MALABSORPTION SECONDARY TO MESENTERIC ISCHEMIA*

By MORTON A. MEYERS, M.D.,† NEIL KAPLOWITZ, M.D.,‡ *and* ALAN A. BLOOM, M.D.§
NEW YORK, NEW YORK AND BRONX, NEW YORK

THE clinical features of the syndrome of abdominal angina due to vascular insufficiency of the intestines are well recognized. In 1958, Shaw and Maynard[34] first directed attention to the association of malabsorption with intestinal ischemia. Further experience has shown that malabsorption may be the initial or the dominant feature of the clinical presentation. Early recognition of the presence of chronic mesenteric ischemia underlying such cases of malabsorption is imperative in order to avoid catastrophic infarction of the intestine. Surgical advances have now rendered most of these arterial occlusions remediable.

The most definitive diagnostic evaluation is accomplished by abdominal aortography. Certain clinical and roentgenographic features may be helpful in the selection of patients with malabsorption for aortography to delineate the sites of arterial occlusion.

REPORT OF A CASE

This 62 year old white male was admitted with a history of diarrhea and a 70 pound weight loss over the past 15 months. Watery brownish bowel movements alternated with bulky yellowish stools. Some abdominal distention, occasional vomiting and frequent eructation were noted. Generalized abdominal discomfort began 4 months prior to admission, becoming principally epigastric and postprandial, occurring especially 20–30 minutes after meals. This led to sitophobia and the ingestion of frequent small meals. Weight loss had advanced, particularly over the previous 3 months.

Physical examination revealed a cachectic male with angular stomatitis. Blood pressure was 120/80 mm. Hg. No abdominal bruit was present. Femoral pulses were intact but the posterior tibial and dorsalis pedis pulses were not palpable The remainder of the physical examination was within normal limits. Stools were negative for occult blood, ova and parasites. Smear of a random stool revealed the presence of numerous fat globules. White blood cell count was 12,000/ml.^{3}. Blood sugar, blood urea nitrogen, electrolytes, calcium, phosphorus, alkaline phosphatase, amylase, serum albumin and globulin, total and direct bilirubin, serum cholesterol, thymol turbidity, lactic dehydrogenase, and urinalysis were all within normal limits. Electrocardiogram showed changes compatible with an old inferior wall infarct. Chest roentgenogram and a barium enema study were normal.

The clinical impression of malabsorption was confirmed by a radioactive triolein study demonstrating excretion of 50.5 per cent of the administered dose of labeled fat in a pooled 72 hour stool collection (normal: <5 per cent). Less than 6.6 per cent of the administered I^{131} label appeared in the urine within 24 hours.

An upper gastrointestinal and small bowel series, utilizing a colloidal barium suspension, demonstrated a "sprue-like pattern," characterized principally by dilated jejunal loops, segmentation, and a transient ileal intussusception (Fig. 1, *A–C*). No hypersecretion was present.

Further studies of intestinal absorption were initiated and abdominal aortography was considered. On the twelfth hospital day, however, the patient developed severe generalized abdominal pain. The abdominal wall was rigid and for the first time an abdominal bruit was heard. He became hypotensive and despite resuscitative measures expired.

At autopsy, there was infarction of the intestine extending from 1 cm. distal to the ligament of Treitz to the rectosigmoid junction with a 0.5 cm. perforation of the midjejunum secondary to infarct necrosis. In the ileum, there was evidence of marked mucosal atrophy

* From the Departments of Radiology,† and Medicine,‡ The New York Hospital-Cornell University Medical Center, New York, New York; and the Department of Medicine,§ Bronx-Lebanon Hospital Center, Bronx, New York.

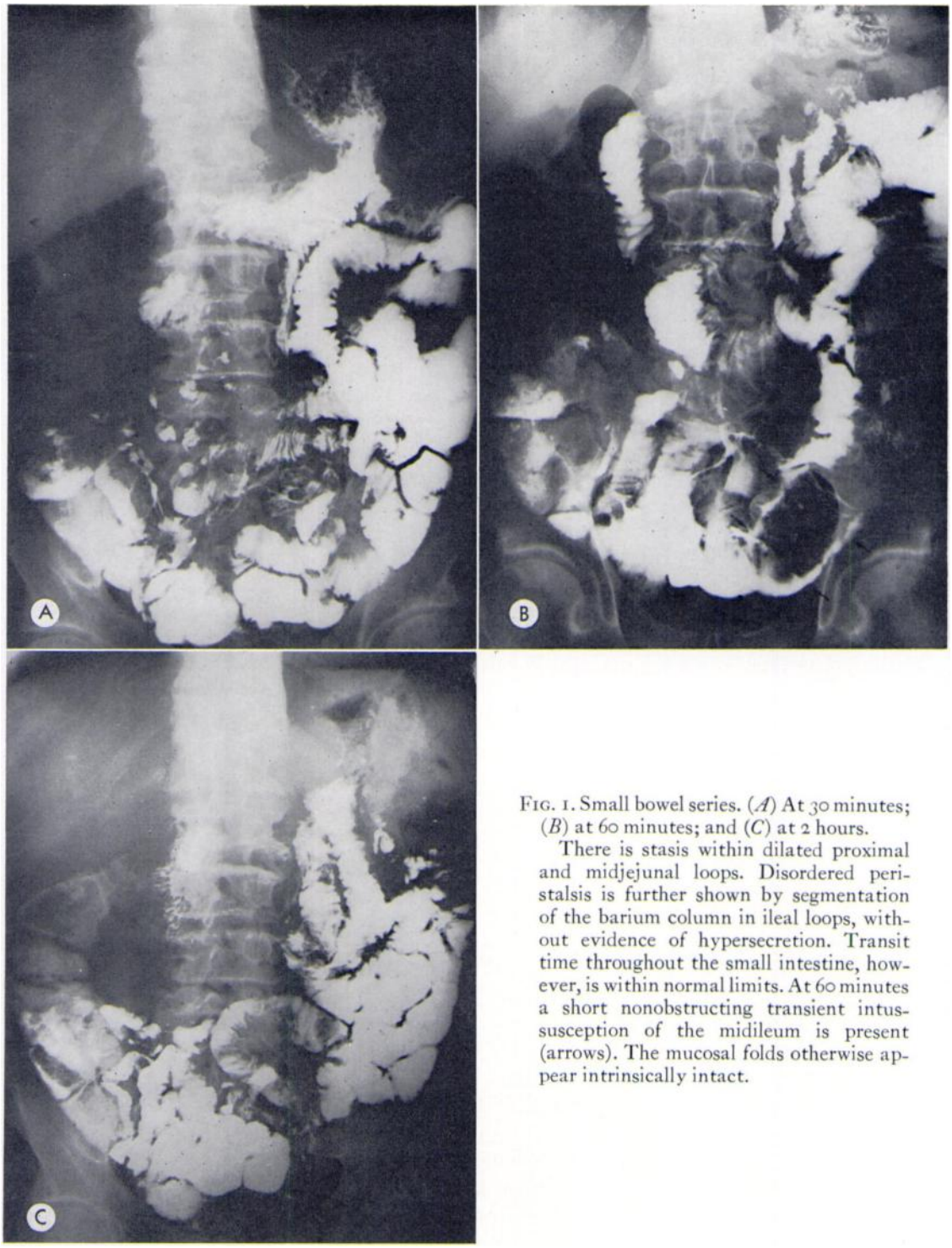

Fig. 1. Small bowel series. (*A*) At 30 minutes; (*B*) at 60 minutes; and (*C*) at 2 hours.

There is stasis within dilated proximal and midjejunal loops. Disordered peristalsis is further shown by segmentation of the barium column in ileal loops, without evidence of hypersecretion. Transit time throughout the small intestine, however, is within normal limits. At 60 minutes a short nonobstructing transient intussusception of the midileum is present (arrows). The mucosal folds otherwise appear intrinsically intact.

and submucosal fibrosis antedating the final episode. The abdominal aorta was involved with moderate atheromatosis with calcification and ulceration of the plaques, occluding the ostium of the inferior mesenteric artery. A common celiacomesenteric trunk was present. A pale yellow to white thrombus of long-standing narrowed its proximal lumen by 50 per cent, extending 1.5 cm. distal to its ostium. Complete occlusion of the remaining lumen had been produced by a bright red and fleshy thrombus. In addition, there was a chronic thrombus in the distal half of the vessel with a possible residual lumen in the area of the occlusion. A 2 cm. prepyloric ulcer of the greater curvature of the stomach had perforated leading to acute peritonitis. Histologically acute centrolobular necrosis of the liver was seen.

The heart showed marked coronary arteriosclerosis.

DISCUSSION

Chronic mesenteric vascular insufficiency has been documented as a cause of the malabsorption syndrome.[8,13,18,21,22,32,34,37,38] Watt *et al.*[37] reported malabsorption in 4 of 5 cases of chronic intestinal ischemia. Morris and DeBakey[22] found frequent abnormal fecal fat excretion in the setting of abdominal angina. The patients reported with ischemic malabsorption have all been shown to have diarrhea, weight loss, and either low serum carotene, abnormal xylose absorption, or increased fecal fat excretion.[8,32,34,38] Correction of the vascular lesions by thromboendarterectomy or bypass graft has been shown to reverse the malabsorption as well as alleviate the pain.[8,34,38] In several instances ischemic malabsorption has been noted following surgical excision of an acute embolic occlusion of a branch of the superior mesenteric artery.[15,34,39] This impairment improves gradually with a complete resolution after several months. Since it is known that villous structure reconstitutes itself rapidly, the explanation for the delayed regression of the malabsorption in this circumstance is not clear. Impaired absorption has also been observed with mesenteric arteriovenous fistulas,[23,24] evidently on the basis of a vascular steal from the intestinal perfusion. In addition to the clinical reports cited, further support for the role of vascular disease comes from studies in which malabsorption has been produced in dogs following partial superior mesenteric artery ligation.[26] These animals develop weight loss and diarrhea with abnormal I^{131} triolein and xylose absorption as well as histologic alterations in the small bowel mucosa. The condition is temporary, however, reverting to normal after several months, presumably as collateral circulation develops.

Abdominal pain has been a concomitant feature in almost all cases of ischemic malabsorption described, but is variable in intensity and character. While it characteristically is postprandial and periumbilical, it may also simulate the pain of pancreatitis with radiation toward the back and relief by a stooped posture. It usually precedes or occurs simultaneously with the malabsorption syndrome, the features of which may dominate the clinical picture until the abdominal angina increases in intensity later in the course. In the case reported, however, diarrhea antedated the onset of abdominal pain, indicating that there is variability in the order of appearance of symptoms.

Certain clinical features in addition to postprandial distress, are of particular significance in distinguishing malabsorption secondary to visceral ischemia: (1) age of onset. In Badenoch's[4] series of 106 patients with idiopathic steatorrhea, all but 14 had the onset of malabsorption in childhood or before the age of 50. In contrast, ischemic malabsorption is seen most commonly after the age of 50; (2) evidence of generalized arteriosclerotic disease; (3) presence of an abdominal bruit.[30]

Not all patients with chronic mesenteric vascular insufficiency and abdominal angina develop malabsorption.[14,19] The weight loss so frequently encountered in this condition may be a consequence of marked reduction of food intake in the avoidance of abdominal pain ("small meal syndrome"), in addition to or instead of frank malabsorption of

nutrients. On the other hand, ischemic malabsorption may not necessarily be accompanied by abdominal pain, as seen in the small vessel disease of periarteritis nodosa.[6]

Malabsorption has been classified into abnormalities of intraluminal digestion, mucosal-cell transport, and lymphatic drainage of the intestine.[35] The exact mechanism for the impaired absorption associated with vascular disease is unknown. Many factors affecting both intraluminal and mucosal phases of digestion are probably involved, including: (1) decreased mucosal cell turnover and villous atrophy with diminished absorptive surface; (2) reduced enzyme production; and (3) altered bowel motility as a result of submucosal fibrosis or autonomic nerve damage with consequent stasis and bacterial overgrowth. Complicating factors must also be considered such as stricture formation with the so-called blind-loop syndrome, decrease in pancreatic enzyme production from coincident hypoperfusion of the pancreas, and localized damage to the terminal ileum with impaired bile salt and vitamin B_{12} absorption.

A spectrum of laboratory tests is performed in the routine evaluation of malabsorption, including blood cell count and smear, prothrombin levels, serum calcium, albumin, carotene and vitamin A. Each of these, however, is nonspecific and unreliable as a screening test. The documentation of the presence of a malabsorption syndrome is generally predicated on the finding of an abnormality in the I^{131} triolein absorption, 72 hour stool fat, d-xylose excretion, and/or radioactive vitamin B_{12} absorption (Schilling) tests. The triolein test has been shown to be a useful screening test for steatorrhea with few false positives.[27] Fecal fat determination is the most sensitive and quantitative assessment of fat malabsorption.[28] Both tests, however, supply no etiologic information nor do they distinguish between the 3 main groups of malabsorptive disorders. The determination of xylose and vitamin B_{12}, while dependent on jejunal and terminal ileal mucosal-cell transport, respectively, may be similarly misleading since each may also be metabolized by overgrowth of luminal bacteria in a variety of conditions.[11] Thus, in mesenteric vascular insufficiency, routine laboratory evaluation may document the presence of malabsorption, but gives no clue to its ischemic origin.

Jejunal biopsy for the direct examination of the histopathology is also nonspecific in most instances. The changes in the small bowel mucosal histology classically associated with idiopathic sprue, consisting of total or subtotal villous atrophy and chronic inflammatory cell infiltration in the submucosa,[7] are by no means pathognomonic. Indeed these findings are a feature of many specific conditions,[36] including gluten-responsive sprue, tropical sprue, lymphoma, bacterial overgrowth, dermatopathic enteropathies, and radiation enteritis. Similar histologic changes have been noted in ischemic malabsorption. Watt *et al.*[37] described a patient with subtotal villous atrophy and plasma cell infiltration in the lamina propria which regressed entirely following revascularization. Carron and Douglas[6] have shown atrophic mucosal changes in patients with steatorrhea secondary to vascular insufficiency of the small intestine produced by periarteritis nodosa. Mucosal atrophy has also been produced following experimental partial ligation of the superior mesenteric artery in dogs.[26] In addition, the presence of submucosal fibrosis associated with malabsorption[13] probably indicates, as in our case, mesenteric vascular insufficiency of some duration. It is thus apparent that small bowel mucosal biopsy cannot distinguish between idiopathic sprue and ischemic malabsorption, with the exception of a truly flat mucosal lesion (total villous atrophy) which is much more consistent with sprue.

Small bowel barium studies are utilized in the routine evaluation of malabsorption, but are generally most specific in delineating localized lesions such as di-

verticula, strictures, enteric fistulas, and conditions such as regional ileitis, Whipple's disease, and intestinal lymphangiectasia.

The early reports of roentgenologic abnormalities in the small bowel in idiopathic steatorrhea emphasized a characteristic "deficiency pattern" based on flocculation and segmentation of a simple barium sulphate suspension. Frazier *et al.*[12] documented that such changes are related to the quality of the intestinal contents and not a reflection of morphologic changes or disordered motor function. It was shown that segmentation and flocculation could be induced in normal subjects by the presence of excess fatty acids, hypertonic solutions and mucus in the small bowel. In the presence of these changes in the contrast material, the caliber and mucosal pattern of the small bowel loops could not be accurately evaluated. It was not until the development of colloidal barium preparations, now in general use, that clumping and precipitation of the barium could be avoided[2] and the primary characteristic features recognized. These include dilatation of the small bowel, particularly in the mid- and distal jejunum, and evidence of increased intraluminal fluid as manifested by progressive dilution of the barium column within the ileum.[17] The features of dilatation and hypersecretion are virtually always present in the active phase of the disease.[17] Transit time through the small bowel may be normal or delayed. The mucosal folds may appear normal, thickened or thinned, depending on the degree of dilatation and the amount of secretion. Short transient nonobstructive intussusceptions may occasionally occur.[31] The exact cause of the small bowel dilatation is not clear but, since there appears to be some correlation between the degree of jejunal dilatation and the severity of the steatorrhea, it may be secondary to the increased bulk of intestinal contents.[16] Diminished serum potassium may also play a role in inducing paralytic ileus in malabsorption.

Descriptions of the roentgenologic abnormalities in the small bowel in reported cases of malabsorption secondary to visceral ischemia are scanty or imprecise. They include: "some tendency to delay in emptying of the proximal jejunum"[21]; "decreased peristalsis with an irregular mucosal pattern"[15]; "a malabsorption flocculation pattern"[37]; "puddling of barium in the small intestine"[8]; and "segmentation of the barium column occurring more proximally than in the usual case of malabsorption."[33] On occasion, a normal small bowel series has been reported,[34] but of interest is the description of a "small bowel deficiency pattern" in a case of abdominal angina without documented malabsorption.[5]

Our case and others previously illustrated do show several roentgenologic features distinct from the classical findings in idiopathic sprue which might be helpful in the differentiation of ischemic malabsorption. The degree of dilatation is relatively mild and tends to be confined to the proximal jejunal loops in contrast to the mid- and distal jejunum in sprue. While over-all transit time may be within normal limits, definite stasis is present within the dilated jejunum. No hypersecretion is seen and segmentation of the barium column, while present to a mild degree, is not a conspicuous feature. Disordered peristalsis may, as in idiopathic sprue, be further reflected by short transient intussusceptions. It would thus appear that the roentgenologic findings in the small bowel may be more directly a consequence of the ischemia than of the resultant malabsorption. These roentgenologic features may be helpful in selecting patients with malabsorption for aortography.

Severe mesenteric vascular involvement occurs almost exclusively with advanced aortic atherosclerosis,[29] with the most extensive and common stenosis extending from the orifice over the proximal 1.5–2.0 cm.[9,10,29] Lateral aortography thus allows definitive delineation of involvement of the orifices and main stems of the celiac and superior mesenteric arteries. This information of the extent and distribution of the

arteriosclerotic occlusions is of crucial importance in the decision and choice of a revascularization procedure.

Because of the rich anastomoses, it has been generally accepted that at least 2 of the 3 visceral arteries must be involved to result in ischemic symptoms. The most constantly involved vessel has been the main stem of the superior mesenteric artery. It is apparent that factors other than the extent and degree of arteriosclerotic occlusion of the mesenteric vessels play a role in the production of ischemic malabsorption. Indeed, Reiner *et al.*[29] have emphasized the pitfalls in transposing their postmortem observations directly to a clinical setting. Paramount among these are: (1) acuteness or chronicity of occlusion, and the development of collateral circulation. Complete arteriosclerotic stenosis of all 3 mesenteric vessels without ischemic signs or symptoms has been described,[20] with intestinal blood supply maintained *via* rich collateral branches; (2) degree of occlusion of the distal vessels. Occlusive lesions of the small mesenteric arteries have been shown in several cases of intestinal ischemia.[1,3] These include: intimal fibrous hyperplasia, medial thinning, elastosis and hypertrophy, and periarterial fibrosis; and (3) other conditions leading to a low perfusion state.[25,32]

CONCLUSIONS AND SUMMARY

Malabsorption may be caused by chronic mesenteric ischemia.

It may be the initial or the dominant feature of the clinical presentation, with the characteristic postprandial pain of "abdominal angina" not appearing until later in the course. In contrast to other malabsorptive disorders, this condition is distinguished by an onset after the age of 50 years in a patient with evidence of generalized arteriosclerotic disease. An abdominal bruit is also commonly present.

The mechanism of impaired absorption is complex and probably related to abnormalities of intraluminal and mucosal phases of digestion. Both absorption tests and jejunal mucosal histology are useful in documenting the presence of a malabsorptive disorder, but often do not distinguish either its mechanism or underlying etiology.

A small bowel series demonstrating the features of mild dilatation of *proximal* jejunal loops with stasis, in the absence of hypersecretion and significant segmentation, is helpful in the differentiation of ischemic malabsorption from idiopathic sprue. These roentgenologic features may be of further assistance in selecting patients with malabsorption for aortography to define the presence and extent of potentially remediable vascular occlusions.

Morton A. Meyers, M.D.
Department of Radiology
The New York Hospital-Cornell
University Medical Center
525 East 68th Street
New York, New York 10021

We wish to thank Richard Marshak, M.D., for constructive review of the manuscript.

REFERENCES

1. Aboumrad, M. H., Fine, G., and Horn, R. C. Intimal hyperplasia of small mesenteric arteries. *A.M.A. Arch. Path.*, 1963, *75*, 196–200.
2. Ardran, G. M., French, J. M., and Mucklow, E. H. Relationship of nature of opaque medium to small intestine radiographic pattern. *Brit. J. Radiol.*, 1950, *23*, 697–702.
3. Arosemena, E., and Edwards, J. E. Lesions of small mesenteric arteries underlying intestinal infarction. *Geriatrics*, 1967, *22*, 122–138.
4. Badenoch, J. Steatorrhoea in adult. *Brit. M. J.*, 1960, *2*, 879–887, 963–974.
5. Bircher, J., Bartholomew, L., Cain, J., and Adson, M. Syndrome of intestinal arterial insufficiency: "abdominal angina." *A.M.A. Arch. Int. Med.*, 1966, *117*, 632–638.
6. Carron, D. B., and Douglas, A. P. Steatorrhoea in vascular insufficiency of small intestine; five cases of polyarteritis nodosa and allied disorders. *Quart. J. Med.*, 1965, *34*, 313–340.
7. Cooke, W. T., Fone, D. J., Cox, E. V., Meynell, M. J., and Gaddie, R. Adult coeliac disease. *Gut*, 1963, *4*, 279–291.
8. Dardik, H., Seidenberg, B., Parker, J. G., and Hurwitt, E. S. Intestinal angina with malabsorption treated by elective revascularization; case report and review of literature with emphasis on absorption studies. *J.A.M.A.*, 1965, *194*, 1206–1210.

9. DERRICK, J. R., POLLARD, H. S., and MOORE, R. M. Pattern of arteriosclerotic narrowing of celiac and superior mesenteric arteries. *Ann. Surg.*, 1959, *149*, 684–689.
10. DICK, A. P., GRAFF, R., GREGG, D., PETERS, N., and SARNER, M. Arteriographic study of mesenteric arterial disease. *Gut*, 1967, *8*, 206–220.
11. DONALDSON, R. M. Small bowel bacterial overgrowth. *Advances Int. Med.*, 1970, *16*, 191–212.
12. FRAZIER, A. C., FRENCH, J. M., and THOMPSON, M. D. Radiographic studies showing induction of segmentation pattern in small intestine in normal human subjects. *Brit. J. Radiol.*, 1949, *22*, 123–136.
13. FRENGLEY, J. D., and REID, J. D. Non-specific enteritis resulting from mesenteric vascular insufficiency. *New Zealand M. J.*, 1964, *63*, 212–218.
14. HEARD, G., JEFFERIES, J. D., and PETERS, D. K. Chronic intestinal ischaemia: successful aorta/superior-mesenteric bypass. *Lancet*, 1963, *2*, 975–978.
15. JOSKE, R. A., SHAMMA'A, M. H., and DRUMMEY, G. D. Intestinal malabsorption following temporary occlusion of superior mesenteric artery. *Am. J. Med.*, 1958, *25*, 449–455.
16. LAWS, J. W., BOOTH, C. C., SHAWDON, H., and STEWART, J. S. Correlation of radiological and histological findings in idiopathic steatorrhea. *Brit. M. J.*, 1963, *1*, 1311–1314.
17. MARSHAK, R. H., and LINDNER, A. E. Malabsorption syndrome. *Seminars Roentgenol.*, 1966, *1*, 138–177.
18. MARSTON, A. Patterns of intestinal ischemia. *Ann. Roy. Coll. Surgeons England*, 1964, *35*, 150–181.
19. MASSON, N. L., and STAYMAN, J. W. Intestinal angina. *Am. J. Surg.*, 1962, *104*, 500–505.
20. MATZ, E. M., and KAHN, P. C. Occlusion of celiac, superior mesenteric and inferior mesenteric arteries. *Vasc. Dis.*, 1968, *5*, 130–136.
21. MAVOR, G. E., and MICHIE, W. Chronic midgut ischaemia. *Brit. M. J.*, 1958, *2*, 534–537.
22. MORRIS, G. C., JR., and DEBAKEY, M. E. Abdominal angina: diagnosis and surgical treatment. *J.A.M.A.*, 1961, *176*, 89–92.
23. MOVITZ, D., and FINNE, B. Postoperative arteriovenous aneurysm in mesentery after small bowel resection. *J.A.M.A.*, 1960, *173*, 42–44.
24. MUNNELL, E. R., MOTA, C. R., and THOMPSON, W. B. Iatrogenic arteriovenous fistula: report of case involving superior mesenteric vessels. *Am. Surgeon*, 1960, *26*, 738–744.
25. PAPP, J. P., and SULLIVAN, B. H., JR. Malabsorption and mesenteric ischemia. *Cleveland Clin. Quart.*, 1965, *32*, 227–231.
26. PASSI, R. B., and LANSING, A. M. Experimental intestinal malabsorption produced by vascular insufficiency. *Canad. J. Surg.*, 1964, *7*, 332–340.
27. PIMPARKAR, B. D., TULSKY, E. G., KALSER, M. H., and BOCKUS, H. L. Correlation of radioactive and chemical fecal fat determination in malabsorption syndrome. II. Results in idiopathic steatorrhea and diseases of pancreas. *Am. J. Med.*, 1961, *30*, 927–939.
28. RAFFENSBERGER, E. C., D'AGOSTINO, F., MANFREDO, H., RAMIREZ, M., BROOKS, F. P., and O'NEILL, F. Fecal fat excretion. *A.M.A. Arch. Int. Med.*, 1967, *119*, 573–576.
29. REINER, L., JIMENEZ, F. A., and RODRIGUEZ, F. L. Atherosclerosis in mesenteric circulation: observations and correlations with aortic and coronary atherosclerosis. *Am. Heart J.*, 1967, *66*, 200–209.
30. ROB, C. Surgical diseases of celiac and mesenteric arteries. *A.M.A. Arch. Surg.*, 1966, *93*, 21–32.
31. RUOFF, M., LINDNER, A. E., and MARSHAK, R. H. Intussusception in sprue. AM. J. ROENTGENOL., RAD. THERAPY & NUCLEAR MED., 1968, *104*, 525–528.
32. SCHWARTZ, C. J., ACHESON, E. D., and WEBSTER, C. U. Chronic midgut ischaemia with steatorrhoea in polycythaemia rubra vera. *Am. J. Med.*, 1962, *32*, 950–953.
33. SCHWARTZ, S., BOLEY, S., SCHULTZ, L., and ALLEN, A. Survey of vascular diseases of small intestine. *Seminars Roentgenol.*, 1966, *1*, 178–218.
34. SHAW, R. S., and MAYNARD, E. P., III. Acute and chronic thrombosis of mesenteric arteries associated with malabsorption: report of two cases successfully treated by thromboendarterectomy. *New England J. Med.*, 1958, *258*, 874–878.
35. SLEISENGER, M. H. Malabsorption syndrome. *New England J. Med.*, 1969, *281*, 1111–1117.
36. TRIER, J. S. Diagnostic value of peroral biopsy of proximal small intestine. *New England J. Med.*, 1971, *285*, 1470–1473.
37. WATT, J. K., WATSON, W. C., and HAASE, S. Chronic intestinal ischaemia. *Brit. M. J.*, 1967, *3*, 199–202.
38. WEBB, W. R., and HARDY, J. D. Relief of abdominal angina by vascular graft. *Ann. Int. Med.*, 1962, *57*, 289–295.
39. ZUIDEMA, G. D. Surgical management of superior mesenteric arterial emboli. *A.M.A. Arch. Surg.*, 1961, *82*, 267–274.