

PAPERS AND ORIGINALS

Five- to Eight-year Results of Truncal Vagotomy and Pyloroplasty for Duodenal Ulcer

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British Medical Journal, 1972, 1, 7-13

Summary

From January 1963 to December 1965 inclusive 192 men with duodenal ulcer were treated by elective truncal vagotomy and pyloroplasty with one death. Ten subsequent deaths were due to causes unrelated to the ulcer or operation, and 17 patients became untraceable. The remaining 164 patients have been followed up for five to eight years. The late results have been compared with those obtained in a previous study of patients five to eight years after truncal vagotomy and gastroenterostomy, truncal vagotomy and antrectomy, and subtotal gastrectomy respectively for duodenal ulcer.

Of the various postgastric operation syndromes early dumping, late dumping, bilious vomiting, and diarrhoea were all less frequent, but not significantly so, after vagotomy and pyloroplasty than after vagotomy and gastroenterostomy.

Recurrent ulceration was commoner after vagotomy and pyloroplasty than after all the other operations, the incidence of proved and suspected recurrent ulcers being respectively 6.7 and 7.3% after vagotomy and pyloroplasty, but only 2.5 and 5.9% after vagotomy and gastroenterostomy, 0 and 5.2% after vagotomy and antrectomy, and 0.9 and 3.7% after subtotal gastrectomy. The differences between vagotomy and pyloroplasty and vagotomy and antrectomy or subtotal gastrectomy are statistically significant, but those between vagotomy and pyloroplasty and vagotomy and gastroenterostomy are not.

Overall assessment (Visick grading) of the outcome gave poorer results after vagotomy and pyloroplasty than after any other operation, with 14% of category IV cases after vagotomy and pyloroplasty, 11% after vagotomy and gastroenterostomy, 8% after vagotomy and antrectomy, and 6% after subtotal gastrectomy—differences that are significant between vagotomy and pyloroplasty and vagotomy and antrectomy or subtotal gastrectomy but not between vagotomy and pyloroplasty and vagotomy and gastroenterostomy.

In the light of these findings it is suggested that truncal vagotomy and pyloroplasty has not lived up to expectations and its place as the currently most popular procedure in the elective surgical treatment of duodenal ulcer should be reconsidered.

Introduction

From 1959 to 1962 many surgeons in Leeds and York participated in a controlled prospective trial of several different forms of operation in the elective treatment of duodenal ulcer, the immediate and long-term results of which have been published (Goligher *et al.*, 1964, 1966, 1968a). When this trial closed for the admission of new cases in the latter part of 1962 the elective operation for duodenal ulcer favoured by surgeons in the University Department of Surgery at the Leeds General Infirmary and by those at the York Hospitals was a truncal vagotomy and pyloroplasty. In practice this meant that about 90% of patients with this condition requiring elective surgery had this operation, the remaining 10% being treated usually by vagotomy and gastroenterostomy because of anticipated technical difficulties from oedema or scarring of the first part of the duodenum if pyloroplasty were attempted. In 1968 a preliminary account was given of the outcome of truncal vagotomy and pyloroplasty two years after operation (Goligher *et al.*, 1968b). Since then the follow-up has been continued so that we are now in a position to report the five- to eight-year results based on an analysis of the 192 male patients treated electively by this operation during January 1963 to December 1965 inclusive, and to compare them with those obtained after other operations as recorded in our previous studies (Goligher *et al.*, 1968a).

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Methods

The 192 operations were performed mainly by seven consultant surgeons, but a few were conducted by four lecturers of senior registrar status. The vagotomy was invariably effected by a subdiaphragmatic division of the vagal trunks on the lower oesophagus. With the exception of an occasional case in which the Finney technique was used, the pyloroplasty was of Heinecke-Mikulicz type, with an 8-10 cm stoma, the suturing in roughly half the cases being in two layers, in the other half in one layer as described by Weinberg *et al.* (1956). In all instances the operation was carried out as an elective procedure, patients undergoing emergency operation for haemorrhage or perforation being excluded. Also excluded were any patients who received at the time of their elective vagotomy and pyloroplasty surgical treatment for other conditions, such as gall stones or hiatal hernia. All patients had suffered from chronic duodenal ulceration as indicated by a history of ulcer-type dyspepsia of many years' duration, in a number of instances marked by episodes of haemorrhage or perforation, and usually supported by clear radiological evidence. In some cases a preoperative and post-operative gastric analysis was carried out to determine the secretion of acid under basal conditions and in response to stimulation by pentagastrin or insulin, but unfortunately such data were available for only a fraction of the patients.

Postoperative care followed conventional lines. Intravenous fluids were administered for the first 48 to 72 hours as a rule. Some patients had intermittent gastric suction via an indwelling nasogastric tube or a temporary gastrostomy, but most had no form of intubation or suction.

On discharge from hospital patients attended a special gastric follow-up clinic six months after operation and then yearly (or oftener if required). At this clinic, which was held in both Leeds and York, many other patients treated by several different gastric operations were being seen as well as those who had had truncal vagotomy and pyloroplasty and form the basis of this study. The interviewing panel of three or four persons was kept in ignorance of the precise operative method that had been used in each case till after it had recorded its collective verdict on the patient's condition at that attendance. In this way an objective and unbiased judgement was obtained.

Findings

Operative Mortality.—One death* occurred in the immediate postoperative period due to acute cardiac failure complicating bronchopneumonia (Table I). Though this fatality could not be attributed to any technical failure of the operation, none the less it must be related to the operation and represents an operative mortality of 0.52%.

Subsequent Deaths.—Ten patients died within five years of discharge from hospital, so far as we can ascertain, from causes unrelated to their operation or to the ulcer for which it was performed (Table I). Of these deaths one was due to a road accident, five to coronary occlusion, two to carcinoma of the bronchus, one to carcinoma of the urinary bladder, and one to bronchopneumonia.

Untraced Cases.—Seventeen patients have been lost to follow-up despite every effort to trace them with the aid of the family doctors and executive councils (Table I). In many of these cases we have limited follow-up data for a few years, but they have not been included in this assessment of late results because they did not extend to at least five years from the time of operation.

Traced Cases.—The remaining 164 patients have been followed up for not less than five years, many of them for seven

*In our earlier report on the results of truncal vagotomy and pyloroplasty (Goligher *et al.*, 1968b) two operative deaths were mentioned, but in one of these fatal cases a colonic carcinoma had been resected at the time of the operation for duodenal ulcer, which disqualified this patient for inclusion in the present study.

or eight years (Table I). Most were assessed regularly throughout that time at the gastric follow-up clinic, as described, but a few, who had defaulted in their attendances more recently, had for the purposes of this inquiry to be contacted in early 1971 by a postal questionnaire or by a visit to their homes.

Comparison with Other Procedures

On the basis of the findings in the 164 patients followed up for five to eight years since operation we can assess the late results of truncal vagotomy and pyloroplasty. These results will be compared with the five- to eight-year results elicited by us in the Leeds/York controlled trial of vagotomy and gastroenterostomy, vagotomy and antrectomy, and Polya subtotal gastrectomy for duodenal ulcer (Goligher *et al.*, 1968a) (Table I). Such a comparison, not being based on a random allocation of

TABLE I—Allocation and Subsequent Fate of 568 Male Duodenal Ulcer Patients Treated by Different Elective Operations

	Operative Methods Used			
	In Leeds/York Trial 1959-62 (Goligher <i>et al.</i> , 1968a)			In Present Study 1963-5
	Vag. & G.E.	Vag. & Antr.	Subtot. Gastrect.	Vag. & P.
No. in each group ..	126	132	117	192
Operative deaths ..	0	0	0	1
Subsequent deaths ..	4	11	3	10
Untraced cases ..	3	5	7	17
Traced cases 5-8 years after operation ..	119	116	107	164

patients, is clearly open to the criticism that the series of cases submitted to vagotomy and pyloroplasty may be somewhat dissimilar from those treated by the other operations. However, all the patients were derived from the same "hospital areas" and were treated mainly by the same surgeons. Moreover, the method of assessment of the patients' condition on follow-up was identical, for exactly the same criteria—and, indeed, virtually the same panel of assessors—were employed both in the Leeds/York trial and in the follow-up of our patients after vagotomy and pyloroplasty.

Frequency of Symptoms Due to Alimentary Dysfunction

The relative frequency of the commoner postgastric operation syndromes five to eight years after truncal vagotomy and pyloroplasty and other elective operations for duodenal ulcer is shown in Table II. *Epigastric fullness* after food, often restricting slightly the size of the meal, was encountered in rather more than a third of the patients after all types of operation. *Early dumping*† was not significantly less frequent after vagotomy and pyloroplasty than after gastroenterostomy, but was so after vagotomy and pyloroplasty than after subtotal gastrectomy ($P < 0.05\%$). *Late dumping*† was a rare symptom after any of the operations, but especially after vagotomy and pyloroplasty and gastrectomy. *Nausea* was fairly frequent after all types of operation, with a slightly increased incidence after subtotal gastrectomy. *Food vomiting* was most encountered after vagotomy and antrectomy, but its incidence was quite low after any of the operations. *Bile vomiting* occurred less frequently after vagotomy and pyloroplasty than after any other operation but the differences were not statistically significant. *Heartburn* was least frequent after gastrectomy. *Flatulence* was equally common after all operations.

†The term dumping is apt to mean different things to different authors. We would define *early dumping* as a sensation of epigastric fullness accompanied by a feeling of faintness, sweating, or palpitation occurring immediately after a meal, and *late dumping* as a feeling of faintness and weakness coming on an hour or more after food and probably due to hypoglycaemia.

TABLE II—Frequency of Symptoms Due to Disturbance of Alimentary Function Five to Eight Years after Operation

Symptom	Operation Used			
	Vag. & G.E. (% of about* 119 Cases)	Vag. & Antr. (% of about* 116 Cases)	Subtot. Gastrect. (% of about* 107 Cases)	Vag. & P. (% of about* 161 Cases)
Epigastric fullness ..	40.2	36.3	36.5	37.1
Early dumping ..	17.9	8.6	21.5	11.9
Late dumping ..	6.0	4.3	0.9	1.9
Nausea ..	12.8	17.2	23.4	17.6
Food vomiting ..	4.3	9.6	5.6	4.4
Bile vomiting ..	14.5	13.8	13.1	10.1
Heartburn ..	19.9	15.7	8.4	12.6
Flatulence ..	17.9	22.8	19.8	20.1
Dysphagia ..	1.1	0.0	0.0	0.6
Diarrhoea ..	26.3	23.2	6.5	21.7

*The percentages relate to the total number of cases in which the particular symptom was elicited, which in some instances were a few less than the numbers indicated.

Alteration of Bowel Habit

The frequency of disturbance of bowel function after truncal vagotomy has aroused much controversy, and the simple statement of incidence of diarrhoea contained in Table II certainly requires amplification. The effect of the four operations on bowel habit is examined more comprehensively in Table III. In comparison with the preoperative state three types of result after operation have been recognized:

TABLE III—Bowel Habit Five to Eight Years after Operation

Bowel Habit	Operation Used			
	Vag. & G.E. (% of 118 Cases)	Vag. & Antr. (% of 112 Cases)	Subtot. Gastrect. (% of 107 Cases)	Vag. & P. (% of 161 Cases)
No change	42.3	39.3	57.0	50.4
Improved	31.4	37.5	36.5	27.9
Diarrhoea	26.3	23.2	6.5	21.7

Unchanged (or more costive) where bowel function has either not altered at all since operation or has tended towards constipation.

Improved, which means that the motions have become a trifle looser than before operation, and possibly a little more frequent—for example, the patient may find that, instead of having one very hard difficult motion every two or three days as before operation, he now enjoys a perfectly easy formed or slightly soft motion with regularity once or twice a day. By no stretch of imagination could this state of affairs be described as diarrhoea or in any way unpleasant. On the contrary it is normally regarded by the patient as one of the most agreeable effects of the operation!

Diarrhoea of varying degrees of severity, ranging from three or four soft or liquid motions daily to eight to ten or more stools of liquid consistency in the 24 hours. Two features particularly characterized the diarrhoea in these cases. One was the great *urgency* of the call to stool often experienced by the patient, so that if he did not get to the lavatory very quickly he might not be able to control the motion. The second feature was that the diarrhoea was usually not continuous but *episodic*, the symptoms occurring in short attacks lasting perhaps a few hours or a day or so, interspersed with periods of normal bowel habits varying from a few days to several weeks or even two to three months.

In *grading patients according to the severity of their diarrhoea* we have taken into account not only the frequency and urgency of stools and the length of the episode and the intervals of freedom, but also—and more important—the amount of physical discomfort or inconvenience suffered by the patient, and whether he was incapacitated from following his work during attacks.

After all four operations between two-fifths and three-fifths of the patients reported that bowel habit was quite unchanged, and about one-third claimed a slight improvement in the ease and regularity of their motions (Table III). As regards actual diarrhoea the overall incidence varied considerably according to the operation performed, being of the order of 22–26% after all three operations involving truncal vagotomy, but only some

6% after subtotal gastrectomy without vagotomy, a difference that is statistically significant ($P < 0.01$). On the other hand, none of the differences in incidence of diarrhoea between the various vagotomy operations was of statistical significance. It must, however, be emphasized that these figures were inflated by the inclusion of many patients with an extremely mild, usually episodic form of looseness (Table IV), which certainly constituted no inconvenience to them. If only the more severe diarrhoea is considered, the incidence is very much lower—5.1, 2.7, and 4.3% after vagotomy and gastroenterostomy, vagotomy and antrectomy, and vagotomy and pyloroplasty respectively, but only 0.9% after gastrectomy without vagotomy (the last being due to a single, perhaps exceptional, case). These differences are not statistically significant.

TABLE IV—Severity and Type of Diarrhoea Five to Eight Years after Operation

Severity and Type of Diarrhoea	Operation Used			
	Vag. & G.E. (% of 118 Cases)	Vag. & Antr. (% of 112 Cases)	Subtot. Gastrect. (% of 107 Cases)	Vag. & P. (% of 161 Cases)
Mild or moderate ..	21.2	20.5	5.6	17.4
Episodic	20.4	17.8	3.7	11.8
Continuous	0.8	2.7	1.9	5.6
Severe	5.1	2.7	0.9	4.3
Episodic	5.1	2.7	0.0	3.1
Continuous	0.0	0.0	0.9	1.2
All forms of Diarrhoea	26.3	23.2	6.5	21.7

Obviously in respect of bowel function Polya subtotal gastrectomy enjoys an advantage over the three vagotomy operations, the results of which are to some extent marred by the occurrence of postoperative diarrhoea. The use of pyloroplasty instead of gastroenterostomy as the drainage procedure with truncal vagotomy does not materially lessen the incidence of diarrhoea.

Recurrent Ulceration

Several difficulties surround the recognition of recurrent ulceration, so that the sureness of diagnosis of this complication may range from absolute certainty through strong suspicion to considerable dubiety. It may therefore be convenient to discuss the criteria used by us in recognizing further ulceration and the degree of confidence in diagnosis achieved in each case.

The occurrence of epigastric pain similar to that experienced before operation was always suggestive of recurrent ulceration. The more typical the pain the greater was the likelihood of it being due to further ulceration. If the operation had included a vagotomy, the finding that the vagal nerve section was incomplete, as shown by a positive—and particularly an early positive—response to the Hollander insulin test further strengthened the probability of the pain being caused by recurrent ulcer. Occasionally the diagnosis was confirmed beyond all doubt by the clear demonstration of an ulcer crater on barium meal examination or gastroscopy, but usually *x-ray* and gastroscopic studies were unhelpful, especially after vagotomy and pyloroplasty, for the considerable deformity produced by this operation in the distal stomach and proximal duodenum made interpretation of the radiological appearances in this region extremely difficult. The occurrence of a major haematemesis or melaena in a patient who has had an operation for peptic ulcer is traditionally regarded as indicative of recurrent ulceration, even in the absence of abdominal pain. We have accepted this convention, provided there had been no history of recent ingestion of medicaments containing aspirin.

In most cases absolute proof of the existence of a recurrent ulcer depended on finding the lesion at re-laparotomy, but there were problems in demonstrating such ulcers. Certainly in some patients with very strong clinical evidence of recurrent ulceration, and in whom no definite recurrence could be found at reopera-

tion, it was difficult to decide whether they had ever had a recurrent ulcer or whether there might have been a recurrence which had temporarily healed, so that it was not apparent at the second laparotomy. After vagotomy and pyloroplasty the presence of fibrosis and adhesions in the pyloric region added to the difficulty of diagnosis of further ulceration in the duodenal bulb. This uncertainty as to the significance of negative or dubious findings in regard to recurrent ulcer at re-exploration often led the surgeon to perform a further antiulcer manoeuvre such as partial gastrectomy or a re-vagotomy, depending on the strength of his clinical suspicions (see Table XI).

The number of patients in whom the existence of recurrent ulceration had been firmly established at re-laparotomy or was still suspected more or less strongly five to eight years after the various operations is given in Table V. In our hands vagotomy and pyloroplasty seemed much more liable to be followed by recurrence than any other operation. Thus, if only cases of proved recurrent ulcer are considered, the incidence was 0.9% after subtotal gastrectomy, nil after vagotomy and antrectomy, 2.5% after vagotomy and gastroenterostomy, but 6.7% after vagotomy and pyloroplasty. This difference in the frequency of recurrence after vagotomy and pyloroplasty as compared with the other three operations reaches statistical significance only in relation to the two resection procedures—subtotal gastrectomy ($P < 0.02$) and vagotomy and antrectomy ($P < 0.01$).

TABLE V—Recurrence of Ulcer Five to Eight Years after Operation

Degree of Certainty of Diagnosis of Recurrence	Operation Used			
	Vag. & G.E. (119 Cases)	Vag. & Antr. (116 Cases)	Subtot. Gastrect. (107 Cases)	Vag. & P. (164 Cases)
Proved at laparotomy	3	0	1	11
Highly suspected ..	4 (2 mel-aena; 2 sev. rec. pain)	2 (1 mel-aena; 1 sev. rec. pain)	1 Melaena	7 (6 lap., no rec. ulcer found but further anti-ulcer operation performed; 1 sev. rec. pain x-ray pos. 5 Rec. pain)
More dubious ..	3 Rec. pain	4 Rec. pain	3 Rec. pain	

The much larger proportion of patients with highly suspected or dubious recurrences after vagotomy and pyloroplasty than after the other operations has also to be taken into account. In this connexion it should be pointed out that, in addition to the 11 patients who were found at reoperation after vagotomy and pyloroplasty to have evidence of recurrent ulceration, there were another seven patients highly suspected on clinical grounds to have recurrence after this operation, who at re-laparotomy did not show any definite ulcers. But in six of these cases a further procedure, such as antrectomy, re-vagotomy, or conversion to a gastroenterostomy, was performed, indicating some degree of uncertainty in the mind of the surgeon whether they should be regarded as examples of recurrence or not. We have decided to list these six cases as highly suspected instances of recurrent ulcer. If proved, suspected, and dubious ulcers are all considered together, the incidence after vagotomy and pyloroplasty is significantly greater than after vagotomy and antrectomy ($P < 0.01$) or subtotal gastrectomy ($P < 0.01$), but not so in comparison with vagotomy and gastroenterostomy.

It would be interesting to know the incidence of recurrent ulcer in patients who had operations incorporating a vagotomy, according to whether the vagotomy was complete or incomplete as determined by the Hollander (1948) insulin tests. Unfortunately insulin tests were performed on only a fraction of the entire series of patients having vagotomy operations. However, of the group of 23 patients with proved or alleged recurrent ulceration after this procedure (Table V), 16 underwent insulin testing as part of the investigation of their recurrent symptoms. The test was negative by Hollander's criteria in four cases and positive in 12 (early positive, in the first hour, in six; late positive

in six). Five of the six patients with early positive responses were eventually proved to have recurrent ulcers; one remains a suspected recurrence and has not had a reoperation.

Overall Assessment of Patients' Fitness

For this purpose we have, as in previous studies (Goligher *et al.*, 1964, 1966), used a slight modification of the well-known Visick (1948) classification, which recognizes essentially four categories of result (Table VI). From the practical point of view both categories I and II can be regarded as highly satis-

TABLE VI—Overall Grading of Results (Modified Visick Classification)

Category	Definition
I. Excellent ..	Absolutely no symptoms. Perfect result
II. Very good ..	Patient considers result perfect, but interrogation elicits mild occasional symptoms easily controlled by minor adjustment to diet
III. Satisfactory ..	Mild or moderate symptoms not controlled by care, causing some discomfort, but patient and surgeon satisfied with result, which does not interfere seriously with life or work
IV. Unsatisfactory ..	Moderate or severe symptoms or complications which interfere considerably with work or enjoyment of life; patient or doctor dissatisfied with result. Includes all cases with proved recurrent ulcer and those submitted to further operation, even though the latter may have been followed by considerable symptomatic improvement

factory, and they are grouped together in our analysis. Category IV comprises the failures. It should be explained that this system of grading does not directly concern itself with post-operative disturbances of nutrition or anaemia, though these ill effects are indirectly considered in so far as they may impair function or reduce the patient's fitness for work or pleasure, which presumably is what really counts. We have arbitrarily placed patients with proved recurrent ulcer permanently in category IV, regardless of the success of subsequent surgical treatment, and have likewise categorized those individuals who required reoperation for bilious vomiting, dumping, etc., even though they may have secured a reasonably good result after their second operation. The grading of patients with suspected or dubious recurrent ulceration has depended on the degree of suspicion, but usually they have been put in category III unless they have had a reoperation, when they have been relegated permanently to category IV.

Applying this classification to our patients at their latest follow-up five to eight years after operation (Table VII), we have found a smaller proportion of cases in categories I and II after vagotomy and pyloroplasty (and vagotomy and gastroenterostomy) than after subtotal gastrectomy or vagotomy and antrectomy, but the difference was not statistically significant. There were proportionally more cases in category IV after the two vagotomy and drainage operations than after gastrectomy or vagotomy and antrectomy; the difference in this respect between vagotomy and pyloroplasty and subtotal gastrectomy was statistically significant ($P < 0.05$).

TABLE VII—Visick Grading Five to Eight Years after Operation

Category	Operation Used			
	Vag. & G.E. (% of 119 Cases)	Vag. & Antr. (% of 116 Cases)	Subtot. Gastrect. (% of 117 Cases)	Vag. & P. (% of 164 Cases)
I.	44	50	49	45
II.	26	28	28	23
III.	19	14	17	18
IV.	11	8	6	14
	} 70	} 78	} 77	} 68

Category IV cases are of special interest in so far as they represent in the main the failures of surgery. Therefore the reasons for regarding the operation as having failed should be examined in each category IV case. Such a scrutiny has already been carried out on the category IV cases after the three operations in the Leeds/York trial (Goligher *et al.*, 1968a) (Tables VIII, IX, and X). The 23 category IV cases after vagotomy and

pyloroplasty are listed in Table XI. No fewer than 19 came to reoperation on a suspicion of recurrent ulcer, but in only 11 was an ulcer found at the second laparotomy. In five of the eight cases without a demonstrable recurrent ulcer a further manoeuvre such as re-vagotomy or gastroenterostomy was performed, but in three cases nothing further was done. It will be noted that one of these latter patients unfortunately died postoperatively, probably of a pulmonary embolism. In 14 of

the 20 patients who had reoperation the second intervention was successful in raising the patient's symptomatic grading to a higher category (to category III in seven, to category II in three, and to category I in four), though, according to the convention enunciated in Table VI, these cases having further operations remain permanently in category IV in our records. The effect of incorporating such upgradings in the assessment of the overall results after vagotomy and pyloroplasty and the operation in the Leeds/York trial is shown in Table XII.

TABLE VIII—Thirteen Category IV Cases after Vagotomy and Gastroenterostomy in the Leeds/York Trial.

1	} Recurrent ulcer leading to re-laparotomy—gastrectomy	} IV*
2		
3		
4	} Severe melaena, x-ray and gastroscopy negative for rec. ulcer	} IV*
5		
6	} Persisting pain, x-ray and gastroscopy negative for recurrent ulcer	} IV*
7		
8	} Bile vomiting, epigastric fullness, and dumping—conversion to pyloroplasty	} III*
9		
10	} Early dumping, epigastric fullness, heartburn, and bile vomiting	} IV*
11		
12	} Early dumping and severe diarrhoea	} IV*
13		

*Indicates what would be the patient's Visick grading since reoperation if he were not by convention retained in category IV.

TABLE IX—Nine Category IV Cases after Vagotomy and Antrectomy in the Leeds/York Trial

1	} Severe melaena: x-ray and gastroscopy negative for recurrent ulcer, but insulin test = incomplete vagotomy	} IV*
2		
3	} Persistent pain, but x-ray and gastroscopy negative for recurrent ulcer	} IV*
4		
5	} Bile vomiting, epigastric fullness, and dumping—conversion to Roux-en-Y anastomosis	} II*
6		
7	} Severe diarrhoea—conversion to Billroth I anastomosis	} II*
8		
9	} Nausea, epigastric fullness and dumping, flatulence, and bile vomiting	} IV*
9		

*Indicates what would be the patient's Visick grading since reoperation if he were not by convention retained in category IV.

TABLE X—Seven Category IV Cases after Subtotal Gastrectomy in the Leeds/York Trial

1	} Recurrent ulcer proved at laparotomy—vagotomy	} III*
2		
3	} Severe melaena	} III*
4		
5	} Bile vomiting, epigastric fullness and dumping, nausea, and flatulence—conversion to Billroth I or Roux-en-Y anastomosis	} III*
6		
7	} Development of pulmonary tuberculosis	} III*
7		

*Indicates what would be the patient's Visick grading since reoperation if he were not by convention retained in category IV.

TABLE XI—Twenty-three Category IV Cases after Vagotomy and Pyloroplasty

1	} Recurrent ulcer proved at laparotomy—gastrectomy	} III*
2		
3		
4	} Recurrent ulcer proved at laparotomy—antrectomy	} IV*
5		
6	} Recurrent ulcer proved at laparotomy—re-vagotomy	} III*
7		
8	} Recurrent ulcer proved at laparotomy—re-vagotomy and antrectomy	} IV*
9		
10	} Further laparotomy, no ulcer	} IV*
11		
12	} Further laparotomy, no ulcer, postoperative death probably due to pulmonary embolism	} III*
13		
14	} Further laparotomy, no ulcer—re-vagotomy	} III*
15		
16	} Further laparotomy, no ulcer—gastroenterostomy	} IV*
17		
18	} Further laparotomy, no ulcer—antrectomy	} III*
19		
20	} Ulcer-type pain and bile vomiting. Negative x-rays	} IV*
21		
22	} Epigastric pain and vomiting. Negative x-rays. Under psychiatric care	} III*
23		
23	} Severe diarrhoea, dumping, and flatulence	} IV*
23		

*Indicates what would be the patient's Visick grading since reoperation if he were not by convention retained in category IV.

TABLE XII—Visick Grading Five to Eight Years after Operation, Incorporating the Results of any Reoperations

Category	Original Operations Used			
	Vag. & G.E. (% of 119 Cases)	Vag. & Antr. (% of 116 Cases)	Subtot. Gastrect. (% of 107 Cases)	Vag. & P. (% of 163* Cases)
I	44	51	49	47
II	26 } 70	30 } 81	28 } 77	25 } 72
III	20	16	17	22
IV	10	5	6	6

One patient died in postoperative period following reoperation.

Discussion

The first essential in any discussion of this study is to re-emphasize that the allocation of patients to vagotomy and pyloroplasty on the one hand, and to the other group of operations on the other, was not in any way randomized. We must admit, therefore, that though we strongly believe the respective series of cases are very similar this contention could be challenged. Some readers may thus take the view that the comparative analysis has been worth while, others that it is valueless.

The advantages claimed by many authors for vagotomy and pyloroplasty over vagotomy and gastroenterostomy is that it is in theory a more physiological procedure and is in fact followed by less trouble with bile vomiting and possibly other sequelae than is the latter operation, though it is admitted that there may be a slightly higher incidence of recurrent ulceration (Weinberg *et al.*, 1956; Burge, 1964; Holt and Lythgoe, 1965; Schofield *et al.*, 1967). Our findings have indeed shown a somewhat lower incidence of bilious vomiting after vagotomy and pyloroplasty (10.1%) than after vagotomy and gastroenterostomy (14.5%), and also a lower incidence of early dumping (11.9% as against 17.9%) and of heartburn (12.6% versus 19.9%). Diarrhoea, too, was noted to be rather less frequent after vagotomy and pyloroplasty (21.7%) than after vagotomy and gastroenterostomy (26.3%). But none of these differences has achieved statistical significance.

RECURRENT ULCERATION

Against these marginal advantages of vagotomy and pyloroplasty must be set the greater frequency of recurrent ulceration following its use than that of vagotomy and gastroenterostomy—and, even more so, of vagotomy and antrectomy and subtotal gastrectomy. Thus the recurrence rate after vagotomy and pyloroplasty ranged from 6.7% for ulcers proved at laparotomy to 14.0% if suspected and more dubious recurrences were also included. The corresponding figures for vagotomy and gastroenterostomy were 2.5 and 8.4%, for vagotomy and antrectomy 0 and 5.2%, and for subtotal gastrectomy 0.9 and 4.6%. The differences between the incidence of proved ulcers and of proved and suspected ulcers after vagotomy and pyloroplasty and after vagotomy and gastroenterostomy are not statistically significant, but the differences in these respects between vagotomy and pyloroplasty and either vagotomy and antrectomy or subtotal gastrectomy are significant.

The high incidence of recurrent ulceration after vagotomy and pyloroplasty is reflected too in the relatively large number of reoperations undertaken after this operation. No fewer than 20 (12.2%) of the 164 patients who had vagotomy and pyloroplasty came to reoperation, 19 for clinically suspected recurrences, and of this group 17 (10.4%) underwent further antiulcer operations such as gastrectomy or re-vagotomy (Table XI). By comparison reoperations after the other primary operations were much less frequent—only 5 in 119 patients treated by vagotomy and gastroenterostomy, three for recurrent ulcer (Table VIII); 5 in 116 patients treated by vagotomy and antrectomy, none for recurrence (Table IX); and 4 in 107 patients treated by subtotal gastrectomy, one for recurrent ulcer (Table XI).

Fortunately the numerous reoperations after vagotomy and pyloroplasty have often been successful in improving the patients' overall symptomatic state, for no fewer than 14 of the 19 patients so treated were able to score a higher Visick grading after their reoperation (compare Tables VII and XII). It could thus be claimed that, though vagotomy and pyloroplasty is a comparatively less effective operation than the others mentioned in curing duodenal ulcer, its deficiencies in this respect may be largely made good by a more radical reoperation as required. It might be argued further that this policy of using the relatively simple and safe operation of vagotomy and pyloroplasty in the first instance and of reserving more major resection procedures for the one case in ten or so that develops recurrence is in the patient's best interest.

Vagotomy and pyloroplasty was shown to be very safe in our experience, with only one operative death in 192 cases, but it was not found to be any safer than the other operations examined, after none of which, including vagotomy and antrectomy and subtotal gastrectomy, was there any operative mortality at all. Admittedly some degree of selection was practised in choosing cases for all four operations, whereby we excluded a small proportion of the patients in whom the duodenum was particularly scarred and deformed owing to very adherent ulcers (Goligher *et al.*, 1968a). Without these exclusions the operative mortality, especially of the resection procedures, might conceivably have been higher. But with a moderate amount of discrimination in their application—and a good standard of surgical expertise—it seems to us that gastrectomy or vagotomy and antrectomy (which both involve the same technical problems of resection) can be carried out with remarkable safety in the elective treatment of duodenal ulcer at the present day. It should also be pointed out that reoperations are often technically difficult and probably carry more risks than does the corresponding primary procedure, as is exemplified by the immediate death of one of our patients after a reoperation secondary to a vagotomy and pyloroplasty (Table XII).

ASSESSMENT OF DIFFERENT OPERATIONS

We recognize that assessment of the respective worth of different operations for peptic ulcer is a complex matter involving a careful balancing of pros and cons. But, however regarded, our findings seem to us to provide no grounds for complacency concerning the results of truncal vagotomy and pyloroplasty in the elective treatment of duodenal ulceration. A question that naturally arises is whether anything can be done to improve the accomplishments of this operation. A good deal of the evidence suggests that recurrent ulcer after vagotomy procedures in general is largely confined to patients whose vagotomy has been shown to be incomplete by a positive response to the Hollander insulin test (Johnston *et al.*, 1967; Fawcett *et al.*, 1969). Unfortunately, even when the operation has been performed by experienced gastric surgeons, incomplete vagotomy rates of between 20 and 50% are common on such testing, depending to a considerable extent on how diligently the test is repeated after the patient has left hospital (Mason and Giles, 1968, 1969; Fawcett *et al.*, 1969; Gillespie *et al.*, 1970; Jordan and Condon, 1970; Kronborg *et al.*, 1970). How this disappointingly high incidence of incomplete denervation can be reduced is not clear.

Burge (1964) made strong claims for his electrical stimulation test as a means of detecting residual intact vagal fibres on the oesophagus during operation and enabling the surgeon to be more certain of doing a complete vagotomy. But opinions on the value of this test have been very mixed (Clark and Murray, 1963; Holt and Lythgoe, 1965; Watkin and Hudson, 1971), and the plain fact is that it has not been widely adopted. Lee (1969) introduced a method of applying a solution of leuco-methylene blue to the outer aspect of the lower oesophagus at operation and alleged that the dye selectively stained nerve tissues, thus facilitating recognition of vagal strands during vagotomy. But others have not been impressed by its reliability

or usefulness (Cox and Cooke, 1970; Frimer *et al.*, 1970). Grassi (1971) designed a test which attempts to assess the completeness of vagotomy during the operation by determining the acidity of the mucosal surface before and after the nerve section by means of a pH probe. But experience with this method is still limited and its value remains to be established.

CHOICE OF OPERATION

It seems to us that there are in fact no very good immediate prospects of being able to reduce the frequency of incomplete nerve section during truncal vagotomy and thus to lessen the high incidence of recurrent ulceration after the operation of vagotomy and pyloroplasty. Under the circumstances we feel considerable misgivings about continuing to accord to this operation pride of place in the elective surgical treatment of duodenal ulcer. The problem, however, is to decide which operation to choose instead. From our data we believe that if the surgeon wishes to continue practising truncal vagotomy with a gastric drainage procedure, vagotomy and gastroenterostomy is in general preferable to vagotomy and pyloroplasty, for disturbances of alimentary function are only marginally more frequent after it, and it seems to afford somewhat better protection against the tendency to recurrent ulceration if the vagotomy should be incomplete. In addition, gastroenterostomy is nearly always applicable in practice, while a pyloroplasty may sometimes be technically difficult and possibly less safe.

But a good case can be made out for reconsidering elective gastric resection, either in the form of antrectomy with vagotomy or even of a two-thirds gastrectomy without vagotomy, for many duodenal ulcer patients. Obviously, if this latter policy were adopted, the utmost care would have to be taken to exclude those cases with very adherent lesions likely to give rise to technical difficulties if resected and to treat them by vagotomy and gastroenterostomy. We appreciate from other studies (Goligher *et al.*, 1968a; Pulvertaft and Cox, 1969), too, that if gastric resection were to be resuscitated in the treatment of duodenal ulcer a higher incidence of metabolic and haematological side effects would have to be accepted, but our experience is that these are seldom of serious consequence and can usually be compensated for by suitable replacement therapy.

Another possibility is to continue using vagotomy in conjunction with a drainage manoeuvre such as gastroenterostomy or pyloroplasty, but to change from a *truncal* to a *selective* vagal nerve section. The underlying principle of selective vagotomy is to divide the vagi below the points of origin of the hepatic and coeliac branches, in order to conserve the vagal supply to the biliary tract and small intestine in the hope of reducing the incidence of post-vagotomy diarrhoea. There has been much controversy about whether the selective technique is successful in this respect, but it seems from the carefully controlled trial of Kennedy and Connell (1969, 1970) of selective versus truncal vagotomy that there is significantly less diarrhoea after the former method. An important bonus of selective vagotomy that emerges from Kennedy and Connell's (1969) study is that there is also a significant reduction in the incidence of incomplete gastric vagotomy, as determined by insulin testing, after the selective operation. We must admit, however, that our own uncontrolled experience in Leeds with selective vagotomy and a drainage operation has been much less impressive in both these respects.

If alterations in the technique of vagotomy are to be contemplated, there is much to be said for the new operation of *highly selective vagotomy*, in which the vagal innervation of the upper two-thirds or so of the stomach is interrupted, but that to the antral region via the nerves of Latarjet is conserved, as is also the extragastric distribution of the vagi (Johnston and Wilkinson, 1970). This technique has also been variously termed *selective proximal vagotomy* (Holle, 1967), *parietal cell vagotomy*

(Amdrup and Jensen, 1970), and *proximal gastric vagotomy* (J. de Miguel, personal communication, 1971). Its effect is to reduce acid production as much as does truncal vagotomy, but to leave the emptying mechanism of the stomach unimpaired, which has the great advantage, as Johnston and Wilkinson (1970) and Amdrup and Jensen (1970) first pointed out, that no accompanying gastric drainage operation is required. During the past two and a half years more than 120 cases of duodenal ulcer have been treated by highly selective vagotomy in Leeds without drainage. Our results to date have been most encouraging, with no operative mortality, no gastric retention, no proved recurrent ulceration, no significant diarrhoea, and high Visick gradings, but obviously longer follow-up studies will be required before a decision can be reached concerning the proper value of this operation in the management of duodenal ulcer.

We should like to express our thanks to the following for their help in the conduct of this study: Mr. F. T. de Dombal, for statistical advice; Mrs. R. Nicholson, Mrs. M. A. Pybus, and Miss E. Bartholomew for secretarial services; Mrs. I. Dent for help in tracing patients; and the Board of Governors of the United Leeds Hospitals and the York Peptic Ulcer Research Trust for grants to defray some of the costs of the investigation.

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Prediction of Hypothyroidism after Partial Thyroidectomy for Thyrotoxicosis

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British Medical Journal, 1972, 1, 13-17

Summary

Hypothyroidism is one of the major complications after thyroidectomy for thyrotoxicosis, but the factors responsible are not well defined. In an attempt to define these factors 278 patients operated on in 1965-9 were studied in detail. The overall incidence of hypothyroidism was 49%. The high incidence of hypothyroidism during 1965-6 led to a policy of leaving larger remnants in the later years of the study, and it became apparent that the most important aetiological factor in postoperative hypothyroidism was small remnant size. There seemed to be an association between the incidence of hypothyroidism and the presence of antithyroglobulin antibodies, but this association was not statistically significant. The data suggested that blood group O might be more common and blood group A less common in hypothyroid patients. The incidence of hypothyroidism seemed to be uninfluenced by the age or sex of the patient, the size of the gland, or the amount and duration of preoperative antithyroid drug therapy.

Though a reasonable prediction of the incidence of hypothyroidism can be made for a group of patients on the basis of remnant size, the fate of the individual can be predicted only within very wide limits. An indication of the future status of the individual patient at one year and subsequently does, however, seem possible from serum protein-bound iodine estimations at one and four months after operation. Hypothyroidism developing later than one year after operation has not been observed in this series. The ability to assess thyroid status early after surgery is of some merit in the long-term supervision of the postoperative thyrotoxic patient, and in this respect surgical treatment seems to have some advantage over radioiodine therapy.

Introduction

The plurality of treatment of the thyrotoxic patient is an indication that none of the methods available is wholly acceptable. Hypothyroidism constitutes the major complication. After radioiodine therapy it is consequent on the biological effect of ionizing radiation on the replicative mechanism of the thyroid follicular cell (Greig, 1965). An incidence of 70% hypothyroidism 10 years after ¹³¹I therapy has been estimated (Nofal et al., 1966), and since the process of interference with cell reproduction is a continuing one it is possible that

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