ANAESTHESIA FOR COMPLETE VAGOTOMY

Postoperative Pulmonary Complications after various types of Gastric Surgery, with special reference to the omission of atropine

BY

MARGARET E. RIDDoch* and CHARLES G. CLARK†
Aberdeen Royal Infirmary, Scotland

SUMMARY

An anaesthetic technique is discussed omitting atropine or hyoscine from premedication to comply with the requirements of the surgeon performing complete gastric vagotomy. Experience in sixty cases reveals no evidence of undesirable reflex activity in the cardiovascular system, and the increase in secretions in the respiratory tract has not proved troublesome. The incidence of postoperative pulmonary complications is compared with that in a control group using conventional premedication, and is shown to be lower in the test group. The relationship of smoking habits, age and sex to postoperative respiratory complications following all forms of gastric surgery is also discussed.

In the treatment of duodenal ulcer vagotomy is often used in combination with gastro-enterostomy, pyloroplasty or some form of gastric resection. Complete gastric vagotomy is desirable, for there is ample evidence that recurrent ulcer after these procedures is in many cases due to vagal nerve trunks which have escaped the surgeon's scrutiny and remained undivided, with subsequent failure to reduce gastric acidity (Dragstedt et al., 1947; Lloyd Davies, 1956). Until recently, the only available method of assessing whether or not vagotomy was complete was to carry out an insulin test meal. Since the gastric secretory response to insulin depends upon intact vagal nerves, a positive response implies inadequate neurectomy (Hollander, 1946).

In 1958, Burge and Vane introduced a method of ensuring complete nerve section at the time of operation. Gastric contractions can be recorded on stimulating the abdominal vagus nerves with an electrode which encircles the lower oesophagus. The operation consists of dividing the nerves until no further response is obtained on stimulation. The electrode is divided circumferentially into four quadrants, each of which can be stimulated individually. This is of assistance in detecting vagal trunks which are not apparent on normal inspection and, therefore, liable to be left uncut. The technique has proved particularly valuable in those cases where the abdominal vagi enter the peritoneum as multiple trunks instead of the more common distribution as single anterior and posterior gastric nerves.

It is evident that a test of this kind is a valuable asset if it can be proved reliable. Since the test is, in effect, a simple physiological exercise, its reliability and reproducibility depend upon strictly controlled conditions, of which the anaesthetic employed is paramount. The anaesthetic technique used in this procedure must abstain from the use of conventional premedication with atropine or hyoscine, because of their anticholinergic properties, and drugs with significant ganglion blocking effects are also precluded.

The present investigation was undertaken primarily to assess the incidence of complications occurring during and after operation carried out under these conditions.

MATERIALS AND METHODS

One hundred and fifty patients suffering from gastro-duodenal ulcer treated by operation, were observed. Sixty patients were treated by vagotomy and gastro-enterostomy, nerve stimulation tests

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*Present address: Edinburgh Central Group of Hospitals.
†Present address: Department of Surgery, University of Aberdeen.
being performed during operation. The remaining patients form a control group and, of these, thirty-four were treated by vagotomy and gastro-enterostomy without a test for complete nerve section. The selection of patients for vagotomy with stimulation tests was not strictly random. Of cases considered suitable for treatment by vagotomy and gastro-enterostomy, two were submitted to the test and the third acted as a control. The actual order of operation was determined by the date of admission to the ward and, with two cases admitted on the same day, the time of admission. In addition, cases treated by partial gastrectomy or gastro-enterostomy alone were included to allow comparison of vagotomy and gastro-enterostomy with other forms of gastric surgery. Premedication for these patients not undergoing vagal nerve stimulation consisted of atropine 0.6 mg or hyoscine 0.4 mg given subcutaneously 1 hour before operation, together with an opiate, usually papaveretum 10–20 mg or pethidine 50 mg. Anaesthesia was induced with sodium thiopentone (50 mg/stone body weight) followed by gallamine triethiodide, usually in a dose of 120 mg.

Gallamine was preferred to d-tubocurarine chloride since the latter has some ganglion blocking properties. It is claimed that the vagolytic action of gallamine is restricted to its action on the heart rate. Under the conditions of the test it did not significantly affect the gastric response to stimulation (Vane, personal communication).

An oral cuffed endotracheal tube was inserted and anaesthesia maintained by controlled ventilation with nitrous oxide and oxygen. Once complete nerve section was achieved, atropine 0.6 mg was given intravenously, and the remainder of the anaesthetic was similar to the control group, curarization being reversed by neostigmine preceded by a further dose of atropine. The postoperative management of all cases was supervised by one of the authors. Each patient was instructed in breathing exercises pre-operatively and was strongly exhorted to cough as soon as he had sufficiently recovered from the anaesthetic. Postural drainage, supervised by a physiotherapist, was performed at least twice a day until any respiratory symptoms had abated. During convalescence from the operation each patient was allocated to one of three groups, depending on the presence or absence of post-operative pulmonary complications.

Group A. No pulmonary complications.

Group B. Mild pulmonary complications. This corresponded to acute bronchitis, with fever, cough and purulent sputum, but without clinical or radiological evidence of pulmonary collapse or consolidation. These cases all responded to treatment by physiotherapy alone.

Group C. Moderate to severe pulmonary complications, with productive cough, pyrexia and signs of toxaemia. There was clinical and radiological evidence of atelectasis or consolidation of part of the lung. These patients were always given an antibiotic.

This classification excludes from consideration cases of early atelectasis without symptoms recovering within 48 hours, and reflects rather the early morbidity from pulmonary complications, which is perhaps a better index for comparison. It also excludes cases of pulmonary embolism, of which there were three, the earliest occurring on the eighth postoperative day. These latter patients have been placed in a group corresponding to their early postoperative respiratory state, two patients being in group A, and one in group B. There was one death in this series, a patient aged 61 years suffering from chronic bronchitis and emphysema. He suffered from pyloric stenosis, and was treated by gastro-enterostomy alone. He died on the tenth postoperative day of bronchopneumonia.

RESULTS

From an anaesthetic standpoint these may be conveniently divided into two phases:
(1) During operation: Observation of the systems which might be affected by the omission of atropine or hyoscine from the premedication, namely those involved in (a) reflex vagal activity and (b) secretions.

(2) Postoperative pulmonary complications.

During Operation.

Reflex vagal activity.

Cardiovascular reflexes. No change was observed in the pulse rate after the initial injection of sodium thiopentone, but following the administration of gallamine triethiodide an average increase of 15 to 30 beats per minute was seen. Because of the possibility of undesirable reflex sequelae, it was considered important to allow sufficient time (at least 3 minutes) for the gallamine to take effect so that intubation could be performed asatraumatically as possible. No arrhythmias were ever found clinically on intubation, or on manipulation or electrical stimulation of the vagal nerves. Continuous e.c.g. recordings were carried out on fifteen patients during induction, endotracheal intubation and inflation of the cuff. In none of these was any change seen, either in rhythm or in wave form. It proved impossible to obtain accurate records during the stimulation procedure because of electrical interference. Serial blood pressure readings taken during intubation and over the 5 minutes immediately following this showed an average rise in systolic blood pressure of 10 to 25 mm Hg within the first 2 minutes after intubation. Inflation of the cuff did not usually cause any further rise in blood pressure.

Respiratory tract reflexes. In those patients anaesthetized without conventional premedication, uninhibited reflex effects of vagal stimulation, such as laryngospasm or bronchospasm, were never seen. Hiccup, however, occasionally proved troublesome and occurred on manipulation of the vagi or on electrical stimulation. It usually responded to the intravenous administration of methylamphetamine (3–5 mg) or to a supplementary dose of thiopentone or gallamine.

Sweating. Considerable sweating occurred in almost all cases during dissection of the vagal nerves, but in the absence of reflex effects on pulse rate and blood pressure it was not considered to be of serious significance. It disappeared when vagal manipulation was completed and atropine was administered.

Secretions.

Despite the absence of irritant inhalational agents, increased salivation and excessive pharyngeal and bronchial secretions were frequently encountered up to the time when atropine was given, due probably to the presence of a foreign body (endotracheal tube and, later, a large gastric tube). Secretions appeared to be more profuse in the heavy smokers though no direct measurements were made. The mouth and pharynx were aspirated during operation and careful pharyngo-bronchial toilet was performed at the end of operation. The secretions were invariably watery in character and any secretion not aspirated was usually easily expectorated by the patient on recovery from the anaesthetic. Negus (1958) showed that the inadequate secretion of mucus following the administration of atropine was associated with cessation of ciliary activity, which normally plays an important part in maintaining the health of the respiratory passages.

Postoperative Pulmonary Complications.

Postoperative chest complications are common in patients suffering from acute or chronic respiratory disease. Each patient had a routine preoperative chest radiograph to exclude conditions such as active tuberculosis. A number of patients gave a history of chronic bronchitis and in some of these there was radiological evidence of emphysema.

Table I shows a comparison between the incidence of pulmonary complications in patients subjected to vagotomy and gastro-enterostomy using the electrical stimulation technique, and those in the control groups receiving conventional premedication. It will be seen that 40 per cent of the test group developed pulmonary complications—considerably less than the percentage following vagotomy and gastro-enterostomy without the test, or partial gastrectomy. The difference is significant (P = <0.05). The incidence in the test group, however, did not differ significantly from that in patients treated by simple gastro-enterostomy.

Of the factors which might be relevant in assessing the incidence of postoperative pul-
### Table I

Comparison of the incidence of chest complications in patients receiving various types of gastric surgery. The difference in \((B+C)\%\) between Group 1 and Groups 2 and 3 is significant \((P = <0.05)\).

<table>
<thead>
<tr>
<th>Operation</th>
<th>Chest complications</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
</tr>
<tr>
<td>Vagotomy and gastroenterostomy (test)</td>
<td>60</td>
</tr>
<tr>
<td>Vagotomy and gastroenterostomy</td>
<td>34</td>
</tr>
<tr>
<td>Partial gastrectomy</td>
<td>45</td>
</tr>
<tr>
<td>Gastroenterostomy</td>
<td>11</td>
</tr>
<tr>
<td>Totals</td>
<td>150</td>
</tr>
</tbody>
</table>

**Group A:** No pulmonary complications.<br>
**Group B:** Mild pulmonary complications.<br>
**Group C:** Moderate to severe pulmonary complications.

### Table II

The effect of smoking on the incidence of pulmonary complications in the whole series. The difference between smokers and non-smokers is highly significant. There is no significant difference between the smokers with increasing consumption of tobacco.

<table>
<thead>
<tr>
<th>No. of patients</th>
<th>Non-smokers</th>
<th>Less than 10 per day</th>
<th>10-19 per day</th>
<th>20 or more per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>((A+B+C)%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>22</td>
<td>13</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>10</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>7</td>
<td>5</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>((B+C)%)</td>
<td>35.3</td>
<td>53.6</td>
<td>63</td>
<td>59.5</td>
</tr>
</tbody>
</table>

**Groups A, B, and C as in table I**

### Table III

This shows the incidence of pulmonary complications in the different age groups in the whole series. The number of females and number of non-smokers are also shown. The difference among the age groups is significant only in patients under 30 years of age \((P = <0.05)\).

<table>
<thead>
<tr>
<th>Age groups</th>
<th>15-29</th>
<th>30-39</th>
<th>40-49</th>
<th>50-59</th>
<th>60-81</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>17</td>
<td>30</td>
<td>25</td>
<td>54</td>
<td>24</td>
</tr>
<tr>
<td>B</td>
<td>12</td>
<td>14</td>
<td>10</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>C</td>
<td>5</td>
<td>12</td>
<td>9</td>
<td>17</td>
<td>8</td>
</tr>
<tr>
<td>((B+C)%)</td>
<td>29.4</td>
<td>53.3</td>
<td>60</td>
<td>59.3</td>
<td>45.8</td>
</tr>
</tbody>
</table>

**Non-smokers**

<table>
<thead>
<tr>
<th>No of females</th>
<th>2</th>
<th>2</th>
<th>4</th>
<th>15</th>
<th>11</th>
</tr>
</thead>
</table>

**Groups A, B, and C as in table I.**

monary complications, smoking habits, age and sex were considered separately.

The majority of the patients were addicted to cigarettes (there were three pipe smokers) and the effect of smoking was assessed by comparing the incidence of pulmonary complications in patients grouped according to their smoking habits, as shown in table II. In this and subsequent tables, Student's "t" test of significance was used. A significantly lower incidence of respiratory complications was noted in the non-smokers, but there was no real difference between groups of patients smoking different numbers of cigarettes per day.

In table III the incidence of complications in different age groups was compared. As expected, there was a lower incidence in patients under 30 years of age, and this was statistically highly significant compared with all other age groups. There was no significant difference, however, in the incidence between the age groups over 30 years—an interesting observation, contrary to the expected rising incidence with increasing years.

The proportions of both non-smokers and females in the age group under 30 years of age was low, so that these factors do not influence the results unless the duration of the smoking habit is considered important. The average age at which ulcer patients in this region start smoking is 19 years in females and 16 years in males (Clark, unpublished observations).

In table IV, the distribution of pulmonary complications between the sexes showed a significantly lower incidence among the females. A comparative picture of all the results is shown in table V.
TABLE IV
The effect of sex on the incidence of pulmonary complications. The difference is significant at the 1 per cent level.

<table>
<thead>
<tr>
<th>No. of non-smokers</th>
<th>Mean age</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>(B+C)%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>110</td>
<td>17</td>
<td>48.8</td>
<td>45</td>
<td>42</td>
</tr>
<tr>
<td>Females</td>
<td>40</td>
<td>17</td>
<td>50.7</td>
<td>24</td>
<td>11</td>
</tr>
</tbody>
</table>

Groups A, B, and C as in table I.

TABLE V
Summary of the results shown in tables I-IV.

<table>
<thead>
<tr>
<th>Operation</th>
<th>No.</th>
<th>Females</th>
<th>Mean age</th>
<th>Non-smokers</th>
<th>Chest complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vagotomy and gastroenterostomy</td>
<td>60</td>
<td>15 (25%)</td>
<td>45.8 (15-67)</td>
<td>11 (18%)</td>
<td>36</td>
</tr>
<tr>
<td>(test)</td>
<td>34</td>
<td>7 (21%)</td>
<td>49 (23-77)</td>
<td>8 (23%)</td>
<td>13</td>
</tr>
<tr>
<td>Vagotomy and gastroenterostomy</td>
<td>45</td>
<td>14 (31%)</td>
<td>49.3 (20-81)</td>
<td>10 (22%)</td>
<td>14</td>
</tr>
<tr>
<td>Partial gastrectomy</td>
<td></td>
<td></td>
<td>66.8 (58-76)</td>
<td>5 (45%)</td>
<td>6</td>
</tr>
<tr>
<td>Gastroenterostomy</td>
<td></td>
<td></td>
<td></td>
<td>34</td>
<td>69</td>
</tr>
<tr>
<td>Totals</td>
<td>150</td>
<td>40</td>
<td></td>
<td>34</td>
<td>69</td>
</tr>
</tbody>
</table>

DISCUSSION

"There is, then, a tendency to examine critically many views on autonomic reflexes and, in particular, the value of atropine given as premedication to suppress vagal activity." Thus Beard (1959) summarized the reflections of several authors on an important facet in the administration of any anaesthetic. The time-honoured place of atropine and hyoscine as components of premedication is attributable to: (a) the depressant effect on reflexes mediated by the vagal nerves—both in the cardiovascular and respiratory systems, and on reflexes involving the pharynx and larynx; (b) the drying action.

In those patients submitted to vagotomy and gastro-enterostomy using the stimulation test, the results of omitting atropine or hyoscine from the premedication have been carefully observed, with particular reference to these effects.

Reflex vagal activity.

The increase in pulse rate following the administration of gallamine triethiodide was considered to result, at least in part, from the selective vagolytic effect of gallamine on the heart, with consequent acceleration due to unopposed sympathetic activity (Doughty and Wylie, 1951). Another possibility arises from the findings of Rollason and Hough (1957) who observed an increase in the pulse rate of more than 10 beats per minute following intubation or inflation of the cuff in twenty-two out of forty cases premedicated with hyoscine. This suggests that the increased pulse rate in the first 5 minutes after induction in our patients may have been partly attributable to intubation as well as to the vagolytic effect of gallamine. Bourne (1954) doubted whether the usual clinical dose of atropine (0.6 mg) used in premedication did, in fact, lessen the incidence of cardiac arrhythmias during the induction of anaesthesia. It has been suggested that the serious arrhythmias sometimes seen during anaesthesia are mediated not through vagal pathways but via the sympathetic nervous system (Goodman, and Gilman, 1958). A third possibility is that certain reflexes have pathways in both divisions of the autonomic nervous system.

The slight rise in blood pressure of 10 to 25 mm Hg on intubation was not considered to be of any significance in relation to premedication, since a pressor response to intubation was found in the series of Rollason and Hough (1957) in
all except four out of twenty-nine patients premedicated with hyoscine; in his patients also, anaesthesia was induced with thiopentone followed by a relaxant.

The conclusion from the results of the present investigation is that the absence from the premedication of an agent to suppress undesirable vagal activity does not increase the anaesthetic hazard to the patient when the technique described in the text is employed.

**Postoperative pulmonary complications.**

The high incidence of pulmonary complications after upper abdominal surgery is well known and the many factors concerned have been discussed by Palmer and Sellick (1953) and Anscombe (1957). Palmer and Sellick emphasized that segmental atelectasis is difficult to diagnose, but an incidence of 43 per cent was found in their control group of patients submitted to partial gastrectomy or herniorrhaphy. Although in the present investigation different criteria have been employed in classifying postoperative respiratory complications, it is of interest to find that patients treated by vagotomy and gastro-enterostomy with stimulation tests showed a similar incidence of complications despite the absence of conventional premedication. However, since the incidence in this series is significantly less than that found in the control group, it seems clear that withholding atropine in premedication carried no increased hazard in respect to the development of respiratory complications.

In the course of this study it was found that women generally fared better than men, and the young better than the old. The most interesting fact, however, was that while non-smokers had a much lower incidence of pulmonary complications than those who smoke, there was little difference among smokers with widely differing consumptions of tobacco. Many of those who smoke undoubtedly suffer from chronic bronchitis resulting from constant irritation of the bronchial tree (Morton, 1944). Heavy smokers would, therefore, be expected to show the highest incidence of complications, but this was not the case. It is possible that the less viscid type of bronchial secretion which occurs in the absence of atropine, and which is relatively easy to expectorate, may have a bearing on this result. Since secretion was most profound in the heavy smokers, the beneficial effects of an easily expectorated sputum may have partly annulled the greater tendency of the patients to develop complications.

In assessing the incidence of respiratory complications the best control is the group of patients with vagotomy and gastro-enterostomy without test, and clearly the results are superior in the test group. It is interesting to note, however, that the vagotomy and gastro-enterostomy patients not submitted to the test had a similar incidence of complications to patients undergoing partial gastrectomy. This latter operation would be regarded by most surgeons as being the more traumatic of the two. In the first three operative groups (table V) there is a small difference in the mean age, but non-smokers are fairly equally distributed. The percentage of females is greatest in the partial gastrectomy group, but this sex factor should, from the authors' earlier observations, tend to reduce the number of complications. It can be concluded that whatever other factors may affect the result, pulmonary complications are less frequent in patients undergoing vagotomy with stimulation tests than in patients submitted to other similar procedures designed to cure ulcer distress. This finding is contrary to the impressions of Lythgoe (1961).

In conclusion, some consideration should be given to the postoperative management of patients treated by the surgical procedures under discussion. Palmer and Sellick (1953) were able to reduce the incidence of respiratory complications in their group of patients from 43 per cent to 9 per cent by using intensive physiotherapy in conjunction with the bronchodilator isopropylnoradrenaline (Isoprenaline). Most patients undergoing gastric surgery have nasogastric suction performed for about 48 hours and the indwelling tube is frequently an impediment to coughing. It has been found that intermittent aspiration of the stomach, twice a day, is adequate in most patients; for this purpose the tube can be passed when required, leaving the patient free to cough without interference. Among patients where this regime has been followed, there have been no serious postoperative pulmonary complications.
CONCLUSIONS
The anaesthetic technique devised to meet the requirements of the surgeon performing complete gastric vagotomy, and accordingly omitting atropine or hyoscine from the premedication, does not involve any increased hazard to the patient. Observation of patients submitted to this technique revealed no untoward cardiovascular effects due to uninhibited reflex vagal activity, and although increased secretions are present in the respiratory tract, these are watery and are therefore easily removed. The incidence of pulmonary complications is lower than that in a comparable group receiving conventional premedication.

ACKNOWLEDGMENTS
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REFERENCES

ZUSAMMENFASSUNG
Eine Narkosetechnik wird erörtert, bei der Atropin oder Hyoscin bei der Prämiedikation weggelassen wird, um den Forderungen des Chirurgen zu entsprechen, der eine vollständige gastrische Vagotomie ausführt. Bei 60 Fällen zeigten die Erfahrungen keinen Hinweis für unerwünschte Reflex-Aktivität von Herzen und Kreislauf, die Sekretionszunahme im respiratorischen Strang ereignete sich nicht als störend. Die Häufigkeit postoperativer pulmonaler Komplikationen wird mit der einer Kontrollgruppe verglichen, die die herkömmliche Prämiedikation erhielt, und war in der Testgruppe niedriger.

Ferner wird die Beziehung von Rauchgewohnheiten, Alter und Geschlecht zu den postoperativen respiratorischen Komplikationen nach allen Arten von Magenchirurgie besprochen.