

Transpyloric fluid movement and antroduodenal motility in patients with gastro-oesophageal reflux

P M KING, A PRYDE, AND R C HEADING

From the Department of Medicine, Royal Infirmary, Edinburgh

SUMMARY The pattern of transpyloric fluid movement and associated antroduodenal motility was compared in patients with gastro-oesophageal reflux (GOR) and healthy controls using real time ultrasonic imaging. A similar number of cyclical periods of antroduodenal motor activity (GOR 94 and control 91) was studied in each group. Mean antral cycle times and the frequency of occurrence of related proximal duodenal contractions (antroduodenal coordination) were similar. Transpyloric fluid movement occurred as a number of discrete episodes in each cycle. Gastroduodenal flow was more frequent in the GOR group (mean 2.7 ± 0.4 episodes per cycle) than in controls (mean 1.7 ± 0.3). The mean duration of these episodes in both groups was similar at around 2.5 seconds. Duodenogastric flow (reflux) was observed in many cycles (GOR 63%; controls 54%), but there was no difference in the mean number of episodes per cycle (GOR 0.79; control 0.74) or their mean duration (two seconds for both). Transpyloric fluid flow only occurs when a pressure gradient is created across the open pylorus. These observations indicate that in GOR the gastroduodenal pressure gradient is positive more frequently than in normal controls. Gastroduodenal liquid flow but not duodenogastric reflux differs in GOR patients and controls.

Gastric emptying is reported to be altered in patients with gastro-oesophageal reflux (GOR)^{1,3} and in addition there have been studies suggesting that duodenogastric reflux might be important in the pathogenesis of reflux oesophagitis.^{4,6} We have used real time ultrasonic imaging to examine the pattern of fluid movement across the pylorus and the associated gastroduodenal motility in a group of patients with GOR and in normal controls.

Methods

PATIENTS

Studies were carried out on 10 patients with gastro-oesophageal reflux (GOR) (five men, five women; mean age 54 years) and 10 normal volunteer subjects (five men, five women; mean age 29 years) as controls. The patients were initially contacted by letter and all gave their informed consent to the ultrasonic examination. All 10 patients had previously been shown to have abnormal reflux into the lower oesophagus by 24 hour pH probe

monitoring⁷ and all were symptomatic at the time of ultrasonic examination.

The subjects were studied after an overnight fast, including omission of any medication for at least 12 hours before the ultrasound examination. Each ingested a 500 ml liquid test meal composed of 433.4 ml water at 37°C to which was added 66.6 ml diluting orange and 2.5 g sodium bicarbonate to bring the pH of the meal up to neutral (pH 7.0). The test meal had an osmolarity of 285 mOsm/l and contained 0.5 g of the bran particles.

During ingestion of the test meal, which usually took around two minutes, and the subsequent 20 minutes, visualisation of the events at the gastro-duodenal junction was achieved by ultrasonic scanning. The ultrasonic images were simultaneously recorded on to videotape and analysis undertaken on a section of the recorded events beginning as soon as possible after ingestion of the test meal, where a clear image of the distal antrum, pyloric canal and proximal duodenum was constantly maintained in conjunction with a sufficient concentration of bran particles suspended in the luminal contents to allow detection of transpyloric movement. The analysis was carried out by two independent observers who

Address for correspondence: Mr P M King, Department of Medicine, Royal Infirmary, Edinburgh EH3 9YW, Scotland.

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noted the timing and duration of contractions of the terminal antrum and proximal duodenum and also the occurrence of episodes of gastroduodenal (forward flow) and duodenogastric (retrograde flow) movement of particles across the pylorus. Contractions were timed from the point where the opposing terminal antral (immediate prepyloric area) or proximal duodenal (first part) walls began to occlude their respective lumina until the subsequent onset of relaxation when the lumina once more became visibly patent. Details of observer variability and the reproducibility of the results have been reported elsewhere.*

Statistical comparisons were made using unpaired Student's *t* test and these were taken to be significantly different if $p < 0.01$.

Results

The sections of the ultrasonic recordings selected for analysis were taken from comparable times in the immediate postprandial period in the two groups of subjects. The analysed sections in the control group began 5.1 ± 2.7 (mean \pm SD) minutes after ingestion of the test meal, while those in the GOR group began after 4.2 ± 3.8 minutes ($t = 0.62$; NS). In all, around 90 cyclical periods of gastroduodenal motor activity were observed in each group (control 91, GOR 94).

The pattern of gastroduodenal motor activity observed in each group was similar. Table 1 shows the mean gastric cycle times and the ratio of related contractions of the proximal duodenum to terminal antral contractions of each subject. The overall gastric cycle time in the control group was 21.3 ± 2.4 seconds and was almost identical to that of the GOR group which was 21.3 ± 2.5 . The ratio of contractions of the proximal duodenum to those of the terminal

Table 1 Mean gastric cycle times (seconds) and ratio of proximal duodenal to terminal antral contractions

Subject	Control		GOR	
	Mean cycle time \pm SD	DC/TAC ratio*	Mean cycle time \pm SD	DC/TAC ratio*
1	22.3 \pm 2.9	0.64	23.5 \pm 2.7	0.82
2	26.6 \pm 2.3	0.57	19.8 \pm 3.9	0.67
3	22.5 \pm 2.7	0.38	21.0 \pm 1.1	1.00
4	18.8 \pm 2.3	0.69	24.3 \pm 2.8	0.56
5	17.5 \pm 2.0	0.60	21.3 \pm 4.2	0.83
6	20.2 \pm 4.1	0.36	25.6 \pm 1.7	0.78
7	21.5 \pm 2.6	0.70	18.0 \pm 1.4	0.17
8	20.3 \pm 2.4	0.56	20.3 \pm 3.8	0.67
9	21.9 \pm 1.8	0.50	20.1 \pm 2.3	0.50
10	20.7 \pm 2.2	0.92	18.7 \pm 4.3	0.58

* Ratio of contractions of the proximal duodenum to those of the terminal antrum.

Table 2 Pattern of episodes of gastroduodenal flow

Subject	Cycles with episodes (%)	Duration* of episodes (Mean \pm SD)	Episodes/cycle (n) (Mean \pm SD)	% Episodes occurring shortly after TAC (%)
Control	96	2.8 \pm 0.7	1.7 \pm 0.4	66
GOR	100	2.3 \pm 0.4	2.7 \pm 0.3	62

*Seconds; TAC – terminal antral contraction.

antrum was also similar in the two groups (control 0.60 ± 0.16 , GOR 0.66 ± 0.23).

Transpyloric fluid movement occurred in both groups as intermittent brief episodes when the pylorus was patent. The timing of occurrence and the duration of the individual episodes was obtained from the chart plots of the 10 subjects in each group.

The pattern of episodes of gastroduodenal flow is summarised in Table 2. Gastroduodenal flow was observed in 96% of cycles in the controls and in all cycles in the GOR group. Significantly more episodes of gastroduodenal flow occurred in each cycle in the GOR group than in controls ($t = 6.4$; $p < 0.001$). The mean duration of these episodes in both groups, however, was no different and was around 2.5 seconds. Over 60% of episodes of gastroduodenal fluid movement occurred within five seconds (controls 4.9 ± 1.1 seconds; GOR 5.3 ± 1.3 seconds) after relaxation of the pylorus and terminal antrum.

The pattern of duodenogastric flow (reflux) is shown in Table 3. The episodes were observed in many cycles in both the control and GOR groups, but there was no difference in their mean duration or the mean number of episodes per cycle. The majority of these episodes of duodenogastric flow (control 66%, GOR 63%) occurred within five seconds (controls 5.5 ± 2.5 seconds; GOR 4.6 ± 1.6 seconds) before the terminal antral contraction.

Discussion

In this study using real time ultrasonic imaging to examine the moment to moment characteristic of

Table 3 Pattern of episodes of duodenogastric flow

Subject	Cycles with episodes (%)	Duration* of episodes (Mean \pm SD)	Episodes/cycle (n) (Mean \pm SD)	Episodes occurring shortly before TAC (n)
Control	54	2.1 \pm 0.5	0.7 \pm 0.4	66
GOR	63	2.1 \pm 0.5	0.8 \pm 0.3	63

*Seconds; TAC – terminal antral contraction.

transpyloric fluid movement during the early stages of the emptying of a liquid test meal in patients with GOR, a significant difference has been found in the pattern of this fluid movement when compared with normal subjects. Our observations do not directly reflect the volume of flow through the pylorus or the rate of gastric emptying but, because fluid movement (flow) can only occur in the presence of a pressure gradient between the lumen of the stomach and that of the duodenum, the results imply that in the patients with GOR this pressure gradient acts in a gastroduodenal direction more often than in controls. Although the average age of the GOR patients was greater than the controls, we know of no reason to believe this might explain the results.

The magnitude and direction of the pressure gradient across the pylorus depends on the relative intraluminal pressures in the stomach and proximal duodenum.⁹⁻¹¹ Intra-gastric pressure is thought to be largely regulated by the tone of the gastric fundus and fundal tone is considered to be a prime factor in the emptying of liquids.¹² This tone is influenced by the vagus nerve.¹³ Regulation of intraduodenal pressure is, however, poorly understood. Interruption of the inhibitory impulses from the vagus causes impairment of the ability of the fundus to relax and accommodate the volume of a meal and this effect is manifest as an increased rate of liquid emptying from the stomach of vagotomised subjects compared with normal controls.¹⁴⁻¹⁶

It has previously been suggested that the fibres of the vagus lying in direct contact with the oesophageal smooth muscle may be compromised by involvement in a panmural extension of the oesophagitis in GOR.¹ In a more recent study, however, vagal impairment in GOR was found not just to be confined to the gastrointestinal tract¹⁷ and the authors felt that vagal impairment was therefore unlikely to be simply a consequence of GOR and might in fact be important in its pathogenesis. If the vagal fibres to the gastric fundus are affected in patients with GOR, then the increase in number of gastroduodenal episodes of flow per gastroduodenal cycle seen in the GOR subjects in this study may reflect increased intra-gastric pressure caused by an impairment of gastric fundal relaxation.

The role of duodenogastric reflux in the pathogenesis of reflux oesophagitis in subjects with an intact stomach is unclear. Under experimental conditions, bile and pancreatic juice are injurious to the oesophageal mucosa^{18,19} and in patients who have undergone gastric surgery bile can undoubtedly be a cause of oesophagitis.²⁰ Several investigators who have studied duodenogastric reflux of bile in patients with symptomatic oesophagitis, found it to be significantly greater in these patients than in controls.^{6,21} In

these studies duodenal or gastric intubation was utilised to permit the direct detection of refluxed material. In contrast, Little and coworkers,²² who used an intra-gastric pH probe to monitor their patients for 24 hours, found a decreased frequency of alkaline duodenogastric reflux episodes. Matikainen and coworkers, however, who used non-invasive cholescintigraphy to detect duodenogastric reflux, found the incidence of reflux in controls and patients with GOR to be similar.²³ A possible basis for these apparently conflicting results may lie with the suggestion that intubation itself may influence the results,^{24,25} and that reflux of duodenal contents and reflux of bile do not necessarily parallel each other.²⁶

Some duodenogastric reflux is a normal occurrence in healthy subjects²⁷ and thus the presence of bile in the stomach cannot be considered pathological, as previously was widely believed,²⁸ but rather the demonstration of abnormal reflux will depend on the use of techniques which will allow it to be quantified.²⁹ Our findings, using a non-invasive method, show that duodenogastric movement of fluid across the pylorus occurred in many gastroduodenal cycles and the pattern of the episodes was similar in the control and GOR groups.

Antroduodenal motility has not been extensively studied in GOR. In this investigation, the pattern and coordination of contractions of the terminal antrum and proximal duodenum observed during the emptying of a liquid test meal were similar in the GOR and control groups. These results conflict with those of Behar and Ramsby who used a perfused catheter system to measure antroduodenal contractility during the emptying of a semisolid meal and found a decreased number of antral contractions in patients with GOR compared with normal controls.³⁰ Antral contractile activity, however, probably plays little part during the emptying of liquid test meals from the stomach^{12,31,32} and it must therefore remain possible that the difference between the nature of the test meal used in this study and that of Behar and Ramsby is responsible for these conflicting results.

In conclusion, this study has shown that in GOR there is a significant alteration in the normal pattern of gastroduodenal, but not duodenogastric, fluid movement. The pattern of antroduodenal motility, however, remains normal.

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