

# **Role of MR Spectroscopy in Fatty Liver**

*Essay*

Submitted for Fulfillment of Master Degree in Radiodiagnosis

*By*

***Sameh Essam Eldin Abd Elraziq***

*M.B., B.Ch.*

*Ain Shams University*

*Supervised By*

***Prof. Dr. Hanaa Abd Elkader Abd Elhamed***

**Professor of Radiodiagnosis**

**Faculty of Medicine**

**Ain Shams University**

***Dr. Yousra Abd Elzaher Abdullah***

**Lecturer of Radiodiagnosis**

**Faculty of Medicine**

**Ain Shams University**

**Faculty of Medicine  
Ain Shams University**

**2013**





بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا

عَلَّمْتَنَا ۖ إِنَّكَ أَنْتَ الْعَلِيمُ

الْحَكِيمُ

(البقرة 32)



## ACKNOWLEDGMENTS

First, and foremost, all thanks and gratitude to GOD, most gracious and most merciful.

I would like to express my deepest gratitude and sincere thanks to Prof. ***Dr. Hanaa Abd Elkader***, Professor of Radiodiagnosis, Faculty of Medicine, Ain shams University for devoting much of her precious time, kind guidance and valuable advice for enriching this work.

I am extremely grateful to ***Dr. Yousra Abd Elzaher***, Lecturer of Radiodiagnosis, Ain shams University for her continuous guidance and valuable suggestions, saving no effort or time to read every word in this work.

Lastly but not least, I would like to thank my dear parents, my Wife and my daughter for their constant support and encouragement and for providing me the environment needed for concentration and progress.



# LIST OF CONTENTS

<b>Introduction.....</b>	<b>3</b>
<b>Chapter One: Anatomy of the liver .....</b>	<b>13</b>
<b>Chapter Two: Pathogenesis of Fatty Liver.....</b>	<b>31</b>
<b>Chapter Three: TECHNIQUES OF FAT DETECTION BY MRI .....</b>	<b>48</b>
<b>Chapter Four: Basic Principles of MR Spectroscopy .....</b>	<b>64</b>
<b>Chapter Five: Role of MR Spectroscopy in Fatty Liver.....</b>	<b>79</b>
<b>Chapter Six: Other Methods for Detection and Quantification of Steatosis .....</b>	<b>89</b>
<b>Summary.....</b>	<b>101</b>
<b>References.....</b>	<b>105</b>
<b>Arabic Summary</b>	

## LIST OF ABBREVIATIONS

<b>CNR</b>	:	Contrast to-Noise-Ratio
<b>FLASH</b>	:	Fast Low Angle Shot
<b>IVC</b>	:	Inferior Vena Cave
<b>LHV</b>	:	Left Hepatic Vein
<b>LP</b>	:	Left Portal Vein
<b>MHV</b>	:	Middle Hepatic Vein
<b>MRI</b>	:	Magnetic resonance imaging
<b>PV</b>	:	Portal Vein
<b>RHV</b>	:	Right Hepatic Vein
<b>RPV</b>	:	Right Portal Vein
<b>SE</b>	:	Spin Echo
<b>SGE</b>	:	Spoiled gradient echo
<b>SI</b>	:	Signal intensity
<b>SNR</b>	:	Signal to-Noise Ratio
<b>SPIO</b>	:	Super Paramagnetic Iron Oxide
<b>SS</b>	:	Single Shot
<b>STIR</b>	:	Short T <sub>1</sub> Inversion Recovery
<b>T</b>	:	Tesla
<b>TE</b>	:	Time of Echo
<b>TR</b>	:	Time of Repetition
<b>Turbo FLASH</b>	:	Turbo fast low-angle shot
<b>USPIO</b>	:	Ultra small superparamagnetic iron oxides
<b>3D-GRE</b>	:	Three Dimensional Gradient Recalled Echo
<b>NAFLD</b>	:	Non Alcoholic fatty liver disease
<b>NASH</b>	:	Non Alcoholic steatohepatitis



## LIST OF FIGURES

<b>Figure 1.1</b>	: The surfaces and external features of the liver .....	14
<b>Figure 1.2</b>	: Relations of the liver .....	15
<b>Figure 1.3</b>	: Segmentation of the liver – Couinaud .....	18
<b>Figure 1.4</b>	: relations of the hepatic artery, bile duct and portal vein to each other .....	21
<b>Figure 1.5</b>	: The portal vein and its tributaries (semi-diagrammatic) .....	22
<b>Figure 1.6</b>	: Arrangement of the hepatic venous territories .....	22
<b>Figure 1.7</b>	: Normal hepatic veins.Axial image .....	25
<b>Figure 1.8</b>	: Portal vein anatomy.....	25
<b>Figure 1.9</b>	: Sagittal MR T2 images of the liver .....	27
<b>Figure 1.10</b>	: CoronalT2MR image of the liver .....	27
<b>Figure 1.11</b>	: Normal MR Liver signal intensity .....	28
<b>Figure 2.1</b>	: (a) Glycogenic hepatopathy (b) Diabetic hepatosclerosis .....	32
<b>Figure 2.2</b>	: Development of nonalcoholic hepatic steatosis .....	35
<b>Figure 2.3</b>	: Histologic features of fibrosis in nonalcoholic steatohepatitis.....	40
<b>Figure 2.4</b>	: Sclerosing hyaline necrosis.....	45
<b>Figure 3.1</b>	: Typical MR imaging examination of the liver	51
<b>Figure 3.2</b>	: Chemical Shift Imaging	52
<b>Figure 3.3</b>	: Schematic illustrates chemical shift misregistration	53
<b>Figure 3.4</b>	: Axial gradient-echo in-phase image acquired at field strength of 3.0 T	55
<b>Figure 3.5</b>	: MR images obtained in an anteroposterior frequency-encoding direction	56
<b>Figure 3.6</b>	: Sagittal T2-weighted MR image	56
<b>Figure 3.7</b>	: Axial gradient-echo opposed-phase image acquired at field strength of 3.0 T	60
<b>Figure 3.8</b>	: an adrenal adenoma and fatty liver in-phase	60
<b>Figure 3.9</b>	: T1-weighted MR images obtained without and with fat saturation	62
<b>Figure 3.10</b>	: Single-shot fast spin-echo (FSE) images obtained without and with fat saturation	63
<b>Figure 4.1</b>	: Diagram shows metabolite frequency relative to water frequency .....	68

<b>Figure 4.2</b>	: MR spectrum obtained in healthy liver in a 36-year-old woman shows the frequency locations of water and lipid peaks .....	70
<b>Figure 4.3</b>	: Diagram shows the T1 recovery curves of fat and water .....	73
<b>Figure 4.4</b>	: Uncorrected MR spectra obtained in liver .....	74
<b>Figure 4.5</b>	: Frequency- and phase-corrected MR spectra obtained in liver .....	76
<b>Figure 4.6</b>	: Phase-corrected spectra from a patient with grade 3 steatosis .....	77
<b>Figure 5.1</b>	: Axial T2-weighted MR image .....	84
<b>Figure 5.2</b>	: Diagram shows the dominant lipid peaks in liver MR spectra .....	85
<b>Figure 5.3</b>	: MR spectra show increasing size of lipid peaks relative to the water peak with increasing steatosis grade .....	86
<b>Figure 6.1</b>	: Longitudinal US images show mild to severe fatty liver disease in three different patients .....	92
<b>Figure 6.2</b>	: Calculation of the hepatic attenuation index for fat quantification at CT .....	97
<b>Figure 6.3</b>	: Dual-energy CT evaluation of liver in a 45-year-old male potential donor for living transplantation ..	98
<b>Figure 6.4</b>	: Images showing Scores of ultrasound elastography .....	100

## LIST OF TABLES

<b>Table 1.1</b>	<b>:</b>	Segmental anatomy of the liver.....	18
<b>Table 2.1</b>	<b>:</b>	causes of non alcoholic fatty liver disease.....	33
<b>Table 2.2a</b>	<b>:</b>	Nash Activity grade.....	43
<b>Table 2.2b</b>	<b>:</b>	Staging of fibrosis for NASH .....	43
<b>Table 2.3a</b>	<b>:</b>	Grading for NAFLD .....	44
<b>Table 2.3b</b>	<b>:</b>	Staging for NAFLD.....	44
<b>Table 4.1</b>	<b>:</b>	Metabolites Detected with Proton MR Spectroscopy .....	70



# Introduction

---



## INTRODUCTION

Fatty liver is a common abnormality among patients undergoing cross-sectional imaging of the abdomen. The image-based diagnosis of fatty liver usually is straightforward, but fat accumulation may be manifested with unusual structural patterns that mimic neoplastic, inflammatory, or vascular conditions. , Fatty liver is a term applied to a wide spectrum of conditions characterized histologically by triglyceride accumulation within the cytoplasm of hepatocytes. The two most common conditions associated with fatty liver are alcoholic liver disease and nonalcoholic fatty liver disease. Alcoholic liver disease is caused by excess alcohol consumption, whereas the nonalcoholic variant is related to insulin resistance and the metabolic syndrome .Other relatively common conditions associated with fat accumulations in the liver include viral hepatitis and the use or overuse of certain drugs. Rarer associated conditions include dietary and nutritional abnormalities and congenital disorders. **(Wanless IR, Shiota K at 2004)**

These conditions all cause a triglyceride accumulation (steatosis) within hepatocytes by altering the hepatocellular lipid metabolism, in particular, by causing defects in free fatty acid metabolic pathways Hepatocytes in the center of the lobule (near the central vein) are particularly vulnerable to metabolic stress and tend to accumulate lipid earlier than those in the periphery Consequently, in many of these conditions, steatosis tends to be most pronounced histologically in the zone around the central veins and less pronounced in zones around the portal triads. In advanced cases, there is diffuse, relatively homogeneous involvement of the entire lobule. There. **(Venkataraman S, Braga L, Semelka RC at 2002)**

Fatty liver may be diagnosed by US if liver echogenicity exceeds that of renal cortex and spleen and there is attenuation of the ultrasound wave, loss of definition of the diaphragm, and poor delineation of the intrahepatic architecture. To avoid false-positive interpretations, fatty liver should not be considered present if only one or two of these criteria are fulfilled. by CT Fatty liver can be diagnosed if the attenuation of the liver is at least 10 HU less than that of the spleen or if the attenuation of the liver is less than 40 HU. In severe cases of fatty liver, intrahepatic vessels may appear hyperattenuated