Contrast Enhanced Mammography Descriptors using Breast Imaging and Reporting and Data System

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Abstract

Contrast-enhanced mammography (CEM) is an emerging breast imaging technique with a potential to develop into a one-stop imaging solution for several conditions which require imaging, especially its role in cancer detection and local staging when combined with ultrasound. In 2022, CEM lexicon was published as a supplement to the American College of Radiology Breast Imaging Reporting and Data System (ACR BIRADS) fifth edition. This pictorial review illustrates the findings that are seen on CEM using ACR BIRADS CEM lexicon to make the reader familiar with the terminologies. In our experience, interpretation and description of findings in CEM using ACR-BIRADS CEM lexicon had a short learning curve and it was easy to implement in practice as most of the terminologies were already in use for interpreting magnetic resonance imaging.

Keywords

- contrast-enhanced mammography reporting
- ACR BIRADS CEM lexicon
- breast cancer
- recombined images

Introduction

Contrast-enhanced mammography (CEM) is an emerging breast imaging technique which has wide applications. Though it was approved by the Food and Drug Administration in 2011, it remained underutilized until recently. In recent years, the number of published research studies on CEM has increased and these results show that CEM has sensitivity on par with dynamic contrast-enhanced magnetic resonance imaging (MRI) for cancer detection.[1,2]

ACR BIRADS MRI lexicon was used to describe findings in CEM.[3,4] In early 2022, CEM lexicon was published as a supplement to ACR BIRADS fifth edition.[3] In this review, we present a pictorial presentation of findings on CEM using ACR BIRADS CEM lexicon to make the readers familiar with findings in CEM and guide them to apply correct terminologies while reading CEM.

All the CEM images presented in this review were acquired using the Hologic 3 Dimensions mammography system at our institution.

Technique

After 1.5 mL/kg injection of intravenous iodinated contrast medium, low-energy (28–31 kVp) and high-energy (45–49 kVp) images of two standard views of each breast are acquired during single compression. Low-energy images serve as conventional 2D mammography images. High-energy images are not interpretable. Low- and high-energy images are postprocessed to produce recombined images (RC images) which contain contrast information.

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ACR BIRADS Contrast-Enhanced Mammography Lexicon

Breast Composition

This is assessed in low-energy images like conventional mammography. One of the following descriptors are used.

a. Almost entirely fatty.
b. Scattered fibroglandular density.
c. Heterogeneously dense.
d. Extremely dense.

Background Parenchymal Enhancement

Background parenchymal enhancement denotes normal enhancement of the patient's fibroglandular tissue (►**Fig. 1**). However, it may not be directly related to the amount of fibro-glandular tissue. The background parenchymal enhancement is progressive over time, and thus, the background parenchymal enhancement (BPE) is assessed at first postcontrast image. At our institution, we routinely take craniocaudal (CC) views of both breasts first followed by mediolateral oblique views. So, we describe the BPE in CC views as minimal, mild, moderate, or marked (►**Table 1**).

BPE is an important component in the interpretation of CEM because the presence of moderate to marked background parenchymal enhancement reduces the sensitivity of CEM. Further, available evidence shows that BPE is an independent predictor of breast cancer risk.[5]

In MRI, it is recommended to schedule elective examinations at the 2nd week of the menstrual cycle when the BPE will be less. But several studies have shown that the outcome may not be affected by the time of menstrual cycle. There are little data about timing the CEM at a particular phase of the menstrual cycle.

Findings

The findings on CEM are divided into three broad categories.

Table 1 Descriptors for background parenchymal enhancement.

Background parenchymal enhancement	1. Level	a. Minimal b. Mild c. Moderate d. Marked
	2. Symmetric/asymmetric	a. Symmetric b. Asymmetric

A. Findings on low-energy images only (►**Figs. 2** and **3**):

These are the abnormalities which are seen on low-energy images without enhancement in RC images. These are described using the ACR BIRADS mammography lexicon.[3]

B. Enhancement in RC images only without low-energy correlate:

Based on the enhancing morphology, these findings may be described as, mass, nonmass enhancement (NME), or enhancing asymmetry (►**Table 2**). The descriptors for enhancing findings in CEM are similar to MRI. Few MRI descriptors like focus are not used in CEM lexicon because of the inherent low resolution of CEM. An additional descriptor specific to CEM is lesion conspicuity (►**Fig. 4**).

I. Mass (►**Figs. 5** and **6**):

A mass is a 3-dimensional space occupying lesion with convex outer margins. The descriptors for mass are margins, shape, and internal enhancement characteristics.

1. Shape.

The shape of the mass can be oval, round, or irregular. If the lesion is elliptical or egg shaped, it is called an oval lesion and it may include two to three lobulations. When the lesion is spherical, ball shaped, circular, or globular, it is a round

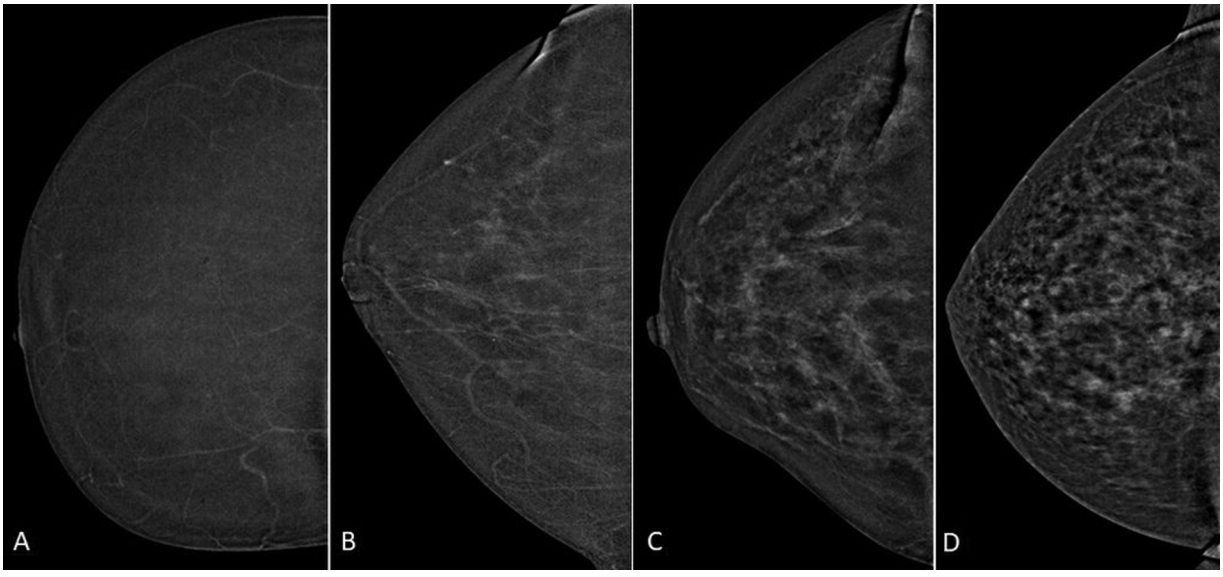

Fig. 1 Background parenchymal enhancement (BPE). (**A–D**) Postcontrast recombined images showing minimal, mild, moderate, and marked background parenchymal enhancement in CEM. CEM, contrast-enhanced mammography.

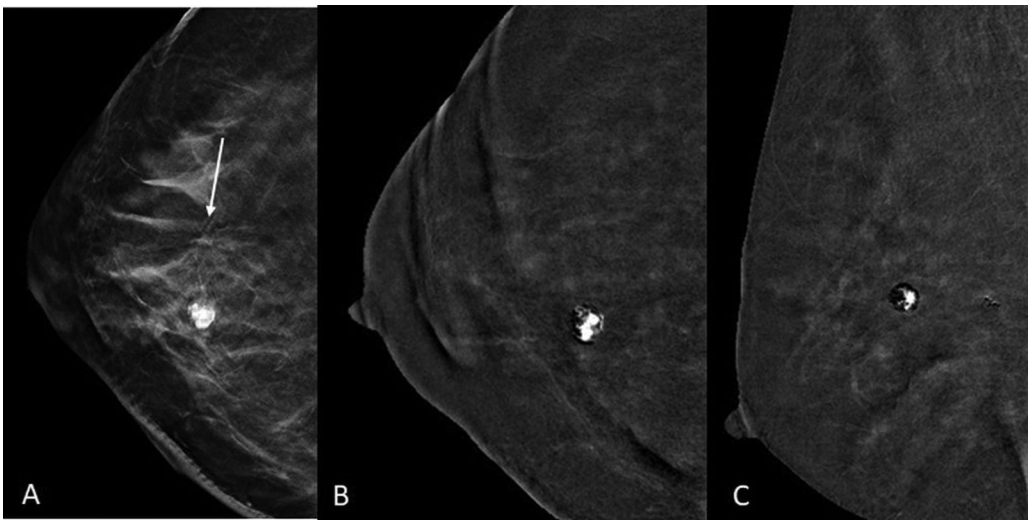

Fig. 2 (**A**) Tomoimage showing an architectural distortion (*arrow*). (**B** and **C**) Postcontrast recombined images in CC and MLO views showing no enhancing correlate. CC, craniocaudal; MLO, mediolateral oblique.

lesion. When the shape of the lesion is neither round nor oval, it is called irregular. Irregular shape implies a suspicious finding.[6]

2. Margins.

The margin is the edge or border of the lesion. Margins describe the behavior of the mass with the surrounding tissue. Margins can be circumscribed or noncircumscribed.

The margin is called circumscribed if it is sharply demarcated and has an abrupt transition with the surrounding tissue. It is important to note that the entire margin of the mass should be sharply demarcated to describe it as circumscribed. If any portion of the margin is not circumscribed, it should be classified based on the most suspicious finding. Masses with noncircumscribed margins are subclassified into irregular or spiculated margins. When the edges are uneven or jagged it is called irregular. Spiculated margins are characterized by radiating lines from the edges. Both irregular and spiculated margins imply that the findings are suspicious.[4]

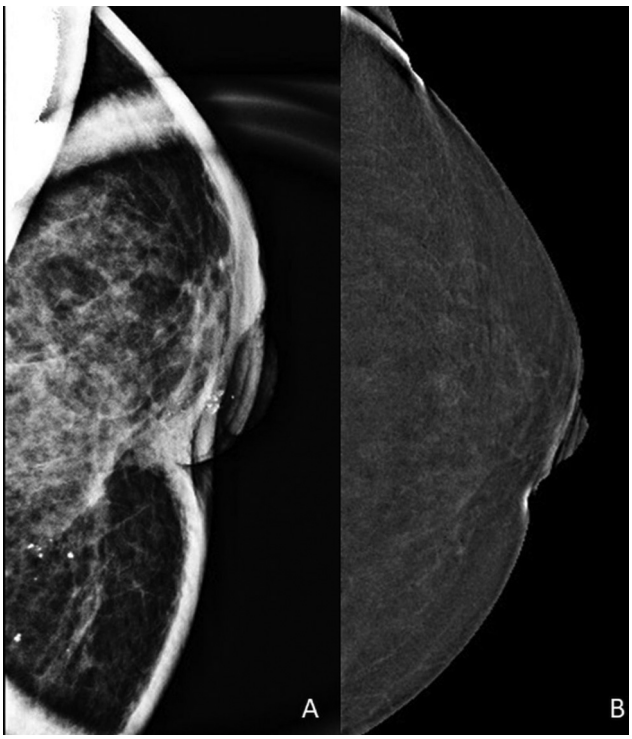

Fig. 3 (**A**) Low-energy image shows fine pleomorphic and coarse heterogeneous calcifications in retroareolar region and inner quadrant. (**B**) Postcontrast recombined images of the same patient shows no significant enhancement corresponding to the calcifications.

Table 2 Descriptors for findings seen on RC image

Mass	Shape	Oval Round Irregular
	Margins	Circumscribed Noncircumscribed **b.** Irregular **c.** Spiculated
	Internal enhancement characteristics	Homogeneous Heterogeneous Rim enhancement
Non mass enhancement	Distribution	Focal Linear Segmental Regional Multiple regions Diffuse
	Internal enhancement pattern	Homogeneous Heterogeneous Clumped
Enhancing asymmetry	Internal enhancement pattern	Homogeneous Heterogeneous
Lesion conspicuity	Low Moderate High	

Abbreviation: RC, recombined images.

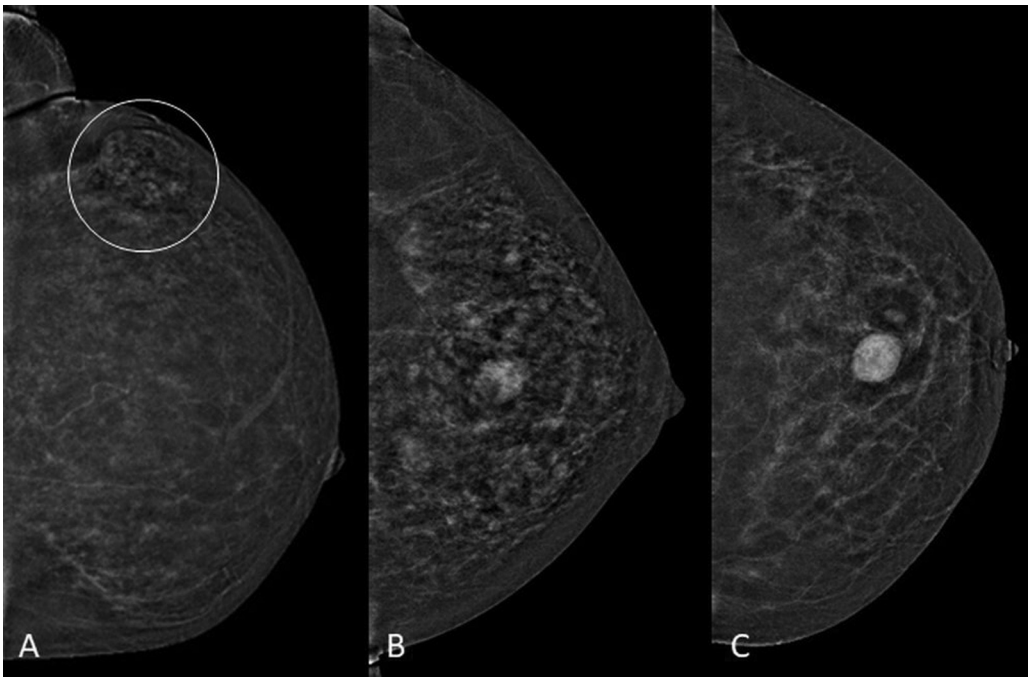

Fig. 4 Lesion conspicuity in RC images: (**A**) lesion with LOW conspicuity, (B) lesion with MODERATE conspicuity, and (C) lesion with HIGH conspicuity. RC, recombined images.

3. Internal enhancement characteristics.

Internal enhancement describes the enhancement pattern within a mass. The three types of internal enhancement patterns in CEM are homogeneous, heterogeneous, and rim enhancement.

It is homogeneous (►**Fig. 5**) when there is confluent uniform enhancement. Heterogeneous (►**Fig. 6**) enhancement is nonuniform enhancement of the mass. When the

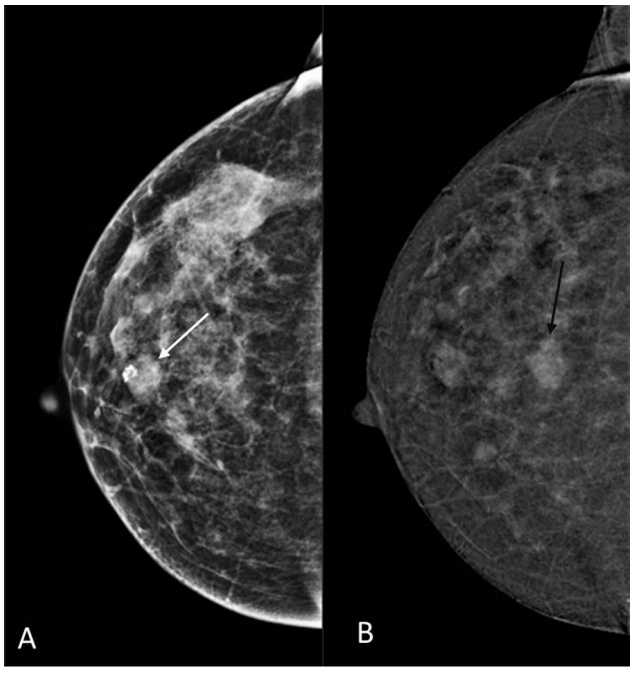

Fig. 5 (**A**) Low-energy image shows an oval mass with circumscribed margins and coarse heterogeneous calcification within (*white arrow*). (**B**) In addition to the lesion seen on low energy images, there is an oval mass with circumscribed margins in RC images without low-energy correlate and homogeneous postcontrast enhancement with moderate conspicuity (*black arrow*). RC, recombined images.

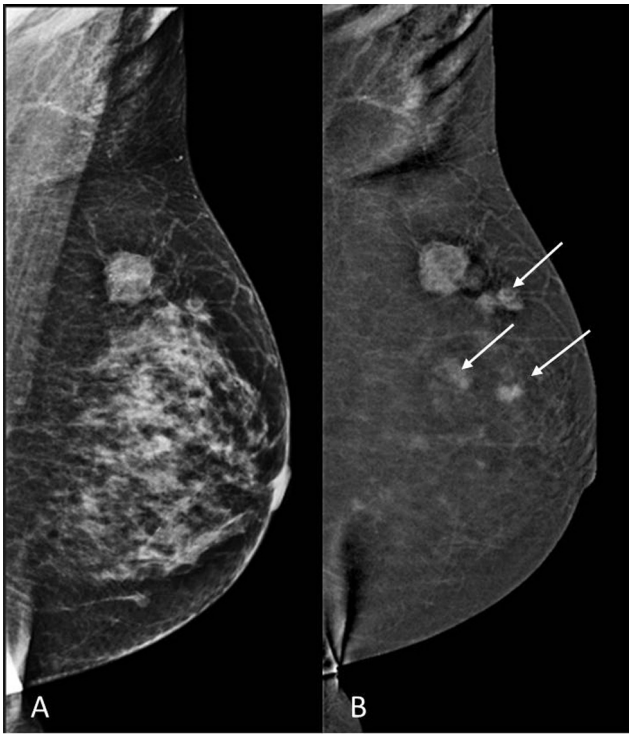

Fig. 6 Mass RC image only: (**A**) low-energy image showing an irregular equal density mass in the upper quadrant. (**B**) In addition to the mass seen on low-energy image, few other irregular masses with noncircumscribed (*irregular*) margins, heterogeneous internal enhancement pattern, and moderate-to-high conspicuity (*arrows*) are seen on RC image only. RC, recombined images.

Fig. 7 (A–C): Non Mass Enhancement(NME) – distribution. RC images showing, A: NME in FOCAL (< one quadrant) distribution, B: NME in linear distribution, C: NME in SEGMENTAL (triangular with apex pointing to nipple) distribution.

enhancement is more pronounced at the periphery of the mass, it is called rim enhancement, and it implies a suspicious finding especially when the enhancing rim is nodular and irregular.

II. Nonmass Enhancement

NME is defined as an enhancing area that is neither a mass nor a focus. It does not have convex outer margins and may have intervening fat or fibroglandular tissue. NME is described in terms of distribution and internal enhancement pattern.

1. Distribution (►**Figs. 7** and **8**)
   Focal—occupies less than one quadrant of breast volume.
   Linear—enhancement arranged in a line or a line of enhancement that branches. Linear NME is a suspicious finding because it represents ductal abnormality.
   Segmental—triangular- or cone-shaped enhancement with its apex pointing to the nipple. Segmental NME is a suspicious finding because it represents enhancement along the duct and its branches involving one lobe.[7]
   Regional—when the NME involves more than one quadrant, it is called regional NME.
   Multiple regions—enhancement in at least two large volumes of tissues separated by normal tissue.
   Diffuse—enhancement throughout the breast.
2. Internal enhancement pattern (►**Fig. 9**)
   Homogeneous—confluent and uniform enhancement.
   Heterogeneous—nonuniform enhancement separated by normal parenchyma or fat.
   Clumped—enhancement of varying shapes and sizes with occasional confluent areas. It is equivalent to pleomorphic calcifications in mammograms and it is suspicious.[7,8]

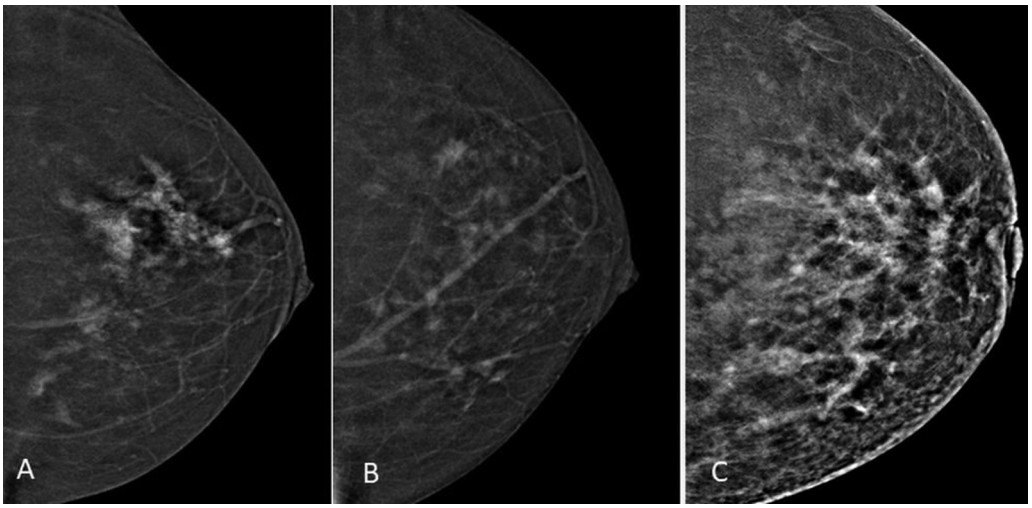

Fig. 8 (A–C): Non Mass Enhancement(NME) – distribution (Contd..). RC images showing, A: NME in REGIONAL (occupying more than one quadrant) distribution, B: NME in MULTIPLE REGIONS distribution, C: NME in DIFFUSE distribution.

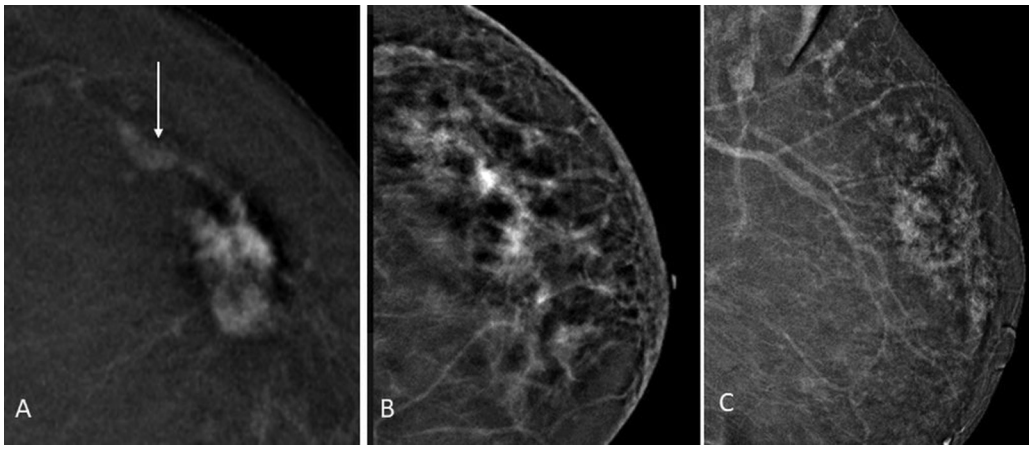

Fig. 9 (**A–C**) Nonmass enhancement (NME)—internal enhancement pattern. RC images showing (**A**) HOMOGENEOUS internal enhancement pattern of NME, (**B**) HETEROGENEOUS internal enhancement pattern of NME, and (**C**) CLUMPED internal enhancement pattern of NME. NME, nonmass enhancement.

III. Enhancing asymmetry (►**Fig. 10**):

For enhancing findings which are seen in one view only, the term "enhancing asymmetry" is introduced in CEM lexicon. If asymmetry is seen in conventional mammogram which exhibit enhancement, it can also be described as enhancing asymmetry.

IV. Conspicuity of the lesion:

Conspicuity of the lesion denoting the degree of enhancement relative to the BPE may be described as low, moderate, or high (►**Fig. 4**). Low conspicuity is enhancement equal to or slightly greater than BPE. High conspicuity is used when the enhancement is much greater than BPE. Moderate conspicuity is the enhancement between the low and high conspicuity.

C. Findings seen on low-energy images with associated enhancement in RC images.

The morphologic characteristics of the findings (mass, asymmetries, architectural distortion, and calcifications) are described from the low-energy images using the ACR- BIRADS mammography lexicon. For mass lesions (►**Figs. 11–16**), shape, margins, and density are described from low-energy images and enhancement patterns are described from the RC images. For all other abnormalities (asymmetries,

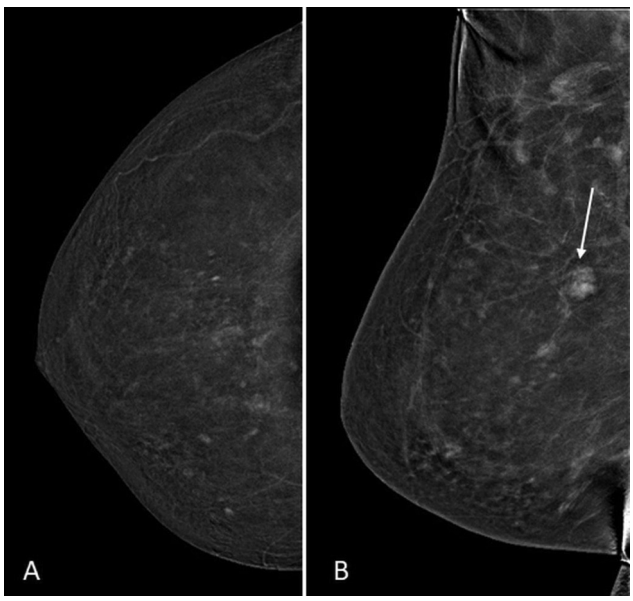

Fig. 10 (**A** and **B**) Enhancing asymmetry: enhancing lesion seen only on MLO view (*arrow in B*) not on CC view (A). CC, craniocaudal; MLO, mediolateral oblique.

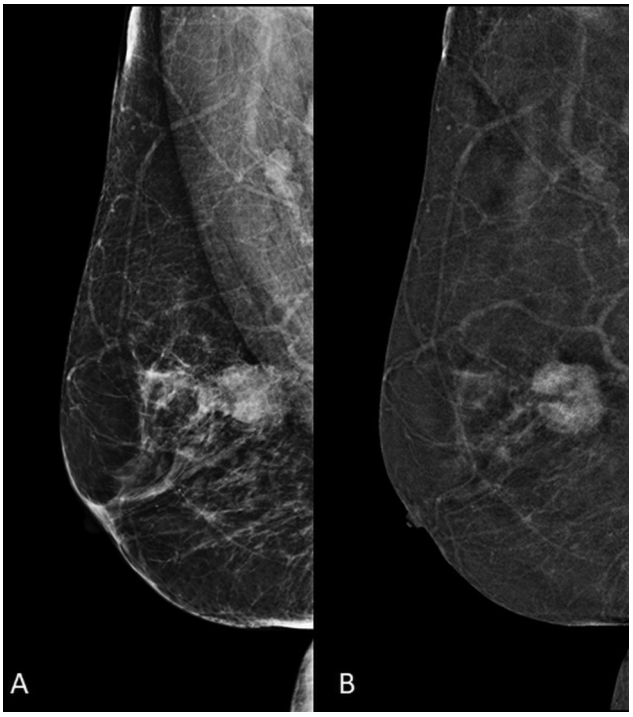

Fig. 11 Mass seen in both low energy and recombined images: descriptors from low-energy image (**A**)—irregular equal density mass with indistinct margins. Descriptors from RC image (**B**)—heterogeneous internal enhancement with enhancement of the entire lesion and high conspicuity. RC, recombined images.

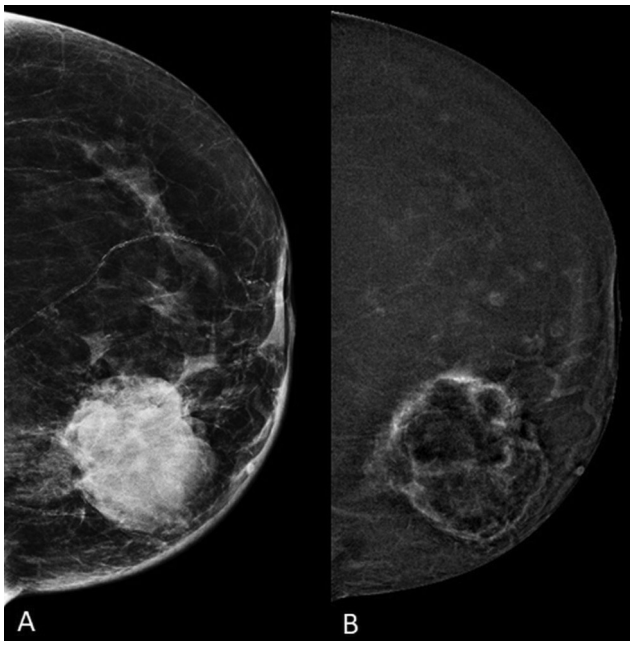

Fig. 12 Mass seen in both low-energy and recombined images: Low-energy image descriptors (**A**) round high-density lesion with indistinct margins. RC image descriptors (**B**) rim enhancement with enhancement of the entire lesion and moderate conspicuity. RC, recombined images.

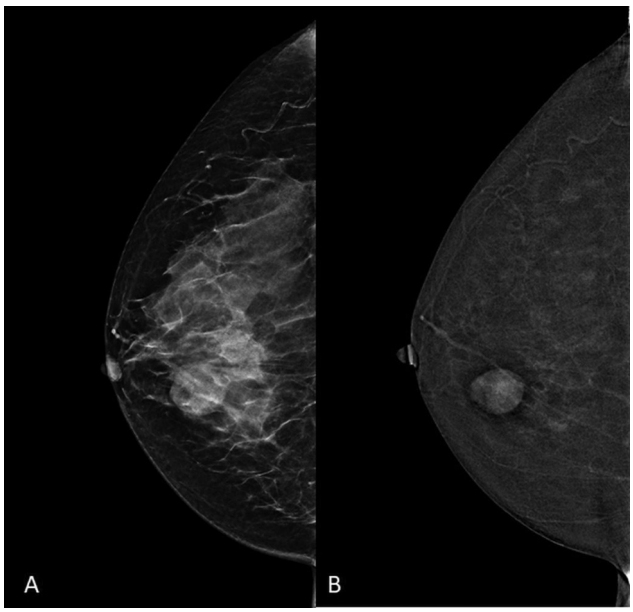

Fig. 13 Mass seen in both low-energy and recombined images: Low-energy image descriptors (**A**) oval equal density lesion with obscured margins. RC image descriptors (**B**) homogeneous enhancement pattern with enhancement of the entire lesion and high conspicuity. RC, recombined images.

architectural distortion [►**Fig. 17**] and calcifications [►**Fig. 18**]), the characteristics of enhancement are described using the CEM lexicon. For example, if an architectural distortion shows enhancement, it should be described as mass/NME based on the appearance in RC images. Further, if it has a morphology of mass, it should be described in terms

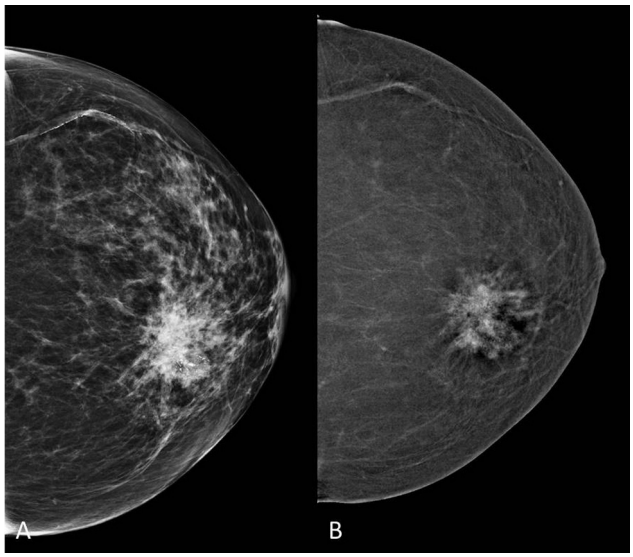

Fig. 14 Mass seen in both low energy and recombined images: low-energy image descriptors (**A**) irregular high-density lesion with spiculated margins. RC image descriptors (**B**) heterogeneous enhancement pattern with enhancement of entire lesion and high conspicuity. RC, recombined images.

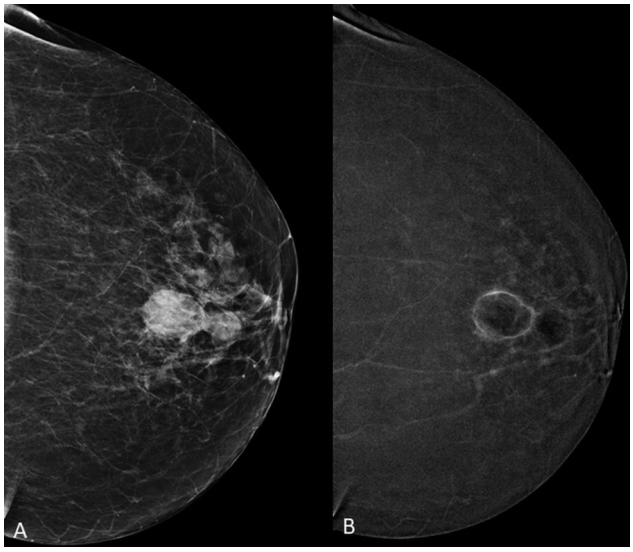

Fig. 15 Mass seen in both low energy and recombined images: low-energy image descriptors (**A**) two oval qual density lesions with circumscribed margins. RC image descriptors (**B**)—the larger lesion shows smooth rim enhancement, and the smaller lesion shows no enhancement. On ultrasound, the larger lesion was a complicated cyst and the smaller lesion was a simple cyst. RC, recombined images.

of shape, margins, and internal enhancement pattern. If it is an NME, distribution and internal enhancement pattern descriptors should be used.

Other descriptors on RC images for the lesions seen on both low energy and RC image include the following factors.

1. Extent of enhancement (►**Fig. 19**):

This descriptor denotes the extent of enhancement relative to the size of the abnormality in a low-energy image. It is described using four categories

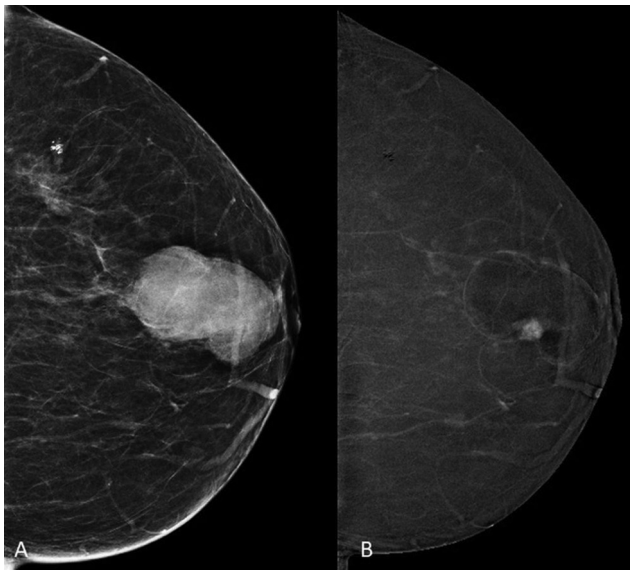

Fig. 16 Mass seen in both low-energy and recombined images: low-energy image descriptors (**A**): oval high-density mass with circumscribed margins. RC image descriptors—rim enhancement with eccentric enhancing soft tissue. HPE—suggestive of papillary neoplasm. HPE, histopathological examination; RC, recombined images.

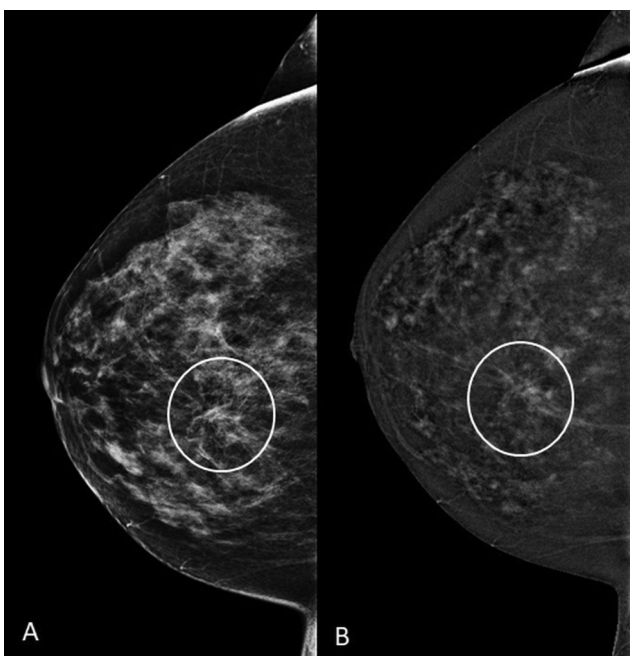

Fig. 17 Architectural distortion with enhancement: Low-energy image descriptor (**A**): focal architectural distortion (*circle*). RC image descriptor (**B**): heterogeneous nonmass enhancement in focal distribution with enhancement of the entire abnormality and low conspicuity (*circle*). RC, recombined images.

(a) Partial enhancement of the mammographic lesion.
(b) Complete enhancement of the mammographic lesion.
(c) Enhancement beyond the mammographic lesion.
(d) No enhancement.

Lesions which do not show enhancement are more likely to be benign.

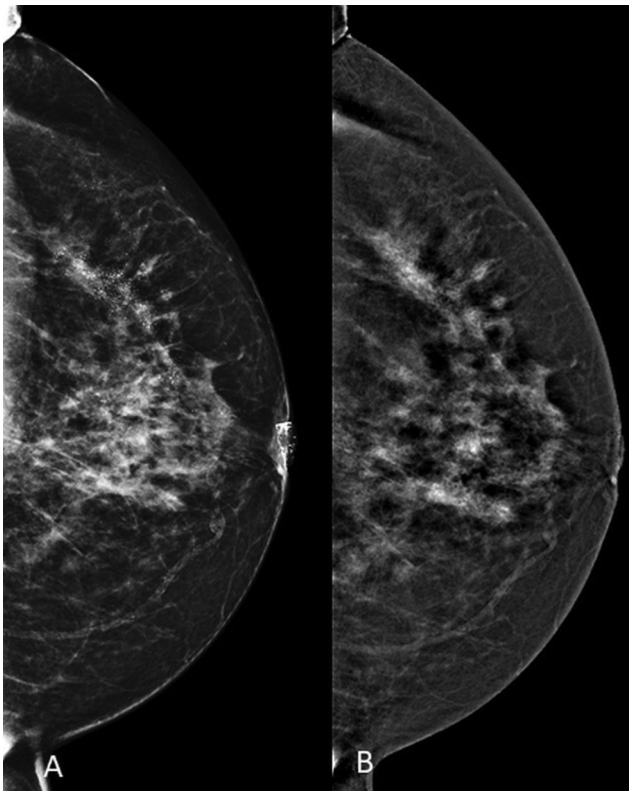

Fig. 18 Calcifications with enhancement: low-energy image descriptors (**A**): fine pleomorphic calcifications in segmental distribution with calcifications involving the nipple. RC image descriptors (**B**): clumped nonmass enhancement in segmental distribution with high conspicuity. RC, recombined images.

2. Lesion conspicuity: Low, moderate, or high as described earlier.

Associated features (►Fig. 20)

These findings are generally seen in low-energy images but can be appreciated in RC images also. These are

(a) Nipple retraction
(b) Nipple invasion
(c) Skin thickening
(d) Skin invasion
(e) Skin retraction
(f) Trabecular thickening
(g) Axillary adenopathy.

Lesion Location

Like mammography, the location is described in terms of side, followed by quadrant, clock-face orientation and depth (anterior, middle, or posterior third).

Report Organization

CEM includes both low-energy and RC image components. So in the report, BIRADS assessment and management should incorporate findings from both the components.

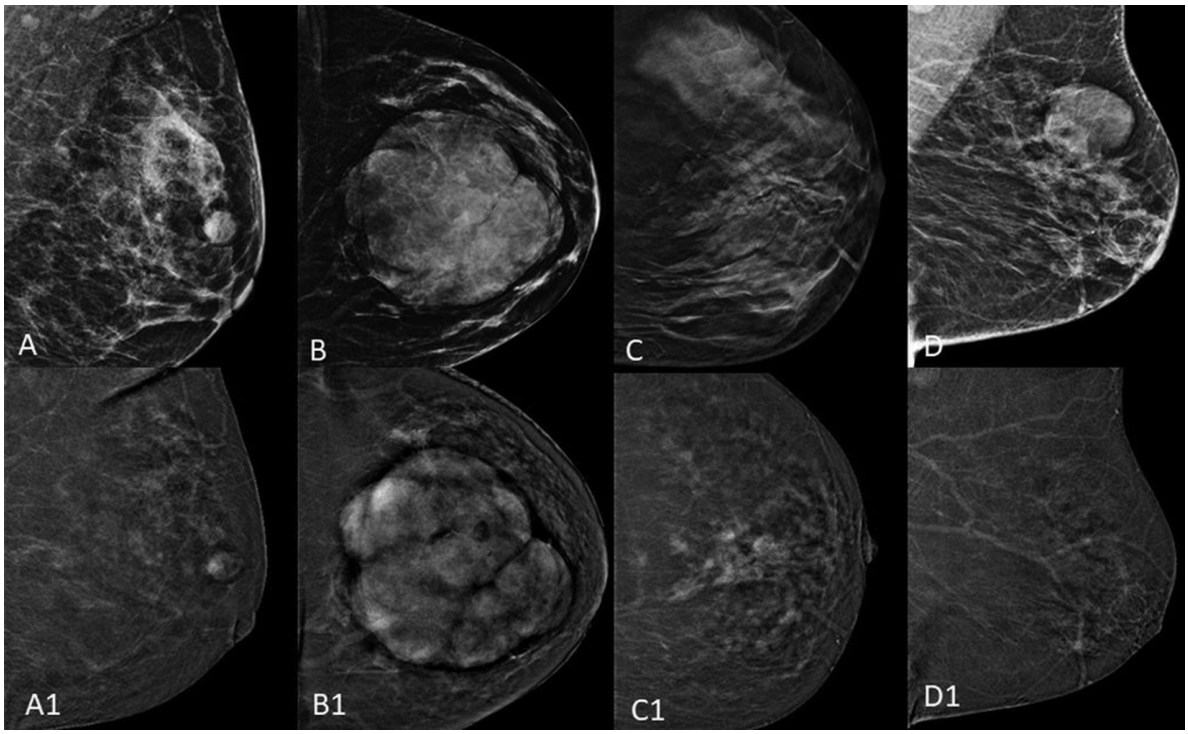

Fig. 19 Extent of enhancement of the abnormality. (**A**) Low-energy image—round equal density mass with circumscribed margins and (**A1**) RC image—partial enhancement. (**B**) Low-energy image—irregular equal density mass with circumscribed margins, and (**B1**) RC image—complete enhancement. (**C**) Low-energy image—focal architectural distortion and (**C1**) RC image—nonmass enhancement with enhancement extending beyond the abnormality. (**D**) Low-energy image showing an oval equal density mass with circumscribed margins, and (**D1**) corresponding recombined image shows no enhancement. RC, recombined images.

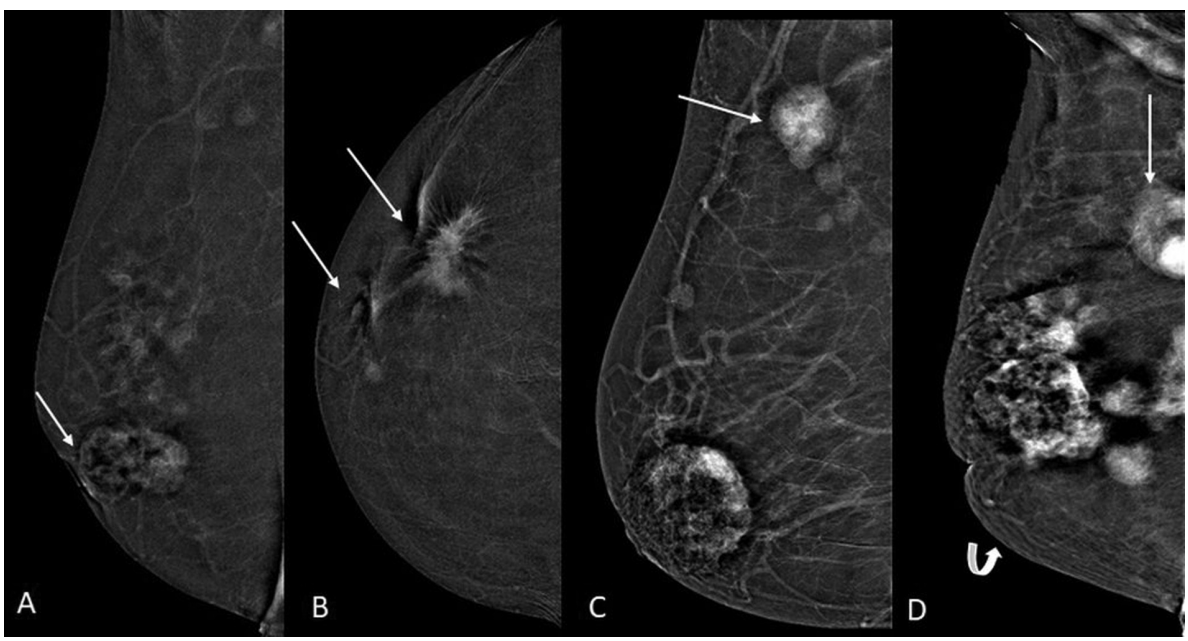

Fig. 20 Associated features in RC images. (**A**) Skin invasion (*arrow*). (**B**) Skin retraction and nipple retraction (*arrows*). (**C**) Axillary lymphadenopathy. (**D**) Skin thickening (*curved arrow*) and pectoral muscle deposit (*straight arrow*). RC, recombined images.

Conclusion

In this pictorial review, we presented findings in CEM using ACR BIRADS CEM lexicon to make the readers familiar with the findings in CEM and terminologies in CEM lexicon. In our experience interpretation and description of enhancing findings in CEM using ACR-BIRADS CEM lexicon had a quick learning curve, it was easy to implement in practice as most of the terminologies were already in use for interpreting MRI.

Conflict of Interest
None declared.

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