Introduction

The liver is considered a common site for many benign, primary malignant and metastatic focal lesions. Accurate detection and characterization of these tumors is crucial before treatment to ensure correct staging, to prevent tumors from being falsely rated as inoperable and patients with inoperable tumors from being scheduled for surgical procedures ***(Parikh et al., 2008).***

MR of liver depends on the signal characteristics (T1 and T2 weighted signal intensities) and post-Gd imaging. The combination of these imaging techniques provides anatomical and functional imaging information to best detect and diagnose liver pathology. Recent applications of new functional methods, especially diffusion-weighted imaging (DWI), have expanded the use of MRI in the evaluation of lesions suspected for malignancy ***(Estorch and Carrio, 2013).***

Many studies have recently started to compare DWI to T1-weighted acquisition in the detection and characterization of liver lesions ***(Kenis et al., 2012).***

Diffusion-weighted imaging (DWI) is a technique for obtaining good image contrast by exploiting the properties of water molecule "diffusion" within tissue; the apparent diffusion coefficient (ADC, expressed in mm^2/s), is a quantitative parameter calculated by DwI, which combines the effects of capillary perfusion and mobility of water molecules, thus reflecting the cellularity of tissues and integrity of cell membranes ***(Kele and Jagt, 2010).***

A high ADC implies that water can move freely, indicating low cellularity and a low ADC implies that water mobility is restricted, indicating high cellularity ***(Bruegel et al., 2008).***

To date, DWI is potentially a very useful instrument for the study of focal hepatic lesion (FHL) and there is continuous and growing interest in order to credit its capacity in detecting and characterizing FHLs, identifying active areas in tumoral tissues, and predicting response to cancer treatment ***(Kele and Jagt, 2010).***

Several studies have reported that ADC can contribute to the differential diagnosis of benign and malignant focal lesions in the liver ***(Kele and Jagt, 2010).***

Dw_MRI examinations have many technical restrictions such as respiratory, cardiac, or peristaltic physiologic activity, all of which affect image quality and make evaluation, which is very sensitive to motion, more difficult. Consequently, prior to the development of fast MRI techniques, diffusion-weighted imaging was limited to cranial examinations. With the development of echo-planar imaging (EPI), a fast MRI technique, radiologists have overcome the long imaging times and related artifacts of conventional techniques, and diffusion-weighted MRI is now available for abdominal evaluations as well ***(Coenegrachts et al., 2007).***

The use of DWI in standard abdomen protocols is becoming usual, because it is not a time-consuming technique, capable of detecting FHL in patients with suspected malignant disease ***(Taouli, 2012).***

Moreover, it is feasible also when it is not possible to administrate gadolinium chelates, as a result of refusal by patients, history of previous allergic reaction, lack of reliable venous access, and risk of nephrogenic systemic fibrosis ***(Bilgili, 2012).***

Aim of the Work

To assess the expanding and auxiliary role of DW-MRI in characterization of focal hepatic lesion (FHL) for better patient management plan.

Anatomy of the Liver

I-Gross Anatomy:

Functional and Morphological Anatomy, Hepatic Surfaces and Relations, Liver Support, Vascular Anatomy, Biliary System.

II- MR Anatomy of the Liver:

- Axial, Coronal, Sagittal Image.
- T1 & T2WIs.

I-GROSS ANATOMY

The liver is the largest solid organ in the body. It lies in the upper part of the abdominal cavity just beneath the diaphragm and mostly under cover of the ribs. It fills the right hypochondrium and extends across the epigastrium into the left hypochondrium ***(Standring, 2005).***

The normal liver is shaped like a wedge with its base against the right abdominal wall, and its tip pointing to the spleen and extends from the fifth left intercostal space to the right midclavicular line down to the right costal margin. It measures 12 to 15 cm coronally and 15 to 20 cm transversely. The median liver weight is 1800 gm in men and 1400 gm in women ***(Schiff et al., 2007).***

A-Functional and Morphological Anatomy:

Liver anatomy can be described using two different aspects: morphological anatomy and functional anatomy. The classical morphological description of the liver anatomy is based on the external appearance. On the diaphragmatic surface, the falciform ligament divides the liver into the right and left anatomical lobes (Fig 1) which are very different from the functional right and left lobes. In this classical morphological description, the quadrate lobe belongs to the right lobe of the liver, but functionally it is part of left lobe ***(Rubin, 2006).***

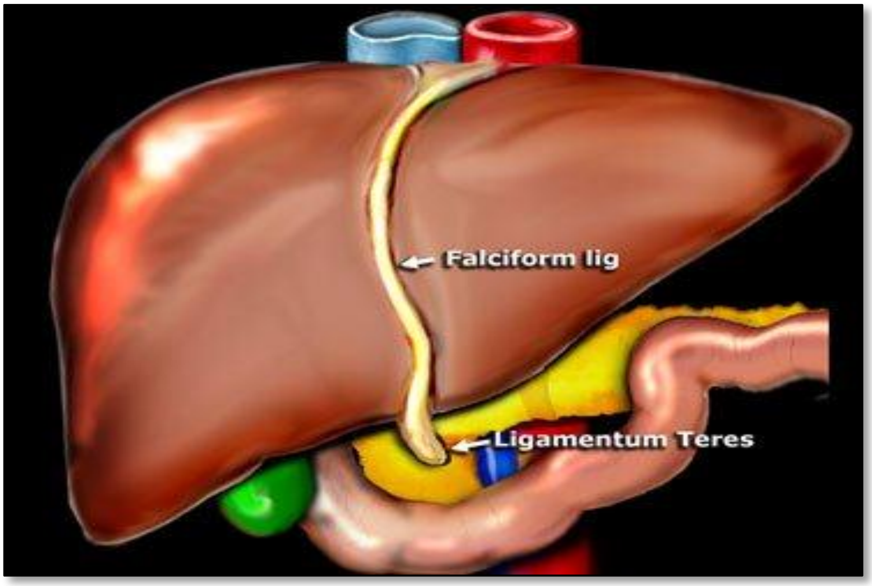

Fig. (1): Gross right and left anatomical lobes of the liver based on falciform ligament ***(Quoted from Rubin, 2006).***

1. Morphological Anatomy:

Historically the gross anatomical appearance of the liver has been divided into **right, left, caudate and quadrate lobes** by surface peritoneal and ligamentous attachments (Fig. 2) ***(Standring, 2005).***

a. The Right Lobe (Lobus Hepatis Dexter)

It is much larger than the left. It occupies the right hypochondrium and it is separated from the left lobe on its upper surface by the falciform ligament. Its inferior and posterior surfaces being marked by three fosse: the portahepatis and the fosse for the gall-bladder and inferior vena cava which separate its left part into two smaller lobes; the quadrate and caudate lobes ***(Standring, 2005).***

b. The Quadrate Lobe (Lobus Quadratus)

It is situated on the inferior surface of the right lobe, bounded in front by, the anterior margin of the liver; behind by, the portahepatis; on the right, by the fossa for the gall-bladder; and on the left, by the fossa for the umbilical vein ***(Standring, 2005).***

c. The Caudate Lobe (Lobus Caudatus; Spigelian Lobe)

It is situated on the posterior surface of the right lobe of the liver. It is situated behind the portahepatis and separates the fossa for the gall-bladder from the commencement of the fossa for the inferior vena cava ***(Standring, 2005).***

d. The Left Lobe (Lobus Hepatis Sinister)

It is smaller and more flattened than the right lobe. It is situated in the epigastric and left hypochondrial regions ***(Standring, 2005).***

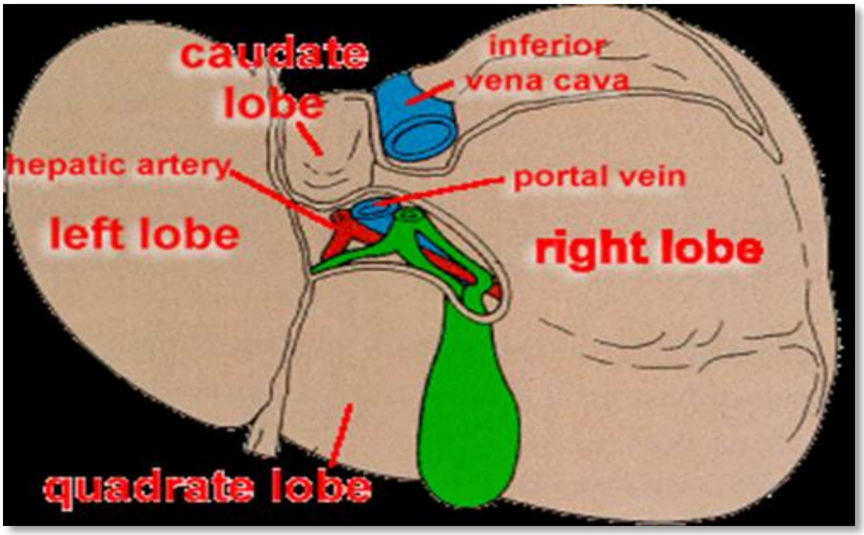

Fig. (2): Gross anatomical lobes of the liver
(Quoted from Rubin, 2006).

2. Functional (Segmental) Anatomy:

The segmental division of the liver is first described by the French surgeon Couinaud (1957) (Fig. 3). This classification was based on the divisions of the portal veins that divide the liver into eight functionally independent segments (Table 1) ***(Schiff et al., 2007).***

Each segment has its own vascular inflow, outflow and biliary drainage. In the centre of each segment there is a branch of the portal vein, hepatic artery and bile duct. In the periphery of each segment there is vascular outflow through the hepatic veins. Couinaud divided the liver into a functional left and right liver by a main portal fissure containing the middle hepatic vein. This is known as Cantlie's line which runs from the middle of the gallbladder fossa anteriorly to the inferior vena cava posteriorly. **Right hepatic vein** divides the right lobe into anterior and posterior segments. **Middle hepatic vein** divides the liver into right and left lobes (or right and left hemi liver), this plane runs from the inferior vena cava to the gall bladder fossa.

Left hepatic vein divides the left lobe into a medial and lateral part. **Portal vein** divides the liver into upper and lower segments, the left and right portal veins branch superiorly and inferiorly to project into the center of each segment ***(Rubin, 2006).***

Table (1): Segments numbering of the liver ***(Quoted from Hagen, 2001)***

- Segment I: Caudate lobe.
- Segments II and III: Left superior and inferior lateral segments.
- Segment IVa and IVb: Medial segments of the left lobe.
- Segments V and VI: Caudal to the transverse plane.
- Segments VII and VIII: Right superior anterior and posterior segments.

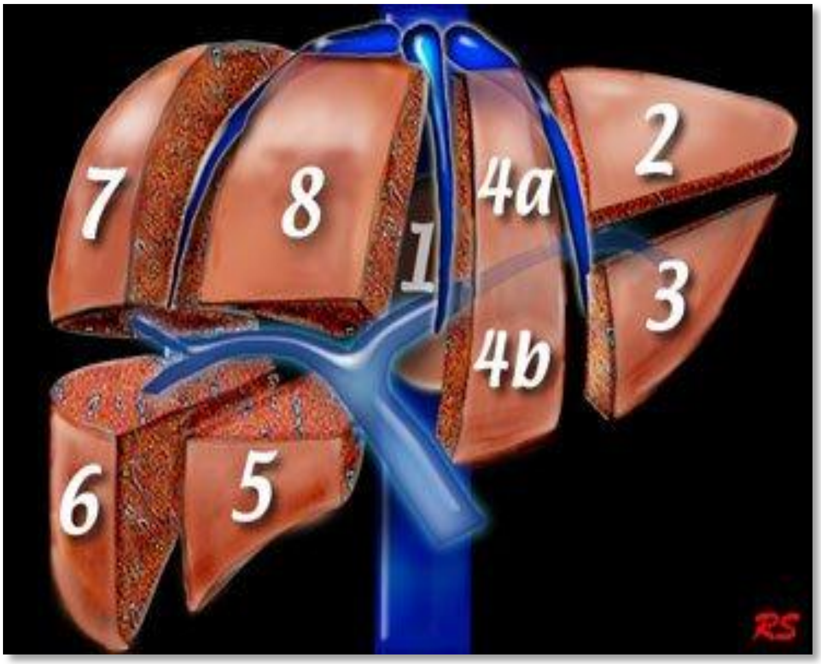

Fig. (3): Liver segmental anatomy according to Couinaud classification ***(Quoted from Rubin, 2006).***

B- Hepatic Surfaces and Relations:- (Fig 4)

- **Superior Surface:** Lies immediately below the diaphragm, separated from it by peritoneum except for a small triangular area where the two layers of falciform ligament diverge ***(Hagen, 2001).***
- **Anterior Surface:** It is covered by peritoneum except at the attachment of the falciform ligament. ***On the right***, the diaphragm separates it from the pleura and six to tenth ribs and cartilages, and ***on the left*** from the seventh and eighth costal cartilages. The median area of this surface lies behind the xiphoid process and the anterior abdominal wall ***(Standring, 2005).***

- **Right Surface:** It is covered by peritoneum. It lies adjacent to the right dome of the diaphragm which separates it from the right lung, pleura and seventh to eleventh ribs ***(Standring, 2005).***

- **Posterior Surface:** It has a deep median concavity corresponds to convexity of the vertebral column. Much of the posterior surface is attached to the diaphragm by loose connective tissue which forms the so-called **` bare area`.** The `*bare area*` is an anterior relation of the upper pole of the left suprarenal gland. **The inferior vena cava** lies in a groove in the medial end of the `*bare area*`. To the left of IVC, the **caudate lobe** is present. To the left of caudate lobe, the fissure for the ligamentumn venosum is present. The posterior surface over the left lobe bears a shallow esophageal and gastric impressions ***(Hagen, 2001).***

- **Inferior Surface:** is bounded by the inferior edge of the liver. It is marked near the midline by fissure of ligamentum teres. Posteriorly, it is related to the ligamentum venosum and the gall bladder. Between the fissure for the ligamentum teres and the gall bladder lies the quadrate lobe ***(Standring, 2005).***

N.B. The Porta Hepatis

The portahepatis is the area of the inferior surface through which all the neurovascular and biliary structures except the hepatic veins pass through it. It is situated between the quadrate lobe in front and the caudate process behind. At the portahepatis, the hepatic ducts lie anterior to the portal vein and its branches, and the hepatic artery with its branches lies between them ***(Rubin, 2006).***

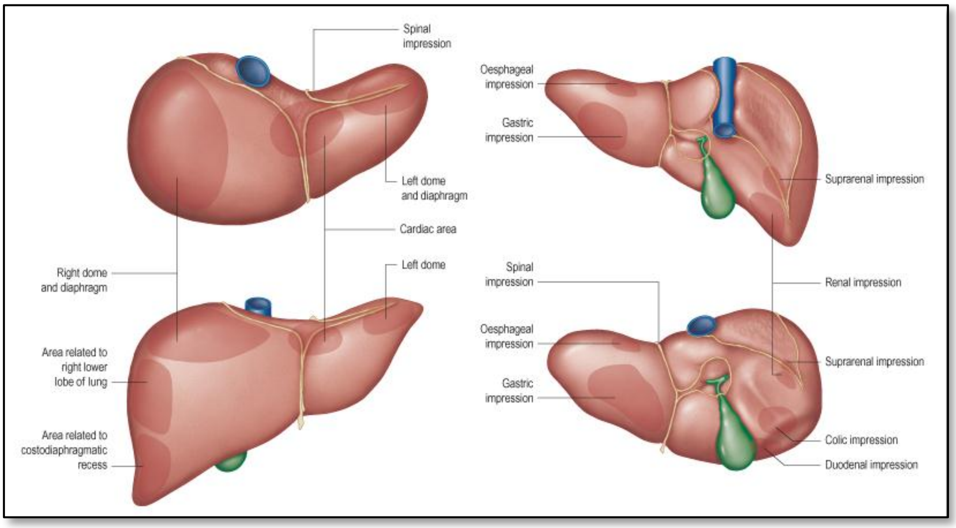

Fig. (4): Showing the relation of the liver: Top left, superior view; top right, posterior view; bottom left, anterior view; bottom right, inferior view ***(Standring, 2005).***

C- <u>The liver Support:</u> The liver is supported in its position in the upper abdomen by: Tone in the anterolateral abdominal muscles and Ligamentous attachments (Fig. 5) ***(Standring, 2005).***

- **Falciform Ligament*:*** The two layers of this ligament descend from the posterior surface of the anterior abdominal wall and diaphragm ***(Rubin, 2006).***

- **Ligamentum Teres*:*** represents the obliterated left umbilical vein. It runs in the lower free border of the falciform ligament ***(Hagen, 2001).***

- **Coronary Ligament:** is formed by the reflection of the peritoneum from the diaphragm onto the posterior surface of the right lobe of the liver ***(Schiff et al., 2007).***

- **Triangular Ligament:** The *left triangular ligament* is a double layer of peritoneum over the superior border of the left lobe of the liver. The *right triangular ligament* is a short structure which lies at the apex of the 'bare area' of the liver ***(Standring, 2005).***

- **Lesser Omentum:** is a fold of peritoneum which extends from the lesser curve of the stomach and proximal duodenum to the inferior surface of the liver. At its lower end, the two layers diverge to surround the structures of portahepatis ***(Standring, 2005).***

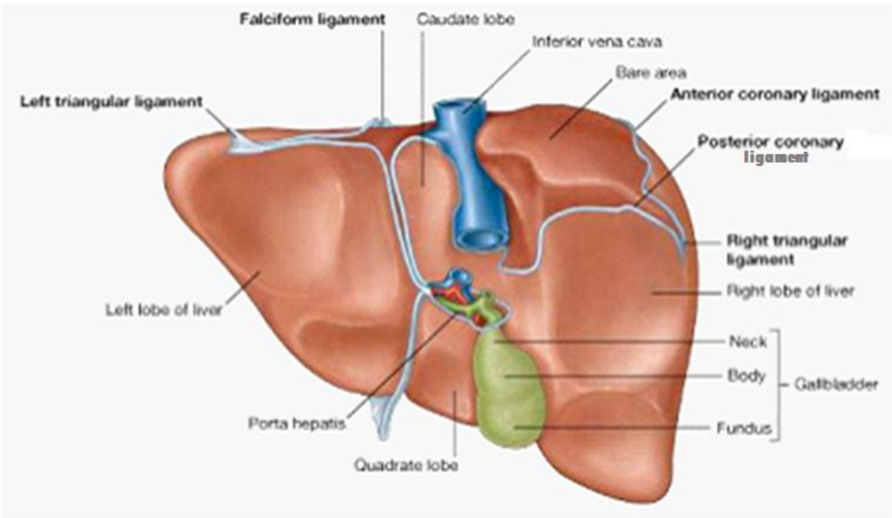

Fig. (5): Ligaments of the liver ***(Standring, 2005).***

D-Vascular Supply of the Liver:

1. Arterial Supply:

Approximately 25% of the blood flow into the liver is supplied by the hepatic artery while the remainder by the portal vein ***(Ryan et al., 2004).***

A. Portal Vein

The portal vein (Fig. 6) begins at the level of the second lumbar vertebra by union of the superior mesenteric and splenic veins. It lies anterior to the inferior vena cava and posterior to the neck of the pancreas. It ascends behind the first part of the duodenum and the common bile duct. It divides into right and left at right end of portahepatis:-

- ***The right branch:*** enters the right lobe and gives an *anterior division* supplying segments V and VIII and a *posterior division* supplying segments VI and VII.
- ***The left branch:*** gives off branches to segments I, II, III, and IV. As it enters the left lobe it is joined by the para-umbilical veins ***(Standring, 2005).***

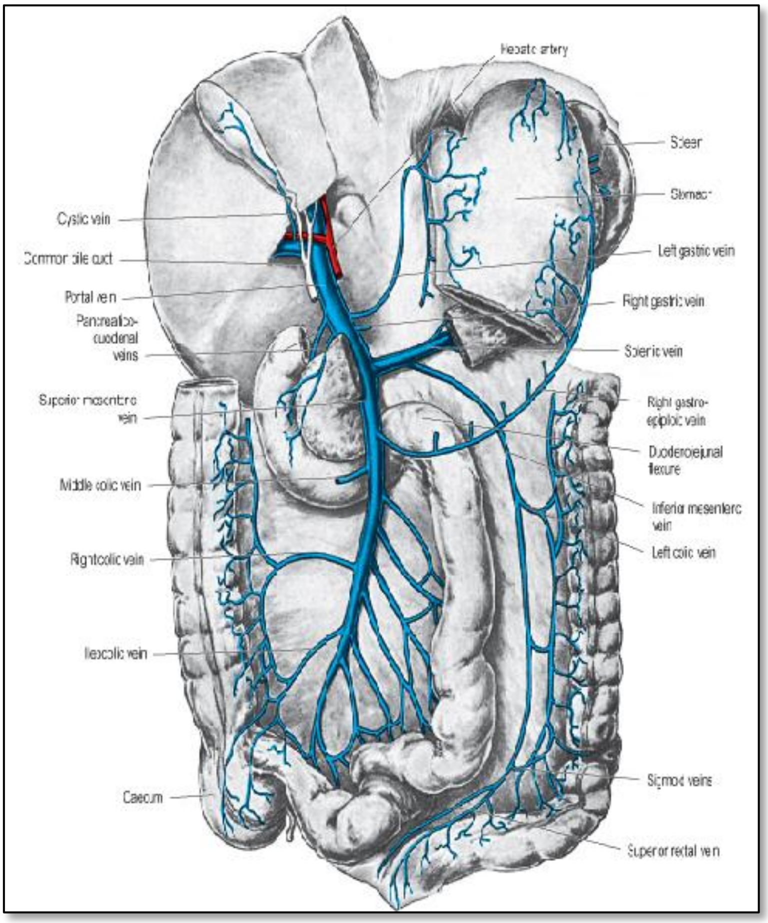

Fig. (6): The portal vein and its tributaries (semi-diagrammatic). Portions of the stomach, pancreas and left lobe of the liver and the transverse colon have been removed ***(Standring, 2005).***