Anatomy of the gallbladder and bile ducts

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Abstract

A detailed knowledge of the gallbladder and bile ducts (together with their anatomical variations) and related blood supply are essential in the safe performance of both open and laparoscopic cholecystectomy as well as the interpretation of radiological and ultrasound images of these structures. These topics are described and illustrated.

Keywords Anatomical variations; bile ducts; blood supply; gallbladder

The biliary ducts (Figure 1)

The *right and left hepatic ducts* emerge from their respective sides of the liver and fuse at the porta hepatis ('the doorway to the liver') to form the *common hepatic duct*, which is, on average, 4 cm in length. This is then joined by the *cystic duct*, draining from the gallbladder, and averaging 4 cm in length, to form the *common bile duct*. This commences about 2.5 cm superior to the first part of the duodenum, then passes posteriorly to it to open at a papilla on the medial wall of the second part of the duodenum. As it passes behind the pancreas, the common bile duct either grooves the posterior aspect of the pancreatic head or actually burrows through it. Usually, the termination of the common bile duct joins that of the main pancreatic duct (the duct of Wirsung), to form a common vestibule, the *ampulla of Vater*, whose opening into the duodenum is guarded by a distinct ring of involuntary muscle, the *sphincter of Oddi* (Figure 2). This junction is pictured in many textbooks as a distinct sac-like structure. However, examination of a normal retrograde pancreatico-cholangiogram will show, in the great majority of cases, that the junction results in a simple tube without any obvious sac-like appearance. Sometimes, the common bile duct and the main pancreatic duct open separately into the second part of the duodenum. The cystic duct usually contains a series of mucosal folds, the *spiral valve of Heister* (see Figure 1). These may render the passage of a soft catheter difficult in the performance of an operative cholangiogram and may first require dilation by means of a metal probe.

The common hepatic duct and the supraduodenal part of the common bile duct lie in the free edge of the lesser omentum, where they have the following relationship (Figure 3):
- the common hepatic and the common bile duct lie anteriorly and to the right;
- the hepatic artery lies anteriorly and to the left;

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- the portal vein lies posterior to these structures;
- the inferior vena cava, separated by the epiploic foramen (the foramen of Winslow) lies still more posteriorly, behind the portal vein.

Note that haemorrhage during gallbladder surgery may be controlled by compression of the hepatic artery, which gives off the cystic branch, by passing a finger through the epiploic foramen (foramen of Winslow), and compressing the artery between the finger and the thumb placed on the anterior aspect of the foramen (Pringle's manoeuvre).

At fibreoptic endoscopy, the opening of the duct of Wirsung can usually be identified quite easily. It is seen as a distinct papilla rather low down in the second part of the duodenum, lying under a characteristic crescentic mucosal fold (Figure 2). Unless the duct is obstructed or occluded, bile can be seen to discharge from it intermittently.

The gallbladder (Figures 1 and 3)

The normal gallbladder has a capacity of about 50 ml of bile. It concentrates the hepatic bile by a factor of about 10 and also secretes mucus into it from the copious goblet cells scattered throughout its mucosa. It lies in a fossa separating the right and the quadrate lobes of the liver (Figure 4). Inferiorly, the gallbladder relates to the first and second parts of the duodenum and to the hepatic flexure of the colon. An inflamed gallbladder may on occasion ulcerate into either of these structures and a large stone, ulcerating through into the lumen of the duodenum may come to impact in the distal small intestine — *gallstone ileus*.

The gallbladder is divided for descriptive purposes into a fundus, body and neck, the latter opening into the cystic duct (Figure 1). Under pathological conditions, a pouch is frequently present on the ventral aspect of the organ, just proximal to the neck, in which lies a solitary, or impacted collection, of calculi. This is termed *Hartmann's pouch*.

Structure

The gallbladder and the sphincter of Oddi contain involuntary muscle, but there are only scattered muscle fibres in the remaining parts of the biliary tract. The mucosa consists of a columnar epithelium, bearing mucus-secreting goblet cells.
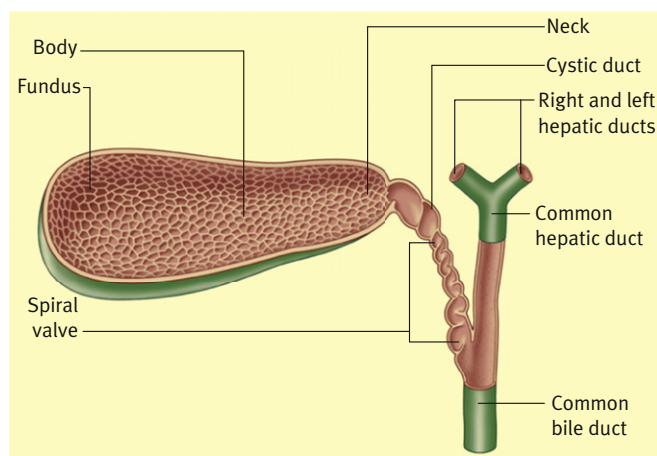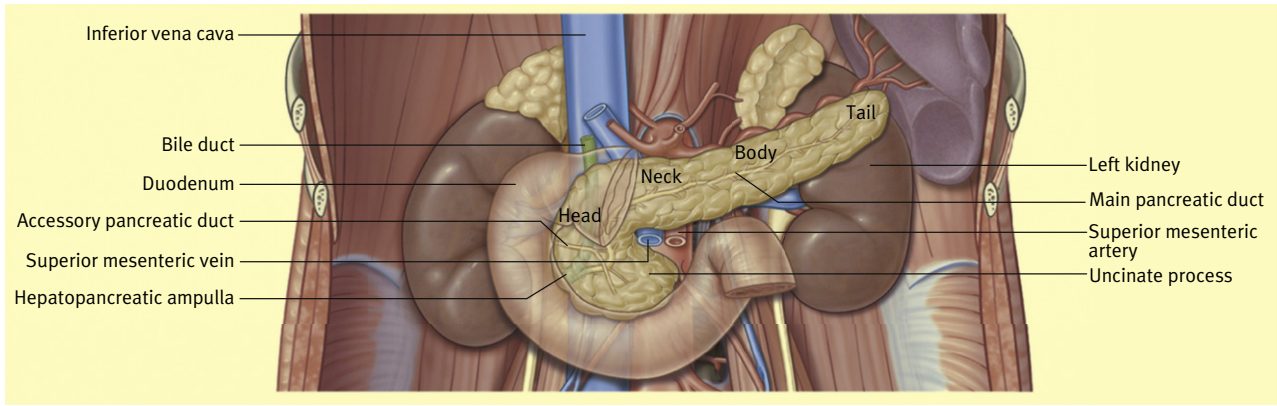

Figure 1 The gallbladder and bile ducts.

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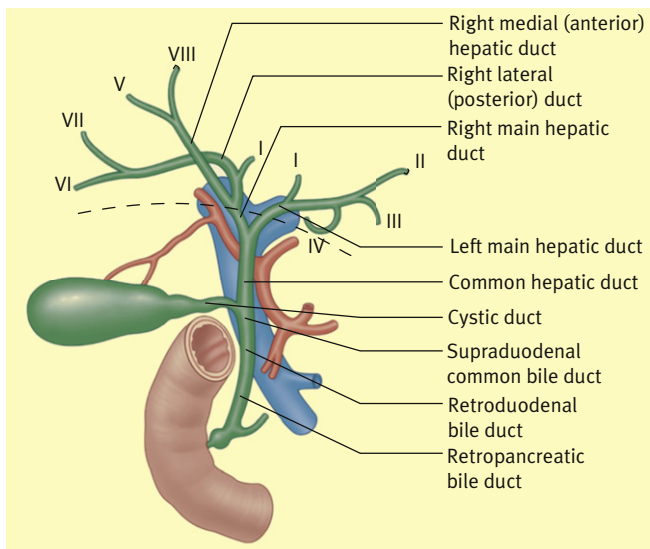**Figure 2** The relations of the common bile duct.

Figure 3 The detailed anatomy of the bile duct system.

Embryology and developmental anomalies (Figure 5)

The gallbladder and its ducts are subject to numerous variations, which are best understood by considering their development. A diverticulum develops from the ventral wall of the duodenum, which differentiates into the hepatic ducts and the liver. Another diverticulum emerges from the side of the hepatic duct to form the gallbladder and the cystic duct. In some animals, including the rat, the deer, the horse and the pigeon, the gallbladder is absent. This knowledge might be a comfort to patients who are to undergo cholecystectomy!

Variations in anatomy include: a long cystic duct, which joins the common hepatic duct behind the duodenum; a short, or even absent, cystic duct, which usually means abandoning laparoscopic cholecystectomy for open surgery; the common duct opening of the cystic duct being on the left side; and the presence of accessory hepatic ducts. Variations in blood supply are common and are considered below.

Blood supply (Figures 6 and 7)

The gallbladder receives the *cystic artery*. Commonly, this arises from the right hepatic artery, and usually passes behind the
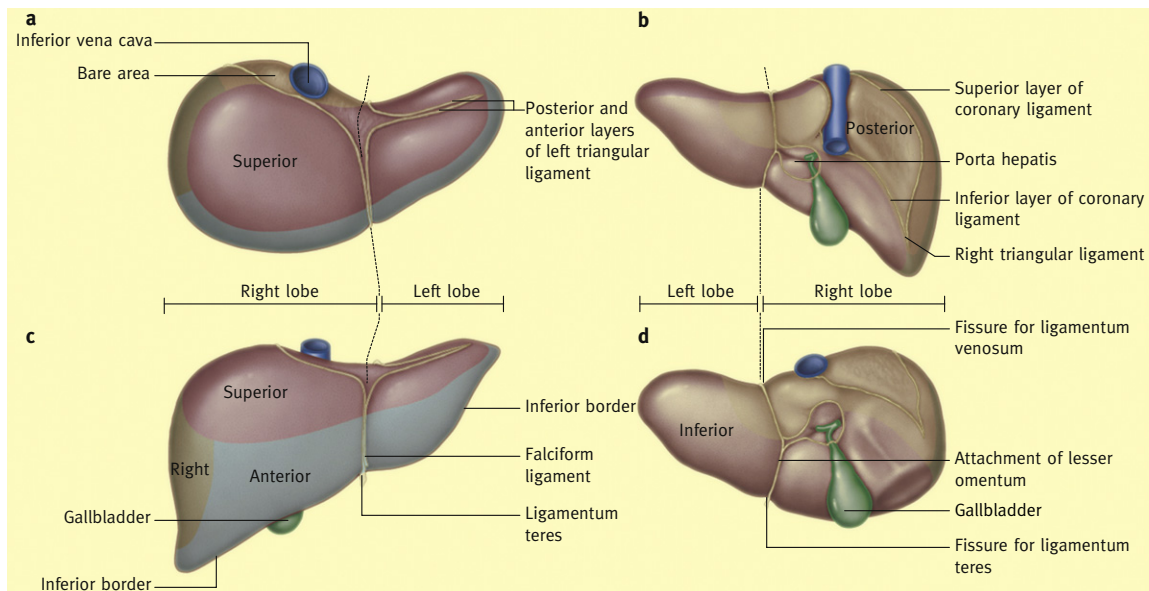

Figure 4 Relations of the gallbladder to the liver.

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Cystic duct variants

a1 Low entry   **a2** Medial side entry **a3** Common drainage **a4** Accessory cystic
with right lateral   duct (segment V)
sectoral duct

Intrahepatic bile duct variants

b Absence of the right hepatic duct

e Multiple ducts forming the common
hepatic duct

c Low drainage of the right lateral sectoral duct **f** Right lateral sectoral duct draining into the
into the common hepatic duct   cystic duct

d Right lateral sectoral duct draining into the left
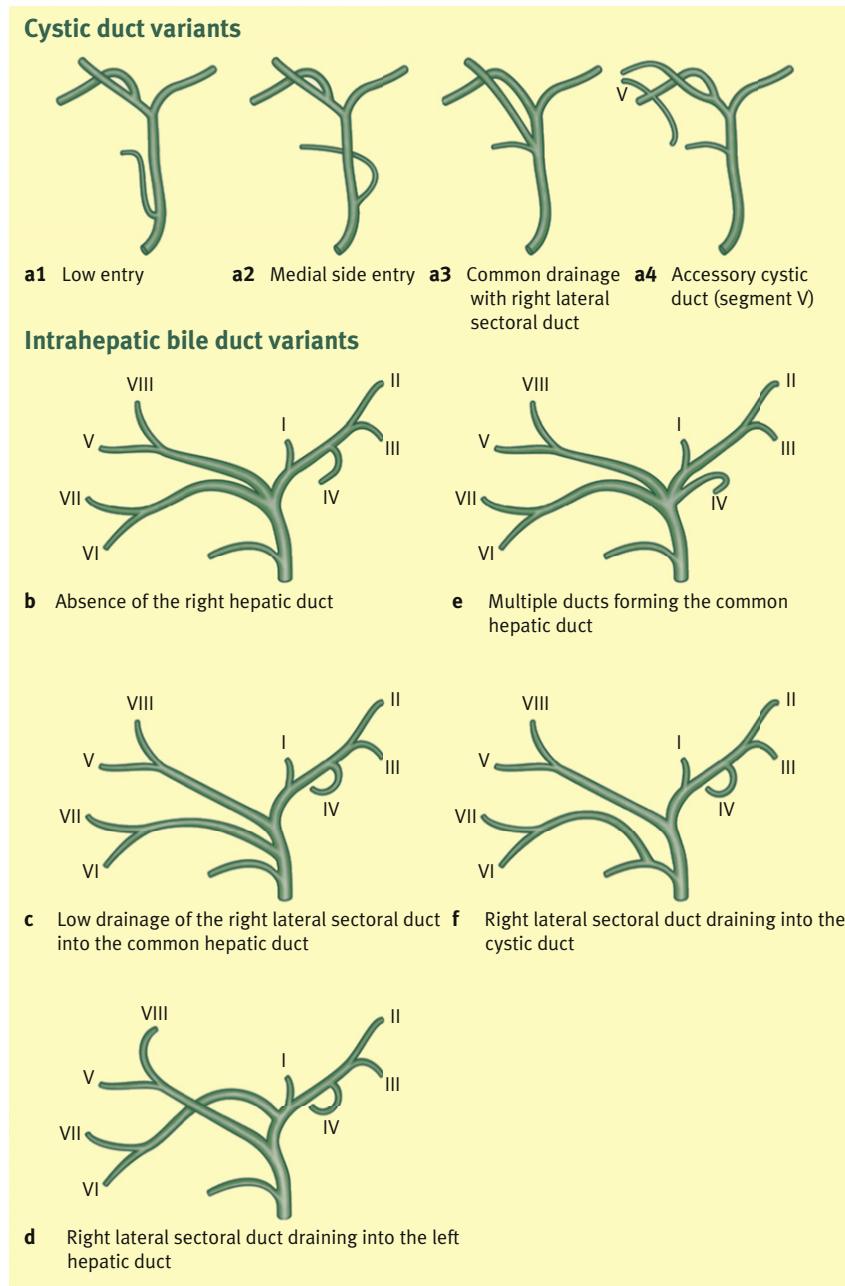hepatic duct

Figure 5 Variations in the anatomy of the bile ducts.

common hepatic duct to reach the neck of the gallbladder and then to branch over the surface of the body of the gallbladder. However, variations in the arrangement and origin of this artery are common. The cystic artery may arise from the left, or from the main hepatic artery, or even from the gastroduodenal artery, and may pass in front of, instead of behind, the bile ducts.

Fortunately for the surgeon, the cystic artery, whatever its origin, is almost invariably situated in a triangle formed by the ventral aspect of the liver, the cystic duct and the common hepatic duct (*Calot's triangle*) (Figure 7). It is sought here by the surgeon at both laparoscopic and open cholecystectomy. In addition, the gallbladder receives numerous arterial twigs from the right hepatic artery via the gallbladder bed in the liver. These are readily seen at laparoscopy and are of great clinical
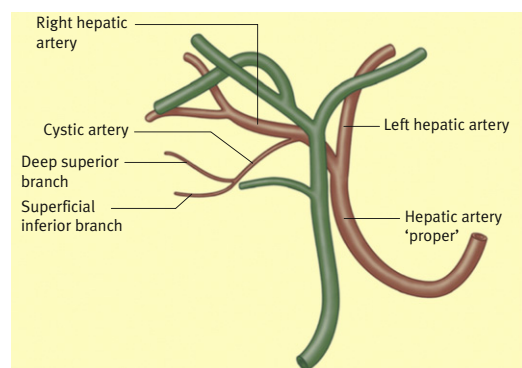
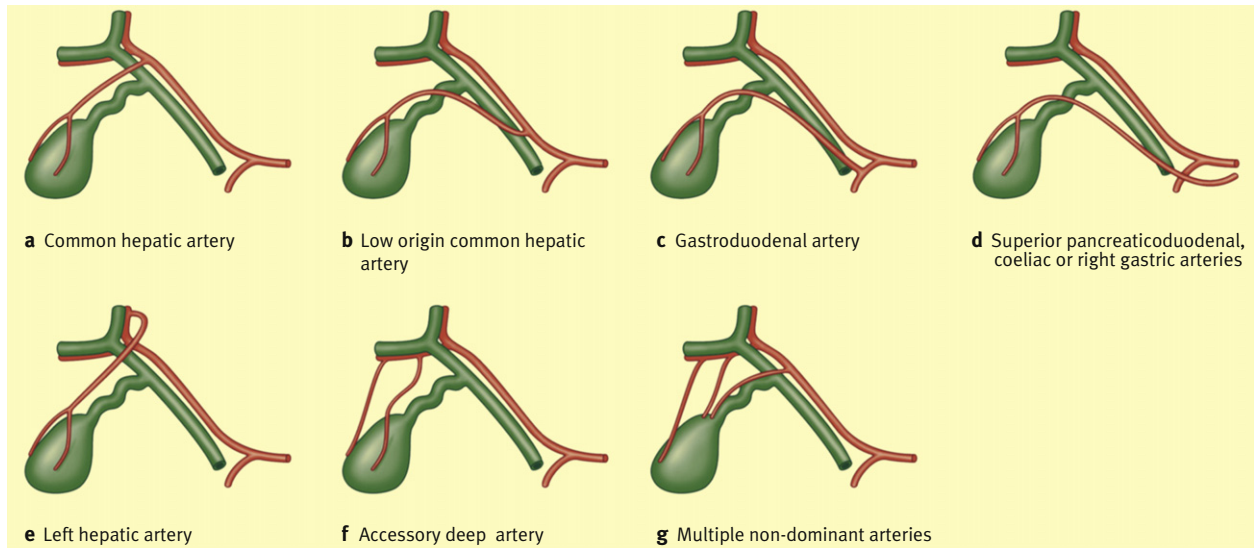**Figure 6** The hepatic artery and its branches.

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Figure 7 Variations in the origin of the cystic artery.

importance. In acute cholecystitis, this rich and multiple arterial supply means that ischaemia of the gallbladder is unlikely to occur and conservative treatment is usually successful. In contrast, the appendicular artery is an end-artery; thrombosis of this vessel in acute appendicitis leads inevitably to gangrene and early appedicectomy is therefore mandatory.

Venous drainage is by numerous veins which accompany the arterial twigs to the gallbladder in its bed, and which are easily visible at laparoscopy, provided the gallbladder is not grossly inflamed or thickened. They drain into the radicles of the right portal vein in the liver bed. Rarely, one or more cystic veins are present and drain from the neck of the gallbladder to the right branch of the portal vein.

Lymphatic drainage
The gallbladder drains into nodes in the porta hepatis and to the cystic node in Calot's triangle, which is found at the junction of the cystic duct with the common hepatic duct. ◆

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