

Introduction

Liver transplantation can provide the definitive treatment for patients with end-stage liver disease (*Paul, 2003*).

Liver transplantation may be in the form of total or partial transplantation. In more than 90% of the human liver transplantation operations, the original liver has been replaced by donor liver (i.e orthotopic) as opposed to original liver remains in place with donor liver added (i.e heterotopic) (*Holbert et al., 1995*).

Color Doppler ultrasound has been proposed as an alternative mean of detecting postoperative complications of liver transplantation. As it's fast, inexpensive and non invasive (*Michael and Federle, 2002*).

Color Doppler ultrasound is mandatory in the postoperative stage for early follow up detection of complications which are: Vascular complications including hepatic artery thrombosis, stenosis, pseudoaneurysm (*Plott et al., 1997*). Portal vein thrombosis and stenosis (*Malassange et al., 1998*). Hepatic vein occlusion is common in patients who have had liver transplantation due to Budd-Chiari syndrome. Splenic artery aneurysm is rare but potentially fatal complication after liver transplantation (*Robertson et al., 1999*).

Helical computed tomography is a useful, accurate and a valuable complement to ultra sonography for detection of vascular complications in liver transplanted patients (*Michael and Feder, 2002*).

Aim of the Work

To high light and evaluate the value of different imaging modalities in the postoperative assessment cases of liver transplantation for early detection of complications which help for adequate management.

Anatomy

The normal liver is a large, wedge shaped organ occupying the right upper quadrant of the abdomen. It extends vertically on the right side from the undersurface of the right hemi diaphragm to the anterior costal margin and horizontally to the left mid clavicular line at the superior pole of the spleen (Byrd.,2001).

Liver anatomy can be described according to different aspects, morphological anatomy and functional (segmental anatomy) (Sherlock and Dooley, 2002).

Morphological Anatomy:

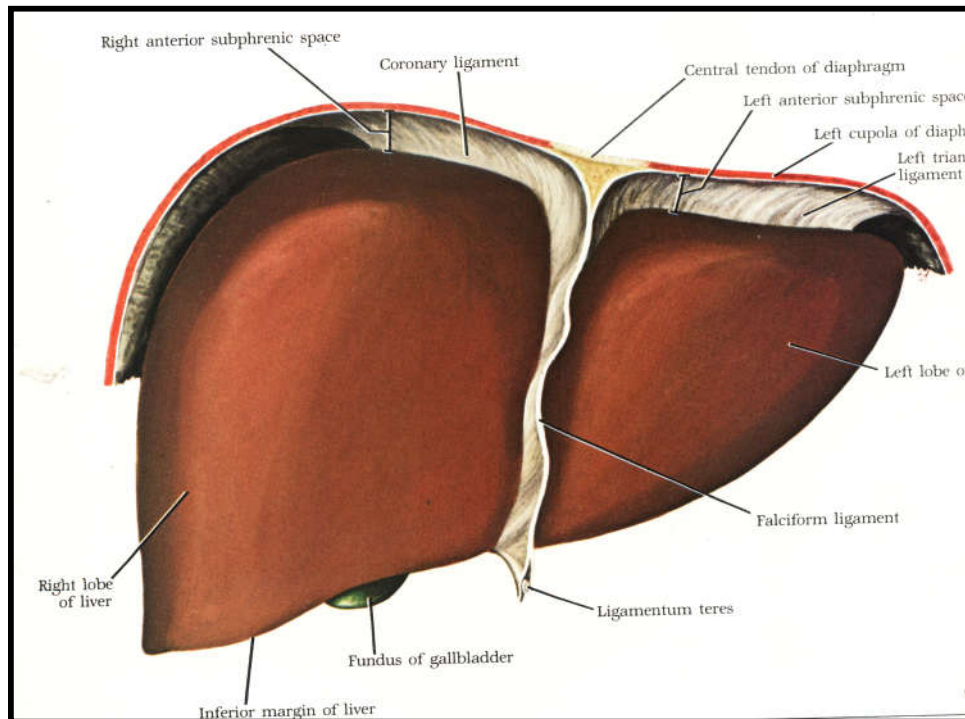


Fig. (1): Liver, anterior view (Quoted from Gray, 2000).

The liver has two surfaces: the diaphragmatic surface and the visceral surface. The diaphragmatic surface has a smooth rounded upper surface with a large dome for the right hemi diaphragm and a smaller dome for the left hemi diaphragm. A depression between these marks the site of the central tendon and overlying heart (**Fig 1**).

The traditional anatomic division of the liver is based on external landmarks on the visceral surface which have an "H" shaped configuration (**Fig. 2**).

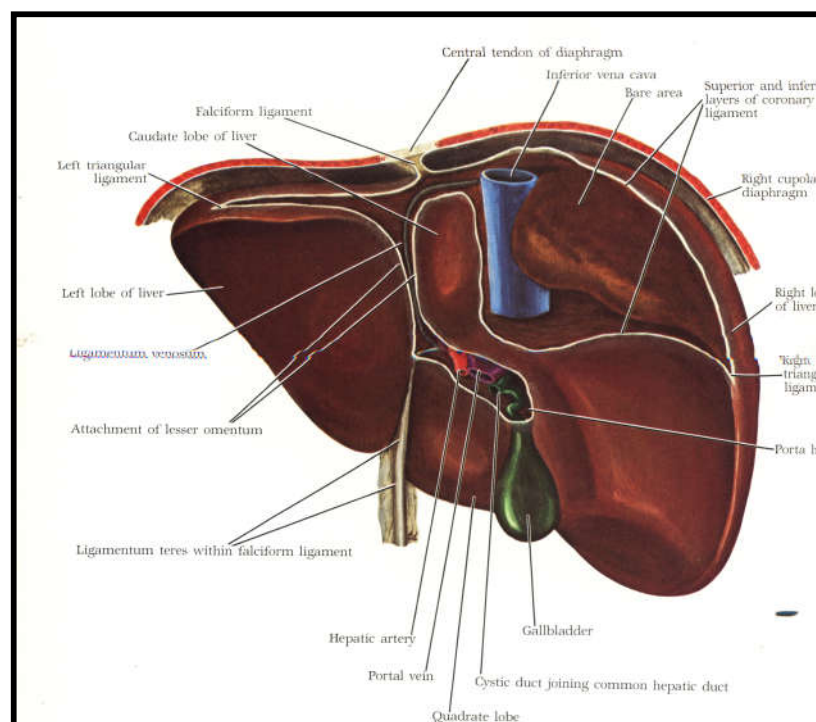


Fig. (2): Liver, posterior view (Quoted from Gray, 2000)

The lateral limb "H" is formed by a line connecting the gallbladder fossa, and the sulcus of the IVC. The medial limb is

formed by the fissure for ligamentum venosum. The crossbar consists of the porta-hepatis (*Byrd, 2001*).

The Right Lobe:

It is six times larger than the left. It occupies the right hypochondrium and separated from the left lobe by the falciform ligament on the diaphragmatic surface and by the left inter segmental fissure on the visceral surface. The falciform ligament marks the anterior surface but the visceral and posterior surfaces are marked by three fossae; the porta, the gall bladder and the IVC (*Abdalla et al., 2002*).

The right lobe is further divided into anterior and posterior segments.

The Caudate Lobe:

The caudate lobe is anatomically distinct from the left and right hepatic lobes, it is interposed between the IVC posteriorly, the left hepatic lobe anteriorly and superiorly, the main portal vein inferiorly.

The caudate lobe is generally considered separately because it usually receives portal pedicle branches from both the right and left portal veins and has an isolated hepatic venous drainage through multiple short veins that enter directly into IVC (*Byrd, 2001*).

The Quadrate Lobe:

It is situated on the visceral surface; it is bounded posteriorly by the porta-hepatis, anteriorly by the inferior margin

of the liver and laterally by the gall bladder fossa on the right and the fissure of ligamentum teres on the left (*Abdalla et al., 2002*).

The Left Lobe:

Lies in the epigastrium and left hypochondrium. Anatomically, it is separated from the right hepatic lobe by the falciform ligament on its diaphragmatic surface. On the visceral surface the falciform ligament separates it from the quadrate lobe, and the fissure of ligamentum venosum separate it from the caudate lobe. Its superior surface is slightly convex, and molded to the diaphragm, and tapers off to the left at about the left mammary line (*Sherlock and Dooley, 2002*).

The left lobe is further divided into medial segment and lateral segment (**Fig 3**).

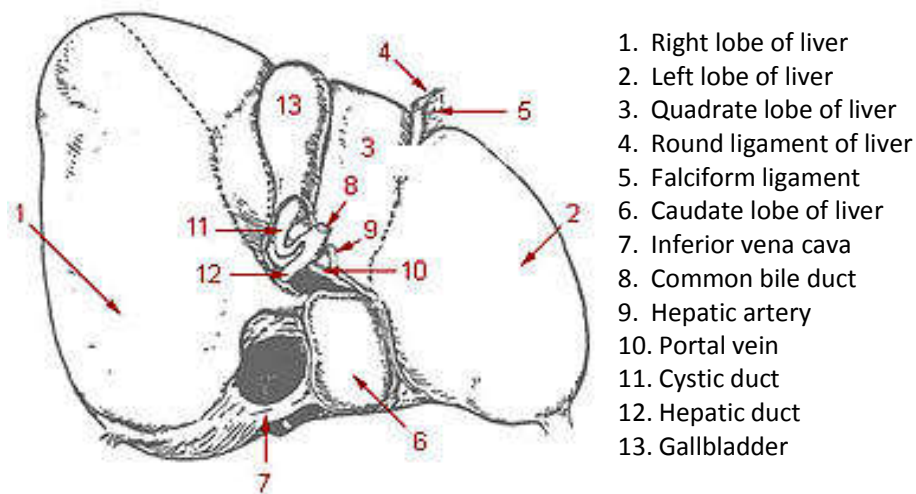


Fig. (3): Hepatic lobes of liver (*Quoted from Gray, 2000*).

Segmental Anatomy of the Liver:

Importance:

Segmental anatomy is crucial in order to precisely localize a focal lesion, to evaluate the possibility of resection, find the adequate technique for resection, and finally to estimate the easiness or the difficulties of a biopsy or of any other percutaneous procedure. Segmental anatomy is the basis of modern hepatic surgery (*Lencioni and Bartolozzi, 2003*).

Basis:

The liver can be divided into eight discrete segments based on the portal pedicle branches and the hepatic venous drainage. Each segment is supplied by a sheath containing branches of the hepatic artery and portal vein, and a draining bile duct, which enters the middle of the segment. The venous drainage is by hepatic veins, which tend to run between segmental divisions (*Couinaud, 1998*).

The left, middle, and right hepatic veins course in three vertical planes called vertical scissurae, which divide the liver into four sectors. Each of these four sectors is subdivided into two segments based on a transverse line drawn through the main right and left portal veins within these sectors, known as the transverse scissurae (*Byrd, 2001*).

Segments:

The liver is divided into right and left livers by the main vertical scissura along the line of the middle hepatic vein. These

right and left livers are both subdivided by the other vertical scissura delineated by the right and left hepatic veins into two sectors (*Lencioni and Bartolozzi, 2003*) (Fig. 4).

The right liver: is divided by the right vertical scissura into an antero-medial sector and a postero- lateral sector. The right portal vein divides into two branches one anterior for the antero-medial sector and one posterior for the postero-lateral sector. The anterior branch divides into a superior branch, for the segment VIII, and an inferior branch, for the segment V, the posterior branch divided into a superior branch, for segment VII, and an inferior branch for the segment VI (*Byrd, 2001*).

The left liver: is divided by the left vertical scissurae into a medial sector and lateral sector. The left portal vein is divided into three branches: lateral posterior for segment II, the lateral anterior for segment III, and a medial branches for the entire medial sector which is segment IV (*Byrd, 2001*).

The caudate lobe (segment I): is the dorsal portion of the liver lying between the portal trunk anteriorly, the IVC posteriorly, the liver surface to the left, and is in complete continuity with segment VII, on its right side

Couinaud (1998) suggested a further classification of the caudate lobe in which the part to the left of the IVC remains as a segment I, and that to the right is redefined as segment IX. Segment IX and segment I together are the “dorsal sector“, which is different from the right and left liver. Individualization

of the dorsal sector may be important in understanding bleeding problems in resection or split-liver transplantations (*Lencioni and Bartolozzi, 2003*).

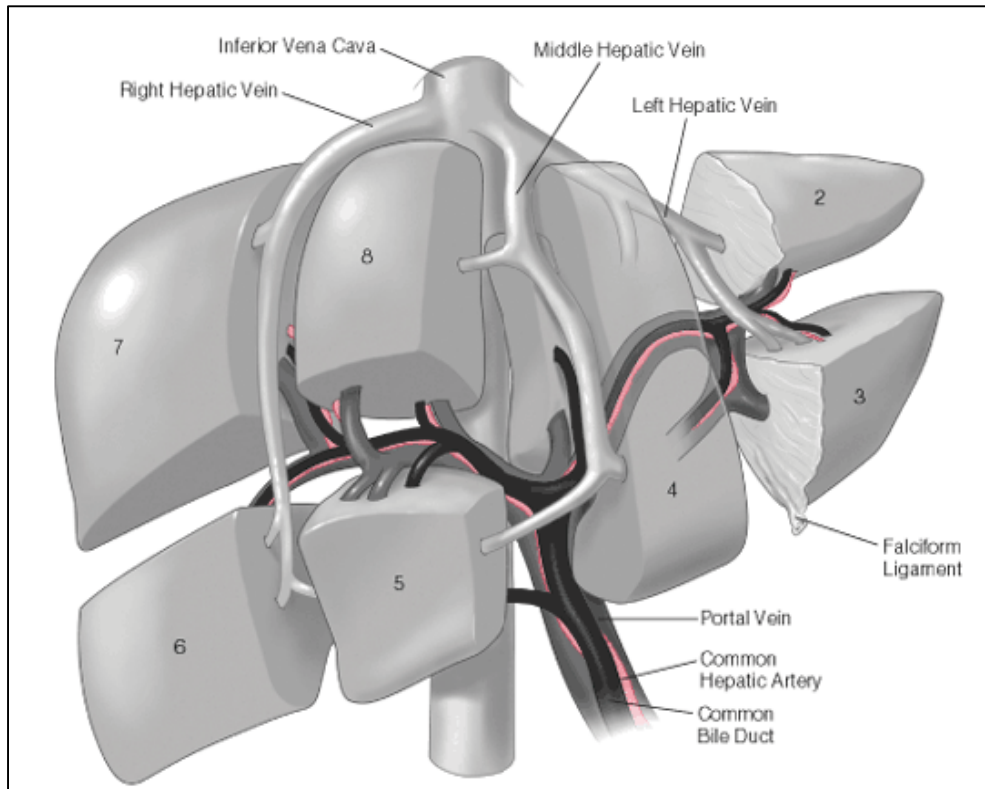


Fig. (4): Segmental anatomy of the liver (*Quoted from Nghiem, 1998*).

Vascular Anatomy:

The liver has dual blood supply; the hepatic artery which provides systemic arterial circulation, and the portal vein, which returns blood from the gut and spleen. Arterial flow is primarily nutritive and provide about 20% of the blood supply; the remainder is supplied by the mesenteric portal drainage, which

is a consequence of gastrointestinal functional activity (*Gore and Remer, 2000*).

The hepatic artery, portal vein, bile ducts, and lymphatic vessels are enveloped in the perivascular fibrous capsule (hepatobiliary capsule of Glisson), which also surrounds the vessels as they course through the portal canals in the liver, and continues with the fibrous hepatic capsule (*Sherlock and Dooley, 2002*).

1-Hepatic Artery:

The common hepatic artery usually arises as one of the three branches of the coeliac trunk with the left gastric and splenic arteries at the level of T12-L1 vertebrae. It courses along the upper border of the pancreatic head, anteriorly and to the right, behind the posterior layer of the peritoneum of the lesser sac. It gives off gastroduodenal, right gastric, supraduodenal and at the upper margin of the duodenum the proper hepatic artery enters the free border of the hepatoduodenal ligament of the lesser omentum. It ascends to the liver, anterior to the portal vein and medial to the common bile duct (*Gore and Remer, 2000*).

Branches: After entering the porta hepatis, the proper hepatic artery divides into right and left branches and occasionally middle hepatic artery. The right lobe is supplied by the right hepatic artery, the medial segment of the left lobe is supplied by the middle hepatic artery augmented by branches of the left hepatic artery, and the lateral segment of the left lobe

receives blood from the left hepatic artery. Branches from the right and left hepatic arteries nourish the caudate lobe. The right hepatic artery gives off the cystic artery. There is no anastomosis between hepatic arteries territories; each is an end artery (*Sherlock and Dooley, 2002*).

Normal Variants: In nearly 25% of population the right hepatic artery arises separately from the superior mesenteric artery and in nearly 25% of population the left hepatic artery arises from the left gastric artery. The entire hepatic artery arises from the superior mesenteric artery in 4%.The left hepatic artery giving rise to the middle hepatic artery in 45% (*Poston and Blumgart, 2003*).

2-Portal Vein:

The main portal vein is formed by the confluence of the superior mesenteric and splenic veins posterior to the neck of the pancreas. It courses cephalad and to the right to form the most posterior structure in the hepatoduodenal ligament, which is invested within the lesser omentum anterior to the foramen of Winslow (*Sherlock and Dooley, 2002*).

Branches: As the portal vein approaches the liver, it is directed superiorly and to the right. The right portal vein appears to continue to the course of the main portal vein but angles some what more to the right, forming a large obtuse angle with the main portal vein. The right portal vein varies from 0 to 3 cm in length before dividing into anterior and posterior segmental branches.

The left portal vein arises from the main portal vein at a more acute angle than the right portal vein and courses to the left and forward for about 3-4 cm, then directly anteriorly in the depth of the fissure for ligamentum venosum (*Lencioni and Bartolozzi, 2003*).

Segmental branches: The right portal vein is often directed somewhat posteriorly and to the right. The anterior segmental branch courses to the right, superiorly and slightly anteriorly. The anterior branch gives off an inferior branch to segment V and a superior branch to segment VIII. The posterior branch gives off an inferior branch to segment VI and superior branch to segment VII. The left portal vein ends blindly at ligamentum teres by giving off medial branch or branches to segment IV and lateral branch to left lobe lateral sector which subdivides into superior branch to segment II and inferior branch to segment III. The caudate lobe is supplied by branches that arise from the proximal parts of the right and left portal veins (*Byrd, 2001*).

Normal Variants: Portal vein variants occur in 20% of cases. In most instances, the portal bifurcation is located higher than usual, and may be strictly intrahepatic, which may represent surgical problem, when ligation of the right or left portal vein is required. The most usual abnormality is the left portal vein arising from the right portal vein or from its anterior branch. Rarely, the right portal vein arises from the intrahepatic left portal vein; usually, the anterior branch of the right portal vein arises from segment IV branch (medial branch) of the left portal vein (*Lencioni and Bartolozzi, 2003*).

3-Hepatic Veins:

There are three major hepatic veins, which for part or their entire course run in the planes that separate each of the four major liver segments. In the proximal part of their course, near their termination in the IVC, the right, middle, and left hepatic veins have relatively horizontal course. Here they are visualized coursing longitudinally in high-level axial sections. As they course distally, they gradually turn inferiorly to assume a more vertical course. Therefore in lower-level axial sections, the hepatic veins are cut more in cross section (*Menu and Lencioni, 1999*).

In high-level axial sections, the left hepatic vein projects almost directly forward and courses temporarily between the medial and lateral segments of the left lobe before entering the lateral segment. The left hepatic vein drains segments III and IV. In high-level axial sections, the middle hepatic vein courses to the right and anteriorly at an angle of 30-60 from the midsagittal or coronal planes. It enters the interlobar plane between the medial segment of the left lobe and anterior segment of the right lobe. The middle hepatic vein drains segments V, VI and IV. In about 85% of populations; the middle hepatic vein joins the left hepatic vein just before the latter enters the IVC (*Gore and Remer, 2000*).

In high-level axial sections, the right hepatic vein typically courses to the right and slightly posteriorly to enter intersegmental plane between the anterior and posterior

segments of the right lobe. As it descends vertically, it turns in the interval between the bifurcations of the right portal vein, therefore, in axial sections near the level of the porta hepatis, the transversely running right portal vein and its segmental branches have a Y configuration, and the right hepatic vein is seen in cross section between the limbs of the Y. The right hepatic vein drains segments VI, VII, and a portion of the anterior segments and enters the IVC separate (*Menu and Lencioni, 1999*).

Venous drainage of the caudate lobe is through multiple short posterior veins that empty directly into the inferior vena cava. Also several posterior accessory veins drain the medial portion of the right lobe, and empty directly into the IVC at lower levels than the main hepatic veins (*Byrd, 2001*).

Normal Variants: A large right inferior hepatic vein, draining the segment VI is found in 15-20% of normal subjects. When a right inferior hepatic vein is present, the right hepatic vein is usually smaller, as it does not drain the segment VI. In some cases, the right hepatic vein is absent, or limited with a very small vessel, when a large inferior right hepatic vein is associated to a predominant middle hepatic vein. There is a balance in territories drained by each hepatic vein. For surgical purposes, evaluation of the approximate territory drained by each hepatic vein is important, especially in order to prevent intraoperative bleeding (*Lencioni and Bartolozzi, 2003*) (Fig 5).

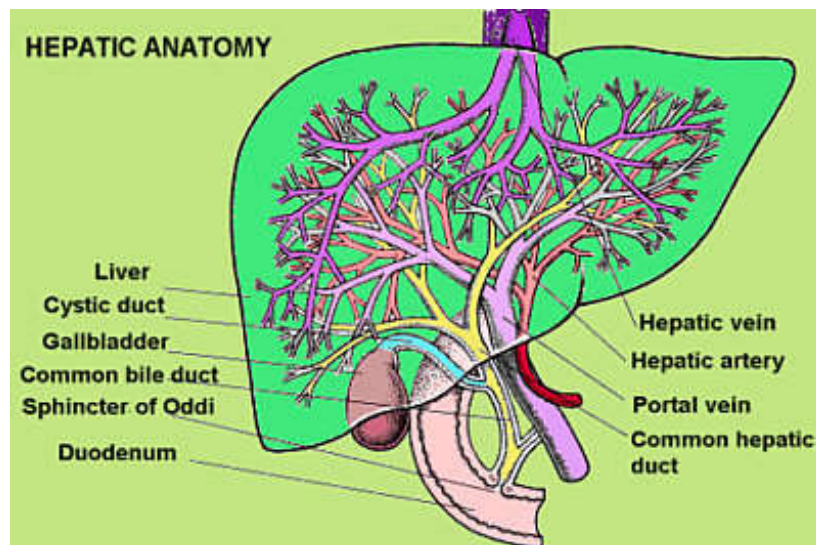


Fig. (5): Intrahepatic vascular and duct system
(Quoted from Netter, 1995).

4-Hepatic Lymphatic:

There are numerous lymphatics within the liver parenchyma and liver capsule. The deep lymphatics carry approximately 80% of the hepatic lymph and converge into two main trunks. The major trunks pass into lymph nodes in the porta hepatis, then to the retropyloric nodes and so to the celiac nodes. The smaller trunk accompanies hepatic veins and terminates in lymph nodes near the IVC (*Gore and Remer, 2000*).

The superficial lymphatics originate in the subperitoneal tissue of the liver surface. Most visceral surface is drained by lymph nodes in the porta hepatis. The diaphragmatic surface drains into the lymph nodes around IVC or towards the celiac