Anatomy of the small intestine

Vishy Mahadevan

Abstract

The small intestine (small bowel) commences at the pyloroduodenal junction and ends at the ileocaecal junction. It comprises, successively, the duodenum, jejunum and ileum. The principal function of the small intestine is the digestion and absorption of ingested food, electrolytes and vitamins and this important functional specialization is reflected in the enormous surface area of the small intestinal mucosa which is the result of the extensive and wavy in folding of the mucosal lining along the entire length of the small intestine. As might be expected from its very active role as a secretory and absorptive viscus, the small intestine has a rich blood supply. This is derived chiefly from the superior mesenteric artery via its inferior pancreaticoduodenal, jejunal and ileal branches. Venous drainage is via corresponding tributaries that drain to the superior mesenteric vein and thence to the portal vein. These vessels are accompanied by lymphatic vessels and autonomic nerve fibres. Developmental anomalies, mechanical obstruction and inflammatory disease affect the small intestine far more commonly than do neoplastic conditions. A Meckel's diverticulum is a relatively common (2%) congenital anomaly of the distal ileum.

In this article, an account of the topographical and surgical anatomy of the duodenum is followed by that of the jejunum and ileum. Various surgically-important features are highlighted.

Keywords Autonomic nerves; duodenum; ileum; jejunum; lymphatic drainage; Meckel's diverticulum; mesentery; superior mesenteric artery and vein

The small intestine extends from the pylorus (which marks the distal end of the stomach) to the ileocaecal junction. It comprises three segments. These are, in succession, the duodenum, jejunum and ileum. Owing to its many distinctive anatomical features, the duodenum is usually considered a separate anatomical entity, different from the remainder of the small intestine. The distinguishing features of the duodenum include its retroperitoneal location, its immobility due to the absence of a mesentery and its numerous intimate surgically-important topographical relationships. By contrast, the jejunum and ileum have a considerably greater mobility within the abdominal cavity owing to their attachment to a suspensory mesentery. Another point of difference between the duodenum and the remainder of the small intestine is that the duodenum has a dual embryological origin, in part from the foregut and partly from the midgut, while the jejunum and ileum are derived exclusively from the midgut. *In common clinical usage the term small bowel (small intestine) usually denotes just the jejunum and ileum and does not include the duodenum.*

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The duodenum

The duodenum commences at the pyloroduodenal junction and ends at the duodenojejunal flexure where it is continuous with the jejunum. The commencement of the duodenum lies somewhat to the right of the midline while its distal end is 2 cm to the left of the midline. The duodenum is the widest, shortest and least mobile of the three segments of the small intestine. Unlike the jejunum and ileum, it does not possess a mesentery.

The duodenum is a C-shaped tube about 25 cm in length (Figure 1) that is moulded around the head of the pancreas. It has two bends along its length, termed the superior and inferior duodenojejunal flexures. These bends allow the subdivision of the duodenum, for descriptive purposes, into four parts (Figure 2). In succession these are the superior part (1st part), descending part (2nd part), horizontal part (3rd part) and ascending part (4th part). In an average adult these parts are, respectively, 5 cm, 7.5 cm, 10 cm and 2.5 cm in length. The initial 2 cm or so of the duodenum, like the stomach, is ensleeved in peritoneum, and consequently has a degree of mobility. The remainder of the duodenum is a retroperitoneal, sessile and immobile structure.

The topographical relations of the duodenum are shown in Figure 1.

The concavity of the C-shaped duodenum is intimately related to, and surrounds the head and neck of the pancreas (Figure 1).

The 1st part of the duodenum lies above the head of the pancreas and passes laterally, upwards and backwards to the right of the vertebral column at the level of the first lumbar vertebra. Situated immediately behind the 1st part of the duodenum are the gastroduodenal artery and common bile duct. Lying still more posteriorly is the inferior vena cava.

Anterior relations of the 1st part of the duodenum are the liver (quadrate lobe) and neck of gallbladder. Chronic cholecystitis may result in inflammatory adhesion of the gallbladder wall to that of the 1st part of the duodenum. Subsequent gradual and progressive erosion of the walls of the gallbladder and duodenum may result in gallstones dropping into the duodenal lumen and being propagated along the small intestine, with possible impaction in the terminal ileum causing small bowel obstruction (gallstone ileus).

The 2nd part of the duodenum lies anterior to the right renal hilum, and immediately lateral to the head of pancreas. Crossing in front of the 2nd part of the duodenum is the commencement of the transverse colon and its mesocolon. The 2nd part of the duodenum is thus vulnerable during mobilization of the hepatic flexure and transverse colon in the course of a right hemicolectomy (Figures 1 and 4). Since the 2nd part of the duodenum is a retroperitoneal structure being plastered down by the posterior parietal peritoneum, mobilization of the 2nd part of the duodenum requires a vertical incision of the peritoneum lateral to the duodenum prior to moving the duodenum anteriorly and medially. This technique is known as *Kocher's manoeuvre*.

The main pancreatic duct and the common bile duct have a common opening into the posteromedial wall of the second part of the duodenum at the major duodenal papilla. As estimated on endoscopy, this papilla is usually 9–10 cm distal to the pyloroduodenal junction. Frequently, a minor duodenal papilla is seen 2–3 cm proximal to the major one. It contains the opening of the accessory pancreatic duct.

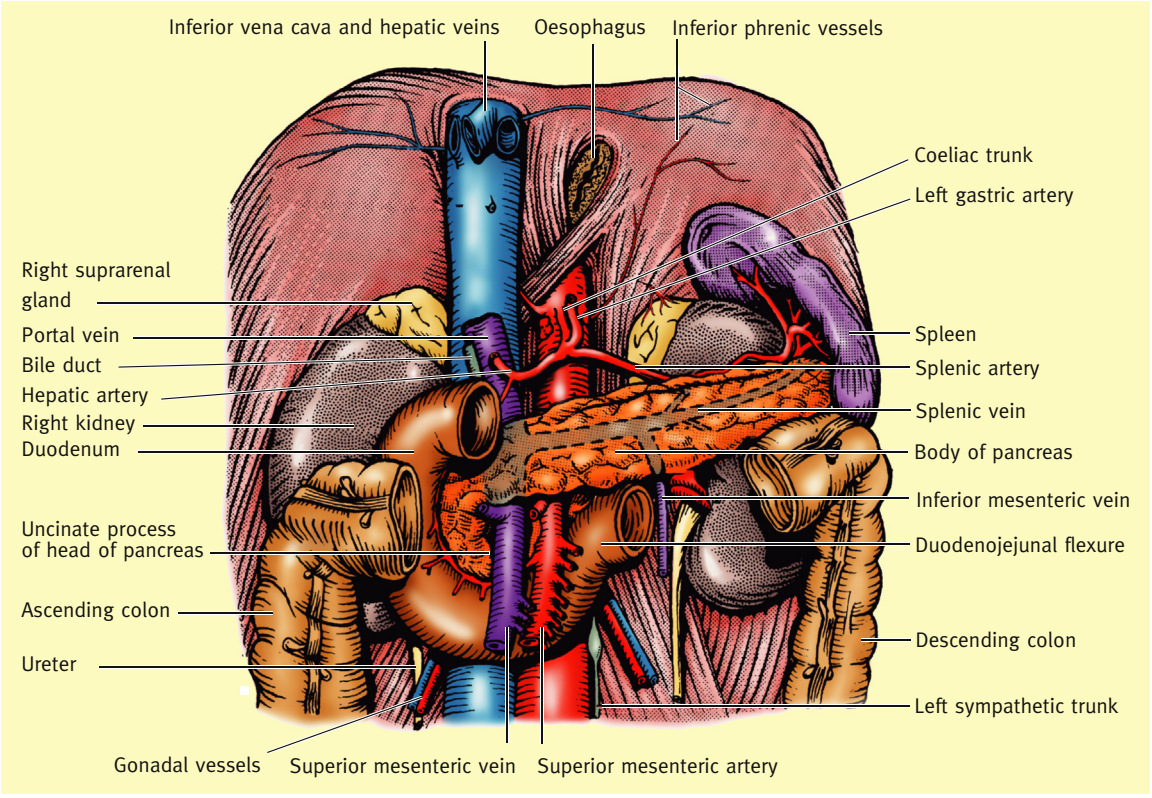

Figure 1 The duodenum and its relationships.

The 3rd part of the duodenum commences at the inferior duodenal flexure and passes more or less horizontally to the left to become continuous with the 4th part of the duodenum, immediately to the left of the aorta. It is covered anteriorly by peritoneum. In its course from right to left, the 3rd part of the duodenum lies inferior to the pancreas and anterior to the ureter and gonadal vessels of the right side as these overlie the ventral surface of the right psoas major muscle. The 3rd part of the duodenum then crosses in front of the inferior vena cava and abdominal aorta and becomes continuous with the 4th part, in front of the left psoas major muscle. Where it crosses the aorta, the 3rd part of the duodenum usually overlies the origin of the inferior mesenteric artery.

Crossing immediately in front of the 3rd part of the duodenum is the root of the small intestinal mesentery containing the superior mesenteric artery and vein (Figures 1 and 4). A tortuous and atherosclerosed superior mesenteric artery may compress the third part of the duodenum against the lumbar vertebral column causing intermittent obstruction of the duodenum. This is an extremely rare cause of high small-bowel obstruction and is known variously as Wilkie's syndrome, Wilkie's disease and superior mesenteric artery syndrome.

The 4th part of the duodenum is the shortest of the four segments of the duodenum. It passes upwards on the left psoas major, lying to the left of the abdominal aorta (Figure 1). It then bends anteriorly at the duodenojejunal flexure. This flexure is typically 2 cm to the left of the median plane at the level of the 2nd lumbar vertebra. Running from the right crus of the diaphragm to gain attachment to the superior and lateral aspects of the duodenojejunal flexure is a fibrous or fibromuscular band termed the suspensory ligament of the duodenum (or ligament of Treitz). It is necessary to divide this ligament in order to mobilize the 4th part of duodenum prior to pancreatico-duodenectomy (Whipple's operation) or when doing an open repair of an abdominal aortic aneurysm.

Arterial supply and venous drainage of the duodenum

The main arterial supply of the duodenum (and the adjacent head of pancreas) (Figures 1 and 3) is by the superior and inferior pancreaticoduodenal arteries. The former is a branch of the gastroduodenal artery (in turn a branch of the common hepatic artery) while the latter is a direct and early branch of the superior mesenteric artery. These two vessels form anterior and posterior anastomotic arterial arcades which lie along the concavity of the duodenum, in the cleft between the duodenum and head of pancreas. The veins draining the duodenum correspond to the arteries, and empty into the superior mesenteric vein and thus into the portal vein.

In terms of embryological development, the duodenum develops from the distal end of the foregut and the proximal part of the midgut. The junction between the two is somewhat distal to the duodenal papilla that receives the common bile duct and main pancreatic duct. The dual origin of the duodenum is reflected in its blood supply: being derived in part from the coeliac artery (the artery of the foregut) and the superior mesenteric artery (the artery of the midgut).

Since the advent of proton pump inhibitors and antimicrobials in the management of acid peptic disease, complications of acid peptic ulceration of the duodenum such as duodenal perforation and duodenal erosive haemorrhage are now rarely seen in the