Anatomy of the pig

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Introduction

The digestive system of swine has anatomic differences from humans. However, the physiology of digestion remains similar to humans. In spite of the anatomic differences, the pig has been used extensively as a gastrointestinal model. Most of the classical models involving the digestive system have been related to nutritional studies to study digestion of the pig and for studying human digestive phenomenon. More recently endoscopic and laparoscopic surgical models have been developed and used extensively in the swine. The size and function of structures such as the biliary system and pancreatic duct make them amenable for studying human sized equipment and biomaterial implants. Surgical modifications have made the intestinal tract amenable to the study of surgical and chronic fistulation procedures.

Laparoscopic surgery has replaced many open operations. The procedures described are commonly performed laparoscopically by many general surgeons but require practice. The porcine model is ideal to train surgeons in laparoscopic procedures since porcine anatomy is generally similar to humans with some minor differences.

Liver

1. Morphological feature

In the human, the liver morphologically consists of 4 lobes; the left, right, quadrate, and caudate lobes although the functional anatomy is more important than the morphological one, which is rarely used in clinical field. Unlike to the human, the porcine liver consists of 5 lobes; the left lateral and medial, right lateral and medial, and caudate lobes. In the ventral view, 4 lobes are seen; the left lateral, left medial, right medial, and right lateral lobes in sequence from left to right. The caudate lobe encircling the vena cava is seen only after lifting other lobes, similarly in human. Although in the human, the inferior vena cava (IVC) is divided the supra-hepatic, and infra-hepatic IVC, they can be called as the “anterior (cranial)” and posterior (caudal)” vena cava in the pig because the pig crawl on four legs. Differently to the human, a long segment of posterior vena cava is wrapped up by the thin hepatic parenchyma. Thus, dissection between the liver and vena cava can be very difficult. The GB is attached to the inferior plane of the right medial lobe.

2. Portal vein and segmental arrangement

The porcine liver is divided into 5 lobes by the deep interlobar fissures, which can be further divided into
8 segments based on the blood supply and biliary drainage even if the segmental classification and nomenclature can be slightly different according to the studies. In the posterior view of the porcine liver, the segment is numbered anticlockwise, starting from the segment I, arranged to the caudate lobe. The left lateral lobe consists of segment II and III and the left medical lobe consist of mono-segment IV, same to the human liver. The segment V/VIII and VI/VII compose the right medical lobe and lateral lobe, respectively.

The porcine portal vein follows an oblique caudal-cranial path from right to left, branching out to eight distinct segments. Portal veins to the right for segments VI, VII, V and VIII and portal veins to the left for segments II, III and IV ventrally branch out in that order from the main portal vein and portal veins to segment I are dorsally located. This porcine portal vein branching pattern is different to the human. In the human, generally, the portal vein is first divided into the left and right, and then branch off segmentally. However, the porcine portal vein first ramifies the right lateral branch and then divides into right medial and left branches. This branching pattern is similar to one of the common variation type of the human portal vein.

According to some studies for porcine liver segmentation using injection and corrosion methodology, a small branch of the left medial portal vein is frequently observed to cross over to the left dorsal portion of the right medical lobe. Thus, some authors calls the area supplied by this branch as segment IV. Based on their segmentation, the right medial lobe consists of segments IV (left dorsal), V (left ventral), and VIII (right dorsal). Instead, the left medial lobe consist of mono-segment III and the left lateral lobe is supplied by two portal branches (dorsal and ventral II).

### 3. Hepatic vein

In the pig, five main hepatic veins and right and left accessory veins are present. The lobar venous drainage is comparatively well-developed, unlikely to the human with the major hepatic veins located in inter-lobar or inter-sectional plane. The porcine main hepatic veins can be named as follows: left hepatic vein (LHV), left middle hepatic vein (LMHV), middle hepatic vein (MHV), right middle hepatic vein (RMHV) and right hepatic vein (RHV). LHV, LMHV and RHV drain the left lateral, left medial and right lateral lobes, respectively. Only the right medial lobe is drained by two major hepatic veins; MHV and RMHV. The caudate lobe drains by various
narrow caliber branches which flow directly into the retrohepatic vena cava along its entire path. Similarly in
the human, main hepatic veins have two main drainage sites on the upper third of the retrohepatic vena cava:
a caudal one to the right, which presents RHV, RMHV and right accessory veins confluence, and a cranial one
to the left, which presents LHV, LMHV, MHV and left accessory vein confluence.

Pancreas

The pancreas is extensive and the tail follows the lesser curvature of the stomach from the spleen to the
proximal duodenum. The body encircles the superior mesenteric vein and extends dorsally to the left kidney. The
pancreatic ducts in the tail and body join at the junction of the two lobes to enter the duodenum distal from
the bile duct. The islet cells are relatively indistinct histologically. Functionally, both the liver and pancreas are
similar to humans.

1. Pancreatic lobes

The pancreas is composed of three lobes featuring a nodular surface with irregular margins. The “splenic”
lobe (corresponding to the tail and body in the human pancreas) is situated posteriorly and is attached to
the spleen and the stomach. The “duodenal” lobe (corresponding to the head of the pancreas) is located adjacent to
the duodenum while the “connecting” lobe (corresponding to the uncinate process) is an extension of the pancreas
which is attached to the anterior aspect of the portal vein. There is a “bridge” of pancreatic tissue serving as
an anatomical connection between the splenic and connecting lobes.

2. Arterial anatomy

The celiac trunk (CT) was the first branch off the abdominal aorta infradiaphragmatically and branched into
the splenic artery, the left gastric artery (LGA), and the common hepatic artery, as is common in the human.
These arteries were immediately identified and transected distally to the pancreas. The splenic artery was the first
branch identified, dissected, and tied. The posterior or dorsal pancreatic artery (PPA) is a small pancreatic branch
originating from the splenic or hepatic artery and was next identified along the upper border of the pancreas.
In some cases the PPA can have its origin more proximal off of the splenic artery, but distal to the celiac
trifurcation. In some animals, more than one PPA was identified with large variability in size.

LGA runs parallel to the left gastric vein to supply the stomach, and the other was the common hepatic artery
which supplies the liver with arterial blood. The proper hepatic artery and common bile duct were ligated and
divided. The gastroduodenal artery arises from the hepatic artery before its bifurcation into the right and left hep-
atic artery. The pyloric region of the gastroduodenal artery exhibits two branches that supply the duodenal lobe
of the pancreas: (1) the superior pancreaticoduodenal artery and (2) the right gastroepiploic (or gastroomental)
artery. The superior pancreaticoduodenal artery supplies the descending duodenum in addition to the duodenal
lobe. This artery anastomoses with the inferior pancreaticoduodenal artery that originates from the superior mesen-
teric artery (SMA). The pancreaticoduodenal vascular arcade runs between the pancreas and the duodenum, and
also extends branches to both organs.
Caudal to the CT was the SMA and the renal arteries (found by following the abdominal aorta to the level of the kidneys). The SMA and the superior mesenteric vein (SMV) were isolated at the lower edge of the pancreas on the left side of the portal vein (PV). The SMA gives branches (jejunal arteries, right colic artery, middle colic artery, and ileocolic artery) that supply the distal part of the descending duodenum to the proximal part of the ascending colon. The connecting lobe, the bridge, and the inferior aspect of the splenic lobe are vascularized by an arterial branch, the inferior pancreatic artery, which emerges from the inferior pancreaticoduodenal arterial arcade.

3. Venous anatomy

The PV collects the blood from stomach, pancreas, intestine, and spleen. The PV from the root of the mesentry to the liver, penetrates the pancreas at an acute angle so that it lies caudally on the ventral surface and rostrally on the dorsal surface of the pancreas. The PV has two branches which drain into it, the splenic vein and the SMV. The splenic vein drains the body and tail of the pancreas and it is partly surrounded by pancreatic tissue. Veins draining blood from the stomach (left gastric vein, left gastroepiploic vein) also come out into the splenic vein.

The SMV passes through the portal ring receiving the inferior pancreaticoduodenal vein. The inferior mesenteric vein (IMV) usually flows into the SMV, which would be considered an unusual variation in the human anatomy. Small branches drain the CL into the SMV. The gastroduodenal vein empties into the SMV immediately before its junction with the splenic vein. The gastroduodenal vein receives small veins from the duodenal lobe. Peripherally, the gastroduodenal vein receives the superior pancreaticoduodenal vein which anastomoses with the inferior pancreaticoduodenal vein.

Conclusion

The liver and pancreas of the swine show similar in those of human. The similar anatomy and physiologic characteristics of swine had made them a valuable animal model of human disease as well as a model for general mammalian physiology. As surgeons become familiar with swine anatomy, they have increasingly more comfortable operating laparoscopically and operative time will decrease. Practice on porcine models can ease the transition into human surgery and thereby increase efficiency and minimize mistakes.

References