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Dynamic Contrast Enhanced Breast MRI: Could it Add to the Diagnosis of Various Breast Lesions?

ENGY Sh. ELKAYAL, M.D.*; MOHAMAD A. MAHMOUD, M.D.*; SAHAR M. MANSOUR, M.D.** and MONA F. ABD-ELHADY, M.D.*

The Department of Radiodiagnosis, Faculty of Medicine, Fayoum and Cairo** Universities*

Abstract

Background: The most common female cancer in Egypt is breast cancer as the age-specific incidence rates show a progressive increase after the age of 30 years, to reach a sharp peak at the age group of 60-64 years. Many early breast carcinomas are asymptomatic. In an effort to overcome the limitations of mammography and ultrasonography, Magnetic Resonance Imaging (MRI) has been explored as a modality for detecting breast cancer in women at high risk and in younger women. Dynamic Contrast-Enhanced MRI (DCE-MRI) has high accuracy for the detection of breast cancer, allowing detection of malignancy that is occult on physical examination, mammography, and sonography.

Aim of Study: Was to assess the ability of contrast enhanced MRI in differentiation between benign and malignant breast lesions.

Patients and Methods: Fifty female patients were included their age ranged from 18-70 years.

Results: Accuracy of DCE-MRI in differentiation between benign and malignant lesions were 90% with sensitivity of 100% & specificity of 70.6%.

Conclusion: We concluded that DCE-MRI can be used as diagnostic tool in detection of breast cancer.

Key Words: *DCE-MRI – MRI.*

Introduction

NOWADAYS cancer breast is the most common cancer and most important leading cause of death in women all over the world **[1]**.

Mammography & ultrasound has been the first method used for the diagnosis of breast cancer as it found recently that mammography could miss 20% of the tumors that can be detected easily by DCE MRI **[2]**.

Magnetic Resonance Imaging (MRI) considered the best modality for detecting breast cancer in young women **[3]**. Accuracy of breast MRI din detection of breast cancer depends on reader experience and use of adequate technique **[4]**.

The American Cancer Society suggested that women with a high risk of breast cancer should receive MRI **[5]**.

DCE MRI can detect smaller size of cancers when it compared with mammography due to the 3D nature of the examination and the dynamic information analyzed based on the Time-Intensity Curve (TIC) of the signal that corresponds to each voxel **[6]**.

Patients and Methods

A descriptive cross-section study conducted upon attendants referred from the Oncology and General Surgery Departments. The study was conducted in Radiology & Imaging Department, Fayoum University Hospital between June 2017 to May 2019. The aim of the study was to assess the ability of contrast enhanced MRI in differentiation between benign and malignant breast lesions.

A total of fifty female patients had DCE-MRI of breast. Their age ranged between 18-70 years with mean age 44 years.

Ethics Committee approval and informed consent were obtained. It included all female patients complaining of breast lesions. It excluded pregnancy, marked kyphosis or kyphoscoliosis, marked

Correspondence to: Dr. Engy Sh. Elkayal, The Department of Radiodiagnosis, Faculty of Medicine, Fayoum University

Abbreviations:

DCE-MRI: Dynamic Contrast Enhanced Magnetic Resonance Imaging.
MRI : Magnetic Resonance Imaging.

obesity cognitive disorder (e.g., mental retardation, dementia). Cardiac pacemakers, older aneurysm clips, new stents or aortic valves, ferromagnetic ocular fragments that could interfere with high-strength magnetic fields.

All patients were subjected to relevant history taking and local examination and MRI imaging.

MRI was performed using the following device: TITAN, TOSHIBA 1.5 Tesla. using the following protocol: Breast MRI examination were performed with patients lying in the prone position, using dedicated double breast coil. Pre-contrast study: Sagittal T1-weighted spin echo sequence for localization purposes. Axial T1-weighted fast spin echo (TR=125msec, TE=5.3msec). Axial T2-weighted fast spin echo sequences (TR=3740msec, TE=90 msec). T2 Short TI Inversion Recovery pulse sequence (STIR) (TR=3510msec, TE=72msec and TI=170msec).

Post contrast dynamic study: A bolus of gadopentetate dimeglumine was injected (0.1mmol/Kg) manually in less than 15 seconds. Imaging was then repeated using THRIVE (T 1 High Resolution Isotropic Volume Excitation with fat suppression) with parameters (TR=3msec, TE=2msec). Multiple post contrast scans were obtained at equally spaced time intervals, typically 1 to 1.5 minutes apart. Typically, 5-7 post-contrast scans are recorded.

Image post processing: Analysis of the pattern of enhancement with proper selection of the Region of Interest (ROI) which corresponds to the part of the lesion showing the strongest and fastest enhancement. The signal intensity in ROI is then plotted over time. Color-coded parametric maps were used to detect maximum areas of contrast uptake in order to determine regions where an area of interest should be applied.

DCE-MRI curves are usually categorized as persistently enhancing (type I), plateau (type II), and washout (type III) according to the TIC shape. This categorization helps to characterize breast lesions as benign or malignant.

Final diagnosis: The reference standard was histologic analysis of biopsy samples. The definitions of the statistical terms provided in the ACR BIRADS glossary were adopted in this study. All cases were given BIRADS scores according to the individual assessment of MRI criteria.

The collected data were organized, tabulated and statistically analyzed using SPSS software (statistical package for social science) version 18. For quantitative data, the mean, Standard Deviation (SD), and range were calculated. Independent *t*-test was used as a test of significance.

Qualitative data were presented as number and percentages, chi square (χ^2) was used as a test of significance.

Cohen's kappa (κ) was performed to determine agreement between MRI & pathology to detect malignant cases among studied patient. Sensitivity, specificity, positive predictive value, negative predictive value & total accuracy measures of MRI in differentiating malignant from benign were presented as % with (95% CI) and calculated using OpenEpi: Open Source Epidemiologic Statistics for Public Health, Version 3.01.

For interpretation of results of tests of significance, significance was adopted at $p \leq 0.05$.

Results

The present study included 50 patients with 17 benign lesions; their mean age was 38.2±11.4 and 33 malignant lesions; their mean age was 46.9± 10.9Fig. (1).

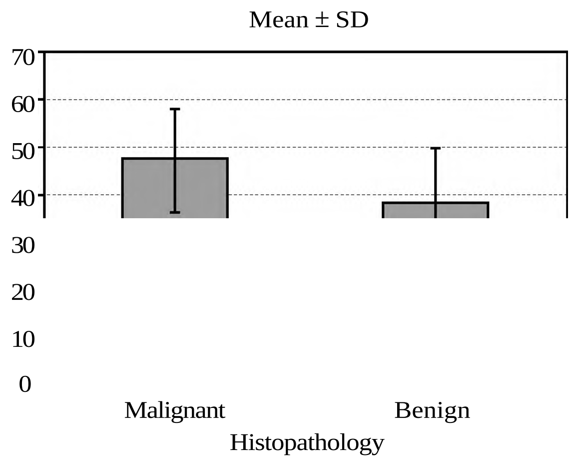


Fig. (1): Age characteristics according to pathology.

Histopathological analysis was done revealing 17 benign lesions and 33 malignant lesions. The different benign pathologies encountered in our study Fig. (2) include ten cases of fibroadenoma, four cases of mastitis, one case for each of infected cyst, Phyllodes tumor and giant juvenile fibroadenoma with infarction. The different malignant pathologies encountered in our study include thirty cases of Invasive Ductal Carcinoma (IDC), two cases of Invasive Lobular Carcinoma (ILC) and one case of mammary carcinoma of the terminal duct.

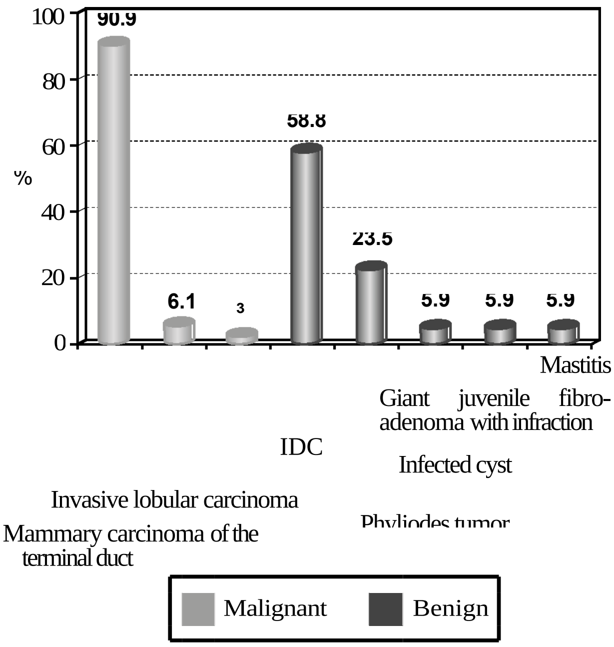


Fig. (2): The different pathologies encountered in our study in descending manner.

MR BI-RADS classification of breast lesions:

The detected 50 breast lesions were classified according to MRI BI-RADS scoring system based on morphologic and kinetic features (Table 1). BIRADS 2 & 3 are benign lesions and BIRADS 4 & 5 are malignant.

Table (1): MRI BIRADS category of the studied breast lesions.

Final assessment category	N. of patients with benign lesions	N. of patients with Malignant lesions	Total
BIRADS 2	3		3 (6%)
BIRADS 3	9		9 (18%)
BIRADS 4		13	13 (26%)
BIRADS 5		25	25 (50%)
Total N. of patients	12	38	50 (100%)

Table (2): MR BIRADS lexicon of breast lesions and their histopathology.

Varible	Malignant (N=33) N (%)	Benign (N=17) N (%)	*p*-value#
BIRADS class:			
Class 2	0 (0.0)	3 (17.6)	<0.0001*
Class 3	0 (0.0)	9 (52.9)	
Class 4	9 (27.3)	4 (23.5)	
Class 5	24 (72.7)	1 (5.9)	

Histopathological analysis was done for the detected breast lesions with correlation with the final BIRADS category (Table 2). All twelve lesions that were diagnosed as benign, proved to be benign. Thirty-eight lesions were diagnosed as malignant, thirty-three lesions were confirmed to be malignant whereas five lesions were benign (4 from BIRADS4 and one from BIRADS 5).

Relation between MRI interpretation and pathology:

Breast lesions categorized by MRI as 44 mass lesions and 6 non-mass enhancement. For mass lesions, 30 lesions were malignant including 29 cases of IDC and one case of ILC with 14 benign lesions including 10 cases of fibroadenoma, one case for each of phyllodes tumor, giant fibroadenoma with infarction, infected cyst and mastitis.

For non-mass enhancement, 3 lesions were malignant including one case for each of IDC, ILC and mammary carcinoma of the terminal duct with 3 benign lesions having mastitis Fig. (3).

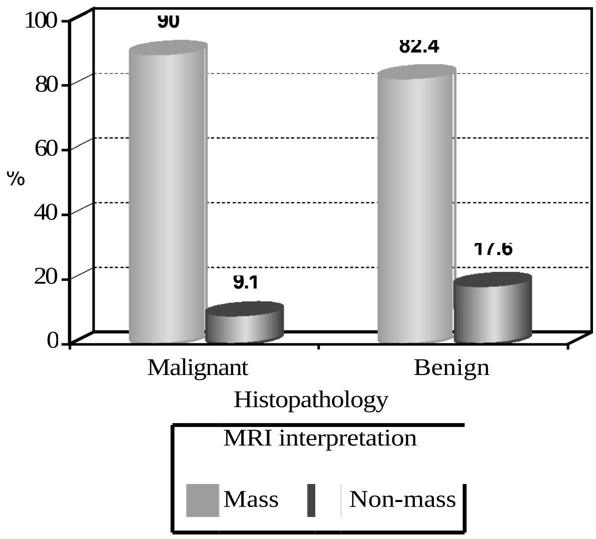


Fig. (3): Relation between MRI interpretation and pathology.

The morphologic criteria of mass lesions including their shape, margin and pattern of enhancement were assessed. For lesions of non-mass enhancement, their morphologic criteria including their distribution and pattern of internal enhancement were assessed.

The dynamic behavior of each detected lesion with quantitative analysis of its signal intensity as well as time to peak and assessment of the shape of the time/signal intensity curve were studied.

Agreement between MRI and pathology:

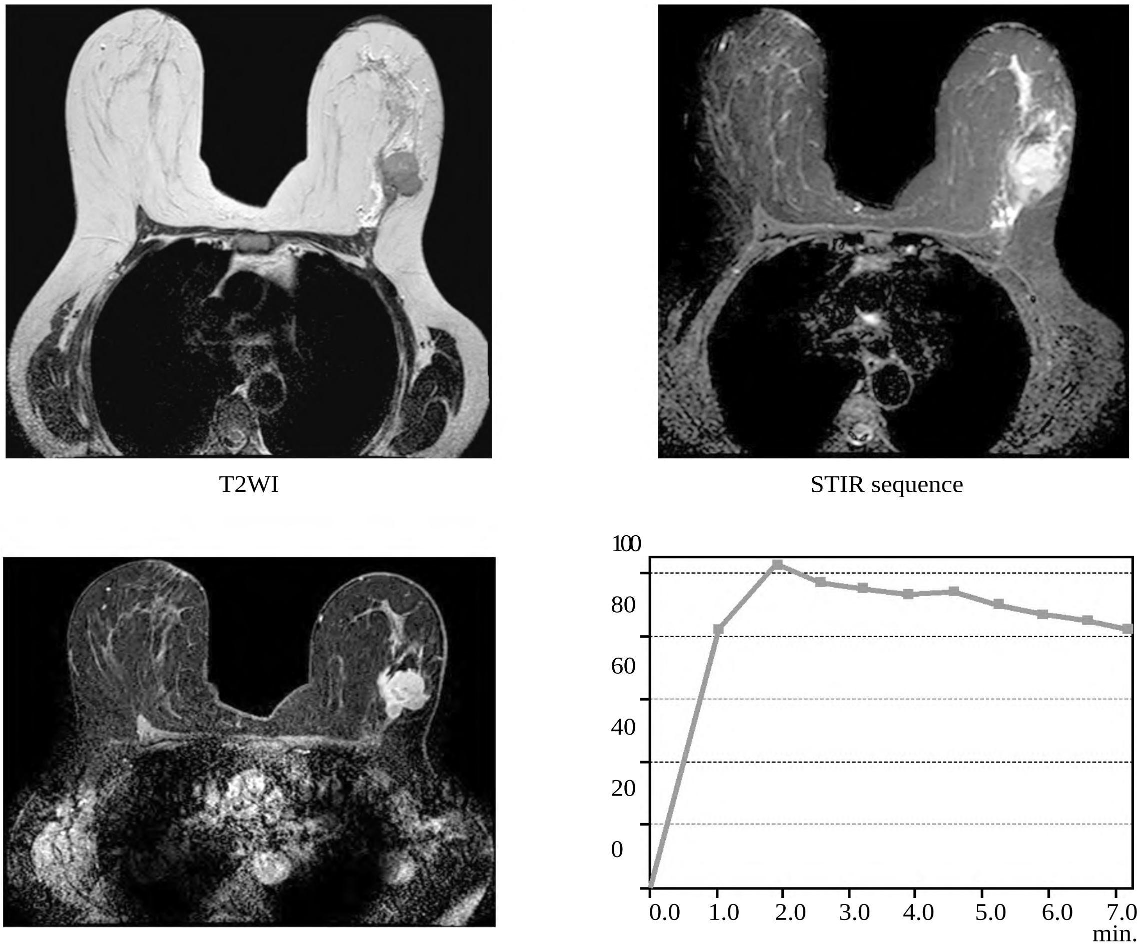
The pathological correlation of the DCE-MRI findings yielded 33 true positive cases, 5 false positive cases, 12 true negative cases and no false negative cases.

Accuracy of MRI:

Sensitivity 100.0%, Specificity 70.6%, PPV 86.8%, NPV 100.0% and total accuracy 90.0%.

Case 1: A 54 years old female complaining of Lt. palpable breast lump. MRI examination revealed Lt. breast oval shape mass lesion with irregular margins with low signal in T 1 and intermediate signal in T2 with high signal in STIR sequence. Post contrast subtraction image showing heterogenous mass enhancement and Kinetic curve analysis showing washout curve pattern with signal intensity percentage=103% with peak of contrast early at 3 minutes (BIRADS V). By histopathology Invasive Duct Carcinoma, grade 3 Fig. (4).

Case 2: A 35 years old female complaining of Rt. palpable breast lump. MRI examination revealed Rt. lower outer quadrant breast rounded shape mass lesion with regular margins with low signal in T1 and high signal in T2 with high signal in STIR sequence. Post contrast subtraction image showing homogenous mass enhancement and Kinetic curve analysis showing rising curve pattern with signal intensity percentage=59% with peak of contrast early at 6.2 minutes (BIRADS III). By histopathology fibroadenoma Fig. (5).



T2WI — STIR sequence

"THRIVE" sequence, post contrast injection — Dynamic curve

Fig. (4): Case of invasive ductal carcinoma (BIRADS V).

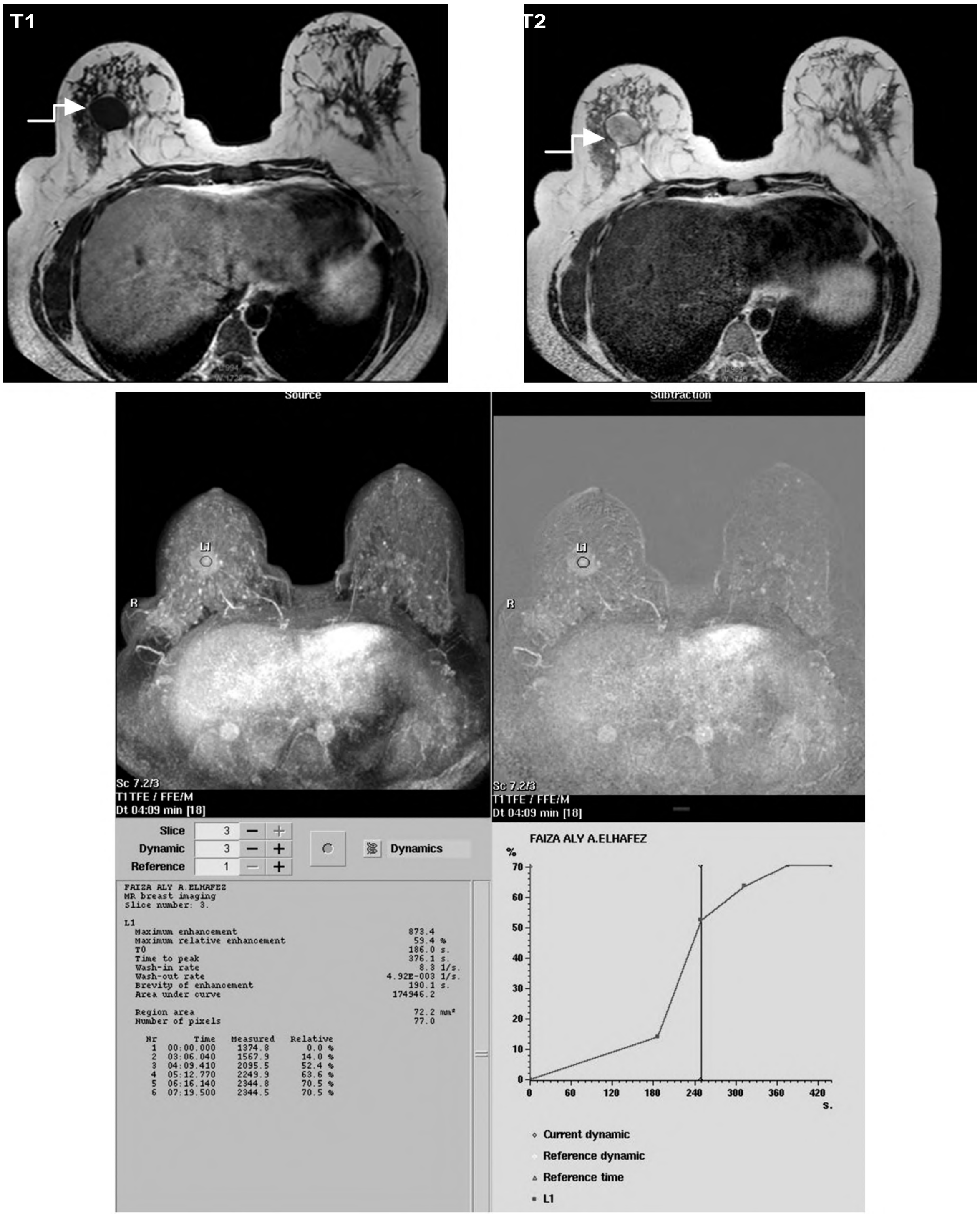


Fig. (5): Case of fibroadenoma.

Discussion

Breast MRI is currently the most accurate technique for breast cancer diagnosis [7].

According to MRI BIRADS lexicon, morphological evaluation of breast lesions is done by assess its shape, margins and pattern of enhancement. Kinetic evaluation is done by detecting the initial and post-initial enhancement of the breast lesion [8].

We conducted a study of 50 patients with 50 breast lesions to evaluate the role of DCE-MRI in characterization of malignant from benign masses. The sensitivity, specificity, positive and negative predictive values of MRI for diagnosis of malignant breast lesions were found to be 100%, 70.6%, 86.8%, and 100% respectively. Overall accuracy of MRI breast was 90%.

This is comparable with Shafqatet; et al., 2011 who reported sensitivity, specificity, positive and negative predictive values of MRI for breast lesions to be 94%, 85%, 90%, and 82% respectively with overall accuracy of 90% **[9]**.

In the present study, the specificity of MRI examination was 70.6%, this was attributed to the relatively small number of the benign lesions, representing 17 (34%) out of the 50 examined lesions. Five of them were interpreted as false positive findings, two cases of fibroadenomas and one case of Phyllodes tumor showed dynamic behavior of contrast uptake similar to that of the carcinoma. Two cases of extensive mastitis exhibited both morphologic and dynamic Kinetics characteristics of carcinoma. One of them proved to be granulomatous mastitis.

Irregular shapes were found in 17 of our included lesions, 16 proved to be malignant (n=16/30, 53.3%) and one lesion was benign (n=1/14, 7.1%). Round shapes were noted in 13 mass lesions, 10 proved to be; 8 malignant (n=10/30, 33.3%) and 3 proved to be benign (n=3/14, 21.4%). Oval shapes were found in 14 mass lesions, 10 proved to be benign (n=10/14, 71.4%) and 4 proved to be malignant (n=4/30, 13.3%).

These results matched with Tozaki; et al., 2006 who showed that most benign lesions had ovoid shape while malignant lesions had irregular shape **[10]**.

In the present study, we found speculated margins in 21 mass lesions, all proved to be malignant (n=20/30, 66.7%) except one lesion was benign (n=1/14, 7.1%). Irregular margins were found in 9 mass lesions, all proved to be malignant (n= 9/30, 30.0%). There were 14 mass lesions with circumscribed margins, 13 of them were benign (n=13/14, 92.9%) and one lesion was malignant (n=1/30, 3.3%).

We agree with El Bakry; et al., 2015 that irregular or speculated margins are common at malignant lesions, while smooth margin is frequent in benign lesions **[11]**.

We agree with Kuhl, 2006 that non-enhancing dark internal septa were only found in fibroadenomas **[12]** while Tozaki; et al., 2006 detected that malignant lesions had heterogeneous internal enhancement **[10]**.

In the present work three benign lesions showed heterogeneous enhancement, their pathological diagnoses were mastitis, benign Phyllodes tumor and giant juvenile fibroadenoma with infarction. Rim enhancement was found in 6 malignant lesions and one benign lesion that proved to be infected cyst. Homogenous enhancement was found in 16 mass lesions, 10 were benign and 6 were malignant. No statistical correlation between type of lesion and their pattern of enhancement except for descriptor of the “non-enhancing internal septa”.

We encountered six lesions that presented with non-mass enhancement pattern: I) Three lesions showed diffuse asymmetrical enhancement, 2 out of them were interpreted as BIRADS 3 and proved to be benign (mastitis) and the remaining one was interpreted as BIRADS 4 and also proved to be benign (granulomatous mastitis). II) Two lesions were interpreted as regional enhancement with suspicious MRI findings and proved pathologically to be malignant. III) The remaining lesion was interpreted as focal enhancement with suspicious MRI findings and also proved pathologically to be malignant.

We performed a quantitative analysis of the signal intensity of the included breast lesions as well as assessment of the time of peak of the injected contrast and the shape of the time/signal intensity curve.

We found out that 20 out of the 33 malignant lesions showed early peak of contrast enhancement (<180sec), while the remaining 13 lesions showed delayed peak (>180sec). In the benign category; 15 lesions showed delayed peak, while 2 lesions showed early peak.

Hoshanot; et al., 2010 reported that the enhancement of the malignant lesions was more likely to peak at the first or the second post contrast series, while the enhancement of the benign lesions was more likely to peak at the 5th or final post contrast time point **[13]**.

We calculated the *p*-value of each type of time signal intensity curve and we found that progressive rising (type I) curve was found in 8 pathologically proven benign lesions (n=8/14, 57.1%) and 2 pathologically proven malignant lesions (n=2/30, 6.7%). Plateau (type II) curve was found in 13 malignant lesions (n=13/30, 43.3%) compared to 3 benign lesions (n=3/14, 21.4%). Early washout (type III) curve was found in 15 pathologically proven malignant lesions (n=15/30, 50%) and 3 pathologically proven benign lesions (n=3/14, 21.4%). *p*-value was significant (<0.05) in characterization benign from malignant masses as progressive curve is detected in benign lesions, while plateau and wash out curves is detected in malignant lesions.

These results were matching with a study done by Ali; et al., 2015 in which type I persistent curve was seen in 89.5% of the benign lesions and 13.9% of the malignant lesions, type II plateau curve was seen in 7.9% of the benign lesions and 25% of the malignant lesions, and type III washout curve was seen in 2.6% of the benign lesions and 61.1% of the malignant lesions **[14]**.

For non-mass enhancing lesions, type I curve was found in 2 (66.7%) pathologically proven malignant lesions and type II curve was present in 3 (100%) benign lesions and 1 (33.3%) malignantlesions.

This agreed with Imamura; et al., 2010 who reported that the pattern of the kinetic curve pattern was unreliable for differentiating benign and malignant non-mass lesions as pattern of enhancement is difficult to interpret in non-mass lesion **[15]**.

Conclusion:

DCE-MRI has high accuracy in characterization of breast lesions.

The way to achieve best results both the morphologic descriptors and kinetics parameters should be considered while diagnosing breast lesions on MR imaging.

References

1- YANG Y., ZHANG Y., WU Q., et al.: Clinical implications of high NQO 1 expression in breast cancers. J. Exp. Clin. Cancer Res., 33: 14, 2014.

2- N. SHUTE: Beyond Mammograms: Research to improve breast cancer screening focuses on sound, light, breath and tissue elasticity. Scientific American, 304: 32-4, 2011.

3- LEHMAN C.D., GATSONIS C., KUHL C.K., et al.: MRI evaluation of the contralateral breast in women with recently diagnosed breast cancer. N. Engl. J. Med., 356: 1295-303, 2007.

4- MANN R.M., KUHL C.K., KINKEL K. and BOETES C.: Breast MRI: Guidelines from the European Society of Breast Imaging. Eur. Radiol., Jul., 18 (7): 1; 6307-1318, 2008.

5- SASLOW D., BOETES C., BURKE W., et al.: American Cancer Society guidelines for breast screening with MRI as an adjunct to mammography. CA Cancer J. Clin., 57 (2): 75-89, 2007.

6- JIANDONG YIN, JIAWEN YANG and ZEJUN JIANG: Discrimination between malignant and benign mass-like lesions from breast dynamic contrast enhanced MRI: Semi-automatic vs. manual analysis of the signal time-intensity curves. J. Cancer, 9 (5): 834-40. doi: 10.7150/ jca. 23283, 2018.

7- WEINREB J., WILCOX P.A., HAYDEN J., et al.: ACR MRI accreditation: Yesterday, today, and tomorrow. J. Am. Coll. Radiol., 2 (6): 494-503, 2005.

8- EL-KHOURY M., LALONDE L., DAVID J., et al.: Breast imaging reporting and data system (BI-RADS) lexicon for breast MRI: Interobserver variability in the description and assignment of BI-RADS category European Journal of Radiology, 84: 71-6, 2015.

9- SHAFQAT G., MASROR I., REHAN M., et al.: Dynamic contrast enhanced MRI breast for lesion detection and characterization with histopathological co relation: Preliminary experience at tertiary care hospital. JPMA, 61: 252, 2011.

10- MACURA K.J., OUWERKERK R., JACOBS M.A. and BLUEMKE D.A.: Patterns of enhancement on breast MR images: Interpretation and imaging pitfalls. RadioGraphics, 26: 1719-34, 2006.

11- EL BAKRY M.A., AMINA A.S., EL-TOKHY N.A., YOSSIF T.F. and CARMEN A.A.: Role of diffusion weighted imaging and dynamic contrast enhanced magnetic resonance imaging in breast tumors. The Egyptian Journal of Radiology and Nuclear Medicine September, Volume 46, Issue 3, Pages 791-804, 2015.

12- KUHL C.K.: Concepts for differential diagnosis in breast MR imaging. Magn. Reson. Imaging. Clin. N. Am., 14: 305-28, 2006.

13- BHOOSHANET N., MARYELLEN L.G., SANAZ A.J., et al.: Cancerous Breast Lesions on Dynamic Contrast-enhanced MR Images: Computerized Characterization for Image-based Prognostic Markers. Radiology, March, Volume 254, Issue 3, 2010.

14- ALI M., AHMED A., ABD ELGABER N., et al.: Role of diffusion weighted imaging and dynamic contrast enhanced magnetic resonance imaging in breast tumors. The Egyptian Journal of Radiology and Nuclear Medicine, 46, 791-804, 2015.

15- IMAMURA T., ISOMOTO I., SUEYOSHI E., et al.: Diagnostic performance of ADC for non-mass like breast lesions on MR imaging. MR in medical sciences, 217-25, 2010.

التصوير بالرنين المغناطيسى للثدى المعزز بالتباين الديناميكى: هل يمكن آن يضيف إلى تشخيص آفات الثدى المختلفة؟

يعتبر سرطان الثدى من آكثر آنواع السرطان التى تهدد الحياة فى جميع آنحاء العالم ويعتبر الآكثر شيوعاً فى مصر. كان النهج العام لتقييم سرطان الثدى هو تقييم ثلاثى: الفحص السريرى والماموجرام والموجات الصوتية آو كليهما وفحص نسيج الجسد.

ومع ذلك لا يمكن إكتشاف جميع آنواع السرطان بواسطة الماموجرام وعلى الرغم آن الموجات الصوتية توفر معلومات عن طبيعة الكتل الصلبة وتوفير معلومات عن إنتشار الورم للغدد التحت إبطية.

وفى محاولة لتحسين معدلات تشخيص سرطان الثدى تم إكتشاف الرنين المغناطيسى بالصبغة كطريقة للكشف المبكر عن سرطان الثدى.

وكان الهدف من الدراسة هو تقييم دور الرنين المغناطيسى للثدى المعزز بالتباين الديناميكى فى تشخيص آفات الثدى المختلفة.

شملت هذه الدراسة على ٥٠ مريضاً تراوحت آعمارهم بين ١٨–٧٠ سنة آشتمل الفحص على متواليات تقليدية وسلسلة ديناميكية. تم تسجيل الخصائص الشكلية والمعلومات الديناميكية مع تصنيف النتائج وفقاً لنظام تصوير الثدى الشعاعى (BI-RADS) وقورنت نتائج كل طريقة مع نتائج الفحص النسيجى.

آثبتت النتائج آن الرنين المغناطيسى للثدى المعزز بالتباين الديناميكى آن لديه حساسية ١٠٠٪، خصوصية ٧٠.٦٪ ودقة ٩٠٪ فى تشخيص آفات الثدى المختلفة.

وإتضح من هذه الدراسة آن الفحص بالرنين المغناطيسى للثدى المعزز بالتباين الديناميكى وسيلة ممكلة يمكن آن تستخدم لتآكيد التشخيص ومعرفة مدى إنتشار الإصابة وخاصة عند التخطيط للتدخل الجراحى.