INTRODUCTION

Orthotopic liver transplantation (OLT) is currently the treatment of choice for patients with severe acute or chronic liver failure for which no other therapy is available ***(Quiroga et al., 2001).***

Over the past several decades, advances in surgical techniques, organ preservation, immunosuppressive therapy, and early detection of postoperative complications have increased survival rates after liver transplantation ***(Caiado et al., 2007).***

However, there are still significant complications, particularly those of vascular origin, which can lead to graft failure and require reoperation unless prompt treatment is instituted ***(Hong et al., 2006).***

Early and accurate diagnosis of vascular complications is crucial for increasing the survival rate of the graft in living related liver transplantation (LRLT) because most stenoses or thromboses are treatable with interventional procedures ***(Kim et al., 2003).***

Since the clinical presentation of posttransplantation vascular complications is frequently nonspecific and varies widely, imaging studies are critical for early diagnosis ***(Quiroga et al., ٢٠٠١).***

Computed Tomography (CT) is a safe, noninvasive, accurate, and reliable method that can be used to show patency, stenosis, or thrombosis of the hepatic vessels in liver transplant patients and to assess the presence and extent of damage to liver parenchyma ***(Brancatelli et al., 2002).***

The use of multidetector CT (MDCT) scanners has led to decreased scanning time and improved overall image quality with thin-section acquisitions. Contrast-enhanced MDCT provides a good noninvasive alternative to conventional angiography ***(Caiado et al., 2007).***

AIM OF WORK

To demonstrate role of multidetector computed tomography in assessment of vascular complications after hepatic transplantation.

ANATOMY OF LIVER

Gross Anatomy

Lobation and segmentation of the liver:-

The liver has four lobes or eight segments, depending on whether it is defined by its gross anatomical appearance or by its internal architecture. Classification of the liver by internal architecture divides it into lobes, segments or sectors. The biliary, hepatic arterial and portal venous supply of the liver tends to follow very similar distributions used to define the hepatic segments. The hepatic venous anatomy follows a markedly different pattern.

The value of the segmental classification, according to vascular and biliary supply, is that surgical resection of a segment, multiple segments or a whole lobe, may be planned and performed to encounter the fewest possible major vascular structures ***(Standring, 2008)***.

Gross anatomical lobes *(Fig.1)*:

The gross anatomical appearance of the liver has been divided into right, left, caudate and quadrate lobes by the surface peritoneal and ligamentous attachments. The falciform ligament superiorly and the ligamentum venosum inferiorly, mark the division between right and left lobes. On the inferior surface, to the right of the groove formed by the ligamentum venosum, there are two prominences separated by the porta hepatis. The quadrate lobe lies anteriorly, the caudate lobe posteriorly. The gallbladder usually lies in a shallow fossa to the right of the quadrate lobe ***(Standring, 2008)***.

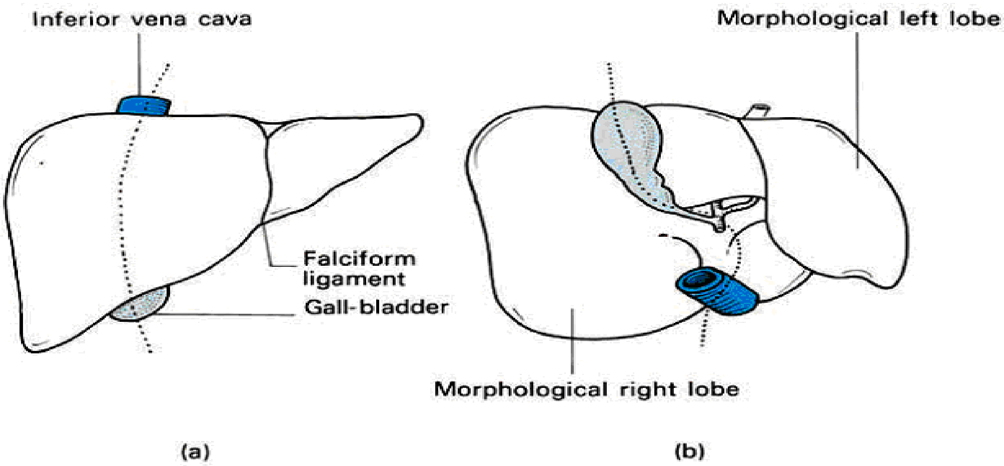

Figure (1): The morphological right and left lobes of the liver shown separated by the dotted line: (a) anterior and (b) ventral aspect. Note that the quadrate lobe is morphologically a part of the left lobe while the caudate lobe belongs to both right and left lobes ***(Ellis, 2006)***

Hepatic segmentation:

Couinaud's segments (Fig. ٢, ٣):

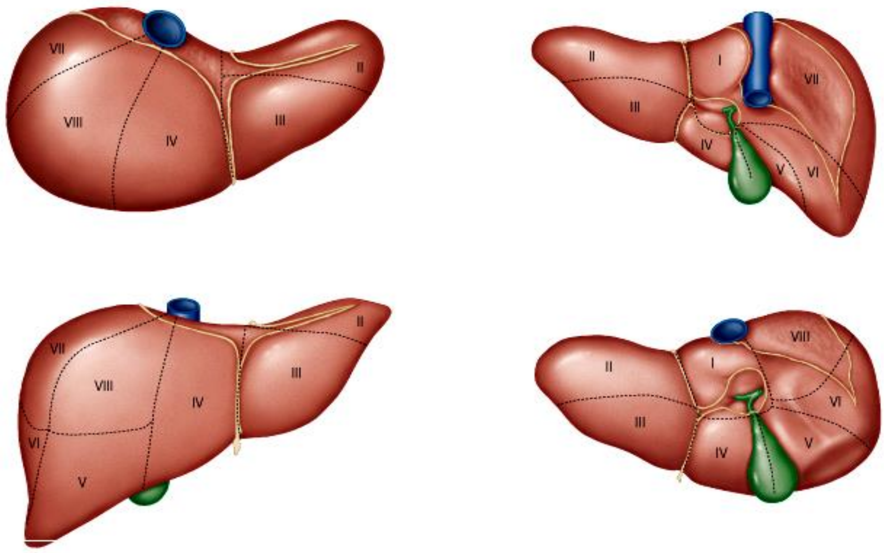

Figure (2): Segmentation of the liver - Couinaud. Top left, superior view; top right, posterior view; bottom left, anterior view; bottom right, inferior view. The segments are sometimes referred to by name - I, caudate (sometimes subdivided into left and right parts); II, lateral superior; III, lateral inferior; IV, medial (sometimes subdivided into superior and inferior parts); V, anterior inferior; VI, posterior inferior; VII, posterior superior; VIII, anterior superior ***(Standring, 2008)***.

There are eight distinct liver segments; each of these segments has its own portal venous supply and separate hepatic venous and biliary ductal drainage. Therefore, each segment theoretically could be individually resected or survive on its own. This system uses the three major hepatic veins as boundary lines to divides the liver into four major sections. The right hepatic vein divides the right lobe into anterior and posterior segments, the middle hepatic vein divides the liver into right and left liver lobes, the left hepatic vein divides the left lobe into medial and lateral segments. Three of these major segments are further subdivided into superior and inferior divisions by imaginary transverse line passing through the respective right and left portal veins. The liver is partitioned into eight segments which are numbered in a counter-clockwise fashion beginning with caudate lobe (segment I). The left liver lobe is divided into two sectors by the left hepatic vein, segments III and IV (anterior sector) are anterior to the vein, whereas, segment II (posterior sector) is posterior to it. Within anterior sector, segment III is separated from segment IV by the umbilical fissure and falciform ligament.

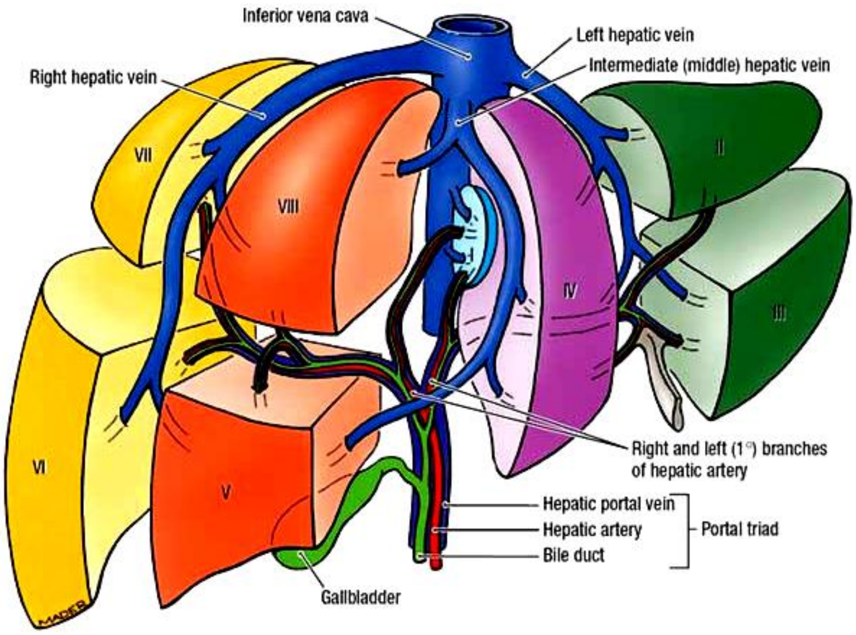

Figure (3): Hepatic segmentation anterior view ***(Agur and Dalley, 2009).***

The right lobe is separated from the left lobe by main portal scissura (Cantlie line) a para sagittal plane that passes through the IVC and the long axis of the gall bladder and contains the middle hepatic vein. The right lobe is divided into the anterior sector (segment V and VIII) and posterior sector (segments VI and VII) by the right portal scissura, an off-coronal plane containing the right hepatic vein and the IVC. Finally, segments V and VI (inferior segments) are separated from segments VII and VIII (superior segments) by an axial plane containing the horizontal portion of the right portal vein ***(Gazelle et al., 1994)***.

Liver Vasculature:-

The vessels connected with the liver are the portal vein, hepatic artery and hepatic veins. The portal vein and hepatic artery ascend in the lesser omentum to the porta hepatis, where each bifurcates. The hepatic bile duct and lymphatic vessels descend from the porta hepatis in the same omentum. The hepatic veins leave the liver via the posterior surface and run directly into the inferior vena cava ***(Standring, 2008)***.

The porta hepatis *(Fig. 4):*

The porta hepatis is the area of the inferior surface through which all the neurovascular and biliary structures, except the hepatic veins, enter and leave the liver. It is situated between the quadrate lobe in front and the caudate process behind. The porta hepatis is actually a deep fissure into which the portal vein, hepatic artery and hepatic nervous plexus ascend into the parenchyma of the liver. The right and left hepatic bile ducts and some lymph vessels emerge from it. At the porta hepatis, the hepatic ducts lie anterior to the portal vein and its branches, and the hepatic artery with its branches lies between the two. All these structures are enveloped in the perivascular fibrous capsule - hepatobiliary capsule of Glisson - a sheath of loose connective tissue which surrounds the vessels as they course through the portal canals in the liver. It is also continuous with the fibrous hepatic capsule. The dense aggregation of vessels, supporting connective tissue, and liver parenchyma just above the porta hepatis is often referred to as the 'hilar plate' of the liver. It may be dissected surgically to gain access to the intrahepatic branches of the bile ducts and vessels ***(Standring, 2008)***.

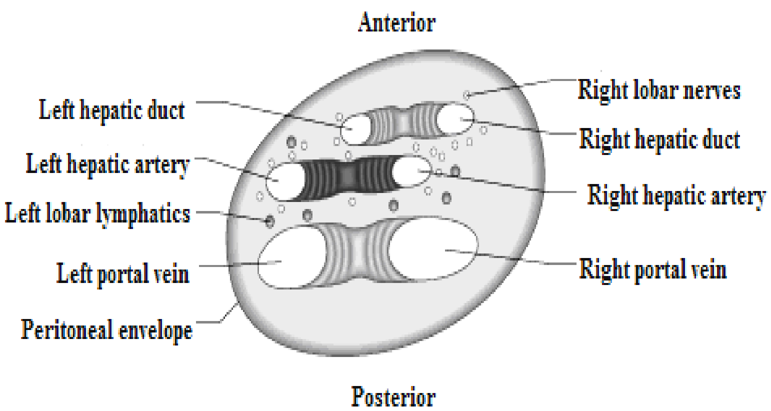

Figure (4): Cross-section of the structures at the porta hepatis ***(Standring, 2008)***.

Common Hepatic Artery (CHA) ***(Fig. 5)***

The CHA also shows a highly variable course along the cranial border of the body and the head of the pancreas. The course is variable in direction, but tortuous courses are usually not observed. According to Michels, anatomic variations most often affect the origin of the hepatic artery ***(Hindman et al., 2009)***.

Most commonly, the CHA arises from the celiac trunk, gives off the gastroduodenal artery (GDA) and the right gastric and supraduodenal artery, and then becomes the proper hepatic artery, which courses obliquely within the anterior hepatoduodenal ligament. The proper hepatic artery then gives off the cystic artery and bifurcates into the right and left hepatic arteries, with a middle hepatic artery that may arise from either the right or left hepatic arterial branch (***Hindman et al., 2009)***; this conventional arterial pattern occurs only ٥٥٪ of the time.

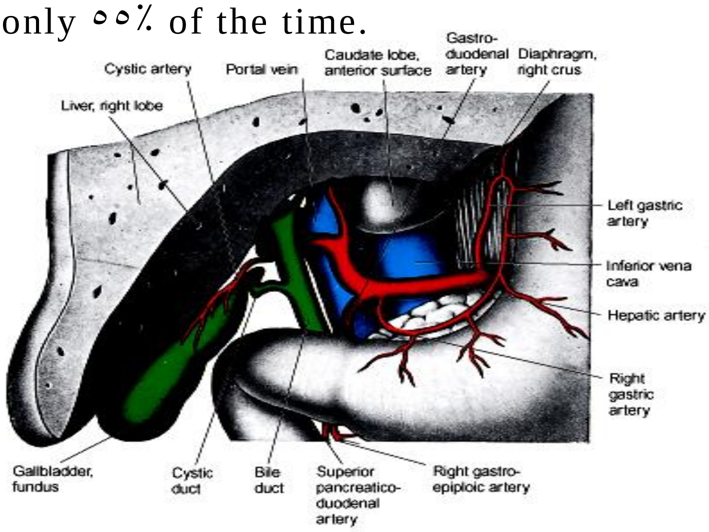

Figure (5): Dissection to show the relations of the hepatic artery, bile duct and portal vein to each other in the lesser omentum: anterior aspect ***(Standring, 2008)***.

The replaced right hepatic artery is a common variant that traverses the pancreatic head as it passes from the superior mesenteric artery (SMA) to the liver, providing branches to the pancreas. Another common variant is the replaced left hepatic artery, which arises from the left gastric artery (LGA), usually associated with the right and middle hepatic artery arising from the proper hepatic artery. Less frequent variations include an accessory left hepatic artery from the LGA, an accessory right hepatic artery from the SMA, and the entire CHA arising from the SMA without any hepatic artery arising from the celiac axis. Many of the major variations described by Michels in his dissection of the arterial trees of cadavers have also been detected in vivo with CT angiography (CTA), and some additional variations have been demonstrated as well ***(Lavelle et al., 2001)***.

Portal Vein ***(Fig. 6):***

The liver has a double blood supply: the proper hepatic artery divides into the right and left hepatic artery and carries oxygenated blood to the liver, and the portal vein carries venous blood from the gastrointestinal tract (GIT) to the liver. The venous blood from the GIT drains into the superior and inferior mesenteric veins; these two vessels are then joined by the splenic vein (whose tributaries include the short gastric veins, the gastroepiploic vein and pancreatic veins) just posterior to the neck of the pancreas to form the portal vein, which runs cephalad and obliquely toward the right to the hilum of the liver, where it is the most posterior structure in the hepatoduodenal ligament. The main portal vein receives the coronary vein and then splits to form the right and left branches, each supplying about half of the liver ***(Hindman et al., 2009)***.

In adults, the length of the main portal vein is typically ٨ cm, and the diameter of the portal vein after its confluence ranges from ٩ to ١١ mm in diameter. Variations in the branching pattern of the main portal vein are less common than variations in the hepatic arteries, veins, and bile ducts, with a reported incidence of ٠,٠٩٪ to ٢٤٪ ***(Atasoy and Ozyurek, 2006)***.

For the majority of cases, the main portal vein divides into a short, oblique right portal vein and a transversely oriented left portal vein ***(Hindman et al., ٢٠٠٩)***.

The right portal vein quickly branches within the right lobe of the liver to supply the anterior segment (V and VIII, and, variably, IV), and the posterior segment (VI and VII) of the right lobe. The cystic vein drains into the right portal vein before the right portal vein enters into the right lobe of the liver. As a single trunk, the left branch of the portal vein turns transversely to the left between the quadrate and caudate lobe. Portal branches to the caudate lobe arise from the transverse portion of the left portal vein, from the first part of the right portal vein, and/or directly from the portal trunk. The left portal vein has a long transverse course to the level of the umbilical fissure, where it gives off medial branches to segment IV and lateral branches to segments II and III ***(Hindman et al., 2009)***.

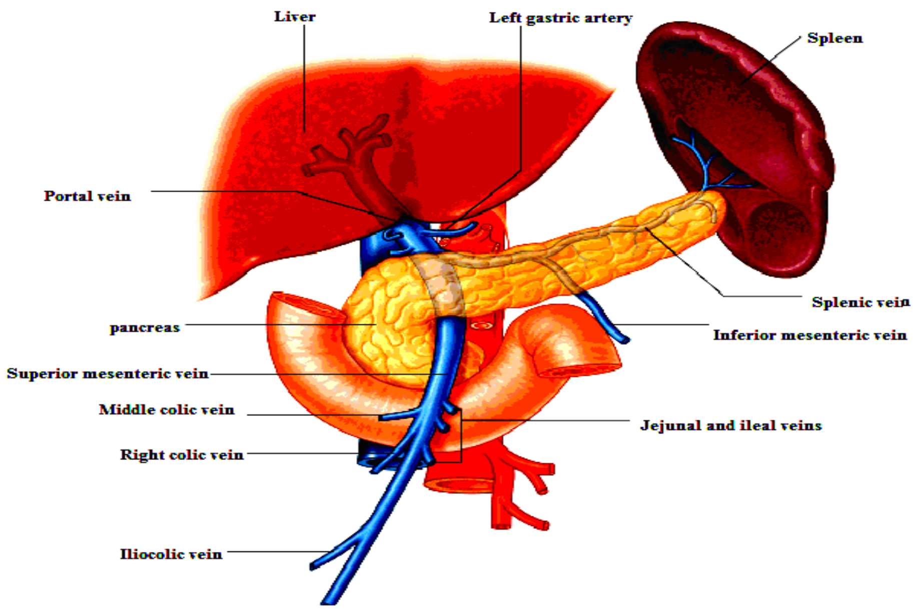

Figure (6): Portal vein ***(Drake et al., 2007)***.

Portosystemic anastomosis *(Fig. 7)*:

The hepatic portal system drains blood from the visceral organs of the abdomen to the liver. In normal individuals, ١٠٠٪ of the portal venous blood flow can be recovered from the hepatic veins, whereas in patients with elevated portal vein pressure (e.g. due to cirrhosis), there is significantly less blood flow to the liver. The rest of the blood enters collateral channels, which drain into the systemic circulation at specific points. The largest of these collaterals occur at:

- The gastroesophageal junction around the cardia of the stomach-where the left gastric vein and its tributaries form a portosystemic anastomosis with tributaries to the azygos system of veins of the caval system;
- The anus the superior rectal vein of the portal system anastomoses with the middle and inferior rectal veins of the systemic venous system;
- The anterior abdominal wall around the umbilicus- the para-umbilical veins anastmose with veins on the anterior abdominal wall.

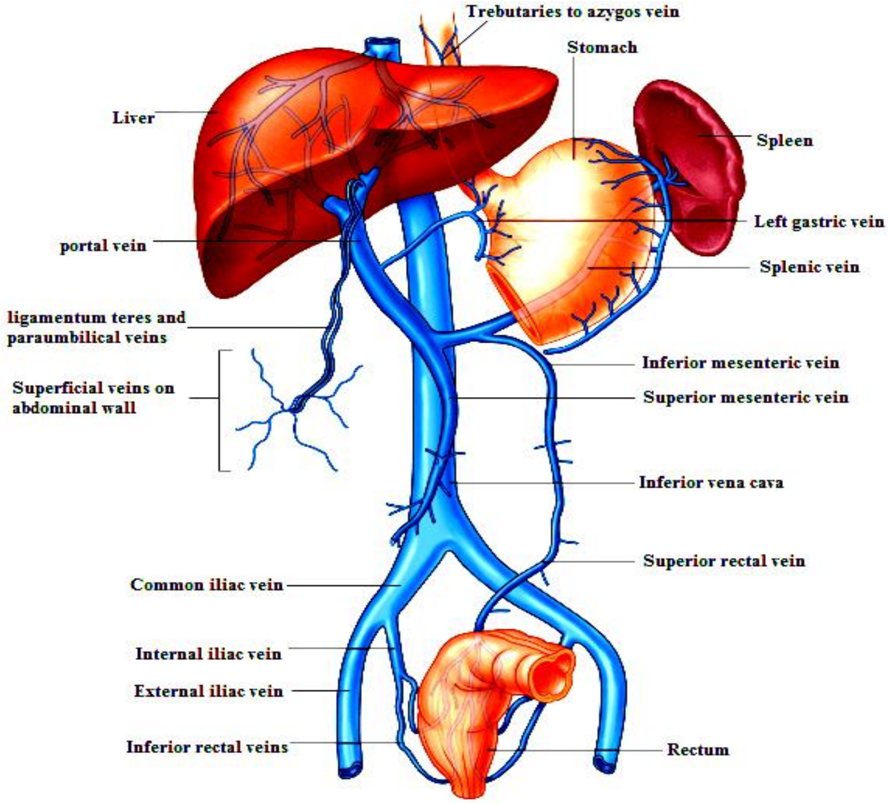

Figure (7): Portosystemic anastomoses ***(Drake et al., 2007)***.

When the pressure in the portal vein is elevated, venous enlargement (varices) tend to occur at and around the sites of portosystemic anastomoses and these enlarged veins are called:

- hemorrhoids at the anorectal junction;
- esophageal varices at the gastroesophageal junction;
- caput medusae at the umbilicus.

(Drake et al., 2007).

Hepatic Veins *(Fig. 8):*

On entering the liver, the blood drains into the hepatic sinusoids. Three major hepatic veins originating from the right and left lobe and from the middle portion of the liver join the inferior vena cava (IVC) just inferior to the diaphragm ***(Hindman et al., 2009)***.

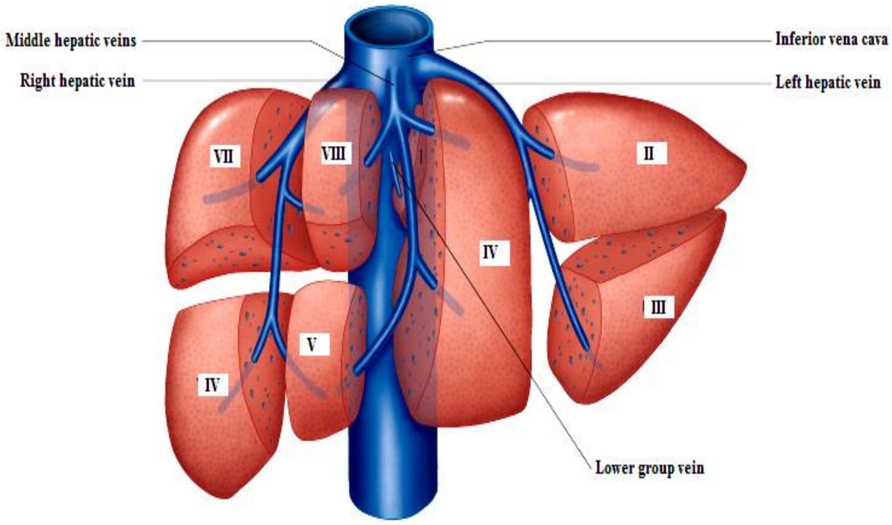

Figure (8): Arrangement of the hepatic venous territories. Multiple lower group veins may be present. Individual segments may drain into more than one hepatic venous territory ***(Standring, 2008)***.