

# Non-mass Enhancement on Breast MRI

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# Breast MRI

- Important screening and diagnostic tool, given its high sensitivity for breast cancer detection

# Breast MRI - Indications

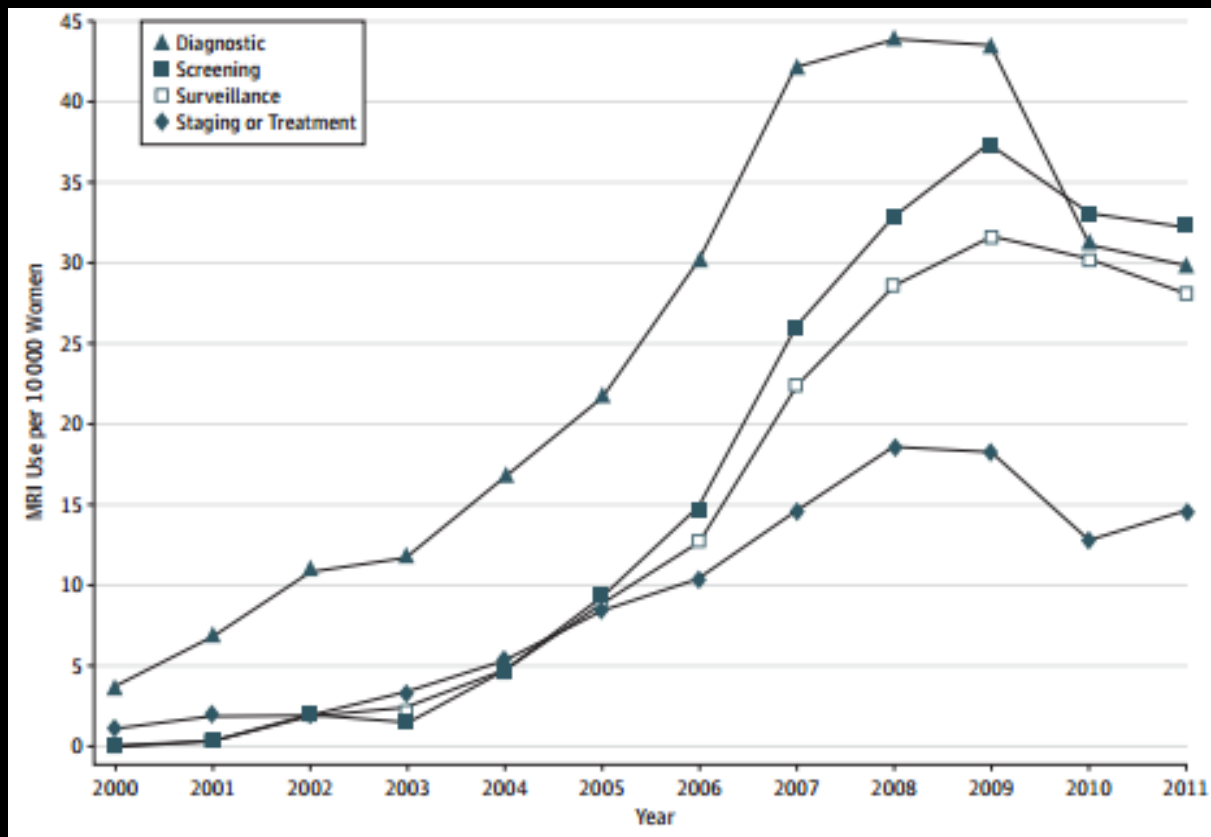
- Screening
  - *High risk screening*
  - Screening of contralateral breast in new breast cancer diagnosis
  - Implant evaluation
- Extent of disease
  - New invasive cancer/DCIS diagnosis
  - Post-lumpectomy with positive margins
  - Neoadjuvant chemotherapy response
- Additional Evaluation
  - Recurrent breast cancer
  - Axillary/metastatic breast cancer with MG/US occult disease
  - One-view MG distortion without sonographic correlate

# Breast MRI – High Risk Screening

- Carriers of *BRCA1* or *BRCA2* gene mutations
- Lifetime breast cancer risk >20% calculated by statistical models
  - Tyrer Cuzick, Gail, Claus
- History of mantle radiation therapy between 10-30 yo
- High risk syndromes
  - Li-Fraumeni syndrome, Cowden disease, Bannayan-Riley-Ruvalcaba syndrome

# Breast MRI - Use

- Rapid increase in volume



# Breast MRI – Non-mass Enhancement (NME)

- BI-RADS<sup>®</sup> definition:
  - an area of enhancement distinct from the surrounding parenchyma
  - not a space-occupying mass or focus (<5 mm area of enhancement)

# NME – Dilemmas

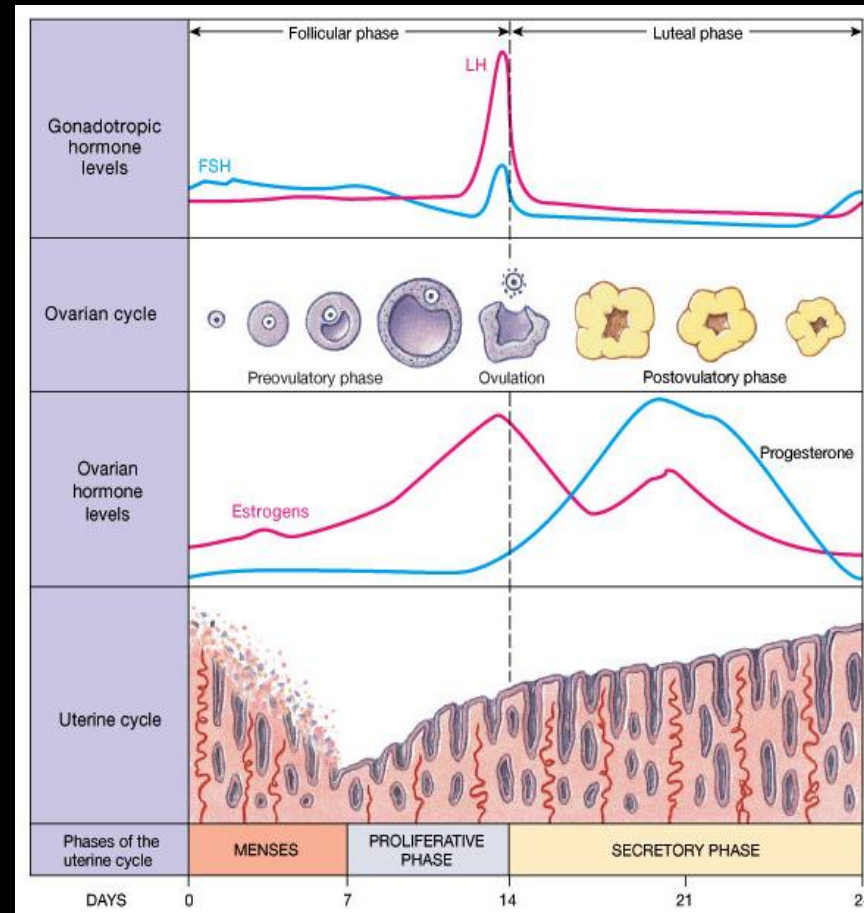
- Substantial overlap between benign, high risk, and malignant processes that can demonstrate NME

# Talk Outline

- Background Parenchymal Enhancement
- Pictorial Review of NME
- Differential Diagnosis
- Predictive Value of Lexicon
- Management
- Takeaways



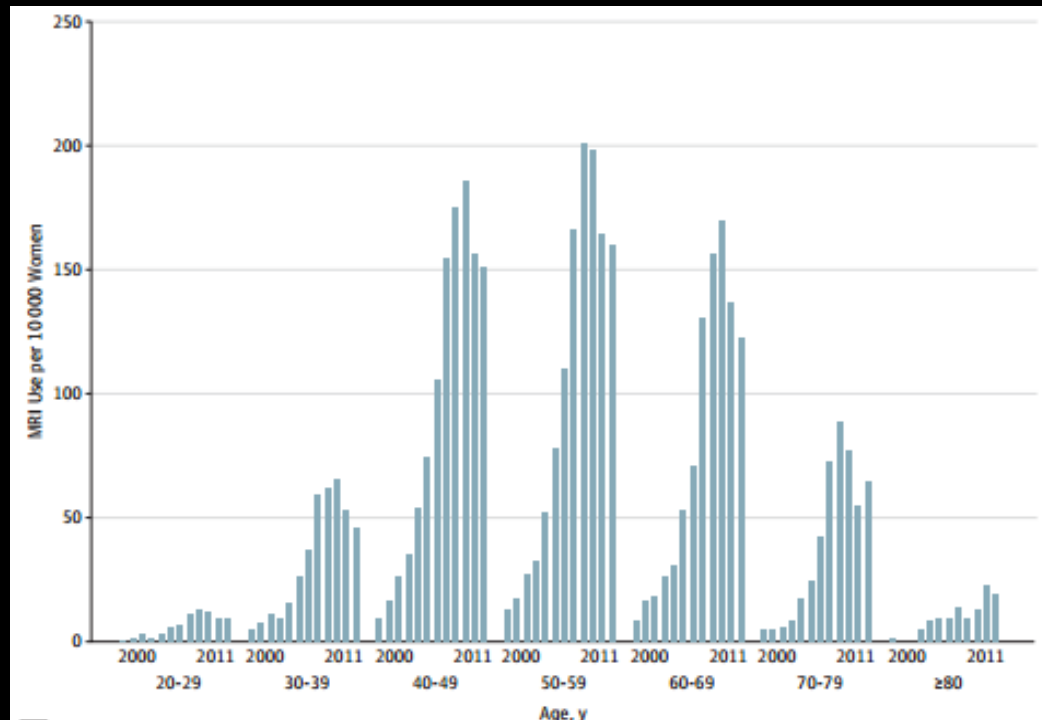
# Background Parenchymal Enhancement (BPE) – Hormonally Mediated



Best performed on days 7-15 of menstrual cycle (proliferative phase)

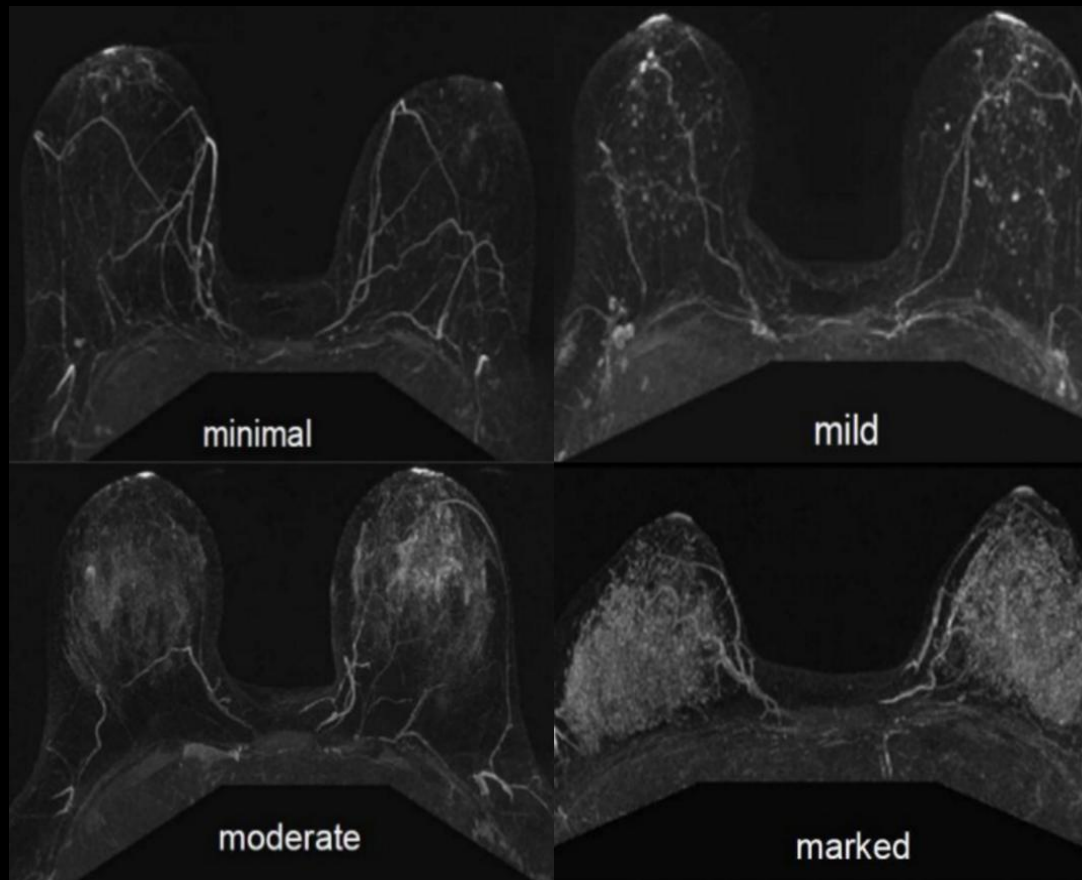
# BPE – Age

- More pronounced in younger and pre-menopausal patients (35-50y), who are constituting a greater percentage of screening patients



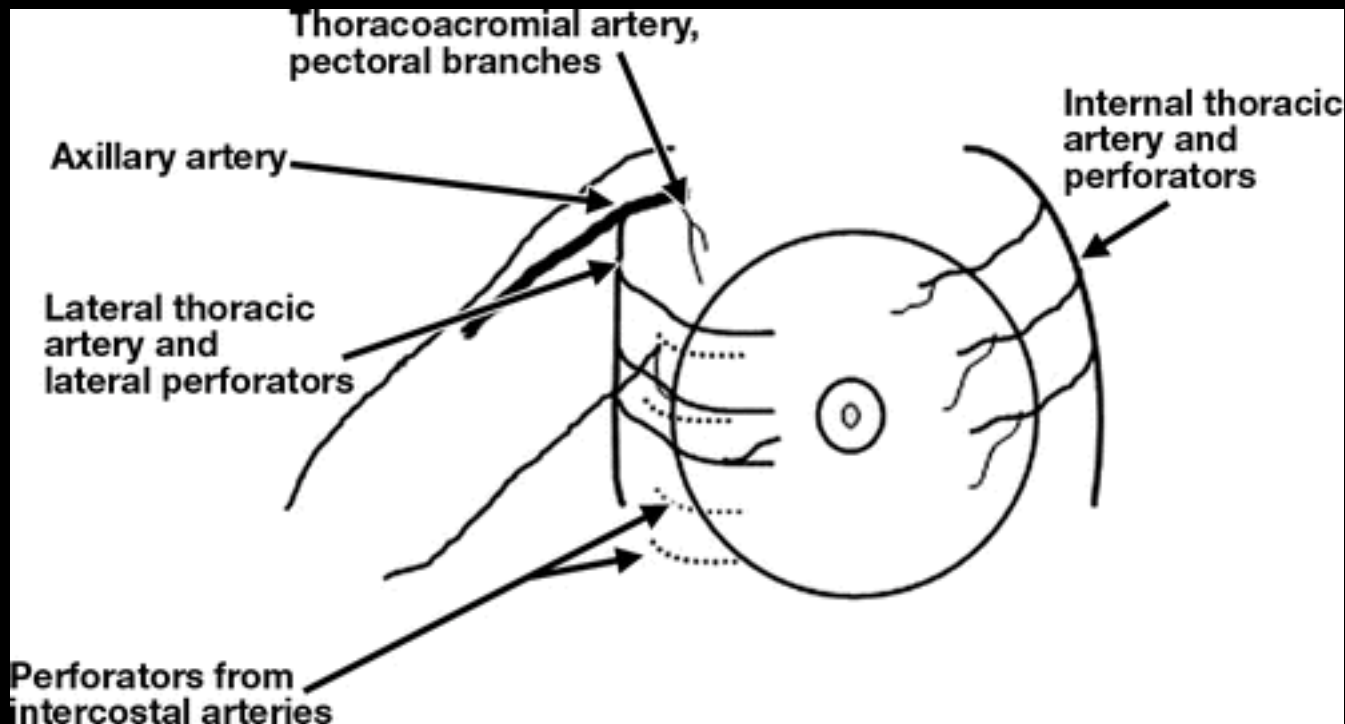
# BPE – Appearance

- Typically symmetric and diffuse

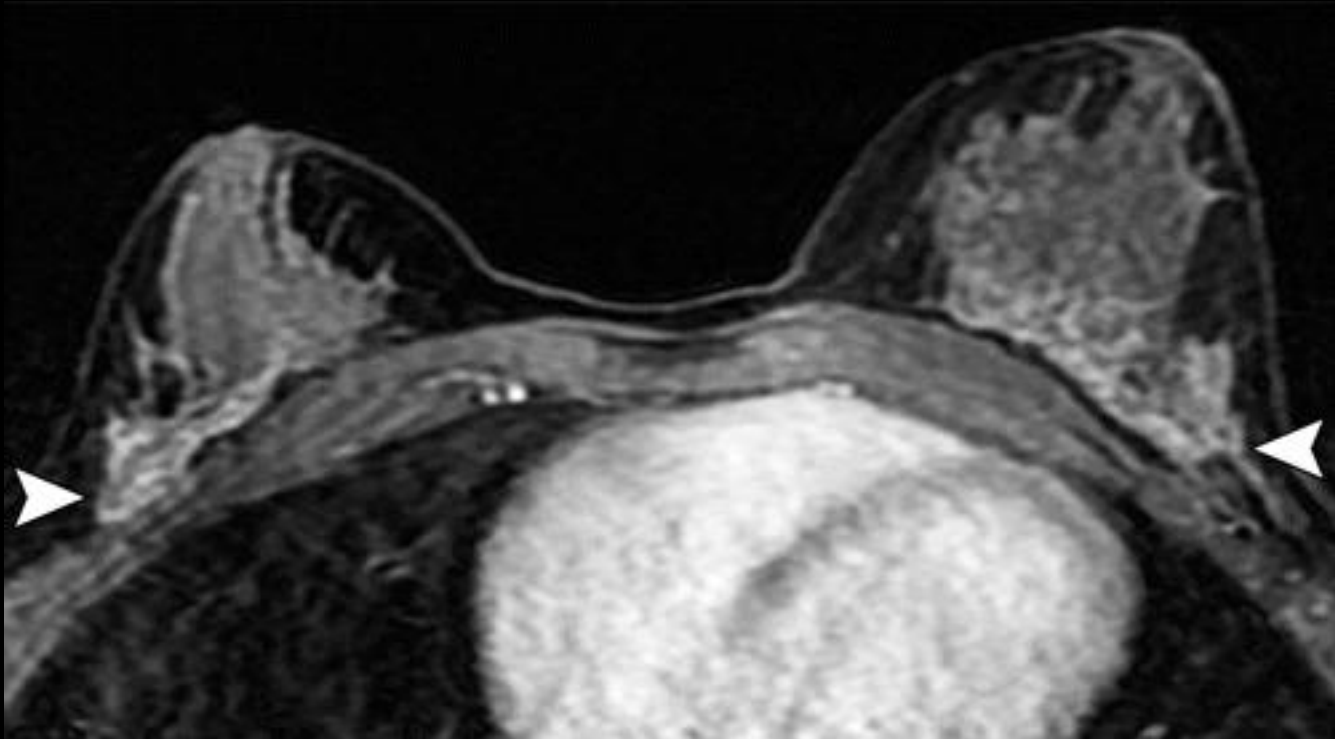


# BPE – “Picture Framing”

- Peripheral to central enhancement of breast tissue secondary to arterial supply



# BPE – “Picture Framing”



# BPE – Difficulties in Interpretation

- Higher false-positive rate in patients with moderate or severe background enhancement
- Higher rates of BI-RADS 3 categorization

**TABLE 3: BI-RADS Categories Assigned Overall and by Enhancement Category**

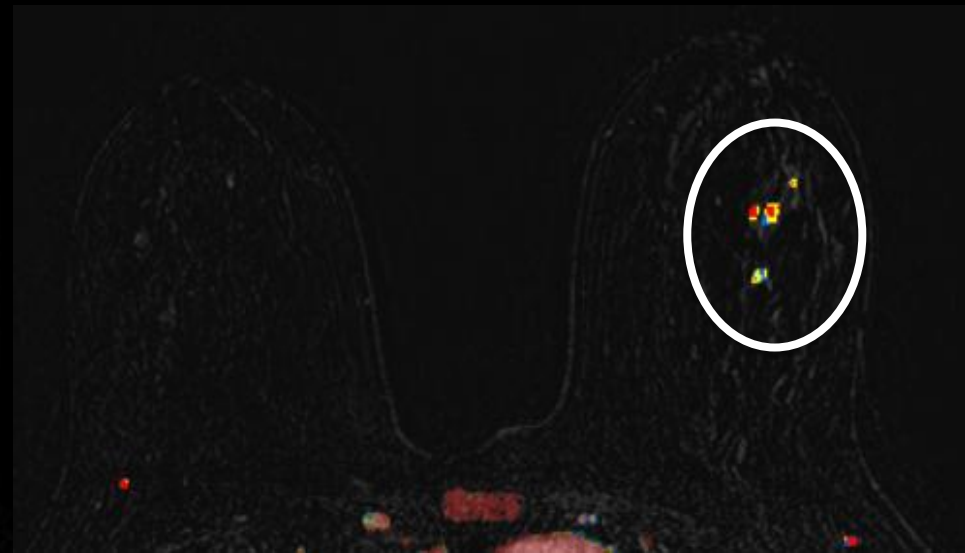
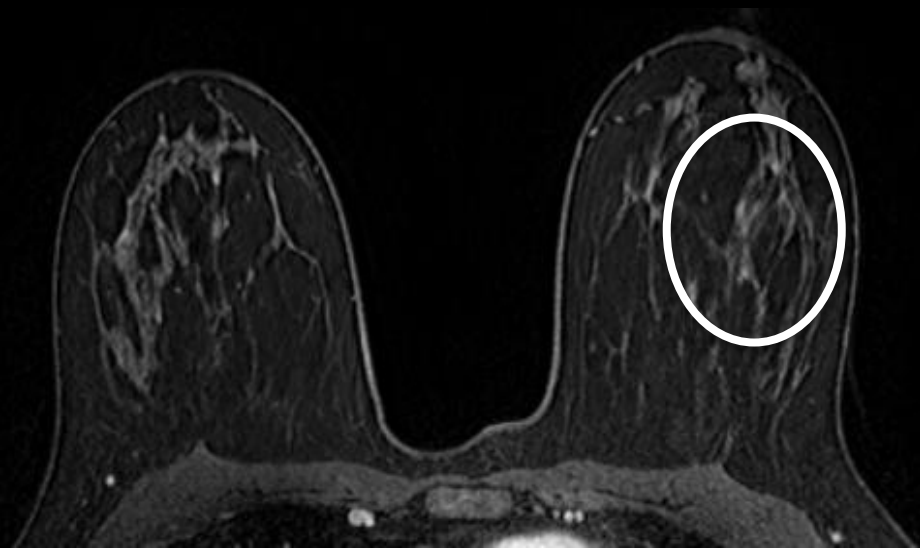
BI-RADS Category	All Women (n = 250)	Background Parenchymal Enhancement			
		Minimal (n = 62)	Mild (n = 85)	Moderate (n = 60)	Marked (n = 43)
1	60 (24.0)	26 (41.9)	16 (18.8)	14 (23.3)	4 (9.3)
2	48 (19.2)	14 (22.6)	17 (20.0)	10 (16.7)	7 (16.3)
1 and 2	108 (43.2)	40 (64.5)	33 (38.8)	24 (40.0)	11 (25.6)
3	109 (43.6)	17 (27.4)	40 (47.1)	27 (45.0)	25 (58.1)
4	28 (11.2)	4 (6.5)	10 (11.8)	8 (13.3)	6 (14.0)
5	5 (2.0)	1 (1.6)	2 (2.4)	1 (1.7)	1 (2.3)
4 and 5	33 (13.2)	5 (8.1)	12 (14.1)	9 (15.0)	7 (16.3)

Note—Data presented are number (%) of patients.

# BPE – Problems

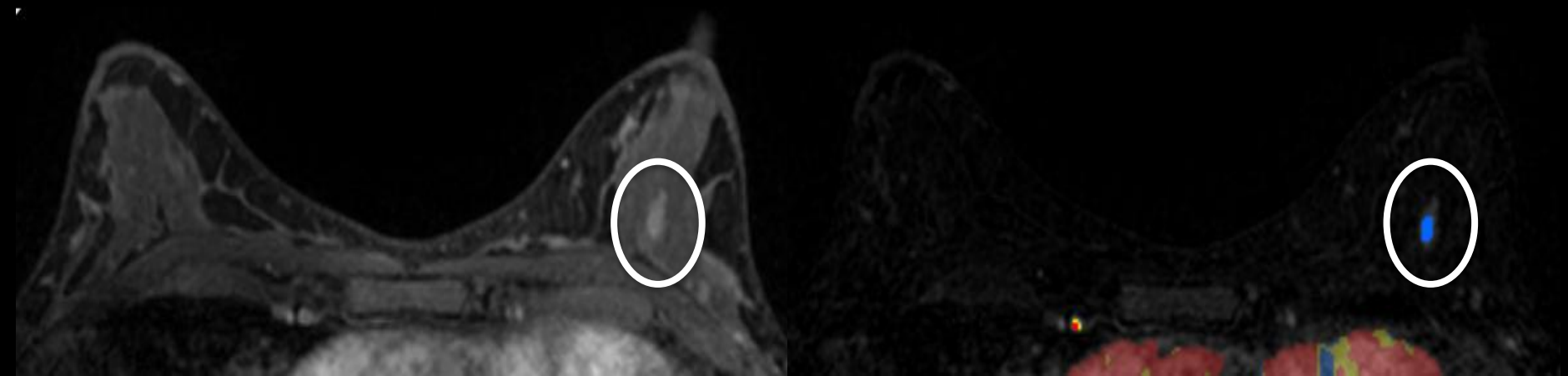
- Can be asymmetric, focal, or regional
  - Frequently described as patchy, focal, or nodular
- Can be difficult to differentiate from NME

# BPE - Nodular



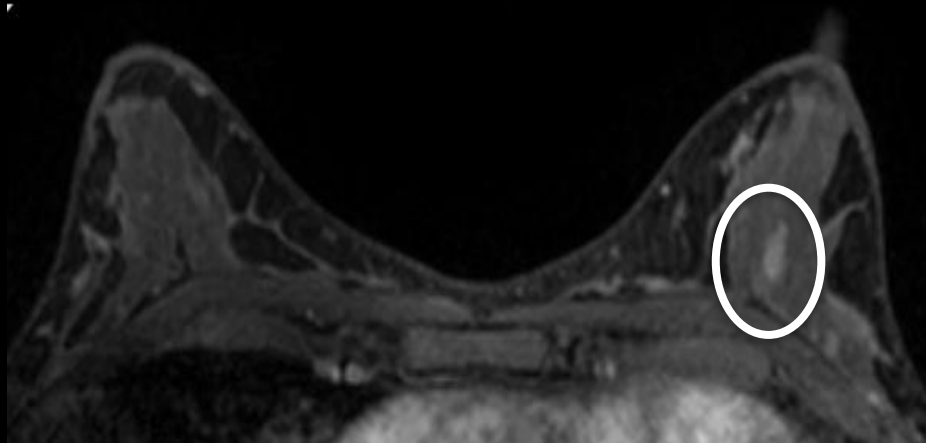


# BPE - Focal



# BPE - Focal

MRI



MRI-guided Biopsy



# Non-mass Enhancement (NME)

ACR BI-RADS® ATLAS

Breast Imaging Reporting and Data System

2013



Non-mass enhancement (NME)	Distribution	Focal
		Linear
		Segmental
		Regional
		Multiple regions
		Diffuse
	Internal enhancement patterns	Homogeneous
		Heterogeneous
		Clumped
		Clustered ring

# Non-mass Enhancement (NME)

ACR BI-RADS® ATLAS  
Breast Imaging Reporting and Data System

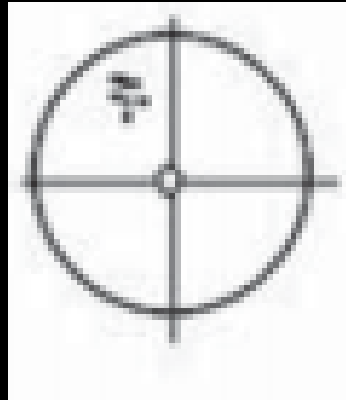
2013



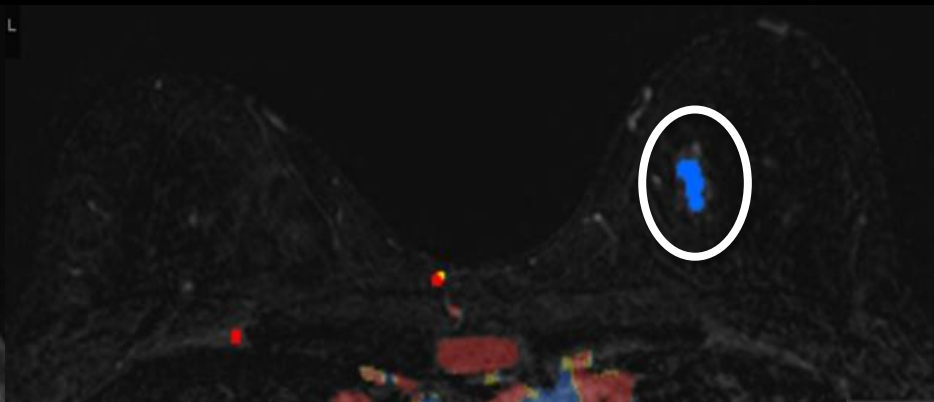
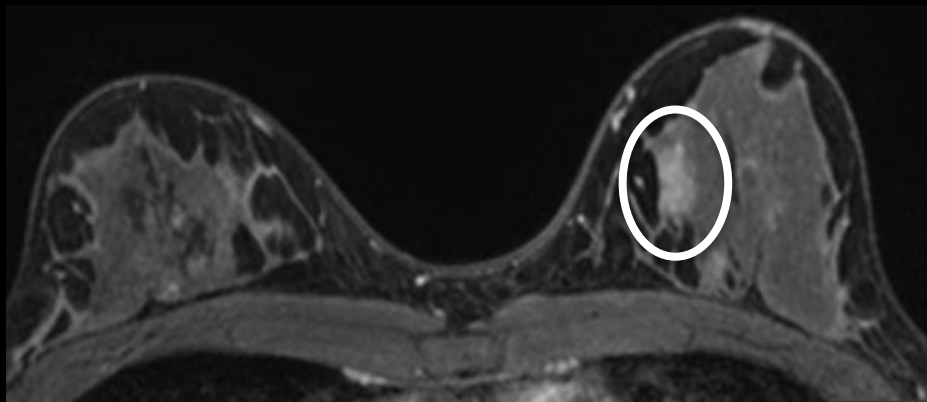
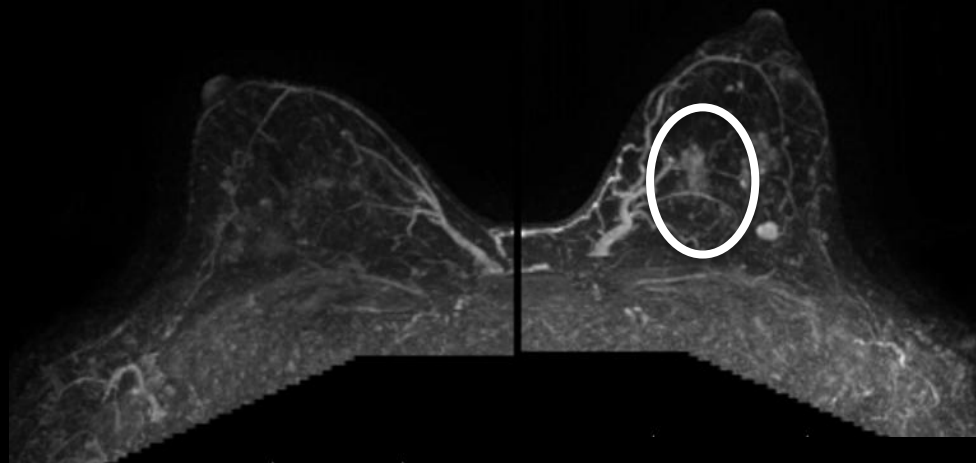
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		Linear
		Segmental
		Regional
		Multiple regions
		Diffuse
	Internal enhancement patterns	Homogeneous
		Heterogeneous
		Clumped
		Clustered ring

# NME Distribution – Focal

- Enhancement in a confined area, <25% of a quadrant

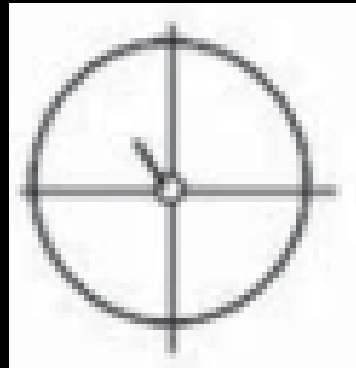


# NME Distribution – Focal

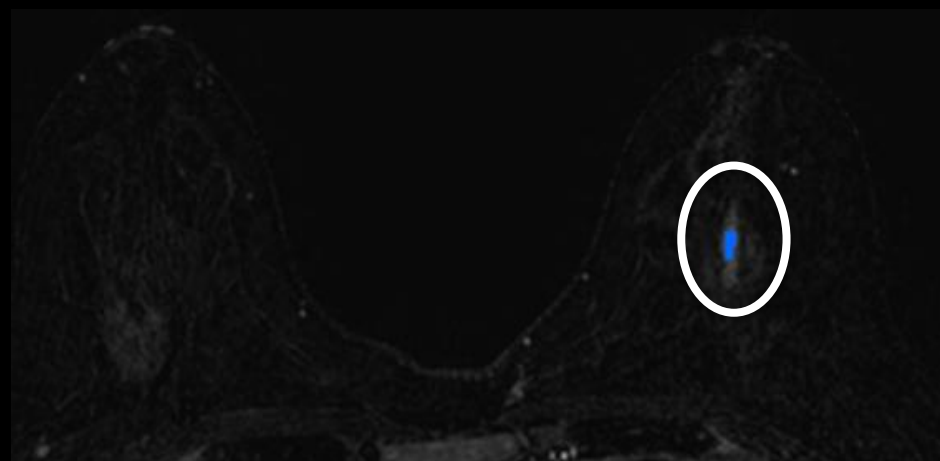
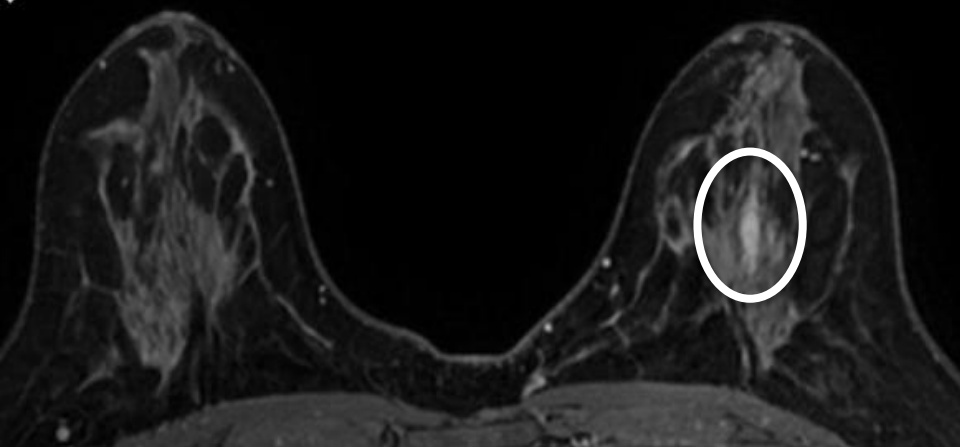
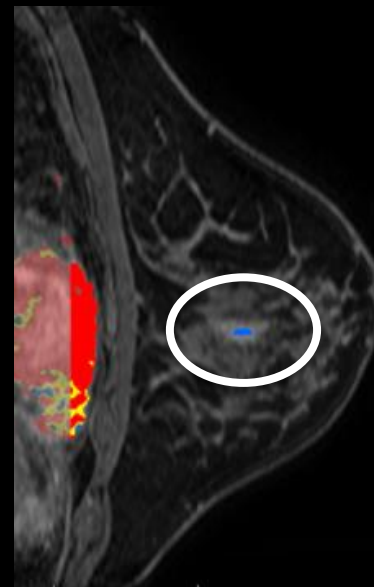
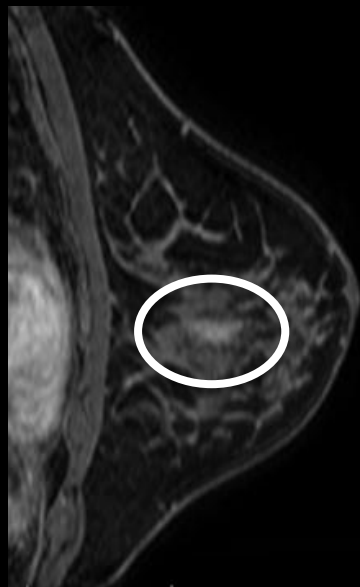


# NME Distribution – Linear/Ductal

- Linear: Enhancement in a line that may not conform to a duct
- Ductal: Enhancement in a line that may have branching, conforming to a duct
  - *“Ductal” distribution eliminated from 2013 BI-RADS® (5<sup>th</sup> edition) due to underuse*



# NME Distribution – Linear



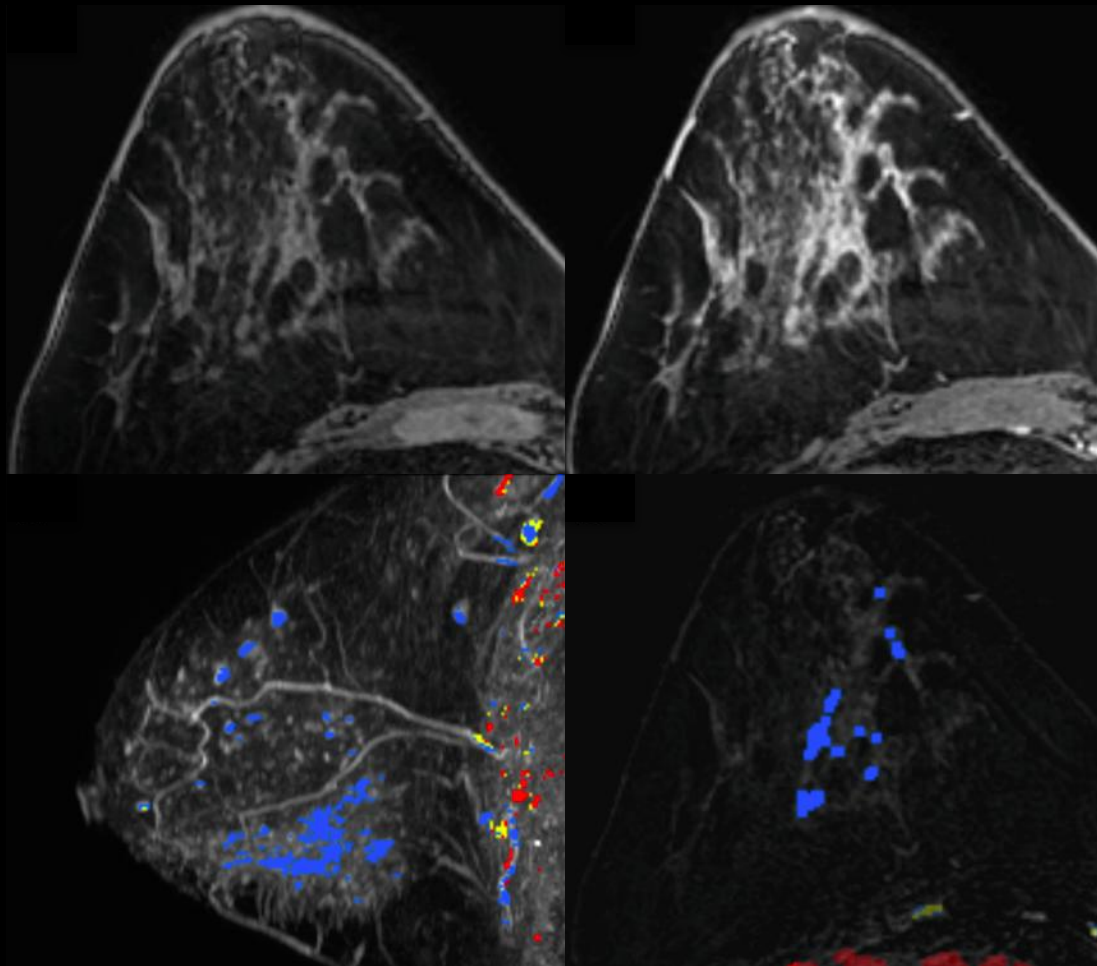


# NME Distribution – Segmental

- Triangular region of enhancement, apex pointing to the nipple, suggesting a duct or its branches

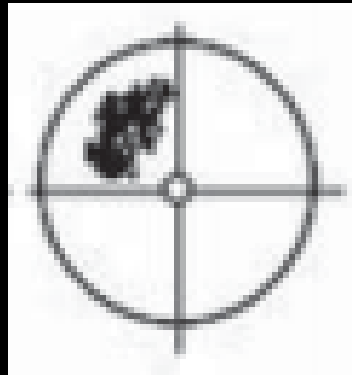


# NME Distribution - Segmental

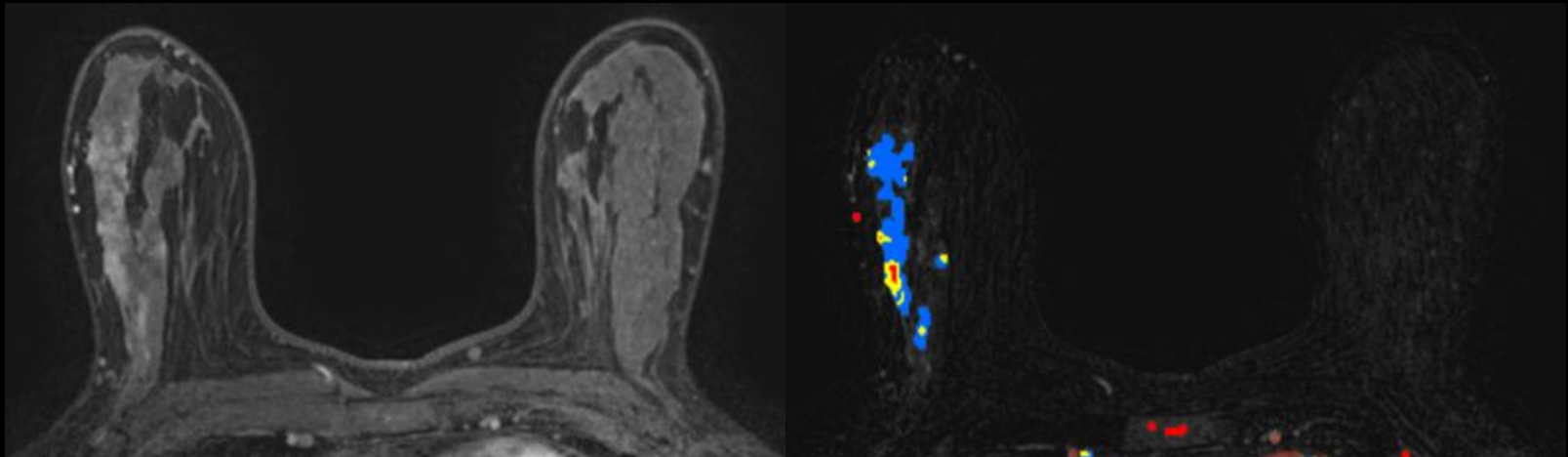
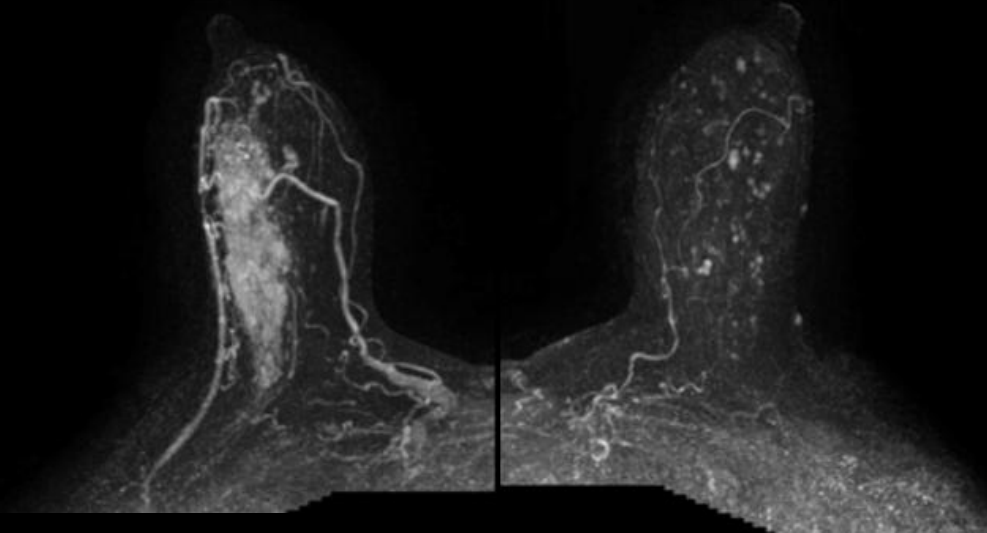


# NME Distribution – Regional

- Enhancement in a large volume of tissue not conforming to a ductal distribution, geographic

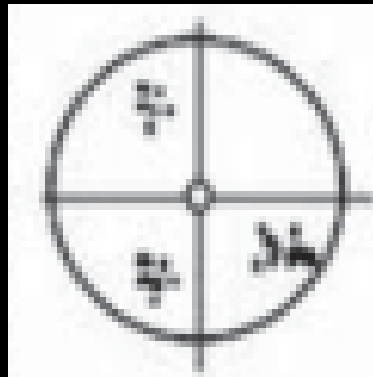


# NME Distribution – Regional

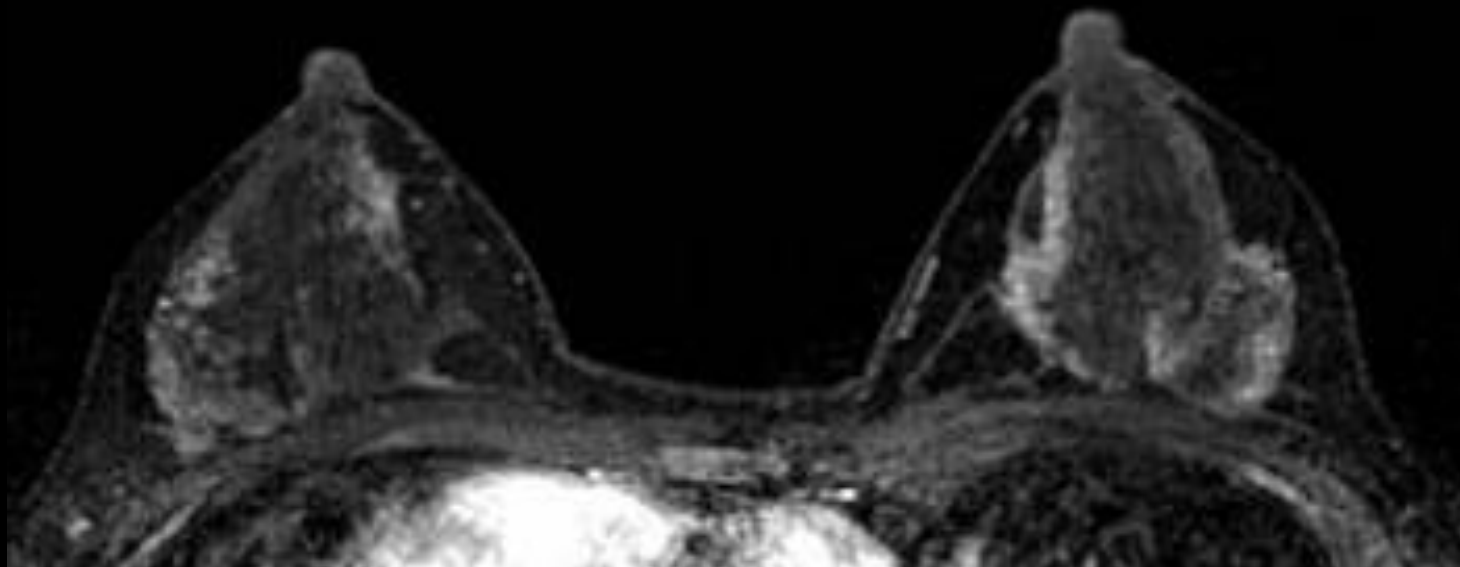


# NME Distribution – Multiregional

- Enhancement in at least two large volumes of tissue not conforming to a ductal distribution, multiple geographic area
  - Typically due to BPE

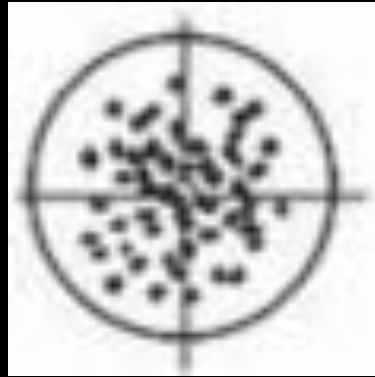


# NME Distribution – Multiregional

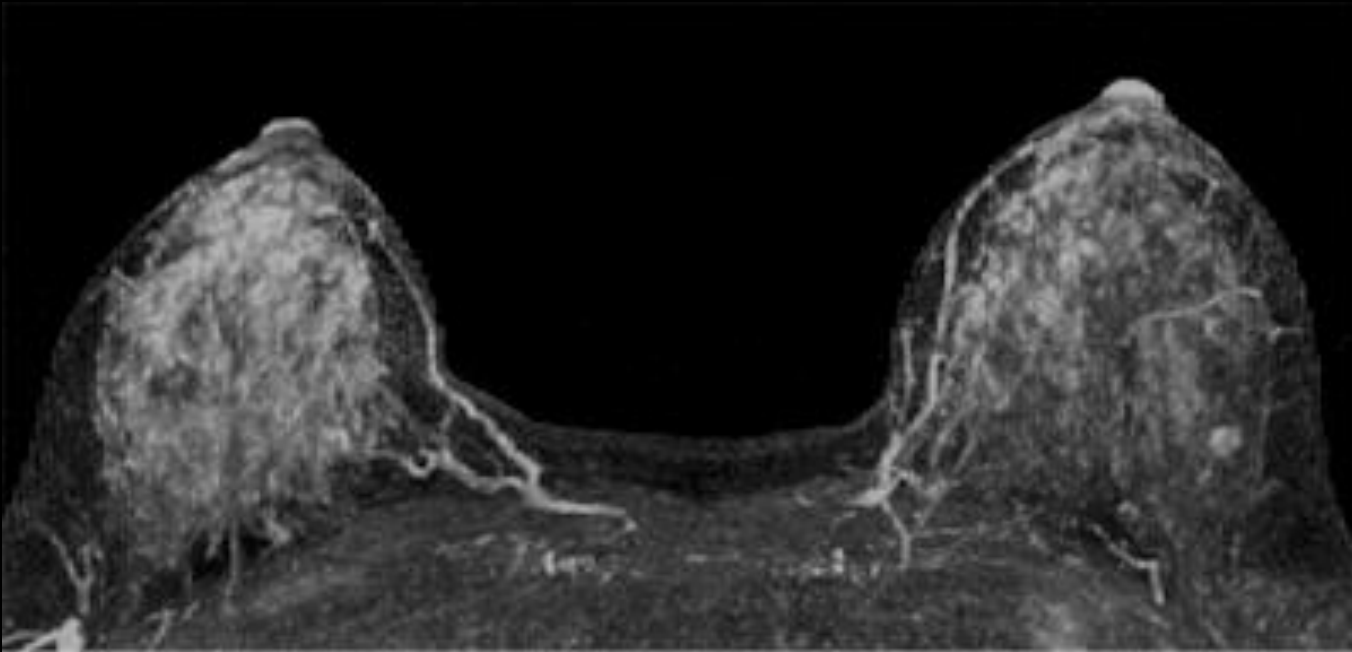


# NME Distribution – Diffuse

- Enhancement distributed uniformly throughout the breast
  - Typically due to BPE



# NME Distribution – Diffuse





# Non-mass Enhancement (NME)

ACR BI-RADS® ATLAS

Breast Imaging Reporting and Data System

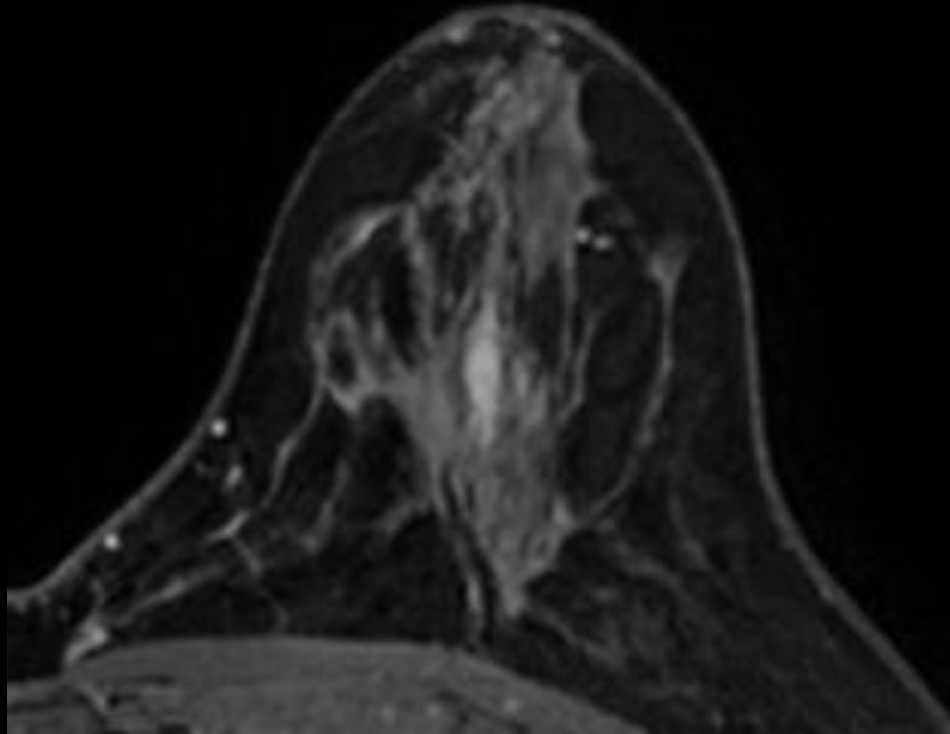
2013



Non-mass enhancement (NME)	Distribution	Focal
		Linear
		Segmental
		Regional
		Multiple regions
		Diffuse
	Internal enhancement patterns	Homogeneous
		Heterogeneous
		Clumped
		Clustered ring

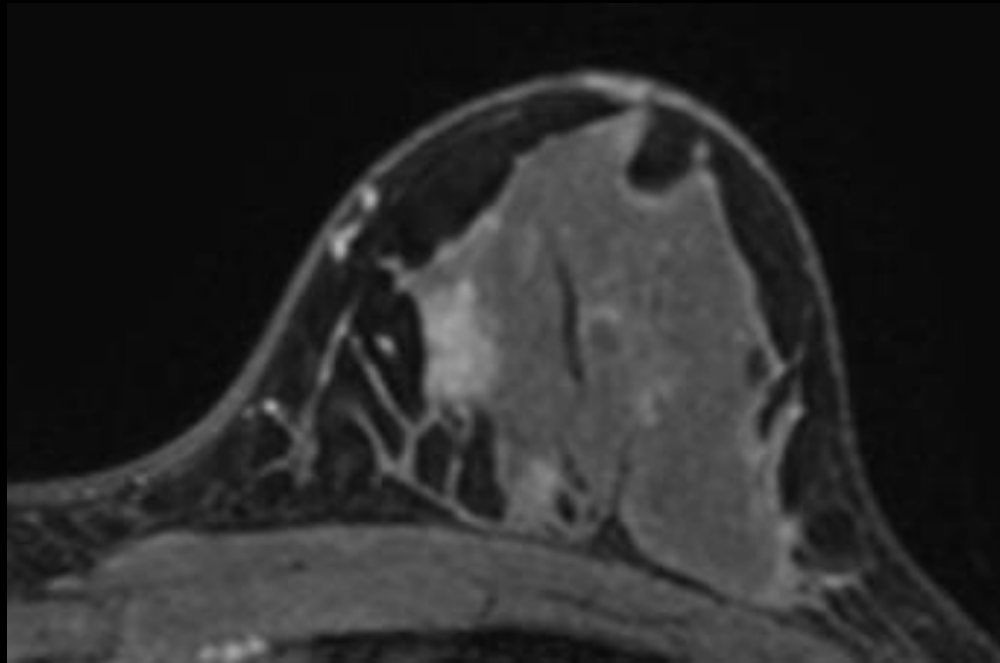
# NME Internal Enhancement – Homogenous

- Confluent, uniform enhancement



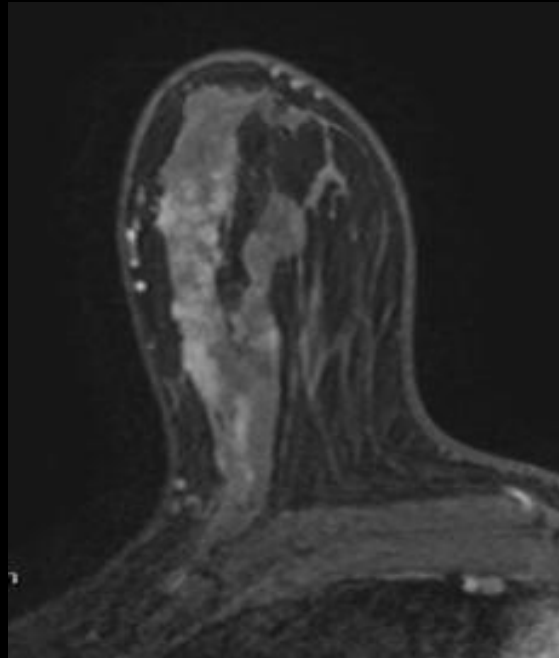
# NME Internal Enhancement – Heterogenous

- Nonuniform enhancement in a random pattern



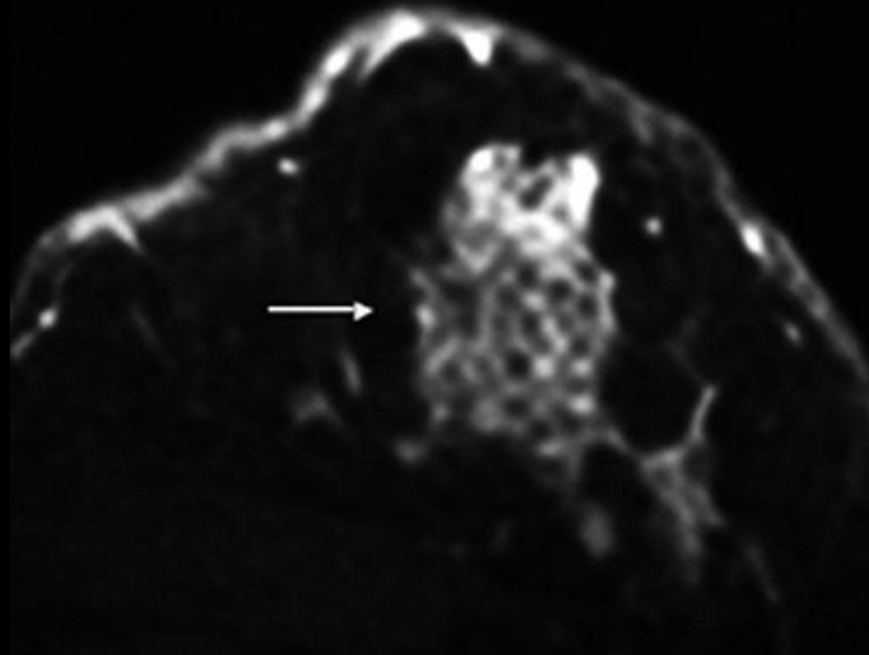
# NME Internal Enhancement – Clumped

- Cobblestone-like enhancement, with occasional confluent areas

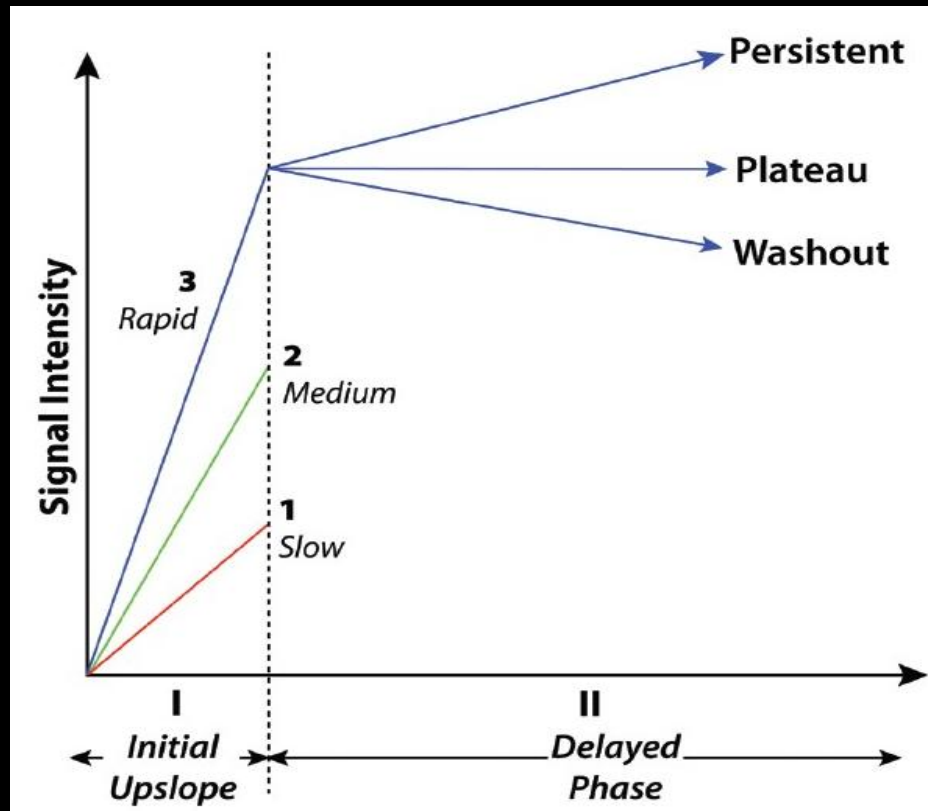


# NME Internal Enhancement – Clustered Ring

- Minute ring enhancements which are clustered
  - *Added in 2013 BI-RADS® (5<sup>th</sup> edition)*



# NME – Kinetics



# NME – Differential Diagnosis

## Benign

- Fibrocystic changes
- Focal adenosis
- Apocrine metaplasia
- Pseudoangiomatous stromal hyperplasia
- Radiation effect

## High Risk

- Radial scar/ complex sclerosing lesion
- Intraductal papilloma
- Flat epithelial atypia
- Atypical ductal hyperplasia

## Malignant

- *Ductal carcinoma in situ*
- Invasive ductal carcinoma
- Invasive lobular carcinoma

# NME – DCIS

- Distribution
  - Most common: linear, segmental
  - Less common: regional, focal
- Internal Enhancement Pattern
  - Clustered ring
  - Clumped
  - Heterogeneous



# Predictive Value of BI-RADS® Lexicon

- Lexicon for *masses* can be highly predictive for malignancy
- Predictive value of *non mass enhancement* lexicon mixed in literature

# Breast Lesions Detected on MR Imaging: Features and Positive Predictive Value

- Retrospective
- Highest PPV:
  - Segmental
  - Clumped Linear/Ductal

**TABLE 3 Nonmass Morphologic Descriptors: Frequency and Positive Predictive Value**

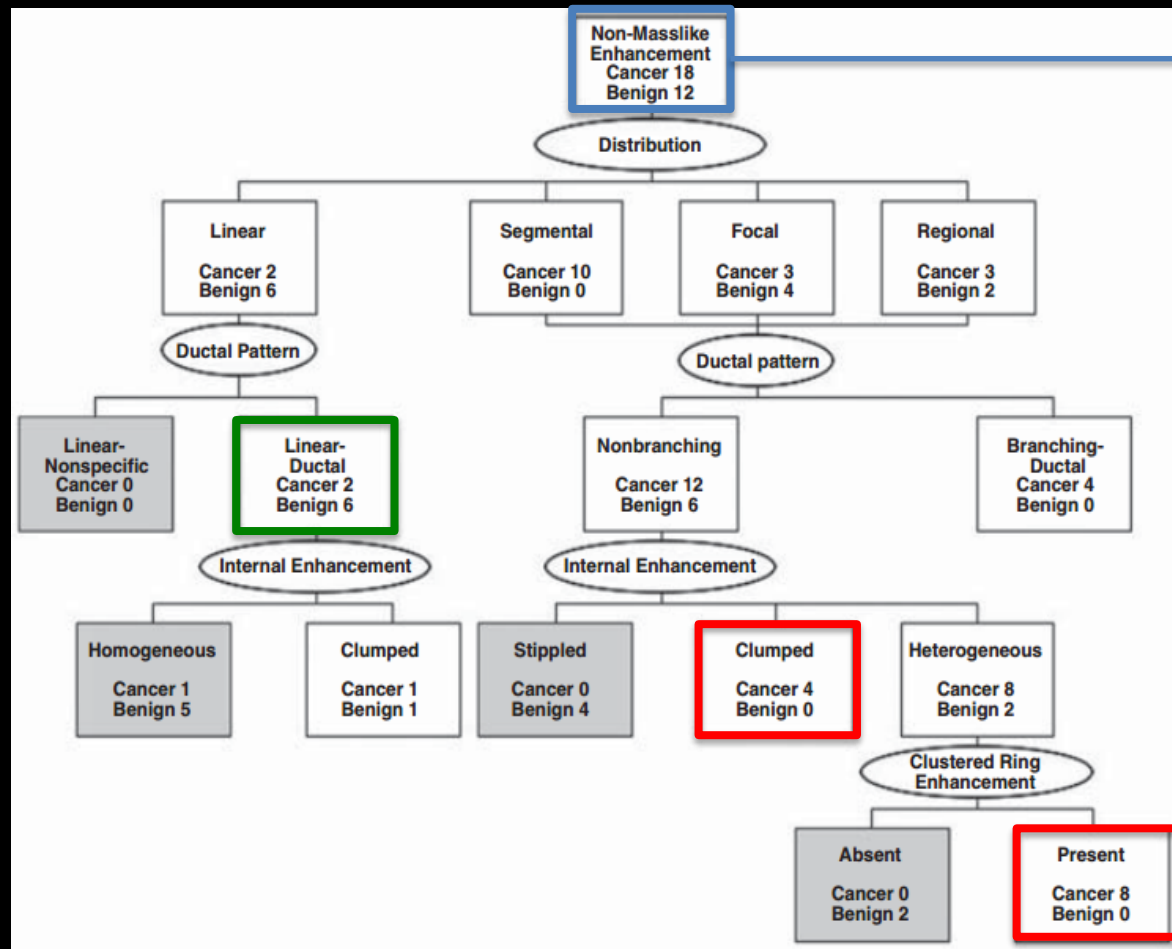
Descriptor	No. of Lesions <sup>a</sup>	No. of Cancers <sup>b</sup>	Cancer Histology <sup>c</sup>	
			Invasive	In Situ
<b>Linear/ductal</b>				
Clumped	16 (40)	5 (31)	0 (0)	5 (100)
Irregular	2 (5)	0 (0)	0 (0)	0 (0)
Smooth	3 (7)	0 (0)	0 (0)	0 (0)
All linear/ductal	21 (53)	5 (24)	0 (0)	5 (100)
<b>Regional</b>				
Stippled	4 (10)	0 (0)	0 (0)	0 (0)
Clumped	3 (8)	2 (67)	1 (50)	1 (50)
Heterogeneous	7 (18)	1 (14)	0 (0)	1 (100)
All regional	14 (35)	3 (21)	1 (33)	2 (67)
<b>Segmental</b>				
Clumped	3 (7)	2 (67)	0 (0)	2 (100)
<b>Linear/nonspecific</b>				
Heterogeneous	2 (5)	0 (0)	0 (0)	0 (0)
<b>All nonmasses</b>	<b>40 (100)</b>	<b>10 (25)</b>	<b>1 (10)</b>	<b>9 (90)</b>



## High-Spatial-Resolution MRI of Non-Masslike Breast Lesions: Interpretation Model Based on BI-RADS MRI Descriptors

- Retrospective
- Most benign descriptors:
  - Linear, homogenous enhancement
- Most frequent malignant descriptors:
  - Segmental, clustered ring enhancement (PPV 100%)
  - Segmental, clumped enhancement (PPV 88%)

# High-Spatial-Resolution MRI of Non-Masslike Breast Lesions: Interpretation Model Based on BI-RADS MRI Descriptors



Small sample size

- Prospective
- Ductal distribution and clumped internal enhancement had highest PPV of malignancy

**Evaluation of Cancers by NMLE Features for BI-RADS Category 0, 3, 4, and 5 Assessments**

NMLE Feature	No. of Patients*	No. of Patients with Cancer	PPV†
<b>Type</b>			
Focal area	27 (26.5)	3	0.111 (0.024, 0.292)
Linear	12 (11.8)	2	0.167 (0.021, 0.484)
<b>Ductal</b>	<b>10 (9.8)</b>	<b>5</b>	<b>0.500 (0.187, 0.813)</b>
Segmental	20 (19.6)	2	0.100 (0.012, 0.317)
Regional	23 (22.6)	1	0.043 (0.001, 0.219)
Multiple regions	6 (5.9)	0	0 (0, 0.459)
Diffuse	4 (3.9)	0	0 (0, 0.602)
<b>Degree of symmetry</b>			
Not applicable	2 (2.0)	0	0 (0, 0.842)
Symmetric	10 (9.8)	0	0 (0, 0.308)
Asymmetric	90 (88.2)	13	0.144 (0.079, 0.234)
<b>Internal enhancement characteristics</b>			
Homogeneous	19 (18.6)	1	0.053 (0.001, 0.260)
Heterogeneous	40 (39.2)	3	0.075 (0.016, 0.204)
Stippled or punctate	13 (12.8)	0	0 (0, 0.247)
<b>Clumped</b>	<b>23 (22.6)</b>	<b>7</b>	<b>0.304 (0.132, 0.529)</b>
Reticular or dendritic	7 (6.9)	2	0.286 (0.037, 0.710)

# NME Kinetics – Predictive Value

- Kinetics not predictive of malignancy

**Evaluation of Cancers by Kinetic Features for BI-RADS Category 0, 3, 4, and 5 Assessments**

Kinetic Feature	No. of Patients*	No. of Patients with Cancer	PPV†
<b>Initial enhancement phase (<i>n</i> = 201)‡</b>			
Slow	40 (19.9)	2	0.050 (0.006, 0.169)
Medium	82 (40.8)	8	0.098 (0.043, 0.183)
Rapid	79 (39.3)	12	0.152 (0.081, 0.250)
Total	201 (100)	22	
<b>Delayed enhancement phase (<i>n</i> = 209)§</b>			
Persistent	98 (46.9)	5	0.051 (0.017, 0.115)
Plateau	66 (31.6)	10	0.152 (0.075, 0.261)
Washout	45 (21.5)	8	0.178 (0.080, 0.321)
Total	209 (100)	23	...

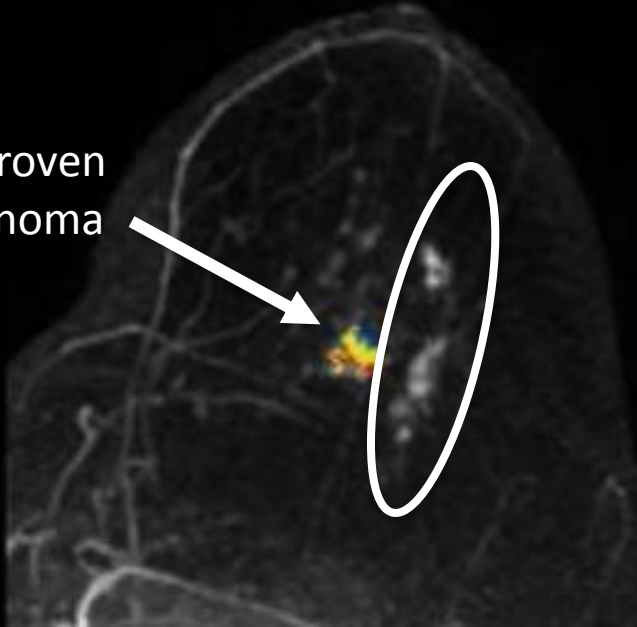
# NME – Predictive Value

- Interobserver variability in MRI interpretation likely resulting in varied PPVs of NME lexicon in the literature

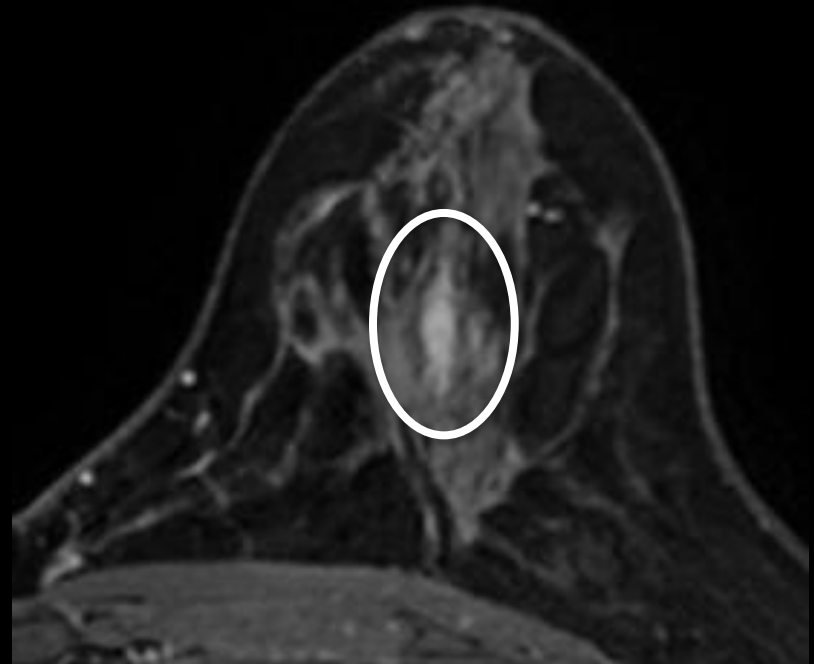
# Case 1 – Linear NME

**Patient A**

Biopsy-proven  
fibroadenoma



**Patient B**

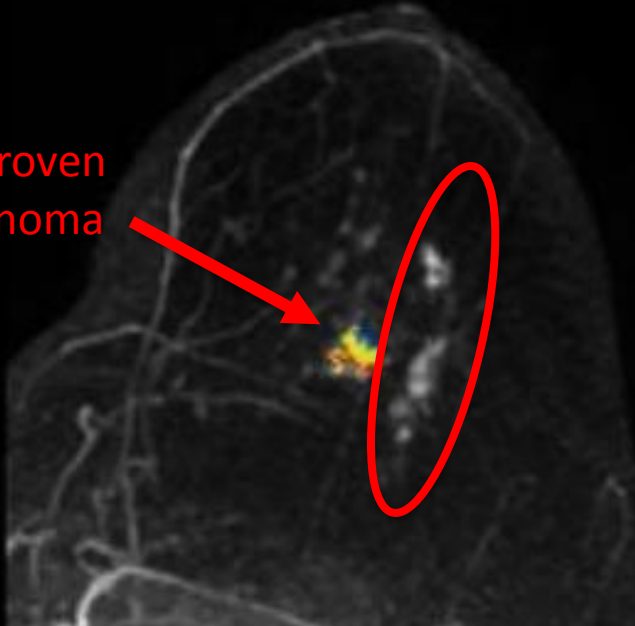




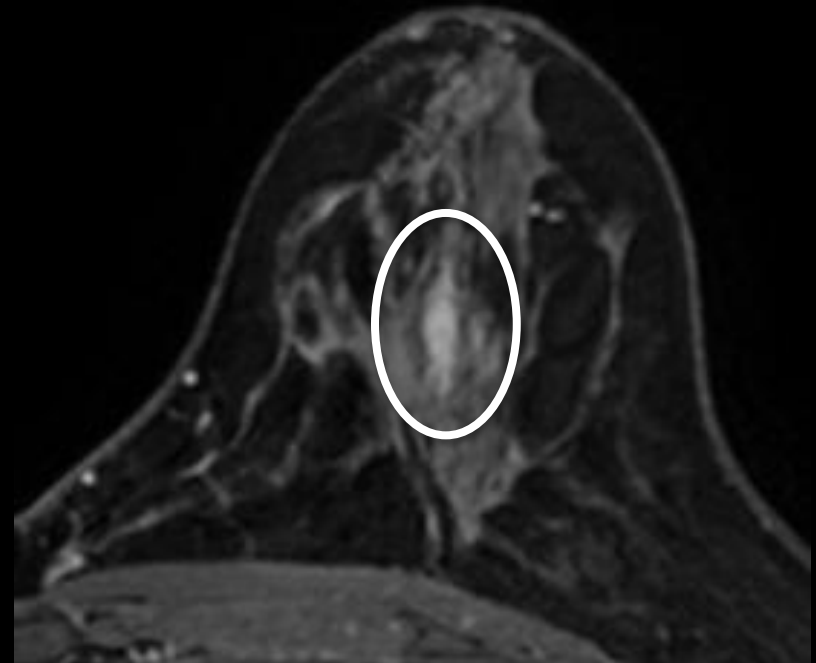
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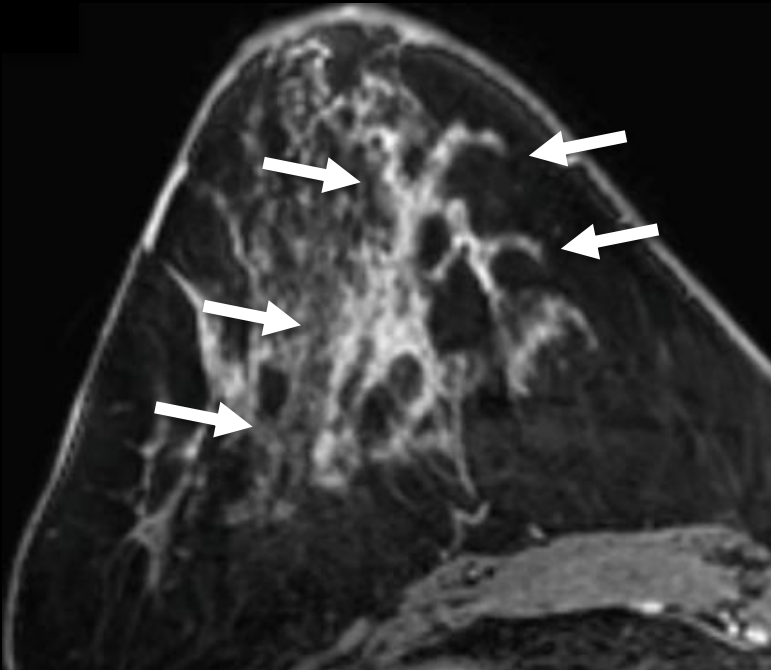


**Patient B**

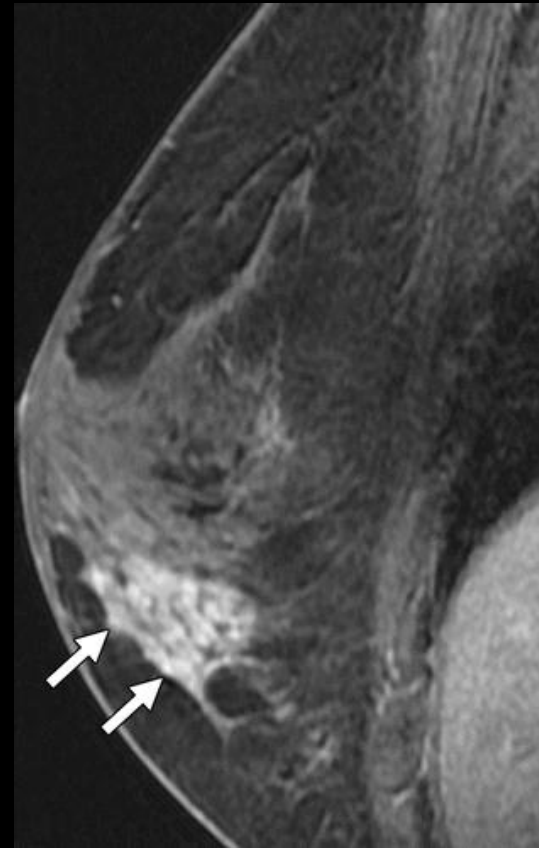


# Case 2 – Segmental NME

**Patient A**

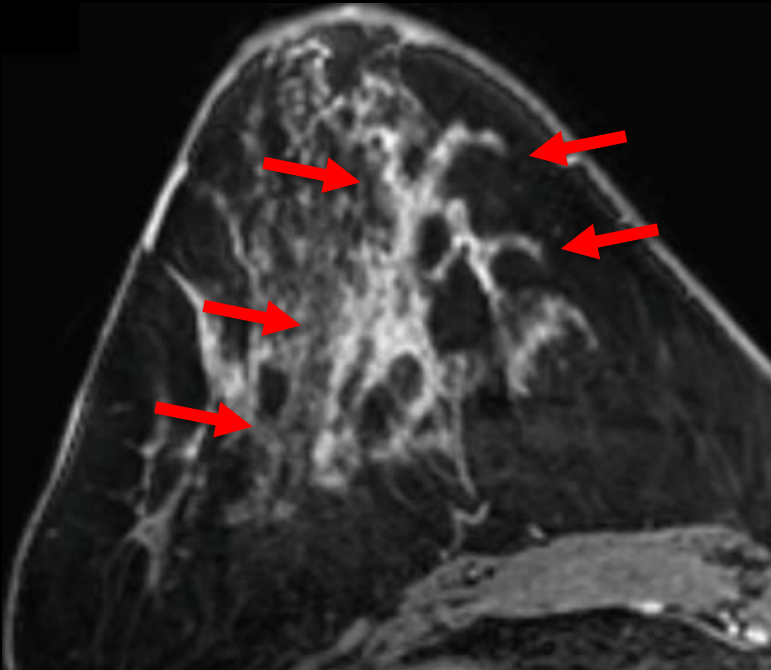


**Patient B**

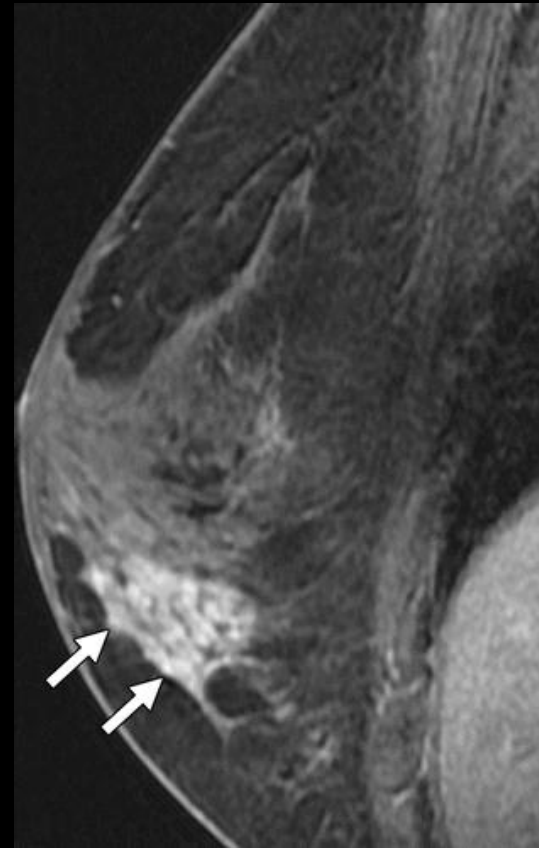


# Case 2 – Segmental NME

**Patient A**



**Patient B**

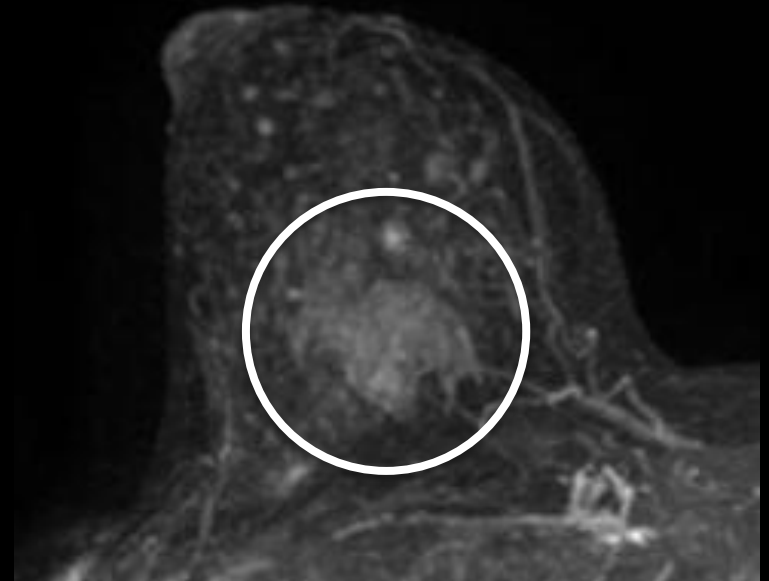


# Case 3 – Regional NME

**Patient A**



**Patient B**

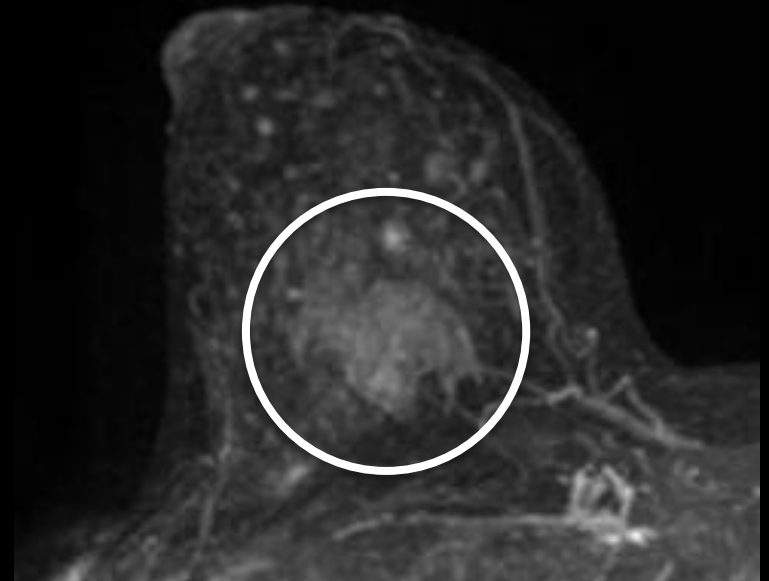


# Case 3 – Regional NME

**Patient A**



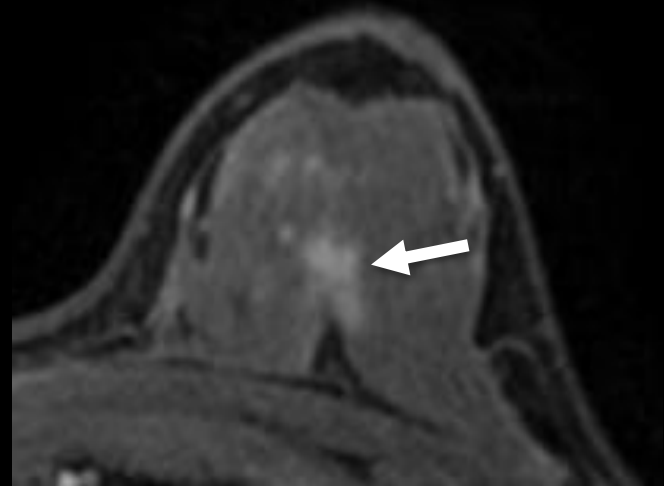
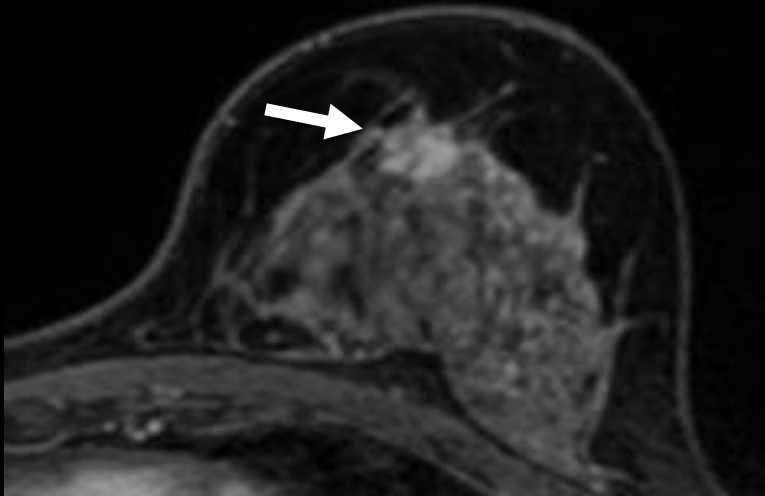
**Patient B**



# Case 4 – Focal NME

**Patient A**

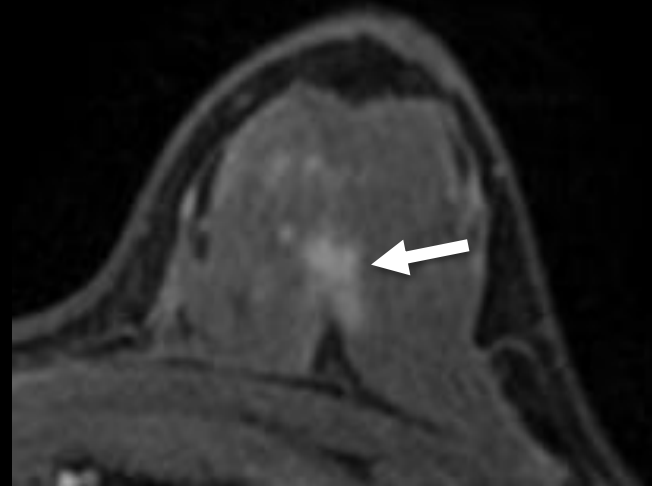
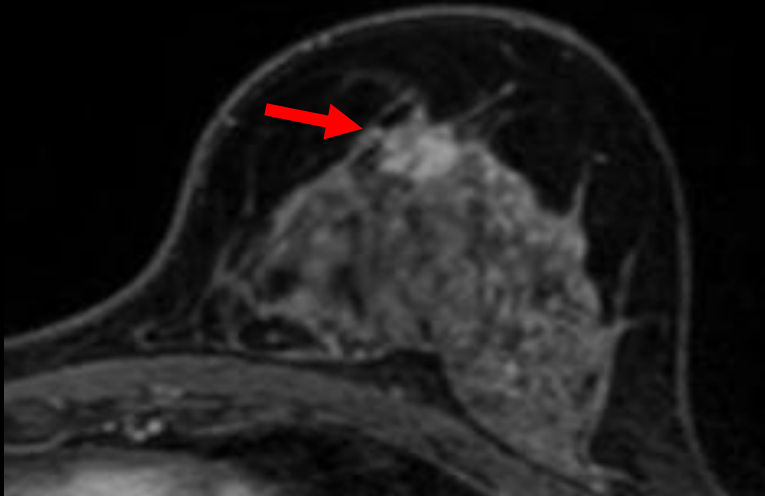
**Patient B**



# Case 4 – Focal NME

**Patient A**

**Patient B**



# NME – Management

- Biopsy (BI-RADS 4) often pursued, given substantial overlap in imaging appearances of benign and malignant causes of NME
- Surveillance (BI-RADS 3) an option, particularly if multiple or bilateral findings of low suspicion



# NME – Rad-Path Concordance

- Does the pathology explain the findings?
- Also correlate with features on other modalities (MG, US)

# NME – Rad-Path Concordance

## Benign

- Fibrocystic changes
- Focal adenosis
- Apocrine metaplasia
- Pseudoangiomatous stromal hyperplasia
- Radiation effect

## High Risk

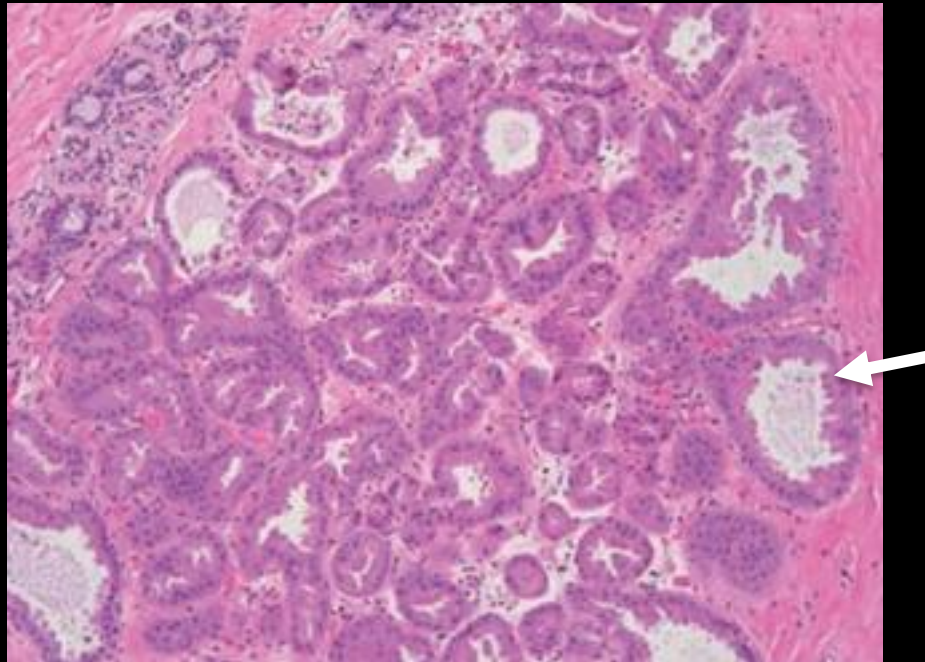
- Radial scar/ complex sclerosing lesion
- Intraductal papilloma
- Flat epithelial atypia
- Atypical ductal hyperplasia

## Malignant

- *Ductal carcinoma in situ*
- Invasive ductal carcinoma
- Invasive lobular carcinoma

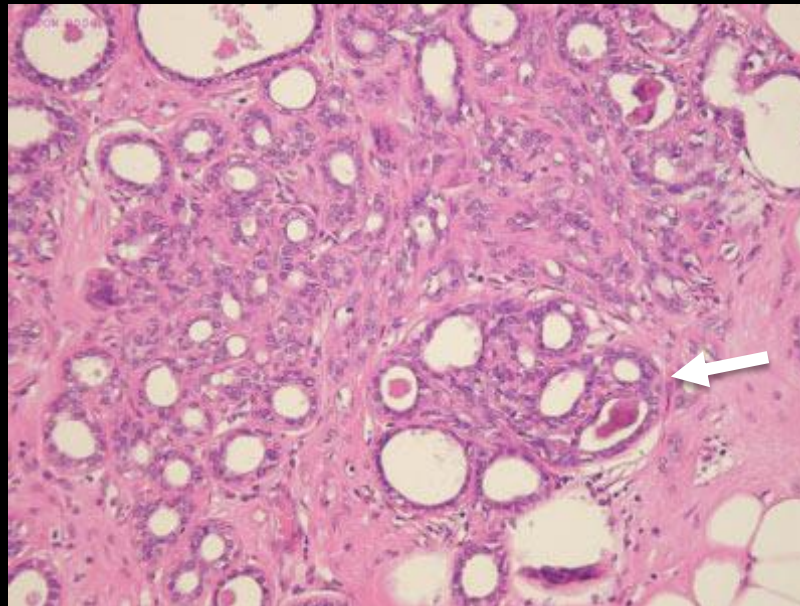
# Rad-Path Concordance – Benign

- Fibrocystic changes/apocrine metaplasia: focal or regional distribution
  - Coarse calcs on MG, lobulated mass on US



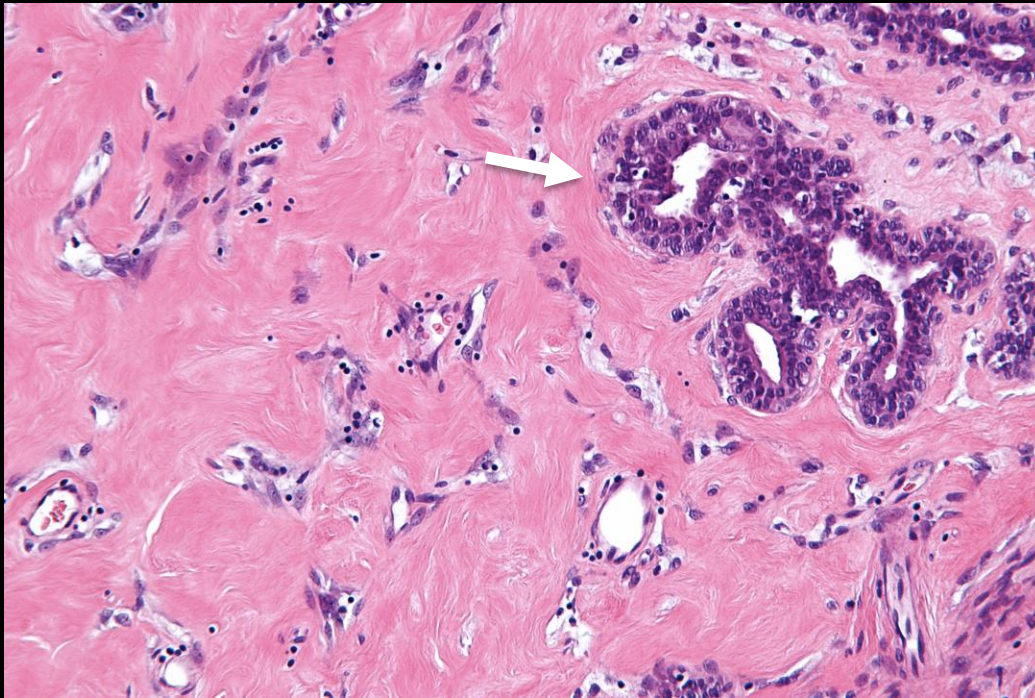
# Rad-Path Concordance – Benign

- Focal adenosis: focal distribution, variable internal enhancement
  - Simple, sclerosing, apocrine, tubular, microglandular
  - Sclerosing adenosis often associated with MG calcs



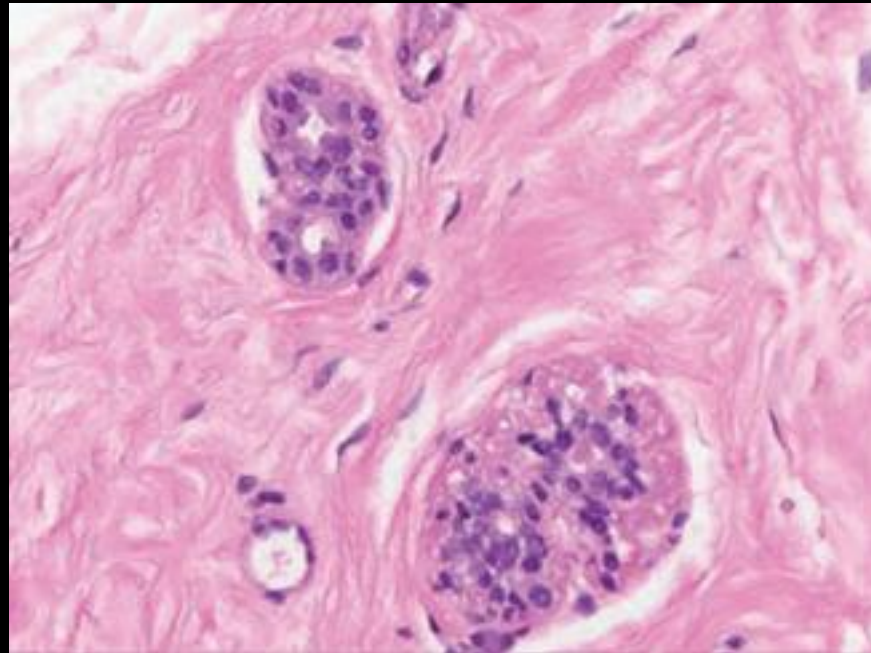
# Rad-Path Concordance – Benign

- PASH: focal or segmental distribution, clumped internal enhancement
  - Often associated with T2 hyperintense cystic spaces



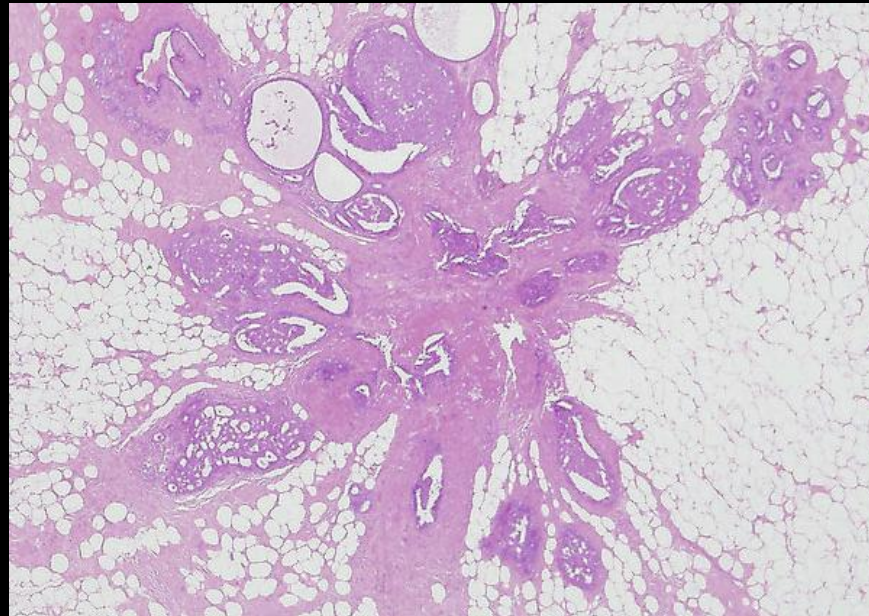
# Rad-Path Concordance – Benign

- Radiation effect: focal or diffuse, within 18 months of treatment completion
  - Persistent focal or diffuse enhancement >18 months after treatment completion raises concern for recurrence



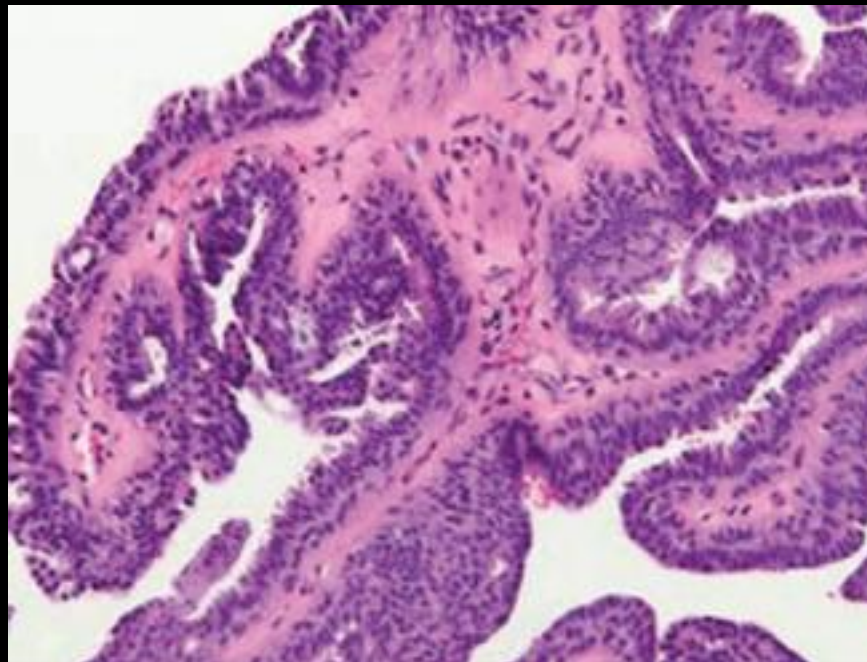
# Rad-Path Concordance – High Risk

- Radial scar/complex sclerosing lesion: linear or clumped NME
  - Often associated with architectural distortion on MG



# Rad-Path Concordance – High Risk

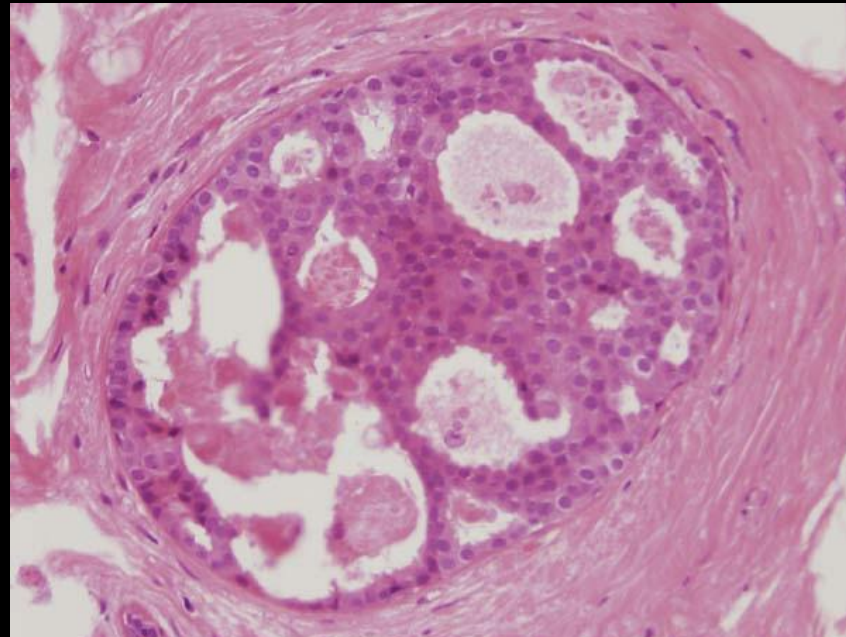
- Intraductal papilloma: mass, focus, or linear NME within 3 cm of nipple
  - Clinically associated with spontaneous, unilateral, bloody nipple discharge





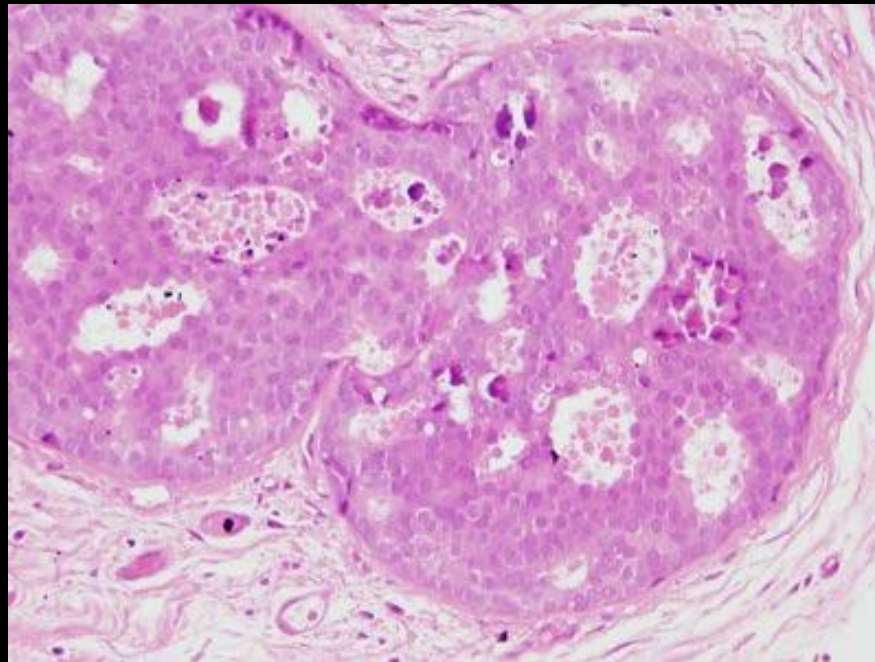
# Rad-Path Concordance – High Risk

- Flat epithelial atypia/atypical ductal hyperplasia:  
variable appearance ranging from mass to non  
mass enhancement
  - Often associated with calcifications on MG



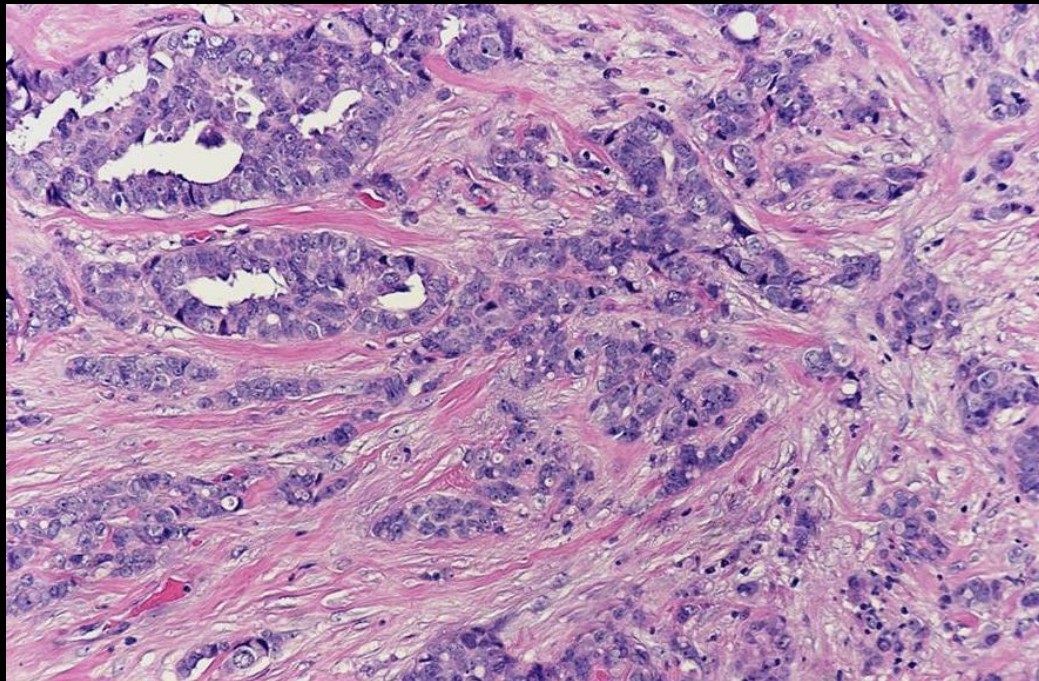
# Rad-Path Concordance – Malignant

- Ductal carcinoma in situ: segmental or linear distribution, clumped or heterogeneous internal enhancement
  - Coarse, heterogeneous or pleomorphic calcs on MG
  - Extent can be overestimated on MR due to periductal and stromal fibrosis



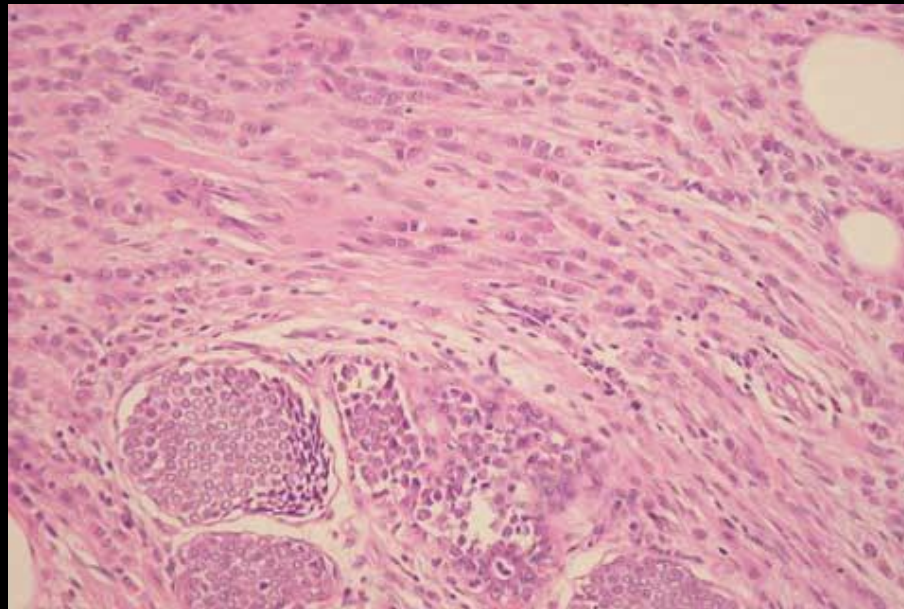
# Rad-Path Concordance – Malignant

- Invasive ductal carcinoma: mass or NME, variable distribution, clumped or heterogeneous internal enhancement
  - Spiculated mass, architectural distortion, associated microcalcifications on MG



# Rad-Path Concordance – Malignant

- Invasive lobular carcinoma: focal or regional NME
  - Asymmetry or distortion on MG, subtle shadowing on US
    - Often occult on MG or US
  - MRI useful in determining extent of disease, which is often underestimated on other modalities



# NME Pearls

- Diffuse or multiregional NME typically due to BPE
- Segmental, clumped enhancement and segmental, clustered ring enhancement most closely associated with malignancy
- Kinetics not predictive of malignancy
- PPV of NME lexicon limited, and given significant overlap between benign and malignant processes, biopsy frequently pursued
- Rad-Path concordance important in ensuring biopsy results explain multimodality imaging findings

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