Gastric mucosal pH

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SUMMARY
During routine studies of oesophageal motility the lowest pH recorded from the stomach has been measured by a stomach electrode on 263 separate occasions.

The mean pH of 117 male patients with duodenal ulceration was 1.3 + 0.3 (mean ± 1 standard deviation), and this was lower than in 17 patients with a gastric ulcer (1.7 ± 0.3) and 19 with a hiatal hernia (1.6 ± 0.4). Patients with a gastric ulcer had a lower pH than those with gastric carcinoma (2.3 ± 0.9).

The lowest pH of duodenal ulcer patients was changed by truncal vagotomy (37 patients) to 1.3 ± 0.8 and by a Polya partial gastrectomy (25 patients) to 3.2 ± 1.8.

If a stomal ulcer was present after a partial gastrectomy the pH was 1.1 and this changed to above 1.9 after vagotomy.

Most studies of gastric secretion have been concerned with the collection of gastric juice through a nasogastric tube, but these may be inaccurate owing to incomplete aspiration, loss through the pylorus, the addition of bile refluxed from the duodenum and swallowed saliva, which have been accounted for with various degrees of efficiency. This paper describes the direct measurement of the lowest gastric pH by a small pH electrode as it is withdrawn from the stomach into the oesophagus. Over 200 patients have been studied and in many instances the pH has been measured both before and after operations for duodenal ulceration. These pH values obtained by direct measurement have been compared with the results of pentagastrin tests.

Materials and methods
Intragastric mucosal pH was measured routinely during the course of oesophageal manometry in 263 separate studies. The pressure recording unit consisted of three small water-filled polythene tubes (internal diameter 1.12 mm). Two had side openings and the third was covered by a 0.5-cm diameter rubber balloon tied over its end. A pH stomach electrode (Pye 240 E07) was attached to the units at a known distance from the balloon. The patient's left middle finger was placed into a beaker full of a supersaturated KCl solution, which also contained a glass reference electrode (Pye 405 E07). Both electrodes were attached to a Pye model 79 pH-meter whose output was monitored continuously on ultraviolet sensitive paper using an SE 2005 6-channel UV recorder. Calibration of the stomach electrode was performed by comparison with buffer solutions of pH 1.0, 1.5 and 2.0. The pressure recording units were passed through the mouth and swallowed into the stomach before being pulled out slowly at 0.5-cm intervals. At least two pressure studies of the gastro-oesophageal junction were recorded from each patient during which a pH profile was obtained as the stomach electrode was withdrawn. The lowest pH of two consecutive pull-through studies was recorded and termed the 'gastric mucosal pH'. There is no direct evidence that this actually represents the H+ concentration at the epithelial surface, but the term is used in contradistinction to 'intragastric pH' which is the result of acid secretion, bile reflux and swallowed saliva.

The patients underwent oesophageal motility tests either as a diagnostic routine or for research purposes connected with study of the gastro-oesophageal sphincter in peptic ulceration. The details of the group are given in Table I. Some patients who had an operation for duodenal ulceration were studied both pre-operatively and then 6–12 months after surgery.

Pentagastrin studies were performed using similar techniques as described by Baron (1970) with a dose of 6 µg/kg given subcutaneously.

Table I: LOWEST INTRAGASTRIC MUCOSAL pH

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of cases</th>
<th>(mean pH ± 1 s.d.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duodenal ulcer (males)</td>
<td>117</td>
<td>1.3 ± 0.3</td>
</tr>
<tr>
<td>Duodenal ulcer (females)</td>
<td>4</td>
<td>2.1 ± 0.6</td>
</tr>
<tr>
<td>Gastric ulcer</td>
<td>17</td>
<td>1.7 ± 0.3</td>
</tr>
<tr>
<td>Hiatal hernia</td>
<td>19</td>
<td>1.6 ± 0.4</td>
</tr>
<tr>
<td>Carcinoma of stomach</td>
<td>8</td>
<td>2.3 ± 0.9</td>
</tr>
<tr>
<td>Postvagotomy</td>
<td>37</td>
<td>1.9 ± 0.8</td>
</tr>
<tr>
<td>Partial gastrectomy</td>
<td>25</td>
<td>3.2 ± 1.8</td>
</tr>
<tr>
<td>Achalasia, diffuse spasm,</td>
<td>36</td>
<td>2.2 ± 1.2</td>
</tr>
<tr>
<td>scleroderma, neurological</td>
<td></td>
<td></td>
</tr>
<tr>
<td>diseases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>263</td>
<td></td>
</tr>
</tbody>
</table>

Results
The largest single group consisted of male patients with a radiologically proved duodenal ulcer in whom the mean value was pH 1.3 (Table I). The values for female patients with a similar condition were higher but the group was too small to allow valid comparisons to be made for sex differences. The majority of patients in the last group of Table I had no indigestion or symptoms of hyperacidity and so could be considered normal from this point of view. No values were obtained from so-called 'normal' people and therefore comparisons have been made between the different pathological groups themselves.

Comparisons between groups
1. Male patients with duodenal ulcer were found to have a significantly lower pH than the other groups

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Two patients with a stomal ulcer (Fig. 1c) following a Polya partial gastrectomy had a maximal acid output after pentagastrin of 1.0 and 8.0 mEq, suggesting that they were unlikely to be secreting excess acid from their gastric remnants. However, in both of these patients the intragastric mucosal pH was 1.1. This changed to 1.9 and 3.5 respectively after truncal vagotomy alone without further reduction in the size of their stomach.

Discussion

Direct measurement of the gastric mucosal pH by an electrode has been made previously for two reasons. Wastell (1972) used a pH probe to delineate the junction between the antrum and body of the stomach peroperatively prior to an antrectomy. Grassi also used a pH probe during operations (Grassi and Orecchia, 1969), but to assess the completeness of a selective vagotomy (Grassi et al., 1971a, b, c) because he was not satisfied with Burge’s test based on intragastric pressure changes (Burge and Vane, 1958). Grassi’s present technique is to perform a selective vagotomy, do a gastrostomy, clean the mucosa and then measure the mucosal pH throughout the fundus and body during continuous perfusion of pentagastrin to stimulate acid secretion (Grassi, 1971). After a successful selective vagotomy the pH changed to between 4.5 and 7.0 whereas it changed only to between 2.0 and 5.5 after an antrectomy alone. If a selective vagotomy was added to the antrectomy the pH became 7.0–7.5 (Grassi et al., 1971a). Grassi has done long-term studies with insulin testing to confirm that the peroperative pH probe test is a reliable indicator of a complete vagotomy (Grassi, 1971). A further paper described how a selective vagotomy alone was only effective in producing a complete vagotomy as indicated by this test in 42 per cent of patients, but if the vagotomy was extended further to include the antrum as well as the body 90 per cent of cases had a complete vagotomy (Hedenstedt and Grassi, 1971). Since the discovery that the pH in some patients did not alter sufficiently after a selective vagotomy had previously caused Grassi to add an antrectomy (Grassi et al., 1971a), it is likely that in spite of a complete selective vagotomy there is a group of patients who need either an antrectomy or a vagotomy extended to include the antrum to change the pH of the fundus and body.

The present study confirmed the sharp change in pH at the junction of the antrum in many instances. It also confirmed the difference in pH of the fundus both after a truncal vagotomy and a partial gastrectomy. In view of Grassi’s finding that there may be a
The stomach it is possible that the figure of 0.8 in solution. In this paper the lowest pH of two consecutive pull-through studies was recorded, but often one or other recording gave a higher figure. After vagotomy the pH usually rises, and although this is true for the group as a whole it is not so for each individual. In Fig. 1a there are 7 patients who had a rise in pH after a vagotomy but it will be seen that preoperatively the pH was higher than 1.6. It is possible that the values for these 7 patients are wrong because of the patchy distribution noted by Grassi, in which case the addition of a third pull-through study might make the test more reliable.

The lack of complete discrimination between a duodenal ulcer patient and normal by measuring the lowest intragastric pH is not surprising in the light of the results of pentagastrin studies. Baron (1970) has suggested that duodenal ulceration is almost completely unknown when the MA0 is less than 12 mEq/hour, that at least one-third of patients with duodenal ulceration have a normal MAO and that one-third are hypersecretors. The results of a pentagastrin test cannot be used to diagnose a duodenal ulcer, although they can be used in a negative fashion to indicate that when secretion is low an ulcer is unlikely to be present. In this study there were radiologically proved duodenal ulcers both when the MAO was less than 12 mEq/hour and when the pH was greater than 1.6. The same absence of complete discrimination for the diagnosis of duodenal ulceration is found both with the pentagastrin test and with measurement of the lowest gastric mucosal pH.

There is, however, one definite use for measuring the lowest intragastric pH and that is after a Polya gastrectomy when there are either recurrent symptoms or a stomal ulcer and when the pentagastrin test indicates that little acid is being produced. The lowest mean intragastric pH recorded in the group of 25 patients after a partial gastrectomy was 3.2 ± 1.8. There were only 4 patients with a pH below 1.5 of whom 3 had stomal ulcers proved endoscopically and 1 had recurrent symptoms which were not fully investigated. Two of the stomal ulcer patients were treated by surgery, and it will be seen from Fig. 1c that when the gastric mucosal pH is less than 1.6 (the upper limit of the duodenal ulcer range) after a Polya gastrectomy it changes after a truncal vagotomy (Fig. 1c). In these 2 patients the MAO was 1.0 and 8.0 mEq/hour. Baron (1970) stated that 'although a recurrent ulcer is extremely rare with an MAO less than 1 mEq/hour, there is no lower limit of MAO or PAO (except zero) below which a recurrent ulcer can be excluded'. The pentagastrin test after a Polya gastrectomy would not seem to be very valuable for diagnosing whether a stomal ulcer is present or not. Although the final diagnosis of a stomal ulcer must still depend on radiology or endoscopy, a low mucosal pH may indicate patients who have or who are going to develop a stomal ulcer. If further experience confirms healing of the ulcer with the relatively simple operation of vagotomy in patients with a low gastric mucosal pH it would constitute an advance because the operation is simpler and safer than refashioning an anastomosis and a further gastric resection.

**References**


