

Technical Surgical Factors Which Enhance or Minimize Postgastrectomy Abnormalities *

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CONTROVERSY still exists concerning the incidence and type of undesirable sequelae that may follow an operation for the relief of peptic ulceration. However many of those who have investigated this problem agree that probably one of the most important factors causing the greatest number of postgastrectomy difficulties is the extremely rapid evacuation of ingested material from the stomach or stomach remnant.^{1-4, 6, 8, 11-13, 18, 20-23, 25, 28, 29, 34, 37, 38}

In 1913 Hertz¹² discussed the symptoms and the effects associated with "too rapid drainage of the stomach" following a gastrojejunostomy. He stated that frequently a sensation of fullness occurred during each meal and became "so unpleasant that the amount of food taken is progressively diminished and a considerable loss of weight may finally occur." Also, he said that in some cases soon after eating, epigastric fullness and borborygmi developed which sometimes was followed by vomiting or diarrhea. Occasionally such patients exhibited palpitation, perspiration and a weak tired feeling which might culminate in syncope.

In 1922 Mix²² described what he called

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a "dumping stomach following a gastrojejunostomy." While his patient occasionally had many of the symptoms that we associate with dumping (weakness, syncope, etc.) he emphasized that the problems were primarily vomiting and undernutrition. Both Hertz¹² and Mix²² demonstrated by fluoroscopic examinations that a very rapid evacuation of food or barium from the stomach occurred and the emptying time could be prolonged if the patient was examined in the recumbent position. Hertz also noted that the symptoms associated with this rapid emptying were minimized or alleviated when the patient ate lying down. These workers^{12, 22} also emphasized that the rapid evacuation of the stomach was associated with a large stoma and suggested that if the symptoms and weight loss could not be remedied by medical management, an operation should be performed to reduce the size of the stoma. If the pylorus was not obstructed they suggested that its activity should be restored by closing the gastrojejunal stoma. Both investigators emphasized that since too large a stoma might lead to undesirable sequelae the stomal size should not be larger than the normal pyloric opening. Mix²² also emphasized that when the anastomotic opening is too large "the stomach does not retain its contents sufficiently long." He went on to state that "nature evidently wishes the stomach to keep its contents an hour or an hour and a half after an ordinary meal."

Many later studies^{3-6, 13, 20, 23, 28, 34} have supported the earlier views of these two workers, that the rate of emptying of the postoperative stomach depends primarily on the stomal size, position and function. Many of these same studies have also demonstrated that the rapid passage of ingested material into the upper intestine is the principle factor which leads to undernutrition, anemia and/or vasomotor symptoms. The use of the term "dumping" should be limited to that proposed by Mix,²² namely to describe the rapid emptying of recently ingested material into the small intestine and need not necessarily imply the presence of specific signs or symptoms.

The undesirable sequelae which might occur following a pyloroplasty, gastroenterostomy or a subtotal gastrectomy are:

1. Recurrent ulceration.
2. Biliary regurgitation.
3. Partial or complete mechanical or functional obstruction at the site of the anastomosis or distal to it.
 - a) efferent limb obstruction.
 - b) afferent limb stasis or obstruction.
4. Early postcibal vasomotor symptoms.
5. Undernutrition due to:
 - a) Low gastrojejunostomy, gastroileostomy or gastrocolic anastomosis or fistula.
 - b) Inadequate assimilation or digestion of fats and protein.
 - c) Inadequate intake of food.
6. Hyper and hypoglycemia.
7. Anemia due to iron or vitamin B-12 deficiency anemia.

It is generally agreed that the most frequent cause of a recurrent ulcer is an inadequate resection of the acid secreting area of the stomach, an incomplete vagotomy, incomplete removal of the antrum, or a combination of these factors.

Biliary regurgitation occurs when there is a free flow of bile and pancreatic juice into the stomach and a partial (organic or

functional) obstruction of the efferent loop which prevents the normal passage of material out of the stomach. We believe that this condition is a specific entity that is characterized by the frequent regurgitation of bile which may also be occasionally associated with vomiting of the entire gastric contents. This should not be confused with the intermittent vomiting of material that may occasionally contain bile.

Proximal loop filling or reflux of ingested material and gastric secretions into the afferent loop occurs in most patients when it is anastomosed to the greater curvature of the stomach.^{10, 36} This occurs less frequently if the efferent loop is put to the greater curvature. While some workers have contended that proximal loop filling is often associated with postcibal distress it is obvious that this is true only if distension of the afferent loop occurs or the efferent loop is partially obstructed.³⁶ Both situations are encountered very rarely.

Obstruction at the anastomosis or just distal to it might occur from a prolapse or swelling of the mucosa into the anastomotic opening, intussusception, herniation or adhesions. Obstruction caused by one of these abnormalities are rare. In our experience they occur less frequently following a gastroduodenal anastomosis than after a gastrojejunostomy. As early as 1906 Paterson²⁶ demonstrated that the passage of material from the stomach could be partially or completely obstructed although at the time of re-operation or necropsy the stoma was apparently patent when examined from the jejunal side. Although such an anastomosis seemed to be patent from below it may be functionally obstructed due to kinking, abnormal position, the mucosal folds, muscular contractions or the distortion produced by food and liquids in the stomach.

The most frequent and important cause for the early postcibal vasomotor symptoms, undernutrition, hyper and hypoglycemia and anemia is the failure of the stomach to store or retain food and gradually

dispense it to the intestine over a period of one to five hours. Most of the reports^{2, 8, 15, 19, 21, 32} in which oral glucose tolerance tests have been done have shown that the dumping or early postprandial symptoms occur just prior to or during the hyperglycemic phase. Beckerman² and Evensen⁸ were able to show a good correlation between the rate of gastric emptying and the rapidity and extent of the rise in the blood sugar. Most observers^{2, 8, 19, 21, 32, 33} believe that hypoglycemia is more apt to follow a rapid increase in the blood sugar concentration to very high levels than when a more gradual increase occurs.

Machella²¹ showed that the epigastric distress, anorexia, palpitation, feeling of warmth and weakness noted in the early postcibal period usually occurred during or before the hyperglycemic phase. He also emphasized that the symptoms could be produced by the oral ingestion of hypertonic solutions other than sugar and did not occur when the hyperglycemia was produced by the intravenous infusion of glucose. Hexoses and alcohol are absorbed rapidly when they pass directly through the stomach and enter the upper small intestine. It is therefore understandable why hyperalcoholemia and hyperglycemia followed by hypoglycemia may lead to symptoms or produce undesirable effects when a rapid evacuation of gastric contents occurs.

One cause for primary and secondary anemias that may occur after subtotal gastrectomy^{11, 14, 17, 24, 40} is the interference with the absorption of iron and vitamin B-12 if these substances pass rapidly through the upper gastro-intestinal tract. The most frequent type of anemia is a microcytic hypochromic anemia and occurs more commonly in postgastrectomized women because of low grade blood loss and reduced iron absorption.

Since the rapid evacuation or dumping of stomach contents has been reported to occur following a pyloroplasty or after gas-

trooduodenal or gastrojejunal anastomosis with or without subtotal gastrectomy or vagotomy, it seems evident that the early postprandial symptoms must be related in some way to the stomal size, position, and function rather than to the amount of stomach resected, the type of anastomosis performed or other factors. The purpose of this study was to evaluate the changes in gastro-intestinal function after various operative procedures, employed for the treatment of peptic ulceration. Observations were made in normal volunteers and patients in an attempt to correlate postgastrectomy signs and symptoms with changes in function.

Methods

A barium food mixture was prepared by adding food equivalent to an average breakfast to 75 Gm. of barium sulphate and mixing it in a blender. The food consisted of 60 cc. of orange juice, 60 cc. of coffee, a slice of toast with a pat of butter, a soft boiled egg and a pinch of salt. This was usually prepared the afternoon or evening before the examination was to be done and kept in the ice-box overnight. The patient was ambulated prior to the x-ray study which was performed between 8:30 and 9:30 a.m. An upright 14 × 17 inch film of the abdomen was taken to position the patient properly so that the diaphragms and the upper abdomen could be visualized. After this film the barium food mixture was ingested over a period of four minutes and upright films of the abdomen were then obtained one minute later and at 20, 45, 60, 90 and 120 minutes. In later studies it was felt desirable to make more observations during the first half hour after the ingestion of the barium food mixture. Therefore the x-rays taken at 90 and 120 minutes were omitted and films were obtained at 10 and 30 minutes in addition to the other films. The patient was not permitted to lie down during the study period. This was done to simulate as much as

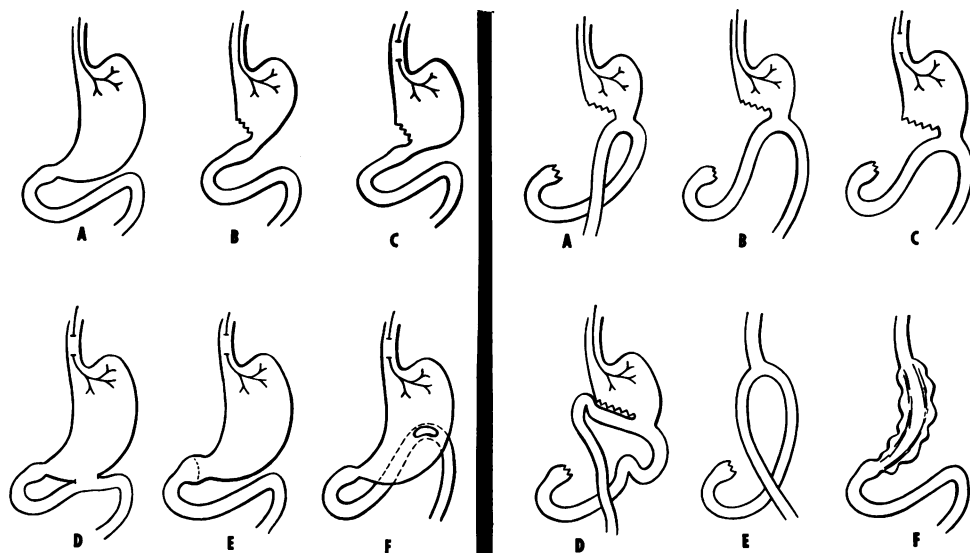


FIG. 1 (Left). Schematic representation of some of the types of operative procedures studied. (A) Normal stomach, (B) Billroth I., (C) Hemigastrectomy, vagotomy with a gastroduodenostomy, (D) Gastrojejunostomy and vagotomy, (E) Pyloroplasty and vagotomy, (F) Vagotomy with abnormally placed gastrojejunostomy.

FIG. 2 (Right). Schematic representation of additional types of subtotal and total gastrectomies studied. (A) Subtotal gastrectomy with gastrojejunostomy (efferent limb to lesser curvature of stomach), (B) Subtotal gastrectomy with gastrojejunostomy (efferent limb to greater curvature of stomach), (C) Hemigastrectomy, vagotomy with a gastrojejunostomy, (D) Subtotal gastrectomy (efferent limb, which is partially obstructed by kink, to lesser curvature of stomach), (E) Total gastrectomy with esophagojejunostomy, (F) Total gastrectomy with a colon transplant (esophagocolostomy, and coloduodenostomy and colocolostomy).

possible the conditions that would usually exist following the ingestion of a normal breakfast.

The barium food x-ray studies were not done in place of the conventional diagnostic upper gastro-intestinal series but were obtained in order to gain some knowledge of the physiology of the gastro-intestinal tract. In many instances, if it was indicated, the patient had the conventional upper G.I. series so that any pathological abnormality as well as the mode of gastric emptying etc., could be observed.

Over one hundred persons have been examined using this technique. Approximately 15 normal volunteers and over 85 persons who had undergone gastric operations from eight days to seven years previously were studied. In most instances studies were obtained eight to 12 days post-

operatively and often at intervals of from three months to four years later.

Additional studies carried out in some of the patients included an oral glucose tolerance test, plasma volume determinations (while resting, after ambulation and following ingestion of hypertonic glucose solution), body weight changes and fecal nitrogen and fat determinations (while the patient was maintained on a constant previously analyzed diet). The daily caloric consumption was frequently determined by means of a weigh back diet and if an anemia occurred postoperatively, its type and cause was investigated. While the results of these latter studies will be reported subsequently their relationship to the patient's symptoms, complaints or nutritional status as correlated with the x-ray studies will be discussed.

Results and Discussion

Figures 1 and 2 show schematically the normal stomach and the various operative procedures which were studied. Since the position of the anastomosis in relation to the colon (ante or post) did not influence function this was not shown. Although the size of the anastomotic stoma was very important in effecting the eventual rate of gastric emptying it was evident from these studies that the position and possibly the mucosal folds and other factors were also important. Forsell⁹ has demonstrated the important role that the mucosal folds and rugae play in controlling the gastric emptying time and their influence on the function of the entire G.I. tract. The antrum and pylorus control the emptying time of the normal stomach and it should be stressed that the internal diameter of the pylorus rarely exceeds one centimeter. Thus in discussing the internal or functional size of an anastomosis, any gastroenterostomy that has an internal diameter greater than 1 cm. is larger than the normal stomach outlet. The importance of anastomotic size has been confused because many workers refer to the Polya anastomosis which utilizes the entire cut end of the stomach as a large stoma and an anastomosis which will admit two or three fingers as a small one.

Kennedy, Reynolds and Cantor¹⁶ studied this problem and came to the conclusion that the jejunal diameter, rather than stomal size, was the factor which controlled the rate of emptying of the stomach. They therefore felt that there was essentially no difference in gastric emptying time between the polya and Hofmeister anastomotic modifications. This is obviously true when the diameter of the gastro-intestinal stoma is as large or larger than that of the jejunum. Since the diameter of the jejunum usually admits three fingers without difficulty, a stoma of this size, although not as large as the Polya modification, is still a large open-

ing. It is obvious however that if the functional stoma size was only a centimeter in diameter that gastric emptying time would be slower than when the anastomosis was of greater diameter. Some differences of opinion have occurred because it has been generally assumed that a Hofmeister anastomosis is synonymous with a small opening which of course is not necessarily true.

It becomes obvious after studying patients following subtotal gastrectomy or gastroenterostomy by fluoroscopy or serial x-rays that often the function of the stoma can not be correlated with the stomal size as estimated by the surgeon. Thus the only way to be sure of the stomal function is to study the patient by roentgenographic methods. Information concerning the emptying rate of the stomach is not obtained by questionnaire or by having a disinterested third party make the observations fluoroscopically. Most radiologists are primarily concerned with the possibility of organic changes or the presence of obstruction and pay little attention to the stomach that is emptying rapidly. It is not uncommon for them to report such a stomach as functioning "normally." Such observers obviously fail to differentiate between the intermittent gradual emptying and a continuous and rapid flow of the barium from the stomach.

Recently a patient, whose stomach emptied very rapidly following a subtotal gastrectomy, stated that the radiologist had reported that his gastroenterostomy functioned normally. However he went on to say that it was necessary to tilt the table to the horizontal position and take films immediately after he swallowed the barium so that the stomach could be outlined. It has been demonstrated that the rate of gastric emptying^{1, 2, 5, 12} as well as the absorption of glucose^{8, 19} and iron²⁴ and changes in the plasma volume¹ which may occur in the patient who has a rapidly emptying stomach may be influenced by a

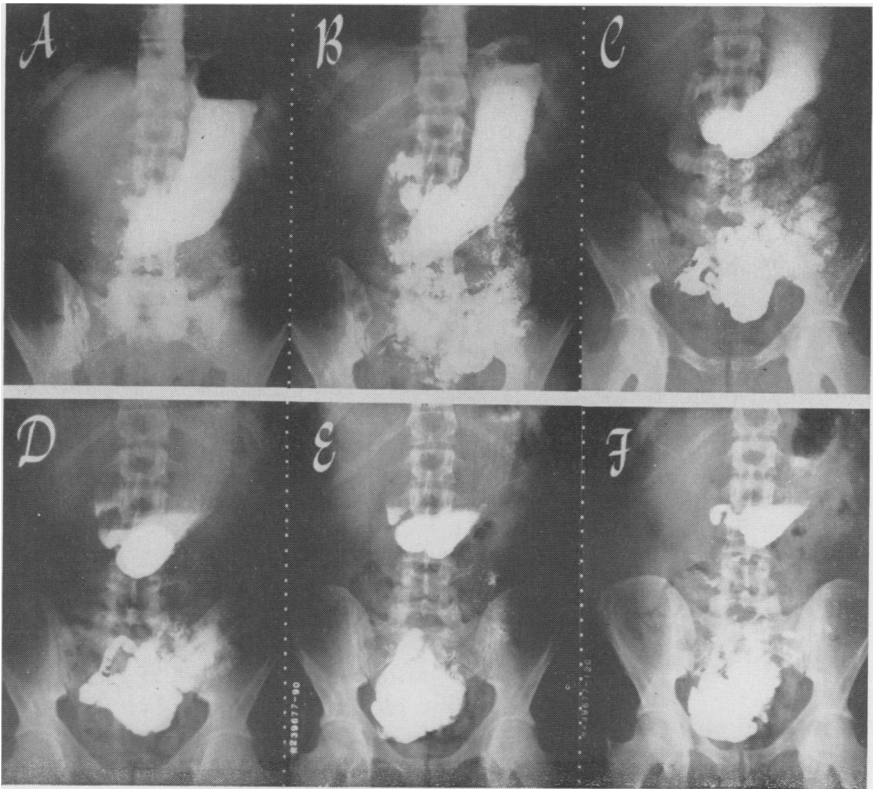


FIG. 3. Upright abdominal x-rays of a normal subject taken (A) 1, (B) 20, (C) 45, (D) 60, (E) 90 and (F) 120 minutes after ingestion of the barium food mixture.

change in position. A failure to appreciate this fact has led to conflicting impressions concerning the significance of the rate of gastric emptying in the production of post-gastrectomy abnormalities. It has been suggested that with the passage of time, dumping may disappear and the patient may exhibit a more normal nutritional state. It is true that the symptoms associated with dumping may disappear and the patient's nutritional status improve when he adjusts his eating habits to avoid the ill effects of a rapidly emptying stomach.

Emery⁷ has demonstrated that the excessive loss of fat and nitrogen in the stool of totally gastrectomized dogs may be prevented by feeding the animal small amounts of food periodically. He also showed that there was slight improvement in the utiliza-

tion of fat and nitrogen if these dogs were given hydrochloric acid, pancreatin and bile but demonstrated that this was due to the fact that the dogs ate much slower. He states that "this would appear to show that the intestines are capable of utilizing fat as effectively and rapidly as they are called upon to do under normal conditions." He thus concluded that there was no significant deficiency of lipolytic and proteolytic enzymes or other substances associated with digestion but that the transit time of foods through the upper small intestine was the most important factor. Polak and Pontes²⁹ believe that because of the rapid passage of food down the small intestines the digestive enzymes often do not mix well with it. These workers showed that by giving bile salts and pancreatin to postgastrectomized

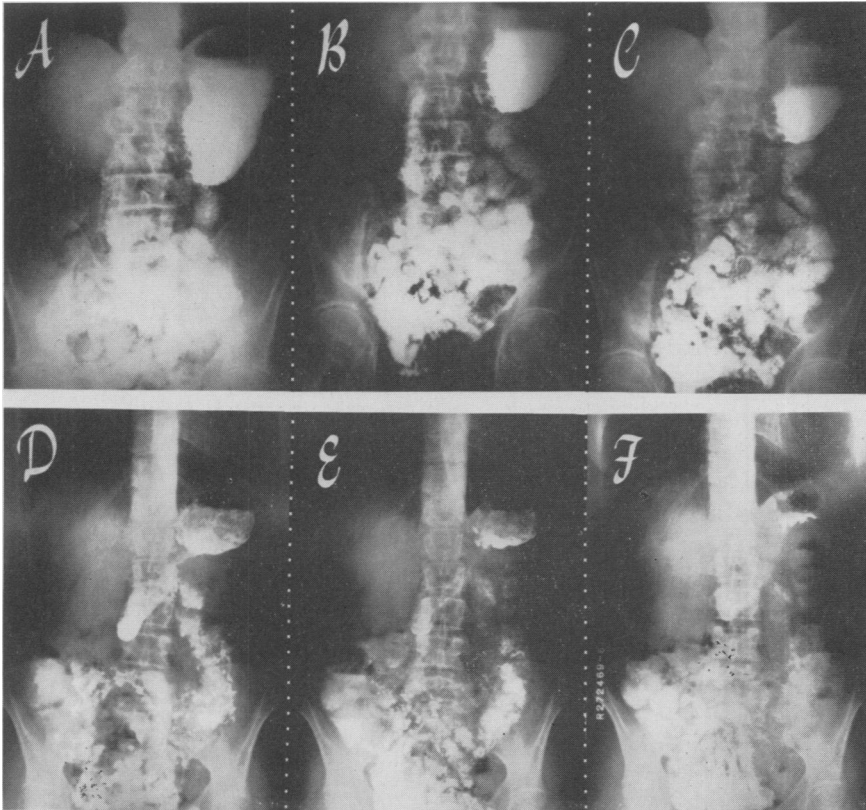


FIG. 4. Upright abdominal x-rays taken of two patients who had a Billroth I subtotal gastrectomy. Roentgenograms A, B and C were of patient H. T. who had a small stoma and D, E and F are of patient G. G. who had a large stoma. The x-rays were taken at the following times after the ingestion of the barium food mixture: (A) 20, (B) 45, (C) 60, (D) 20, (E) 30 and (F) 60 minutes.

patients with steatorrhea the amount of fat lost in the stool could be reduced to normal. We believe therefore that it is unlikely that the rate of gastric emptying changes with the passage of time and that this may be demonstrated by barium food x-rays as well as challenging the patient orally with a hyperosmolar solution to elicit symptoms.

Figure 3 depicts the rate of emptying of the normal stomach. In the normal persons examined, a very small amount of barium had left the stomach during the five minutes which elapsed from the onset of the ingestion of the barium food mixture and the first x-ray (Fig. 3A). At 20 minutes (Fig. 3B) the head of the barium column in normals had entered the ileum or ad-

vanced well down in the jejunum. Because of the accumulation of gastric secretions the stomach appears to contain a greater quantity of material in spite of the fact that 10 to 25 per cent of the ingested barium food mixture has passed on into the small intestines. Subsequent x-rays showed the barium column to become denser in the ileum and the amount in the stomach to gradually diminish. The amount of fluid in the stomach varied but the barium content gradually decreased so that at from 45 to 75 minutes there was approximately 50 per cent of the barium still in the stomach. At two hours there was from 10 to 25 per cent of the barium remaining in the stomach and the head of the barium meal had not

entered the cecum in any of the normal subjects studied. These findings are in keeping with those of other workers.^{27, 35, 38, 39}

Van Liere and Sleeth³⁹ determined the normal variations in the emptying time of nine normal subjects using a baium carbohydrate meal (15 Gm. of farina, 1 Gm. of salt were cooked in 350 cc. of water until the total volume was 200 cc. The next morning 50 Gm. of barium sulphate was added and the meal eaten at 8:30 a.m.). Of 77 tests the arithmetic mean (average) of the emptying time of the nine subjects was 2.07 hours with the extremes for the 77 tests being 0.75 and 3.50 hours. Pendergrass, Ravdin, Johnston and Hodes²⁷ also reported the results of their studies and concluded that following a water-barium meal the normal stomach was usually empty within two hours. The emptying time was increasingly prolonged when protein, glucose and olive oil were added to the water-barium meal. These workers²⁷ also showed that malnutrition and nephrosis delayed gastric emptying while in patients with hyperthyroidism the rate of gastric emptying was accelerated. Thus it is evident from our observations and the reports of others^{27, 35, 38, 39} that the normal stomach usually empties over approximately a two hour period and the head of the meal is near the cecum by this time.

Figure 4 shows the results in two patients who had a Billroth I type anastomosis comparable to that schematically represented in Figure 1B. The upper row of films (A, B and C) are the x-rays of a 67-year-old man taken one year after approximately 60 per cent of his stomach had been resected. He has continued to feel well, to maintain his weight and his blood count has remained normal. He has an excellent appetite, no food dyscrasias, and can consume a good sized meal without distress. Serial x-rays following a barium food mixture show the emptying of his stomach to be slightly faster but very com-

parable to that of a normal stomach. No barium entered the cecum during the two hour study.

The lower row of x-rays (Fig. 4D, E and F) were recently obtained from a woman who was operated on in 1951 for a penetrating marginal ulcer which occurred following a posterior gastroenterostomy performed 25 years previously. At the second operation approximately 70 to 80 per cent of her stomach was resected, the duodenum mobilized and an end-to-end gastroduodenal anastomosis was performed. The anastomotic stoma was larger than the normal pylorus. Since her operation she has found it necessary to eat slowly and limit fluids at meal time. She has been about 25 pounds below her expected normal weight and was unable to gain until recently when she stopped working. She now eats frequently throughout the day and often while lying down. She has gained eight pounds in approximately six months since making these adjustments in her eating habits. The first of her films shown (Fig. 4D) was taken after 20 minutes and it can be seen that the stomach contains only a small amount of barium mixed with fluid and the head of the barium column has already reached the ascending colon. Because of the rapid gastric emptying time and an increased small intestinal transit time with no history of dumping symptoms, it was decided to give this woman a hypertonic test meal to see if symptoms could be produced. While sitting she was given 100 ml. of 50 per cent glucose solution. Her fasting blood sugar was normal, pulse 74 and blood pressure 126/78. Within twenty minutes the patient felt weak and warm and complained of abdominal cramps. Her blood pressure fell to 76/50, pulse rose to 92 and shortly after she passed a watery stool that practically filled the bed pan. Her blood sugar was elevated during this reaction and subsequently fell to a normal control level. Her symptoms subsided when she was put

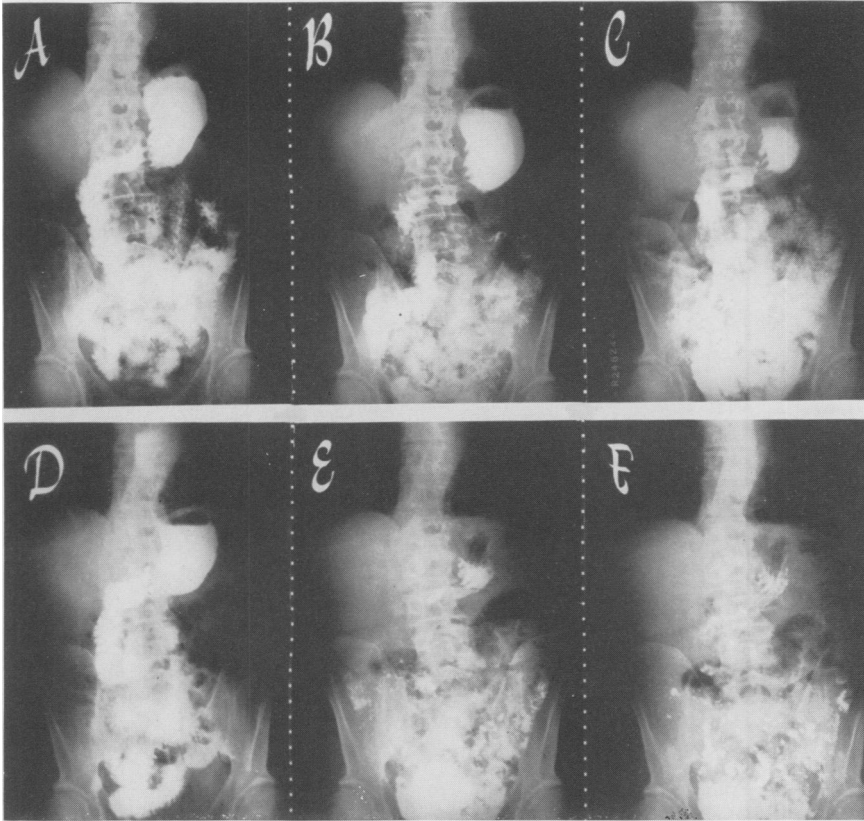


FIG. 5. Upright abdominal x-rays taken of patient F. A. who had a large stoma Billroth I subtotal gastrectomy. The upper three roentgenograms were taken April 1956, and the lower three October 1957. The x-rays were taken at the following times after ingestion of the barium food mixture: (A) 1, (B) 20, (C) 45, (D) 1, (E) 45 and (F) 60 minutes.

in bed, although her pulse remained elevated and blood pressure low for a half an hours.

This 65-year-old woman whom we had interviewed periodically for seven years since her Billroth I subtotal gastrectomy was thought to have a fairly good functional result. The barium food studies, her undernourished state, and inability to eat normal quantities of food during the three regular meals while sitting, strongly suggested that she was a dumper who had been able to avoid symptoms by adjusting her eating habits. After inducing the severe dumping attack we questioned the patient and she stated she had not previously had an episode like the one we provoked by

giving her a hypertonic glucose solution. She had been mildly inconvenienced by the frequent small feedings and anorexia but she believed that this was a small price to pay for getting rid of the pain and disability which was associated with her marginal ulcer.

Figure 5 shows x-rays (A, B and C) of a 56-year-old man, taken 1, 20 and 45 minutes respectively after he ingested the barium food mixture. This study was carried out a year after he had had a 70 to 80 per cent resection of the stomach for a prepyloric adenocarcinoma. The x-rays in the lower half of Figure 5 (D, E and F) are of the same patient and were taken two and one half years postoperatively. It

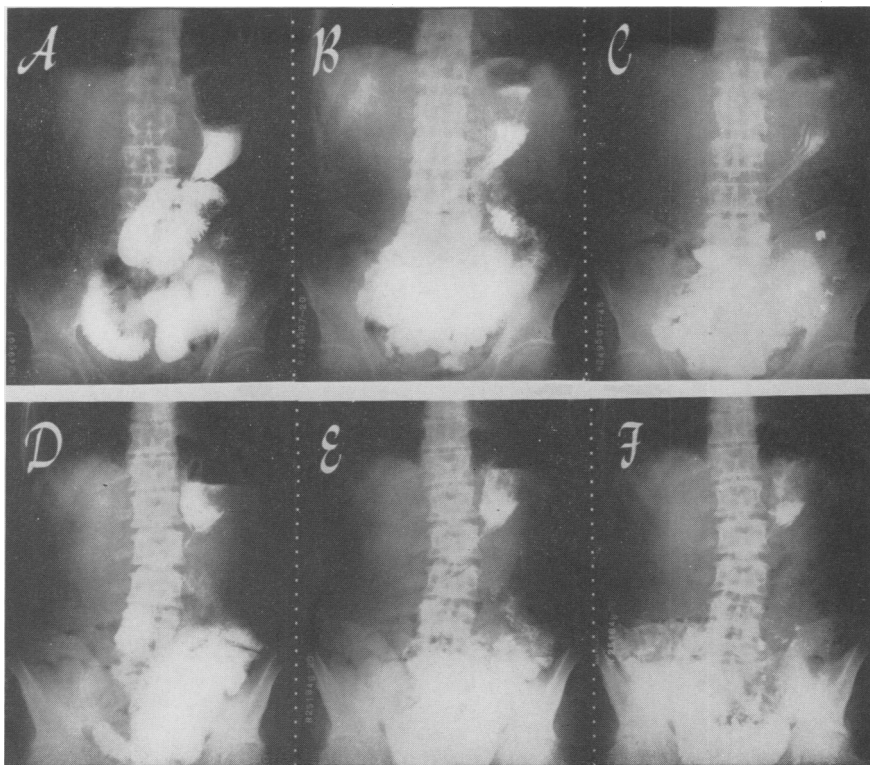


FIG. 6. Upright abdominal x-rays taken of two patients, F. R. who had a subtotal gastrectomy, vagotomy, with a large stoma gastroduodenostomy, and J. Z. who had a subtotal gastrectomy, vagotomy with an end to side gastroduodenostomy. The x-rays were taken at the following times after the ingestion of the barium food mixture: (A) 1, (B) 20, (C) 45, (D) 1, (E) 20 and (F) 60 minutes.

should be noted that a small amount of barium has entered the cecum in 45 minutes after the ingestion of the barium food mixture during both examinations (C and E).

Figure 6 shows studies obtained of two men in their 40's each of whom had a hemigastrectomy vagotomy with a moderately large end-to-side gastroduodenostomy. While both patients have had fairly good results they cannot eat a normal sized meal and have not been able to attain their ideal weights. The daily caloric intakes of both of these men were found to be sub-optimal when the amount of food consumed was measured by means of the weigh-back diet. While these latter three patients were not challenged with hypertonic dextrose and had gained some weight,

their slightly undernourished state was believed to be a result of anorexia that occurred when the upper small bowel was distended by food which emptied out of the stomach too rapidly.

Figure 7 shows the x-rays of W. K. a 37-year-old negro who had a hemigastrectomy vagotomy with an end to end gastroduodenostomy. The relatively normal gastric emptying time and small intestinal transit time was associated with good results (no undesirable symptoms and a maintenance of weight).

Figure 8 shows the x-rays of W. E. prior to the ingestion of the barium food mixture on his ninth postoperative day. It shows a dilated stomach which was filled with a large amount of liquid and food particles, although no food or water had been in-

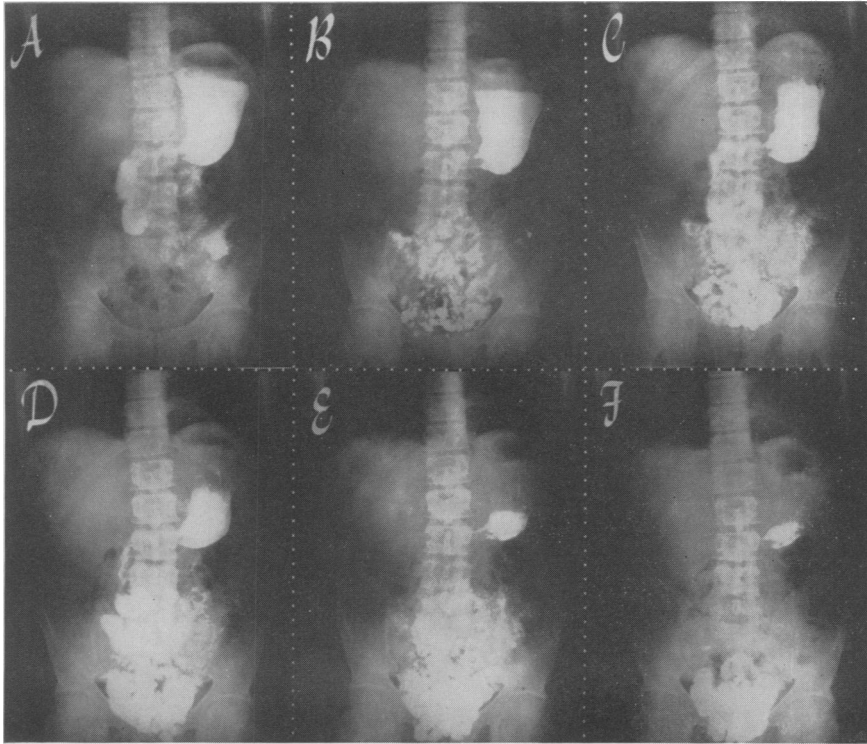


FIG. 7. Upright abdominal x-rays of patient W. K. who had a hemigastrectomy, vagotomy with an end-to-end gastroduodenostomy. The x-rays were taken at (A) 1, (B) 20, (C) 45, (D) 60, (E) 90 and (F) 120 minutes after ingesting the barium food mixture.

gested for the preceding twelve hours. The subsequent x-rays taken 1 and 60 minutes after the ingestion of the barium food mixture also show a markedly dilated gastric remnant with stasis. Since the patient had been eating well he was discharged on a Saturday before the x-rays were checked. When the films were examined several days later and a partial obstruction noted, the patient was called. His wife reported he was doing well and had gone on a short auto trip. He checked frequently and although he complained of occasionally regurgitating liquid gastric contents especially when lying down, having a foul smelling breath and a bad taste, he did not believe these difficulties were severe enough to be concerned about. The lower row of x-rays (D, E and F) were taken a year postoperatively. At the second study his

stomach was not as dilated as it was earlier, he had a good appetite, slow emptying and transit times and no further regurgitation or foul breath. He was studied four years after his hemigastrectomy and had gained about 25 pounds which brought his weight up to the normal range for his age and height. He is able to eat large meals, and drink alcoholic beverages without ill effects and is no longer troubled with halitosis or the regurgitation of gastric contents. While the patient's initial postoperative x-rays showed marked stasis due to a partial obstruction this gradually diminished and his postoperative results are now classified as excellent.

Eight other patients who had a hemigastrectomy-vagotomy with a small stoma gastrojejunostomy or gastroduodenostomy showed stasis of their gastric contents by

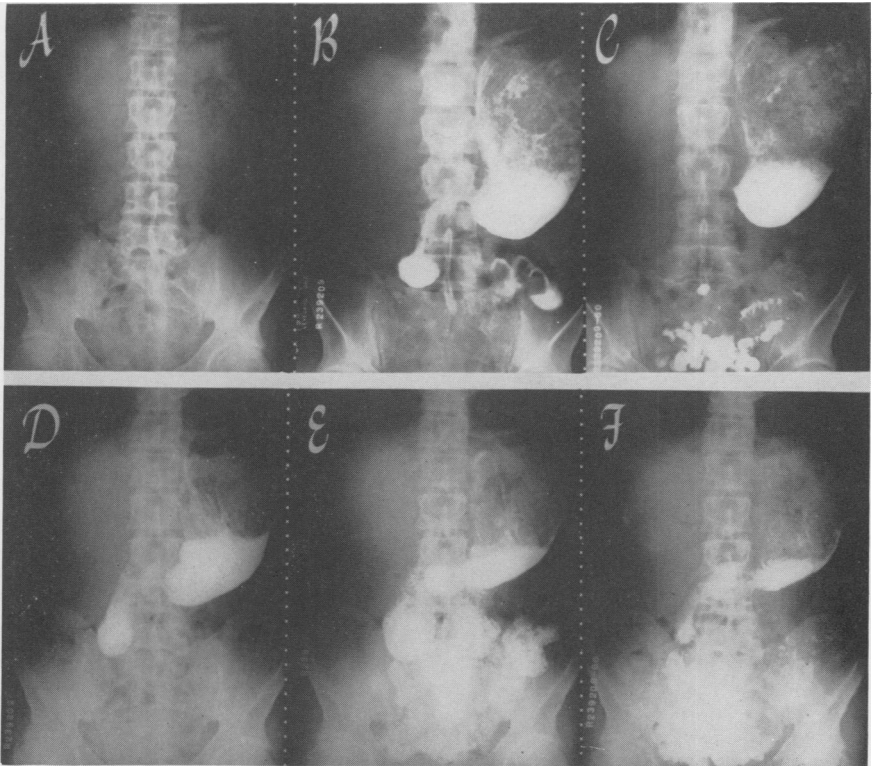


FIG. 8. Upright abdominal x-rays of W. E. who had a hemigastrectomy, vagotomy, and a small stoma gastroduodenostomy performed nine days before the upper pictures were taken. The first studies (A, B, C) were carried out in October 1955, and the second group of x-rays were taken in May 1956. X-ray (A) was taken prior to the ingestion of the barium food mixture and the others were obtained at the following times after taking the mixture: (B) 1, (C) 60, (D) 1, (E) 20 and (F) 60 minutes.

x-rays studies. They also had similar complaints although most of them were not as marked as those of W. E. (Fig. 8). Their symptoms gradually disappeared during the first four to eight postoperative months. Their appetites have progressively improved and they have gained weight. Subsequent x-rays of these patients showed a gradual restoration towards normal of their gastric emptying and small intestinal transit times. Although these patients exhibited a functional stomal obstruction for one to two and one-half weeks following a vagotomy and a small stoma anastomosis we have not to date found it necessary to reoperate a patient for a gastroduodenal stomal obstruction. The x-ray appearance

of stasis as illustrated by Figure 8 has been encountered only in patients following vagotomy in association with a functionally small stoma. Because of the frequency of gastric stasis in the early postoperative period we are no longer alarmed by such x-rays if the patient is convalescing satisfactorily. This x-ray appearance of stasis is considered desirable since in our early postoperative studies it is indicative that a small stoma was made, in conjunction with a complete vagotomy. Although a follow up of these patients for at least 15 years is necessary, at present we believe that their long term results with respect to ulcer recurrence and postgastrectomy disabilities will be satisfactory. To date there has been

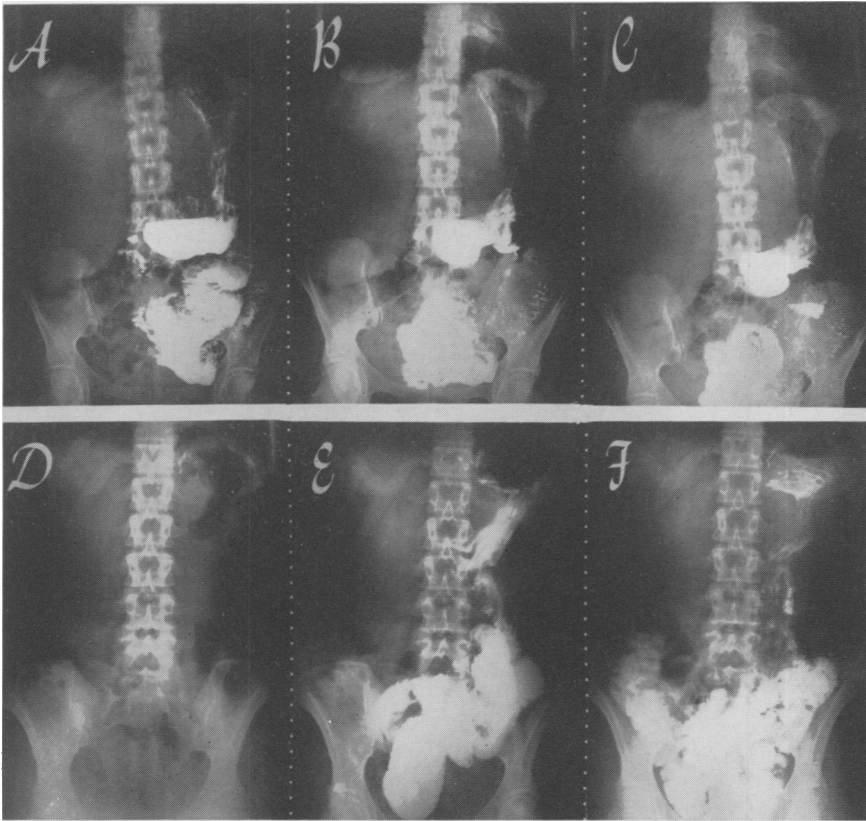


FIG. 9. Upright abdominal x-rays taken of two patients who had marked dumping symptoms and undernutrition. Patient M. D. had a vagotomy and large stoma gastrojejunostomy placed high on the greater curvature of the stomach and K. F. had a vagotomy and large stoma, gastrojejunostomy performed several years before the study. The x-rays were taken at the following intervals after ingestion of the barium food mixture: (A) 1, (B) 60, (C) 90, (E) 1 and (F) 15 minutes. X-ray D was obtained before the barium food mixture was given.

no known recurrence of an ulcer in the hemigastrectomized vagotomized patients included in this study when the entire antrum has been removed and a complete vagotomy performed.

Figure 9 (A, B and C) shows the x-rays taken 1, 60 and 90 minutes after the ingestion of the barium food mixture by a middle-aged woman who had a vagotomy and a gastrojejunostomy for a duodenal ulcer four years earlier. The x-rays show a rapid gastric emptying time although there is some puddling and stasis in the antrum. During the last few years the patient complained of abdominal pain, anorexia, weight loss, and severe dumping symptoms. Re-op-

eration six months ago revealed a gastric ulcer and a large gastrojejunal stoma located well above the most dependent portion or the greater curvature of the stomach (schematically represented in Fig. 1F). The distal 40 to 45 per cent of the stomach was resected and the gastrojejunal anastomosis was made considerably smaller. The patient now is achlorhydric, free of ulcer pain and dumping symptoms, and has gained 12 pounds since her second operation. Recent studies reveal a normal gastric emptying time and no symptoms after the ingestion of a hypertonic sugar solution.

Figure 9 (D, E and F) shows x-rays of a 37-year-old woman taken before, 1 and 15

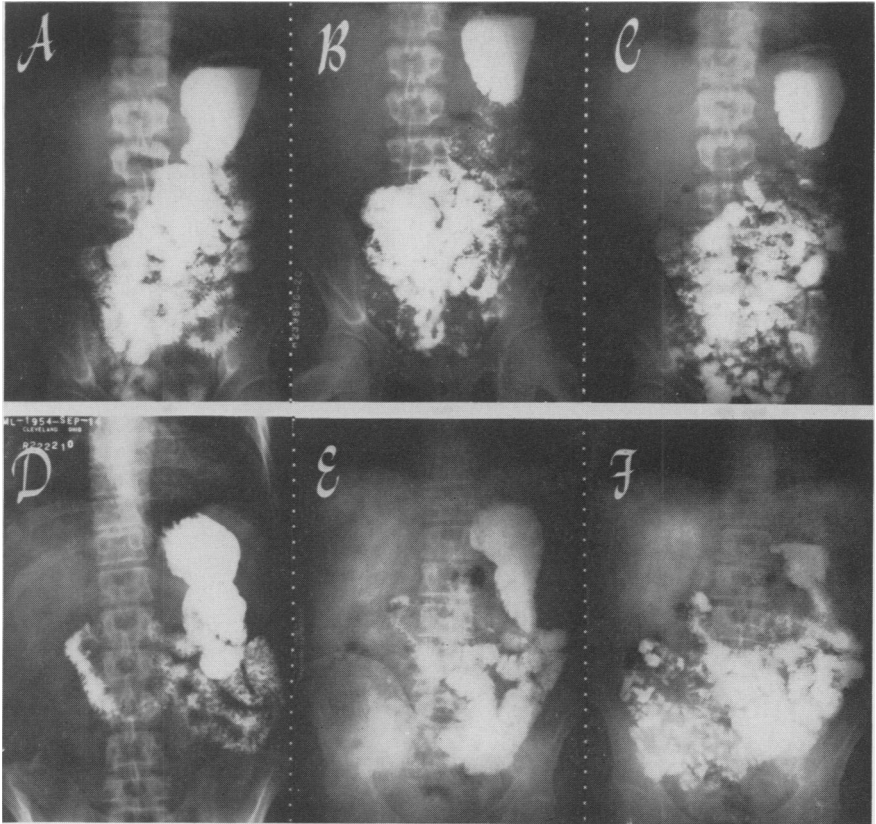


FIG. 10. Upright abdominal x-rays of two men, D. C. and J. S., who both had a 75 per cent subtotal gastrectomy and a small stoma gastrojejunostomy. X-rays A (1 min.), B (20 min.) and C (45 min.) are of patient D. C. who had the efferent limb of the jejunum attached to the greater curvature of the stomach. The x-rays of J. S., who had the efferent limb fixed to the lesser curvature side of the stomach, were taken at (D) 1, (E) 20 and (F) 90 minutes after the ingestion of the barium food mixture. Note that the efferent limb is filled with barium back to the first part of the duodenum.

minutes after the ingestion of the barium food meal. This patient had a vagotomy gastrojejunostomy seven years previously. A gastric analysis showed no free hydrochloric acid after 15 units of insulin intravenously. During the seven years prior to these studies she had frequent incapacitating diarrhea and vasomotor symptoms and had lost 50 pounds. The patient had been told by several different physicians that her problems were due to a psychoneurosis. Several months ago she was re-operated and a hemigastrectomy with a small stoma gastroduodenostomy was performed. Since operation she has been free of diarrhea and

dumping symptoms which previously were daily problems. Her complaints which were considered to be psychoneurotic in origin have disappeared.

Figures 10 and 11 show the x-ray studies of four men who had 60 to 75 per cent resections of the stomach and small stoma gastrojejunostomies. X-rays D, E and F in Figure 10 are those of a patient who had an antecolic gastrojejunostomy with the efferent limb to the lesser curvature (shown schematically in Fig. 2A). The other three patients had the efferent limb fixed to the greater curvature (Fig. 2B). Since their operations two to four years ago, all of these

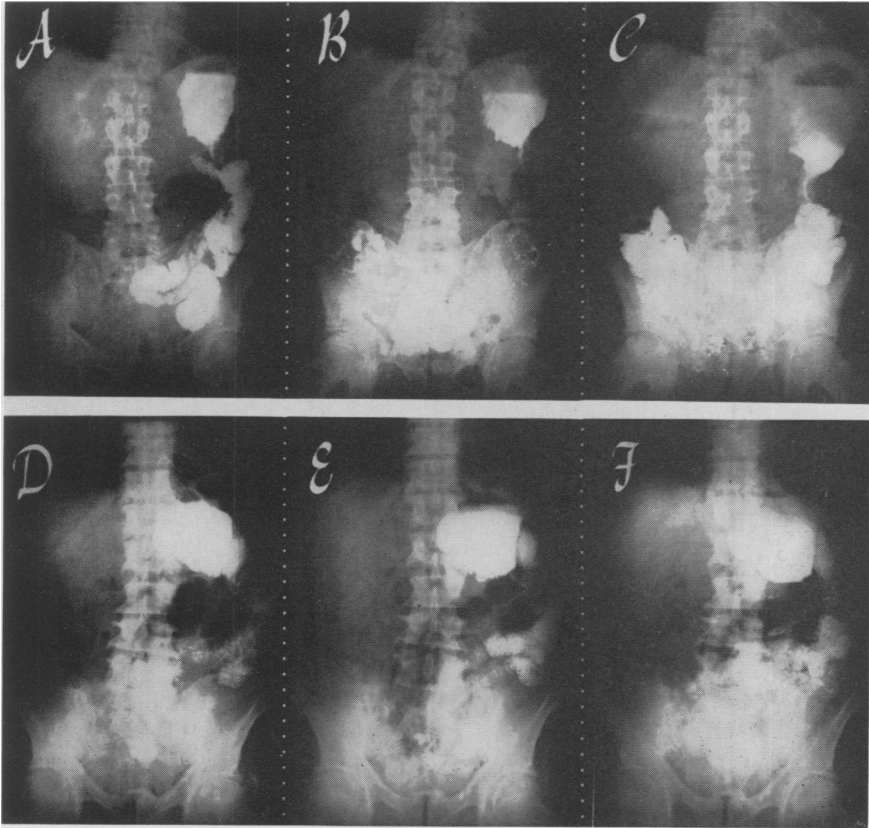


FIG. 11. Upright abdominal x-rays of S. S. and J. P. who had approximately three-quarters of the stomach resected and a small stoma gastrojejunostomy performed (efferent limb attached to the greater curvature of the stomach). X-rays A, B and C were taken 1, 45 and 90 minutes and films D, E and F at 1, 20 and 60 minutes after the ingestion of the barium food mixture.

patients exhibit moderately slow gastric emptying times, have maintained their weights and have been asymptomatic. In Figure 10 (D, E and F) the afferent limb can be seen to fill completely. However, unless there is stasis in the afferent limb because of a partial obstruction near the gastrojejunostomy no ill effects have been noted from this filling.

Figures 12 and 13 show the x-rays of four men who had subtotal gastrectomies with large stoma gastrojejunostomies. All of these patients have moderate to severe dumping symptoms unless they eat small amounts, avoid milk, ice cream and fluids with their meals, or lie down during or after eating. They are well under the range

of their expected normal weights and yet despite this and the periodic occurrence of severe dumping symptoms, they consider themselves better than they were before their operations.

When the patient whose x-rays are shown in Figure 12 (A, B and C) was given 150 ml. of a 50 per cent dextrose solution he developed palpitation, oligemic hypotension and passed a copious liquid stool. His plasma volume as measured by radioactive iodinated albumin showed a decrease of 35 per cent from the control value. His plasma volume decreased 12 per cent as a result of ambulation and an additional 23 per cent after he ingested the hypertonic solution. He also had a feeling of

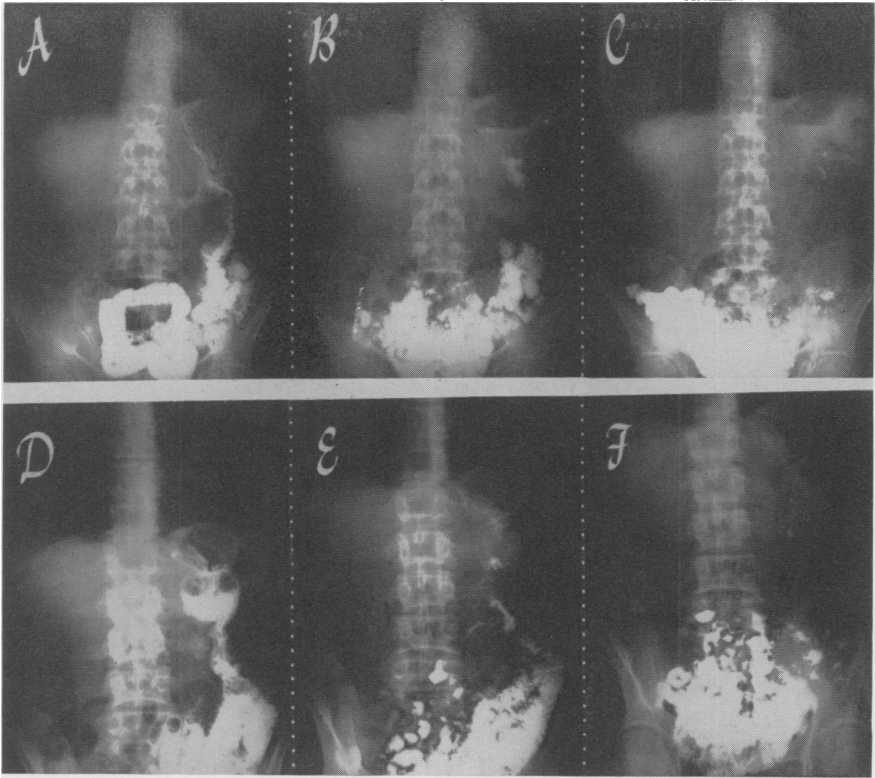


FIG. 12. Upright abdominal x-rays taken of B. P. and L. S. who both had approximately three-quarters of the stomach resected and gastro-intestinal continuity re-established by a large stoma gastrojejunostomy (the efferent limb was anastomosed to the greater curvature of the stomach in both cases). X-rays of B. P. were taken at (A) 1, (B) 20 and (C) 60 minutes after the barium food mixture, and of L. S. at (D) 1, (E) 20 and (F) 45 minutes after the barium food mixture.

warmth probably associated with peripheral vasodilatation which Hinshaw and his associates¹³ have demonstrated in patients who have a severe reaction.

The x-rays shown in Figure 13A, B and C are of a 130 pound, 6 ft. 2 inch man who had repeated episodes of pyloric obstruction prior to his operation. Although these x-rays show a moderately rapid gastric emptying time he has been able to continue working as an automobile mechanic. Normal quantities of nitrogen and fat were measured in his stool when he was maintained on a previously analyzed diet. Thus his state of undernutrition was not due to incomplete ingestion and absorption of fats and protein but resulted from an inade-

quate daily caloric intake (1,200 to 1,500 calories). C. V., a 58-year-old man whose x-rays are shown in the lower half of Figure 13 (D, E and F), also showed a moderately rapid gastric emptying time and the barium was in his cecum 20 minute after its ingestion. He stated that prior to his subtotal gastrectomy he had been able to consume two or three cocktails in approximately an hour, but since his operation this amount caused him to lose consciousness.

The x-rays shown in Figure 14 are those of a 35-year-old man and a 34-year-old woman following a hemigastrectomy vagotomy with a large stoma gastrojejunostomy. The man had filling of his afferent limb with stasis and anorexia. He was markedly

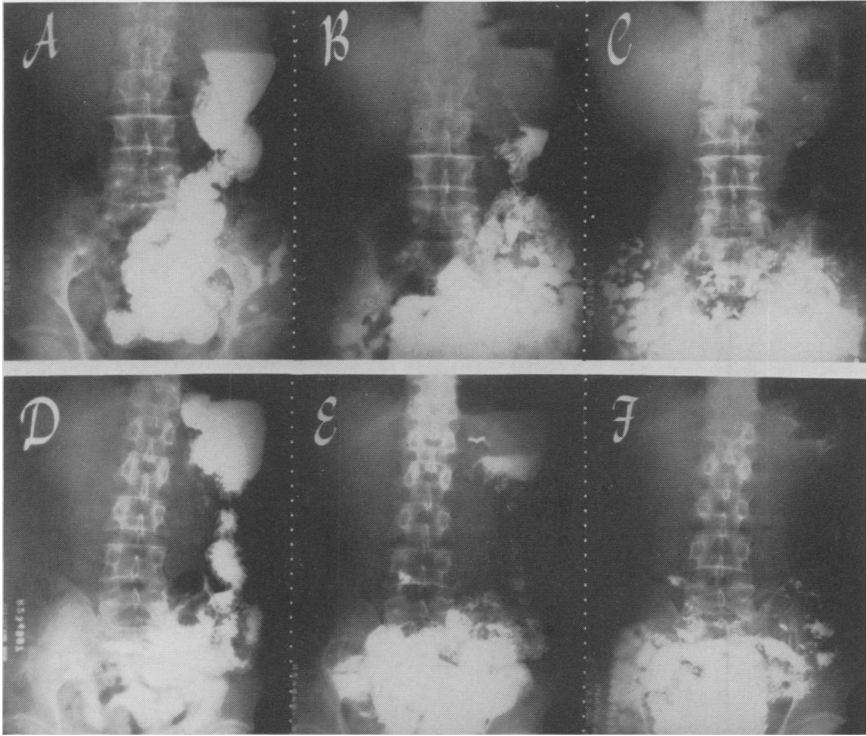


FIG. 16. Upright abdominal films of two patients who exhibited undernutrition and of C. V. (D) 1, (E) 20 and (F) 60 minutes after the ingestion of the barium food mixture. Both patients had approximately three-quarters of their stomachs resected four (F. V.) and 20 years (C. V.) before these examinations were made. A large stoma gastrojejunostomy with the efferent limb anastomosed to the greater curvature was performed in both instances.

undernourished and anemic. X-rays of the woman show that more fluid had accumulated in the stomach at 45 and 60 minutes (E and F) than was present at one minute (D) following the ingestion of the barium-food mixture. Since the gastric remnant was empty and subsequently fluid accumulated in it, this must represent gastric and/or duodenal secretions. It should be noted that barium entered the cecum within 20 to 45 minutes.

The x-rays shown in Figure 15A, B and C were those of a 48-year-old woman who regurgitated bile one to three times daily and only occasionally vomited bile and food. The afferent loop can be seen to fill readily but the barium and duodenal secretions after refluxing back into the stomach leave very slowly through the efferent loop.

Although a little barium has left the stomach the total amount of fluid in the gastric remnant appears to be as great or greater at 60 minutes (B) than at 20 minutes (A). the amount of barium in the stomach after 60 and 90 minutes (B and C) is greater than that noted in the normal volunteer (Fig. 3) at comparable intervals (D and E). The supernatant fluid which was regurgitated when a fluoroscopic examination of her stomach was being conducted was primarily bile. These x-rays demonstrate the rather rare but typical problem that exists in a patient with true biliary regurgitation (free flow of afferent loop contents into the stomach) with partial obstruction to the efferent loop. The partial efferent loop obstruction in this patient which was caused by kinking was demonstrated at a second

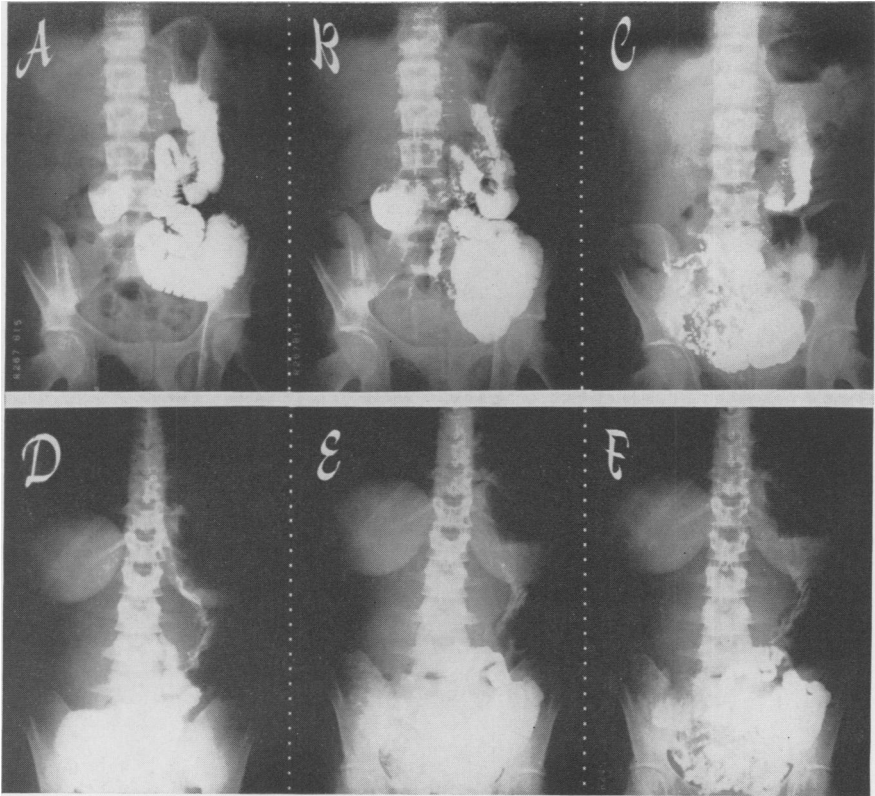


FIG. 14. Upright abdominal x-rays taken of two patients (J. R. and A. M.) who had a hemigastrectomy vagotomy with a gastrojejunostomy. The x-rays were obtained for J. R. (A) 1, (B) 20 and (C) 60 minutes after the ingestion of the barium food mixture. Note the filling of the afferent limb due to stasis in films A and B. The x-rays were obtained for A. M. at (D) 1, (E) 45 and (F) 60 minutes.

operation and is depicted schematically in Figure 2D.

The lower row of x-rays (D, E and F) were taken 10 days postoperatively following a hemigastrectomy vagotomy and a small stoma gastrojejunostomy. The patient had considerable difficulty eating soft and solid foods for several months postoperatively. Re-operation was considered but not undertaken because of previous similar experiences in other patients (W. E., Fig. 8). He was given nourishing liquids for almost a month and then gradually increased to soft foods and eventually a full diet. He lost over 10 per cent of his body weight during the first few months while on the liquid diet but now almost two years later

is back to his preoperative weight, and has a good appetite and no dietary restrictions. Recent x-rays show a more normal gastric emptying time.

Figure 16 shows the x-rays of two patients who were undernourished and had severe dumping symptoms which were not relieved by diet and medication. X-rays A and D were taken one minute after the ingestion of the barium food mixture during the initial work up of these patients. Both of these patients had large stoma gastrojejunostomies following a subtotal gastric resection as depicted schematically in Figure 2B. It was reported that each patient had 70 to 75 per cent of his stomach resected. The man (A. S.) whose x-ray is

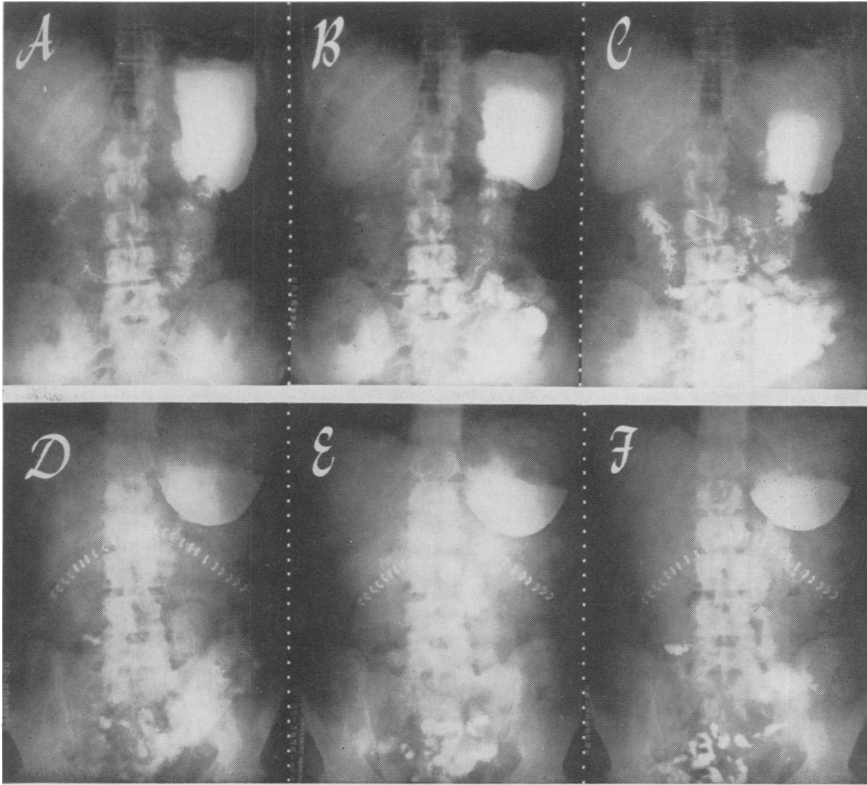


FIG. 15. Upright abdominal x-rays obtained from two patients who had a hemigastrectomy performed. C. B. (A, B and C) had approximately 70 per cent of the stomach resected and the continuity re-established by antecolic gastrojejunostomy (efferent limb to the lesser curvature of the stomach). The x-rays were taken at (A) 20, (B) 60 and (C) 90 minutes after the ingestion of the barium food mixture. Note the filling of the afferent limb and the delayed outflow through the efferent limb. This patient exhibited biliary regurgitation. Patient R. D. (D, E and F) had a hemigastrectomy vagotomy and small stoma gastrojejunostomy performed 10 days before this study was carried out. The x-rays were taken at (D) 20, (E) 45 and (F) 90 minutes after the patient ingested the barium food mixture.

shown in Figure 16A had a retrocolic gastrojejunostomy while the man (F.R.) whose x-rays are shown in Figure 16 D had an antecolic gastrojejunostomy. At re-operation a vagotomy and a small stoma gastroduodenostomy was performed on each of the patients. In closing the gastrojejunostomy a small additional segment of the stomach was resected and in spite of this it can be seen in the subsequent x-rays of A. S. (B and C) and F. R. (E and F) that the gastric remnants had dilated and now have a considerably greater storage capacity. These patients have gained weight, no longer

have symptoms associated with dumping or complaints which were believed to be of psychoneurotic origin.

Figure 17 (A, B and C) shows the x-rays of an undernourished patient who had severe dumping symptoms often culminating in unconsciousness. He had a hemigastrectomy vagotomy with a large stoma gastrojejunostomy (Fig. 2C). Again it should be noted that the stomach is empty one minute (A) after the ingestion of the barium food mixture and that the head of the barium column had entered the distal small intestine. Barium can be seen in the cecum

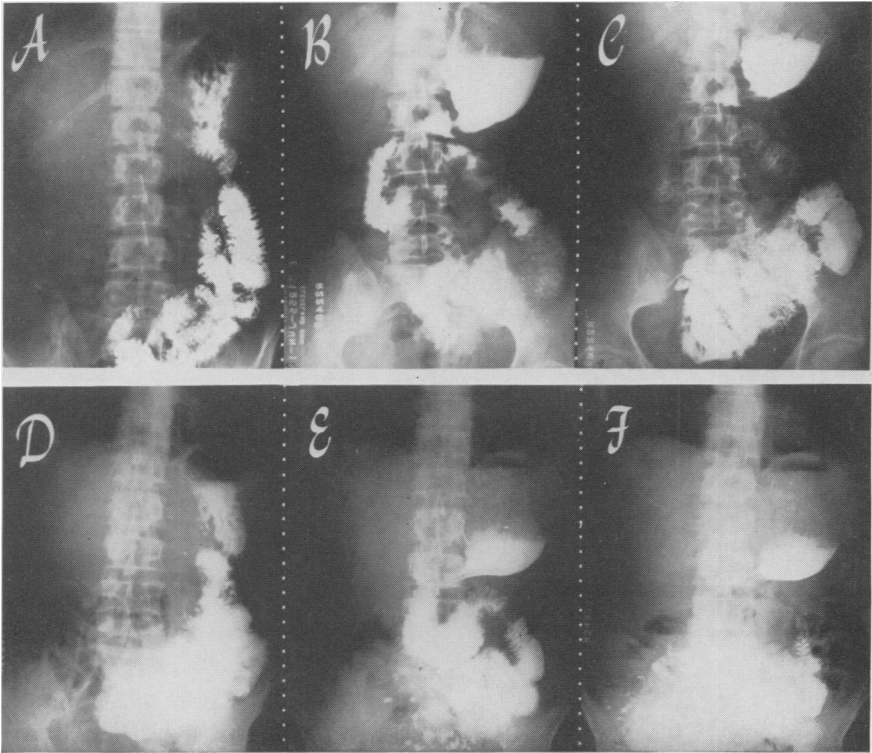


FIG. 16. Upright abdominal films of two patients who exhibited undernutrition and had severe dumping symptoms. They had approximately 75 per cent of the stomach resected and a large stoma gastrojejunostomy performed seven and three years previously. X-rays A (A. S.) and D (F. R.) were taken one minute after the ingestion of barium. X-rays B (one minute) and C (60 minutes) were taken approximately one year after A. S. was reoperated and a small stoma gastroduodenostomy was performed. In spite of the fact that a small segment of the stomach had been resected, the reservoir capacity was greatly increased. X-rays E and F are upright abdominal films taken of F. R. one minute (E) and 60 minutes (F) after the ingestion of the barium food mixture. Again the greater storage capacity and slower emptying of the stomach can be noted.

in 20 minutes (B). When he was maintained on a constant previously analyzed diet less than 10 per cent of the ingested nitrogen and fat was recovered in this patient's stool. He would take only 800 to 1,200 calories daily. This patient who normally should have weighed 130 to 136 pounds, weighed only 96 pounds. After reoperation and converting his anastomosis to a small stoma gastroduodenostomy, x-rays (Fig. 17D, E and F) show a much greater gastric reservoir capacity than previously existed. He has not had dumping symptoms and has gained 12 pounds during the first eight months after re-operation.

Figure 18 shows serial x-rays of two patients who had their entire stomach removed. The man whose x-rays are shown in A, B and C had an esophagojejunostomy (Fig. 2E) while the other patient (D, E and F) had a segment of transverse colon anastomosed between the esophagus and duodenum (Fig. 2F). Both patients show rapid passage of the ingested barium into and through the small intestine and have adjusted their dietary habits to avoid dumping symptoms. The first patient who was operated on over five years ago for a malignancy, has no evidence of recurrence. The second patient had a total gas-

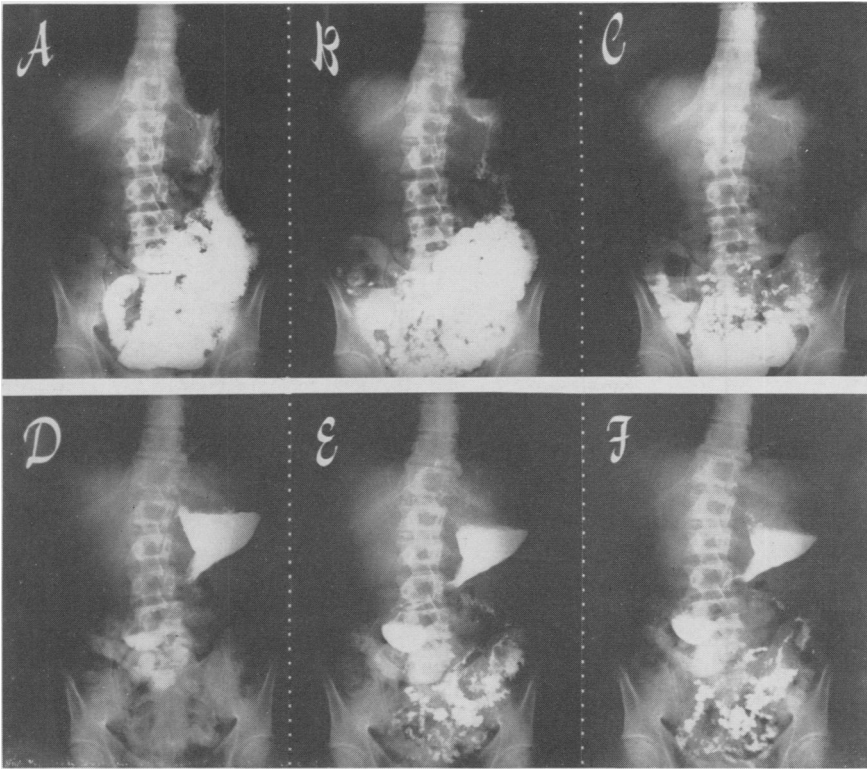


FIG. 17. Upright abdominal films A, B and C were taken at 1, 20 and 60 minutes after the ingestion of the barium food mixture by patient H. D. who had a hemi-gastrectomy vagotomy with a large stoma gastrojejunostomy (efferent limb to the greater curvature of the stomach) performed several years before. This patient had lost considerable weight and had marked dumping symptoms which improved after reoperation and conversion to a small stoma end to end gastroduodenostomy. X-rays D, E and F were taken after the conversion operation at 1, 60 and 120 minutes respectively.

trectomy because of a refractory microcytic anemia and hypoproteinemia which resulted from diffuse hypertrophic gastritis. Because the operation eliminated the source of the chronic blood loss she is no longer a bed invalid. Although she maintains a good nutritional state and avoids severe dumping symptoms by eating small amounts at frequent intervals in a recumbent position her present disabilities are considered to be minor in comparison to her preoperative problems. The x-ray study taken at 1, 20 and 60 minutes (D, E and F) after the ingestion of the barium food mixture shows that the segment of the transverse colon is not functioning as a "reservoir" in this patient.

Summary

Since the important observations of Hertz¹² 45 years ago there have been numerous articles^{1, 3-6, 8, 11, 13-15, 17-25, 28-34, 36-38, 40} which have contributed immensely to our understanding of the postgastrectomy abnormalities but few have pointed out any better than he did, the importance of a small stoma in the prevention of dumping symptoms and undernutrition. The primary etiologic factor causing the dumping signs and symptoms^{1, 4, 13, 21, 30} is now generally believed to be due to rapid flooding of the upper small intestine with recently ingested foods because of a failure of the material to be retained in the stomach. Vasomotor

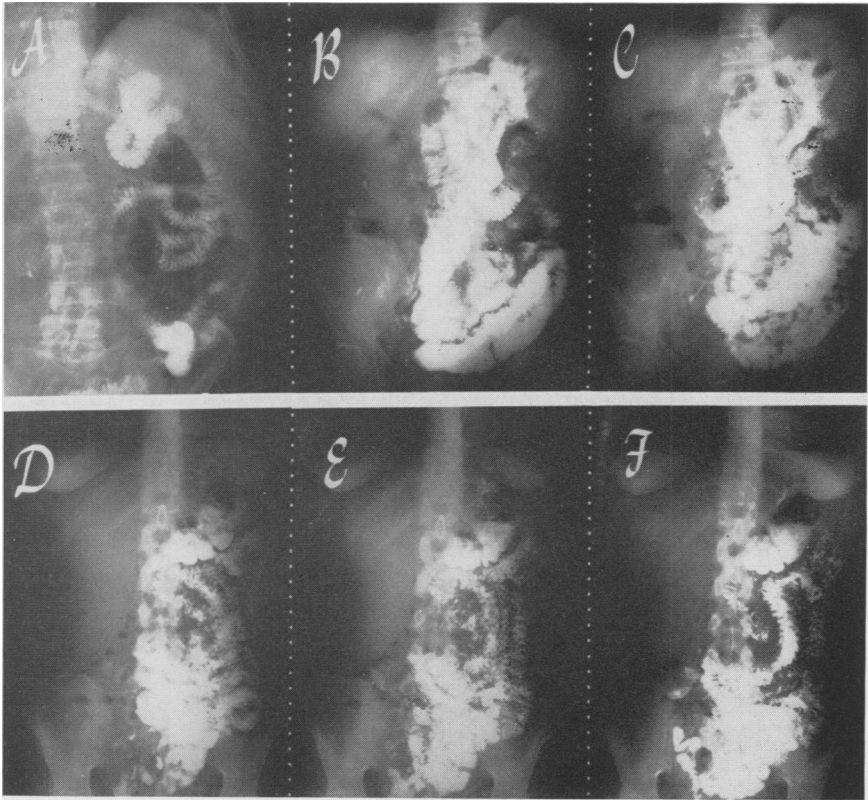


FIG. 18. Upright films of the abdomen taken immediately (A) after the ingestion of the barium food mixture and at (B) 10 and (C) 30 minutes later in S. R. who had a total gastrectomy (end-to-end esophagojejunostomy) several years before. Upright x-ray films of the abdomen were taken of P. V. at 20, 45 and 60 minutes after the ingestion of the barium food mixture. P. V. had a total gastrectomy for non-malignant disease two months prior to the time these x-rays were taken.

symptoms may occur or may be mild or absent if the patient is resting or recumbent.¹ Hinshaw and his associates¹³ have demonstrated that vasomotor symptoms may be mild or absent because some patients have a compensatory peripheral vasoconstriction with shunting of blood to vital organs when the plasma volume decreases. These patients may have anorexia a feeling of fullness or diarrhea especially when hyperosmolar fluids are ingested. These workers¹³ have also shown that the vasomotor signs and symptoms may be severe if a peripheral vasodilatation occurs with a decrease in the plasma volume (due to the rapid translocation of extracellular fluid into the gut).

The patients presented in this paper

demonstrate the fact that the functional stomal size is the primary factor in the development of dumping, signs and symptoms and undernutrition. Good, fair and bad results with respect to the occurrence of these undesirable postoperative sequelae have been shown in patients with gastroenterostomy and vagotomy and with subtotal gastrectomy and gastroduodenostomy or jejunostomy with and without vagotomy. In each instance the results can be correlated with the size of the anastomotic stoma and the rate of gastric emptying as shown by the barium food x-ray studies. The best results were seen in the patients who had a small stoma and a gastric emptying time which approximated that seen in the normal subjects. Patients with large stomata

had rapid emptying of food or barium into the upper small intestine (dumping). These patients exhibited the signs and/or symptoms associated with dumping or were able to avoid them by adjusting their eating habits.

It has also been pointed out that the diagnosis of dumping can only be made by determining the rate of gastric emptying. Latent symptoms associated with dumping may become evident after the ingestion of a hypertonic solution.

Several investigators have given barium food meals to postgastrectomized patients and reported that there was only slight³⁶ or no change^{27, 35} in the rate of gastric evacuation. One is not justified in assuming that a change in gastric emptying time is not possible following operation, since some of our patients and patients studied by others^{1, 4, 6, 10-12, 20, 22, 23, 25, 28, 29, 34, 37, 38} have shown a markedly accelerated rate of gastric emptying.

In the past some investigators^{6, 10, 15} have been unable to explain why an occasional patient is encountered who has a rapid gastric emptying time (dumping) but does not exhibit symptoms. Recent studies^{1, 13} have shown that there are many factors which govern the presence of absence as well as the type and severity of symptoms that may be associated with dumping. Distension and stasis in the stomach or afferent loop may produce symptoms that are comparable to those seen with dumping. The symptoms may be exaggerated or not effected when this type of patient assumes the recumbent position. The barium food x-ray studies is an objective method of differentiating the underlying cause.

Since the rate of recurrent ulceration following operative treatment for peptic ulcer is now quite small, attention should be focused on the avoidance of the other undesirable postgastrectomy or gastroenterostomy sequelae. Our studies over the past five years have shown that we have obtained the best overall results in patients

who had a hemigastrectomy vagotomy with a small stoma gastroduodenostomy.

The complete evaluation of the results of the various operations employed in the treatment of peptic ulceration should include the following examinations:

1) The rate of gastric emptying and small bowel transit time by roentgenography.

2) The patient's daily caloric intake estimated by means of a weigh-back diet.

3) Testing of patient for postprandial hypoglycemia and latent symptoms associated with dumping by the oral administration of hypertonic dextrose.

4) Blood counts, and if the patient is anemic its cause should be determined.

5) Gastric analysis with histamine and/or insulin stimulation.

Conclusions

1. After gastric resection or a gastroenterostomy the rate of the emptying of the stomach is primarily related to the size and position of the stoma. The presence of mucosal folds may alter the effective stomal size.

2. "Dumping" by definition refers to rapid gastric evacuation which may be associated with (a) anorexia which leads to a decreased food intake resulting in undernutrition, (b) vasomotor symptoms, (c) diarrhea. When symptoms associated with dumping are latent provocative tests should be employed in an attempt to demonstrate them.

3. The internal diameter of the stoma should probably not exceed two centimeters.

Acknowledgment

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We are also indebted to the following members of the staff of the Metabolic Division of the University Hospitals of Cleveland, Olga Savastenk, R.N., Head Nurse, Agnes Furman, R.N., Myrtle Edwards, R.N., Joyce Hofschild, R. N. and Evelyn Paul, dietitian.

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DISCUSSION

DR. R. F. BOWERS: Dr. Gilchrist, Gentlemen: This, I think, is an important piece of work which will help all of us who use gastrojejunostomy after gastric resection.

Most surgeons agree that the low ulcer recurrence rate after the Billroth II procedure is desirable, and that the employment of vagotomy as an adjunct to the resection in certain patients favorably influences the low recurrent ulcer rate. The literature tends to bear out this contention.

The only disadvantage with the gastrojejunostomy type of anastomosis lies in the postgastrectomy symptoms which apparently are increased, compared to other reconstructions.

Since 1950, we have been trying to do something about it. We did not want to yield to the urge of adopting the Billroth I operation, because our recurrent rate (less than 2%) was so good.

First, we still believe that good results following gastric resection for ulcer can be had in a large number of patients, only if the patient is properly selected for operation, regardless of the type of operation employed. The well-known indications must not be abused if we expect a high percentage of good postgastrectomy results.

It was apparent, as Dr. Abbott indicated, that rapid emptying of the stomach played a major role in the disagreeable symptoms and we decided to use a narrow stoma, attempting to slow the food stream and therefore lessen or prevent the symptoms.

A protocol was formulated as follows: one hundred peptic ulcer patients were subjected to gastric resection with gastrojejunostomy reconstruction, usually of the Hoffmeister type, but with the size of the stoma made small. During the same period of time, a control group of 100 peptic ulcer patients were subjected to the same procedure, but with the size of the stoma made large. The small stoma measured by the operator's index finger or thumb, proved to be 1.5 cm. to 2.5 cm. in length, versus the large stoma, which measured by several fingers proved to be 2.5 to 4.5 cm. in length. The same criteria for indications and all other phases of the handling of these patients were identical, as far as could be allowed in a clinical experiment of this type. Vagotomy accompanied the resection in about 50% of the patients in each group.

We ended with this state of affairs: 69% showed some postoperative obstruction of various degrees, while 31% showed no delay in gastric emptying. Fifty-nine of these obstructions were mild, temporary and required no difficult therapeutic efforts. Ten were considered to have a severe degree of obstruction. During the first 20 cases, we made the stoma too small, and I am sure that Dr. Abbott would warn us about that. It was necessary to re-operate and slightly enlarge 3 of these 10 stomas, with excellent results in 2 and fair results in the third one.

Here are some of the findings that we believe to be significant: