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Postgastrectomy malnutrition

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Earlier more enthusiastic reviews of the results of partial gastrectomy for the treatment of peptic ulcer such as those of Lake (1948) and Ross and Walsh (1949) make an interesting contrast to the more recent reports detailing various complications following this operation such as anaemia (Pitney, 1955; MacIntyre and Stent, 1956; MacLean and Sundberg, 1956; Welbourn, Nelson, and Zacharias, 1956; Lous and Schwarz, 1959; Baird, Blackburn, and Wilson, 1959; Hobbs, 1961; Deller, 1962; Deller, Richards, and Witts, 1962) and bone disease (Deller and Begley, 1963).

Nutritional complications are amongst the most serious seen and a large number of papers have appeared in recent years on the incidence and causes of the excessive weight loss seen in a proportion of postgastrectomy patients. The reported incidence of weight loss varies but is in most cases substantial (Muir, 1949; Ivy, Grossman, and Bachrach, 1950; Rauch, 1952; Baron, 1954; Wallensten, 1954; Zollinger and Ellison, 1954; Ellison, 1955; Kiefer, 1959; Brookes, Waterhouse, and Thorn, 1960; Postlethwait, Shingleton, Dillon, and Willis, 1961; Culver, 1962). In a series of 100 postgastrectomy patients operated upon a year or more previously reviewed by the writer at the Repatriation General Hospital, Heidelberg, 25 were found to be 6 kg or more below their usual preoperative weight.

Most explanations as to the cause of the weight loss have included dietary deficiency (Johnston, Welbourn, and Acheson, 1958; Lawrence, Vanamee, Peterson, McNeer, Levin, and Randall, 1960; Culver, 1962) and defective absorption (Wollaeger, Comfort, Weir, and Osterberg, 1946; Muir, 1949; Baron, 1954; Ellison, 1955; Lawrence *et al*, 1960; Barker, Malm, and Reemtsma, 1960). The alleged causes of defective absorption included intestinal hurry (Glazebrook and Welbourn, 1952), the type of operation performed (Butler, Capper, and Naish, 1954; Stammers, 1955), loss of reservoir function of the stomach (Brain and Stammers, 1951; Hedenstedt, 1959; Annersten, 1959), intestinal stasis with bacterial proliferation (Duncan, Goudie, MacKie, and Howie, 1954; Kinsella, Hennessy, and George, 1961), jejunal atrophy (Paulley, Fairweather, and Leeming, 1957; Lees, and Grandjean, 1958; Joske and Blackwell, 1959; Rubin, Branborg, Phelps, and Taylor, 1960; Deller *et al*, 1962; Jones, Williams, Cox, Meynell, Cooke, and Stammers, 1962; Scott, Williams, and Clark, 1964), and inadequate mixing with or secretion of bile and pancreatic juice (Annis and Hallenbeck, 1952; Polak and Pontes, 1956; Shingleton, Isley, Floyd, Sanders, Baylin, Postlethwait, and Ruffin, 1957; Herner and Ysander, 1960; White, Lundh, and Magee, 1960; Butler, 1961; *Gastroenterology*, 1962).

MATERIALS AND METHODS

The present study was done on 30 patients selected according to two main criteria: (1) having had a partial gastrectomy for peptic ulceration a year or more previously; (2) being 6 kg or more below the usual preoperative weight.

The investigation was divided into the following features:—

1 CLINICAL ASPECTS
The type of operation and its indication
Interval between operation and onset of weight loss
The amount of weight lost
Other symptoms and signs
Diet (classified as adequate, poor, and very poor according to details of the main meals eaten as described by the patient)

2 RADIOLOGY
Plain *x*-ray examination of the abdomen (looking for pancreatic calcification)
Barium meal and follow through *x*-ray examination

3 BIOCHEMICAL FEATURES
Average 24-hour faecal fat excretion based on a three-day collection on a diet containing approximately 80 to 100 g fat a day
Serum albumin and globulin
Glucose tolerance test
Xylose absorption test (quantity of xylose excreted in the urine in five hours following an oral dose of 25 g)

Twenty-four hour urinary diastase excretion (in Wohlgemuth units)

4 HAEMATOLOGY
Haemoglobin
White cell and differential count
Blood film

Other investigations as required to elucidate the cause of any anaemia present

5 SMALL BOWEL BIOPSY (using the Baker-Hughes multiple biopsy tube)

The results of these investigations are summarized in Tables I-III respectively.

TABLE I

CLINICAL FEATURES

Case	*Age (years)*	*Sex*	*Type of Operation and Reason*	*Interval between Operation and Onset of Weight Loss*	*Amount of Weight Lost (kg)*	*Symptoms and Signs*	*Diet*	*Response of Body Weight to Replacement Therapy with Pancrex 5 Powder*			
								Weight (kg)		*Gain (kg)*	*Diet during Trial*
								Before Treatment	*After Treatment*		
1	63	M	Billroth I for gastric ulcer which had perforated and bled	9 years	12·7	Abdominal discomfort, regurgitation of bile, tiredness dependent oedema	Very poor	43·2	60·2	17·0	Adequate
2	49	M	Polya for bleeding duodenal ulcer followed by excision of anastomotic ulcer 4 years later	5 years	9·1	Slight dependent oedema, pallor, enlarged liver	Poor	49·4	55·9	6·5	Poor
3	40	M	Polya for bleeding duodenal ulcer	6 months	16·3	Diarrhoea with passage of 10 pale motions daily	Adequate	48·5	60·3	11·8	Adequate
4	46	M	Billroth I for chronic duodenal ulcer	Uncertain	6·4	Tiredness, exertional dyspnoea, apical pansystolic murmur	Poor	76·2	79·4	3·2	Poor
5	49	M	Polya for duodenal ulcer	Uncertain	26·4	Persistent epigastric pain and diarrhoea	Poor	65·3	71·6	6·3	Poor
6	62	M	Polya for bleeding duodenal ulcer	2 years	12·7	Recurrent diarrhoea	Adequate	55·8	61·2	5·4	Adequate
7	33	M	Polya for chronic duodenal ulcer	6 months	11·4	Malaise, mild fever	Adequate	55·3	58·5	3·2	Adequate
8	65	M	Polya for chronic duodenal ulcer	Uncertain	14·6	Recurrent epigastric pain	Poor	55·1	61·0	5·9	Adequate
9	43	M	Polya for previously perforated duodenal ulcer	6 months	8·2	Intermittent epigastric pain and diarrhoea	Adequate	55·1	61·4	6·3	Poor
10	55	M	Polya for chronic duodenal ulcer	Uncertain	14·1	'Dumping' symptoms and occasional loose bowel motions	Poor	63·9	70·3	6·4	Poor
11	45	M	Polya for duodenal ulcer with pyloric stenosis	3 years	6·4	Recurrent epigastric pain and diarrhoea with 3-4 watery motions daily	Adequate	60·2	65·2	5·0	Adequate
12	63	M	Polya for duodenal ulcer	Uncertain	19·2	Epigastric pain	Poor	57·1	63·9	6·8	Poor
13	37	M	Polya for duodenal ulcer with recurrent bleeding	Uncertain	31·8	Epigastric pain, melaena	Adequate	55·3	59·8	4·5	Adequate
14	55	M	Polya for duodenal ulcer with pyloric stenosis	5 years	9·6	Epigastric pain, anorexia	Poor	59·0	63·5	4·5	Very poor
15	58	F	Polya for bleeding gastric ulcer penetrating the pancreas	3 years	12·6	Weakness, oedema, 3-4 loose motions daily	Poor	34·0	37·2	3·2	Deceased
16	65	M	Polya for giant gastric ulcer	12 months	29·5	Angina pectoris, central abdominal pain going through to the back, occasional vomiting and intermittent dysphagia	Poor	44·5	50·9	6·4	Poor

RESULTS

It can be seen from Table I that there were 28 men and two women in the series studied, this being due partly to the fact that the majority of the cases were drawn from a hospital with a predominantly male population (the Repatriation General Hospital, Heidelberg), and partly to the fact that many more men than women undergo partial gastrectomy because of the known male predominance of duodenal ulceration. The ages ranged from 36 years to 69 years, the mean age being 53·5 years.

All but two of the cases had a Polya type partial gastrectomy, the two exceptions having had a Billroth I type operation. This largely reflects the popularity of the former procedure, at least in

TABLE I—*continued*

CLINICAL FEATURES

Case	*Age (years)*	*Sex*	*Type of Operation and Reason*	*Interval between Operation and Onset of Weight Loss*	*Amount of Weight Lost (kg)*	*Symptoms and Signs*	*Diet*	*Response of Body Weight to Replacement Therapy with Pancrex 5 Powder*			
								Weight (kg)		*Gain (kg)*	*Diet during Trial*
								Before Treatment	*After Treatment*		
17	69	F	Polya for gastric ulcer	Immediately after operation	9·3	Smooth tongue	Very poor	36·3	38·6	2·3	Very poor
18	57	M	Polya for duodenal ulcer which had perforated on three occasions	3 months	11·6	Epigastric pain, vomiting	Poor	44·5	51·7	7·2	Adequate
19	56	M	Polya for bleeding gastric ulcer	6 months	12·2	Pain in right hypochondrium, occasional vomiting, alternating constipation and diarrhoea	Poor	54·0	60·0	6·0	Poor
20	53	M	Polya for bleeding duodenal ulcer	13 years	18·5	Pallor	Adequate	47·7	69·9	22·2	Adequate
21	47	M	Polya for duodenal ulcer which had previously perforated	12 months	7·1	Upper abdominal discomfort, anorexia, diarrhoea	Poor	50·8	54·0	3·2	Poor
22	53	M	Polya for a gastric ulcer which had previously bled	9 months	10·5	Epigastric pain through to the back, intermittent diarrhoea	Poor	57·6	62·6	5·0	Poor
23	68	M	Polya for gastric and duodenal ulcers	8 years	12·7	Cachetic with signs of obstructive lung disease	Very poor	41·3	50·8	9·5	Deceased
24	36	M	Polya for duodenal ulcer with obstructive symptoms	9 years	12·7	Recurrent attacks of severe epigastric pain for 9 years, persistent diarrhoea 5 months	Adequate	49·9	56·2	6·3	Adequate
25	59	M	Polya for gastric ulcer which had failed to heal	12 years	6·0	Left-sided upper abdominal pain	Poor	50·8	51·0	0·2	Very poor
26	62	M	Polya for duodenal ulcer with persistent pain	Nil	18·7	Two pale bulky motions daily, chronic cough with exertional dyspnoea, signs of obstructive lung disease	Adequate	53·1	61·7	8·6	Adequate
27	62	M	Polya for duodenal ulcer with obstructive symptoms	7 years	17·2	Upper abdominal discomfort after meals, gynaecomastia	Adequate	49·8	55·2	5·4	Adequate
28	54	M	Polya for bleeding duodenal ulcer	2 months	5·5	Upper abdominal pain	Adequate	49·5	58·1	8·6	Adequate
29	54	M	Polya for duodenal ulcer	12 months	7·3	Epigastric pain radiating through to the back, recurrent diarrhoea	Adequate	59·4	66·7	7·3	Adequate
30	53	M	Polya for chronic duodenal ulcer	5 years	15·9	Tiredness	Adequate	54·0	61·7	7·7	Adequate

Melbourne, rather than necessarily implying such a vast difference in the incidence of nutritional complications between the two operations.

Indications for surgery included haemorrhage in 10 cases, previous perforation or penetration in four, obstruction in two, and failed medical treatment in 14. Twenty-three cases had a duodenal ulcer, six cases a gastric ulcer, and one case both a gastric and duodenal ulcer.

The time interval between the operation and the development of weight loss varied from three months (not counting those patients who never regained the weight lost in the immediate postoperative period) to as long as 13 years, although it was difficult to be sure of the validity of some of the figures quoted by the patients. There seems little doubt, however, that there was often an appreciable delay before significant weight loss became apparent.

The amount of weight lost varied quite markedly as well, ranging from the minimum of 6 kg required to qualify for the study, to as much as 31·8 kg with a mean of 13·6 kg. There seemed to be no correlation between the amount of weight lost and the time interval between the operation and the onset of weight loss.

Amongst the associated symptoms occurring in conjunction with weight loss, upper abdominal pain was the most common, occurring in 18 cases (60%), with diarrhoea being the next in frequency having occurred in 14 cases (46·7%). Apart from these there were no other symptoms which occurred with any degree of frequency. Diet was considered adequate in only 12 of the 30 cases, being poor in 14 and very poor in four.

Faecal fat studies revealed that in every instance the average daily fat excretion was in excess of the accepted upper limit of normal of 5 to 6 g, the range varying between 7·3 g and 75 g, and the mean being 18·6 g.

The serum albumin level was below the usually accepted lower limit of normal of 3·5 g per 100 ml in eight cases, normal in 20 cases, and not done in two cases.

The glucose tolerance test was normal in 11 cases (36·6%), diabetic in type in eight cases (26·8%), and of the 'lag-storage' variety in the remaining 11 cases (33·3%). No flat curves such as encountered in intestinal malabsorption were seen.

The xylose absorption test was carried out in 29 of the 30 cases, and was below an acceptable lower limit of excretion of 4 g in five hours in only eight cases.

The 24-hour urinary diastase excretion was performed in 27 cases and in 10 of these was above

TABLE II

BIOCHEMICAL FEATURES

Case	*Serum Proteins (g per 100 ml)*		*Glucose Tolerance Test (mg per 100 ml fasting and at 30, 60, 90, and 120 min respectively)*	*Xylose Excretion in 5 Hours after Test Dose of 25 g*	*24-Hour Urinary Diastase (Wohlgemuth units)*
	A	*G*			
1	2·35	1·9	Normal	4·4	—
2	2·8	3·3	Normal	8·1	—
3	3·2	2·6	90, 316, 300, 230, 130	7·7	4,834
4	3·9	3·2	Normal	8·5	121,000
5	4·1	2·95	Normal	3·9	20,216
6	4·05	2·45	112, 292, 192, 118, 106	8·7	30,500
7	4·0	3·5	Normal	6·0	46,000
8	4·0	2·7	85, 203, 218, 114, 66	4·0	7,200
9	4·5	2·6	Normal	5·0	7,775
10	4·0	2·3	83, 189, 212, 81, 46	—	54,000
11	3·9	2·4	Normal	3·7	51,750
12	4·1	2·0	74, 204, 135, 114, 82	2·7	33,000
13			Normal	5·4	1,680
14	3·85	2·45	Normal	6·1	28,210
15	2·2	3·9	69, 227, 165, 128, 181	2·8	—
16	3·85	2·25	108, 212, 238, 200, 142	6·1	25,000
17	4·5	3·1	Normal	6·1	17,000
18	2·3	3·0	82, 216, 132, 136, 115	2·5	21,000
19	3·6	3·1	94, 198, 208, 122, 66	14·0	16,650
20	2·8	3·3	86, 220, 264, 204, 148	2·8	56,400
21	4·1	2·8	94,230, 236, 156, 96	5·5	70,000
22	5·0	3·7	Normal	4·8	6,500
23	3·85	3·05	95, 216, 276, 145, 85	2·5	10,800
24	3·1	3·2	138, 320, 264, 160, 128	10·4	10,000
25	2·8	4·25	98, 236, 198, 118, 81	5·8	70,649
26			41, 192, 201, 201, 200	5·0	13,140
27	4·0	3·5	81, 265, 142, 88, 61	4·6	12,600
28	3·23	3·48	66, 188, 200, 142, 104	8·0	35,631
29	3·55	3·15	88, 179, 238, 198, 123	2·0	13,600
30	3·05	3·05	83, 258, 192, 81, 50	5·2	1,219

TABLE III

HAEMATOLOGICAL FEATURES

Case	*Haemoglobin (g/100 ml)*	*Blood Film*	*Other Investigations*
1	10·0	Normocytic, normochromic	—
2	7·4	Hypochromia	Serum iron 35 micrograms per 100 ml; occult blood negative
3	14·0	Normal	—
4	13·3	Normal	—
5	16·4	Normal	—
6	11·6	Hypochromia	—
7	13·8	Normal	—
8	14·0	Normal	—
9	16·4	Normal	—
10	13·8	Normal	—
11	14·4	Normal	—
12	12·1	Normal	Positive occult blood
13	15·3	Normal	—
14	15·1	Normal	—
15	6·6	Macrocytosis	Serum iron 34 micrograms per 100 ml; vitamin B_{12} studies normal
16	10·0	Hypochromia	—
17	13·8	Normal	—
18	12·1	Hypochromia	Positive occult blood.
19	14·4	Normal	—
20	10·4	Mild hypochromia	—
21	14·4	Normal	—
22	16·0	Normal	—
23	12·6	Mild hypochromia	Serum iron 117 micrograms per 100 ml
24	15·0	Normal	—
25	11·0	Hypochromia and macrocytosis	Serum iron 28 micrograms per 100 ml; bone marrow showed erythroid hyperplasia; Schilling's test normal
26	9·5	Hypochromia	—
27	12·6	Normal	—
28	12·1	Normal	—
29	14·7	Normal	—
30	12·5	Normocytic Normochromic	—

the upper limit of normal of 30,000 Wohlgemuth units.

Radiological investigations revealed the presence of pancreatic calcification in one case (no. 3), two instances of stomal ulcer (nos. 12 and 13), and one each of a narrow stoma (no. 2) and a dilated jejunal loop (no. 15). In all other cases the radiological examinations carried out were normal.

A haemoglobin level below 13·5 g per 100 ml was present in 14 cases (46·7%), three of these being below 10 g per 100 ml. Hypochromia was noted in the blood films of eight of the anaemic cases, and macrocytosis in two cases but in neither of these latter was an abnormality detected in vitamin B_{12} absorption studies although folic acid absorption was abnormal in one of them.

Jejunal biopsy was carried out in 22 cases, the specimens being obtained in each instance from the efferent loop where a Polya type gastrectomy had been done. Those excluded were nos. 1, 2, 12, 13, 25, 26, 29, and 30. In 20 of the 22 cases the histology was considered to be normal. One case (no. 11) demonstrated partial villous atrophy and another patient (no. 15), in whom a dilated jejunal loop had been demonstrated radiologically, had partial villous atrophy in the specimen taken from the dilated loop and normal histology in the mucosa distal to the dilated portion.

A THERAPEUTIC TRIAL

For reasons to be discussed subsequently, the results suggested to the writer that the usual basis for steatorrhoea and, to a varying extent, the weight loss found in this group of patients, was pancreatic insufficiency, and to put this hypothesis to the test it was decided to conduct a therapeutic trial with pancreatic enzyme replacement therapy.

In conducting such a trial, however, certain problems arise which have to be taken into consideration when making a final assessment and which, incidentally, do not appear to have been given any serious attention when such trials have been reported by other workers.

The first problem is to determine whether the preparation being used is, in fact, effective. Pancreatic enzymes, being proteins, are sensitive to such factors as temperature and *p*H changes. A number of the currently available commercial preparations when subjected to studies *in vitro* in the biochemistry laboratory demonstrated poor degrees of activity indeed, and presumably must be at least equally ineffective *in vivo*. Other factors to be considered are the medium in which the preparation is dispensed, and the time at which it is taken. Enteric-coated tablets cannot be relied upon to release their coating at the right time so as to ensure maximum contact between the enzymes and the food ingested. For a similar reason if the preparation is taken before or after meals, adequate mixing with the food cannot be guaranteed. The preparation used in this trial was Pancrex 5 powder because it was found to be the most effective one available as judged by the above criteria, and it was prescribed in a dosage of 3 to 5 g taken during the course of each meal.

Another important factor to consider is the patient's dietary intake during the trial. Since the desired effect of the medication is simply to increase the digestion of the food that has been ingested, the amount of substrate provided will obviously be a distinct limiting factor determining the degree of effectiveness of the treatment, especially in relation to the extent of any weight gain.

Prolonged medication of any kind always poses the problem as to whether the patient is continuing

to take the drug involved in a conscientious manner, and the experience of other workers with groups such as those on long-term antituberculous therapy, indicates that the proportion of patients failing to take one or more of the prescribed drugs can be alarmingly high. The fact that the preparation used in this trial has a particularly unsavoury odour (compared by several of the patients to blood and bone manure) and therefore not calculated to make the meals more appetising, added to the difficulties of inducing the patients to persist with the treatment. It was for these reasons that it was decided to assess the effect of therapy after approximately six months. This appeared to be a sufficiently long period for any appreciable effect to have taken place without, at the same time, being too long to maintain the patient's interest and cooperation. Nevertheless, it was found that in some cases the degree of improvement while the patient was in hospital where his treatment could be supervised was not as well sustained after discharge when supervision was continued on an outpatient basis.

The final problem to consider is the availability of some objective method of assessing the effectiveness or otherwise of any treatment undertaken. This could best be achieved by recording the patient's weight and faecal fat excretion both before and after treatment. A controlled group treated by placebo is not included.

The results of the trial are recorded in detail in Table I, and graphed in Figure 1.

All patients gained some weight, the range being 0·2 kg to 22·2 kg; the mean weight gain was 6·73 kg $\pm$ 0·77 (SEM), $t = 8{\cdot}7$ and $P > 0{\cdot}001$, making this highly significant.

Follow-up faecal fat estimations were not available on seven of the 30 patients. Two of these seven (cases 15 and 23) died from intercurrent conditions, and the other five either lived long distances from Melbourne or failed to cooperate when further stool collections were asked for. Of the 23 patients who had follow-up faecal fat studies, 20 showed a reduction in the degree of steatorrhoea ranging from 18·8% to 98·8%. Of the three patients showing an increase in faecal fat excretion, one (case 8) had only very mild steatorrhoea to start with and the increase was of an insignificant order (0·62%), while another (case 24) was an alcoholic who at the time the repeat estimation was done had been drinking quite heavily and admitted to not having taken his medication. His condition deteriorated to such an extent that subsequently he had to be readmitted to hospital where under supervision his condition improved remarkably with a 12·7 kg gain in weight. The overall average decrease in steatorrhoea (or, looking at it another way, the increase in fat absorption), including the three cases discussed above, was 49·7%. The SEM for this was $\pm$ 7·7, $t = 6{\cdot}5$ and $P > 0{\cdot}001$, again a highly significant result.

DISCUSSION

An analysis of the results indicates that both dietary deficiency and defective absorption played a significant role in the weight loss encountered in the

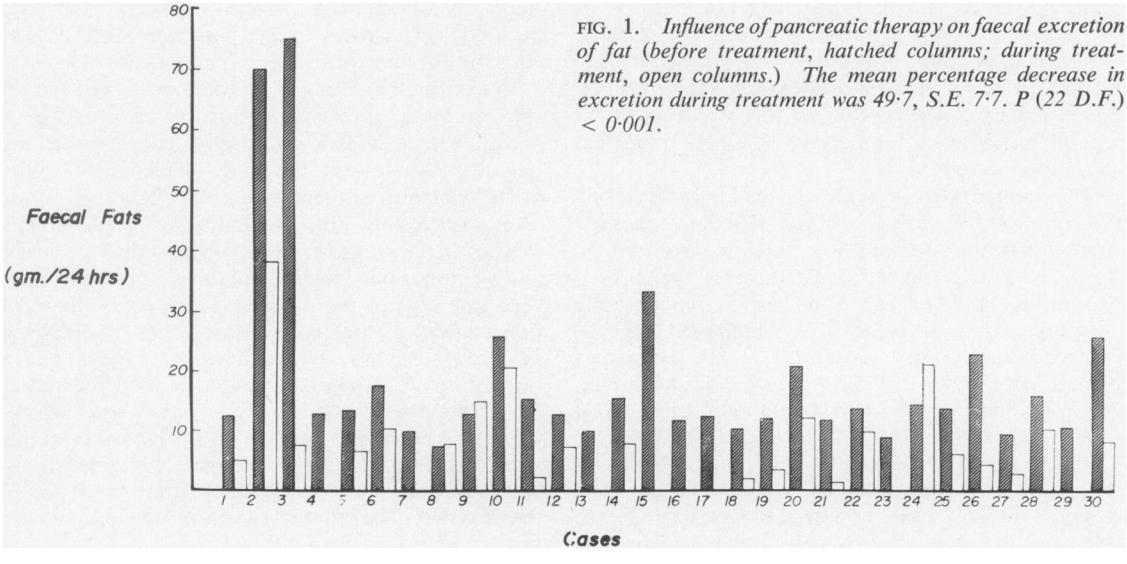

FIG. 1. *Influence of pancreatic therapy on faecal excretion of fat (before treatment, hatched columns; during treatment, open columns.) The mean percentage decrease in excretion during treatment was 49·7, S.E. 7·7. P (22 D.F.) < 0·001.*

patients studied, and although poor diet alone could easily have produced all the degrees of weight loss encountered, it is clear that this was not the case in the present study since 40% of the patients were considered to have had an adequate diet and in many of the others the amount of weight lost was out of proportion to the dietary defect.

Malabsorption as evidenced by steatorrhoea was, on the other hand, found in all cases and even the milder degrees could well have been significant, assuming that the calories continued to be lost in the faeces over a long period of time and were not compensated for by a commensurate increase in food intake.

It would appear difficult to deny, considering the above facts, that malabsorption was an important factor contributing to the weight loss encountered in many of the patients studied and it remains to determine the cause of the defective absorption. Two possibilities have, in practice, to be considered, namely, incomplete digestion resulting in the main from deficiency of pancreatic enzymes and/or bile salts, and defective small intestinal function. Having made this decision one has further to determine the actual basis for the digestive or small intestinal disturbance as the case may be.

Pancreatic insufficiency presents with steatorrhoea as the main clinical manifestation and often little else, whereas intestinal malabsorption is characteristically associated with more widespread disturbances affecting electrolytes, haematinic agents, and vitamins (Hillman, 1964).

Evidence of intestinal malabsorption such as abnormalities of xylose absorption, serum albumin, vitamin B_{12}, and folic acid, and mucosal changes on small bowel biopsy were absent in the majority of the cases, and even in those in which one of these abnormalities was found it was not as a rule associated with other features expected with a small bowel defect. An exception to this was case 15 in whom radiological evidence of small intestinal stasis was present.

The comparatively high incidence of anaemia (14 out of 30 cases) requires special comment since this is not a feature of pancreatic insufficiency. It will be noted that in all but three of the cases it was mild, and all but one were hypochromic suggesting iron deficiency. This high incidence of postgastrectomy anaemia is now a well recognized phenomenon (Owren, 1952; Larsen, 1952; McIntyre, 1956; Wallensten, 1958; Birnbaum *et al*, 1959; Baird *et al*, 1959; Deller, 1962; Klipstein, 1962, Weir and Gatenby, 1963; Deller, Perry, and Witts, 1963). In the majority of cases it is due to iron deficiency and it seems unlikely that the latter is primarily due to intestinal malabsorption since one would expect to find a proportionate incidence of folic acid deficiency, the latter being absorbed from the same region of the small bowel. This, in fact, is not the case.

Turning now to evidence of pancreatic insufficiency, we find radiological evidence of pancreatic calcification in one case, a diabetic glucose tolerance curve in eight cases, and a raised urinary diastase in 10 cases. Apart from the eight diabetic glucose tolerance curves, 11 patients had the so-called 'lag-storage' curve, the latter having in the past been attributed to rapid absorption in post-gastrectomy patients (Lawrence, 1936; Gilbert and Dunlop, 1947; Moore, 1950). However, this type of curve has also been described in peptic ulcer patients who have had no operation (Evenson, 1942; Platt, Dotti, and Beekman, 1949), and it is a point of some interest that two of the patients in the present series (cases 20 and 24) had had glucose tolerance curves on previous occasions which were of the 'lag-storage' type, demonstrating a transition from this type of curve to a diabetic one, suggesting that at least in some cases the 'lag-storage' curve may be a prediabetic phenomenon.

Apart from the type of indirect evidence of pancreatic insufficiency cited above, as well as the negative evidence of intestinal malabsorption as a basis for the steatorrhoea in the majority of the cases, there is the more direct evidence gained by the statistically significant response of both the weight loss and steatorrhoea to pancreatic replacement therapy detailed above.

Granted that pancreatic insufficiency is the usual basis for steatorrhoea in postgastrectomy patients, it remains to decide whether this is due to inadequate mixing with, or diminished stimulation of, pancreatic juices, as contended by several workers, or whether pathological changes in the pancreas, such as pancreatitis or pancreatic atrophy, may be involved.

Evidence suggesting a pathological change in the pancreas rather than just a disturbance of function in at least a significant proportion of the patients includes (1) the high incidence of upper abdominal pain in the absence of evidence of stomal ulcer, suggesting the possibility of a pancreatic origin for the pain; (2) raised urinary diastase levels and/or abnormal glucose tolerance curves in more than one half of the patients; (3) direct evidence of pancreatitis in three cases. Case 3 had radiological evidence of pancreatic calcification. Case 1 had a laparotomy for obstructive jaundice nine years after his gastrectomy and all that was found was a thickened pancreas. Case 18 had a laparotomy one year after his gastrectomy following a haematemesis. A stomal ulcer was removed and with it a portion of the pancreas. The latter showed histological evidence of chronic pancreatitis.

There are several theoretical possibilities as to why postgastrectomy patients might develop pancreatitis or pancreatic atrophy, including direct trauma to the pancreas at operation, interference with the blood supply, increased tendency to duodenal reflux (McCutcheon, 1962), and disuse atrophy due to loss of the gastric stimulus to pancreatic secretion. The present study has failed to elucidate which factor or factors predominate. Alcohol was thought to be playing at least an aggravating role in four of the cases.

Although a secretin test may provide useful evidence of pancreatic dysfunction (Marks and Tompsett, 1958; Sunn and Shay, 1960), this was not done because the technical problems involved in postgastrectomy patients would tend to invalidate any results obtained.

Although the results of the present study suggest pancreatic insufficiency as the usual cause of steatorrhoea in postgastrectomy patients, other well recognized causes must always be borne in mind, as illustrated by evidence of intestinal stasis in case 15, and the subsequent discovery of a gastrocolic fistula in case 2 following relapse after an initial response to pancreatic replacement therapy.

SUMMARY AND CONCLUSIONS

Approximately 25% of patients undergoing partial gastrectomy for the treatment of peptic ulceration lose an excessive amount of weight after operation, quite apart from any immediate postoperative loss.

Thirty postgastrectomy patients operated upon a year or more previously, who were 6 kg or more below their usual preoperative weight, were subjected to a combined clinical, biochemical, radiological, haematological, and histological study in an attempt to elucidate the cause or causes of the weight loss. Poor dietary intake was thought to be an important factor in 60% of the patients. Malabsorption as evidenced by steatorrhoea was found in all the patients and thought to be a significant factor in most. Evidence suggesting pancreatic insufficiency as the usual cause for the steatorrhoea was confirmed by the statistically significant response of both the weight loss and the steatorrhoea to pancreatic replacement therapy with Pancrex 5 powder. There was evidence of both a direct and indirect kind to suggest that pancreatic disease rather than just disturbed function or poor mixing was the basis for the pancreatic insufficiency found.

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