The Pattern of Arteriosclerotic Narrowing of the Celiac and Superior Mesenteric Arteries *

JOHN R. DERRICK, M.D., HARRY S. POLLARD, M.D., ROBERT M. MOORE, M.D.

From the Department of Surgery, University of Texas School of Medicine, Galveston, Texas

Introduction

ALTHOUGH the cause of arteriosclerosis remains obscure, its deleterious effects throughout the body have become increasingly apparent. In the past clinicians have focused their attention chiefly upon coronary artery sclerosis, cerebral arteriosclerosis and occlusive arterial disease of the lower extremities. Present thought and current investigation, however, suggest that any or all areas of the body may be affected by the decreased blood flow resulting from arteriosclerotic narrowing of major and minor vessels.

The tissues of the body vary widely in terms of their oxygen utilization and oxygen demand. The "critical areas" would appear to be those in which function is impaired by slight deficiencies in the circulation to them. The oxygen transport is dependent upon the volume flow of blood and the arterial oxygen content. For vessels of medium size, according to Poiseuille's Law, blood flow varies directly with the fourth power of the radius of the lumen. Thus, if viscosity of the blood, loss of energy through friction, and length of vessel concerned are constant, the diameter of the vessel is the critical factor in determining the volume flow of blood.

Fortunately for man, though inconvenient for science, biological adaptability and compensation defy exact prediction. This is exemplified by the cyanotic child with congenital heart disease whose tissues "adapt" and function well in the presence of a low oxygen content. Adaptability is seen in a different form in individuals who have major arteries interrupted but suffer no serious damage because collateral channels furnish the oxygen demands of the affected area. In this regard, it appears that the biological adaptability of youth is variable, but always good, whereas in senior members of the population it is only variable.

Method of Study

At necropsy 110 unselected aortas of patients ranging from 28 years to 86 years of age were examined carefully, and their branches measured in a study to define the incidence and pattern of arteriosclerosis of the arteries to the abdominal viscera. Gross anatomic observations were confirmed by roentgenologic studies after the aortas had been redistended with air.

The cross sectional area of each visceral artery was calculated from the diameter as measured in three places: (1) at its aortic ostium, (2) at its narrowest point, which invariably was within 1.5 cm. of the aortic ostium, and (3) at a point 1.5 cm. distal to the aortic ostium, at which site the vessel was usually pliable and free of arteriosclerotic changes. Because of the elasticity of the aorta, removal from the body resulted in a shrinkage which varied from 8

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to 28 per cent. In general, the greater the arteriosclerotic involvement the less this shrinkage.

Observations

Forty-four per cent of the celiac arteries examined demonstrated some narrowing secondary to arteriosclerosis. Twenty-one per cent were found to have, at some point within 1.5 cm. of the aortic orifice, a reduction of 50 per cent or more in the calculated cross sectional area of the artery. In many instances the geometric detail of occlusion made calculation of the cross sectional area very difficult.

In a previous publication,[2] it was reported that narrowing of the superior mesenteric artery was found to be present in thirty-seven per cent of aortas examined. Subsequent study of additional specimens has verified this figure.

Another technique for studying the excised aorta, suggested by Dr. Truman Blocker, has served to illustrate the same patterns detected by the method of anatomical measurement. After tying all visceral effluents, and suturing all holes in the aorta and its branches, each specimen was redistended with air to a pressure equal to the subject's ante mortem blood pressure. Roentgenograms were then made. These portrayed the changes, and provided an opportunity to check the anatomical measurements.

The pattern of arteriosclerotic involvement of the aorta most frequently observed was: the area just above the aortic bifurcation demonstrated the earliest changes, and in late cases the most marked changes. This is the area in which most aortic aneurysms occur. The second area most frequently involved was in the region of the orifices of the abdominal visceral branches. Aortas with no gross evidence of arteriosclerotic involvement had widely patent orifices, with rather sharp margins. The thickening of the intima observed in early arteriosclerosis tended to smooth and round out the orifices, without appreciable encroachment on the openings. The orifice areas exhibiting significant arteriosclerotic changes were narrowed in one or more of three ways (Fig. 1):

(1) thickening of the intima which narrowed the aortic orifice,
(2) a concentric area of thickening just inside the orifice,
(3) a plaque of atheromatous tissue, just inside the orifice, which involved only a part of the circumference of the vessel.

Clinical Study

During the past year we have attempted to find a practical and accurate means for diagnosing visceral arterial insufficiency. Although various absorption studies have

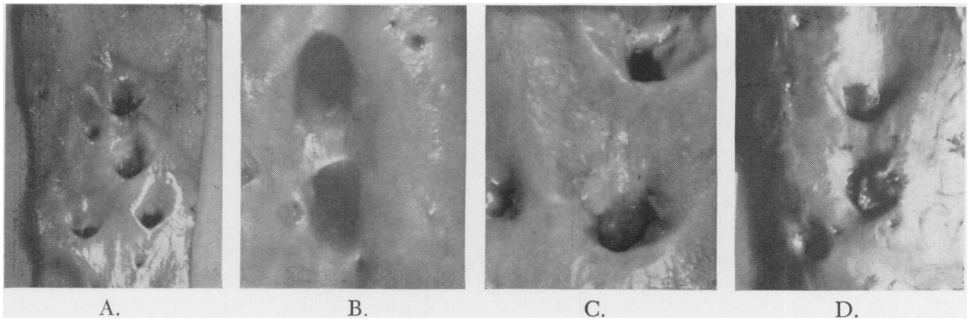

FIG. 1. A., Normal. B., Thickening of the intima which narrowed the aortic orifice. C., A concentric area of thickening just inside the orifice. D., A plaque of atheromatous tissue, just inside the orifice, which involved only a part of the circumference of the vessel.

been used in an effort to detect occlusive disease, abdominal visceral arteriography seems at present to offer the only accurate means of preoperative diagnosis. Perhaps as more experience is gained, simpler and safer procedures will supplant arteriography. In the meanwhile, however, it is important to document all cases so that present experience will lead to a better understanding. Therefore, the findings in a patient who was operated upon recently with a preoperative diagnosis of insufficiency of the celiac and superior mesenteric arteries are reported.

Case Report

Patient I. M. Unit History #56935-M. A negro male, aged 67 years, was admitted for study on October 14, 1958. The present illness had its onset approximately 18 months prior to admission, at which time the patient began to suffer vague epigastric pain associated occasionally with painful abdominal cramping. The pain was relieved on occasions by analgesics, but not by antiacids or by foods. After several months he observed that ingestion of any type of food tended to provoke the pain, and this resulted in his taking increasingly smaller amounts of food. There was an occasional bout of nausea associated with the severe episodes of pain, but never any vomiting. There was no passage of blood in the stools. Increasing constipation was noted from the onset, and for the past 6 to 8 months three or four enemas per week had been required to obtain adequate evacuations. Various laxatives had also been tried.

Four months prior to admission the patient had had a complete gastro-intestinal study in another hospital. There were no positive findings, but since there had been a weight loss of 25 pounds an occult cancer was suspected. An exploratory laparotomy had been performed, the surgeon reporting that he had been unable to find any gross pathologic lesion. There was no observation relative to the circulation to the intestine. Tissue removed from the stomach for study led to a pathological diagnosis of atrophic gastritis. The postoperative course had not been remarkable and the patient had been discharged 10 days after operation. Following discharge, however, the abdominal pain continued and grew worse. During the interval until admission to the John Sealy Hospital, the character of the pain had changed to the extent that it had become constant in nature, rather than intermittent and associated only with the taking of food. A regimen of six small feedings per day in conjunction with an antispasmodic drug brought symptomatic relief only for short periods of time.

Physical examination on admission revealed an elderly negro male, in no acute distress but showing evidences of marked weight loss. The temperature, pulse rate and respiratory rate were normal; the blood pressure was 160/80. There was moderate arcus senilis and minimal arteriosclerotic changes in the fundi. Peripheral pulses were present, strong and equal. The heart and lungs were normal to examination. The abdomen was scaphoid and considered negative to palpation. Auscultation, however, revealed a systolic murmur, limited to a small area just above and to the left of the umbilicus. There were no other pertinent physical findings.

A complete gastro-intestinal study was done. The usual radiologic and laboratory investigations were negative. In view of the apparent association of the discomfort with ingestion of food, absorption studies were performed. Triolein absorption tests demonstrated impaired fat absorption. D-xylose absorption determination was reported as abnormal with a total value of 3.6 grams of glucose. Examination of the stool showed that undigested meat fibers were present. Results of amylase and glucose absorption tests were within normal limits.

In recent months a technique patterned after the method of Rappaport [5] has been devised, the superior mesenteric artery, the celiac or either renal artery being cannulated by means of a catheter introduced through the femoral artery under fluoroscopic guidance. Using this method a catheter was placed at the orifice of the patient's superior mesenteric artery, and 8 cc. of dye injected rapidly. The resulting arteriogram demonstrated marked narrowing at the aortic junction of the superior mesenteric artery, and very little flow of dye into the vessel. A reflux of dye out of the artery in a cephalad direction permitted a degree of visualization of the celiac artery in addition, and there was suggested narrowing of that vessel also.

With the impression that this patient had generalized arteriosclerosis, and that the abdominal complaints were the result of insufficiency of the superior mesenteric artery along with questionable insufficiency of the celiac axis, an exploratory laparotomy was performed under general endotracheal anesthesia, for the purpose of examining the abdominal arteries. Palpation revealed good pulsation in the inferior mesenteric artery, but complete absence of pulses in the superior mesenteric and celiac arteries. When one of the major

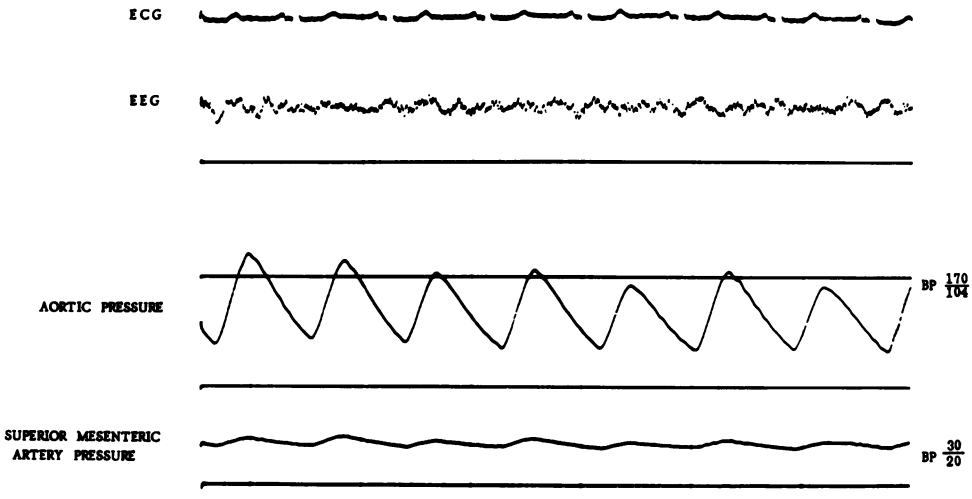

FIGURE 2

superior mesenteric branches was opened the bleeding was very slight, and the flow from the open artery was nonpulsatile. Simultaneous pressure measurements were taken from a primary division of the superior mesenteric artery and from the abdominal aorta (Fig. 2). The superior mesenteric pressure was less than 35 mm. of mercury while the systolic pressure in the aorta was 180 mm. Since no pulsation could be detected in any of the celiac branches, the splenic artery pressure was also measured and found to be less than 35 mm. at a time the aortic pressure was recorded at 180 (Fig. 3). For enzyme studies and determination of oxygen saturation, samples of blood were taken from the splenic vein, the superior mesenteric vein, the portal vein and the brachial vein. It was found that there was a significant elevation of the enzyme level throughout the portal bed as compared to that of the systemic venous blood. Similarly, there was a marked decrease in the oxygen saturation of the portal venous blood as compared to the blood in the systemic vein.

To obtain better exposure of the entire upper abdominal aorta it was necessary to extend the incision along the 8th intercostal space, opening the left chest and incising the diaphragm radially. The viscera of the left upper quadrant were reflected medialward to facilitate approach to the aorta. A common iliac artery homograft with its bifurcation into external and internal iliac arteries

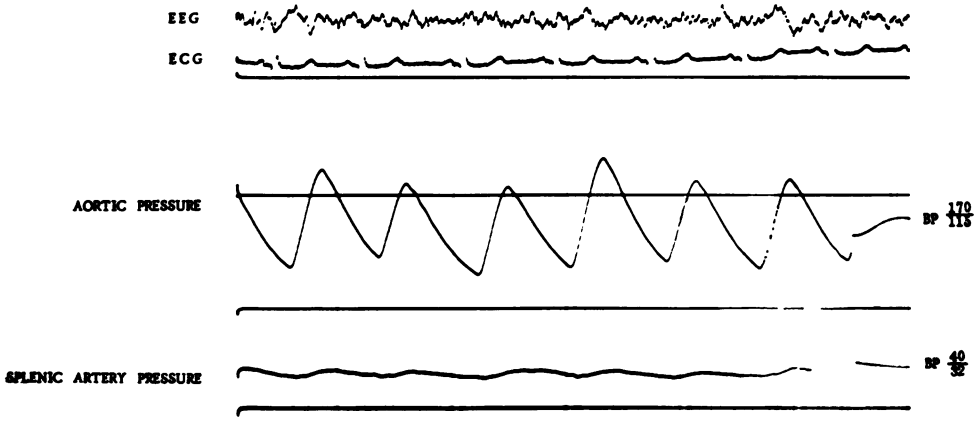

FIGURE 3

was used for a bypass graft. The proximal end of the graft was sutured end-to-side to the descending thoracic aorta; distal anastomoses were also done end-to-side to the celiac axis and the superior mesenteric artery. Size 0000 silk was used for the anastomosis. Following completion of the bypass there was vigorous pulsation in the homograft, the arterial tree in the mesentery became plainly visible, and pulsation could be felt in the smaller mesenteric arteries. A drain was placed in the left upper quadrant and brought out through a stab wound. The abdomen was closed in layers.

Gastric suction was maintained for five days postoperatively, after which the patient was allowed to take sips of liquids by mouth. Oral feedings were increased progressively until, at the end of the 7th postoperative day, he was taking adequate amounts of food and drink. He continued to improve, and appeared to experience no pain although he was ingesting larger quantities of food than he had before operation. On the 14th postoperative day, however, evidences of intestinal obstruction intervened, and a disastrous sequence of complications followed. In fear that the intestine had lost its viability, laparotomy was performed promptly. At operation, however, it was found that the entire intestine was healthily pink and that the arterial arcades were readily visible. There were adhesions throughout the entire abdomen, and the obstruction was at the splenic flexure of the colon which had become incarcerated between adhesions in the left upper quadrant. During the process of freeing the adhesions the jejunal lumen was inadvertently entered, necessitating an intestinal suture. Following this operation convalescence was again interrupted, first, by a partial wound dehiscence requiring secondary suture, and, a week later, by development of a small intestinal fistula. At a third laparotomy an intestinal resection and anastomosis was performed. At this time, 28 days after insertion of the bypass graft, the color of the intestine was still good, and mesenteric pulsations were palpable, though weak. A few days after this operation, when it was thought that he was finally on the road to recovery, the patient expired unexpectedly. Permission for autopsy could not be obtained.

Discussion

In 1868, Chiene [1] described a necropsy at which a woman of 65 years was found to have complete obliteration of the celiac and superior mesenteric arteries, although there was no evidence of visceral gangrene. Shaw and Maynard,[6] during this current year, have described two patients with the malabsorption syndrome who were found at operation to have a similar vascular insufficiency. In these cases a good result was obtained by superior mesenteric endarterectomy. The case now reported, in which the issue was less fortunate, was one in which a similar situation was suspected because of abdominal pain associated with quantity food intake. The location of the pain was, by and large, epigastric and periumbilical. Although there is no completely satisfactory explanation of the pain associated with visceral arterial insufficiency, it is possible that ischemia is a central feature.[3, 4]

In the absence of a demonstrable gastrointestinal lesion, the inability to ingest adequate quantities of food without suffering abdominal pain should lead to a consideration of the presence of visceral arterial insufficiency, particularly if a malabsorption syndrome can be demonstrated. Certainly, vascular insufficiency in other areas of the body should add to one's suspicion. The presence of a systolic murmur to the left and above the umbilicus, as was discovered in this case, should also afford a clue to the presence of superior mesenteric artery narrowing. Finally, arteriography of the individual visceral arteries, the practicability of which has been demonstrated, should be of great aid in establishing a definite preoperative diagnosis.

Palpation for the pulsations of individual abdominal arteries becomes an essential part of certain exploratory operations. Similarly, collateral circulation should always be investigated before one sacrifices any of the major arterial trunks to the abdominal organs.

The low perfusion pressures found in the superior mesenteric and celiac branches in the case reported, were shock levels according to conventional standards. They illustrate the marked loss in effective pressure to an area supplied through long collateral

channels. They point out, further, the ability of the organs to adapt to a low perfusion pressure when its development has occurred over a considerable period of time. Sudden decreases to such low levels would probably be fatal in most instances.

Summary

The incidence and the patterns of arteriosclerotic involvement of the superior mesenteric artery and the celiac axis are described.

The case of a male of 66 years, in whom the preoperative diagnosis of celiac and superior mesenteric artery insufficiency was made, is reported; the operative findings, the mode of treatment by means of a bypass homograft, and the postoperative complications are related.

Several clinical and physiologic principles are discussed as they pertain to deficient arterial blood supply and its effects upon the abdominal viscera.

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