Original Article

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Role of Dynamic Contrast Enhanced Magnetic Resonance Imaging and Mammogram in Evaluation of Breast Lesions with Pathological Correlation

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Abstract

Background: To perform mammography and dynamic contrast enhanced MRI in patients with clinically suspicious breast lumps and correlating the findings with pathology in patients of positive imaging. **Subjects and Methods**: total of 40 patients evaluated through MRI BI-RADS lexicon (General Electric Medical Systems) at 1.5T in combination with dynamic kinetic analysis of time and signal curves for lesion characterization. **Results**: The mean age was 44 years, maximum of patients (n=22) belongs to age group of 41-60 years (52.5%). Five lesions showed dark internal septations, as benign. 11 lesions (33.5%) showed heterogenous enhancement, as malignant. Early rim enhancement is observed in 3 lesions (9%). Out of which two of them were proven to be malignant and one lesion was an infective abscess. Invasive Duct Cell Carcinoma was the common histology in the malignant lesions, observed in 13 out of 18 (72.2%). Fibroadenoma was the common benign breast lesion, observed in 8 out of 19 (42.1%). In 4 post operative patients, 2 (50%) were post operative fibrosis, 1 (25%) was recurrence and 1 (25%) was post operative collection. In 18 malignant lesions, 11 patients (61.1%) had skin retraction, 10 patients (55.5%) had skin thickening, 9 patients (50%) had axillary lymphadenopathy, 2 patients (11.1%) had nipple retraction, and one patient (5.6%) had pectoralis involvement. In our study, MR imaging alone has Sensitivity of 88.8%, specificity of 86.3%, PPV of 84.2%, and NPV of 90.4% with Accuracy 87.5%. **Conclusion :** The dynamic contrast enhanced MRI is important tool to evaluate the postoperative breast in differentiating between benign postoperative changes. By combining kinetic analysis with morphological analysis it add benefit to categorise the breast lesions into benign and malignant with increased confidence levels. CE-MRI with both morphology and kinetic curve assessment has a Sensitivity of 94.5%, Specificity of 100% with Accuracy of 97.5%.

Keywords: Lymphadenopathy, Breast cancer, mammography, Dynamic contrast enhanced MRI, Positive Predictive Value.

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Introduction

Breast cancer is leading cancer mortality in women. Currently screen film x-ray mammography, real time ultrasound, color Doppler and MRI are being utilised for detection of breast cancer. Although mammography is the best diagnostic method for early detection, problems still exist. Even with high quality screening, about 40%of carcinomas are detected only when they are larger than 1.5 cms, and 20% to 40% of the carcinomas become apparent in the interval between screenings. [1,2]

The limitations of the x ray mammography have led to development of complimentary imaging techniques. The most accepted adjunct modality is breast sonography which is widely used in diagnostic evaluation of women with abnormal screening mammography or clinical exams. [3] However, in the case of small lesions, sonography is not sensitive and specific enough to rule out malignant disease.

Dynamic contrast material enhanced MRI of breast with gadolinium based contrast is well accepted. Breast carcinomas generally show faster and stronger signal intensity increase after a bolus injection of gadolinium.

Dynamic contrast enhanced MRI is a very sensitive method and have capable of detecting even small lesions. Effective results may achieved when contrast enhanced MRI was used as an additional modality in cases with significant risk of breast cancer and where assessment by conventional imaging was equivocal. Early contrast enhanced MR imaging studies showed marked increased signal intensity in cancers compared

to surrounding fibro-glandular tissue, with sensitivities 100% for invasive disease. [4]

Initial reports regarding use of dynamic contrast enhanced MR imaging to measure increased uptake of contrast in suspicious breast lesion revealed specificity of 30-85% and sensitivity of 90-99%. [5] However limited literature exists as regards application of this technique Vis a Vis sonomammography. The current study designed to prove the usefulness of dynamic contrast enhanced MRI as compared to sonomammography in the evaluation of suspicious breast lesions.

Subjects and Methods

Source of data

Patients referred to mammography unit in department of Radiodiagnosis of Osmania General Hospital, Hyderabad for screening or clinically suspicious breast lumps. All the patients are evaluated according to MRI BI-RADS lexicon in combination with dynamic kinetic analysis of time/signal intensity curves for lesion characterization as benign or malignant.

Time period: December 2015 to January 2018

Sample size: 40 patients

Type of study: prospective

Inclusion criteria

1. Patients with clinically suspicious breast lumps.
2. Patients with family history of breast neoplasms.

Exclusion criteria

1. Patients with contraindications to MRI: patients with ferromagnetic implants, claustrophobia etc
2. Patients with pre-existing spine deformities and physically disabled patients.
3. Male patients.

Data acquisition

Informed consent will be taken from all the patients.

All the MRI examinations are performed on echo speed system (General Electric Medical Systems) at 1.5T. Imaging of all patients in prone position in a dedicated double breast coil. Compression device is used.

The following sequences were obtained.

1. A transverse T1W spin-echo sequence was performed for localization purposes.
2. Axial T2W fast spin echo sequences
3. Fat suppressed T2W fast spin-echo sequence
4. A 3D axial fat suppressed T1W fast gradient is recalled echo sequence was obtained before, then 6 sets of images after bolus injection of 0.1mmol/kg of gadodiamide with an acquisition time 60 seconds for each set for 84 images.

Fat suppression and subtraction of pre contrast from the first set of post contrast images was done.

Morphologic analysis done on post processed subtracted images using MRI BI-RADS Lexicon (American College of Radiology) and visual kinetic analysis of time signal intensity was done.

Results

A random study of 40 patients done in our institute to evaluate the diagnostic value of DCE-MRI in breast lesions. All these patients were clinically suspected to have breast lesions. The mean age is 44 years. The maximum of patients (n=22) were in the age group of 41-60 years (52.5%). There is only one patient below the age of 20 years.

35 patients (87.5%) presented as mass lesion and 5 patients (12.5%) presented as non mass like enhancement. MRI description of non mass like enhancement showing non mass like enhancement, 1 patient presented with ductal enhancement, 1 with segmental, 1 with regional and 2 with multiregional enhancement.

Table 1: BIRADS lexicon and enhancement

Type of lesion by BIRADS lexicon	No. of lesions
Focus / Foci	0
Mass	35 (87.5%)
Non mass like enhancement	5 (12.5%)
Non mass like enhancement	
Focal	0
Linear/Ductal	1
Segmental	1
Regional	1
Multiregional	2
Diffuse	0

Out of 19 benign lesions 8(42%) had round shape and 8 (42%) had oval shape. Out of 16 malignant lesions 12 (75%) had irregular shape. Out of 19 benign lesions, 16 (82%) had well circumscribed margins.

Out of 16 malignant lesions 10 (62.5%) had spiculated margins [Table 2].

Out of 33, 14 lesions (42.5%) had homogenous enhancement which are mostly benign. Five lesions showed dark internal septations which were all benign. 11 lesions (33.5%) showed heterogenous enhancement which are mostly malignant.

Table 2: Mass morphologic descriptors and Kinetic Curve Assessment.

Descriptor	Benign lesions	Malignant lesions
Descriptor (shape)		
Round Oval Irregular Total	8 8 3 19	1 3 12 16
Descriptor (margin)		
Circumscribed Irregular Spiculated	16 1 2	2 4 10
Total	19	16

Early rim enhancement is seen in 3 lesions (9%). Out of which two of them were proven to be malignant and one lesion was an infective abscess.

Out of 40 lesions, 22 were benign, when analysed by Kinetic Curve Assessment 17 lesions (77.3%) showed Type I curve i.e., progressive pattern.5 lesions (22.7%) showed Type II curve i.e., plateau pattern. None of them showed Type III curve i.e., washout pattern [Table 3].

In 18 malignant lesions 10 lesions (55.6%) showed Type III curve, 7 lesions (38.9%) showed Type II curve, 1 lesion (5.6%) showed Type I curve.

Table 3: Assessment of Kinetic Curve in benign and malignant lesions

Type of curve	Benign lesions	Malignant lesions
Type I	17	1
Type II	5	7
Type III	0	10
Total	22	18

Table 4: BI-RADS assessment Category

BI-RADS Category	No. of lesions
Category 0	0
Category 1	0
Category 2	7
Category 3	12
Category 4	10
Category 5	11
Category 6	0

Histopathology of lesions:

Table 5: Histopathology of lesions

Histology / Cytology	No. of lesions
1) Malignant	
i) Invasive Breast Cancer	
Ductal	13
Lobular	2
Medullary	0
Mucinous	0
ii) Non-Invasive Breast Cancer	
Ductal Carcinoma In Situ	2
Intracystic Papillary carcinoma	1
2) Benign	
Fibroadenoma	8
Intracystic Papilloma	1
Fibrocystic disease	5
Pagets disease	1
Phyllodes tumor	1
Abscess	1
Infective Etiology	2

Invasive Duct Cell Carcinoma was the most common histology in the malignant breast lesions in our study, seen in 13 out of 18 (72.2%).

Fibroadenoma was the most common benign breast lesion, observed in 8 out of 19 (42.1%).

Post operative Histopathalogical Lesions :

In 4 post operative patients ,2 (50%) were post operative fibrosis, 1 (25%) was recurrance and 1 (25%) was post operative collection.

Table 6: Associated findings

Associated findings	Benign	Malignant
Nill	14	6
Nipple Retraction	0	2
Nipple Invasion	1	0
Skin Retraction	1	11
Skin Thickening	3	10
Axillary Lymphhadenopathy	4	9
Pectoralis Involvement	0	1
Architectural Distortion	0	1
Cysts	5	0

In 18 malignant lesions, 11 patients (61.1%) had skin retraction, 10 patients (55.5%) had skin thickening, 9 patients

(50%) had axillary lymphadenopathy, 2 patients (11.1%) had nipple retraction, one patient (5.6%) had pectoralis involvement.

In 22 benign lesions, 5 patients (22.7%) had cysts, 4 patients (18.2%) had axillary lymphadenopathy.

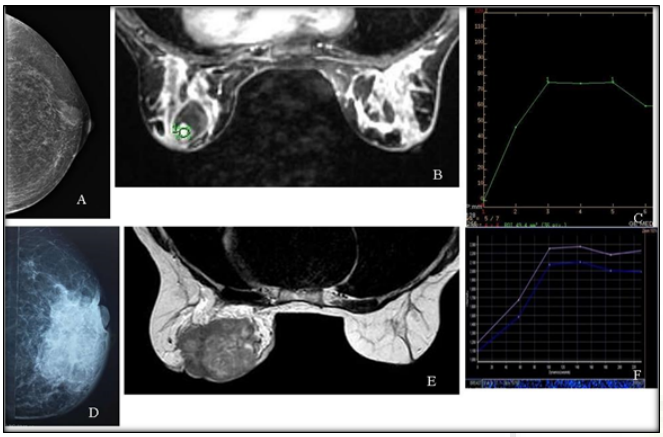

Figure 1: Patient-2: Intracystic Papillary Carcinoma. A. Left breast mammogram. B. DCE MRI-Post contrast axial T1W image C. kinetic curve. (patient 2) D.Patient 4. Inflammatory Ductal Cell Carinoma . Left breast mammogram. E. Pre contrast axial T2W image. F. kinetic curve.

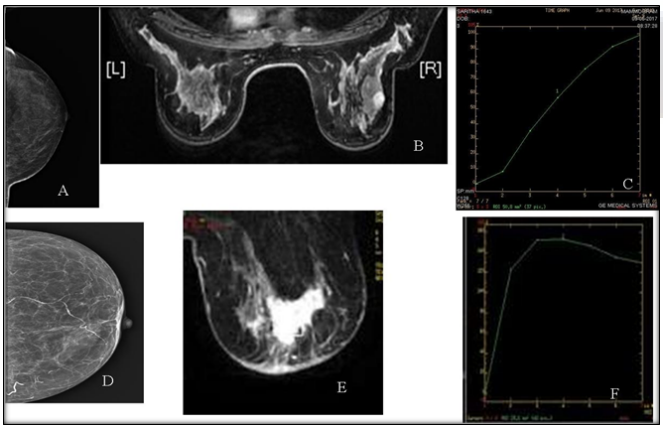

Figure 2: Patient 6: Fibroadenoma A. mammogram of right breast. B. Post contrast axial T1W image. C. kinetic curve. D. Patient 7-Invasive Lobular Carcinoma. Mammogram of right breast. E. Post contrast axial T1W image. F. dynamic curve.

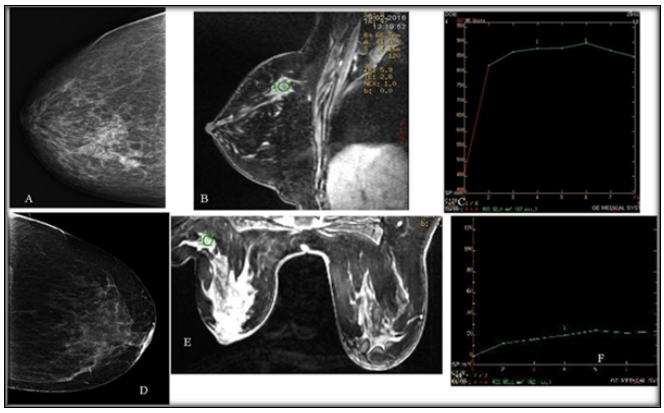

Figure 3: A. Patient 8– Invasive Ductal Cell Carcinoma. Mammogram right breast. B. Post contrast sagittal T1W image C. Dynamic curve. D. Patient 9. Infective etiology (koch's) . Mammogram of left breast. E. Post contrast axial T1W image. F. kinetic curve

Discussion

The sensitivity of MR imaging for detection of breast cancer is very high, and approaches 100% for invasive carcinoma.

In our study we found that morphological appearance of lesion on post contrast study and qualitative assessment of time signal intensity curves are most useful imaging parameters for breast MRI and our results are comparable to previous tudiest. [6,7]

Morphological Analysis:

Out of 40 patients, 35 patients (87.5%) presented as mass lesions and 5 patients (12.5%) presented as non mass-like enhancement. Out of 5 patients showing non mass-like enhancement, 1 patient presented with ductal enhancement, 1 with segmental enhancement, 1 with regional enhancement and 2 with multi regional enhancement.

In 35 patients presented as mass lesions, 19 patients has histological diagnosis of benign disease. Out of 19 patients, 5 patients had fibrocystic change. All these patients showed multiple well defined rounded cysts with no or minimal enhancement of cyst wall on contrast administration. Morphologic features in MRI nearly had 100% NPV for diagnosis of malignancy in fibrocystic change.

Eight patients had histopathological diagnosis of Fibroadenoma, in these 5 lesions (62.5%) showed dark non enhancing internal septations. So, dark non enhancing internal septations had 100% PPV for Fibroadenoma).

Kuhl et al., [8] reported that dark septation if present within a lobular oroval mass are typical of fibroadenomas.

In 35 patients presented as mass lesions, 16 patients had malignant histology. In these 12 lesions (75%) had irregular shape and 10 patients (62.5%) had spiculated margins.

Hence the sensitivity of irregular shape and spiculated margins for malignant disease are 75% and 62.5% respectively.

Out of 12 patients with spiculated margins, 10 patients has malignant histology and out of 15 lesions with irregular shapes, 12 had malignant histology. So PPV of spiculated margins and irregular margins for malignant disease are 83.3% and 80% respectively.

Turnbull et al.[9] reported that the most frequent morphological finding among the malignant lesions was heterogeneous internal enhancement.

In our study 11 lesions showed heterogenous enhancement which are mostly malignant.

In our study 14 lesions had homogenous enhancement which are mostly benign. 5 lesions showed dark internal enhancement which were all benign. 3 lesions showed rim enhancement which were all malignant.

Lesions showed heterogenous enhancement which are mostly malignant

Data from American College of Radiology BI-RADS and Numes et al, update of breast MR imaging architectural interpretation model, 219:484-94 shown following PPV for different morphologic features.[10]

Table 7: Positive predictive value of morphologic features for malignancy

Feature	%PPV	PPV of present study
Round mass	5-17	6.25
Mass with non-enhancing internal septations	0-2	0
Ductal enhancement	24-85	-
Rim enhancement	40-86	66.6
Irregular margin	32-84	25
Spiculated margin	80-91	62.5

Present study had low %PPV for irregular margins (25%) and spiculated margins (62.5%). This could be due small sample size, it is not the representative sample of general population. This study correlated for %PPV for rim enhancement (66.6%) which is between 40%-86%.

Kinetic Curve Assessment:

Our study revealed that the enhancement kinetics are shown by the time signal intensity curves differ significantly for benign and malignant enhancing lesions, so can be used as an aid in differential diagnosis. In malignancies washout and plateau curves prevail and benign lesions show progressive enhancement.

In our study group of 40 patients, 22 patients had histopathalogical diagnosis of benign disease, when analysed by Kinetic curve assessment, 17 lesions (77.2%) showed Type 1 curve i.e., progressive pattern, 5 lesions (22.7%) showed Type 2 curve i.e., plateau pattern and no lesions showed Type 3 curve. In 18 malignant lesions, 10 lesions (55.5%) showed Type 3 curve i.e., washout pattern, 7 lesions (38.9%) showed Type 2 curve i.e., plateau pattern and 1 lesion (5.5%) showed Type 1 curve i.e., progressive pattern.

In Susan et al.[11] study group, 83% of the benign lesions exhibited a steady or curved time-signal intensity curve. In contrast 57% of malignant lesions exhibited a washout time-signal intensity curve. Using the shape of time signal intensity curve alone, the authors reported a sensitivity of 91%(92 of 101), a specificity of 83%(137 of 165), a positive predictive value of 77%(92 of 120), a negative predictive value of 94%(137 of 146) and a diagnostic accuracy of 86%(229 of 266). The likelihood of breast cancer associated with Type 1,2 or 3 time curves was 6% (9 of 146), 64% (34 of 53) and 87% (58 of 67) respectively.

Involvement of skin, pectoralis muscle, or chest wall:

In our study out of 18 malignant lesions, 11 patients (61.1%) had skin retraction, 10 patients (55.5%) had skin thickening, 9 patients (50%) had axillary lymphadenopathy, 2 patients (11.1%) had nipple retraction and 1 patient (5.6%) had pectoralis involvement. Out of 22 benign lesions, 5 patients (22.7%) had cysts and 4 patients (18.2%) had axillary lymphadenopathy.

Similar results were shown by Morris and colleagues reported on 19 women who had posterior enhancing breast masses at preoperative breast MR imaging.[12] Hence it's concluded that violation of the fat plane without other findings did not indicate muscle or chest wall involvement; extension of tumor into underlying chest wall or muscle was indicated by abnormal enhancement within these deep structures .

Post Operative Scar Vs Recurrence

In our study out of 4 post operative lesions, 1 (25%) was recurrent lesion, 2 (50%) were scar tissue and 1 (25%) was post operative seroma. With DCE-MRI we can diagnose with 100% sensitivity for scar tissue and recurrent lesions.

Giles R, showed nodular enhancement in all cases of invasive carcinoma and linear enhancement was observed in cases of DCIS recurrence.[13] The majority of scars showed no

enhancement after major breast surgery, fresh scars may exhibit contrast enhancement. Scar enhancement is relatively subtle and occurs more or less evenly in the entire scar. This is in contrast to recurrent cancer, which exhibits a mass effect within the scar and causes focal enhancement that is confined to a part of the scar.

Both malignant and benign lesions are identified with high resolution MR imaging. Malignant lesions tend to have an irregular and spiculated margins and demonstrated heterogenous and peripheral rim enhancement. Fibroadenomas cocnsistently have lobulated and well defined rounded or ovoid lesions with smooth margins and non enhancing internal septations as specific morphologic feature. MRI offers superb visualisation of the posterior breast tissue can assess contiguous involvement better than conventional imaging, and also detects multifocal or multicentric lesions. Routinely we do bilateral imaging for breast MRI, by this we can detect synchronous lesions also. So, helps in pre operative staging of malignant lesions and provides better planning and management of the breast lesions. Surgical outcomes proved to be best with the knowledge of the tumor extent, multi centricity, multi focality and synchronous breast lesions.

Conclusion

Dynamic contrast enhanced MRI is a valuable tool in evaluation of postoperative breast as it has high specificity in differentiating the postoperative changes. Breast MRI minimizes unnecessary intervention and optimizes diagnosis of recurrence in its early stages.

In our study, MR imaging alone has Sensitivity of 88.8%, Specificity of 86.3%, Positive Predictive Value of 84.2%, and Negative Predictive Value of 90.4% and Accuracy of 87.5%. By combining kinetic analysis with morphological analysis we had additional benefit to correctly categorise the breast lesions into benign and malignant and that increased the confidence of diagnosis. CE-MRI with both morphology and kinetic curve assessment has a Sensitivity of 94.5%, Specificity of 100% and Accuracy of 97.5%.

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