# Radiological anatomy of the abdomen

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## Abstract

Advances in technology have led to significant developments in techniques for imaging the abdominal and pelvic organs, in both the elective and emergency surgical settings. Improvements in the quality and availability of imaging has had a profound effect on the delivery of high-quality surgical care and has improved outcomes by providing accurate preoperative diagnosis and staging, leading to a reduction in exploratory and futile operations, while permitting better planned precision surgery and a growing range of interventional radiology interventions. This article will describe the essential anatomical interpretation of the common radiological imaging techniques relevant to the abdomen and pelvis and describe the rationale for selection of the most appropriate imaging modality.

**Keywords** Abdomen; anatomy; imaging; pelvis

## Selection of imaging modality

The choice of imaging modality will vary according to the suspected diagnosis, organ system of interest, patient age and body habitus. In most circumstances, the choice will lie between ultrasound (US), computed tomography (CT) and magnetic resonance imaging (MRI). In the most general terms, US and MR infer the advantage of avoiding the use of ionizing radiation, but US is limited by larger body habitus and overlying bowel gas and MRI by its availability and time for acquisition, along with the requirement for specialist reporting. CT allows the rapid acquisition of images and modern machines provide high-definition output, but the modality does involve exposure to relatively high doses of radiation and so its use tends to be limited in children and younger adults.

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### Ultrasound

US is operator dependent, but has the advantages of being radiation free, has superior spatial resolution for accurate measurement and is mobile and cheap to access. It is most often used as a first-line investigation in children presenting with abdominal symptoms or adults with conditions such as gallstones, biliary obstruction or ovarian cysts. In addition to greyscale images from ultrasound, colour Doppler is also available to assess the patency of a blood vessel and the velocity of flow. It is frequently used to differentiate solid from cystic lesions.

### Computed tomography

CT is the main workhorse in the investigation of the acute abdomen. It can be performed with or without intravenous contrast. In specific situations, oral contrast can also been given to increase the diagnostic accuracy, such as looking for an anastomotic leak and for increasing the definition of bowel loops from surrounding organs. When CT of the abdomen is performed without contrast, it is used to investigate the presence of radio-opaque calculi within the urinary tract or as the initial scan prior to giving intravenous contrast during the investigation of acute haemorrhage.

Intravenous contrast is often given via a peripheral cannula as a bolus injection followed by a saline flush. The different phases of CT refer to the timing of scan after the contrast injection is given. The most commonly used phases are early arterial, late arterial, portovenous, urographic and delayed phases which refers to start of scanning after 15 seconds, 30–40 seconds, 70 seconds, 90 seconds and 5–20 minutes after the injection, respectively. The early arterial phase is also known as CT angiography. It is used for the interrogation of the abdominal aorta. The late arterial phase is performed to investigate the abdominal visceral vessels such as the hepatic, splenic arteries or to locate gastrointestinal (GI) haemorrhage. It can also be performed in conjunction with portovenous phase imaging to look for arterialized lesions such as hepatocellular carcinoma and neuroendocrine tumours. The portovenous phase is the most commonly used phase and is used to investigate the presence of abdominal collections, appendicitis, diverticulitis, GI perforation in the acute setting and as a staging tool to identify the spread of malignant disease. The delayed phase imaging is most frequently used in the investigation of haematuria or renal trauma.

### Magnetic resonance imaging

MRI does not involve the use of ioniszing radiation and has superior soft tissue contrast, which can be manipulated by altering the sequence timings and produces images with different tissue appearances/contrast weighting known as T1-, T2- and PD-weighted images. Heavily T2-weighted images such as MR cholangiopancreatography (MRCP) is used to investigate the biliary tree and the presence of gallstone. Post-contrast images can also be acquired after injection of intravenous contrast. Like multiphase CT, post-contrast images can be acquired for different phases. Oral contrast is given during MR enterography, which plays a key role in the management of patients with inflammatory bowel disease. MR takes longer to perform than CT, is noisier and can be claustrophobic for patients. Children will




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require sedation or general anaesthesia in order to acquire good quality images. MR also has poorer spatial resolution than CT and is usually not suitable for imaging abnormalities smaller than 5 mm.

## Liver

The liver lies high in the abdominal cavity, occupying most of the right hypochondrial region, extending into the epigastrium and to the medial part of the left hypochondrium. The liver is, for the most part, surrounded (and protected) by the lower circumference of the rib cage. It is enveloped in a thin connective tissue layer, termed Glisson's capsule. The liver is moulded to the under surface of the diaphragm and is consequently somewhat wedge-shaped. It may be said to possess two surfaces: diaphragmatic and visceral (Figure 1).

### Functional anatomy of the liver

While the traditional morphological anatomy of the liver describes two unequal lobes, left and right, separated by the falciform ligament, modern liver surgery is a precision activity and based on the functional segmental anatomy developed from the descriptions of Couinaud in 1957. This description divides the liver into eight segments based on the portal divisions and locations of the hepatic veins and forms the basis of anatomically based liver surgery. This system forms the consensus agreement for describing liver anatomy in surgical publications throughout Europe, Asia and the Americas and should replace the older description of lobes and sectors that was based on the location of variable visible landmarks, such as grooves and fissures.

### Visceral surface of the liver

The entire visceral surface of the liver is covered by peritoneum except where the peritoneum is lifted off the surface by the gallbladder. The visceral surface of the liver is thus separated from all the viscera to which it is related. The exception is the gallbladder which contacts the visceral surface of the liver directly without any intervening peritoneal layer.

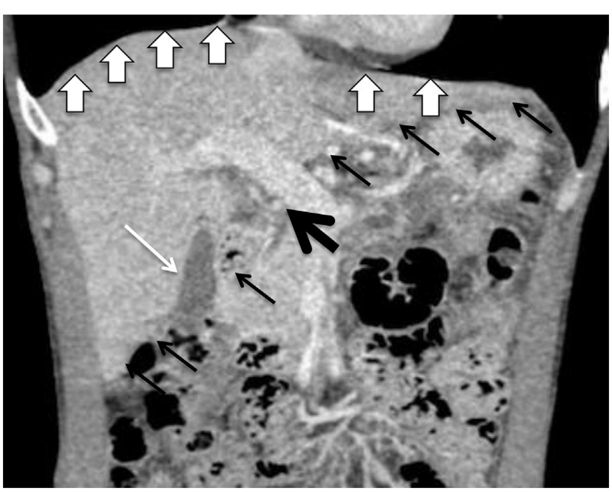

**Figure 1** A coronal CT demonstrating the diaphragmatic (thick white arrows) and visceral (narrow black arrows) surfaces of the liver. The locations of the porta (thick black arrow) and gallbladder (narrow white arrow) are indicated.

The notable features on the visceral surface are: (i) the porta hepatis; (ii) the gallbladder fossa (cystic fossa) which accommodates the gallbladder; and (iii) fissures for the ligamentum teres and ligamentum venosum.

The porta hepatis is a transverse fissure, 5 cm long, through which the right and left branches of the hepatic artery and right and left branches of the portal vein enter the liver and the right and left hepatic ducts accompanied by lymphatic vessels emerge from the liver.

Occasionally, a tongue-like projection of liver extends from the anterior edge of the liver just lateral to the fundus of the gallbladder. This anatomical variant is called Riedel's lobe (Figure 1).

### Segmental anatomy of the liver

On the basis of portal divisions and venous drainage the liver is divided into two functional halves; the right and left 'hemilivers'. The two are demarcated by *Cantlie's line* which corresponds to an oblique plane that passes through the gallbladder fossa and the fossa for the inferior vena cava, and in which plane runs the middle hepatic vein.

Each hemiliver is divided into two sections. The two sections of the right hemiliver are termed the right anterior and right posterior sections. The plane of division between the two sections in the right hemiliver is demarcated by the right hepatic vein. There are no surface landmarks that can be used to indicate this plane. The hepatic veins can be readily identified on both ultrasound and contrast CT imaging (Figure 2a and b).

The two sections of the left hemiliver are termed left medial section and left lateral section. The plane of division between the two sections is the falciform ligament, which forms an obvious surface landmark.

Each hepatic section is further sub-divided into segments. There are eight segments in all: two in each of the sections, except in the left medial section which has just one segment.

The level of portal bifurcation marks the division of each section into its segments, with each segment lying either above or below the level of the bifurcation. The left lateral section comprises segments II (superior) and III (inferior). The left medial segment comprises just segment IV (though this is nominally divided into segments IVa and IVb). The right anterior section comprises segment VIII and V and the right posterior section segments VII and VI (Figure 3a and b).

Segment I (synonymous with the caudate lobe) does not belong to any section and takes both its blood supply from, and gives biliary and venous drainage to, both the left and right hemilivers, as well as having direct venous drainage to the IVC.

### Portal vein and hepatic artery

The liver is unusual among solid organs in having both an arterial and a venous blood supply, via the hepatic artery and portal vein, respectively. The portal vein provides 70−75% of the inflow while the hepatic artery supplies the remainder (25−30%). Deoxygenated venous blood is returned by the hepatic veins to the inferior vena cava.

The portal vein and hepatic artery run towards the porta hepatis within the hepatoduodenal ligament (the free edge of the lesser omentum).




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