Dynamic Contrast Enhanced-MRI examination for highly suspicious breast lesions detected initially on mammography: MR and mammographic Findings.

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Abstract: The objective of our study was to assess the clinical utility of mammography directed dynamic contrast enhancing-MRI (DCE-MRI) examination to search for highly suspicious breast lesions detected initially on mammography. **Material And Methods**. A prospective review was performed of the records of 50 patients with breast abnormalities initially detected on mammography between September, 2009 and March, 2010. All lesions were detected on mammography study and were subsequently evaluated with DCE-MRI which was performed using mammography images as a guide to lesion location and morphology. Pathological findings were confirmed by subsequent per-cutaneous biopsy. **Results:** Of the 50 mammography-detected lesions, DCE-MRI correlation was made in all patients including 80% (40 cases) malignant lesions and 20% (10 of cases) benign lesions. MRI diagnosis was based on qualitative and quantitative assessment of each lesion. The qualitative assessment of shape, margin, pattern of enhancement, skin thickening and enhancement, as well as, chest wall involvement. The quantitative evaluation of threshold enhancement, early peak, early washout and type of curve. **Conclusion**: Quantitative assessment of the type of contrast enhancement kinetic curveon breast DCE-MRI resulted in significantly higher diagnostic performance for establishing or excluding malignancy compared with assessment based on the standard qualitative method for breast lesion detected initially on digital mammography.
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1. Introduction

Breast cancer detection in women with a genetic susceptibility or strong family history is considered mandatory compared with breast cancer screening in the general population. However, screening modalities depend on the level of risk. ***(1).*** Management options for high-risk women range from close mammographic surveillance to prophylactic mastectomy. ***(2).*** Diagnosis of breast cancer can be achieved by different radiological modalities including mammography (considering that 10-15 % of breast cancer is not detected by mammography) and ultrasonography which is useful in differentiation between solid and cystic masses ***(3).***

Conventional mammography has been the primary screening and diagnostic tool for breast cancer for more than 20 years. The false positive rate at mammography is typically reported in the range of 60-80%***(3)***. In recent years, results of many studies have shown that MRI has strong potential to improve sensitivity and specificity in the diagnosis and evaluation of breast cancer. ***(4)***. Breast MRI has high sensitivity in breast cancer detection, reported to be as high as 94-100% but lower specificity (5).

Breast magnetic resonance (MR) imaging continues to become an important component of the clinical work-up of patients suspected to have breast carcinoma. Dynamic contrast material–enhanced (DCE) MR imaging enables the visual differentiation of lesions from normal tissue owing to the increased vascularity and capillary permeability of breast lesions (**6**). Dynamic MR imaging has emerged as a modality that is possibly complementary to mammography and ultrasonography (US) because of the additional three-dimensional spatial and temporal information about the lesion that it yields (**7**). Dynamic contrast-enhanced MRI (DCE-MRI) has been widely used to improve the specificity of MRI in characterizing breast lesions [**8**].

The most widely used form of DCE-MRI analysis is the assessment of the type of time–signal intensity curve (i.e., kinetic curve) by categorizing the washout pattern of a gadolinium contrast agent. These patterns are classified as type I, persistently enhancing (progressive), which is suggestive of benignity; type II, plateau type, which has an intermediate probability for malignancy; and type III, washout type, which is indicative of malignancy. [**9**]. The American Cancer Society now recommends that

women at high risk of breast cancer undergo yearly breast cancer screening with breast MRI in addition to mammography these recommendations were prompted by several studies of MRI screening of women at high risk of breast cancer***(10).***

2.Material And Methods:

All patients included in this study attended to Radiodignosis department in Al- Hussein hospital, Al-Azhar university in Cairo, the study started at Jun, 2009 & finished at December,2010.

Patients were subjected to the following History and clinical examination of the rest, conventional Mammography, dynamic post contrast MRI study and biopsy and histopathology correlation.

Conventional Mammography: Was obtained with "SIOTTO, CORMANO (MI) ITALY), Craniocaudal, Mediolateral & Mediolateral oblique views were taken on three comparable films each one including single view for both breast.

MRI Examination: Was performed with a1.5-T super-conducting magnet system imager (Magnetom Impact Expert 42SP/AS; Siemens Medical Systems, Erlangen, Germany, 1996).

The patient lie prone, head first on the scanner table, with the median sagittal plane perpendicular to the center of the table.

At first, the protocol consisted of a T2-weighted turbo spin-echo sequence with a 280–320-mm field of view, 31 sections acquired, 3-mm section thickness, no intersection gap, 3800/120, turbo factor of 19, two signals acquired, and 512 _ 512 matrix.

The standard dynamic protocol consisted of pulse sequence (axial and coronal T1-weighted fast low angle shot **(FLASH)** three-dimensional **(3D)** gradient- echo sequence with linear phase encodeordering), virtually identical contrast-determining parameters (270/4.6 and 90° flip angle),29 sections acquired, 3-mm section thickness, no intersection gap, and an identical bilateral field of view (280–320 mm). The standard dynamic protocol has been consisted of seven dynamic image stacks: one acquired prior to the injection of contrast material and the remaining six acquired directly after the injection of gadopentetatedimeglumine (**Magnevist; Schering, Germany**) in a dose of 0.1 mmol per kilogram of body weight and maximum dose of 20 ml for each patient. The bolus was injected into an ante-cubital vein, followed by a flush with 30 mL of saline.

Dynamic acquisition was achieved with a full 256 _ 256 matrix, an in-plane resolution of 1.25 _ 1.25 mm for a 320-mm field of view, and a temporal resolution of 69 seconds.

The respective dynamic series of the standard dynamic protocols were transferred to a workstation, image subtraction was performed by subtracting the pre-contrast images from all post-contrast images.

Enhancing lesions were identified on subtracted images and were further evaluated by using a region-of-interest–based analysis with manually drawn regions of interest. These regions of interest were selectively placed into the area of the lesion where the enhancement was strongest in the first non-subtracted post-contrast image.

Care was taken to avoid non enhancing or slowly enhancing lesion areas. Region of interest diameter was adjusted to the respective lesion diameter, with a mean region of interest diameter of 5 mm (range, 2–10 mm). Lesion signal intensity was plotted versus time to yield the signal intensity time curve.

Mammography imaging analysis:

Mammographic images were evaluated regarding the presence or absence of:

- Architectural distortion.
- Abnormal opacities (Density, site, size, shape, margin).
- Micro-calcification (Number, shape, distribution).
- Secondary signs (Skin thickening, nipple retraction).

Over all breast density was also evaluated.

The overall impression of presence of highly suspicious abnormality on mammographic examination is considered.

MR Imaging analysis:

Quantitative image analysis:

Enhancing lesions were identified on subtracted images and were further evaluated by using a region-of-interest–based analysis with manually drawn regions of interest. These regions of interest were selectively placed into the area of the lesion where the enhancement was strongest in the first non-subtracted post-contrast image.

Care was taken to avoid non enhancing or slowly enhancing lesion areas. Region of interest diameter was adjusted to the respective lesion diameter, with a mean region of interest diameter of 5 mm (range, 2–10 mm). Lesion signal intensity was plottedversustime to yield the time–signal intensity curve.

Lesion enhancement rates (ie, wash-in rates) were calculated according to the formula [(SI_t _ SI)/SI] _ 100, where SI is the signal intensity of the lesion in the pre-contrast image and SI_t is the signal intensity of the lesion in each dynamic phase on post-contrast images.

Quantitative image analysis was based on assessment of quantitative signs including wash-in pattern and threshold level of enhancement, early washout and type of time–signal intensity dynamic curve.

Qualitative image analysis:

In our study five morphological criteria were analyzed. These are lesion shape, margin, and enhancement pattern as well as skin and chest wall involvement.

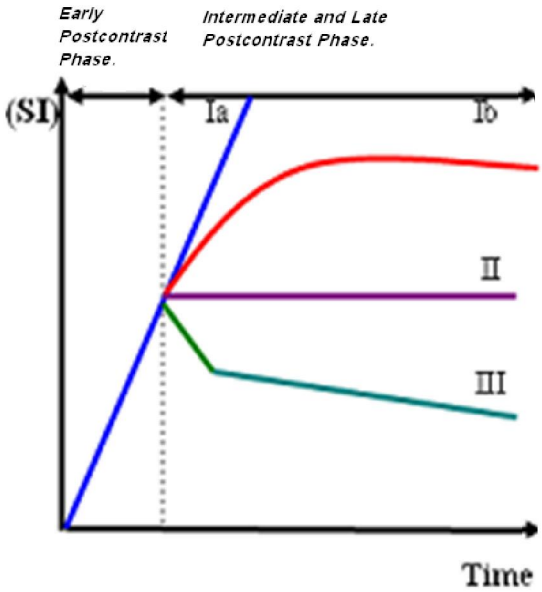


Diagram 1: Schematic drawing of the time-signal intensity (**SI**) curve types. Type I corresponds to a straight (**Ia**) or curved (**Ib**) line; enhancement continues over the entire dynamic study. Type II is a plateau curve with a sharp bend after the initial upstroke. Type III is a washout time course. In breast cancer, plateau or washout-time courses (**type II or III**) prevail. Steadily progressive signal intensity time courses (**type I**) are exhibited by benign enhancing lesions ***(Quoted from Azmy, et al., 2007)***.

3. Results:

Fifty female patients are included in the current study classified into two groups:

First group include 43 patients having breast complaint either breast lump or other breast symptoms.

The second group includes 7 patients with surgically excised breast lump proved by pathology to be malignant.

Age range of our study female patients was 35-75 years, 20% of our cases were (35-45) years old, 40% of cases were (46-55) years old, 25% cases were (56-65) years old and 15% of cases were (66-75) years old.

In 60 % of cases (30), the tumor was located in the right breast while, in 40% of cases (20) the tumor was located at left breast. High percentage of lesions are located at right and left upper outer quadrants and equal about 50% and 65% respectively.

52 % of lesions were 1- 2.5 Cm in its longest dimension. 38 % of lesions were 2.6-5 Cm in its longest dimension, 5% of lesions were less than 1 Cm in its longest dimension and 5% of lesions were more than 5 Cm in its longest dimension.

Mammography result:

Mammography was performed for 50 patients. 35 lesions appear as highly suggestive of malignancy or known biopsy-proven malignancy lesion (BIRAD grades V and VI) on mammogram, 28 of them were truly malignant **(true positive)** while the other 7 lesions (no post operative recurrent lesion) was benign **(false positive)**. Another 15 appear as suspicious abnormality (BIRAD grades III and IV) on mammogram, 3 of them were truly benign **(true negative)** while the other 12 lesions were malignant **(false negative).**

DCE-MRI result:

MRI diagnosis was based on qualitative and quantitative assessment of each lesion. The qualitative assessment of shape, margin, pattern of enhancement, skin thickening and enhancement as well as chest wall involvement. The quantitative evaluation of early peak, early washout, threshold level of enhancement and type of time-signal intensity dynamic curve.

A. Statistical evaluation of each qualitative signs used in the study:

Evaluation of shape of the lesion by DCE-MRI was detected; two breast lesions showed oval shape (it was benign). Eighteen breast lesions showed macro-lobulated shape (8 benign 'scar tissue" and 10 malignant). Thirteen lesions showed speculated shape (all were malignant). Taking into consideration that oval and lobulated shape lesions are almost benign and speculated lesions are almost malignant. Sensitivity, specificity and accuracy of this sign in the assessment of benign and malignant lesions were 75 %, 100% and 80% respectively.

Assessment of margin of the lesion; Two breast lesion showed well defined margin (it was benign). Sixteen breast lesions showed ill-defined margin without surrounding enhancing streaks (eight were benign & the other eight were malignant). Thirty two lesions showed ill-defined with surrounding enhancing streaks (all were malignant). Taking into consideration that well defined margin are almost benign and ill-defined lesions (whether surrounded with enhancing streaks or not) are almost malignant. Sensitivity, specificity and accuracy of this sign in the assessment of benign and malignant lesions were 100%, 20% and 84% respectively.

Pattern of lesions enhancement on DCE-MRI had following result; Two breast lesions showed no enhancement or MRI signal intensity increases by less than 2% after the injection of contrast agent

during the first 90 seconds and also within next 7 minutes (all were benign). Seventeen breast lesions showed homogeneous enhancement (eight benign and nine malignant). Thirty one lesions showed heterogeneous enhancement (all were malignant). Taking into consideration that benign lesions do not enhance or show homogeneous enhancement and malignant lesions show heterogonous pattern of enhancement. Sensitivity, specificity, and accuracy of this sign in the assessment of benign and malignant lesions were 77.5%, 100% and 82% respectively.

Skin thickness and abnormal enhancement on MRI shows next results; seven breast lesions have average skin thickening less than 2 mm (three benign and four malignant). Forty three breast lesions showed abnormal skin thickening with abnormal enhancement (seven were benign and thirty six were malignant). Taking into consideration that almost benign lesions do not show skin thickening and skin thickening occur almost with malignant lesions. Sensitivity, specificity, and accuracy of this sign in the assessment of benign and malignant lesions were 90%, 30%, 86% respectively.

Assessment of chest wall involvement on MRI, twenty breast lesions showed no chest wall involvement (ten benign and ten malignant). Thirty breast lesion showed chest wall involvement (all were malignant). Taking into consideration that almost benign lesions do not show chest wall involvement and chest wall is almost involved with malignant. Sensitivity, specificity, and accuracy of this sign in the assessment of benign and malignant lesions were 75%, 100%, 80 % respectively.

Table (1) summarizes the statistics of MRI qualitative signs used in the study:

Parameters	MRI Qualitative				
	Shape.	**Margin.**	**Pattern of enhancement.**	**Skininvolvemen.**	**Chest wall involvement.**
Sensitivity	75	100	77.5	90	75
Specificity	100	20	100	30	100
Accuracy	80	84	82	86	80

B. Statistical evaluation of each quantitative signs used in the study:

Assessment of early peak pattern of enhancement on dynamic curve study have following result; five breast lesions showed slow wash-in (all were benign). Ten lesions showed moderate wash-in (five benign and five malignant). Thirty-five breast lesions showed fast wash-in (all were malignant). Taking into consideration that presence of slow and moderate wash-in with benign and presence of fast wash-in with malignant. Sensitivity, specificity, and accuracy of this sign in the assessment of benign and malignant lesions were 87.5%, 100% and 90% respectively.

Early wash out enhancement pattern on DCE-MRI shows twenty-five breast lesions showed no early washout with type I and II dynamic curve (ten benign and fifteen malignant). Twenty-five breast lesions showed early washout type III curve (all were malignant). Taking into consideration that absence of early washout goes with benign and presence of early washout goes with malignant. Sensitivity, specificity, and accuracy of this sign in the assessment of benign and malignant lesions were 62.5%, 100% and 70% respectively.

On evaluation of type of enhancing curve, the DCE-MRI was carrying following result two breast lesions showed no enhancement so no curve with intensity increases by less than 2% after the injection of contrast agent during the first 90 seconds and also within next 7 minutes (it was benign). Eight breast lesions showed type I curve (all were benign). Fifteen breast lesions show type II curve (all were malignant). Twenty-five breast lesions show type III curve (all were malignant). Taking into consideration that absence of enhancement and type I curve goes with benign and type II and III curve goes with malignant. Sensitivity, specificity, and accuracy of this sign in the assessment of benign and malignant lesions were 100%, 100% and 100% respectively.

Threshold level of enhancement for breast lesions on DCE-MRI shows; two breast lesions had that no enhancement with threshold level less than 2% (it was benign). Three breast lesions showed threshold of enhancement less than 50% (all were benign). Ten breast lesions showed threshold of enhancement 50-89% (five were benign and five were malignant). Thirty five lesions showed threshold enhancement more than 90 (all were malignant). Taking into consideration that absence of enhancement and threshold enhancement less than 90 goes with benign and threshold of enhancement more than 90 goes with malignant. Sensitivity, specificity, and accuracy of this sign in the assessment of benign and malignant lesions were 87.5%, 100% and 90% respectively.

Table (2) summarizes the statistics of MRI quantitative signs used in the study:

Parameters	MRI Quantitative			
	Wash-in pattern.	Washout.	Type of dynamic Curve.	Threshold level of enhancement.
Sensitivity	87	62.5	100	87
Specificity	100	100	100	100
Accuracy	90	70	100	90

Histopathological result:

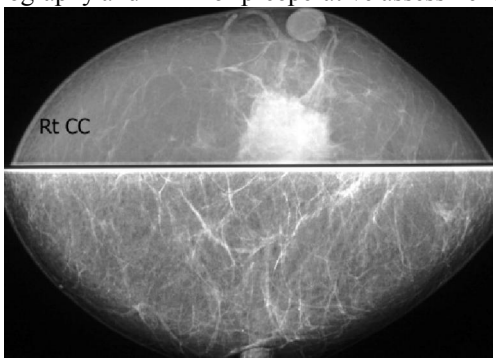
Histopathological analysis showed 50 breast lesions. The malignant lesions were 40 lesions (80%). 30 cases were infiltrative duct carcinoma (60%), 10 cases were invasive lobular carcinoma (20 %).

Ten cases (20%) were benign (two was fibrocystic disease, one case was calcified intra-mammary enlarged lymph node &the other seven cases with history of surgical removal of malignant breast lump showed no recurrence).

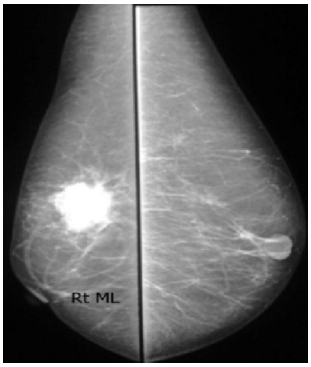
Table (3) Histopathological results:

Breast lesions	Frequency	percentage
Infiltrative duct carcinoma	30	60
Invasive lobular carcinoma	10	20
Benign (including no recurrence)	10	20
Total	**50**	**100**

Fig. 1- A female patient 40 years old presented by right breast lump opposite 12 O'clock who underwent breast mammography and MRI for preoperative assessment:

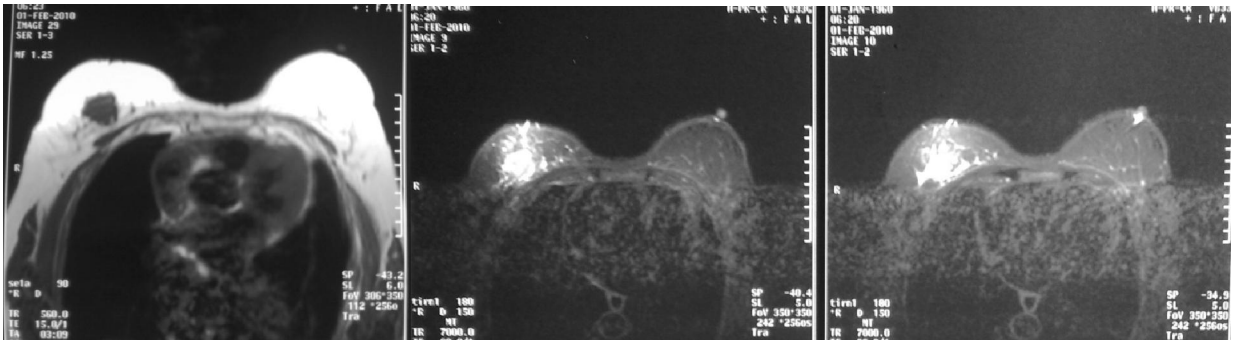


(A)

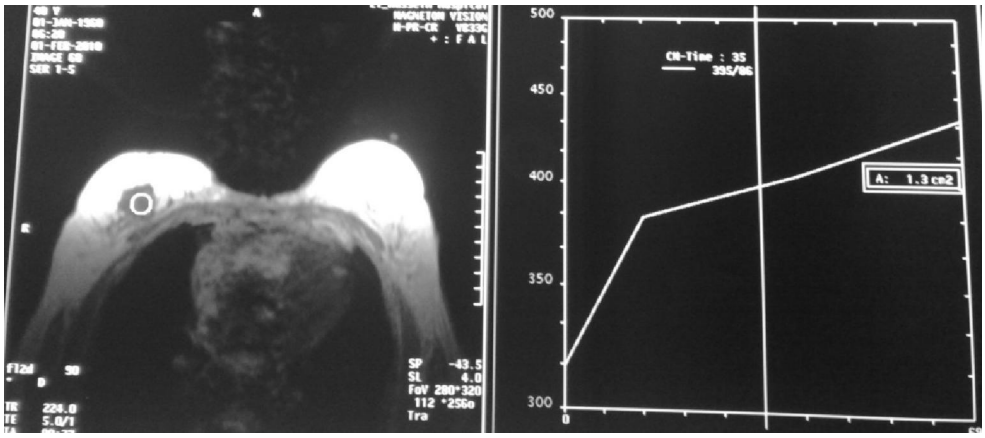


(B)

A and B: Craniocaudal &Mediolateral mammographic views of the breast showing a round shape density with irregular lout-lines at the right retro-areolar and upper outer quadrant with subtle distortion of adjacent parenchyma, no overlying skin thickness.



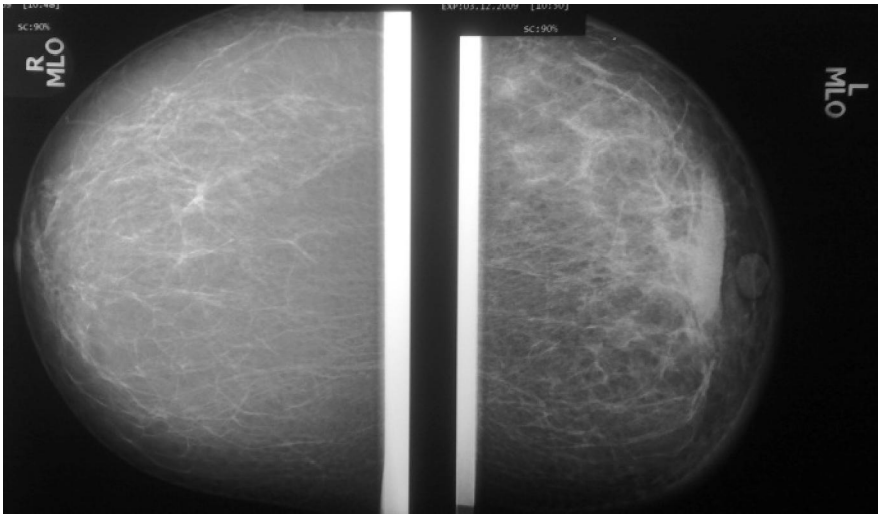
(C)



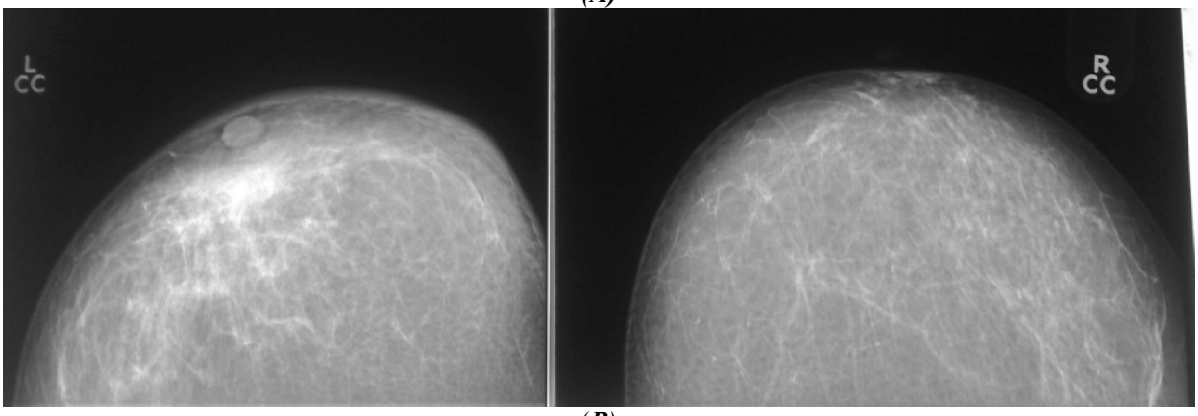
(D)

C: Axial plane pre-contrast T1WIs and fat-suppressed contrast-enhanced 3D fast MR image reveals good delineation of irregular outline mass with anterior chest wall involvement, followed by fast wash-in pattern of enhancement on initial first 1 minute and type II plateau curve on **D**. (**Pathology:** ***Invasive lobular carcinoma).***

Fig. 2— 45 years old female patient presented by left breast pain with positive history of lumpectomy, mammography and DCE-MRI was done :

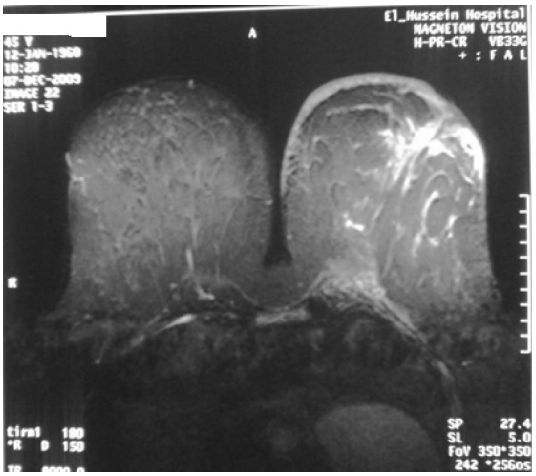


(A)



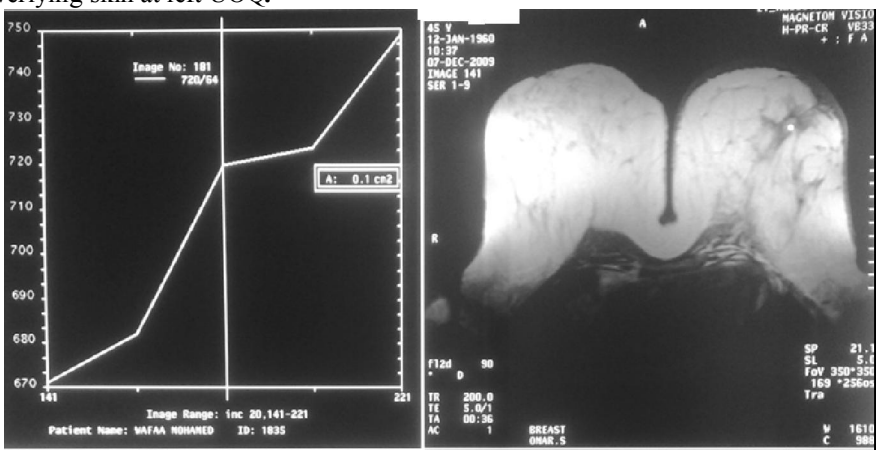
(***B)***

A and B: Craniocaudal &Mediolateral mammography views of shows left retro-areolar and left UOQ partially ill defined focal density with distortion of adjacent parenchyma, and associated retracted thickened overlying skin, no micro-calcification.



(C)

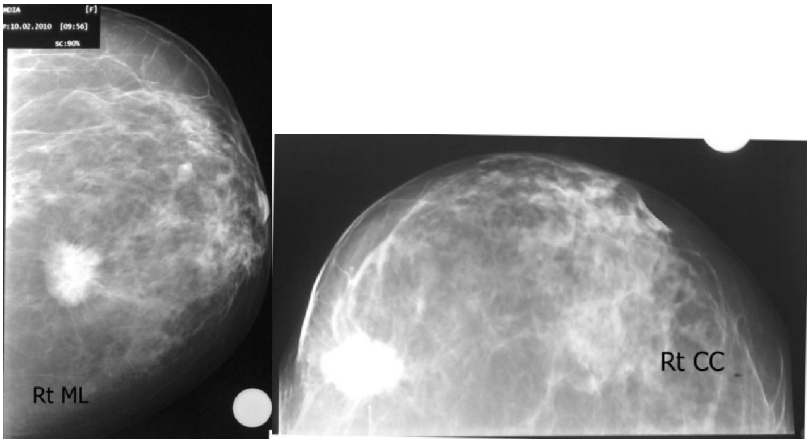
C: Axial plane fat-suppressed contrast-enhanced 3D fast MR image showing ill defined enhancing soft tissue band with thickened overlying skin at left UOQ.



(D)

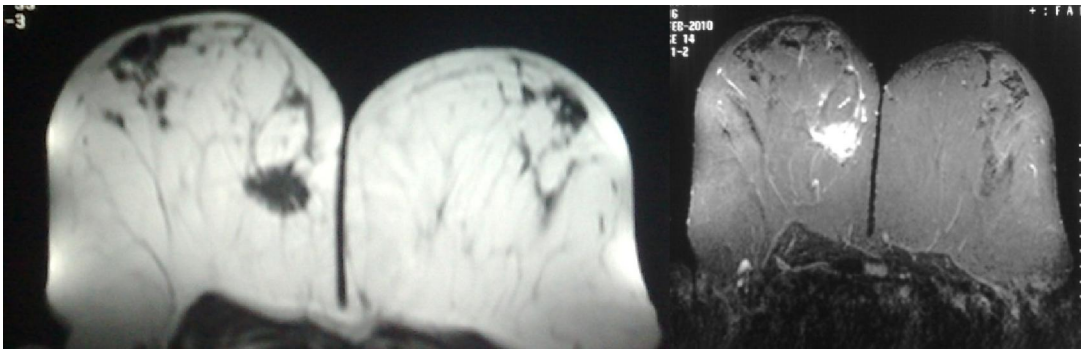
D: Time/relative signal intensity curve showing slow wash-in pattern of enhancement followed by continuous progressive enhancing (persistent) curve. (**Pathology:** ***No recurrence with benign type I curve).***

Fig. 3— 70 years old patient presented with right breast lump, mammography and DCE-MRI for pre-operative assessment:



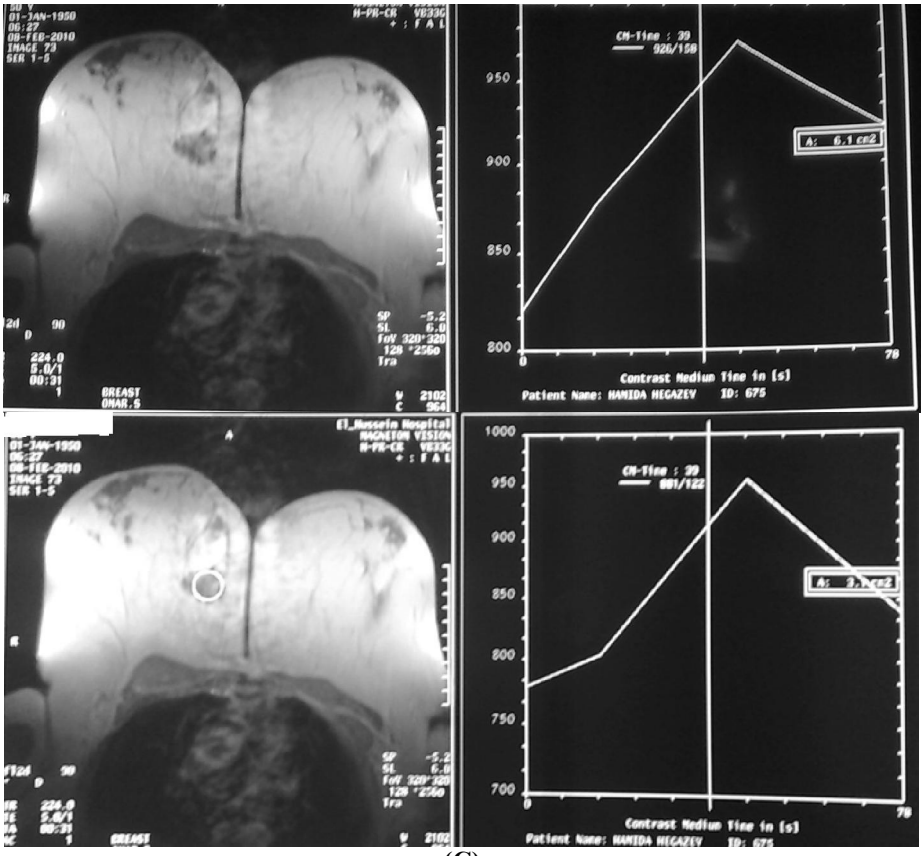
(A)

A: Mediolateral and cranio-caudal mammographic views of right breast showing ill defined focal density with irregular speculated borders and distortion of adjacent parenchyma at right left inner quadrant (LIQ).



(B)

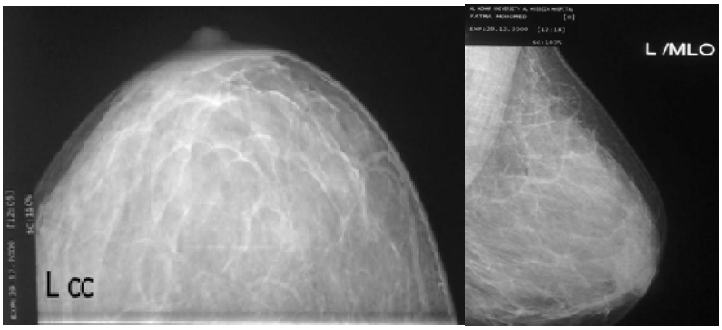
B: Axial plane non enhanced T1WIs and fat-suppressed contrast-enhanced 3D fast MR image showing better delineation of the mass with heterogeneous enhancing pattern noted at right lower inner quadrant.



(C)

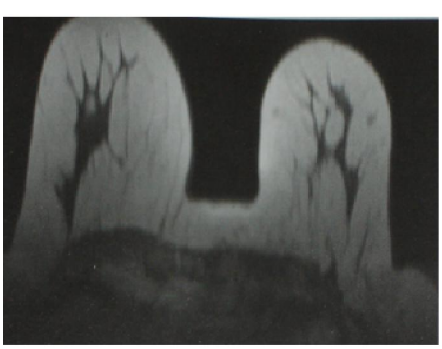
C: Time/relative signal intensity curve showing maximal intensity within first 1 minutes then rapid washout type III curve. (**Pathology:** ***Infiltrating duct carcinoma).***

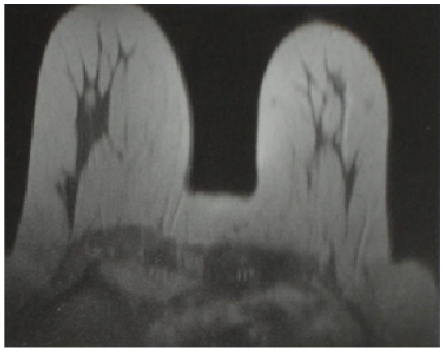
Fig. 4— 37 years old female with positive family history of breast cancer presented by breast lump:
(A)

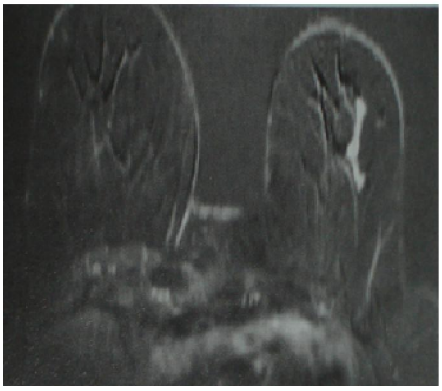


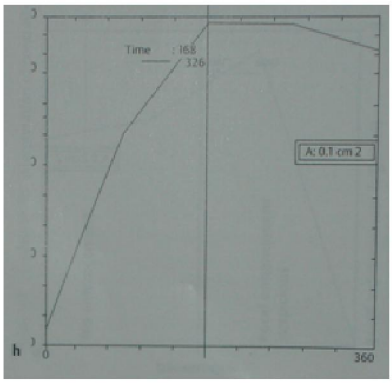
(A) Craniocaudal &Mediolateral mammographic views show no abnormal findings.

(B)





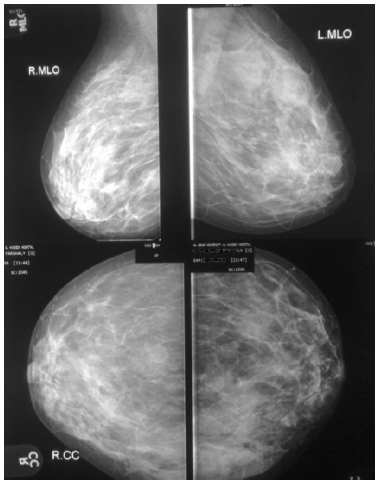




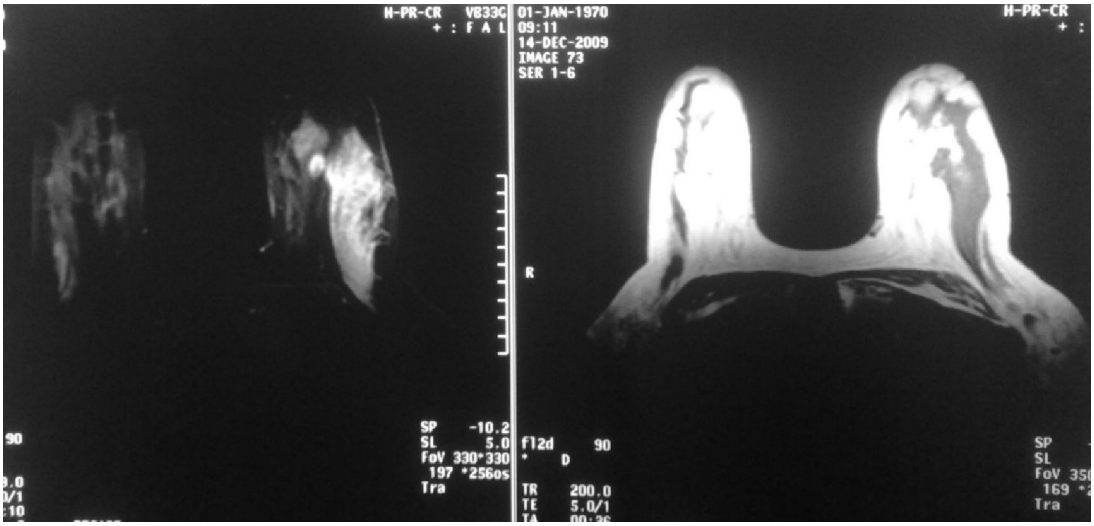
(B) Pre-contrast axial FLASH 3D image showing no significant finding. Same axial plane post contrast FLASH 3D,there is peripheral nodular enhancement on left outer breast quadrant.
Same axial plane fat-suppressed contrast-enhanced 3D fast MR image showing strong tubular ductal enhancement in the upper outer quadrant of the left breast.

Time/relative signal intensity curve showing maximal signal intensity enhancement with moderate wash-in pattern on first 2 minute followed by plateau type II curve. (**Pathology: *Infiltrating duct carcinoma).***

Fig. 5—A female patient 38 years old presented by bilateral breast swelling and pain:
(A) Craniocaudal &Mediolateral mammographic views of both breast showing heterogeneous dense fibro-glandular tissue with variable size oval shaped dense focal lesions with partial obscured margins at the upper outer quadrants.



(B)



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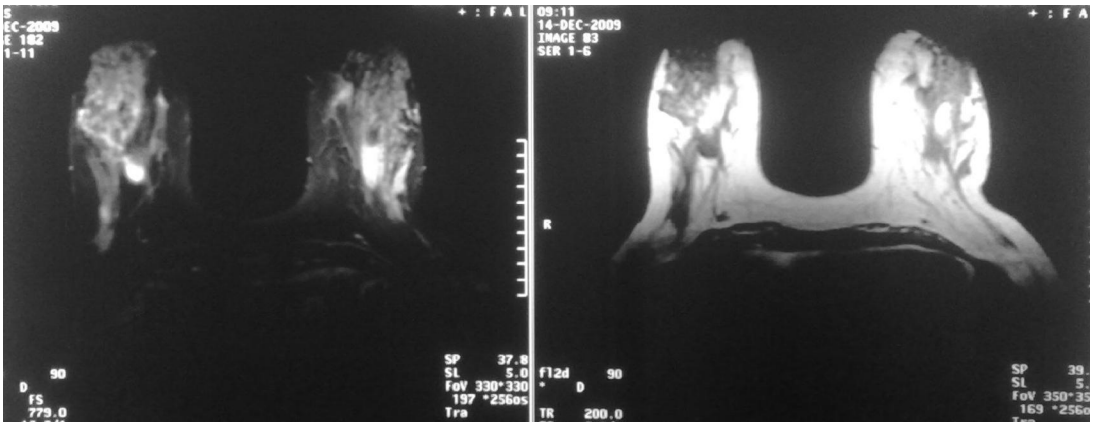
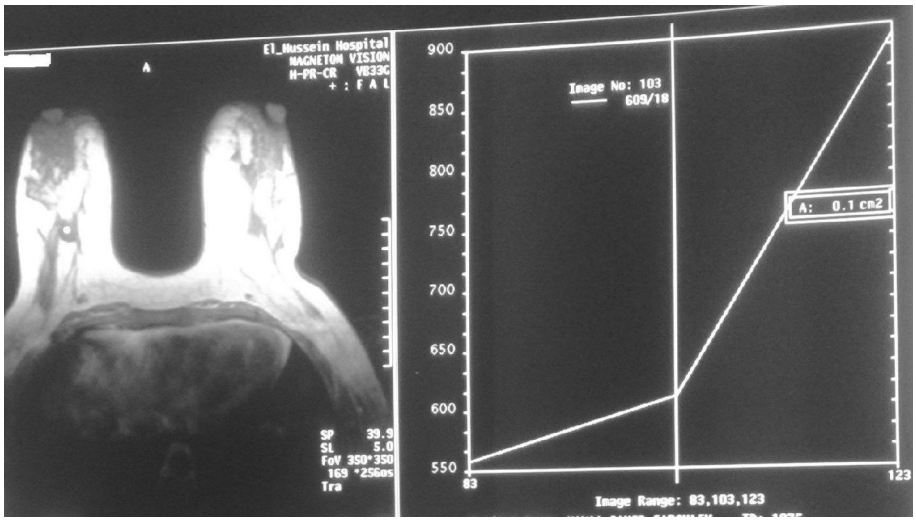


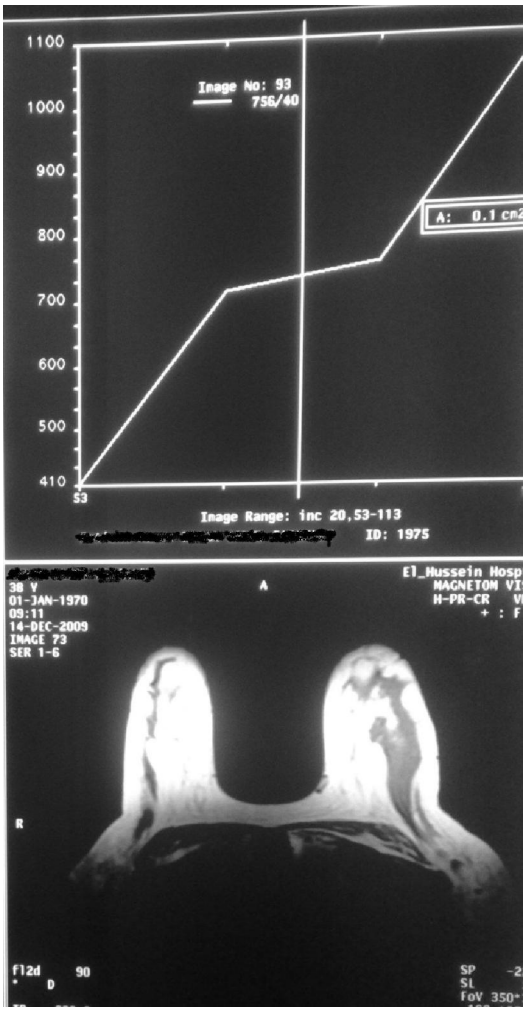
(B)&(C) Pre and post axial FLASH 3D images showing an ill defined heterogeneous enhancing mass lesions at the upper quadrants of both breast.

(D)



(D)&(E) There is slow wash-in pattern of enhancement with persistent type I dynamic curve on bilateral breast lesions. (**Pathology:** ***fibrocystic {fibroadenosis} disease)***

(E)



4. Discussion:

Technologic advances in combining mammography with U/S have produced an even high diagnostic accuracy. While mammography is the most sensitive technique for detecting cancer in the fatty breast tissue, U/S is more useful in woman under 35 years and in woman with dense, fibrous, glandular breasts. U/S also gives information about tissue characteristics that mammography does not provide ***(4).***

Mammography is the primary imaging modality for breast cancer screening and diagnosis ***(12).*** In case of dense breast, mammography may not detect malignancy. This disadvantage of mammography has become more important in the recent years which have witnessed a substantial increase in the incidence of malignancy in young women ***(13).***

One of the major limitations of mammography is the overlap in the appearance of benign and malignant lesions. Some of the abnormal densities on the mammograms are actually caused by superimposition of normal densities, not all patients with suspected densities on mammography would have breast cancer ***(5).***

Both mammography and ultrasonography have well recognized limitations either due to factors in the breast parenchyma such as dense breast in young females, post-operative changes, effect of radiation or factors in the modality itself such as the inability of mammography to demonstrate the deep part of the breast and the operator dependency of ultrasonography ***(14).***

The results of clinical investigations suggest that MR imaging can provide clinically important information that cannot be obtained by conventional imaging methods, and that this will, in the future, be valuable adjunctive breast imaging tool just as breast ultrasound is today ***(5)***.

In addition, MR imaging has emerged as the single most effective imaging tool for the diagnosis of implant rupture, also it can detect invasive and noninvasive breast carcinoma that is both clinically and mammographically occult ***(5).***

Dynamic contrast-enhanced (DCE)-magnetic resonance imaging (MRI) of the breast has emerged as an adjunct imaging tool to conventional X-ray mammography due to its high detection sensitivity. Despite the increasing use of breast DCE-MRI, specificity in distinguishing malignant from benign breast lesions is low, and inter-observer variability in lesion classification is high **(15).**

MR imaging has also been recommended for preoperative staging of breast cancer, especially for determining multifocality in same quadrant (lesions with more than one intra-ductal or invasive focus) and multicentricity (lesions involving more than one quadrant) as it has higher sensitivity than mammography in detection of multifocal and multicenteric tumor lesions ***(16).***

We conducted a prospective study of 50 patients to evaluate the dynamic MR imaging (quantitative and qualitative analysis) role in the final diagnosis using the histopathological results as the gold standard for reference. The results were correlated with those of mammographic results.

In our study we found 28 lesions at the upper outer quadrant (UOQ) (15 at right side and 13 at left side). This coincide with ***Bland et al.(17)***who mentioned that most of breast lesions are located at UOQ because it contains most of the fibro-glandular tissue ***(17).***

In the current study, the mammography examination of both benign and malignant lesions showed an overall sensitivity of 80%. These results were compatible to that of many previous studies in which the sensitivity of mammography ranged from 44% (***18)***, 63**% *(16)*** to 87% ***(19).***

On the other hand, specificity of the mammography examination for both benign and malignant lesions in our results was 70 %. This result matches with previous study in which specificity equal 70% ***(16),*** **and** less than results of other studies 93 % ***(18)*** to 97 % ***(20).***

Comparing the sensitivity and specificity of MR imaging in this study, we found that the sensitivity for detection of malignancy was 98.07%, the specificity for characterization was 96.96% while accuracy was 97.64%, the positive and negative predictive values were 98.07% and 96.96% respectively.

These results matches with many other studies, where MR imaging sensitivity ranged from 89% ***(21)***to 97% ***(22)****;* while specificity ranged from 67% ***(21)*** to 96%***(22),***a rather similar values were supplied by ***(23)***but his study group were evaluated using 1.0 Tesla.

Various values of sensitivity and specificity for MR imaging were given in the literature. Sensitivity ranged from 86% ***(20)***94.4% ***(13)*** to 100% ***(24);*** while specificity ranged from 72% ***(13)***80% ***(25)*** to 100%***(20)***. These wide differences between the results of the different studies can be explained by many factors including the criteria for selection of the patients, the technique of imaging, and the method of interpretation of the obtained images. Sensitivity and specificity of a certain modality in the general population would be different from the corresponding values in specialized centers. Furthermore, the values of sensitivity and specificity vary with the technical criteria of the study and method of evaluation of obtained images. This is particularly true in case of MR imaging in which the results depend on several

technical factors such as the pulse sequences, whether spin echo ***(14),***gradient echo 2D ***(26)*** or 3D ***(27),*** the examined volume (both breasts, one breast, or part of one breast), the slice thickness, the inter slice gap, the method of fat suppression, the dose of the contrast agent, and the timing of imaging in relation to the start of injection of the contrast agent.

Various methods have been used for recognition of enhancement on contrast –enhanced MRI of the breast such as comparison of the pre- and post-contrast images ***(14),*** subtraction technique ***(28),***and fat suppression ***(29).*** In our study we relied on both, the subtraction and the comparison of the non-subtracted pre- and post-contrast images.

Comparison of the pre-and post-contrast images has the disadvantage of missing subtle enhancement particularly if it is closely related to fat. Furthermore, this method necessitates that the pre- and post-contrast images should be taken using the same window width and level as well as the same magnification. For these reasons it is not advisable to relay on comparison of the pre- and post contrast images alone for detection of enhancing lesions. In our study subtracted images were initially evaluated for the purpose of detection, then the non subtracted images were viewed for the purpose of characterization.

As for the image subtraction technique, it gives much better chance for lesion detection, however it has got the disadvantage of being susceptible to motion artifacts. More over our study has demonstrated that detection of some morphological signs which are very specific for malignancy such as the peripheral washout sign is not possible on the subtracted image alone.

Some authors relay only on qualitative evaluation of the obtained contrast enhanced MR images ***(5).***

Others, have advocated quantitative analysis as the primary method of lesion characterization by establishing threshold of enhancement above which the lesion is considered malignant or by measuring the slope of the enhancement curve on dynamic studies ***(30).***

In this work, we used both qualitative and quantitative method for image analysis. Evaluation of the individual sign is necessary to determine the degree of confidence of a diagnosis that is based on any of these signs or any combination of the different signs.

In our study four quantitative signs were analyzed. Early peak with wash-in pattern of enhancement, early washout, type of enhancement curve as well as threshold of enhancement **(Table 2).**

Regarding wash-in pattern of enhancement we found that fast wash-in enhancement was considered indicative of malignancy in the present study with a sensitivity of 87% and a specificity of 100%.

This result showed lower sensitivity and higher specificity than the study carried out by ***Gilles et al. (28)*** who found that fast wash-in pattern of enhancement was an indicative of malignancy with sensitivity of 95% and specificity 53%. This agrees with ***Harms and Flamig et al.(31),***they mentioned that early fast wash-in pattern of enhancement is considered the hall mark of malignant breast neoplasm. Detection of malignancy based on enhancement which occurs within the first two minutes after injection of contrast agent. However ***Fobben et al. (32)***said as many benign lesions such as fibroadenoma and proliferative mastopathy also show enhancement in the first two minutes, it may be difficult to differentiate between malignant and benign lesions on bases of this sign alone.

Considering the early washout and type of enhancement curve we found early washout and type III curve were indicative of malignancy with a sensitivity of 62.5%, 100%, specificity of 100%, 100% and accuracy of 70%, 100% respectively.

These results agree with ***Helal et al. (13),*** they stated that It has been noticed that enhancement of malignant neoplasm has a characteristic shape with an early peak followed by rather sharp decline, while enhancement of benign lesions shows a relatively delayed peak without early washout.

Considering the threshold of enhancement we found that all malignant lesions show threshold above 60%. Rest of benign lesions show threshold less than 60%. These findings agree with non-standerdized different thresholds for malignant tumor diagnosis including enhancement level higher than 60% ***(13).***

Our results indicate that time signal intensity curves obtained from dynamic MR imaging of enhancing breast lesions provide diagnostically useful information. The evaluation of time signal intensity curves seems suitable to assist in lesion differential diagnosis, thus contributing an overall specificity of the dynamic breast MRI.

Evaluation of lesion time curve kinetics has already shown considerable effect on the management of lesion in breast MR imaging. It should be well understood that the analysis of lesion enhancement kinetics should not be used as a standalone diagnostic criterion but that it should be integrated onto the process of lesion differential diagnosis ***(33).***

Quantitative analysis cannot be relied upon alone in the diagnosis for following reasons partial volume effect may interfere with obtaining the correct measurements using the region of interest (ROI) particularly when the lesion is smaller than the slice thickness used. As well as, a large ROI may

result in false measurements if it contained parts of the non-enhancing peri-lesional tissue. This is also true for the ROI which extend to include central non enhancing necrotic tissue within a malignant tumor. The choice of ROI is subjective. ***Gribbestad et al. (26)*** have recommended placing the ROI in the most enhancing part of the lesion. ***(26)***However, this necessitates preliminary measurements of more than one location within the lesion to determine the most enhancing part if it is not visually obvious.

The threshold of enhancement above which malignancy is diagnosed cannot be standardized due to differences in the pulse sequences, magnetic field strength, dose of contrast agents, and the methods of calculation of enhancement.

Though it has been initially hypothesized that the quantitative assessment of the degree of enhancement can predict the grade of malignant tumors. A study has proved that there is no correlation between the degree of enhancement and the tumor grading on histopathological examination ***(34).***

In our study five morphological criteria were analyzed. Lesion shape, margins, enhancement pattern as well as skin and chest wall involvement **(Table 1).**

Irregular shape was indicative of malignancy with sensitivity 75% and specificity 100%. This result show low sensitivity and relative higher specificity than the study carried out by ***Helal et al.(13)***who reported a sensitivity of 83.3% and specificity 72.7% ***(13).***

Ill define margins was indicative of malignancy with sensitivity of 100% and specificity of 20%. ***Heywang et al. (14)*** reported that irregular outlined or star like enhancement is the most frequent sign of malignancy with sensitivity 88% and reported that this sign has a specificity of 40%. ***Orel et al., (5)***have also reported that ill definition of the border in 15 of 16 carcinomas and well definition in 9 of 10 fibroadenomas.

Regarding pattern of enhancement we found that, the absence of enhancement was found to be a statistically significant sign that indicate the absence of malignancy.

Our results showed that heterogeneous enhancement was indicative of malignancy with sensitivity of 77.5% and specificity of 100%. This agrees with ***Kuhl et al.(36) who*** mentioned that in-homogeneity of enhancement is in favor of malignant lesions while homogeneity of enhancement is in favor of benign lesions.

Our results showed that presence of skin thickness has sensitivity of 90% and specificity of 100%. Also in this study, we found that chest wall involvement was noted in association with 30 cases which was malignant. This was compatible with ***Harms et al. (35)*** who stated that although the signs of spread of malignancy to skin, chest wall muscles, lymph nodes, pleura, lungs or bony structures indicate a rather advanced stage of malignant neoplasm and in this case, they represent a strong evidence for the diagnosis of the enhancing breast lesion as malignant.

Quantitative combination of morphological, kinetic, and spatiotemporal features is feasible and provides a higher discriminating power than using the three different classes of features separately**(37).**

MRI was the sole evidence for detection of multifocality and bilateral incidence of carcinoma. In 26 % of women the outcome of MRI was the most important for converting breast conserving surgery to mastectomy **(38).**

Conclusion:

From the results of our study we can conclude the following:

- Dynamic contrast enhanced MR imaging of the breast with gadolinium- based contrast agents gives an important additional information and can be used as a problem solving method whenever conventional modalities are equivocal.
- Dynamic contrast enhanced MR imaging gives better assessment of the morphological criteria than conventional modalities as regarding the shape, size, location, margin as well as involvement of the skin and chest wall.
- The double breast coil is preferred than single coil because it allows reduction of time and contrast agent, help in detection of bilateral lesion and comparison of the MR appearances of both breasts.
- Both quantitative and qualitative criteria are needed for lesion interpretation.
- Subtraction images and 3-D studies are mandatory for lesion detection, while comparing non enhanced and post contrast images is essential for detection of peripheral washout sign.
- MR imaging has higher sensitivity, specificity and accuracy than mammography.
- Absence of enhancement on MR examination totally exclude malignancy.
- The following qualitative MRI signs are considered malignancy signs: speculated shape, ill defined margin with enhancing surrounding streaks, heterogeneous enhancement, skin thickening and chest wall involvement. However skin thickening and margin can not be depended upon in post irradiation, postoperative cases and inflammatory cases. Early fast wash-in

enhancement pattern, early washout and type (III) curve are considered quantitative malignant signs.

- As breast implants are not widely used in Egypt, so MRI researches on breast implants are limited, while it is popular in developed countries.

Based on our results we found that MR imaging is helpful in the following conditions:

1. Detection of suspected malignancy in a breast with dense parenchymal tissue.
2. Characterization of indeterminate lesions by mammography.
3. Detection or exclusion of recurrence after breast conservative surgery.
4. Evaluation of chest wall involvement in malignant cases.
5. Exclusion of bilaterality and multicentricity as well as exact determination of the tumor size if conservative surgery is planned.
6. Detection of malignant breast lesions in patients with free mammographic examination.

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