INTRODUCTION

Liver transplantation is currently accepted as a first line treatment for patients with end-stage acute or chronic liver diseases ***(Angela et al., 2007).***

Graft survival and overall patient survival have steadily improved since the first transplants were performed in the early 1960s, but a significant percentage of transplants develop complications related to vascular and biliary insufficiency. Graft ischemia after liver transplantation is associated with a high incidence of morbidity and mortality ***(Hong et al., 2006).***

Biliary and vascular complications and rejection of the transplanted liver are the main causes of malfunction and loss of the hepatic graft. Advances in medical therapy over the last few years have led to a more efficient diagnosis and treatment of postoperative complications after orthotopic liver transplantation, thereby increasing the survival rate after liver transplantation ***(Horrow et al., 2007).***

Vascular complications include; hepatic artery stenosis and thrombosis, portal vein stenosis and thrombosis, caval and hepatic veins obstruction, arterial pseudo aneurysm. Biliary complications include; biliary leakage, stricture and obstruction ***(Quiroga et al., 2001).***

A multimodality approach including ultrasonography and cross-sectional imaging studies often is most effective for diagnosis. Each imaging modality has specific strengths and weaknesses, and the diagnostic usefulness of a modality depends mainly on the patient's characteristics, the clinical purpose of the imaging evaluation, and the expertise of imaging professionals ***(Angela et al., 2007).***

Ultrasound is the initial imaging modality of choice for detection and follow-up of early and delayed complications from all types of liver transplantation. Knowledge of the surgical technique of liver transplantation permits early detection of complications and prevents misdiagnosis ***(Jane et al., 2003).***

Doppler study in the postoperative period is a safe, accurate and non invasive method of demonstrating, evaluating non vascular complications in the hepatic parenchyma and bile duct abnormalities and extra hepatic tissue in the recipient ***(Quiroga et al., 2001).***

Color Doppler flow and pulsed Doppler U.S. evaluate vessel patancy, and are frequently used to distinguish dilated bile ducts and blood vessels and also can evaluate the extrahepatic portal venous system ***(Jonathan et al., 2004).***

Aim of the Work

The aim of this study is to evaluate the sensitivity of Duplex ultrasound in detection most of vascular complication after liver transplantation in correlation with CT angiography.

Chapter One

NORMAL ANATOMY OF THE LIVER

Gross Morphology:

The liver is the largest gland in the body. It has considerable individual variations in size and shape. It is situated in the cranial and right parts of the abdominal cavity occupying most of the right hypochondrium, epigastrium and not uncommonly extending to the left hypochondrium. It has two surfaces: diaphragmatic and visceral surfaces. The diaphragmatic surface is dome shaped and conforms to the diaphragm. It is divided into superior, anterior, right and posterior portions or surfaces ***(Blumgart and Hann, 2000).***

A- Diaphragmatic surface:

1-The superior portion: It is completely covered by peritoneum except for a small triangular area where the two layers of the falciform ligament diverge. The major landmark of the superior surface is the sagittal groove which is a deep notch providing access for the ligamentum teres that runs in the free edge of the falciform ligament. This portion is related through the diaphragm to the base of the right lung, pericardium and the heart on its extreme left side.

2-The anterior portion: It is completely covered by peritoneum except along the line of attachment of the falciform ligament. It lies against the diaphragm, the costal margin, and the xiphoid process and the abdominal wall.

3-The right portion: It is covered by peritoneum and merges with the other three parts of the diaphragmatic surface and continues down to the right margin that separates it from the visceral surface ***(Bismuth et al., 1993).***

4-The posterior portion: A large part of this posterior portion of the diaphragmatic surface is not covered by peritoneum and this uncovered area is frequently called the bare area that is bounded by the superior and inferior reflections of the coronary ligament. This surface is broad and rounded on the right but narrow on the left. To the right of vena cava and partially on the visceral is a small triangular depressed area that is named supra-renal impression for the suprarenal gland and to the left of the ductus venosus fossa there is oesophageal groove for antrum cardium of the eosophagus ***(Blumgart and Hann, 2000).***

B- The visceral or inferior surface:

It is facing downward, backward and to the left, and it is covered by visceral peritoneum except at the porta hepatis, fissure for ligamentum teres and fossa for the gall bladder. This surface bears the imprint of the adjacent viscera and this surface is closely related to the pylorus, the duodenum, the gall bladder, the right colon, the hepatic flexure, the right third of the transverse colon, the right kidney and the right supra-renal gland (Diag.1) ***(Blumgart and Hann, 2000).***

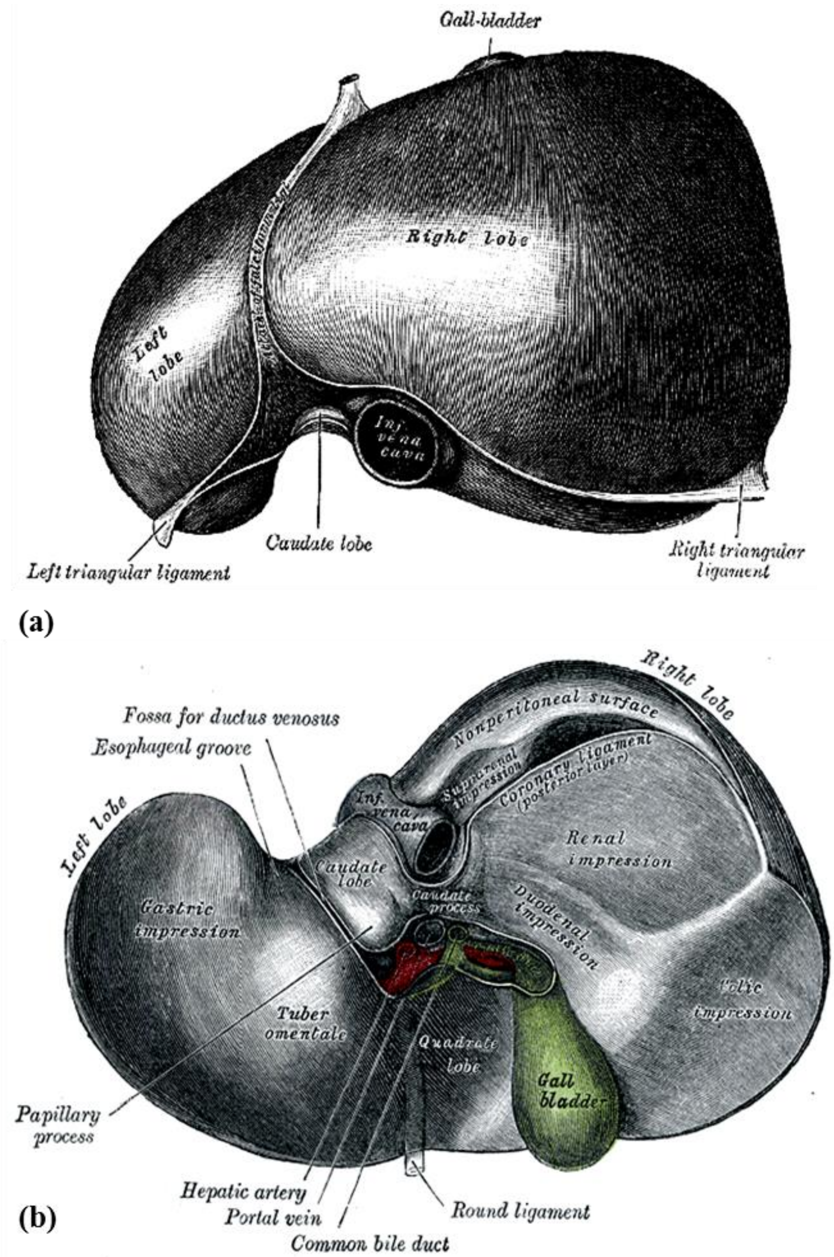

Fig. (1): (a): The superior, anterior and right lateral surfaces of the liver **(b):** The inferior surface of the liver ***(Quoted from Gray's anatomy, 2005).***

Liver lobes:

The liver is traditionally divided into four lobes; the right and the left lobes and two lesser subdivisions, the quadrate and caudate lobes.

However, the anatomical division of the liver is based on the external landmarks on the visceral surface that includes the porta hepatis, fossae (for the gallbladder & inferior vena cava) and the deeper fissures (for ligamentum teres and the ligamentum venosum) all these structures combine to form an H-shape configuration using this approach the lateral limb of the "H" is formed of a line connecting the gall bladder fossa and the sulcus for inferior vena cava, while the more medial limb of the "H" is formed by the fissure for ligamentum venosum and the cross bar of the "H" consists of porta hepatis, its vessels and ducts ***(Anderson, 1993).***

The right lobe of the liver extends from the right lateral margin of the liver laterally and the sulcus for the inferior vena cava dorsally to the gall bladder ventrally. The left lobe lies completely to the left of the falciform ligament and the fissure for ligamentum venosum. The quadrate lobe: appears somewhat rectangular, it is situated on the visceral surface of the right lobe, bounded ventrally by the inferior margin; dorsally by the porta hepatis; on the right by the fossa for the gall bladder; and on the left by the fossa for the umbilical vein. The caudate lobe: is situated upon the dorsal surface of the right lobe, opposite the tenth and eleventh thoracic vertebrae. It is bounded inferiorly by the porta hepatis; on the right, by the fossa for inferior vena cava; and on the left, by the fossa for the ductus venosus (Ligamentum venosum). It is nearly vertical in position somewhat concave in the transverse direction. The caudate process is a small elevation of the hepatic substance that extends obliquely lateral from the caudate lobe to the visceral surface of the right lobe. It is situated dorsal to the porta hepatis and separates the fossa for the gall bladder from the fossa for the inferior vena cava ***(Anderson, 1993).***

Sometimes the liver may have an accessory lobe that is named the Riedel's lobe which is not truly an accessory lobe at all, but simply it is a downward extension of the lateral aspect of the right lobe and it is a fairly common variation of normal anatomy and may extend as far as the iliac crest and it has no pathological significance. It is common in women ***(Parulekar and Bree, 1997).***

Segmental Anatomy of the Liver:

The segmental anatomy is based on the internal vascular skeleton of the liver and not on the external attachment of lobar landmarks. The classification of *Couinaud and Bismuth*, which is based principally on the position of the major hepatic vascular structures, defines eight hepatic segments. The liver is divided primarily into two main parts that include the left and right lobes. The left liver lobe is supplied by the left branch of the portal vein and the left hepatic artery and the right liver lobe is supplied by the right branch of the portal vein and the right hepatic artery. In addition to these two lobes of the liver, there is a separate small caudate lobe (segment I) that has its own blood supply ***(Parulekar and Bree, 1997).***

Blood supply:

The liver receives blood from two sources. Arterial (oxygenated) blood is furnished by hepatic artery and venous blood which is carried to the liver by the portal vein ***(Covey et al., 2004).***

Hepatic artery:

The common hepatic artery normally arises from the celiac trunk. After giving rise to the gastroduodenal artery behind the pylorus, it becomes the proper hepatic artery that passes through the hepatoduodenal ligament anteromedial to the portal vein and anterior to the common bile duct. In the liver hilum it bifurcates into the right hepatic artery and left hepatic artery. The middle hepatic artery that supplies segment IV originates with equal frequency from right or left hepatic artery (Diag. 6). The right branch of the hepatic artery normally passes behind the common hepatic duct and in the liver divides into anterior and posterior sectoral branches. The left branch divides into medial and lateral sectoral branches ***(Soin et al., 1996).***

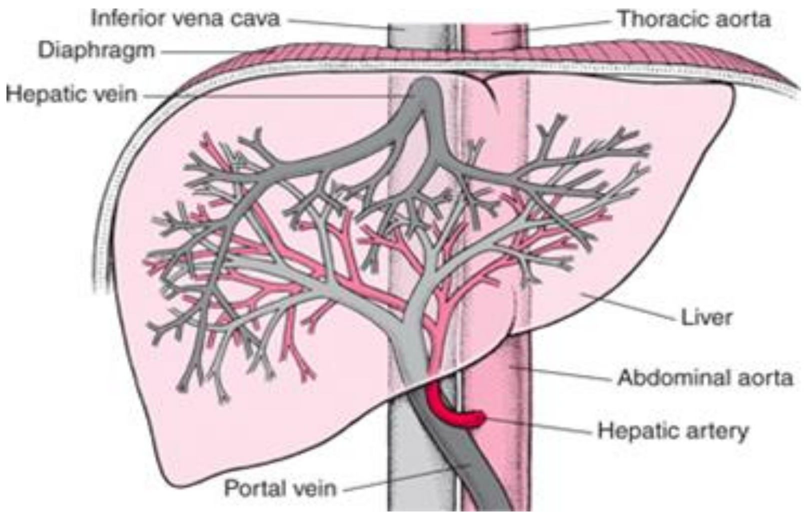

Fig. (2): Blood Supply of the Liver
(Quoted from Mark et al., 2003).

Portal vein:

Venous blood is carried to the liver by the portal vein which originates behind the neck of the pancreas by the union of the splenic and superior mesenteric veins. It ascends behind the first part of the duodenum to pass in the free margin of the lesser omentum and divides in the porta hepatis into right and left branches which in turn gives sectoral branch like arteries. The portal bifurcation may be extrahepatic (48%), intrahepatic (26%) or located right at the entrance of the liver (26%).

On the right, the portal vein divides into two branches: anterior and posterior supplying the anterior (V & VIII) and posterior (VI &VII) segments of the right lobe respectively. On the left there are two parts to the (main) left portal vein: the extrahepatic portion (pars horizontalis i.e. the horizontal part) and intrahepatic portion (pars umbilicalis) i.e. umbilical or vertical part. From this point the vertical segment is divided into medial (IV) and lateral (II&III) segment of the left lobe (Diag. 7a&b) ***(Prokop, 2003)***.

The hepatic artery and the portal vein have equal-sized right and left branches. They lie together as they ramify in each half of the liver and they are everywhere accompanied by tributaries of the hepatic ducts; the three together lie in portal canals ***(Baba et al., 2000).***

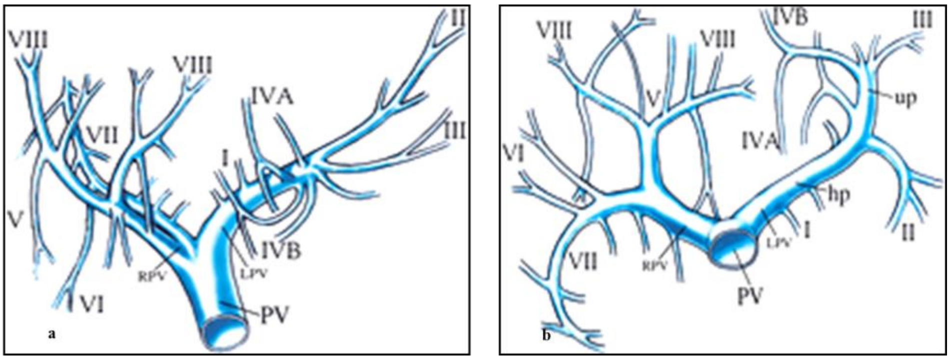

Fig. (3): The normal portal vein (PV) branches from anterior **(a)** and inferior **(b)** perspectives. ***(Quoted from Baba et al., 2000)***.

Venous return:

The presence of the three hepatic veins forming a "W" shape with its base on the inferior vena cava is considered the standard anatomy for these veins. The three hepatic veins course in the vertical fissures that separate the liver segments.

Chapter Two

SONOGRAPHIC ANATOMY OF THE LIVER

The liver is a large, pyramidal shaped organ and liver sectional anatomy may be best described imaged and defined using by real time ultrasound imaging. Conventional real time ultrasound, produces images of thin slices of the liver on the screen, and so it is essential that the operator scans the entire organ systematically/ritually, in at least two anatomical planes, to be entirely convinced that the entire volume of the liver tissue and structures has been imaged. The operator must then synthesise this 2 dimensional information in their brain to develop a 3 dimensional map of the individual patient`s liver anatomy and pathology. This requires good hand-eye-brain coordination ***(Christoph et al., 2010).***

For orientation, three levels of the central portion of the liver can be differentiated:

- Level of the confluences of the liver veins (Fig. 4).
- Level of the Pars umbilicalis of the (left) portal vein branch (Fig. 5).
- Level of the gall bladder (Fig. 6).

Fig. (4): Confluences of the liver veins. This "junction" level is the first one in ultrasound examination of the right liver lobe by subcostal scanning sections steeply "looking" upwards, preferably in deep inspiration. VCI: inferior vena cava. LLV: Left liver vein. MLV: Middle liver vein. C: Confluens of the LLV and MLV. RLV: Right liver vein. The RLV often separately joins the inferior vena cava, whereas the LLV and MLV often reveal a common trunk ("C"). ***(Quoted from Bates, 2004).***

Fig. (5): "Pars umbilicalis" of the portal vein – scanning planes display the left and right liver lobes in a more downwards orientated view into the right liver lobe as compared to the level of the Confluence of the liver veins. PA: Portal vein. PU: pars umbilicalis of the portal vein. VCI: Inferior vena cava ***(Quoted from Bates, 2004).***

Fig. (6): Gallbladder level as the most caudate scanning plane. GB: Gallbladder. LTH: Ligamentum teres hepatis. S4: Segment IV of the liver (quadrate lobe) ***(Quoted from Bates, 2004).***

Analyzing the ultrasound examination, these levels mean the access for a number of (more or less) parallel scanning sections, which in there summary in the examiner's brain form an real time three dimensional copy of the given patient's individual anatomy and pathology.

Standardized scanning in a ritualized sequence of probe- and patient positions and of scanning planes is mandatory to cover all segments and the complete liver surface. The patient should be examined from sub- and intercostally in the decubitus position as well in modified slightly oblique positions with the right arm above the head and the right leg stretched during all respiration cycles to identify the best approach and to avoid artifacts caused by the thorax. Examination in the standing position is additionally helpful due to its weight, the liver moves caudally by gravity, and scanning from sub- or intercostal probe positions – according to the individual anatomy - avoids the interposed lung which is mainly true for the right posterolateral (superficial) parts of the liver using the intercostal approach ***(Christoph et al., 2010).***

Examination criteria:

An acronym has shown to be didactically helpful [“SSOTM”]:

- S = size
- S = shape
- O = outline
- T = texture
- M = measurement