أعوذ بالله من الشيطان الرجيم

"قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ"

سورة البقرة الآية (٣٢)

List Of Abbreviations

3D = three dimensional.
ADC= apparent diffusion coefficient.
APA= arterio-portal anastomoses.
BH= breath hold.
CCA = cholangiocellular carcinoma.
CT = computed tomography.
CV= central venule.
DW= diffusion weighted.
DWI= diffusion weighted imaging.
DW MRI= diffusion weighted magnetic resonance imaging.
EHE= epithelioid heamangioendothelioma.
EPI= echo planar imaging.
FFE= fast field echo.
Fig= figure.
FLC= fibrolamellar carcinoma.
FLL= focal liver lesions.
FNH= focal nodular hyperplasia.
FS= fast spin.
FSE = fast spin echo.
GB= gall bladder.
Gd = gadolinium.
Gd DTPA= gadolinium diethylenetriamine pentaacetic acid (hepatocyte-specific contrast agent taken by hepatocytes and excreted into biliary system).
GI= gastrointestinal.
GRAPPA= generalized auto- calibrating partially parallel acquisition.
GRE= gradient recalled echo.
HA= hepatic artery.
H& E= hematoxylin and eosin
HCC= hepatocellular carcinoma.
HCV= hepatitis C virus.
HMS= hepatic microvascular subunits.

IVC = inferior vena cava.
min= minute.
MR= magnetic resonance.
MRI = magnetic resonance imaging.
msec= millisecond.
NEX= number of excitations.
PV= portal vein.
PSC= Primary sclerosing cholangitis.
RT= respiratory triggered.
SE= spin echo.
sec= second.
SGE= spoiled gradient echo
SI= signal intensity.
SNR=signal to noise ratio.
SOR= standard of reference.
SPAIR = spectral attenuated inversion recovery (fat suppression MRI technique).
T= tesla.
TE= echo time.
THRIVE= high resolution isotropic volume examination.
TR= repetition time.
TSE= turbo spin echo.
US= ultrasonography.
VIBE= volumetric interpolated breath hold examination.
WIs= weighted images.

List Of Contents

Item	Page
Introduction and aim of the work	1
Chapter 1: Anatomy of the liver	4
I-Gross morphology of the liver	4
II-Histological considerations of the liver	13
III-MRI anatomy of the liver	18
Chapter 2: MRI liver techniques	25
I-Conventional technique of MRI liver	25
II-Principles of diffusion weighted MR imaging	30
Chapter 3: Pathology and MRI appearance of hepatic focal lesions	42
I-Cyst and cyst like lesions	42
II-Benign focal liver lesions	49
III-Malignant focal liver lesions	59
Chapter 4: Discussion	74
Summary and conclusion	83
Algorithm Of DWI MR role	86
References	87
Arabic summary	97

INTRODUCTION

Accurate detection and characterization of focal liver lesions is important for treatment planning such as hepatocellular carcinoma (HCC) and metastases. The size and number of lesions can affect therapy. For example, patients with limited resectable metastatic lesions may benefit from curative resection, and patients with fewer than three small HCCs are candidates for liver transplantation. Patients with more extensive disease should instead undergo trans-arterial chemo-embolization, radiofrequency ablation, or systemic chemotherapy ***(Heslin et al ,2001).***

Today, focal liver lesions are diagnosed using ultrasonography (US) and/or computed tomography (CT). Additionally, magnetic resonance imaging (MRI) is preferred when further characterization of these masses is needed. MRI has many advantages (e.g., high contrast resolution, the ability to obtain images in any plane, lack of ionizing radiation, and the safety of using particulate contrast media rather than those containing iodine) that make it a favored modality ***(Semelka et al, 1992).***

Focal nodular lesions characterization with Magnetic resonance imaging (MRI) is based on their morphology, signal intensity on different sequences and on their behaviors with paramagnetic contrast agents (Gadolinium). However, even with regular protocol studies, including above

mentioned sequences, there are still lesions where an accurate differentiation between benign and malignant lesions is not always achieved ***(Vergara et al, 2010).***

Diffusion is the term used for the randomized microscopic movement of water molecules known as "Brownian motion". Diffusion is known to be a sensitive parameter in microscopic tissue characterization ***(Namimoto et al, 1997).***

Diffusion-weighted MR imaging (DWI), theoretically described as far back as the 1950s and 1960s by ***Carr and Purcell (1954)*** and ***Stejskal and Tanner (1965),*** has become an established method in neuroradiology since the introduction of the intravoxel incoherent motion technique by ***Le Bihan et al (1988).***

Diffusion-weighted 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).***

DW-MRI can help characterize focal hepatic lesions by enabling measurement of lesion apparent diffusion coefficient ***(Parikh et al, 2008).***

DW imaging could potentially improve care of patients with cancer and cirrhosis by improving liver lesion detection over that achieved with standard breath-hold T2-weighted imaging ***(Parikh et al , 2008).***

Diffusion weighted technique should be used as an additional sequence to supplement conventional MRI protocol studies for proper characterization of focal liver lesions ***(Vergara et al, 2010).***

AIM OF THE WORK

The aim of this study is to show the growing and useful role of DW-MRI in the characterization of hepatic focal lesions for better patient management plan.

Anatomy of the liver

I- Gross morphology of the liver

The liver is the largest intra abdominal organ weighting 1400-1800 gm in adults. It is wedge shaped (with its rounded base to the right) and occupies the right hypochondrium, epigastrium and left hypochondrium as far as left midclavicular line ***(Standring et al, 2005)***.

1- Hepatic surfaces and relations (Figs 1.1 and 1.2)

It has 5 surfaces; right, anterior, posterior, superior and inferior surfaces. The first four surfaces are continuous through the rounded ill-defined borders and mostly related to the diaphragm, which separates theses surfaces from thoracic organs and structures. The remained inferior (visceral) surface is related to abdominal viscera and is limited below by a sharp inferior border. ***(Giovannelli et al, 1997).***

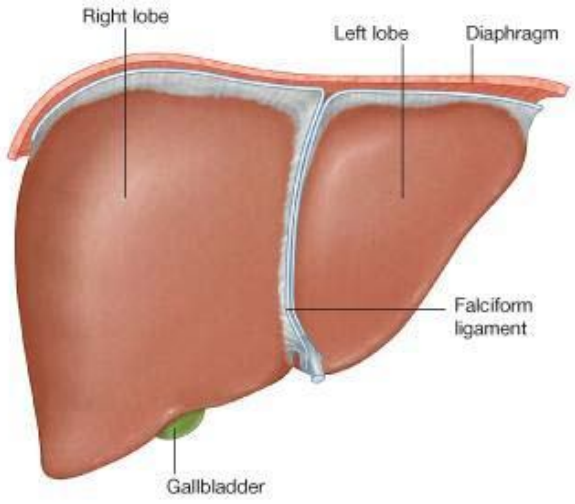


Fig (1.1) The Antero-superior surface of the liver ***(Standring et al, 2005).***

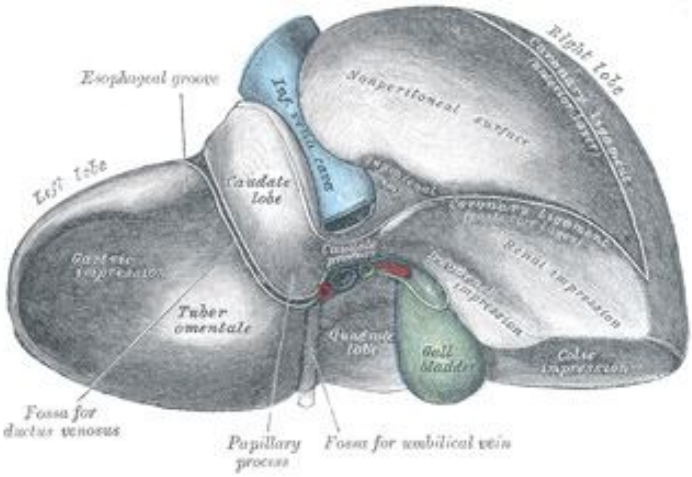


Fig (1.2). The Visceral and Posterior surfaces of the liver ***(Standring et al, 2005).***

N.B: The Porta Hepatis

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 ***(Standring et al, 2005).***

2- Hepatic capsule (Fig.1.3)

The liver is covered by a thin connective tissue capsule (Glisson`s capsule) as shown in (Fig.1.3) that becomes thicker at the hilum where the PV and the hepatic artery enter the organ and where the right and the left ducts and lymphatic exit ***(Michael et al, 2003).***

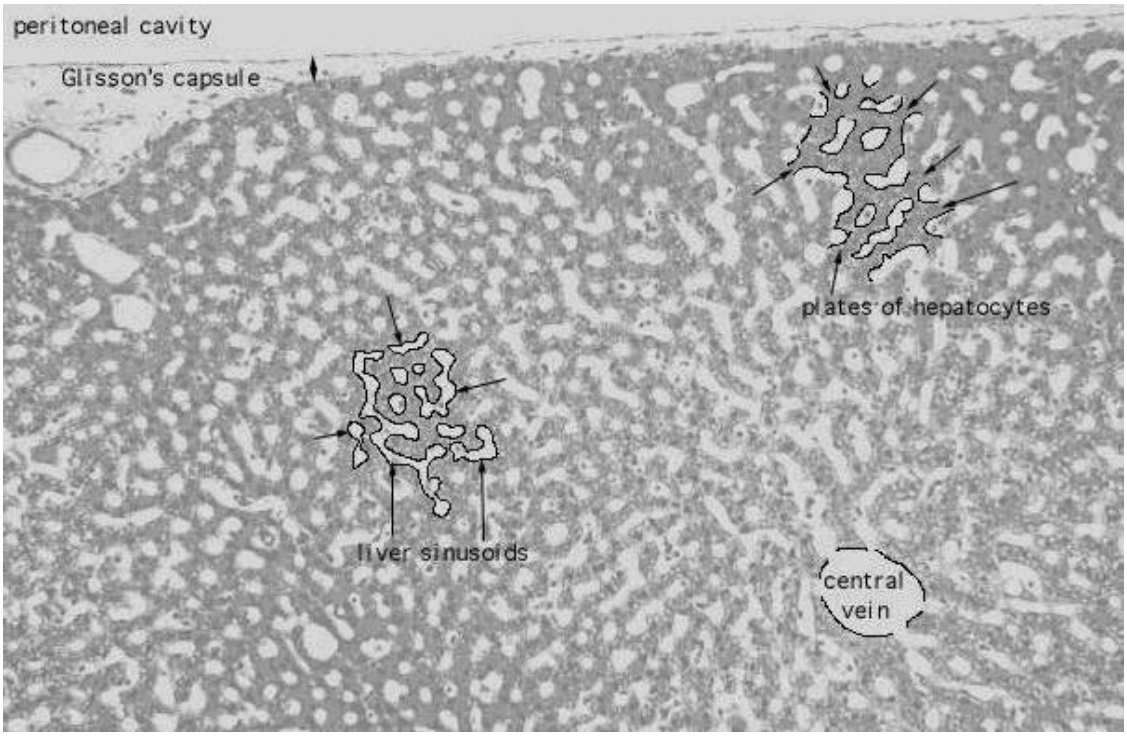


Fig (1.3). Glisson`s capsule ***(Michael et al, 2003).***

3- Segmental anatomy of the liver:-

An understanding of the segmental anatomy of the liver is critical for localization and appropriate management of hepatic neoplasms. The system proposed by Goldsmith and Woodburne 1957 does not provide a level of detail adequate for the surgical planning of subsegmental hepatic resection.

That proposed by Couinaud 1957 provides the surgically relevant imaging techniques and is easily applicable to sectional imaging techniques. (Fig. 1.4) ***(Heiken, 1998).***

The Couinaud classification divides the liver into 8 independent segments, each of which has its own vascular flow, outflow and biliary drainage (Fig. 1.5). The main portal vein divides into two branches, right and left, defining a right liver and a left liver. The plane of separation between the right and the left liver can be approximated as a plane going from the gall bladder fossa to the vena cava in which runs the middle hepatic vein (Fig.1.8) ***(Majno et al., 2005).***

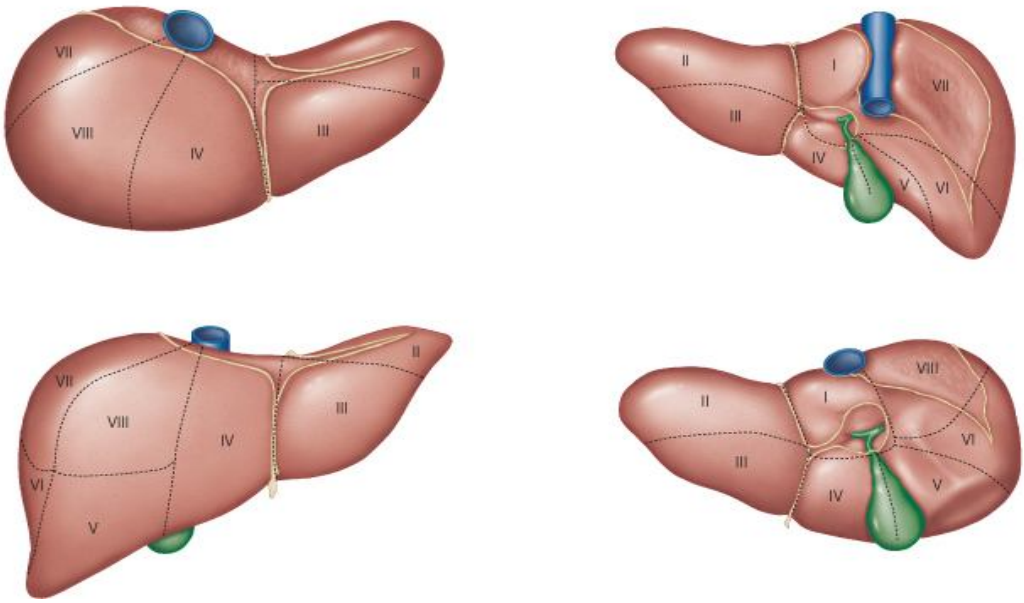


Fig (1.4). showing Segmentation of the liver - Couinaud. **(*Standring et al, 2005*)**

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.

The caudate lobe is considered segment one .The segments in the right liver are divided as follows: the first landmark is the right hepatic vein. All that is anterior and to the left of the right hepatic vein will be in the right anterior sector (segments 5 and 8), all that is posterior and to the right will be in the right posterior sector (segments 6 and 7). The second landmark should be the third order bifurcation of the portal vein (where the right sectorial branches separate into segmental branches). Normally, however, it is not necessary to follow the sectorial into the segmental branches as the plane where the segmental branches originate can be approximated to the plane passing by the main portal bifurcation. In each sector the inferior segments (5 and 6) will lie caudal to the portal bifurcation, and the superior segments (7 and 8) will be cranial to it. Therefore in the right anterior sector segment 5 will be below and segment 8 above, and in the posterior sector segment 6 below and segment 7 above ***(Majno et al., 2005).***

As for the left liver, the main landmark is the left portal vein, and the second landmark is the left hepatic vein. The left portal vein describes a smooth arch from the main bifurcation to the umbilical ligament. All liver tissue comprised by the concavity of the arch and the middle hepatic vein will be segment 4. On the convexity of the arch, on the left side (the left lobe of the gross anatomy) the distal part of the left hepatic vein will separate segment 2 (posteriorly and superiorly) from segment 3 (more anteriorly and inferiorly) ***(Majno et al., 2005)***

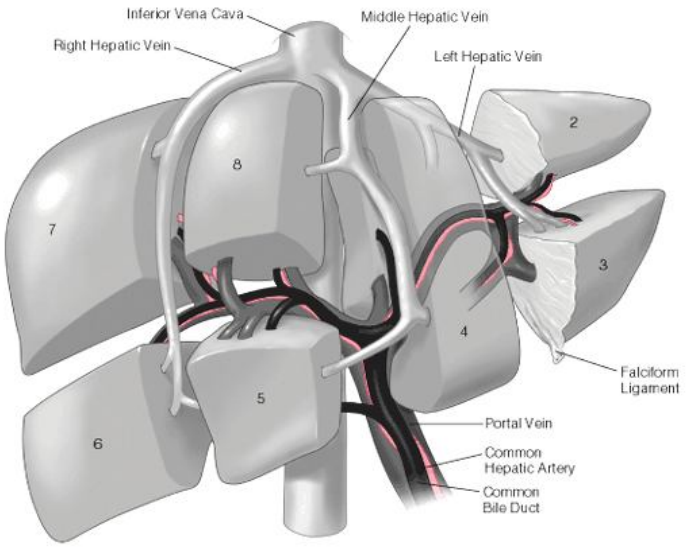


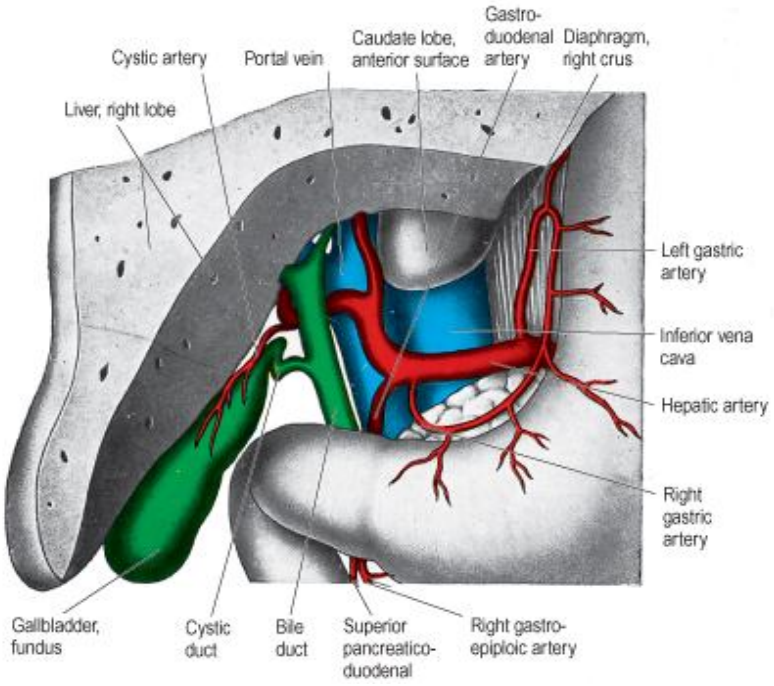
Fig.(1.5): Diagram shows the surgical segments of the liver ***(Soyer et al., 1994).***

4-Blood supply & Lymphatic drainage of the liver (Fig.1.6):

The liver receives a dual blood supply from both the portal vein and the hepatic artery. Although the portal vein carries incompletely oxygenated venous blood from the intestine and the spleen, it supplies up to half the oxygen requirement of the hepatocytes because of its greater flow. This dual blood supply explains the low incidence of hepatic infarction ***(Gosling et al, 2002).***

A) Arterial supply:

The arterial blood supplied to liver by the is the



common hepatic artery. This is most commonly the second branch of the celiac axis. It divides into right and left branches just below the porta hepatis. The left hepatic artery divides into medial and lateral segmental branches. The right hepatic artery divides into anterior and posterior segmental branches ***(Standring et al, 2005).***

Fig (1.6):Dissection to show the relations of the hepatic artery, bile duct and portal vein to each other in the lesser omentum: anterior aspect. ***(Standring et al, 2005)***

B) The Portal vein:

The portal vein (Fig. 1.7) 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 porta hepatis:-

- ***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 et al, 2005).***

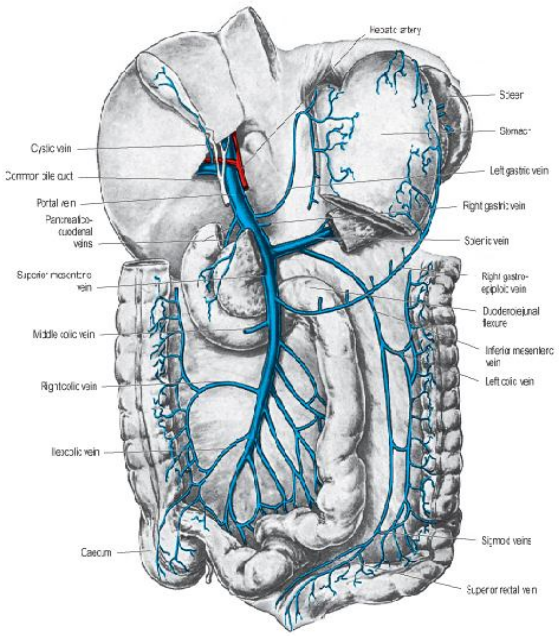


Fig (1.7): The portal vein and its tributaries (semi-diagrammatic). Portions of the stomach, pancreas and left lobe of the liver and the transverse colon have been removed. ***(Standring et al, 2005).***

c) Venous drainage:

The hepatic veins (Fig. 1.8) convey blood from the liver to the inferior vena cava. The veins commence as intra-lobular veins, which drain the sinusoids and lead to sublobular veins, which eventually unite into hepatic veins. These emerge from the posterior hepatic surface to open directly into the inferior vena cava in its groove on the posterior hepatic surface. Hepatic