Pancreas

Gross and Microscopic Anatomy

The pancreas (A1) is a wedge-shaped organ, 13–15 cm long, that lies on the posterior abdominal wall at the level of L1–L2. It extends almost horizontally from the C-shaped duodenum to the splenic hilum and may be divided by its macroscopic features into three parts:

Head of pancreas (B2). The head of the pancreas, which lies in the duodenal loop, is the thickest part of the organ. The hook-shaped uncinate process (B3) projects posteriorly and inferiorly from the head of the pancreas surrounding the mesenteric vessels (B4). Between the head of the pancreas and the uncinate process is a groove called the pancreatic notch (B5).

Body of pancreas (B6). Most of the body of the pancreas lies in front of the vertebral column. The body has an eminence, near the neck, called the omental tuberosity (B7) which extends into the omental bursa (see p. 222).

Tail of pancreas (B8). The tail of the pancreas extends to the splenorenal ligament of the spleen.

The retroperitoneal pancreas is covered on all sides by connective tissue. The transverse mesocolon (B9) passes horizontally along the anterior surface of its head and body. The anterior surface is divided by the root of the mesocolon into an anterosuperior surface (B10), which faces upward, and an anteroinferior surface (B11), facing downward.

The 2 mm thick pancreatic duct (B12) runs along the long axis of the gland near its posterior surface. It usually opens with the bile duct onto the major duodenal papilla (B13). In rare instances, the ducts may open independently into the duodenum. A patent accessory pancreatic duct (B14) is not uncommon. It drains above the main excretory duct into the minor duodenal papilla.

Microanatomy. The pancreas is a predominantly exocrine gland. The endocrine part consists of the pancreatic islets (see p. 324).

The exocrine part (C) is purely serous, and its secretory units, or acini (C15), contain polarized epithelial cells. Draining the secretory units are long intercalated ducts (C16) that begin within the acini and form the first part of the excretory duct system. In cross-section the invaginated intercalated ducts appear as centroacinar cells (CD17). The intercalated ducts drain into larger excretory ducts which ultimately unite to form the pancreatic duct. The fibrous capsule surrounding the pancreas sends delicate fibrous septa into the interior of the organ, dividing it into lobules.

Neurovascular Supply and Lymphatic Drainage

Arteries. Arterial supply to the head of the pancreas, like that of the duodenum (see p. 200), is provided by branches of the gastroduodenal artery (common hepatic artery): the posterior superior pancreaticoduodenal artery and the anterior superior pancreaticoduodenal artery. Both vessels anastomose with the inferior pancreaticoduodenal artery from the superior mesenteric artery. The body and tail of the pancreas receive their blood supply from the pancreatic branches which are branches of the splenic artery.

Veins. Venous drainage is via short veins named after the corresponding arteries. They empty via the splenic vein and superior mesenteric vein into the hepatic portal vein.

Nerves. Sympathetic fibers to the pancreas arise from the celiac plexus; parasympathetic fibers arise from the vagus nerve.

Regional lymph nodes. Lymph from the head of the pancreas drains into the pancreaticoduodenal nodes and from there usually to the hepatic nodes. Lymph from the body and tail of the pancreas drains to the pancreatic nodes lying along the superior and inferior borders of the pancreas. The pancreatic nodes drain into the celiac nodes.

Function. The exocrine pancreas produces a secretion containing lipase which breaks down fat, amylase which breaks down carbohydrates, and precursors of protease which breaks down protein.
Pancreas: Gross Anatomy and Microanatomy

A Position of pancreas

B Pancreas and excretory ducts, in situ

C Microanatomy of pancreas

D Acinus in longitudinal and transverse section
Topography of the Omental Bursa and Pancreas

Omental Bursa

The omental bursa is a nearly completely closed peritoneal cavity containing a capillary film that lies behind the stomach (A1) and lesser omentum and in front of the parietal peritoneum-covered pancreas (A2). The omental foramen (arrow) is the only natural entrance to the omental bursa. The peritoneal relations in and around the omental bursa have already been discussed in greater detail (see p. 188).

The omental bursa is visible in its entirety only after it has been freed by one of various surgical routes (dividing the lesser omentum, gastrocolic ligament, or transverse mesocolon).

Vestibule of omental bursa. The omental foramen leads to the vestibule of the omental bursa which is bounded anteriorly by the lesser omentum and posteriorly by the parietal peritoneum. Projecting into the vestibule is the papillary process of the caudate lobe of the liver (AB3). To the left of the papillary process is the prominent gastropancreatic fold (A4) that divides the vestibule from the main part of the cavity.

Main cavity. The greater part of the omental bursa consists of the superior recess of omental bursa, extending upward between the esophagus and inferior vena cava; the splenic recess of omental bursa (A5), extending to the left between the splenic ligaments and stomach; and the inferior recess of omental bursa (A6), extending downward between the stomach and transverse colon.

Omental foramen. The anterior boundary of the omental foramen is formed by the hepatoduodenal ligament, a part of the lesser omentum. Lying in the hepatoduodenal ligament are the hepatic artery proper (B7), the bile duct (B8), and the hepatic portal vein (B9). On inserting a finger into the omental foramen, the hepatic portal vein, lying furthest posteriorly in the hepatoduodenal ligament, can be felt at the anterior boundary of the omental foramen; behind the hepatic portal vein the inferior vena cava can be palpated. The pulse of the left gastric artery (B10) can be palpated in the gastropancreatic fold (A4).

Pancreas

The pancreas lies on the posterior wall of the omental bursa. Its anterior surface is covered by parietal peritoneum, and its head is surrounded by the duodenum. The pancreas lies in close proximity to the large trunks in the upper abdomen. Running along its superior border (B11) is the splenic artery (B12) which is accompanied by the splenic vein (B13) passing deep to it. Behind the body of the pancreas, the splenic vein receives the inferior mesenteric vein which unites behind the head of the pancreas with the superior mesenteric vein (B14) to form the hepatic portal vein (B9). The superior mesenteric artery (B15), which originates from the aorta, passes behind the pancreas and descends along the duodenojejunal flexure (B16) before proceeding through the pancreatic notch to the uncinate process, over the superior border of the horizontal part of the duodenum and into the root of the mesenteries.

Additional structures lying posterior to the pancreas are, from right to left: the bile duct, inferior vena cava, aorta, left adrenal gland, left kidney, and vessels of the left kidney. The tail of the pancreas projects into the splenic hilum and thus also has a topographical relationships to the left colic flexure and descending colon (B17).

Clinical note. Disorders of the pancreas (inflammation, cancer of the pancreatic head) can spread to the adjacent duodenum or cause obstruction of the hepatic, bile, and pancreatic ducts with resultant obstructive jaundice. Pancreatic disease can also cause a backup in the hepatic portal vein or inferior vena cava.

Diagnosis of pancreatic disease has been greatly improved by the use of modern imaging techniques such as CT and ultrasonography.

AB18 Right lobe of liver, AB19 Gallbladder, A20 Round ligament of liver, AB21 Left lobe of liver, AB22 Spleen
Topography of Omental Bursa and Pancreas

A Topography of omental bursa

B Topography of pancreas
Early Development

Ovulation is the release of the egg cell with its surrounding zona pellucida and corona radiata (= follicular/granulosa cells) and reception by the infundibulum of uterine tube via the abdominal ostium of uterine tube. Fertilization must occur within 6–12 hours, after which the egg cell is no longer viable. Fertilization normally occurs in the ampulla of uterine tube. The zygote is transported to the uterus within 4 or 5 days, propelled by ciliary action of the tubal epithelial cells, the production (flow) of tubal fluid, and contractions of the muscular wall of the uterine tube. All these actions are regulated by hormones.

Zygote development is also regulated by hormones. The zygote is nourished by substances found in tubal fluid, including pyruvate, lactate, and amino acids.

Cleavage. As it moves through the uterine tube, the zygote undergoes a series of mitotic divisions termed cleavage. With each cleavage the dividing cells, blastomeres, become smaller since they remain encased in the inelastic zona pellucida (ABC1) (see p. 312).

Morula. By around the third day after conception the zygote reaches the 16-cell stage at which point it resembles a mulberry and hence is termed a morula (A). The morula can be divided into a central, inner cell mass called the embryoblast (BC4) (embryonic disc) and a covering layer called the trophoblast (BC2) which later gives rise to the fetal portion of the placenta. In the blastomere stage the cells resemble each other. In terms of cytology, they are omnipotent cells and are indeterminate; thus as late as the 8-cell stage, complete separation can produce multiple offspring.

Blastocysts. In subsequent stages of development, a fluid-filled cavity arises from the confluence of widened intercellular spaces containing fluid secreted by the blastomeres. The zygote is now referred to as a blastocyst (B), and the fluid-filled cavity is the blastocyst cavity (BC3). The cells of the inner cell mass (embryoblast) now lie on one side, and the cells of the outer layer (trophoblast) flatten to form the epithelial wall of the blastocyst (BC2). At the same time, the endometrium (C78) is prepared for blastocyst implantation by progesterone secreted by the corpus luteum. The lining of the uterus thickens and becomes more vascularized and receptive to implantation, allowing the blastocyst to burrow into it and receive nourishment. Implantation (C) (nidation) of the blastocyst in the endometrium occurs at a favorable site (from which it will not be easily moved), usually in the posterior (D9) or anterior wall (D10) of the uterine cavity.

C7 Functional layer of endometrium, C8 Uterine epithelium

Implantation. Implantation (nidation, day 6–7 after conception) involves a series of phases. In the first phase, apposition, the blastocyst comes into contact at its embryonic pole (BC4) (implantation pole) with the epithelium of the endometrium. The second phase is adhesion, requiring adhesion molecules which are only available for 24 hours (the so-called window of implantation). Only then can invasion occur: the trophoblast of the embryonic pole proliferates and forms villi, erodes the uterine epithelium, and invades the endometrium (C6). Trophoblast cells that come into contact with endometrial cells form the syncytiotrophoblast containing multiple nuclei without identifiable cell boundaries. Nonfused trophoblast cells produce the inner layer known as the cytotrophoblast. The cytotrophoblast consists of a single layer of cuboidal epithelial cells. The previously single-layered trophoblast now consists of two layers (see p. 312).

Clinical note. Implantation outside of the uterine cavity resulting in extrauterine pregnancy (ectopic pregnancy) can occur in the abdominal cavity (D11) or ovary (D12), demonstrating that the sperm can travel into the abdominal cavity and fertilize an egg cell there (abdominal pregnancy). Most ectopic pregnancies are tubal pregnancies (D13) (in the uterine tube). Implantation of the blastocyst in the uterine tube can erode the mother’s vessels and cause life-threatening hemorrhage. Implantation in the isthmus (D14) of the uterus results in placenta previa in which the placenta obstructs the birth canal.
Cleavage, Morula, Blastocyst, Implantation

A Morula

B Blastocyst

C Implantation

D Implantation sites in extrauterine pregnancy and placenta previa
Embryonic Period, cont.

Stage 10–12 (Week 4). Somite formation continues in stages 10–12: there are 4–12 somites in stage 10, 13–20 somites (AB1) in stage 11 (AB), and 21–29 somites in stage 12. In stage 10 the neural folds (AB2) begin to close to form the neural tube. The brain develops at the anterior end, and the spinal cord forms at the posterior end. The cranial and caudal ends of the neural tube remain open, as the superior neuropore (AB3) and inferior neuropore (AB4). In stage 11 the embryo is curved and has a cephalic (B5) and a caudal folding (B6). The first two pairs of branchial arches (B7) appear, and the optic vesicles are visible. The superior neuropore closes. In stage 12 there are three pairs of branchial arches. The inferior neuropore closes and the otic pit is visible. The primordial heart is composed of a loop in which contractile activity begins. The limb buds of the upper limbs appear.

Stage 13–15 (Week 5). The embryo becomes markedly curved and has 30 or more somites (the exact number is difficult to ascertain). In stage 13 four pairs of branchial arches can be seen; the lens placode has been established, and the limb buds of the lower limbs appear. In stage 14 the lenses and nasal pit are visible; the optic cup has formed; limb differentiation continues. In stage 15 the cerebral vesicles are present and the hand plates have developed.

Stage 16–18 (Week 6). Stages 16–18 are characterized by continued differentiation of the limbs and development of the foot plate (C8) and finger rays (C9). In stage 18 the elbow is visible and the toe rays appear. Ossification of the mesenchymal condensations begins. Facial development includes formation of the auricular hillocks, the nasolacrimal groove, the apex of the nose, the eyelids, and retinal pigmentation.

Stage 19–20 (Week 7). The flexure of the embryo decreases, since its trunk is lengthening and straightening and its head is becoming larger relative to its trunk. The limbs are also becoming longer, growing anteriorly beyond the primordial heart. Restricted space in the abdominal cavity causes the intestinal loop of the midgut to herniate into the umbilical cord.

Stage 21–23 (Week 8). The stages in the last week of the embryonic period are characterized by differentiation of the typical human features. The head flexure reduces, and the neck is established (DE10). The external ear (D11) develops and the eyelids (D12) appear. The limbs become longer and the fingers (D13) divide into separate digits. The toes establish and chondral ossification begins. Sex-specific differences begin to become apparent on the external genitalia.

Fetal Period (Overview)

The fetal period is characterized by differentiation and maturation of organ systems as well as a rapid growth of the fetus. The size of the fetus is measured in centimeters or millimeters as crown-rump length (CRL) (sitting height) or crown-heel length (CHL) (standing height). In ultrasound examinations the biparietal diameter (BPD) of the cranium and the femur length can also be determined to help more precisely assess size and age. The fetus weighs about 10 g at the beginning of week 9 and about 3400 g by birth.

Major changes taking place during the fetal period are measured in months. A main feature is the apparent disproportionate growth of the head in relation to the trunk and limbs. At the beginning of the fetal period the head makes up nearly one-half of the length of the body; at the end of the fetal period it is makes up only one-fourth.
Embryonic and Fetal Periods

A Early stage 11, posterior aspect
B Late stage 11, lateral aspect
C Stage 17
D Stage 23
E Ultrasound image, stage 23