

**THE DIAGNOSTIC ROLE OF
MULTIPARAMETRIC MRI IN PATIENTS
WITH SONOMAMMOGRAPHIC BI-RADS
3 AND BI-RADS 4 BREAST LESIONS**

Thesis

*Submitted for partial fulfillment of MD Degree in
Diagnostic Radiology*

By

Salma Hassan Sayed Tantawy

M.B.B.Ch., M.Sc.

Supervised by

Prof. Dr. Lobna Abdel Monem Habib

Professor of Diagnostic Radiology

Faculty of Medicine-Ain Shams University

Dr. Merihane Ahmed Nasr

Lecturer of Diagnostic Radiology

Faculty of Medicine-Ain Shams University

*Faculty of Medicine
Ain Shams University*

2019

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قالوا

لَسْبَدَانِكَ لَا عِلْمَ لَنَا
إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ
الْعَلِيمُ الْعَظِيمُ

صدق الله العظيم

سورة البقرة الآية: ٣٢

Acknowledgment

*First and foremost, I feel always indebted to **ALLAH**, the Most Kind and Most Merciful.*

*I'd like to express my respectful thanks and profound gratitude to **Prof. Dr. Annie Mohamed Nasr ElDin**, Professor of Diagnostic Radiology - Faculty of Medicine- Ain Shams University for her keen guidance, kind supervision, valuable advice and continuous encouragement, which made possible the completion of this work.*

*I am also delighted to express my deepest gratitude and thanks to **Dr. Lobna Abdel Monem Habib**, Professor of Diagnostic Radiology, Faculty of Medicine, Ain Shams University, for her kind care, continuous supervision, valuable instructions, constant help and great assistance throughout this work.*

*I am deeply thankful to **Dr. Merihane Ahmed Nasr**, Assistant Professor of Pediatrics, Faculty of Medicine, Ain Shams University, for her great help, active participation and guidance.*

I would like to express my hearty thanks to all my family for their support till this work was completed.

Last but not least my sincere thanks and appreciation to all patients participated in this study.

Salma Hassan Sayed Tantaawy

Special Thanks

To . . .

Prof. Dr. Nivine Chalabi, for her great help,
continuous encouragement & enormous support
throughout the entire work.

List of Contents

Title	Page No.
List of Tables	i
List of Figures.....	iii
List of Abbreviations	ix
Introduction	1
Aim of the Work	5
▪ Anatomy of the Breast.....	6
▪ Pathology of Common Breast Lesions.....	31
▪ Technique and Physical Principles of MRI in Breast Lesions.....	58
▪ Role of MRI in the Evaluation of BIRADS III and BIRADS IV Breast Lesions.....	77
Patients and Methods.....	130
Results	141
Illustrative Cases	172
Discussion.....	204
Summary	216
References	219
Arabic Summary	

List of Tables

Table No.	Title	Page No.
Table (1):	Risk factors for breast cancer	38
Table (2):	WHO classification of breast cancer	46
Table (3):	BI-RADS MRI lexicon characteristics	92
Table (4):	ACR BI-RADS-MRI lexicon classification form	96
Table (5):	BIRADS assessment categories	102
Table (6):	Fischer score for evaluation of breast masses in MRI	106
Table (7):	Pathognomonic descriptor combinations used to differentiate DCIS from FC	122
Table (8):	Typical breast MR imaging findings in some frequent breast diseases	126
Table (9):		140
Table (10):	P-values <0.05 were considered statistically significant.....	140
Table (11):	Age of the study population.....	141
Table (12):	Clinical presentation	142
Table (13):	Result of sonomammographic examination	143
Table (14):	Result of MRI examination	145
Table (15):	Result of histopathological examination	148
Table (16):	Diagnostic accuracy of T2WI signal characteristics	149
Table (17):	Diagnostic accuracy of DWI	150
Table (18):	ADC values	151
Table (19):	Comparison of ADC value in benign or malignant lesions.....	151

List of Tables (cont...)

Table No.	Title	Page No.
Table (20):	Diagnostic accuracy of an ADC value of $\leq 1.3 \times 10^{-3} \text{ mm}^2/\text{s}$ for discrimination between malignant or benign lesions	153
Table (21):	Shows the minimum, maximum, mean and standard deviation of the signal intensity increase in benign and malignant mass and non mass lesions	155
Table (22):	Diagnostic accuracy of kinetic curve type	156
Table (23):	Diagnostic accuracy of the MRI characteristics of the margin of mass lesions	157
Table (24):	Diagnostic accuracy of MRI pattern of enhancement of mass lesions	158
Table (25):	Diagnostic accuracy of sonomammographic BIRADS	159
Table (26):	Diagnostic accuracy of MRI BIRADS	160
Table (27):	Receiver-operating characteristic (ROC) curve analysis for discrimination between malignant or benign lesions using various combinations of MRI and sonomammographic parameters	162
Table (28):	Agreement between MRI BIRADS and sonomammographic BIRADS for discrimination between malignant or benign lesions	170

List of Figures

Fig. No.	Title	Page No.
Figure (1):	Component of the breast.....	7
Figure (2):	Line diagram showing anatomical detail in the mediolateral oblique view, as seen on this standard mammographic projection.....	9
Figure (3):	Arterial supply and venous drainage of breast.....	12
Figure (4):	Lymphatic drainage of the breast	14
Figure (5):	Lymphatic drainage of the breast.....	15
Figure (6):	A. The distribution of tissue density is more clearly defined on MRI in this patient with heterogeneously dense tissue. B. The vascular network around and supplying the breast is clearly seen on maximum intensity projection subtracted images following contrast administration	19
Figure (7):		20
Figure (8):	Nipples on MRI may enhance intensely, mildly or not at all depending on blood supply.....	21
Figure (9):	Lymph node in the posterior medial breast.....	23
Figure (10):	Benign lymph node with vessel radiating to hilum	23
Figure (11):	Normal enhancing breast structures	24
Figure (12):	MRI axial sections of both breasts in a patient for implant evaluation.....	25
Figure (13):	Multiple normal appearing Level I axillary lymph nodes posterior to pectoralis major muscle.....	27
Figure (14):	Ectopic breast tissue in the axillary tail on a lateral image.....	28
Figure (15):	Vessel extending through the chest wall was able to be followed over multiple sequential images	28
Figure (16):	Maximum intensity projection of breast demonstrates course of vessels.....	29
Figure (17):	MLO view of mammography demonstrating dense parenchyma with no abnormalities	30
Figure (18):	Intra-ductal carcinoma.....	42

List of Figures (cont...)

Fig. No.	Title	Page No.
Figure (19):	This mammogram reveals multiple clusters of small, irregular calcifications in a segmental distribution.	44
Figure (20):	Typical breast coil.....	61
Figure (21):	An example of the 3D FLASH sequence.....	67
Figure (22):	An example of 3D fast spoiled gradient recalled echo sequence.....	68
Figure (23):	Fat suppression makes enhancing lesions easier to appreciate	69
Figure (24):	DCIS in the left breast	71
Figure (25):	MIP obtained from 3D T1 weighted sequences shows multiple cysts	75
Figure (26):	53-year-old woman with palpable nodule of right breast. No abnormalities were seen on mammogram.....	76
Figure (27):	Mammogram of probably benign mass.....	79
Figure (28):	Ultrasound of probably benign mass.....	81
Figure (29):	Ultrasound of suspicious mass with infiltrative margin.....	81
Figure (30):	Spot compression magnification mammogram showing a cluster of round calcifications.....	82
Figure (31):	Spot compression magnification mammogram showing suspicious cluster of fine pleomorphic calcifications.....	83
Figure (32):	Mammogram showing focal asymmetry.....	84
Figure (33):	Focus, mass, and non mass-like lesion.....	93
Figure (34):	Shape: Axial post-contrast images demonstrates the shapes of masses in the BI-RADS lexicon, including a round (long arrow) (a, fibroadenoma), oval (short arrow) (b, IDC), lobular (arrow head) (c, malignant phyllodes) and irregular (double arrows) (d, IDC)	94
Figure (35):	Margins: Axial high resolution fat-saturated T1-weighted delayed post-contrast images shows the different margins of masses in the BI-RADS lexicon, including smooth (a, fibroadenoma), irregular	95

List of Figures (cont...)

Fig. No.	Title	Page No.
Figure (36):	Internal enhancement: Axial high resolution fat-saturated T1-weighted delayed post-contrast images	98
Figure (37):	Non-mass-like enhancement distribution.....	99
Figure (38):	Kinetic assessment.....	101
Figure (39):	High grade DCIS.	108
Figure (40):	Radial sclerosing lesion.....	109
Figure (41):	Peripheral (rim) enhancement on MRI is a worrisome sign.	110
Figure (42):	Benign lesions are usually round or oval, with sharply defined margins, on contrast-enhanced MRI.	110
Figure (43):	Changes in signal intensity and ADC value during the menstrual cycle in a 27-year-old woman.....	112
Figure (44):	IDC with central necrosis	114
Figure (45):	DCIS and fibrocystic disease.....	115
Figure (46):	Invasive lobular carcinoma	116
Figure (47):	Mucinous carcinoma	117
Figure (48):	Intraductal papilloma.....	118
Figure (49):	Fibroadenoma with myxomatous change.....	119
Figure (50):	Benign phyllodes tumor.	120
Figure (51):	Bilateral fibrocystic disease in the breasts	121
Figure (52):	Mastitis	123
Figure (53):	Multiple cysts	124
Figure (54):	Hemorrhage.....	125
Figure (55):	Overview of a ruptured implant.....	128
Figure (56):	Intracapsular rupture of a silicone implant	129
Figure (57):	Time intensity curves	135
Figure (58):	Result of sonomammographic examination.....	144
Figure (59):	Result of MRI examination.	147
Figure (60):	A pie chart showing the percentage of patients with benign or malignant lesions by histopathological examination.....	148
Figure (61):	Mean ADC value (columns) in benign or malignant lesions.	152

List of Figures (cont...)

Fig. No.	Title	Page No.
Figure (62):	Sensitivity and specificity of various ADC values.	154
Figure (63):	True positive, true negative, false positive and false negative rates for various ADC values.	154
Figure (64):	Summary of the diagnostic profile of various radiological parameters.....	161
Figure (65):	Receiver-operating characteristic (ROC) curve analysis for discrimination between malignant or benign lesions using predicted probabilities of a combination of T2WI + DWI + ADC value.....	163
Figure (66):	Receiver-operating characteristic (ROC) curve for discrimination between malignant or benign lesions using predicted probabilities of a combination of T2WI + DWI + ADC value + Sonomammography.	164
Figure (67):	Receiver-operating characteristic (ROC) curve for discrimination between malignant or benign mass lesions using predicted probabilities of a combination of Margin + Enhancement + Kinetic Curve Patterns.	165
Figure (68):	Mammography showing a well circumscribed mass in the right lower outer quadrant.	173
Figure (69):	Complementary ultrasound showing RT LOQ oval homogenous iso- to hypoechoic mass with a macrolobulated margin & posterior acoustic enhancement.....	173
Figure (70):	(A) Axial T1WI, (B) Axial T2WI.	173
Figure (71):	MRI axial A) Dynamic THRIVE sequence and B) Subtraction image.....	174
Figure (72):	(A) DWI at b value = 500, (B) ADC map.	174
Figure (73):	(A) Mammography CC view of the left breast, (B) MLO view of the left breast.....	177
Figure (74):	U/S of the left breast.....	177
Figure (75):	(A) T1WI, (B) T2WI, (C) STIR.....	178
Figure (76):	(A) T1WI, (B) T2WI, (C) STIR.	179

List of Figures (cont...)

Fig. No.	Title	Page No.
Figure (77):	(A) DWI, (B) ADC map	178
Figure (78):	Early post contrast fat suppressed T1W images, (C) Time-intensity curve	179
Figure (79):	(A) MLO view, (B) CC view of the left breast showing an area of architectural distortion at its UOQ.	181
Figure (80):	U/S shows a cluster of microcysts.	181
Figure (81):	(A) T1WI, (B) T2WI, (C) STIR. MRI shows an ill defined lesion at the UOQ of the left breast, exhibiting low SI on T1WI, intermediate SI on T2WI and relatively high SI on STIR images, showing multiple related small cystic spaces.	182
Figure (82):	DWI, showing an area of true diffusion restriction, with the ADC value of 1.6×10^{-3} mm ² /sec.	182
Figure (83):	(A) Post contrast fat suppressed T1WI, (B) Post contrast subtracted images, (C) Time-intensity curve.	183
Figure (84):	(A) MLO view, (B) CC view of the left breast,	185
Figure (85):	Ultrasound shows a complex partially cystic/partially solid lesion, with thick internal septa and moderate vascularity at its solid component.	185
Figure (86):	(A) T1WI, (B) T2WI, (C) STIR.	186
Figure (87):	(A) DWI, (B) ADC map	186
Figure (88):	(A), (B) Post contrast fat suppressed T1WI	187
Figure (89):	Ultrasound of the left breast shows a retroareolar dilated duct with inspissated secretions within its lumen, in addition to a nearby complex cystic lesion showing a thick wall, thick internal septations and echogenic content, measuring 4 x 3 cm.	189
Figure (90):	(A) Axial T1WI, (B) Axial T2WI	190
Figure (91):	(A) Delayed post contrast image, (B) Time intensity curve.	190
Figure (92):	(A) DWI “inverted”, (B) ADC map	190

List of Figures (cont...)

Fig. No.	Title	Page No.
Figure (93):	(A) CC view, (B) MLO view	192
Figure (94):	Complementary ultrasound shows a homogenously hypoechoic well defined lesion in the left UIQ.	192
Figure (95):	(A) Axial T1WI, (B) Axial STIR.	192
Figure (96):	(A) Dynamic THRIVE sequence. (B) Subtraction image, (C) Time/signal intensity analysis of ROI	193
Figure (97):	(A) DWI at b value = 500, (B) Post processing ADC map	193
Figure (98):	(A) MLO view, (B) CC view of the left breast	195
Figure (99):	(A) T1WI, (B) T2WI, (C) STIR images.	195
Figure (100):	(A) Axial post contrast fat suppressed T1WI, (B) Sagittal post contrast fat suppressed T1WI of the left breast, (C) Time-intensity curve	196
Figure (101):	(A) DWI, (B) ADC map..	196
Figure (102):	(A) T1WI, (B) T2WI, (C) STIR..	199
Figure (103):	(A) Post contrast fat suppressed T1WI, (B) Post contrast MIP of the left breast, (C) Time-intensity curve..	200
Figure (104):	(A) DWI, (B) ADC map	200
Figure (105):	(A) Mammography CC view of both breasts. (B) Ultrasound of the left breast	202
Figure (106):	(A) Axial T1WI, (B) Axial T2WI,	202
Figure (107):	(A) Delayed post contrast T1WI, (B) Time intensity curve of the left operative bed lesion,	203
Figure (108):	(A) DWI, (B) Post processing ADC map of the left breast suspicious lesion,	203

List of Abbreviations

Abb.	Full term
<i>2D</i>	<i>Two dimensional</i>
<i>3D</i>	<i>Three dimensional</i>
<i>ACR</i>	<i>American Colleague of radiology</i>
<i>ADC</i>	<i>Apparent Diffusion Coefficient</i>
<i>AHRQ</i>	<i>Agency for Health Care Research and Quality in the United States</i>
<i>ALH</i>	<i>Atypical lobular hyperplasia</i>
<i>AUC</i>	<i>Area under curve</i>
<i>BAK</i>	<i>bias-adjusted kappa</i>
<i>BI-RADS</i>	<i>Breast Imaging Reporting and Data System</i>
<i>BRCA</i>	<i>Breast cancer gene</i>
<i>CC</i>	<i>Craniocaudal</i>
<i>CI</i>	<i>Confidence interval</i>
<i>CSL</i>	<i>Complex sclerosing lesion</i>
<i>DCIS</i>	<i>Ductal Carcinoma in Situ</i>
<i>DDE</i>	<i>Dichlorodiphenyl dichloroethylene</i>
<i>DDT</i>	<i>Dichlorodiphenyl trichloroethane</i>
<i>DES</i>	<i>Diethylstilbestrol</i>
<i>DNA</i>	<i>Deoxyribonucleic acid</i>
<i>DWI</i>	<i>Diffusion weighted imaging</i>
<i>DWI</i>	<i>Diffusion-weighted MR imaging</i>
<i>eGFR</i>	<i>Estimated glomerular filtration rate</i>
<i>FLASH</i>	<i>Fast low angle shot</i>
<i>FN</i>	<i>False negative</i>
<i>FNR</i>	<i>False Negative Rate</i>
<i>FOV</i>	<i>Field of view</i>
<i>FP</i>	<i>False positive</i>
<i>FPR</i>	<i>False Positive Rate</i>
<i>FSPGR</i>	<i>Fast spoiled gradient recalled echo</i>

List of Abbreviations (cont...)

Abb.	Full term
<i>Gd</i>	<i>Gadolinium</i>
<i>Gd-DTPA</i>	<i>Gadolinium-diethylenetriamine pentaacetic acid</i>
<i>GRE</i>	<i>Gradient –echo sequences</i>
<i>HRT</i>	<i>Hormone replacement therapy</i>
<i>IDC</i>	<i>Invasive Ductal carcinoma</i>
<i>IDC-NST</i>	<i>Invasive Ductal carcinoma-No Special Type</i>
<i>ILC</i>	<i>Invasive lobular carcinoma</i>
<i>L/AP</i>	<i>Longitudinal/ antero posterior</i>
<i>LCIS</i>	<i>Lobular carcinoma in situ</i>
<i>LR-</i>	<i>Negative Likelihood Ratio</i>
<i>LR+</i>	<i>Positive Likelihood Ratio</i>
<i>MBC</i>	<i>Metaplastic breast cancer</i>
<i>MIP</i>	<i>Maximum intensity projection</i>
<i>MLO</i>	<i>Mediolateral oblique</i>
<i>MPR</i>	<i>Multiplanar reformatted images</i>
<i>MRI</i>	<i>Magnetic Resonance Imaging</i>
<i>NEX</i>	<i>Number of excitations</i>
<i>NOS</i>	<i>Not otherwise specified</i>
<i>NPV</i>	<i>Negative Predictive Value</i>
<i>OR</i>	<i>Odds ratio</i>
<i>PABAK</i>	<i>Prevalence-adjusted and bias-adjusted kappa</i>
<i>PPV</i>	<i>Positive Predictive Value</i>
<i>ROI</i>	<i>Region of interest</i>
<i>RR</i>	<i>Relative risk</i>
<i>SD</i>	<i>Standard deviation</i>
<i>SI</i>	<i>Signal intensity</i>
<i>SLN</i>	<i>Sentinel lymph node</i>
<i>SPAIR</i>	<i>SPectral Attenuated Inversion Recovery</i>