Twenty-four hour gastric acidity after vagotomy

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SUMMARY Twenty-four hour intragastric pH during normal daily activity has been studied by nasogastric intubation and aspiration of gastric samples in seven patients four years after vagotomy (four truncal, three selective). Two of these patients also had pre- and early postoperative studies. Mean pH was inversely correlated with basal, insulin- and pentagastrin-stimulated acid outputs. However, one of four patients after truncal vagotomy with drainage, and two of three after selective vagotomy and drainage had most of their hourly intragastric pH values more acidic than pH 3.5 despite more than 70% reductions in preoperative stimulated-acid outputs.

Gastric surgeons do not know which aspect of gastric secretion they are trying to reduce when operating for peptic ulcer, because the aetiology of gastric and duodenal ulcer is not understood. There is a wealth of data on basal and stimulated acid outputs after gastric operations, but we know of only one pilot study (Baron, 1973) of their effects on intragastric acidity. We have, therefore, studied 24 hour intragastric pH during daily life in patients with duodenal ulcer disease before and after truncal or selective vagotomy and drainage.

Methods

We studied seven men with duodenal ulcer. Four patients had undergone truncal vagotomy and drainage and three selective vagotomy and drainage four years previously. Two of these patients (one truncal, one selective) also had an exactly similar study performed both before and two weeks after operation. They were all symptom free since their operation and at the time of this study. The subjects attended hospital at 0800 having had nothing to eat or drink since midnight. A small radio-opaque nasogastric tube (12-14 F.G. Rayx Porges Neoplex Levin, Porges, Paris, France) was passed and positioned fluoroscopically in the most dependent portion of the stomach. They were then admitted to a general ward for 24 hours where their activities regarding meals, fluids, bath, and toilet were as

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normal as possible. They were allowed to smoke, eat, and drink as they wished, and they kept a personal record of the time and nature of any food or drink taken. Every hour on the hour a nurse aspirated about 10 ml gastric juice which was immediately frozen. The patient had nothing to eat or drink after midnight and at 0800 the following morning a standard basal, insulin (0.2 unit/kg intravenous bolus) and pentagastrin (6 µg/kg I.M.) test (Baron, 1972) was performed to determine basal acid output (BAO) and peak acid outputs in response to insulin (PAO_I) and pentagastrin (PAO_{Pg}). The pH of the 24 hour gastric samples was measured (Dynecap pH meter, W. G. Pye & Co., Cambridge, England) and the presence of food particles or bile noted. The data presented are the observed results, and no corrections have been made for pyloric loss, duodenal reflux, or body build.

Results

The pH and acid output data from the seven patients have been summarised in Table 1.

TRUNCAL VAGOTOMY

Mr R. J. was studied two days before and 10 days after truncal vagotomy and gastroenterostomy as well as four years later (Fig. 1). Before operation all but one of his 24 hourly juice samples were more acid than pH 2. Immediately after operation his pH profile had completely changed with each sample above pH 2 and only three less than pH 3.5. This was accompanied by a 97% reduction in pentagastrin-stimulated and a negligible acid response to insulin. His pH profile four years later was even less acidic.

Table 1 Twenty-four hour intragastric pH and acid output data before and after truncal or selective vagotomy in seven patients

Vagotomy and patients	Time (yr)	% of hourly samples		Acid output (mmol/h)					
		< pH 2	< pH 3.5	BAO	PAO _I		PAO _{Pg}		% Reduction
					% Reduction		% Reduction		
Truncal									
RJ	Preop.	96	96	12.5	—		51		
	Postop.	0	13	0.2	98	0.9	1.8	97	
	4	0	0	0	100	0	3.9	92	
TW	4	0	0	0	100	0	0.8	97	
FG	4	0	0	0.6	90	0.4	2.4	95	
PG	4	29	86	0.2	78	1.2	4.6	76	
Selective									
PM	Preop.	41	50	1.1		15.5	21.6		
	Postop.	4	13	0.9	12	0	6.6	69	
	4	21	50	0.1	87	0.1	17.2	20	
JM	4	68	91	1.1	—	16.8	24	—	
WK	4	71	100	2.3	8	8.8	11	75

Fig. 1 Twenty-four hour pH profile preoperative, 10 days postoperation, and four years later, of Mr R. J., aged 64 years. Truncal vagotomy and gastroenterostomy for duodenal ulceration performed 3 March 1972. The arrows indicate the time of breakfast, morning coffee, lunch, tea, evening meal, and night-cap respectively.

The pH of every sample was more than 5, and his pentagastrin and insulin-stimulated acid outputs remained low.

R.J.'s pH samples at four years are compared with those of three other patients who had undergone truncal vagotomy and pyloroplasty (Fig. 2). Two patients (T.W. and F.G.) had similar results with the pH of all samples above 3.5 and all acid outputs

reduced by 90% or more. One patient (P.G.) showed more acidic pH levels throughout the 24 hours as well as less reduction in both BAO and PAO_{Pg}.

SELECTIVE VAGOTOMY

Mr P.M. was also studied before and after operation and at four years. His 24 hour pH profile before

Fig. 2 Twenty-four hour pH profiles of four patients four years after truncal vagotomy. Arrows indicate meal-times.

Fig. 3 Twenty-four hour pH profile preoperative, eight days post operation, and four years later of Mr P.M., aged 54 years. Selective vagotomy and pyloroplasty performed for duodenal ulceration 10 February 1972. Arrows indicate meal-times.

operation had only 50% of his samples more acid than pH 3.5 (Fig. 3) and his PAO_{Pg} was lower than that of the patient R.J. However, his pH pattern eight days after selective vagotomy and pyloroplasty was less altered than R.J., with 13% of samples more acid than pH 3.5, and only a 69% reduction in pentagastrin-stimulated acid. These reductions were not maintained four years later when again 40% of his gastric samples were more acid than pH 3.5, and pentagastrin-stimulated acid had risen almost to the pre-vagotomy value.

The other patients (J.M. and W.K.) four years after selective vagotomy and pyloroplasty showed even more acidic 24 hours pH patterns with most samples more acid than pH 2 (Fig. 4). J.M. was still secreting substantial amounts of acid after both insulin and pentagastrin, while W.K. had a 75% reduction in stimulated acid outputs.

CORRELATION BETWEEN ACIDITY AND ACID OUTPUT (Table 2)

The results from pre-, postoperative, and four year studies in all seven patients have been used to calculate the correlation between the mean pH (of 24 hourly samples) and basal, insulin, and pentagastrin-stimulated outputs. The data for basal and insulin stimulated acid outputs are not normally distributed (Kolmogorov-Smirnov one-sample test) and correlations have been performed with the

Fig. 4 Twenty-four hour pH profiles of three patients four years after selective vagotomy. Arrows indicate meal-times.

Table 2 Correlation between mean 24 hour pH and acid output in all studies on all seven patients

Mean pH	BAO	PAOI	PAOP _g
1.69	12.5	—	51.0
5.25	0.23	0.94	1.77
6.35	0.02	0	3.9
5.4	0	0	0.76
5.4	0.61	0.4	2.39
2.7	0.21	1.19	4.64
3.07	1.06	15.47	21.6
4.32	0.93	0	6.62
3.6	0.27	0.12	17.19
2.2	1.1	16.8	24.0
1.9	2.34	8.79	10.9
Correlation coefficient	$r_s = 0.784$	$r_s = -0.761$	$r = -0.789$
P	< 0.01	< 0.01	< 0.01

non-parametric Spearman's rho (r_s). The penta-gastrin outputs were normalised by log transformation before calculation of the correlation coefficient r . There are significant inverse correlations between mean 24 hour pH and basal, insulin, and pentagastrin-stimulated acid outputs.

Discussion

We are not aware of any comparable data on the effect of vagotomy on intragastric acidity. However, one of us has reported two studies in 1962 with a protocol similar to the present study (Baron, 1973). Twelve one-hourly gastric samples were taken overnight followed by an augmented histamine test. A 62 year old woman with a duodenal ulcer had a pH profile similar to that of R.J. This profile also changed 18 days after truncal vagotomy and gastro-jejunosomy, together with a 92% reduction in maximal acid output. By contrast, a man aged 64 years after a Billroth I gastrectomy for gastric ulcer showed an almost unaltered pH pattern despite a 63% reduction in maximal acid output. These two cases illustrate trends also seen in the present study. All our patients have had a clinically successful operation, and all but one with a reduction in stimulated acid output of more than 69%, regarded by most accepted criteria as an adequate vagotomy. However, after vagotomy (one truncal, three selective) the stomach contents were markedly acid for appreciable periods during normal daily activities.

Intragastric acidity profiles have been used to assess antisecretory agents (Pounder *et al.*, 1976) and by way of comparison four men with duodenal ulcers who had a successful truncal and pyloroplasty between 20 and 33 months early were studied by hourly gastric aspiration for five hours during the morning (Pounder *et al.*, 1975). The mean pH values of the four patients was less than pH 3.5 throughout the study. Only one of our four patients after truncal vagotomy (P.G.) had a similar profile and further data are needed to test the suggestion of Pounder and his colleagues that intragastric pHs are commonly below 2 after truncal vagotomy. Our limited data suggest that after selective vagotomy both higher intragastric acidity and a smaller reduction in acid output occur than after truncal vagotomy but we cannot, of course, decide whether the selective vagotomies were less complete than the truncal vagotomies or whether there is a fundamental difference between truncal and selective vagotomy in their alterations of gastric physiology.

Duodenal ulcers are related to the milieu encountered in the duodenal cap and until reliable long-term physiological studies of pH in the first part of the duodenum are undertaken it will not be possible to determine accurately the relative importance, in the aetiology of duodenal ulcer disease, of acid concentration as compared with the volume of acid and pepsin outputs of the stomach, or the acid load entering the duodenum (Malagelada *et al.*, 1976). However, the significant correlations found in the

present study between intragastric acidity and basal, insulin, and pentagastrin-stimulated acid outputs suggest that these commonly used measurements of acid output in response to pharmacological stimuli are valid indices of the physiological variations in 24 hour acidity before and after gastric operations.

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