (three hours) and, therefore, does not require overnight admission to hospital. The standard meal used was designed to stimulate gastric acid secretion (egg protein, coffee) and to lower the pH of gastric content (orange juice), so that any episodes of reflux that might occur in the period immediately after ingestion would be more readily detectable. The supine position was chosen since there is evidence, both direct (Babka *et al.*, 1973) and indirect (Spencer, 1969; Pattrick, 1970; Johnson and DeMeester, 1974) that normal subjects have tighter sphincters when supine than when upright. Reflux was demonstrable in nine of 10 subjects during the first postprandial hour, and in five of these oesophageal pH was less than 5 for between 11 and 75% of this first hour. As these individuals were young, healthy, and completely free of symptoms, one must conclude that episodic lower oesophageal sphincter incompetence is a normal phenomenon after eating. Clinically significant lower

oesophageal sphincter incompetence therefore requires quantitative rather than qualitative definition, and factors other than lower oesophageal incompetence—the ability of the oesophagus to empty itself of refluxed material, the degree of noxiousness of gastric content, the capacity of the oesophageal mucosa to withstand assault—are pertinent to the development of symptomatic gastro-oesophageal reflux and of reflux oesophagitis.

It has become abundantly clear that the correlation between lower oesophageal sphincter competence and a single measurement of lower oesophageal sphincter pressure is imperfect, and, as Pope (1976) has emphasised, the assessment of lower oesophageal sphincter competence should rely not upon an indirect measurement of lower oesophageal pressure, but upon the direct measurement of distal oesophageal pH. By the same token, continuous measurement of lower oesophageal sphincter pressure, which is fraught with technical difficulties, is not an optimal method for assessment of the influence of various agents and conditions upon the competence of the lower oesophageal sphincter. Such assessments should be based upon direct measurement. The test described in this report is simple, well tolerated, relatively short in duration, and can readily be repeated. It, therefore, appears to be well suited to the investigation of agents thought to impair or enhance competence of the normal or abnormal lower oesophageal sphincter.

Investigation of competence of the lower oesophageal sphincter by measurement of distal oesophageal pH has been criticised on the grounds that the response of the pH electrode will be the same to a drop as to a pint of refluxing gastric content. However, though it is true that this method does not truly measure volume of refluxed fluid, the pH electrode accurately measures pH of the oesophageal mucosa at a given point, and the duration of mucosal content with fluid at a given pH; and these are the factors which appear to have the greatest pathogenetic significance in the context of reflux oesophagitis.

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