

Abnormal Small-Bowel X-ray Patterns Associated with Active Duodenal Ulcer

JAMES S. BERNSTEIN, M.D., VICTOR W. GROISSER, M.D.,
and LEWIS R. LAWRENCE, M.D.

DIFFUSE ABNORMALITIES in the roentgenographic appearance of the small intestine have been noted in a wide variety of functional and organic conditions. The following classification of these conditions is drawn from lists of several authors.¹⁻⁶

- I. Primary nutritional deficiencies
 - A. Avitaminoses
 - B. Primary malnutrition
 - C. Intestinal hookworm
- II. Secondary nutritional deficiencies
 - A. Malabsorption due to intrinsic small bowel disease
 - 1. Tropical sprue
 - 2. Nontropical sprue
 - 3. Celiac disease
 - 4. Regional enteritis
 - 5. Scleroderma
 - 6. Whipple's disease
 - 7. Tuberculous enteritis
 - B. Malabsorption due to small-bowel lymphatic obstruction
 - 1. Lymphoma
 - 2. Mesenteric adenitis
 - C. Digestive defects
 - 1. Chronic pancreatitis
 - 2. Mucoviscidosis
 - D. Malnutrition due to debilitating disease
- III. Metabolic disorders
 - A. Conditions associated with hypoproteinemia
 - 1. Nephrosis

From the Medical and Radiology Services, Veterans Administration Hospital, New York, N. Y.; the Department of Medicine, Cornell University Medical College; and the Department of Radiology, New York University School of Medicine.

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- 2. Malnutrition, primary and secondary
- 3. Protein-losing enteropathies
- B. Conditions associated with hypokalemia
- C. Hyperthyroidism
- D. Severe anemia
- E. Lead poisoning
- F. Porphyria
- IV. Autonomic disorders
 - A. Diabetic visceral neuropathy
 - B. Combined systems disease
 - C. Tabes dorsalis
 - D. Vagotomy
 - E. Sympathectomy
 - F. Delayed gastric emptying
 - 1. Previous fatty meal in normal patient
 - 2. Diabetic gastric atony
 - G. Cardiospasm
 - H. Emotional disturbances
- V. Miscellaneous intestinal diseases
 - A. Intestinal purpuras
 - B. Ulcerative colitis
 - C. Gastrointestinal allergy
- VI. Experimental causes
 - A. Autonomic drugs
 - 1. Ganglionic blocking agents
 - B. Changes in intestinal lumen contents
 - 1. Administration of fat, especially fatty acid
 - 2. Administration of hypertonic solutions (saline, bicarbonate, glucose)
 - 3. Administration of lactic or acetic acid
 - C. Induced hypoproteinemia (in animals)
- VII. Conditions associated with a qualitative or quantitative change in intestinal lumen mucus
 - A. ?Emotional disturbances
 - B. ?Group II A

Except for diseases having disseminated or multifocal lesions, these abnormalities tend to produce a rather characteristic pattern. The salient features of this pattern are: segmentation and coarse flocculation of the barium; dilatation of isolated loops; coarsening, widening, irregularity, or even obliteration of mucosal folds; and marked increase or decrease of the barium transit time through the small bowel. "Deficiency pattern" and "disordered motor pattern" have been extensively used to describe this

group of findings. The ambiguity of the terms reflects uncertainty of the etiology. For several years, one of us (L.R.L.) has observed these small-bowel abnormalities in patients with peptic ulcer. To our knowledge, active ulcer has not heretofore been listed among the conditions associated with this pattern.*

The purpose of this paper is to document the association of active peptic ulcer and abnormal small-bowel X-ray patterns and to report the results of experimental X-ray studies performed to elucidate the mechanism of these changes.

METHOD

One of the authors (L.R.L.) regularly reviewed the upper gastrointestinal X-ray series performed by the resident staff of the Department of Radiology at the Veterans Administration Hospital. Over an 18-month period, 37 cases with clinically active peptic ulcer disease and abnormal small-bowel patterns were selected for further study. All initial gastrointestinal X-ray series were performed with conventional U.S.P. barium. The small-intestine pattern was considered abnormal if one or more of the following was observed in the jejunum or the jejunum and ileum:

1. Segmentation of the distal or midportion of the barium column (Segmentation of the "tail" of the column was disregarded.)
2. Dilatation of separate intestinal loops, either widely spaced, or multiple
3. Coarse flocculation of barium
4. Thickening, widening, irregularity or obliteration of mucosal folds

Almost all of the selected cases fulfilled two or more of these criteria. A case fulfilling only one criterion was included in the study if the abnormality was unusually striking. Marked increase or decrease in barium transit time was not considered significant without other findings. During the 18-month period these features were not seen in normal patients.

A radiologic diagnosis of active peptic ulcer disease was made if an ulcer niche was demonstrated in the stomach, duodenum, or jejunum adjacent to gastroenterostomy; or if the classic picture of peptic inflammatory disease of the duodenum was seen—i.e., marked distortion and thickening of mucosal folds, and persistent spasm or a fixed pattern of deformity. Cases with equivocal findings such as "duodenal irritability" and "duodenitis, mild" were excluded. Twenty-five of the 37 patients were

*Under the subheading "Secondary Nutritional Deficiencies," Golden¹ includes chronic peptic ulcer in a list of causes of "disordered motor pattern." The listing is not amplified or documented in the text but it seems reasonable to infer that the small-bowel changes are considered directly related to malnutrition rather than to ulcer disease itself. Our patients were well nourished and had no chronic wasting disease.

available for re-examination when they were symptom-free or markedly improved. They were restudied with the same U.S.P. barium mixture used for the initial X-rays. In 13 of the 37 patients, an additional small-bowel X-ray series was done with nonflocculant barium* 2-8 days after an abnormal intestinal pattern was demonstrated by a conventional U.S.P. barium study. The proportion of solid to liquid was the same in the U.S.P. barium and nonflocculant barium mixtures.

The clinical record of every patient was reviewed to discover any association of the X-ray findings and the symptoms or therapy of the patient. Also, the clinical data and symptom pattern of the entire group was studied to determine whether small-bowel abnormalities were associated with a special segment of the ulcer-bearing population or with any recognizable variant of the ulcer syndrome. Cases with inadequate clinical data were excluded.

RESULTS

Thirty-seven patients with unequivocal peptic ulcer disease had definite abnormal small-bowel patterns and sufficient available clinical information for study during the 18-month selection period. Thirty-six of the patients were male, an expected proportion in a veterans' hospital. Thirty-six patients had a duodenal ulcer and one had a marginal ulcer after gastroenterostomy for duodenal ulcer. We did not find any patients who had a gastric ulcer and an abnormal small bowel on X-ray. The age range was 25-69 years, with a mean of 42. The duration of symptoms varied from 4 days to more than 25 years.

Five patients had a history of upper gastrointestinal bleeding manifested by tarry stools in all 5 and by hematemesis in one. In none was the bleeding severe enough to require blood transfusions. Since blood in the intestine can alter motility and X-ray pattern, it is important to note the interval between the last tarry stool and the gastrointestinal X-rays showing small-bowel abnormalities. This interval varied from 5 to 12 days.

Retrospective analysis of the clinical records yields no basis for suspecting that the group spectrum of disease severity differed perceptibly from any random inpatient group of ulcer patients. Moreover, in attempting to discern any recurring atypical clinical features, we were impressed by the regularity with which a classic ulcer syndrome appeared in the histories. As noted above, neither malnutrition nor marked weight loss were mentioned as a clinical problem. In seven cases in which the serum albumin was determined, it was normal. Clinical signs of vitamin deficiency were not apparent in any patient. Neither diarrhea nor constipation

*Micropaque, Damancy & Co., Ltd., Ware Herts, England.

were mentioned. No evidence was found for the coexistence of other conditions capable of producing this type of abnormal small-bowel X-ray pattern. In 4 patients, however, the X-ray pattern was so disturbed that diagnoses of intrinsic small-bowel disease were considered (Fig. 1 is one example). In all four, the X-ray appearance improved or reverted to normal on re-examination.

Because of the observation that abnormal small-intestine patterns occur in association with transient severe emotional stress,^{4,7} a particular search of the records was made for written evidence of such phenomena. No evidence of any striking emotional stress was found. Admittedly, the clinical records of a general hospital do not often contain sufficiently detailed personal history notes for our purpose. Equally important, even if one had more personal information, the difficulties in assessing the patient's emotional state at the time of X-ray examination would still be prohibitive. Four of the 37 patients had been admitted to a psychiatric service at one time or another. Two of these suffered a schizophrenic reaction 5 and 8 years previously. One patient was on the psychiatric service at the time of study with a diagnosis of "severe anxiety reaction." Three other patients were considered to have "acute anxiety."

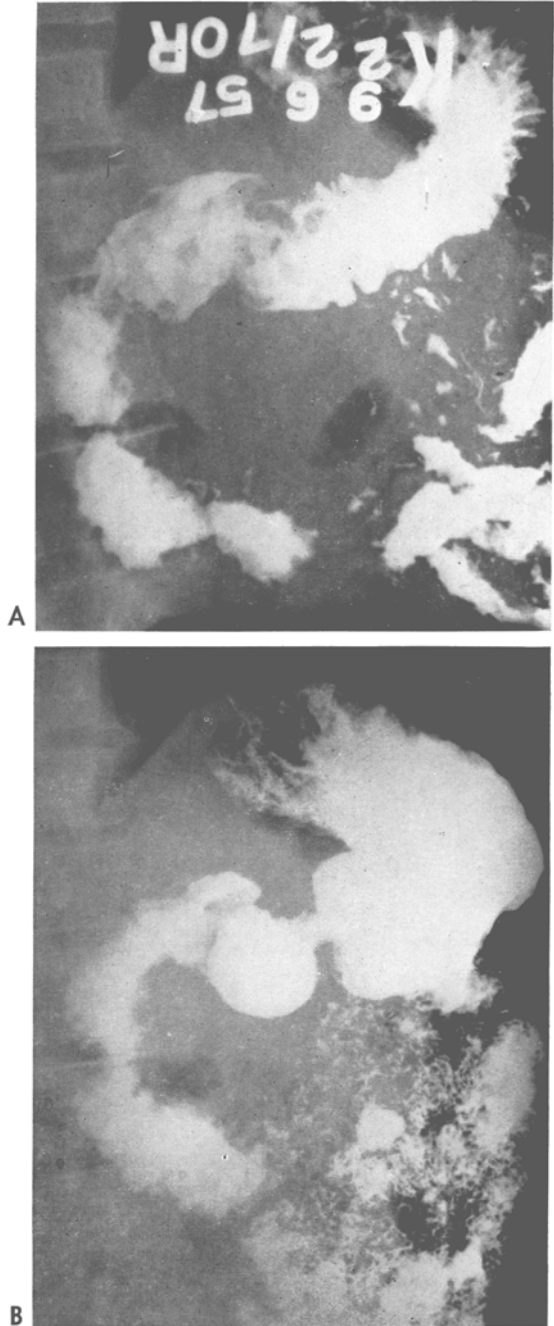
The temporal relation of ulcer symptoms to abnormal small-bowel patterns found in X-ray studies with U.S.P. barium sulfate is presented in Table 1. Of the 25 patients examined more than once with a U.S.P. or conventional barium mixture, 23 had concomitant correction or marked amelioration of the abnormal small-bowel pattern and relief or marked improvement of symptoms. The improvement was attained in 18 of the 23 during standard medical management, and in 5 after subtotal gastrectomy. Seventeen of the 18 had pain and one had painless bleeding. Of the 5 whose pattern improved after operation, 2 were operated on for intractable pain and 3 for recurrent bleeding. Twelve patients were ex-

TABLE 1. RELATION OF ABNORMAL SMALL-BOWEL X-RAY PATTERNS TO IMPROVEMENT OF ULCER SYMPTOMS

Twenty-five patients examined twice with conventional U.S.P. Barium Mixture.

	<i>No. of patients</i>
Abnormal pattern present when symptomatic	
Pattern improved or normal when patient better or well	18
Pattern improved or normal after subtotal gastrectomy (patients clinically well)	5
Pattern persisting when patient improved or well	1
Abnormal pattern not present when patient very symptomatic, but appeared when patient improving.	1
TOTAL	25

Fig. 1A. Thirty-four-year-old Negro male admitted with 10 days of abdominal pain and hematemesis on day of admission. Patient had many previous admissions for tuberculosis of cervical glands, tuberculous arthritis, and pleuritis. This study, 5 days after admission, shows marked coarsening and distortion of mucosa of antrum and duodenal bulb. Remainder of duodenum and jejunum shows gross disturbance in mucosal pattern. A diagnosis of tuberculous enteritis was entertained but patient was first treated for ulcer. **B.** Patient responded to ulcer regimen. This study, performed one month later, still shows polypoid changes in duodenal bulb, but small-bowel pattern has largely reverted to normal. Both studies done with conventional barium.



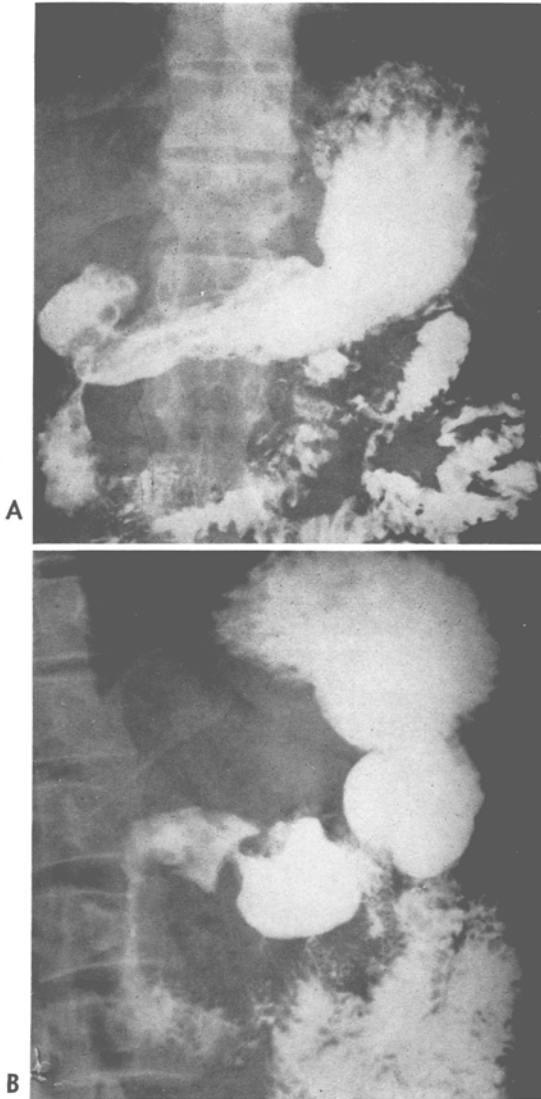


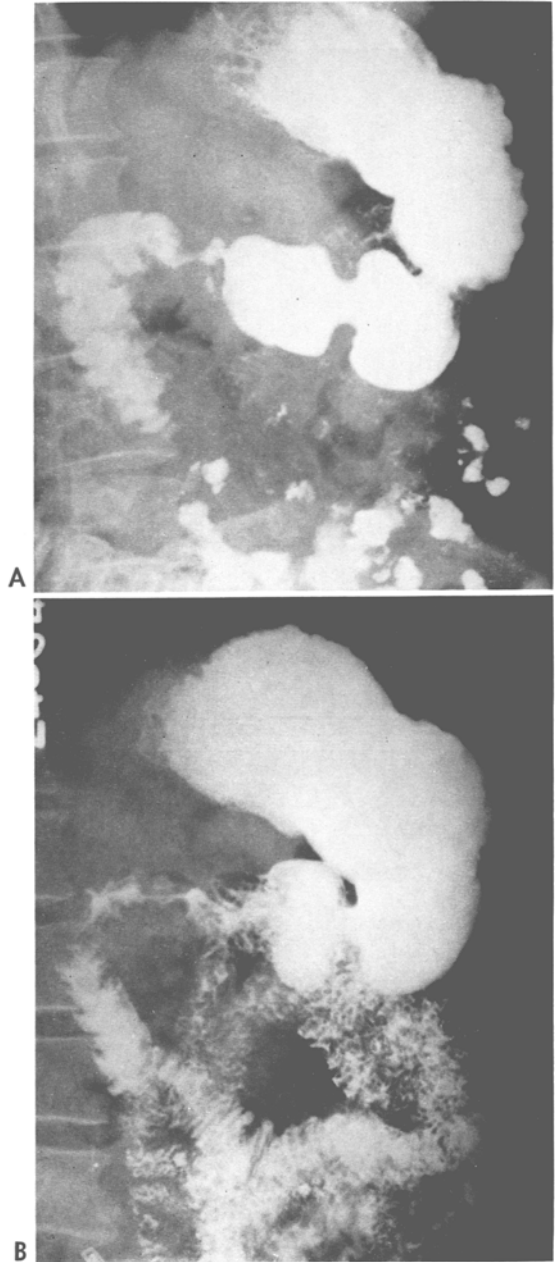
Fig. 2A. A 42-year-old man with 12-year classic ulcer story and deformed apex of bulb having pain when study was done. Segmentation, distortion and loss of normal mucosal pattern are seen in jejunum. **B.** Same patient admitted 3 months later for unrelated complaint; no gastrointestinal symptoms. Duodenal irregularity still present, but small-bowel pattern normal. Both studies made with conventional barium.

amined only once with conventional barium. Eleven of these had pain at the time of the X-ray examination and one had had recent bleeding. Six of the 12 were later examined with nonflocculant barium.

X-ray improvement concurrent with symptomatic improvement is demonstrated in Fig. 1-4. Improvement in the X-ray pattern after surgery for ulcer is illustrated in Fig. 4 and 5. One of the four cases in which the

Small-Bowel X-ray Patterns

Fig. 3A. Sixty-year-old man with 4 days of epigastric pain relieved by food. No previous gastrointestinal symptoms. Deformity of bulb clearly seen. In small bowel there is marked segmentation, irregularity of calibre, and loss of mucosal pattern. There was no delay in gastric emptying. **B.** Same patient called for a repeat examination when feeling perfectly well. Deformed bulb again noted but small-bowel pattern normal. Both studies made with conventional barium.



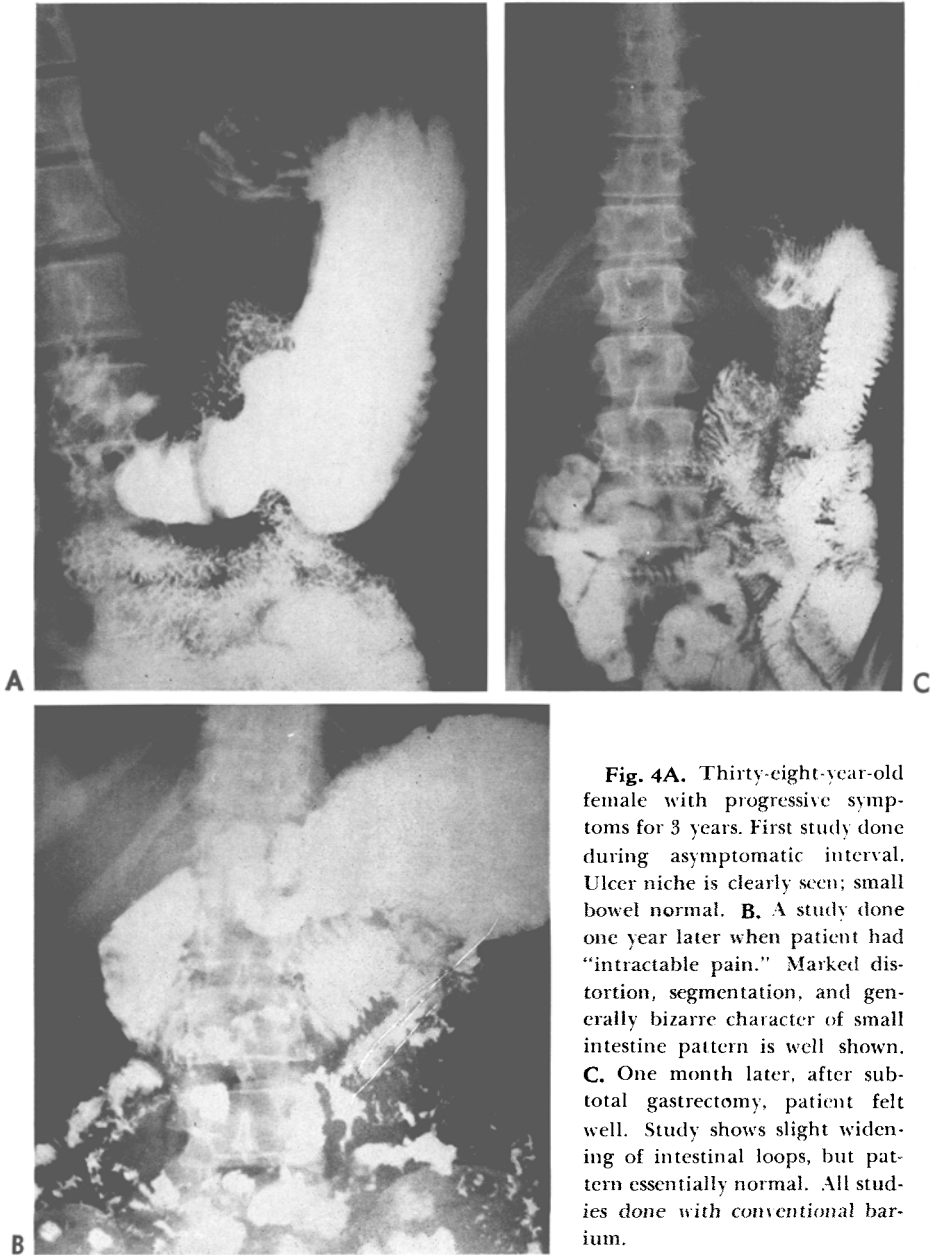


Fig. 4A. Thirty-eight-year-old female with progressive symptoms for 3 years. First study done during asymptomatic interval. Ulcer niche is clearly seen; small bowel normal. **B.** A study done one year later when patient had "intractable pain." Marked distortion, segmentation, and generally bizarre character of small intestine pattern is well shown. **C.** One month later, after subtotal gastrectomy, patient felt well. Study shows slight widening of intestinal loops, but pattern essentially normal. All studies done with conventional barium.

changes were of such severity that a diagnosis of intrinsic small-bowel disease was considered is shown in Fig. 1.

Thirteen patients with active peptic ulcer and abnormal small-bowel patterns seen on conventional barium studies were restudied within 8 days with a nonflocculant barium mixture. Previously, 6 of the patients had had one examination and 7 had had two examinations with U.S.P. barium. In all 13 patients, the appearance of the small-bowel studied with Micropaque was normal or only minimally altered. In 4 instances the improvement with Micropaque coincided with clinical improvement. In 7 patients with initially abnormal small-bowel patterns, there was no significant change in clinical status between the conventional and Micropaque studies. In all of these 7, the X-ray pattern was clearly improved in the Micropaque study. The improvement in such patients is illustrated in Fig. 6 and 7.

DISCUSSION

The abnormal small-intestine X-ray pattern described in the introduction was initially reported in association with diseases considered caused by dietary deficiencies. A full discussion of the background of the deficiency theory of pathogenesis was given by Ettinger.³ An experimental study on the role of dietary deficiency by Barden *et al.*⁸ showed that lowering the serum protein of dogs produced delayed barium transit time and abnormal X-ray patterns. More recent knowledge, however, has made it clear that the common factor in the growing list of diseases manifesting this pattern could not be dietary deficiency. Nevertheless, the term "deficiency pattern" is still used. The dominance of the deficiency theory 25 years ago led Mackie and Pound⁹ to ascribe small-intestine X-ray changes in 29 of 37 cases of ulcerative colitis to nutritional defects. Although little evidence is now available to support the belief that dietary deficiency is of prime importance in ulcerative colitis, it would be well to re-explore these findings in terms of possible changes in serum protein or in small-bowel motility or contents.

It seems most unlikely that any appreciable dietary deficiency in general or hypoproteinemia in particular was present in our group of generally healthy patients.

Considerable attention has been devoted to the possibility that abnormal motor phenomena are responsible for this pattern. A thoughtful discussion of the theoretical and experimental basis for this theory was presented by Golden.¹ Direct evidence of motor changes is scant. There is, however, evidence that interruption of an autonomic pathway may be associated with abnormal small-bowel X-ray patterns. The inference is drawn that the abnormal pattern seen with such autonomic interruption is probably

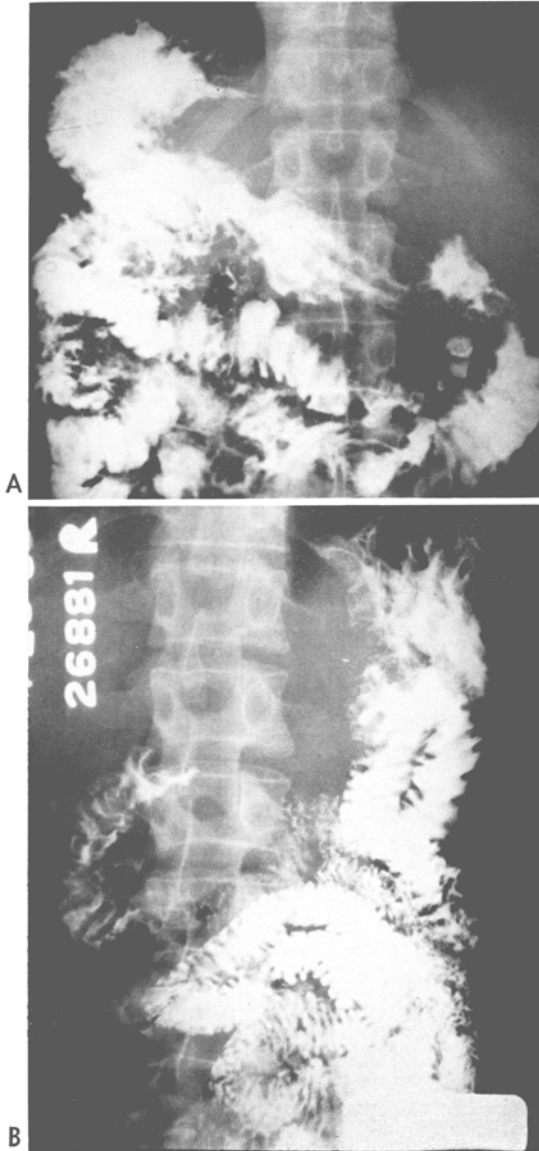
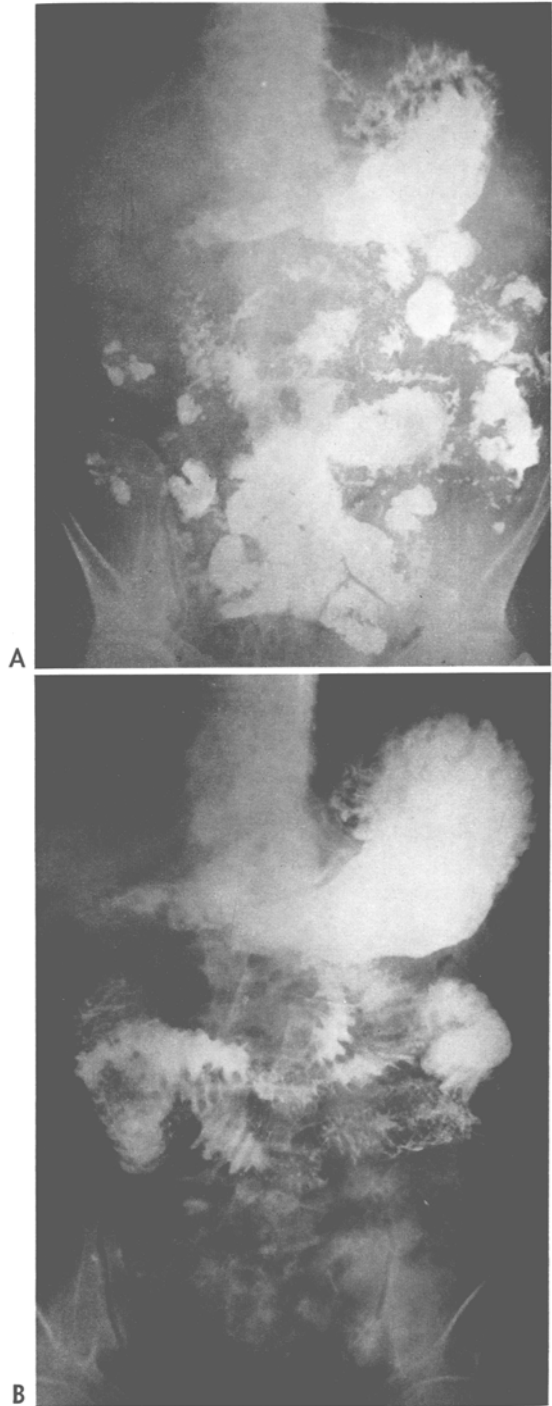


Fig. 5A. Forty-two-year-old Negro male with "intractable" duodenal ulcer. (In this picture, right and left are reversed.) Duodenal bulb was persistently deformed. Small bowel reveals lack of symmetry of folds, irregularity in lumen calibre and in valvulae conniventes. **B.** After surgery, minimal coarsening of folds in juxtastomal loops are seen but over-all pattern is normal. Patient was free of pain. Both studies done with conventional barium.

mediated through motor changes. Hodges *et al.*¹⁰ described this pattern in some patients with various neurologic diseases and in others after vagotomy and sympathectomy. The common denominator in these patients presumably was the interruption of sympathetic or parasympathetic pathways to the small intestinal musculature. Another observation supporting a role

Fig. 6A. Conventional barium study of symptomatic patient. Marked disorganization of small-bowel pattern evident with flocculation, segmentation, and loss of mucosal detail. **B.** Micropaque study on same patient 6 days later. No significant change in patient's symptoms. Although some irregularity in height of folds persists, there is no segmentation or coarse flocculation.



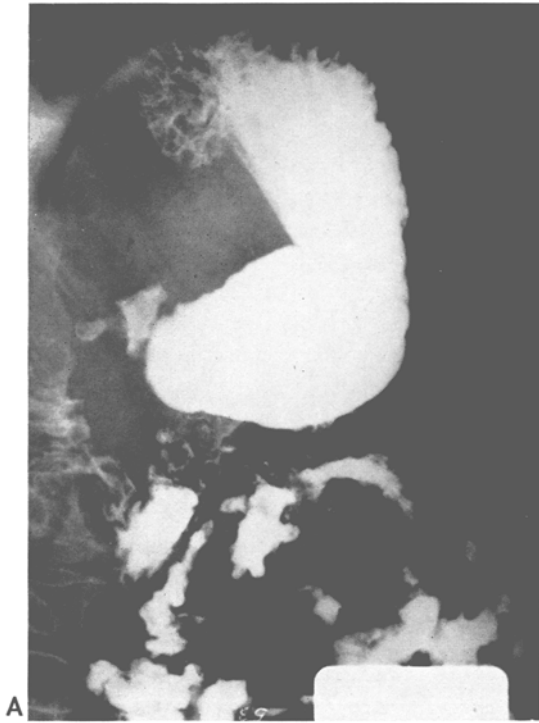
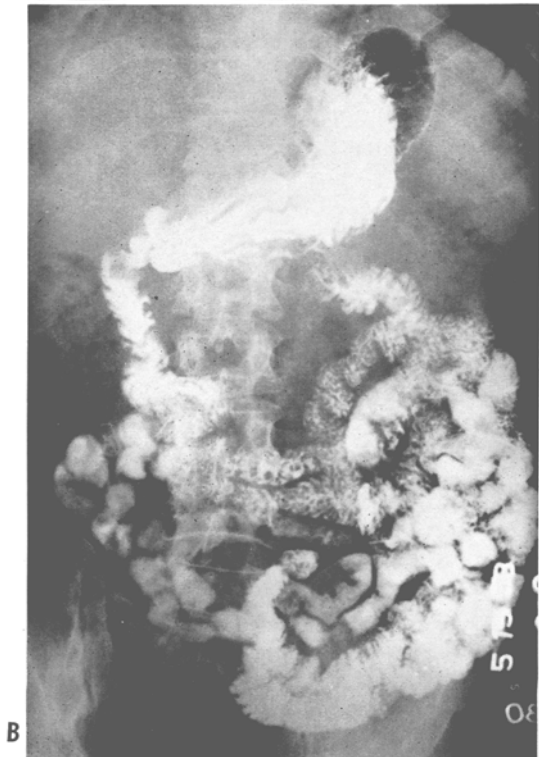


Fig. 7A. Conventional barium study of symptomatic patient. Duodenal deformity and niche demonstrated. Small intestine shows bizarre clumping with total loss of normal mucosal pattern. There is no delay in gastric emptying. **B.** Micropaque study one week later when patient was comparably symptomatic. Duodenal bulb is unchanged, but small-bowel pattern is now normal.



for autonomic interruption in the pathophysiology of this pattern was made by Ingelfinger and Moss,¹¹ who obtained data suggesting loss of myenteric plexi in sprue. It is not known whether loss of these plexi is a constant feature of those sprue patients who exhibit abnormal small-bowel X-ray patterns.

In our group of peptic ulcer patients we have no data on possible autonomic pathway derangement.

Abnormal small-bowel patterns associated with acute emotional disturbances have been reported by Goin⁷ and Friedman.⁴ Data relating motility changes in the small intestine to emotional reactions¹² may be interpreted to suggest that these X-ray changes may be caused by altered intestinal motility. To evaluate the role of altered motor activity in the pathogenesis of abnormal small-intestine X-ray patterns and, indeed, to study small-bowel motor function in general, it is necessary to try to isolate the variable of emotion. Emotional artifacts of discomfort and cumbersome apparatus, which have often been unavoidable in methods of obtaining intraluminal pressure data, may be largely eliminated by a radiotelemetering system.¹³ By this method, striking differences in small intestinal intraluminal pressure records have been observed in patients with "functional" symptoms compared with "normal" patients.¹⁴ Pressure data obtained in such a manner may eventually help answer the question of whether small-bowel motor dysfunction occurs in duodenal ulcer disease and whether this dysfunction contributes to the abnormal X-ray pattern we have described. Moreover, intraluminal pressure data, obtained in a near-basal state, would be desirable to assess directly the possible "small-bowel motor dysfunction" presumed present in many of the conditions listed at the beginning of this article.

A much different approach to the pathogenesis of this abnormal X-ray pattern has been based on the effects of changes in intestinal contents. Early observations by Snell and Camp¹⁵ and Kantor¹⁶ stressed the importance of large amounts of unabsorbed fat in the gut lumen. Adding olive oil to barium produced the familiar abnormal pattern.¹⁷ It should be noted, however, that the effect of neutral fat could be related to slowed gastric emptying caused by fat in the intestine. To avoid any small-bowel X-ray changes which might be due to variation in gastric emptying, Frazer *et al.*⁵ studied the effects of a number of substances introduced into the intestinal lumen. In studying the effects of fat, they found, in contrast to Pendergass *et al.*,¹⁷ little change in pattern when olive oil was introduced but marked changes when products of hydrolysis of long-chain fatty acids were present. This observation may explain why an abnormal small-bowel pattern is a less prominent feature of patients with biliary obstruction than in sprue where fat digestion is normal but absorption is defective. Frazer

and co-workers also found that hypertonic saline, bicarbonate, and glucose all caused marked segmentation of the barium column without the other features of the pattern we have described.

More recently, the degree to which various intestinal contents tend to aggregate and cause gross flocculation has been studied as a factor in the genesis of abnormal X-ray patterns. Kirsh and Spellberg⁶ studied patients with conventional barium and with the addition of carboxymethyl cellulose, a compound which was found to prevent flocculation *in vitro*. They found that this substance corrected abnormalities they had discovered in normal patients but did not correct the abnormal patterns encountered in patients with pancreatic steatorrhea or ileitis. Zimmer¹⁸ found improved mucosal detail when using a nonflocculant barium mixture, one which he had previously shown to sediment much more slowly than conventional barium with intestinal juice *in vitro*. Frazer *et al.*⁵ believed *in vivo* flocculation may have been the cause of abnormal patterns produced by substances which did not cause flocculation *in vitro*, such as hypertonic solutions. They thought these substances may act *in vivo* by stimulating secretion of intestinal mucus which, in turn, flocculates the barium. Knoefel *et al.*¹⁹ observed that quality of mucosal visualization deteriorates above a critical particle size of barium. Moreover, the greater the volume ratio of gastric juice and mucin to barium, the poorer the visualization.

As a preliminary conceptual scheme of pathogenesis, it would appear that the X-ray picture of "disordered motor pattern" of the small bowel is the nonspecific resultant of varying contributions of the following components: alterations in the physicochemical state of intestinal contents causing agglomeration of barium contrast media; disturbances in intestinal motor function causing irregularities of lumen calibre and distortion of mucosal folds; and diffuse structural changes in the mucosa and submucosa.

Our data with the use of a nonflocculant barium mixture suggest that agglomeration is an important factor in the genesis of abnormal small-bowel X-ray patterns in peptic ulcer patients. Micropaque corrected the abnormality in every instance. The nature of the physicochemical conditions which cause flocculation of U.S.P. barium in these patients is not clear. Nor, moreover, is it apparent why these conditions seem to be related to the presence of symptoms. It is possible that some peptic ulcer patients, particularly when symptomatic, present large increments of gastric mucus to the small intestine. It is also possible that the intestine itself at times, perhaps as a result of a functional disturbance of autonomic pathways, produces excessive or qualitatively altered mucus. The answers to these questions lie in areas of small-intestine physiology in which current knowledge is sparse.

The discussion of the roles of motility, emotion, and intestinal contents in pathogenesis provides background for a return to the problem of nomenclature. The term "deficiency pattern" is so limited in scope that in only a few of the conditions listed at the beginning of this article is dietary deficiency likely to be a significant factor in the genesis of the abnormal pattern. The term "disordered motor pattern" does not include agglomeration of intestinal contents and barium. It is clear that in most of the conditions listed, more than one of the factors just discussed are probably operative in pathogenesis. A new descriptive term for the pattern common to all these conditions is needed to fit a multiple-factor concept of cause.

CONCLUSION

1. The association of unequivocal active peptic ulcer disease with the abnormal small-bowel X-ray pattern commonly known as "disordered motor pattern" is documented in 37 cases. The association has not been previously reported. These X-ray changes can be severe enough to suggest the presence of intrinsic small-bowel disease.

2. Marked improvement of the abnormal small-bowel pattern concurrent with relief of symptoms occurred in 23 of 25 patients examined more than once with a U.S.P. barium mixture.

3. Thirteen patients were restudied with nonflocculant barium. The abnormal pattern was corrected in every patient. In seven instances correction was obtained though the patient was still symptomatic.

4. Current knowledge relevant to the pathogenesis of this pattern is reviewed and the application of this knowledge to our group of patients is discussed.

187 Hempstead Ave.
Rockville Centre, L. I., N. Y.

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