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Role of dynamic contrast enhanced 3T MRI for differentiation of benign and malignant breast lesions with histopathological correlation-

Radiology

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ABSTRACT

The aim of the study was to differentiate benign and malignant breast lesions on the basis of qualitative and quantitative criteria on dynamic contrast enhanced MRI with histopathological findings as gold standard. The study was done on 54 patients who underwent MRI based on suspicious mammographic, ultrasound and clinical examination findings. Dynamic contrast enhanced MR imaging was performed on 3Tesla machine. The morphological features of the lesions and time signal intensity curves on dynamic contrast enhanced MRI were evaluated. Histopathological correlation was done either by fine needle aspiration cytology (FNAC) or biopsy. On analysis of qualitative criteria of MRI it was seen that lesions with irregular margins, heterogeneous enhancement were associated with malignancy and lesions with smooth margins, homogenous enhancement were benign. Quantitative assessment of kinetic curve in dynamic contrast enhanced study shows significant association between Type II, III curves with malignant lesions and Type I curve with benign lesions.

KEYWORDS:

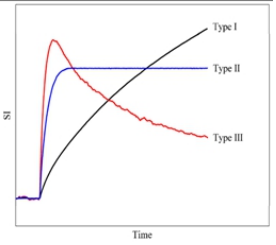
Breast cancer, Dynamic contrast enhancement MRI, qualitative and quantitative analysis of breast lesions.

Introduction-

Dynamic contrast enhanced MRI is a noninvasive technique used for differentiation of benign and malignant breast lesions . Dynamic contrast-enhanced MRI (DCE-MRI) has been used to improve the specificity of MRI in characterizing breast lesions [1-5] .The most widely used form of DCE-MRI analysis is the assessment of the type of time–signal intensity curve (i.e., kinetic curve).

After MRI breast, kinetic curve is plotted on the basis of wash in and wash out pattern of contrast. The kinetic curve (time signal intensity curve) is of three types: type I persistently enhancing (progressive), characteristic of benign lesion; type II plateau type ; and type III washout type, both II and III are suggestive of malignancy [6].

Several reports have demonstrated that DCE-MRI data from malignant lesions tend to exhibit "washout" curves, while benign lesions tend to show persistent signal increase with time after contrast injection [7,8].



American Cancer Society has recommended that women at high risk of breast cancer should undergo yearly breast cancer screening with MRI in addition to mammography. These recommendations were prompted by several studies of MRI screening of women at high risk of breast cancer[9]

Aim of the study:

Evaluation of radiological (both morphological and dynamic contrast enhanced) distinguishing features of benign and malignant lesion with histopathological findings as gold standard.

Material and Methods-

This study was performed in the Department of Radiodiagnosis, Dr. RMLIMS, Lucknow from February 2014 to July 2016 after approval by the institutional ethics committee.

Inclusion criteria:

- Clinically suspected breast lesion & known case of breast lump.
- Indeterminate palpable findings with negative mammogram & ultrasound.
- Patients with multicentric breast disease.

Exclusion criteria:

- Patients with a preexisting histopathologically confirmed diagnosis of invasive breast cancer.
- History of allergic reactions to intravenous gadolinium based contrast agents.
- Contraindication to administration of intravenous contrast – eg. Renal insufficiency
- Ferromagnetic prosthesis / patients who have metallic surgical implants that are not compatible with an MRI machine and claustrophobic patients are general exclusion criteria.

Dynamic contrast enhanced 3T MRI was done using GE SIGNA OT HDxt-32 Channel MRI machine (WB0427) after informed written consent. Before the patient was prepared for the scan, an IV cannula was inserted at appropriate site. All patients were placed in prone position with the breasts supported in cups of the coil and judicious padding was done to reduce motion artifact .Before the start of scan

the patient was instructed not to move during the whole pre- and post-contrast multi-series set. This entire series with mild compression of the breasts is sufficient to reduce motion artifact.

MRI sequences-

Sequence	TR	TE	Flip angle	Slice thickness	Matrix size	FOV	NEX
Water Sag FSE T2	2380	86	90	6mm	384x224	36x36	6
Water Axial FSE T2	3300	88	90	6mm	384x224	32x32	6
Axial FSE T2 (In phase)	3380	85	90	6mm	384x224	32x32	6
Axial FSE T2 (Out phase)	3320	83	90	6mm	384x224	32x32	6
Axial 3D T1	6	2.4	83	2.2mm	384x256	34x34	0.7
Dynamic study sequence							
Post contrast axial vibrant	6.1	2.3	83	2.2mm	384x256	34x34	0.7

For breast MRI, the first scan subset was the pre-contrast series. For contrast study, the dose of Gd-DTPA (omniscan) of 0.1 mmol per kg body weight was used. Contrast was injected at a rate of 2ml/sec, through a pressure injector (Spectris Solaris ^{EP}) followed by a saline flush. A 20–40 second time delay was taken to allow time for the contrast agent to reach the breast. Then seven post-contrast series were run continuously for 6–8 minutes (one series of approx. 1minute).

Lesions were characterized on the basis of morphology which included pre and post contrast visualization of lesion, margins of lesions and type of enhancement. The dynamic parameter studied was the time- signal intensity curves, which were acquired with the help of dedicated software Functool (provided by GE healthcare). These curves demonstrated the initial slope of enhancement, occurring within the first two minutes after contrast administration, and delayed enhancement pattern.

Observation & Results-

This study was performed in the Department of Radiodiagnosis, Dr. RMLIMS, Lucknow from February 2014 to July 2016. 64 patients underwent the described MRI protocol. Four of them were lost to follow up and six patients did not have further histopathological evaluation so they were excluded from the study. In qualitative image analysis three morphological criteria were analyzed : lesion shape, margin, enhancement on contrast with comparison of the pre- and post contrast images. In quantitative image analysis the type of time signal intensity curve was analyzed. On the basis of qualitative and quantitative criteria, the lesions were classified as benign and malignant. 54 patients had 66 histopathology specimens (these included more than one specimen for multifocal breast cancer patients).

CR NO.	AGE	SEX		MRI QUALITATIVE	MRI QUANTITATIVE	HISTOPATHOLOGICAL FINDINGS
			SHAPE &MARGIN	PATTERN OF ENHANCEMENT	KINETICS	
1	55Y	F	RC	HOMOGENEOUS	TYPE I	F
2	45Y	F	IRS	HOMOGENEOUS	TYPE III	IDC
3	35Y	F	IRS	HETROGENEOUS	TYPE III	IDC
4	40Y	F	RC	HOMOGENEOUS	TYPE I	F
5	43Y	F	OC	HOMOGENEOUS	TYPE I	F
6		F	IRS	HETROGENEOUS	TYPE II	IDC
7	50Y	F	IRS	HETROGENEOUS	TYPE II	IDC
8	45Y	F	RIR	HOMOGENEOUS	TYPE III	DCIS
9	53Y	F	IRS	HETROGENEOUS	TYPE I	F
10	45Y	F	IRS	HETROGENEOUS	TYPE II	DCIS
11	43Y	F	IR	HETROGENEOUS	TYPE II	DCIS
12	52Y	F	IRS	HETROGENEOUS	TYPE II	IDC
13	47Y	F	IRS	HETROGENEOUS	TYPE II	IDC
14	49Y	F	IRS	HETROGENEOUS	TYPE II	ILC
15	39Y	F	IRS	HETROGENEOUS	TYPE III	IDC
			IR	HETROGENEOUS	TYPE III	IDC
16	36Y	F	OC	HOMOGENEOUS	TYPE I	F
			RC	HOMOGENEOUS	TYPE I	IDC
17	50y	F	IRS	HETROGENEOUS	TYPE II	IDC
18	40Y	F	RC	HOMOGENEOUS	TYPE I	F
19	45Y	F	IRS	HETROGENEOUS	TYPE II	IDC
20	36Y	F	IRS	HOMOGENEOUS	TYPE I	F
21	32Y	F	RC	HOMOGENEOUS	TYPE I	F
22	39Y	F	OC	HOMOGENEOUS	TYPE I	F
23	45Y	F	OC	HOMOGENEOUS	TYPE I	F
24	50Y	F	IRS	HETROGENEOUS	TYPE III	IDC
25	34Y	F	RC	HOMOGENEOUS	TYPE I	F
26	37Y	F	IRS	HETROGENEOUS	TYPE III	IDC
27	36Y	F	RC	HOMOGENEOUS	TYPE I	F
28	40Y	F	RC	HOMOGENEOUS	TYPE I	F
29	55Y	F	IRS	HETROGENEOUS	TYPE III	IDC
30	39Y	F	RC	HOMOGENEOUS	TYPE I	F
31	37Y	F	RC	HOMOGENEOUS	TYPE I	F
32	43Y	F	RC	HOMOGENEOUS	TYPE I	F
33	38Y	F	RC	HOMOGENEOUS	TYPE I	F
34	32Y	F	RC	HOMOGENEOUS	TYPE I	P
35	40Y	F	RC	HOMOGENEOUS	TYPE I	F

36	39Y	F	RC	HOMOGENEOUS	TYPE I	P
37	53Y	F	IRS	HETROGENEOUS	TYPE III	IDC
			IRS	HETROGENEOUS	TYPE III	IDC
38	36Y	F	RC	HOMOGENEOUS	TYPE I	F
39	40Y	F	IRS	HOMOGENEOUS	TYPE I	F
40	45Y	F	OC	HETROGENEOUS	TYPE III	IDC
			IR	HETROGENEOUS	TYPE II	ILC
41	48Y	F	IRS	HETROGENEOUS	TYPE II	ILC
42	50Y	F	IRS	HETROGENEOUS	TYPE III	MC
			IRS	HETROGENEOUS	TYPE III	IDC
43	44Y	F	OC	HETROGENEOUS	TYPE I	ILC
44	49Y	F	IRS	HETROGENEOUS	TYPE III	MC
45	42Y	F	IR	HOMOGENEOUS	TYPE I	ADH
46	47Y	F	OC	HOMOGENEOUS	TYPE I	ADH
			IRS	HETROGENEOUS	TYPE I	F
47	41Y	F	RIRS	HETROGENEOUS	TYPE I	IDC
			RC	HETROGENEOUS	TYPE II	F
48	49Y	F	IRS	HETROGENEOUS	TYPE III	IDC
			IRS	HETROGENEOUS	TYPE I	IDC
49	50Y	F	IRS	HETROGENEOUS	TYPE III	IDC
			IRS	HETROGENEOUS	TYPE III	IDC
50	41Y	F	OC	HOMOGENEOUS	TYPE II	IDC
51	48Y	F	IRS	HOMOGENEOUS	TYPE I	P
			IRS	HETROGENEOUS	TYPE III	IDC
52	56Y	F	IRS	HETROGENEOUS	TYPE II	IDC
53	49Y	F	IRS	HETROGENEOUS	TYPE III	IDC
54	42Y	F	IRS	HOMOGENEOUS	TYPE I	ALH
			RIRS	HETROGENEOUS	TYPE III	IDC
			RC	HETROGENEOUS	TYPEII	IDC

RC=Rounded Circumscribed, IR=Irregular, IRS=Irregular Spiculated, OC=Oval Circumscribed, RIRS= Rounded Irregular Spiculated, F=Fibroadenoma, P=Papilloma, IDC=Invasive ductal carcinoma, ILC=Invasive Lobular carcinoma, DCIS=Ductal Carcinoma in situ, ADH=Atypical Ductal Hyperplasia, ALH= Atypical Lobular Hyperplasia, MC=Mucinous Carcinoma

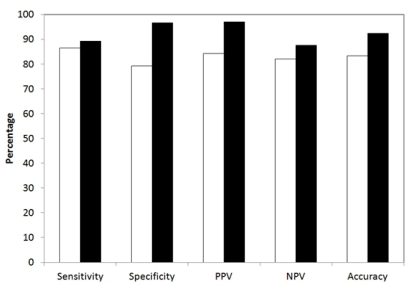
Table No. 1 MRI features of detected breast lesions

Features	Benign	Malignant
Focal mass Pre contrast		
Yes	21	32
No	7	6
Shape		
Round	18	5
Oval	6	2
Irregular	4	31
Margin		
Circumscribed	25	4
Irregular speculated	3	34
Enhancement		
Homogeneous	23	7
Heterogeneous	5	31
Kinetics		
Type I	26	3
Type II or III	2	35

Statistical Analysis: Data was analyzed using Statistical Package for Social Sciences, version 21.0. Chi-square test, Fisher exact test and kappa-statistic were calculated. Diagnostic efficacy of two criteria was expressed in terms of sensitivity, specificity, positive and negative predictive values.

Table 2: Comparison between Quantitative and Qualitative criteria

SN	Imaging criteria	TP	FP	FN	TN	Sens	Spec	PPV	NPV	Accuracy
1.	Qualitative	32	6	5	23	86.5	79.3	84.2	82.1	83.3
2.	Quantitative	33	1	4	28	89.2	96.6	97.1	87.5	92.4
'p' value (Fisher exact test)		0.111		0.721		1.000	0.102	0.111	0.721	0.181



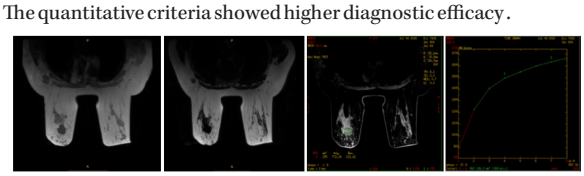
Quantitative criteria of dynamic contrast MR imaging had higher sensitivity, specificity, positive predictive, negative predictive and accuracy values as compared to qualitative criteria.

Table 3: Level of Agreement between quantitative and qualitative criteria

Qualitative		Quantitative		Total
		Malignant	Benign	
	Malignant	30	8	38
	Benign	4	24	28
Total		34	32	66

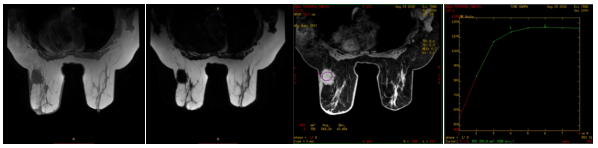
% Agreement = 54/66; 81.8%

Measure of agreement κ=0.635; p<0.001 - Substantial agreement
The quantitative criteria showed higher diagnostic efficacy.



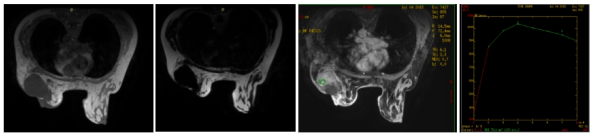
(A) (B) (C) (D)

(Figure-1) MRI breast shows well defined hypo to isointense lesion in left breast on T1 and T2 WIs (A & B respectively). On post contrast images, the lesion is showing homogeneous enhancement(C) and type I (D) signal intensity curve.



(A) (B) (C) (D)

(Figure-2) MRI breast shows irregular isointense lesion with spiculated margins in left breast on T1 and T2 WIs (A & B respectively) .On post contrast images the lesion is showing heterogeneous(C) enhancement and type II (D) signal intensity curve.



(A) (B) (C) (D)

(Figure-3) MRI breast shows irregular isointense lesion in left breast on T1 and T2 WIs(A & B respectively) . On post contrast images the lesion is showing heterogeneous enhancement(C) and type III (D) signal intensity curve.

Table No. 4 Pathological finding of MRI detected breast lesions-

Findings	Occurrence
Benign cases	
Fibroadenoma	22
Papilloma	3
Atypical ductal hyperplasia	2
Atypical lobular hyperplasia	1
Malignant cases	
Invasive ductal carcinoma	29
Invasive lobular carcinoma	4
Ductal carcinoma insitu	3
Mucinous carcinoma	2

Discussion-

Dynamic contrast enhanced MRI is a convenient method for characterizing the breast lesions by using multiple parameters that include qualitative and quantitative image analysis. In qualitative image analysis three morphological criteria were analyzed. These were lesion shape, margin, enhancement on contrast with comparison of the pre- and post contrast images [10] . In quantitative image analysis type of enhancement curve was analyzed. These qualitative and quantitative image analysis criteria are comparable with BIRAD MRI lexicon, which includes the morphological criteria for evaluating breast lesions namely shape, margins and enhancement characteristics, enhancement distribution and internal enhancement pattern.

In our study, the most common benign lesion was fibroadenoma and the most common malignant lesion was invasive ductal carcinoma .The results of our study was comparable with Li et al. who demonstrated the same results[11]. In our study the most common shape of benign lesion was either ovoid or rounded and the shape of malignant lesions were irregular. In our study the margins of benign lesions were variable with predominance of circumscribed while the margins of malignant lesions were irregular spiculated. Most of the benign lesions showed homogenous enhancement, most of the malignant lesions showed heterogeneous enhancement. Morris demonstrated the same in his study[12].

In conclusion diagnostic accuracy of quantitative criteria of dynamic contrast enhanced MRI was found to be better than qualitative criteria.

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