

An evaluation and comparison of the early and late results of standardized Polya gastrectomy

DONALD KEMP¹

From the West Middlesex Hospital, Isleworth

EDITORIAL COMMENT This is a late follow up of an important series of gastrectomies carried out in the London area. It is to be noted that in all the cases the main branch of the left gastric artery was tied which would probably mean an incidental division of the coeliac branch of the posterior vagus nerve. The results give an interesting standard against which to judge the vagotomy and selective vagotomy operations. In making such comparisons it must be borne in mind that the operative mortality recorded for gastrectomy is considerably below the average throughout the country.

Of recent years, partial gastrectomy has become less popular as the operation of choice in elective peptic ulcer surgery. This trend is not surprising in the light of the voluminous literature revealing the defects of the operation. The inconsistency of published results, however, suggests that variations in operative technique and post-operative management may be important factors in the determination of the final result. That these variations occur is indeed the case, not only between different series, but, more importantly, within a given series. Failure to include details of operative technique and management in follow-up studies adds to the confusion and makes any attempted analysis of the results of 'partial gastrectomy' superficial and uncritical. Partial gastrectomy remains the yardstick by which other operations for peptic ulcer are judged, but, for those surgeons who must be guided by the more extensive experience of others, published comparisons are often misleading for the reasons outlined above, that is to say, more often than not the yardstick is an assortment of techniques and managements, hardly to be used as a basis for forecasting the likely outcome of a particular type of gastrectomy. It therefore is essential to know just what is implied when the term 'partial gastrectomy' is used.

With the passage of time it has become apparent that the mechanics of the operation do have some bearing on the results of partial gastrectomy (Capper and Welbourn, 1955; Abbott, Krieger, and Levey, 1958; Woodward and Hastings, 1960; Illingworth, 1960). Thus a well-constructed Polya gastrectomy should feature an adequate removal of parietal cell mass plus all of the antrum; a small rather than large

stoma; and a short, uninked afferent loop. Equally it may be stated that other factors appear to have little, if any, bearing on the result. Thus, the presence or absence of a valve, the direction of the afferent loop, and whether the anastomosis is retro-colic or ante-colic all seem to be unimportant as far as results are concerned.

The present investigation was undertaken for a number of reasons. First, all the operations in this series have been performed by an individual surgeon who has used an unvarying technique throughout, thereby standardizing the three desirable features listed above. Secondly, certain points in the management of these patients are not widely accepted but it is hoped that presentation of their successful application will help to disperse many of the old undesirable stigmata associated with the operation, particularly those concerning post-operative care and diet. Finally, a consecutive series is a proposition because of the suspected stability of the population in the area under investigation.

It should be made clear that no case is to be presented for or against Polya gastrectomy as the treatment of choice for peptic ulcer. As both gastric and duodenal ulcers are treated alike in this series, it is the operation and management of the patient which are under consideration rather than the pros and cons of the application to specific ulcer patterns.

MATERIAL AND METHODS

As all the patients in this series have had comparable operations, the opportunity is taken to consider them in two groups. In this way the results of an early group (1950-51) can be compared with those of a later group (1959-63). The two groups consist of unselected, con-

¹ Present address, Department of Surgery, University of Florida, Gainesville, Florida, U.S.A.

secutive cases, the former numbering 120 and the latter 250 cases. Polya gastrectomy has been the treatment in each case and only elective operation for benign peptic ulcer is considered. The main indication for surgery was intractable or chronic pain, a lesser number of patients suffering mechanical obstruction or chronic blood loss.

Gastroscopy and/or barium studies were used to establish the diagnosis. Although acid studies formed part of the pre-operative investigation in the 1950-51 group, of recent years this has been dispensed with and at no time has it determined the type of operative treatment undertaken.

When possible, follow-up was achieved by interview, otherwise a questionnaire was used. The response to follow-up request is given in Table I. The interviewed patients were carefully questioned regarding their post-operative state and then briefly examined by the writer. In all interviewed patients haemoglobin was estimated and in addition in the 1950-51 group serum vitamin B₁₂ was estimated. Any past treatment for anaemia was noted. Haemoglobin levels were estimated by the Cyanmet method; serum vitamin B₁₂ assay employed *Euglena gracilis* Z as the test organism (Anderson, 1964).

The time elapsed since gastrectomy ranged from one to five years in the 1959-63 group and from 15 to 16 years in the 1950-51 group. Before the interview the writer had had no contact with any patient in the series.

POINTS ON OPERATIVE TECHNIQUE AND POST-OPERATIVE MANAGEMENT

Certain features of technique and management deserve emphasis because of their suspected importance and bearing on the final result.

At the outset the patient is told that the operation will cure his ulcer and in the future he will be able to eat a normal diet without medication. Immediately before going to the theatre a thin stomach tube is passed and any contents aspirated. The tube is removed in the theatre.

ANAESTHETIC In all cases regional anaesthesia formed the basis of analgesia and relaxation. Over the 1950-51 period a multiple peripheral nerve block and local infiltration method was used. For the more recent cases epidural anaesthesia provided excellent access (Buck, 1963). Occasionally a super-added 'sleeping' general anaesthetic was administered for comfort.

INCISION A midline epigastric incision was used in all cases.

MANAGEMENT OF THE DUODENAL STUMP The duodenum was sectioned proximal to, through, and distal to the ulcer crater. To provide sufficient stump for closure, especially in densely adherent penetrating ulcers on the pancreas, the duodenum was deliberately opened around the ulcer margin and the

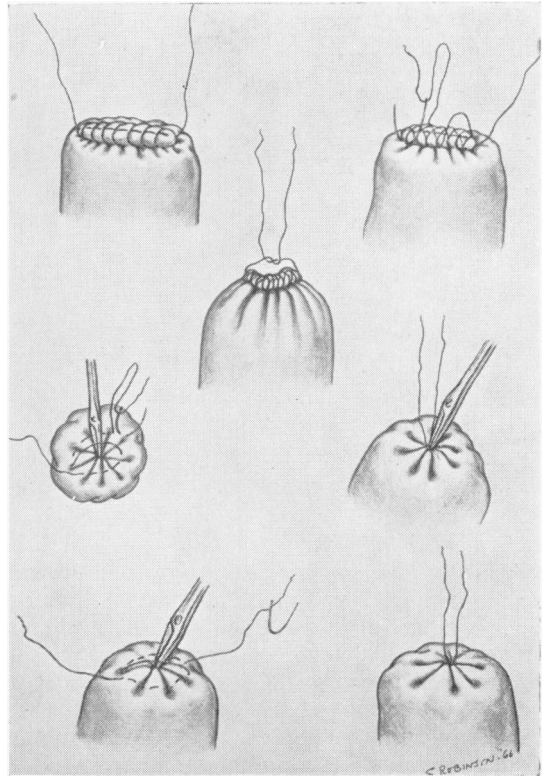


FIG. 1. Closure of duodenal stump using double invagination and Lane's pursestring.

defect sutured before transection in the normal way. The first step in stump closure is to convert the latter into an inverted cone. This was accomplished by inserting a four- or five-loop running stitch over the duodenal clamp, and, after removal of the clamp, the cut end of the stump was crimped so that its diameter was reduced considerably. More all-coats stitches incorporated 'dog-ears' to give a nicely pointed stump for invagination. A Lane's pursestring was then inserted through the sero-muscular layer (Fig. 1) and the first invagination completed. A further invagination followed in most cases but, if there was insufficient stump to allow this, one invagination sufficed. The stump was then covered with a further pursestring which included the lateral duodenal wall, the right gastric pedicle, and the peritoneal reflection overlying the pancreas near the gastroduodenal artery.

LIGATION OF THE LEFT GASTRIC PEDICLE A very high ligation of these vessels was accomplished almost at the origin of the left gastric artery rather than on the lesser curvature of the stomach. By depressing the body of the pancreas and elevating the transected

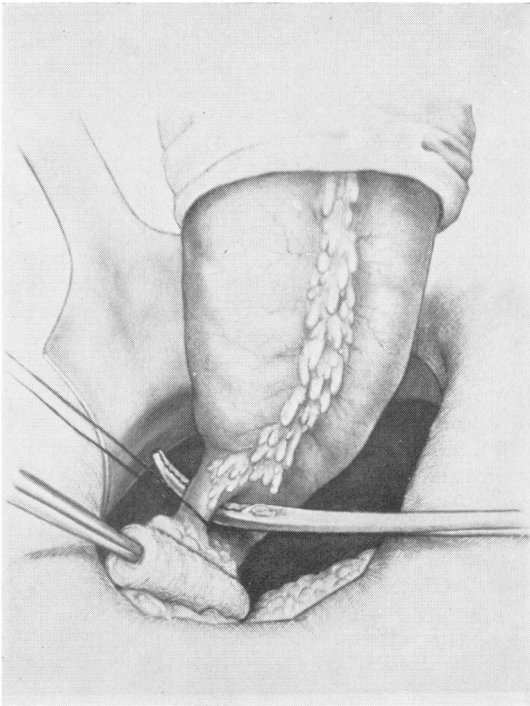


FIG. 2. High ligation of the left gastric pedicle facilitated by elevation of the stomach and depression of the pancreas, thereby 'bowstringing' the pedicle.

stomach, the assistant 'bowstrings' the left gastric pedicle which was then doubly ligated. A third ligature was placed directly around the artery after division of the pedicle. (Fig. 2).

PROXIMAL TRANSECTION Lesser curve section was consistently high varying from 1 to 4 cm. below the gastro-oesophageal junction, the more conservative sections tending to be for gastric ulcers. Greater curve section was below the lowest short gastric vessels, approximately two-thirds of the way up the greater curve. An estimated 70%-75% gastrectomy was therefore performed, including nearly all of the lesser curve. The procedure was facilitated in all cases by the use of a stapling clamp of the von Petz type.

THE DUODENO-JEJUNAL FLEXURE A point was made of seeking and dividing adhesions on the medial aspect of the flexure. This mobilizes the afferent loop and allows it to travel to the left with the stomach without kinking. The afferent loop varies from 4 to 7 cm. in length in the resting state.

THE STOMA Lane's twin clamps were used to perform a two-layered anastomosis in front of the colon with an afferent loop to the lesser curve. The stoma was small but big enough just to allow apposition of the tips of the thumb and index finger.

VALVE A small valve was constructed at the end of the procedure.

SUTURE MATERIAL All intra-abdominal work was performed with chromic catgut.

Operating time was usually under 60 minutes and intravenous infusion of any kind was rarely necessary.

The surgeon made a point of speaking to the patient before leaving the theatre, re-assuring him that the ulcer was now cured and a new life awaited him.

The post-operative régime is standardized as far as possible. Immediate post-operative hydration is maintained with a rectal drip with gradually increasing oral intake of water over the first three days. Free fluids are allowed on the fourth day and at this stage a little food is permitted. By the sixth post-operative day the patients are usually on three standard ward meals per day with routine supplements. While in hospital patients are encouraged to eat so much that they feel uncomfortable. Second portions, particularly of breakfast, are offered after the first post-operative week. Eighteen days in hospital after operation are compulsory and during this time the aim is to establish a new pattern of life for the patient so that his confidence is restored in his ability to eat three normal-sized meals a day without dietary control and without medicines. Occasionally hiccoughs or vomiting are a worry in the immediate post-operative stages; the passage of a gastric tube usually shows this to be due to gastric stasis and one or two aspirations with removal of the tube are usually sufficient to rectify the condition.

Patients return to their former occupation five weeks after surgery and no follow-up appointment is made. All patients are asked to return to the hospital if they are at all worried about their operation, the idea being that routine follow-up every year, or more frequently, saps the patient's confidence in the operation as well as suggesting side effects which may not exist. The majority of patients, therefore, have not been interviewed or treated since they left the hospital after gastrectomy. This adds interest and significance to the series as one is dealing with a group of patients who have been trained in hospital to eat three adequate meals a day and have, generally speaking, not had any supplemental iron, vitamins, or other forms of medication.

RESULTS

DEATHS The one death occurring as a direct result of surgery was that of a 48-year-old man who died on the seventh post-operative day. Post-mortem examination revealed a severe bronchopneumonia and a 'large amount of blood' in the peritoneal cavity. All the main ligatures were intact.

The operative mortality for the 1950-51 cases was nil and for the 1959-63 group 0.4%. The overall mortality is therefore less than 0.3%.

Of the 18 patients known to have died inter-current deaths, none can be justifiably attributed to the effects of gastrectomy. Tables I and II set out the frequency and causes of death in all cases.

The isolated example of the Zollinger-Ellison syndrome is worth recording in greater detail.

This man first presented for gastrectomy in 1962 at the age of 53. He had anterior and posterior duodenal ulcers with stenosis. A Polya gastrectomy was performed with good recovery. Seven months later a further resection was performed, this time for anterior and posterior penetrating stomal ulcers, the former into the left costal margin and the latter into the omentum. Nine months passed before he returned with an efferent loop ulcer 1 in. from the stoma. On this occasion a total gastrectomy was performed with a Roux-en-Y reconstruction. No pancreatic abnormality was apparent although a careful

search was made. The patient returned a fourth time in a cachectic state and very lethargic. Examination revealed bilateral leg oedema, ascites, and a hard, irregularly enlarged liver. He had also developed a mild diabetic state. Laparotomy was performed and the presence of a pancreatic tumour with secondary deposits in the liver confirmed. A biopsy showed islet cell tumour of α type. The patient died two months after discharge from hospital, 29 months after his first operation.

AGE, SEX, AND DURATION OF SYMPTOMS The overall ratio of males to females is 3.9:1. After the age of 40 the ratio falls to 3.6:1 to reach 3.2:1 in the 50 and over age groups. Both the 1950-51 and 1959-63 groups are considered together in this estimate as distribution is similar and more significance can be attached to the greater number when combined.

The majority of operations were carried out on patients in their fifth and sixth decades (Table III), this pattern being maintained within the sexes.

The symptoms of gastro-duodenal ulceration are phasic, remissions occurring as part of the natural history of the disease or with the help of medication and dietary precautions. The length of history has been assessed from the time of the first symptom. The distribution of cases with reference to the duration of symptoms is shown in Table IV. In both groups the highest incidence is found in those cases with a history of five to 10 years. An apparent difference between the groups is the much higher

TABLE I

DEATHS AND RATE OF FOLLOW-UP

Year	No. of Cases	Operative Mortality	Mortality since Discharge	Cases Traced		Untraced	Rate of Follow-up, (%)
				Interview	Questionnaire		
1950-51	120	0	12	80	6	22	82
1959-63	250	1	6	219	12	12	95

TABLE II

CAUSES OF OPERATIVE AND LATER DEATHS

Year	Operative Mortality	Cause of Death	Other Deaths	Cause of Death	Time after Operation
1950-51	0	—	12	Coronary (3)	13, 14, 7 yr.
				Carcinoma of lung (3)	13, 5, 5 yr.
				C.V.A. (2)	7, 10 yr.
				Carcinoma in gastric remnant (1)	9 yr.
				Massive gut haemorrhage, site not found at necropsy (1)	2 yr.
1959-63	1	Haemorrhage into peritoneal cavity 7th day, all ties intact at necropsy	6	'Heart failure' (1)	8 yr.
				Unknown, had tabes dorsalis (1)	2 yr.
				α -Cell carcinoma of pancreas (1)	2 yr.
				Coronary (1)	7 mth.
				Lymphosarcoma (1)	18 mth.
Carcinomatosis (1)	2 yr.				
Carcinoma pancreas (1)	3 yr.				
Carcinoma lung (1)	4 yr.				

TABLE III

AGE AT THE TIME OF POLYA GASTRECTOMY

Group	Sex	Age in Years						Total	
		10-19	20-29	30-39	40-49	50-59	60-69		70-79
1950-51	Male	0	9	22	38	21	8	0	98
	Female	0	0	5	5	10	2	0	22
1959-63	Male	1	13	30	55	59	31	7	196
	Female	0	2	8	19	15	10	0	54

TABLE IV

DURATION OF SYMPTOMS BEFORE GASTRECTOMY

Group		Duration of Symptoms (yr.)					Total
		Less than One	1-5	5-10	10-20	Over 20	
1950-51	No. of cases	2	34	50	32	2	120
1959-63	No. of cases	26	68	74	58	23	249 ¹

¹One case also presented suffering from painless chronic blood loss.

TABLE V

TYPE OF ULCER FOUND AT OPERATION

	Sex	TYPE OF ULCER FOUND AT OPERATION				Total Gastric Ulcer	Total
		Duodenal Ulcer	Pyloric Channel Ulcer	Gastric Ulcer	Gastric + Duodenal Ulcer or Pyloric Scar		
1950-51	Male	72 (73%)	—	19 (19%)	7 (7%)	26 (26%)	98
	Female	14 (64%)	—	6 (27%)	2 (9%)	8 (36%)	22
1959-63	Male	135 (69%)	7 (4%)	19 (10%)	35 (18%)	54 (27%)	196
	Female	30 (56%)	2 (4%)	14 (26%)	8 (15%)	22 (41%)	54

incidence of cases with very short histories being accepted for gastrectomy in the more recent series.

PATHOLOGY AT OPERATION All operative specimens were opened personally by the surgeon and his findings recorded both in the case notes and on the pathology form. Internal and external scarring in the pyloro-duodenal region and pyloric thickening and nodularity were all more carefully sought in the more recent series, especially in the presence of gastric ulcer. The intact pyloric channel was not examined digitally to assess its size. The results are shown in Table V. The incidence of the outstanding pathology has remained constant, namely, in the 1950-51 group duodenal ulcer has accounted for 71.6% and gastric ulcer 28.4% of cases, and in the 1959-63 group the corresponding figures are 69.6% and 30.4%. The higher incidence of gastric ulcer in females is also apparent and proportionately the same in both groups. The significant difference lies in the proportion of gastric ulcers which have associated pyloro-duodenal scarring. Thus, in the 1959-63 group both sexes show an increased incidence of disease in this region; in males, combined

ulcer is nearly twice as common as gastric ulcer as a single entity. As stated above this apparent discrepancy may be due to an increased awareness of this possibility on the part of the surgeon. By the same token any channel ulcers seen in the 1950-51 group would have been labelled duodenal ulcers.

GASTRIC ULCER IN RELATION TO AGE AND SEX The incidence of gastric ulcer in this series (including those patients with pyloro-duodenal pathology) in relation to age and sex is shown in Figure 3. It can be seen how the incidence undergoes a stepwise increase with age common to both sexes.

SYMPTOMS AFTER GASTRECTOMY The incidence of the post-gastrectomy symptoms is set out in Tables VI and VII. Capper and Welbourn (1955) defined the 'dumping syndrome' as 'a feeling of epigastric fullness, distension, or pressure accompanied by one or more of the following symptoms: drowsiness, fatigue and muscular weakness, palpitations, sweating, and a sense of warmth. Nausea and colic, borborygmi and diarrhoea may also be present, but are not regarded as pathognomonic. Nor does

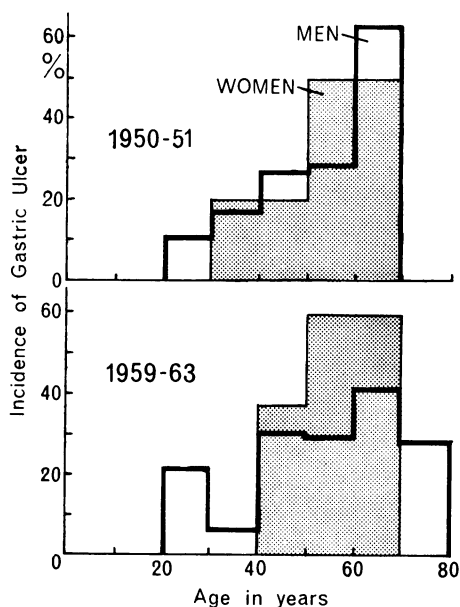


FIG. 3. Incidence of gastric ulcer according to age and sex.

fullness alone constitute the syndrome'. This definition is accepted as a basis in the present study as it fits in well with the symptom groups. Thus, the largest group of patients complained of nausea and/or fullness as isolated symptoms, never at any time having experienced dumping as defined above.

It should be made clear that the 'fullness' referred to is not that which follows overeating but a sensation of bloatedness which is determined more by the quality than quantity of food; in general the same types of food caused both nausea and fullness and were named by the patients with regularity as milk, tea, or coffee (particularly sugared), pastries, heavy puddings, and chocolates. It has been a simple matter for them to omit the offending food from their diet and rid themselves of the symptom. Many of these patients declared themselves symptom free until asked specifically about foods which made them feel sick or distended. By the same token, some cases have been omitted from the results because of trifling and varied symptoms, for example, excessive flatus or mild indigestion after eating cucumber.

The patients who have been accepted as true dumpers were all of the 'early' type, there being no apparent example of the 'late' or hypoglycaemic dumper. The symptoms included all those listed above as well as dizziness, lightheadedness, headache, and one case of syncope. Vomiting or diarrhoea was uncommon in this category but when it occurred the case has been included as a dumper rather than in the vomiting or diarrhoea group.

No case of 'bilious vomiting' was seen. All of those who vomit do so after some dietary indiscretion, presumably due to reduced gastric capacity. There were two patients who made themselves vomit first thing in the morning by drinking a glass of warm water, and a further patient whose vomiting responded to cholecystectomy for gall-

TABLE VI

Group	Sex	RESULTS OF OPERATION ACCORDING TO SYMPTOMS					Total
		Nausea and/or Fullness	Dumping	Vomiting	Diarrhoea		
1950-51	Male	14 (20%)	3 (4%)	1 (1.4%)	1 (1.4%)	19 (27%)	} 28 (32.3%)
	Female	7 (44%)	2 (12%)	0	0	9 (56%)	
1959-63	Male	18 (10%)	11 (6%)	2 (1.1%)	2 (1.1%)	33 (18%)	} 48 (20.8%)
	Female	10 (20%)	2 (4%)	0	3 (6%)	15 (31%)	

TABLE VII

Group	INCIDENCE OF PROVEN AND SUSPECTED RECURRENT ULCERATION			Total
	Proven Anastomotic Ulcer	Painless Haematemesis and/or Melaena with Negative Barium Study	Prandial Pain with Negative Barium Study	
1950-51	0	3 (3.4%) ¹	1 (1.2%)	86
1959-63	3 (1.3%) ²	2 (0.9%) ¹	4 (1.7%)	231

¹Of these five patients, three had a history of recent aspirin intake.

²Includes one case of Zollinger-Ellison syndrome.

All cases were originally duodenal ulcer patients and all were males with the exception of two females in the 1959-63 prandial pain group. None of the 17 deaths had evidence of recurrent ulcer, the remaining case being the Zollinger-Ellison syndrome.

stones. All three have been excluded from the results.

Diarrhoea was defined to the patient as an increase in the frequency or looseness of bowel habit since the time of the operation. The severity of the diarrhoea has been mild in all cases, the worst case suffering four to five bowel actions a day for two or three days at approximately four-monthly intervals.

The results show a higher overall incidence of symptoms in women and, on analysis, it is apparent that the higher incidence of nausea and fullness in women is the factor largely responsible for the difference. The incidence of dumping is fairly constant throughout with the exception of the women in the 1950-51 group. The numbers available for study in this group are small and the figure is probably artificially high. At interview it was apparent that many patients had lost their symptoms with the passage of time and that some had acquired symptoms even after many years of post-operative comfort. Most of the latter suffered transient attacks of nausea or mild dumping often precipitated by emotional or domestic upsets.

Secondary surgical intervention has been undertaken in none of these patients.

Table VII shows the cases which at some stage have been suspected of having an anastomotic ulcer. Of the three patients with recurrent ulcers, one presented as a perforation and was oversewn, one was diagnosed on barium meal and had a further gastric resection, and the third had a pancreatic α -cell carcinoma. The figures quoted in the table are biased slightly in favour of the operator as gastric ulcer patients are also included, these having an almost negligible recurrent ulcer rate. If the patient with the Zollinger-Ellison syndrome is excluded and the results for duodenal ulcer only are considered, the recurrent ulcer rate for the 1959-63 group is approximately 1.2%. In addition to the definite recurrences, two patients required hospital admission and transfusion for painless gastro-intestinal tract bleeding, a further three being managed at home for similar disturbances. In all cases barium studies and, in some cases, gastroscopy proved negative for ulcer. Aspirin intake was associated with the haemorrhage in three of the five cases. The remaining group of patients suffered pain with or after meals as an isolated symptom. In only one case was it of a persistent and troublesome nature and in spite of a negative barium meal a further laparotomy was performed and this proved negative.

GRADING Visick (1948) described five grades into which results may be conveniently grouped.

Grade I No gastric symptoms (fullness after extra large meal allowed).

Grade II No pain; mild occasional symptoms only, easily controlled by care, including rest, limitation of meal size (but not to the point of hunger), and rejection of certain articles of diet.

Grade IIIs Mild symptoms not controlled by care but satisfactory, that is, no interference with the patient's enjoyment of life or his efficiency at work.

Grade IIIu The same as IIIs but patient not happy with the result. Symptoms may be more incapacitating than in IIIs or patient's reaction to his symptoms may be more marked. Overall improvement.

Grade IV Not improved; recurrent ulcer or symptoms as bad as or worse than the original ulcer.

In general there has been little difficulty in grading the results. The main problem of grading is in comparing severe post-cibal symptoms with pre-operative ulcer pain. In these cases the patient has decided into which grade he should be placed. The painless haematemesis and/or melaena poses a different problem, as in all five cases there were no associated symptoms, and no evidence of recurrent ulceration. Only one of the five had suffered more than one episode of bleeding. All have been included in grade I, for their incapacity can only be assessed in terms of time lost from work, and, as Visick pointed out, this should be a separate consideration.

Table VIII shows that, using this method of grading, 93% of both the 1950-51 and 1959-63 groups had excellent results, there being no sex difference. A further 3-4% are regarded as satisfactory. Grades IIIu and IV are failures, and there are two and eight of these in the 1950-51 and 1959-63 groups respectively. There appears to be no overall difference between the groups or the sexes, although, as has already been shown, there are differences between the sexes within grades.

The low recurrent ulcer rate, the absence of bilious vomiting and troublesome diarrhoea have all materially contributed to these figures.

TIME LOST FROM WORK DUE TO GASTRECTOMY Table IX shows the amount of time lost from work and the reason for this loss in each of the 11 cases concerned. In no instance has the gastrectomy been responsible for a change in job although in one case severe dumping symptoms brought about premature retirement. There were three cases of pulmonary tuberculosis in the 1950-51 group and one case in the 1959-63 group. It is likely that the gastrectomy contributed to the establishment of this disease in each case but as this is only presumed the cases are not included in the table; each of these suffered many months' loss of work. There were only two causes responsible for time off work, namely, dumping

TABLE VIII

Group	Sex	VISICK GRADING OF GASTRECTOMY RESULTS					Grand Total	
		Grade		Total	IIIs	IIIfu		IV
		I	II					
1950-51	Male	44 (62.9%)	22 (31.4%)	66 (94.3%)	3 (4.3%)	1 (1.4%)	0	70
	Female	6 (37.5%)	9 (56.3%)	15 (93.7%)	0	0	1 (6.3%)	16
1959-63	Male	142 (78.0%)	29 (15.9%)	171 (93.9%)	4 (2.2%)	1 (0.5%)	6 (3.3%)	182
	Female	28 (57.1%)	18 (36.7%)	46 (93.9%)	2 (4.0%)	1 (2.0%)	0	49

TABLE IX

Group	Sex	ANALYSIS OF TIME LOST FROM WORK DUE TO GASTRECTOMY			
		No. of Cases	Cause	Total Time off Work	Changed Job
1950-51	Male	2	Recurrent melaena Dumping	Five weeks A few days	0
	Female	0			
1959-63	Male	9	Dumping Dumping Dumping Dumping Melaena Haematemesis Stomal ulcer Zollinger-Ellison syndrome	Has stopped work with severe symptoms aged 64 Three or four days Less than one week Two days Two weeks Two weeks Five weeks Months (eventual death)	0
	Female	0			

symptoms and recurrent ulceration (be this due to erosions or stomal ulcer).

ALTERATION IN WEIGHT AFTER GASTRECTOMY Pre-operative weights were recorded as a routine in the 1950-51 series but only spasmodically for the later group. It was therefore impossible accurately to compare pre- and post-operative weight gains or losses. When present, however, the pre-operative weight has been used in assessment of weight change. In the majority of cases patients were asked simply what change, if any, had occurred in their weight since the time of operation. If patients were ignorant of their weight at interview, they were weighed and asked to compare that weight with their pre-operative weight. The results are shown in Table X. In each group approximately 10% lost weight.

In Table XI the patients who lost weight are recorded according to any associated symptoms or disease known to be present. No cause and effect is assumed by doing this, in particular, in those with nausea and fullness, who, for all practical purposes, should be placed in the 'no apparent reason' category.

ANAEMIA AFTER GASTRECTOMY The most satis-

factory screening test for anaemia is the haemoglobin estimation. The arbitrary values of 12.6 g./100 ml. for males and 12.1 g./100 ml. for females have been chosen as the limits below which the patients are designated 'anaemic'. These figures are chosen for purposes of comparison with the prevalence of anaemia in the community, an aspect of post-gastrectomy anaemia which has commanded little, if any, attention.

The results are tabulated into groups according to age and sex (Table XIIa and XIIb). The ages given are those at the time of interview and not at the time of operation so that all females in the 'under 45' category were still menstruating or had only recently stopped when haemoglobin was estimated. There were no pre-menopausal patients available for study in the 1950-51 group, and the number of male patients available for comparison is in any case too small to be significant. The results show a high incidence of anaemia in all categories except the males in the 1959-63 group. Of particular interest and severity is the anaemia in the post-menopausal 1950-51 group and the pre-menopausal 1959-63 group; in both the incidence of anaemia is 50% or more and in only one case out of 30 did the haemoglobin exceed 13.5 g./100 ml. (92%). In males,

TABLE X

Group	Sex	WEIGHT CHANGES AFTER OPERATION			Total
		Weight Change			
		Gained	No Change	Lost	
1950-51	Male	31 (44%)	34 (49%)	5 (7%)	70
	Female	6 (38%)	7 (44%)	3 (18%)	16
1959-63	Male	88 (48%)	77 (43%)	17 (9%)	182
	Female	31 (63%)	12 (25%)	6 (12%)	49

TABLE XI

ASSOCIATED FACTORS IN CASES LOSING WEIGHT

Group	Sex	Factor in Weight Loss					No Apparent Reason	Total
		Nausea or Fullness	Dumping	Small Meals	Initially Overweight	Associated Disease		
1950-51	Male	1	—	—	—	One tuberculosis chest + carcinoma of oesophagus One tuberculosis chest One carcinoma lung	1	5
	Female	2	—	—	—	—	1	3
1959-63	Male	4	1 ⁵	—	2	One thyrotoxic and diabetic	5	17
	Female	1	—	1	—	—	4	6

¹One case also had anastomotic ulcer for which further gastric resection was undertaken.

TABLE XIIa

POST-OPERATIVE HAEMOGLOBIN LEVELS IN MALES

Group	Age	Haemoglobin (g./100 ml.)				Over 14.0	Percentage Anaemic
		6.5-8.5	8.6-10.5	10.6-12.5	12.6-14.0		
1950-51	No. cases under 45	—	—	1	1	3	1/5 (20%)
	No. of cases over 45	2	4	15	30	8	21/59 (36%)
1959-63	No. cases under 45	—	—	2	23	24	2/49 (4%)
	No. cases over 45	—	3	13	45	66	16/127 (13%)

TABLE XIIb

POST-OPERATIVE HAEMOGLOBIN LEVELS IN FEMALES

Group	Age	Haemoglobin (g. /100 ml.)				Over 13.5	Percentage Anaemic
		6-8	8.1-10	10.1-12	12.1-13.5		
1950-51	No. cases under 45	—	—	—	—	—	—
	No. cases over 45	2	3	6	5	—	11/16 (69%)
1959-63	No. cases under 45	—	2	5	6	1	7/14 (50%)
	No. cases over 45	—	2	5	15	7	7/29 (25%)

anaemia appears to be more common when the gastrectomy is performed after the age of 45, but in all age groups some deterioration in haemoglobin level occurs with the passage of time. The reverse appears to be true in women; the pre-menopausal patient is more commonly anaemic than the post-menopausal. Once again, however, the highest incidence of anaemia is found in the 1950-51 group (this group contains 11 anaemic cases, four of which were pre-menopausal at the time of the gastrectomy).

In a few cases, all in the 1950-51 group, associated disease or therapy may have influenced the results to a minor degree. Thus, two patients who had normal haemoglobin values were taking iron tablets, and three of the anaemic cases suffered from carcinoma of the lung, oesophagus, and rectum respectively. Some of the anaemic had taken iron tablets in the past.

SERUM B₁₂ LEVELS AFTER PARTIAL GASTRECTOMY The frequency and pattern of the early serum vitamin B₁₂ levels after partial gastrectomy have received attention from a number of workers, and although varying incidences of deficiency have been reported, the studies made by Deller and Witts (1962) suggest an initial steep regression of serum B₁₂ levels on time, which after the sixth post-operative year appears to level off to an almost horizontal regression line. These authors suggested the possibility of a new steady state being established in the metabolism of vitamin B₁₂. Because of the necessarily high cost of the B₁₂ assay it was decided that the large 1959-63 group should be excluded from this particular investigation and that the 1950-51 group (mainly of 1950) used to test the probability of a new steady state persisting at 16 years after gastrectomy. The results are shown in Figure 4. Eleven patients (14%) had subnormal serum vitamin B₁₂ levels (less than 160 $\mu\mu\text{g./ml.}$); 21 patients (26%) were less than 200 $\mu\mu\text{g./ml.}$ The lowest values were found in gastric ulcer patients (75, 90, and 125 $\mu\mu\text{g./ml.}$ respectively), and the highest in duodenal ulcer patients. The mean value for all cases was 322 $\mu\mu\text{g./ml.}$ and that for duodenal and gastric ulcer cases, 349 and 255 $\mu\mu\text{g./ml.}$ respectively. Anderson (1964), using the same assay method, found the mean value for normal subjects to be 472 $\mu\mu\text{g./ml.}$

Patients with serum B₁₂ levels below 140 $\mu\mu\text{g./ml.}$ were further investigated. Three such cases existed, two males and one female, all having had a gastrectomy for gastric ulceration. The serum levels were as above and all three were anaemic with haemoglobin values of 6.5, 10.5, and 8.7 g./100 ml. respectively. Sternal marrow histology demonstrated minor megaloblastic changes and neutrophil polylobu-

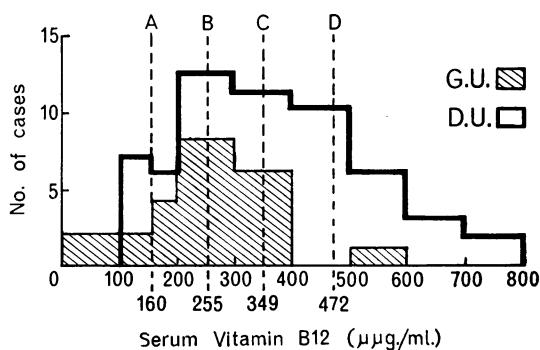


FIG. 4. Serum vitamin B₁₂ levels 16 years after gastrectomy: (a) lower limit of normal range (160 $\mu\mu\text{g./ml.}$); (b) mean value for gastric ulcer cases (255 $\mu\mu\text{g./ml.}$); (c) mean value for duodenal ulcer cases (349 $\mu\mu\text{g./ml.}$); (d) mean value for normal subjects (472 $\mu\mu\text{g./ml.}$) (Anderson, 1964).

lation in the first two cases only. All three showed absence of haemosiderin.

DISCUSSION

In any elective procedure for a benign condition the operative mortality must be a first consideration in deciding the suitability of that procedure. National figures from Britain (Johnson, 1962) and the U.S.A. (Paine, 1962) place the operative mortality for partial gastrectomy at 4.5% and 5.7% respectively. In common with reports from other more specialized centres the mortality rate in the present series is well below the national figure. Because there has been no patient selection and the cases are consecutive, the mortality rate of 0.27% is worthy of more detailed analysis. Brookes, Waterhouse, and Thorn (1960) found that the majority of post-operative deaths were due to leaking suture lines, respiratory and cardiovascular causes, and that, with the exception of the former, the mortality increased with age. Their findings are in accordance with the experience of others (Armstrong and Penick, 1960; Everson, Hutchings, Eisen, and Witanowski, 1957). A leaking duodenal stump is probably the commonest intra-abdominal cause of post-operative death. In over 2,000 consecutive gastrectomies done in the manner described earlier there has been no instance of a leaking duodenal stump for operations on elective benign ulcers (Ferguson, personal communication). The writer believes that the technique of closure is important but equally significant is the correct timing of surgery and the care taken to ensure the absence of increased intraduodenal pressure. Surgery is best undertaken when the ulcer is 'quiet' as evidenced by symptoms and abdominal signs, and

distension of the duodenum is avoided by minimizing the incidence of paralytic ileus and afferent loop obstruction due to mechanical causes. In all but about 2% of the cases regional or epidural anaesthesia was used. Apart from the excellent relaxation this affords, it materially assists the patient in the immediate post-operative period, for physiotherapy to the chest can be commenced on his return to the ward. The absence of an intragastric tube and the early commencement of an adequate caloric intake are believed to be additional factors important in the reduction and control of chest complications.

The incidence of post-gastrectomy symptoms for any given series will depend on the thoroughness of follow-up, whether a questionnaire or interview method has been used and on the definitions accepted for the various symptom groups. To be of any practical value symptoms must then be graded according to severity and patient suffering. When this is done minor variations in definitions are of no account in the final assessment of results. Thus in the present series although there is a 32.3% and 20.8% incidence of non-ulcer type symptoms in the 1950-51 and 1959-63 groups respectively (Table VI), and a high incidence of nausea and dumping in the 1950-51 female group, the inconvenience to the patient is reflected in the 94% incidence of excellent results in all categories (Table VIII). The reason for the higher incidence of symptoms in the 1951-51 group was not apparent during interview. The statement is generally made that symptoms begin two or three weeks after discharge from hospital and tend to improve with time. The greater age of the earlier group may be considered a factor but Visick (1948) found the highest incidence of symptoms in the under-50 age groups. That symptoms are often phasic or commence some years after gastrectomy has been observed both in this and other series (Brookes *et al.*, 1960; Capper and Welbourn, 1955; Visick, 1948). The possibility of the stoma widening with time is not discounted; no case of stomal narrowing has ever been observed as sometimes occurs after pyloroplasty. During reconstructive procedures Woodward and Hastings (1960) fashioned stomas estimated at less than 1.5 cm. in diameter with improved results. In view of other reports, however, it is assumed that the relatively small numbers studied account for much of the discrepancy.

The proximal ligation of the left gastric pedicle enables (a) a high gastric resection, including nearly all of the lesser curve; (b) complete removal of the gastrin-secreting mucosa; and (c) increased mobilization of the stomach remnant. The latter is regarded as an important concomitant to the short afferent

loop so that kinking is avoided. As well as the possibility of obstruction, the long afferent loop acts as a reservoir for duodenal, pancreatic, and biliary secretions, the secondary effect of this being a predisposition to bilious vomiting and poor mixing of gastric efflux with the secretions. Although these arguments are still the subject of debate the absence of bilious vomiting and the low incidence of diarrhoea and recurrent ulceration lend support to the thesis.

As has already been noted, there is frequently an emotional element in the production of the post-gastrectomy symptoms. Alvarez (1949) was aware of this when he described a number of classical 'dumpers' who had had no gastric surgery whatsoever. Confidence to eat a normal diet and enjoy it for the first time in many years does not come easily after gastrectomy. For this reason the patient is encouraged to eat early and normally in the post-operative period. The idea of tubeless gastrectomy is not a new development. Priestley (1954) described an almost identical post-operative routine and stressed the importance of not allowing the patient to 'give in' to the early sense of fullness which many experience due to their suddenly reduced capacity. In more recent years Hendry (1962) has championed the concept. Delayed gastric emptying has occasionally necessitated the passage of a stomach tube but no other difficulties have been encountered.

Much has been written on the problem of weight control following Polya gastrectomy, and most surgeons would now hesitate before recommending gastrectomy in the grossly underweight individual or in those who have suffered from tuberculosis. On the other hand, loss of weight is not synonymous with malnutrition, in some cases being beneficial and only rarely causing concern. In the present series weight loss has not been a matter of concern (Tables X and XI). Maintenance of weight has persisted so that after 15 years of gastrectomy life the 1950-51 group still shows only a small incidence of weight loss, many of these having associated debilitating disease.

The changes which are known to occur in the physiology of the post-gastrectomy state involve the metabolism of minerals, vitamins, and organic foodstuff. It is possible therefore that the reasons for malnutrition and weight loss are complex. After a series of investigations and tests at the Massachusetts General Hospital, Culver (1962) concluded that in the post-gastrectomy patient inadequate caloric intake seems to be the chief cause of malnutrition. Weight gain was promoted in almost all subjects who underwent a supervised caloric intake of 2,200 to 3,000 calories per day. The added weight was lost after patients had left the metabolic unit and this

suggested that their normal intake was inadequate. A further interesting correlation between anaemia and caloric intake has been suggested by the findings of Baird, Blackburn, and Wilson (1959). The post-operative feeding programme is therefore of great importance and the sooner the patient is indoctrinated into normal eating habits the better his nutritional status will be. This can only be satisfactorily carried out under supervision while the patient is still in hospital. There seems little to recommend a prolonged medical programme over a period of several months as suggested by Heffernon (1964).

POST-GASTRECTOMY ANAEMIA Perhaps the most pleasing aspect of this investigation is the small proportion of patients who found themselves limited to small meals and 'picky' eating. The quality and amount of food eaten by most patients is maintained at or better than the standards set for them while in hospital. It is therefore distressing to find the incidence of anaemia at such high levels especially in the female groups. The question of the incidence of anaemia in the community naturally arises. This is such an important consideration that the little attention it has received is surprising. That anaemia does occur, however, and often in a high percentage of the population, has been known for many years. Age and sex patterns were defined as long ago as 1935 (Davidson, Fullerton, and Campbell, 1935) and have since received confirmation by others. Because of changes in living standards and the effects of war, one cannot accept these earlier figures as being applicable to the present day. More recent surveys show the age and sex patterns to persist (Kilpatrick, 1961; Kilpatrick and Hardisty, 1961; Jacobs, Kilpatrick, and Withey, 1965; Parsons, Withey, and Kilpatrick, 1965). These writers, designating 'anaemia' to any male with haemoglobin below 12.6 g./100 ml. and to any female with the level below 12.1 g./100 ml., found a maximum incidence of anaemia (24.0% to 28.0%) in females during their reproductive life. Anaemia in males was rare (less than 5% before the age of 45) but there was an increase in incidence in both sexes after the age of 65, this latter change, they note, occurring more commonly in males. Most of the cases were hypochromic in type.

No dogmatic statement concerning the true effect of gastrectomy on haemoglobin levels can be made by comparing the results of the present series with those above. Although the criterion for anaemia has been the same there are many other factors, such as laboratory techniques, living standards, and geographical variations, which must be constant before such a comparison could be attempted. Using the

figures as a guide, however, the incidence of anaemia in the pre-menopausal woman and generally in the 1950-51 group leaves much to be desired. Gastrectomy appears to accentuate the already present differences in the incidence of anaemia which exist in the community and the effect increases with the passage of time.

The rapid onset of anaemia in the pre-menopausal (1959-63) group is consistent with the findings of Baird and others (1959) and emphasizes the need for careful follow-up in this age group. In further agreement with the results in the 1959-63 group, these workers found the post-menopausal group to be the next most severely affected. Baird and his co-workers concluded that the factors of fundamental importance in causing post-gastrectomy anaemia are (a) defective absorption of organic iron when taken with food and (b) inability to increase iron absorption in response to need. Added to these factors, haemorrhage and defective diet may be contributory factors. One is hereby offered an explanation of the high incidence of anaemia in patients apparently enjoying normal meals. The 69% incidence in the 1950-51 females is presumably due to the progressive nature of the anaemia plus the fact that four of the 11 anaemic cases were pre-menopausal at the time of gastrectomy.

As a corollary to these findings it is apparent that reference to anaemia after gastrectomy is meaningless if a time, age, and sex factor is unspecified. Equally important is the criterion chosen for the designation of anaemia; Baird and others (1959) chose haemoglobin 10.4 g./100 ml. as the lower limit of normal for their female patients, while Deller and Witts (1962) chose 11.6 g./100 ml. as their corresponding lower limit. On these criteria assessment of the present series would result in a lower incidence.

Apart from the obvious need for prolonged follow-up the significance of anaemia is minimized by the usually ready response to inorganic iron preparations. Some authorities, for example Tanner (1966), have suggested regular prophylactic iron supplements to be taken from the time of the operation. This may be one answer but not all cases respond to the same degree and regular follow-up cannot be dispensed with.

SERUM VITAMIN B₁₂ LEVELS; For screening purposes serum vitamin B₁₂ assay is the most accurate method of detecting deficiency in this vitamin. Due to the haematological effects of associated iron and folic acid deficiencies, diagnosis based on clinical and histological methods alone is unreliable. Mollin and Hines (1964), for example, found that 21% of 52 patients with megaloblastic anaemia following partial gastrectomy had serum vitamin B₁₂ levels

within the normal range; the presumption was that these patients were deficient in folic acid. The same authors also showed that by first treating a severe iron-deficiency anaemia, a previously masked megaloblastic change may become apparent for the first time.

Age and sex do not appear to affect the distribution of serum vitamin B₁₂ levels (Deller and Witts, 1962); for this reason, and to add significance to the results, further breakdown into these categories has not been attempted in the present report. On the other hand, these authors demonstrated a significant difference in the percentage incidence of gastric and duodenal ulcer patients having subnormal levels of serum vitamin B₁₂, the former group of patients having the higher incidence. The same pattern is seen in the present series, but, because of the small numbers involved in this category, a more significant difference is apparent when the means of the total values are considered. The overall incidence of deficiency (14%) compares favourably with the incidence reported by Deller and Witts (1962) and Mollin and Hines (1964). The former workers found an overall incidence of 14% investigated from one to 12 years after partial gastrectomy and a 22.6% incidence in those investigated 10 to 12 years after operation. The latter group found a 15% incidence of deficiency in patients investigated one to 20 years after operation. These results cast some doubt upon the acceptability of the seemingly high incidence of 51% reported by Jones, Williams, Cox, Meynell, Cooke, and Stammers (1962) in patients investigated five to six years after gastrectomy.

Not all patients with a serum vitamin B₁₂ deficiency develop a megaloblastic anaemia due to this deficiency. The determination of the true incidence of the latter is an intricate matter and not the purpose of the present study. Many of the so-called vitamin B₁₂ deficiency anaemias which have been reported are due to folic acid deficiency, either wholly or in part, a deficiency which exists, according to Mollin and Hines (1964), in 40% of patients investigated from one to eight years after partial gastrectomy. In spite of the doubt concerning the true incidence of this anaemia, two points seem clear, namely, the incidence is quite low (probably in the region of 1-4%), and the serum values necessary to produce the change are in general higher than those found in pernicious anaemia (Baird *et al.*, 1959; Deller and Witts, 1962; Mollin, 1962; Mollin and Hines, 1964).

The cause of vitamin B₁₂ deficiency in these patients remains uncertain. The amount of stomach resected would seem a basic consideration in this respect but Deller and Witts (1962) could find no significant correlation between the two, although

they admit the difficulty in accurate assessment of the amount of stomach resected. The lower values found in the gastric ulcer patients tend to support this thesis as, in general, more conservative gastrectomies are performed for gastric ulcers. Diffuse chronic gastritis appears to be the most important determinant in the development of low serum vitamin B₁₂ levels. This is more commonly found in association with gastric ulcer and persists after removal of the ulcer. The immediate cause of the poor absorption of vitamin B₁₂ in these cases appears to be lack of intrinsic factor (Magnus, 1952; Deller and Witts, 1962; Mollin and Hines, 1964; Ardeman and Chanarin, 1966). The relatively low incidence of vitamin B₁₂ deficiency in the present series is not readily explained. As mentioned previously, Deller and Witts (1962) found a 22.6% incidence of deficiency in patients investigated 10 to 12 years after gastrectomy. In the present series there was a 14% incidence after 16 years of gastrectomy life. The difference may be due to the higher percentage of gastric ulcer patients in the former series (42%) as compared with 29% in the present series.

SUMMARY

A follow-up study of 370 Polya type partial gastrectomies is reported. The cases are divided into two groups consisting of a 1950-51 group of 120 cases and a 1959-63 group of 250 cases. Operations were performed for consecutive elective benign gastro-duodenal ulcers, a standard technique of operation and post-operative management applying in each case. The latter have been described in some detail because of their suspected importance in the outcome of the operation. Certain features in technique have been stressed, in particular, the desirability of complete antral excision, a short unknicked afferent loop, and a small stoma. Post-operatively, gastric tubes are avoided and a ward diet commenced on the sixth day, the only complication experienced being occasional delay in gastric emptying.

Rate of follow-up in the 1950-51 and 1959-63 groups was 82% and 95% respectively. Nearly all cases followed-up were personally interviewed by the writer.

There was one death in the series giving an overall mortality rate of less than 0.3%.

Ulcer pathology was of similar incidence in both groups, duodenal ulcer accounting for 70% and gastric ulcer for 30%. There was an increased recognition of pyloro-duodenal pathology in association with gastric ulcer in the 1959-63 patients, amounting to an incidence of combined pathology in 64% of gastric ulcer cases. The percentage incidence of gastric ulcer increased with age in both groups.

Nausea and fullness were the commonest symptoms but were rarely troublesome unless associated with dumping symptoms. These symptoms were more common in females and unexpectedly more common in the 1950-51 group, although this may have been a reflection on the relatively small numbers involved. The incidence of dumping symptoms was similar in both the 1950-51 and 1959-63 group, namely, 5.8% and 5.5% respectively. Vomiting and diarrhoea, as separate entities, were rare, occurring in three and six instances respectively; there was no significant difference between the incidence in the two groups.

The proven recurrent ulcer rate was 1.3% including one case of the Zollinger-Ellison syndrome. There were five additional cases of painless haematemesis and/or melaena in which no ulcer could be demonstrated on barium study or gastroscopy. Three of these cases gave a recent history of aspirin ingestion.

Using the Visick method of grading symptoms, excellent results were obtained in 93 to 94% of cases with a further 2 to 4% classed as satisfactory. No difference was found between the two groups. Failures were due in all cases to severe dumping attacks or recurrent ulceration.

Loss of time from work due to the partial gastrectomy had occurred in two of the 1950-51 group and in nine of the 1959-63 group, incidences of 2.4% and 3.9% respectively. No patient had changed his work due to the operation although in one instance work had to be ceased altogether because of severe symptoms. The causes of loss of working time were severe dumping, recurrent ulceration, and bleeding. Four cases of tuberculosis are excluded from this assessment.

Both groups had an incidence of between 9 and 10% of patients who failed to maintain their pre-operative weight. This loss of weight was often beneficial in that it occurred in grossly overweight patients. No cases were seen who came into the category of 'gastrectomy wrecks'. Just under half of the patients in each group gained weight.

There was an obvious difference between the groups in the incidence of anaemia. The onset of anaemia was most rapid in the pre-menopausal female reaching an incidence of 50% in the 1959-63 group. Severity of anaemia increases with the time elapsed since operation, being most marked in the 1950-51 female group all of whom were post-menopausal. The incidence of anaemia in the community as a whole is high, particularly in the pre-menopausal female where the incidence has been placed at 24 to 28% by recent workers.

The mean serum vitamin B₁₂ level for the 1950-51 group was 322 μg./ml., considerably less than the

mean for normal subjects (472 μg./ml.). Duodenal ulcer patients had a mean value of 349 μg./ml., and gastric ulcer patients, 255 μg./ml. Fourteen per cent of cases had subnormal serum levels but only three cases had values below 140 μg./ml. These three cases were all originally gastric ulcer patients and the two cases with serum levels below 100 μg./ml. showed megaloblastic and iron-deficiency anaemia whereas the remaining case (serum level 125 μg./ml.) showed iron deficiency only.

My sincere thanks are due to Mr. W. J. Ferguson for permission to review his personal cases; to Miss S. Robinson for Figs. 1 and 2; to Mr. D. A. Vinten for the photographs; and to the staff of the Department of Pathology for their assistance in haemoglobin estimations and bone marrow examination. This investigation was assisted by a grant from the Medical Research Fund of the West Middlesex Hospital, and the writer has pleasure in thanking the Medical Committee of the hospital for their sponsorship.

REFERENCES

- Abbott, W. E., Krieger, H., and Levey, S. (1958). Technical surgical factors which enhance or minimize postgastrectomy abnormalities. *Ann. Surg.*, **148**, 567-593.
- Alvarez, W. C. (1949). The dumping syndrome: what makes it and how to avoid it. *Gastroenterology*, **13**, 212-214.
- Anderson, B. B. (1964). Investigations into the 'Euglena' method for the assay of the vitamin B₁₂ in serum. *J. clin. Path.*, **17**, 14-26.
- Ardeaman, S., and Chanarin, I. (1966). Gastric intrinsic factor secretion after partial gastrectomy. *Gut*, **7**, 217-219.
- Armstrong, R. A., and Penick, R. M. (1960). Surgical treatment of benign peptic ulcer. *Ann. Surg.*, **152**, 109-118.
- Baird, I. M., Blackburn, E. K., and Wilson, G. M. (1959). The pathogenesis of anaemia after partial gastrectomy. I. Development of anaemia in relation to time after operation, blood loss, and diet. *Quart. J. Med.*, **28**, 21-34.
- Brookes, V. S., Waterhouse, J. A. H., and Thorn, P. A. (1960). Partial gastrectomy for peptic ulcer. *Gut*, **1**, 149-162.
- Buck, M. (1963). Epidural anaesthesia for partial gastrectomy. *Brit. J. Anaesth.*, **35**, 645-648.
- Capper, W. M., and Welbourn, R. B. (1955). Early post-cibal symptoms following gastrectomy. *Brit. J. Surg.*, **43**, 24-35.
- Culver, P. J. (1962). Postvagotomy and gastrectomy—nutrition and steatorrhea. *Ann. N.Y. Acad. Sci.*, **99**, 213-221.
- Davidson, L. S. P., Fullerton, H. W., and Campbell, R. M. (1935). Nutritional iron-deficiency anaemia. *Brit. med. J.*, **2**, 195-198.
- Deller, D. J., and Witts, L. J. (1962). Changes in the blood after partial gastrectomy with special reference to vitamin B₁₂. I. Serum vitamin B₁₂, haemoglobin, serum iron, and bone marrow. *Quart. J. Med.*, **31**, 71-88.
- Everson, T. C., Hutchings, V. Z., Eisen, J., and Witanowski, M. F. (1957). Partial gastrectomy versus vagotomy with gastroenterostomy in treatment of duodenal ulcer. *Arch. Surg.*, **74**, 547-554.
- Heffernon, E. W. (1964). Dietary management after gastrointestinal surgery. *Surg. Clin. N. Amer.*, **44**, 659-663.
- Hendry, W. G. (1962). Tubeless gastric surgery. *Brit. med. J.*, **1**, 1736-1737.
- Illingworth, C. F. W. (1960). Post-gastrectomy syndromes: a review. *Gut*, **1**, 183-192.
- Jacobs, A., Kilpatrick, G. S., and Withey, J. L. (1965). Iron deficiency anaemia in adults: prevalence and prevention. *Postgrad. med. J.*, **41**, 418-424.
- Johnson, H. D. (1962). Peptic ulcer in hospital. *Gut*, **3**, 106-117.
- Jones, C. T., Williams, J. A., Cox, E. V., Meynell, M. J., Cooke, W. T., and Stammers, F. A. R. (1962). Peptic ulceration: some haematological and metabolic consequences of gastric surgery. *Lancet*, **2**, 425-428.

- Kilpatrick, G. S. (1961). Prevalence of anaemia in the general population. *Brit. med. J.*, 2, 1736-1738.
- , and Hardisty, R. M. (1961). The prevalence of anaemia in the community. *Ibid.*, 1, 778-782.
- Magnus, H. A. (1952). Gastritis. In *Modern Trends in Gastro-enterology*, edited by F. Avery Jones. pp. 323-351. Butterworth, London.
- Mollin, D. L. (1962). Vitamin B₁₂ metabolism in man using cobalt 58 (58 Co) as a tracer. *Proc. roy. Soc. Med.*, 55, 141-145.
- , and Hines, J. D. (1964). Observations on the nature and pathogenesis of anaemia following partial gastrectomy. *Ibid.*, 57, 575-580.
- Paine, J. R. (1962). Immediate results of subtotal gastric resection for benign peptic ulcer. *Surgery*, 51, 561-568.
- Parsons, P. L., Withey, J. L., and Kilpatrick, G. S. (1965). The prevalence of anaemia in the elderly. *Practitioner*, 195, 656-660.
- Priestley, J. T. (1954). Reflections on surgical treatment of duodenal ulcer. *Arch. Surg.*, 69, 455-463.
- Tanner, N. C. (1966). Disabilities which may follow the peptic ulcer operation *Proc. roy. Soc. Med.*, 59, 362-368.
- Visick, A. H. (1948). Measured radical gastrectomy. *Lancet*, 1, 505-510 and 551-555.
- Woodward, E. R., and Hastings, N. (1960). Surgical treatment of the post-gastrectomy dumping syndrome. *Surg. Gynec. Obstet.*, 111, 429-437.