The Anatomic Basis of Vascular Compression of the Duodenum

John T. Akin, John E. Skandalakis, Stephen W. Gray

Compression of the third or fourth part of the duodenum by the superior mesenteric artery or one of its branches is the anatomic basis for many cases of duodenal obstruction. Various names have been applied: superior mesenteric artery syndrome, Wilkie's disease, and arteriomesenteric ileus. Fluctuation in reported prevalence and the frequent association with neurosis have produced occasional skepticism as to its objective existence. We believe it to be a real disease entity with an anatomic basis best described by the name vascular compression of the duodenum.

Rokitansky is credited with first describing duodenal compression by the superior mesenteric artery. By 1908, Laffer in this country was able to collect 217 cases including four of his own. Interest lagged until 1927 when Wilkie reported 75 cases of his own. Not all of these older cases were well documented. Barner and Sherman critically reviewed the subject in 1963 and found only 281 cases that they considered acceptable.

Embryology

A brief review of the development of the small intestine will explain how the superior mesenteric artery and the duodenum reach the positions in which they are found in the adult abdomen.

The superior mesenteric artery of the adult, together with the celiac axis and the inferior mesenteric artery, is a remnant of the arterial part of the primitive vitelline circulation which supplies the embryonic yolk sac with blood. Originally paired and segmentally arranged, the pairs have fused and their number reduced to three by the 6th week of development. The superior mesenteric artery extends past the intestine and into the yolk sac as long as the organ persists in the umbilical cord. It is the extension that supplies blood to a persistent Meckel's diverticulum.

Up to the middle of the 5th week the midgut is contained within the body of the embryo. Late in the 5th week it begins to elongate faster than does the embryo itself, and pushes out into the umbilical cord. At the same time the herniated intestinal loop rotates 90 degrees counterclockwise so that the future duodenum lies to the right of the embryonic superior mesenteric artery, and the future colon lies to the right. With the return of the elongated intestines to the abdomen during the 10th week, the proximal portion of the loop, the small intestine, returns first. As a consequence, the duodenal portion passes to the left, beneath the superior mesenteric artery. The colon returns soon afterward, so that the transverse portion lies in front of both the duodenum and the artery. Growth of the colon continues after the intestines return to the abdomen. The cecum, at first under the liver, eventually descends to the right lower quadrant of the abdomen. The adult position of the intestines is usually reached only after birth and ends with the fusion of the ascending and descending mesocolon with the abdominal peritoneum.

It should be emphasized that patients with vascular compression of the duodenum have normally rotated intestines. Cases are known in which compression is the result of intestinal
malrotation with grossly altered vascular and intestinal relationships. These rare cases are not included in our discussion of the syndrome.

**Surgical Anatomy**

One of the consequences of man's erect posture is that the superior mesenteric artery leaves the aorta at an acute downward angle rather than at a nearly right angle as in quadrupeds. It is through this vascular angle, between the aorta and the superior mesenteric artery, that the third or fourth portion of the duodenum passes. The posterior limb of the angle is formed by the vertebral column and the paravertebral muscles as well as by the aorta; the anterior limb is formed by the superior mesenteric artery in the mesentery and sometimes by one of its first two branches, the middle and right colic arteries, in the overlying transverse mesocolon. The duodenum is suspended in the angle by the ligament of Treitz. The uncinate process of the pancreas and the left renal vein occupy the narrowest part of the angle above the duodenum. These relationships are shown diagrammatically in sagittal section and in anterior view. The duodenum usually crosses the vertebral column at the level of the third lumbar vertebra and the superior mesenteric artery usually arises from the aorta at the level of the first lumbar vertebra. The suspensory muscle of the duodenum (ligament of Treitz), consisting of smooth muscle and fibrous tissue, connects the duodenal flexure and the right crus of the diaphragm.

**Variations of the Ligament of Treitz**

Haley and Peden showed that the attachment of the ligament of Treitz is variable. It may be attached to the duodenojejunal flexure only, to the flexure and the fourth and even the third parts of the duodenum, or the fourth and third parts of the duodenum only. We have also seen the ligament formed by multiple, separate divisions. Attachment to the flexure and the fourth part is the most frequently encountered. It has been suggested that there is hypertrophy of the smooth muscle fibers in the ligament of Treitz in patients with the clinical syndrome of vascular compression of the duodenum.

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**Variations in the Level of the Duodenum**

In most patients the duodenum crosses the vertebral column at the level of the third lumbar vertebra. In the remainder, more often in women, it crosses at a lower level. In a few it may cross at the level of the second lumbar vertebra. In such cases the ligament of Treitz may be shorter than usual, bringing the duodenum higher into the angle between the superior mesenteric artery and the aorta. A short ligament does not always raise the level of the third
part of the duodenum but may, instead, raise only the flexure, increasing the angulation of the
distal fourth part of the duodenum. Either the third or fourth part of the duodenum crosses
the vertebra, although in about 1 per cent of individuals the duodenojejunal junction lies to
the right of the spine.

Crossing the spine at a lower level might seem to allow more room for the duodenum,
but this is not necessarily the case. The spine turns anteriorly at the lumbar curve, reaching
its most anterior position at the fourth lumbar vertebra so that the space between the anterior
and posterior limbs of the angle is no greater at the level of the fourth lumbar vertebra than
at the level of the third. This lumbar curvature is usually greater in women than in men.

The Superior Mesenteric Artery and Its Branches

The superior mesenteric artery arises from the aorta at the level of the first lumbar
vertebra in most individuals. This level may vary from that of the twelfth thoracic vertebra
to that of the disc between the second and third lumbar vertebrae, but 75 per cent will arise
between the upper one third of the first lumbar vertebra and the disc between the first and
second lumbar vertebrae. Its course and relation to structures posterior to it are shown. A
groove on the anterior surface of the duodenum sometimes indicates the track of the superior
mesenteric artery. The authors have observed this groove.

At the inferior border of the pancreas, the superior mesenteric artery gives off the
middle colic artery. This vessel lies in the transverse mesocolon and crosses the third part of
the duodenum in its normal position. The right colic artery to the mesocolon arises at the
level of the inferior border of the duodenum; it may or may not cross the duodenum. Either
the superior mesenteric artery itself or the middle colic artery may compress the duodenum;
the right colic artery can rarely be implicated.

Some measurements of the normal angle formed by the superior mesenteric angle and
the aorta have been made in cadavers and, by radiography, in living patients. Three of the
living patients had clinical evidence of duodenal compression which was confirmed by
surgery in two. The published measurements are shown.

Discussion

It is apparent from these relationships that the duodenum may become compressed by
relatively minor alterations of the normal anatomy. Such alterations may be produced by
extrinsic or intrinsic factors.

Extrinsic Factors

Prolonged abdominal compression can decrease the aortomesenteric angle. A body
case is an occasional source of such compression. Such vascular compression of the
duodenum has been called the "cast syndrome" by Dorph.

Prolonged bed rest in the supine position results in continuous, unrelieved pressure on
the superior mesenteric artery and the duodenum by the weight of the overlying transverse
colon.
Intrinsic Factors

Progressive lordosis or scoliosis may decrease the distance between the lumbar vertebrae and the superior mesenteric angle.

Marked, rapid weight loss may result in loss of fat so that the superior mesenteric artery impinges more directly on the duodenum.

Most cases of vascular compression of the duodenum cannot be explained so readily. A high duodenum with a small aortomesenteric angle may leave adequate room for the duodenum in childhood, but the space may become inadequate as the duodenum grows with age. More affected patients are in the first three decades of life than in any other comparable period. The greater lumbar curvature in women, perhaps increased by child bearing, may be reflected in the greater number of affected women over 30 years of age.

We suggest that the duodenum fits so exactly into the vascular angle that apparently normal variations of the aortomesenteric angle, the level at which the duodenum crosses the vertebral column, the length and attachment of the ligament of Treitz, or the degree of lumbar spinal curvature may all predispose to duodenal compression. With a high duodenum the third or fourth part may be compressed by the angle formed by the superior mesenteric artery and the aorta. With a short ligament of Treitz the angulation of the duodenojejunal attachment may contribute to the obstruction. With a low duodenum, the compression will be between the superior mesenteric or middle colic artery and the lumbar vertebrae or the paravertebral muscles. Increasing lordosis of age will contribute further to the danger of compression. We believe there is an anatomic basis for vascular compression of the duodenum which must be differentiated from anorexia nervosa.