

# **CHARACTERIZATION OF HEPATIC FOCAL LESIONS USING MRI WITH NEW CONTRAST MATERIALS**

Essay

Submitted For Partial Fulfillment Of  
The Master Degree **In Radiodiagnosis**

Presented By

**Abeer Abdallah Elmehy**  
(M.B.B.CH)

Supervised By

**Prof. Dr. Sherif Abou-Gamrah**

Assistant Prof. of Radiodiagnosis  
Faculty of Medicine-Ain Shams University

**Dr. Amir Louis Louka**

Lecturer of Radiodiagnosis  
Faculty of Medicine- Ain Shams University

Faculty of Medicine  
Ain Shams Univerity  
2010

## **Acknowledgement**

First of all, thanks to ALLAH who allowed and helped me to accomplish this work.

I would like to thank heartily and to express my utmost gratitude to Prof. Dr. Sherif Abou-Gamrah, Assistant prof. of Radiodiagnosis, Faculty of Medicine, Ain shams University, who gave me a lot of his precious time and unlimited experience. His continuous encouragement, valuable guidance and constant support have made this work possible.

I also appreciate too much the guidance offered by Dr. Amir Louis Louka, Lecturer of Radiodiagnosis, Faculty of Medicine, Ain shams University, for his fruitful suggestions, valuable directions and enthusiastic supervision throughout this work.

Lastly, I wish to extend my thanks to all staff members, in radiodiagnosis department, Eldemerdash Hospital, Ain Shams University who have been of help to me during the preparation of this piece of work.

Abeer Abdallah Elmehy

# List of Tables

<b>Table. No.</b>	<b>Title</b>	<b>Page No.</b>
<b>Table (1):</b>	Extracellular and hepatocyte-selective gadolinium chelates used in liver MR imaging examination. ....	64
<b>Table (2):</b>	The mechanisms of effect and clinical properties of contrast agents used in liver MR imaging examination.. ....	71
<b>Table (3):</b>	Superparamagnetic iron oxides used in liver MR examination and RES-specific contrast agents.....	73

# List of Figures

<b>Fig. No.</b>	<b>Title</b>	<b>Page No.</b>
<b>Figure (1):</b>	External features of the liver. ....	6
<b>Figure (2):</b>	Liver lobes and segments.. ....	11
<b>Figure (3):</b>	Segmentation of the liver- Couinaud.....	13
<b>Figure (4):</b>	The relation of the hepatic artery, bile duct and portal vein to each other in the lesser omentum: anterior aspect.....	16
<b>Figure (5):</b>	The internal features of the liver. ....	19
<b>Figure (6):</b>	Axial T1-weighted in- and opposed-phase gradient-echo (GRE).....	21
<b>Figure (7): A–G</b>	Axial maximum intensity projection (MIP).....	23
<b>Figure (8):</b>	Axial MR images of the liver. ....	25
<b>Figure (9):</b>	Sagittal MR images of the liver.....	26
<b>Figure (10):</b>	Coronal MR images of the liver.....	27
<b>Figure (11):</b>	Large (multiacinar) regenerative nodules.....	31
<b>Figure (12):</b>	Focal nodular hyperplasia (FNH) of the liver.....	32
<b>Figure (13):</b>	Hepatocellular adenoma. An axial arterial phase dynamic contrast-enhanced three- dimensional gradient-echo MR.....	34
<b>Figure (14):</b>	HCC in the right lobe A) MnDPDP-enhanced.....	36
<b>Figure (15):</b>	Imaging study of cholangiocarcinoma.. ....	38

## List of Figures (Cont...)

<b>Figure (16):</b> A) Gadolinium DTPA-enhanced MRI. ....	40
<b>Figure (17):</b> Mn-DPDP-enhanced T1-weighted (170/4.4; flip angle, 80°) MR.....	48
<b>Figure (18):</b> Showing formation of a spin echo at time.....	53
<b>Figure (19):</b> Showing dephasing of the magnetisation vector by T2* and rephasing by a 180 degree pulse to form a spin echo. ....	54
<b>Figure (20):</b> T1-w GRE unenhanced (A), in the arterial phase (B) and 20 minutes after injection of Gd-EOB-DTPA.. ....	80
<b>Figure (21):</b> FNH in the right lobe .....	82
<b>Figure (22):</b> MR imaging appearance of typical FNH.. ....	83
<b>Figure (23):</b> MR imaging appearance of a FNH lesion with a prominent pseudocapsule.....	84
<b>Figure (24):</b> Multiple lesions of telangiectatic FNH. ....	85
<b>Figure (25):</b> MR imaging appearance of multiple FNH lesions. ....	86
<b>Figure (26):</b> NRH in a patient with an autoimmune disorder. ....	87
<b>Figure (27):</b> a-d. Hepatic adenoma. a. Transverse non- enhanced T1-weighted MR.....	89
<b>Figure (28):</b> Large single adenoma in a 45-year-old woman.....	90

## List of Figures (Cont...)

<b>Figure (29):</b> Axial T2-weighted image with fat saturation demonstrate a large fluid filled structure in the right lobe of the liver..	92
<b>Figure (30):</b> 48-year-old woman with hemangioma in the right lobe	94
<b>Figure (31):</b> Typical hepatic hemangioma at MRI.	96
<b>Figure (32):</b> 40-year-old woman with hemangioma.	97
<b>Figure (33):</b> Transverse fat-suppressed T2W image	99
<b>Figure (34):</b> Dysplastic nodules.	101
<b>Figure (35):</b> Large hepatocellular carcinoma at MRI (arrows).	103
<b>Figure (36):</b> Nodule-within-a-nodule enhancement pattern.	104
<b>Figure (37):</b> Hepatocellular carcinoma at MRI.	105
<b>Figure (38):</b> Transverse MR	107
<b>Figure (39):</b> A 57-year-old man with HCC in the right lobe	109
<b>Figure (40):</b> Fibrolamellar HCC.	110
<b>Figure (41):</b> Hypervascular metastases in a 55-year-old man with a carcinoid tumor.	111
<b>Figure (42):</b> a, b. Transverse fat-suppressed T2W	112
<b>Figure (43):</b> Hypovascular metastases in a 59-year-old patient with colon cancer.	113
<b>Figure (44):</b> 60-year-old man with small hepatic metastasis from colorectal carcinoma.	115

## List of Figures (Cont...)

<b>Figure (45):</b> Multiple metastases—improved detection with Gd-EOB-DTPA at the hepatocyte phase of enhancement.....	116
<b>Figure (46):</b> Dynamic Gd-enhanced MR versus unenhanced MR for lesion detection—role of 3D FS T1w GRE imaging.) .....	117
<b>Figure (47):</b> 63-year-old woman with metastatic colonic carcinoma. T2-weighted fast spin-echo MR.....	118
<b>Figure (48):</b> 57-year-old man with surgically confirmed 0.4-cm liver metastasis from rectal cancer. ....	119
<b>Figure (49):</b> Cholangiocarcinoma.....	120
<b>Figure (50):</b> Intrahepatic cholangiocarcinoma at MRI (arrows).) .....	122
<b>Figure (51):</b> A 36-year-old woman with CCC and metastatic lesions .....	123

## LIST OF ABBREVIATIONS

<b>NRH</b>	Nodular regenerative hyperplasia
<b>FNH</b>	Focal Nodular Hyperplasia
<b>HA</b>	Hepatocellular Adenoma
<b>HCC</b>	Hepatocellular carcinoma
<b>FHCC</b>	Fibrolamellar Variant of HCC
<b>IHE</b>	Infantile Hemangioendothelioma
<b>AML</b>	Angiomyolipoma
<b>EHE</b>	Epithelioid hemangioendothelioma
<b>HB</b>	Hepatoblastoma
<b>IPT</b>	Inflammatory Pseudotumor
<b>SE</b>	Spin echo sequence
<b>GRE</b>	Gradient recalled echo sequence
<b>FOV</b>	Field of View
<b>STIR</b>	Short T1 inversion recovery
<b>FLAIR</b>	Fluid attenuated inversion recovery
<b>MAST</b>	Motion artifact suppression technique
<b>FLASH</b>	Fast Low-Angle Shot
<b>GRASS</b>	Gradient-Recalled Acquisition in the steady state
<b>HASTE</b>	Half Fourier Acquisition Single Shot Turbo Spin Echo
<b>VIBE</b>	Volumetric Interpolated Breath-Hold Examination
<b>FIRM</b>	Fast inversion-recovery motion-insensitive
<b>DWI</b>	Diffusion-weighted Imaging
<b>SENSE</b>	Sensitivity Encoding
<b>SMASH</b>	Simultaneous Acquisition of Spatial Harmonics
<b>Gd-DTPA</b>	Gadopentate dimeglumine
<b>Gd-DTPA-BMA</b>	Gadodiamide
<b>Gd-DOTA</b>	Gadoterate meglumine
<b>Gd-HP-DO3A</b>	Gadoteridol
<b>Gd-BOPTA</b>	Gadobenate dimeglumine
<b>Gd-EOB-DTPA</b>	Gadoxetic acid(Gadolinium-ethoxybenzyl-diethylenetriaminepentaacetic acid)
<b>Mn-DPDP</b>	Mangafodipir trisodium
<b>CMC-001</b>	Copenhagen Malmö Contrast
<b>SPIO</b>	Superparamagnetic iron oxide
<b>USPIO</b>	Ultrasmall superparamagnetic iron oxide
<b>VSOP-C184</b>	Very small SPIO particle, citrate coating, 184th formulation



# CONTENTS

<b>Introduction</b> .....	1
<b>Aim of the work</b> .....	3
<b>Review of literature</b> .....	4
○ Anatomy of the Liver.....	4
○ Histopathological classification of hepatic focal lesions.....	28
○ Basic principles and techniques of magnetic resonance imaging.....	49
○ Contrast media used in liver MRI.....	62
○ Diagnostic imaging of hepatic focal lesions using the new MRI contrast agents.....	77
<b>Summary and Conclusion</b> .....	124
<b>References</b> .....	126
<b>Arabic summary</b> .....	--

## INTRODUCTION

The liver is the largest of the abdominal viscera, occupying a substantial portion of the upper abdominal cavity. It performs a wide range of metabolic activities necessary for homeostasis, nutrition and immune defense. (*Standring et al., 2005*).

Hepatic focal lesions constitute a daily challenge in the clinical settings. However, noninvasive methods can be useful in the detection and characterization of these lesions. The noninvasive diagnosis of liver lesions is usually achieved with contrast material-enhanced computed tomography and magnetic resonance (MR) imaging. Dynamic three-dimensional gradient-recalled-echo MR imaging provides dynamic contrast-enhanced thin-section images with fat saturation and a high signal-to-noise ratio and is excellent for the evaluation of various focal hepatic lesions (*Elsayes et al., 2005*)

Metastases are the most common malignant liver lesions and the most common indication for hepatic imaging. Specific characterization of liver metastases in patients with primary non-hepatic tumors is crucial to avoid unnecessary diagnostic work-up for incidental benign liver lesions. Magnetic resonance (MR) is rapidly emerging as the imaging modality of choice for detection and characterization of liver lesions due to the high specificity resulting from optimal lesion-to-liver contrast. (*Elsayes et al., 2005*).

With the recent advances in MR contrast agents, MR may replace computed tomographic arterial portography. MR imaging has several advantages over CT such as no risks from radiation exposure and no adverse reactions to iodinated contrast agents. Indeed, MR is rapidly evolving as the primary imaging modality for the detection and characterization of liver lesions including metastases (*Ward et al., 2006*)

The ideal contrast agent for liver MR examinations must have a strong magnetic effect, little if any side effects and biodistribution differentiation. (*Reimer et al., 2004*)

There are two classes of MRI contrast agent available commercially to image the liver: **liver-specific** and **liver-nonspecific contrast agents**. The liver-specific agents are divided into two groups: hepatocyte-selective and reticuloendothelial-specific contrast agents. Reticuloendothelial-specific agents are ferumoxides and ferucarbotran; hepatocyte-specific agents are gadobenate dimeglumine and gadoxetic acid. The nonspecific contrast agents are Gd-chelates, such as Gd-DTPA-BMA and Gd-DTPA (*Huppertz et al., 2005*).

## **AIM OF THE WORK**

The aim of this work is to evaluate the role of contrast enhanced MRI in detection and characterization of hepatic focal lesions regarding its advantages over other modalities used in liver imaging using new contrast agents, so allow early and appropriate management of liver tumors.

## **Anatomy of the Liver**

**T**he liver is a vital organ as it has a wide range of functions, including detoxification, protein synthesis, and production of biochemicals necessary for digestion. The liver is necessary for survival; there is currently no way to compensate for the absence of liver function. (*Maton et al., 1999*)

### **Position and shape:**

The liver is located in the upper right-hand portion of the abdominal cavity beneath the diaphragm and on top of the stomach, right kidney, and intestines. It extends from the right lateral aspect of the abdomen 15 to 20 cm transversely toward the xiphoid. (*Standring et al., 2005*).

### **Fixation of the liver:**

Several factors contribute to maintain the liver in place. The attachments of the liver to the diaphragm by the coronary and triangular ligaments and the intervening connective tissue of the uncovered area would hold up the posterior part of the liver. (*Standring et al., 2005*)

## External features

### Peritoneal attachments to the liver:

The liver is connected to the under surface of the diaphragm and to the anterior wall of the abdomen by five ligaments. (**Fig. 1**)

#### *The falciform ligament*

It is a broad and thin antero-posterior peritoneal fold. It is attached by its left margin to the under surface of the diaphragm, and the posterior surface of the right Rectus sheath; by its right margin it extends from the notch on the anterior margin of the liver to the posterior surface. (*Standring et al., 2005*).

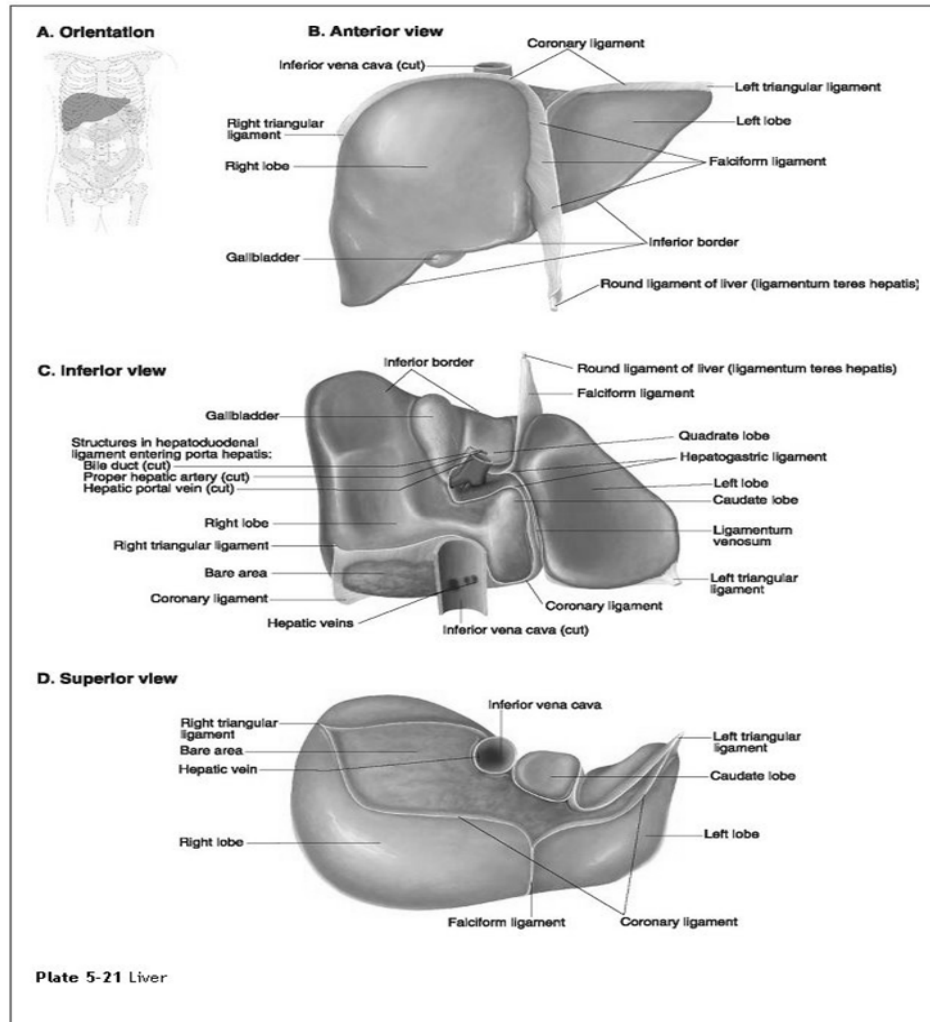
#### *The coronary ligament*

It consists of an upper and a lower layer. The upper layer is formed by the reflection of the peritoneum from the upper margin of the bare area to the under surface of the diaphragm. The lower layer is reflected from the lower margin of the bare area on to the right kidney and suprarenal gland (*Standring et al., 2005*).

#### *The triangular ligaments*

The **right triangular ligament** is situated at the right extremity of the bare area. It is formed by the opposition of the upper and lower layers of the coronary ligament. The **left**

**triangular ligament** connects the posterior part of the upper surface of the left lobe to the diaphragm. (*Standring et al., 2005*).



**Figure (1):** External features of the liver (*Lippincott Williams & Wilkins Atlas of Anatomy, 1st Edition. 2008*).