

MR Diffusion Weighted Imaging in non Infarct Brain Lesions

Essay

*Submitted for Partial Fulfillment of Master Degree
in **Radiodiagnosis***

By

Ibrahim Badawy Rady

M.B., B.Ch.

Ain Shams University

Under Supervision of

Prof. Dr. Amany Emad Rady

Professor of Radiodiagnosis

Faculty of Medicine - Ain Shams University

Dr. Khaled Ahmed Mohamed Ali

Lecturer of Radiodiagnosis

Faculty of Medicine - Ain Shams University

Faculty of Medicine

Ain Shams University

2018

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قالوا

سبحانك لا علم لنا
إلا ما علمتنا إنك أنت
العليم العظيم

صدق الله العظيم

سورة البقرة الآية: ٣٢



Acknowledgment

✍ First and foremost, I submit all my gratitude to **Allah** who gave me the strength to accomplish this work.

✍ I would like to express my sincere appreciations and cordial thanks to **Dr. Amany Emad Rady**, Professor of Radiology, Ain Shams University, for her unlimited help, kind guidance, and continuous support.

✍ I would also like to express my sincere thanks and deepest gratitude to **Dr. Khaled Mohamed Ahmed Ali**, Assistant Professor of Radiology, Ain Shams University, to whom I am very grateful and deeply indebted for his kind supervision, continuous guidance, fruitful criticism and encouragement.

✍ Finally I could not miss to thank all members of **Radiology Department, Ain Shams University Hospitals.**

✍ Also I am thankful to **My family** for their support throughout my life and this work.

✍ **Ibrahim Badawy**



Contents

Subjects	Page
List of Abbreviations.....	I
List of Figures.....	III
Introduction.....	1
Aim of Work.....	3
Review of literature	
- Cross sectional MRI anatomy	4
- The Physics of Diffusion.....	28
- Diffusion-weighted MR imaging of the brain ischemia	38
- Diffusion-weighted MR Imaging in non-infarct lesions of the brain.....	41
Summary.....	103
Conclusion and Recommendations.....	104
References.....	105
Arabic Summary	

List of Abbreviations

ADC	:	Apparent diffusion coefficient
CE	:	Contrast enhanced
CNS	:	Central nervous system
CPA	:	Cerebellopontine angle
CPM	:	Central pontine myelinolysis
CT	:	Computed tomography
DAI	:	Diffuse axonal injury
DWI	:	Diffusion weighted imaging
eADC	:	Exponential ADC
EPM	:	Extra-pontine myelinolysis
FLAIR	:	Fluid attenuation inversion recovery
FOV	:	Field of view
FSE	:	Fast spin echo
GBM	:	Glioblastoma multiform
GD-DTPA	:	Gadolinium diethylenetriaminepentacetate
HIE	:	Hypoxic ischemic encephalopathy
i.e	:	Id est (latin) = that is
JPA	:	Juvenile pilocytic astrocytoma
MRI	:	Magnetic resonance imaging
MS	:	Multiple sclerosis
n	:	number

List of Abbreviations

PCNSL	:	Primary CNS lymphoma
PRES	:	Posterior reversible encephalopathy syndrome
TB	:	tuberculosis
TE	:	Time for echo
TR	:	Time of repetition
WE	:	Wernicke's encephalopathy

List of Figures

Figure	Title	Page
Fig.(1)	Axial T2WI of the brain	6
Fig.(2)	Axial T2WI of the brain near the vertex	7
Fig.(3)	Sagittal T1-weighted image in a paramidline location	8
Fig.(4)	Sagittal T1-weighted far-lateral	9
Fig.(5)	Axial T2-weighted image at the level of the midbrain	9
Fig.(6)	Sagittal T1-weighted midline image	11
Fig.(7)	Coronal T2-weighted image	12
Fig.(8)	Axial T2-weighted image through the basal ganglia	14
Fig.(9)	Coronal T2WI MR showing primary (tentorial) fissure	15
Fig.(10)	Axial T1WI at level of middle cerebellar peduncles	15
Fig.(11)	Coronal T2WI MR showing some of vermian lobules	16
Fig.(12)	Coronal T2WI MR image showing the horizontal fissure	17
Fig.(13)	Axial T1WI showing the inferior cerebellar peduncle	18
Fig.(14)	Axial T2-weighted image through the basal ganglia	19

Figure	Title	Page
Fig.(15)	Sagittal T2-weighted image showing the brainstem	20
Fig.(16)	Axial T2-weighted image through the inferior midbrain	22
Fig.(17)	Axial T2WI image through the inferior pons	23
Fig.(18)	Axial T1WI image through the pons at level of CN5 root	23
Fig.(19)	Axial T2-weighted image through the medulla	24
Fig.(20)	Fat-saturated sagittal T2WI images, depicts normal sella	26
Fig.(21)	Unenhanced sagittal T1WI fat-saturated image through the midline sella turcica	26
Fig.(22)	Enhanced sagittal T1 fat-saturated MR image through the midline	27
Fig.(23)	illustrates the Brownian motion	28
Fig.(24)	Diagram shows the diffusion-driven random trajectory	30
Fig.(25)	Diffusion-weighted spin echo sequence	32
Fig.(26)	Two traditional structural MR images and a diffusion-weighted image	33
Fig.(27)	Diffusion image and ADC maps of a subject with edema	34
Fig.(28)	Patient with acute onset of left sided weakness	40

Figure	Title	Page
Fig.(29)	Case of cerebral abscess	42
Fig.(30)	Pathologically proved cerebral abscess	43
Fig.(31)	Patient with Right subdural empyema	44
Fig.(32)	Possible Herpes encephalitis	46
Fig.(33)	Herpes encephalitis	47
Fig.(34)	Tuberculous meningitis with vasculitis	49
Fig.(35)	Tuberculous abscess	50
Fig.(36)	Creutzfeld-Jacob disease (sporadic type)	51
Fig.(37)	Creutzfeldt–Jacob disease	52
Fig.(38)	Diffuse axonal injury	55
Fig.(39)	diffuse axonal injury lesions	56
Fig.(40)	Subacute hematoma	57
Fig.(41)	chronic intracerebral hematoma	59
Fig.(42)	Epidermoid cyst	61
Fig.(43)	Left temporal arachnoid cyst	62
Fig.(44)	Postoperative residual epidermoid tumor	62
Fig.(45)	Forty nine-year-old woman with meningioma	64
Fig.(46)	MRI images of a patient with atypical meningioma	64
Fig.(47)	High grade glial tumor and gliomatosis cerebri	66
Fig.(48)	Representative low-ADC lesion in a patient with glioblastoma	68
Fig.(49)	a patient with primary CNS lymphoma	69

Figure	Title	Page
Fig.(50)	A 63-year-old female with diffuse large B-cell lymphoma	70
Fig.(51)	Eleven-year-old boy with cerebellar juvenile pilocytic astrocytoma	71
Fig.(52)	A 5-year-old boy with medulloblastoma	72
Fig.(53)	Sixteen-year-old boy with ependymoma	73
Fig.(54)	ADC maps in cerebellar JPA and medulloblastoma	74
Fig.(55)	A 41-year-old man with a poorly differentiated adenocarcinoma from the lung	77
Fig.(56)	A 67-year-old man with a well differentiated adenocarcinoma	78
Fig.(57)	Patient with biopsy proven glioblastoma multiforme	80
Fig.(58)	Ring enhancing lesion in right frontal lobe	80
Fig.(59)	Appearance of hypoxic-ischemic encephalopathy on axial DWI	82
Fig.(60)	Neonatal HIE in a 6- day- old boy	84
Fig.(61)	A 43-year-old woman with arterial hypertension	87
Fig.(62)	Hypertensive encephalopathy	88
Fig.(63)	5-fluouracil (5-FU) toxicity in a 62-year-old man	90
Fig.(64)	Acute Wernicke's Encephalopathy	92
Fig.(65)	Wernicke's encephalopathy	93

Figure	Title	Page
Fig.(66)	Maple syrup urine disease	95
Fig.(67)	Adrenoleukodystrophy	95
Fig.(68)	Multiple sclerosis type IA lesion female	98
Fig.(69)	Type IVB lesions in a patient with MS	99
Fig.(70)	Extra-pontine myelinolysis	101
Fig.(71)	Osmotic demyelination	102

Introduction

Diffusion weighted imaging (DWI) is a relatively new method in which the images are formed by the contrast produced by the random microscopic motion of water molecules in different tissues. Although DWI has been tried for different organ systems, it has been found its primary use in the central nervous system ⁽¹⁾.

Diffusion-weighted (DW) magnetic resonance (MR) imaging provides potentially unique information on the viability of brain tissue. It provides image contrast that is dependent on the molecular motion of water, which may be substantially altered by disease. The method was introduced into clinical practice in the middle 1990s, but because of its demanding MR engineering requirements—primarily high-performance magnetic field gradients—it has only recently undergone widespread dissemination ⁽²⁾.

Diffusion-weighted imaging (DWI) has greatly enhanced the ability of MRI to diagnose cerebral infarct early and accurately. This technique exploits the phenomenon of diffusion, which is related to Brownian motion at the molecular level. DWI takes advantage of the fact that intracellular water molecules are much more limited in their movement than extracellular ones, because they quickly bump into the cell membrane that contains

them. The more restricted the movement of water, the brighter it will be on DWI sequences ⁽³⁾.

DWI consists of a DW image, also called the diffusion trace, and an apparent diffusion coefficient (ADC) map. DW image is a T2-weighted echoplanar background image attenuated by the rate of apparent diffusion. DW image, together with qualitative and quantitative assessment of the ADC map has been widely used in the diagnosis of acute cerebral infarction, owing to the reliable distinction of cytotoxic and vasogenic edema⁽²⁾.

Diffusion-weighted MR imaging not only has the advantage of enabling differentiation of acute stroke from chronic stroke ⁽⁴⁾. DWI has recently been described and suggested in the differential diagnosis of various non-infarct lesions of the brain which are hyperintense in the diffusion trace image, such as infectious, neoplastic and demyelinating diseases, encephalopathies (including hypoxic- ischemic, hypertensive, eclamptic, toxic, metabolic and mitochondrial encephalopathies) leukodystrophies, vasculitis and vasculopathies, hemorrhage and trauma. The pathophysiologic changes for such hyperintense DWI include high viscosity, high cellularity, vacuolization and compartmentalization of water ⁽²⁾.

Aim of the work

To study the role of Diffusion weighted MR imaging in the evaluation of non-infarct lesions of the brain.

Cross Sectional Magnetic Resonance Anatomy of the Brain

Computed tomography (CT) and magnetic resonance imaging (MRI) have revolutionized the study of the brain by allowing doctors and researchers to look at the brain noninvasively. These diagnostic imaging techniques have allowed for the first time the noninvasive evaluation of brain structure, allowing doctors to infer causes of abnormal function due to different diseases ⁽⁵⁾.

The exquisite detail provided by brain magnetic resonance imaging scans can make interpretation simultaneously straightforward and complicated, particularly to the novice. For this reason, it is essential to become familiar with normal structures before describing the pathologic condition ⁽⁶⁾.

The overwhelming advantage of MR imaging is its ability to provide images with increased signal to noise ratios. Tissue characteristics with respect to different imaging sequences provide valuable clues when interpreting an MR image of the brain. Therefore, it is important to understand the accentuated tissue features on each scan ⁽⁷⁾.