Hot topics in breast MRI

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Find the cancer!
CASE 1

70 y.o recalled from screening MG to evaluate a new developing density in the Rt breast

Extent of the disease:
> or < than on MG or US

Lymph node status:

Status of Contralateral breast:

How was the breast parenchyma on MG?
Right breast 9 o’clock mass
1cm diameter
Right Breast 3 o’clock
2nd look US

Second-look US

Name ____________________________

MRN ____________________________

R L

R L

Lesion 1: Rt 3:00 11x 9mm
1.2 x 1.1 cm
R 3 o’clock mass
Right 3 o’clock lesion
CC View
Objectives

- Understand what is new to the breast MRI indications in the last few years
- How did high risk screening with MRI make it to the ACR/SBI guidelines
- Define breast density and background parenchymal enhancement (categorization)
- Obtain a better understanding of personalized screening using Ab-MRI and Ultrafast MRI
Breast MRI vs. Mammo

<table>
<thead>
<tr>
<th>Mammography</th>
<th>Breast MRI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quicker and more cost efficient</td>
<td>More sensitive for detecting breast cancer</td>
</tr>
<tr>
<td>Better characterization of calcifications</td>
<td>No radiation</td>
</tr>
<tr>
<td>No IV contrast</td>
<td></td>
</tr>
</tbody>
</table>

- Cancers detected...

<table>
<thead>
<tr>
<th>Modality</th>
<th>Additional cancers detected per 1000 screened*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Tomosynthesis</td>
<td>0.5-2.7</td>
</tr>
<tr>
<td>Screening ultrasound</td>
<td>1.8-4.6</td>
</tr>
<tr>
<td>Abbreviated breast MRI</td>
<td>15.5-18.1</td>
</tr>
</tbody>
</table>

- Additional cancers detected per 1000 screened, as compared to FFDM, which detects 2-7 cancers per 1000 screened.
ACR recommendations for breast MRI

- Screening
- Extent of disease
- Additional evaluation of clinical or imaging findings: e.g. problem solving, nipple discharge
# Risk factors for breast cancer

Breast density is associated with breast cancer!

<table>
<thead>
<tr>
<th>Hereditary</th>
<th>Sporadic and Familial</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full penetrance genes:</strong></td>
<td>- Age</td>
</tr>
<tr>
<td>- BRCA 1 and 2</td>
<td>- Early age at menarche and late age menopause</td>
</tr>
<tr>
<td>- PTEN (Cowden syndrome)</td>
<td>- Late age at full term pregnancy or no pregnancy</td>
</tr>
<tr>
<td>- STK 11 (Peutz-Jeghers syndrome)</td>
<td>- Combination hormone therapy (estrogen and progestin)</td>
</tr>
<tr>
<td>- TP 53 (Li-Fraumeni syndrome)</td>
<td>- Breast density</td>
</tr>
<tr>
<td>- CDH1</td>
<td></td>
</tr>
<tr>
<td><strong>Moderate penetrance genes (MPGs):</strong></td>
<td>- Obesity</td>
</tr>
<tr>
<td>- PALB2</td>
<td>- Alcohol use</td>
</tr>
<tr>
<td>- CHEK2</td>
<td>- Exercise</td>
</tr>
<tr>
<td>- ATM</td>
<td></td>
</tr>
<tr>
<td><img src="image" alt="Proven" /></td>
<td></td>
</tr>
<tr>
<td>- NF1</td>
<td>- DCIS, LCIS</td>
</tr>
<tr>
<td>- NBN</td>
<td>- ADH (DIN1B), ALH</td>
</tr>
<tr>
<td>- BARD1</td>
<td>- Number of biopsies</td>
</tr>
<tr>
<td>- MSH</td>
<td>- Fibrocystic disease</td>
</tr>
<tr>
<td><img src="image" alt="May be associated" /></td>
<td>- Radiation</td>
</tr>
<tr>
<td>[image]</td>
<td></td>
</tr>
</tbody>
</table>

- Family history of breast or ovarian cancer without a definitive pattern of inheritance
To evaluate screening breast MRI performance across women with different elevated breast cancer risk indications.
Evidence-based guidelines recommend adjunctive screening with MRI.

- Adding MRI demonstrates sensitivities of 71%–100%.
- Added by ACS in 2007 and NCCN guidelines since 2017.

1. Women who are BRCA mutation carriers and their first degree, untested relatives.
2. Li-Fraumeni and other high-risk predisposition syndromes and polygenic mutations such as Cowden, CHEK-2, PALB2.
3. Women who received radiation to the chest between the ages of 10–30 years.
4. **20-25% or greater lifetime risk of breast cancer** based on risk models heavily reliant on family history (eg, BRCAPRO, Tyrer Cuzick).
Define Intermediate Risk women

(1) Women with personal history (PH) of breast cancer

(2) Personal history of high risk lesion (HRL) such as ADH, ALH, LCIS.

(3) Women with dense breasts

(4) Women with approximately 15%–20% or greater lifetime risk of breast cancer based on risk models heavily reliant on family history (eg, BRCAPRO)
- n = 5170 screening breast MRI exams from 2637 patients
- BRCA/chest XRT
- PH
- HRL
- FH

### Performance of screening MRI across different breast cancer risk indications

<table>
<thead>
<tr>
<th></th>
<th>BRCA/RT</th>
<th>PH</th>
<th>HRL</th>
<th>FH</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CDR</strong></td>
<td>26</td>
<td>12</td>
<td>15</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td><strong>PPV3</strong></td>
<td>41</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>29</td>
</tr>
<tr>
<td><strong>Sensitivity</strong></td>
<td>84</td>
<td>88</td>
<td>75</td>
<td>77</td>
<td>84</td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>92</td>
<td>95</td>
<td>92</td>
<td>91</td>
<td>93</td>
</tr>
</tbody>
</table>

Highest CDR

Lowest CDR
Multiple publications have shown favorable screening MRI performance in women with a personal history of breast cancer or high-risk lesion.

<table>
<thead>
<tr>
<th>Study</th>
<th>Methodology</th>
<th>PH vs. genetic risk</th>
<th>CDR</th>
<th>PPV3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lehman et al</td>
<td>HRL only</td>
<td>12-16/1000</td>
<td>20-24%</td>
<td></td>
</tr>
<tr>
<td>Azari-Kleinman et al</td>
<td>HRL only</td>
<td>12-15/1000</td>
<td>21-24%</td>
<td></td>
</tr>
<tr>
<td>Similar CDR and higher PPV3</td>
<td>PH vs. genetic risk</td>
<td>17/100</td>
<td>19-25%</td>
<td></td>
</tr>
</tbody>
</table>

Lehman et al

Azari-Kleinman et al

Schwartz et al

Friedlander et al
Proven wider acceptance

- Clinical evidence has grown supporting screening breast MRI in women with personal history of breast cancer or a cancer diagnosis before age 50 years.

- 2017 NCCN and 2018 ACR recommendations added their support to consideration of annual screening breast MRI in women with HRL.
1. Breast MRI Screening

a. High-risk patients

b. Intermediate-risk patients

c. Newly diagnosed breast malignancy can detect occult malignancy in the contralateral breast in at least 3% to 5% of patients

d. Breast augmentation and Implant evaluation
Amount of fibroglandular tissue classification on MRI

- Almost entirely fatty
- Scattered fibroglandular tissue
- Heterogenous fibroglandular tissue
- Extreme fibroglandular tissue
BPE classification

A. Minimal
B. Mild
C. Moderate
D. Marked
CASE 2:

Clinical Information: 48 year old female enrolled in a breast cancer screening MRI study for high risk women. Patient is a BRCA 1 mutation carrier.
Figure 1, T1 W post-contrast subtraction image: Irregular heterogeneously enhancing mass with irregular margins measuring 10 mm is seen in the right breast 12:00 position (red arrow).

Figure 2, T1 W post-contrast subtraction image from 6 months prior: A small focus was seen at right breast 12:00 position (yellow arrow), however was not thought to be suspicious given background additional foci in the same breast which have been stable over past 2 years. 6 month follow up MRI was recommended at that time.
WILL YOU BIOPSY THIS LESION?

YES
NO

No
Do MRI directed US first
- Lesion demonstrates interval increase in size, suspicious features on MRI (spiculated morphology mass).
Fig 3 to 6: MRI directed US demonstrates an irregular indeterminate mixed echogenic mass that measures 5 x 7 x 4 mm with apical blood flow. This could correspond to the lesion seen on MRI. US guided biopsy was subsequently performed.
PATHOLOGY

- Biopsy performed: IDC grade 3
Discussion:
This case shows the importance of screening high risk patients with MRI to pick up small invasive cancers that are mammographically occult.

Importance of second look US in identifying lesions

Figure 5, low power H&E: Clusters of ducts and tubules with loss of architecture and malignant cells in loose nests (red arrows).

Figure 6, high power H&E: Multiple pleomorphic and mitotic nuclei (red arrows) suggesting grade 3 IDC.
Dense Breasts: What to do next?

A health system may recommend such women receive additional screenings, such as through ultrasounds or MRIs. In Illinois, insurance companies must cover certain supplemental screenings for women with dense breast tissue.

The American College of Radiology supports informing women about their breast density, but warns that supplemental screening “should be a thoughtful choice after a complete risk assessment, not an automatic reaction to breast density itself.”

The legislation, signed by Gov. Bruce Rauner on Friday, was spearheaded by Glenview resident and breast cancer survivor Patti Beyer. Beyer doesn’t have a family history of breast cancer, but she does have dense breast tissue – a risk factor for the disease. According to the American Cancer Society, women who have dense breast tissue have a “slightly” higher risk of developing breast cancer than those who do not.

Educate and inform women of their breast density in order to achieve their best chances for early detection of breast cancer.
Abbreviated Breast Magnetic Resonance Imaging

Comparison of Abbreviated Breast MRI vs Digital Breast Tomosynthesis for Breast Cancer Detection Among Women With Dense Breasts Undergoing Screening

Christopher E Comstock, Constantine Gatsonis, Gillian M Newstead, Bradley S Snyder, Ilana F Gareen, Jennifer T Bergin, Habib Rahbar, Janice S Sung, Christina Jacobs, Jennifer A Harvey, Mary H Nicholson, Robert C Ward, Jacqueline Holt, Andrew Prather, Kathy D Miller, Mitchell D Schnall, Christiane K Kuhl
# AB-MRI Sensitivity and Specificity

## Table 3. Diagnostic Indices

<table>
<thead>
<tr>
<th>Index</th>
<th>MIP Images*</th>
<th></th>
<th>FAST Images</th>
<th></th>
<th>FDP</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>95% CI</td>
<td>%</td>
<td>95% CI</td>
<td>%</td>
<td>95% CI</td>
</tr>
<tr>
<td>First screening round (n = 443)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Sensitivity</td>
<td>90.9</td>
<td>58.7 to 99.7</td>
<td>100.0</td>
<td>71.5 to 100.0</td>
<td>100.0</td>
<td>71.5 to 100.0</td>
</tr>
<tr>
<td>Specificity</td>
<td>NA</td>
<td>NA</td>
<td>94.4</td>
<td>91.8 to 96.4</td>
<td>94.9</td>
<td>92.4 to 96.8</td>
</tr>
<tr>
<td>PPV</td>
<td>NA</td>
<td>NA</td>
<td>31.4</td>
<td>16.9 to 49.3</td>
<td>33.3</td>
<td>18.0 to 51.8</td>
</tr>
<tr>
<td>NPV</td>
<td>99.7</td>
<td>98.2 to 100.0</td>
<td>100.0</td>
<td>99.1 to 100.0</td>
<td>100.0</td>
<td>99.1 to 100.0</td>
</tr>
<tr>
<td>Entire screening period (n = 606)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>92.1 to 96.0</td>
<td>93.9</td>
<td>91.7 to 95.7</td>
</tr>
<tr>
<td>PPV</td>
<td>NA</td>
<td>NA</td>
<td>24.4</td>
<td>12.9 to 39.5</td>
<td>23.4</td>
<td>12.3 to 38.0</td>
</tr>
<tr>
<td>NPV</td>
<td>99.8</td>
<td>98.7 to 100.0</td>
<td>100.0</td>
<td>99.3 to 100.0</td>
<td>100.0</td>
<td>99.3 to 100.0</td>
</tr>
</tbody>
</table>

Abbreviations: FAST, first postcontrast subtracted; FDP, full diagnostic protocol; MIP, maximum-intensity projection; NA, not applicable; NPV, negative predictive value; PPV, positive predictive value.

*MIP images were read as positive or negative depending on whether significant enhancement was observed; no actual differential diagnosis was attempted based on MIP images.
**Current Imaging Protocol**

**MRI FULL PROTOCOL WITH ULTRAFAST**

- **T₂ weighted TSE**
  - 200 slices, 1 mm thick
  - In-plane resolution <0.75 mm
  - Axial
  - 5 min

- **Pre-contrast fat sat masks & Post contrast images x 4**
  - Same FOV and slice thickness as T2WI
  - Each scan takes 1 min
  - 250 axial sections
  - T₁ weighted gradient echo imaging
  - 0.75 x 0.75mm in-plane in a 0.8 mm thick slice

- **Post processing**
  - Bolus injection of contrast
  - T2, T1PRE, UFAST, DWI
  - 1 min, 2 min, 3 min, 4 min

**Post contrast sequence**
EMERGING IMAGING PROTOCOL

ABBREVIATED MRI without ULTRAFAST

Bolus injection of contrast

1 min  2 min

T2  T1 Pre  UFAST  POST contrast sequence
Abbreviated MRI

A: MIP
B: Subtraction
D: T1 FS pre-contrast
E: T1 FS post-contrast

T2 or STIR added
Under 10 mins
Abbreviated MRI vs. standard MRI

- AbMR and Ultrafast MRI reflect increasing understanding of breast cancer as a heterogeneous disease.
- AbMR with only one post contrast sequence can sometimes limit lesion characterization. It is getting popular as a screening tool.
- Breast MRI is standard of care in high risk screening and will most likely expand into average risk screening using AbMRI.
- These newer techniques might answer some shortcomings of mammographic screening especially in women with dense breasts, and help reduce interval cancers, maximize diagnostic accuracy.
- Preferential detection of biologically more aggressive tumors may indeed be the greatest mortality benefit.
AbMR vs. full protocol MRI

**PROS**
- High NPV of 99 to 100%
- AbMR high conspicuity and discrimination of malignant lesions
- Similar sensitivity (86-100%)
- Lesser time
- Less images
- Cheaper
- Better detection of IDC and high grade DCIS

**CONS**
- Low sensitivity for low grade malignancies
- Slightly low specificity
- Single post contrast point
- Lack of standard kinetic data
45 yo, BRCA 1, dense breasts

- High NPV of 99.8 to 100%
43 yo dense breasts

- Detects more aggressive tumors such as IDC and high grade DCIS
Staging MRI

- Has made it to the list of breast MRI indications a while back
- Breast cancer subtypes have become essential to estimate prognosis and guide systemic therapy.
- CAD and AI based softwares available e.g. Qlarity

FULL PAPER

Role of MRI in the staging of breast cancer patients: does histological type and molecular subtype matter?

ALMIR G V BITENCOURT, PhD, NARA P PEREIRA, MD, LUCIANA K L FRANÇA, MD, CAROLINE B SILVA, MD, JOCIANA PALUDO, MD, HUGO L S PAIVA, MD, LUCIANA GRAZIANO, MD, CAMILA S GUATELLI, MD, JULIANA A SOUZA, MD and ELVIRA F MARQUES, MD
CASE 4:

Clinical information: 47 year old female presents with a palpable left breast mass. No family history of breast cancer.
Concordant!

- Surgical Pathology Report

FINAL PATHOLOGIC DIAGNOSIS A. Breast, left @ 2:00, ultrasound-guided core biopsy: - High grade Ductal carcinoma in situ,
Summary

- ACR/SBI recommendations are in favor of breast MRI screening for patients with PH, dense breast, HRL, genetic mutations.

- Ultrafast and Ab-MRI have strong potential in screening these individuals.

- Risk stratification studies have initiated such as WISDOM and hopefully we can perform the right test for the right reason.
Future breast cancer screening tests

Personalized risk-based screening

AI and deep learning

Non-imaging techniques (liquid biopsy)

Good training dataset

Benign masses

Malignant masses
Algorithms based on risk stratification and breast density

- **Breast cancer risk**
  - **High risk**
    - Non-entirely fatty breasts
      - MRI only (25-39 y)
      - MRI+2DMMG (> 39 y)
    - Entirely fatty breasts
      - MRI only (25-39 y)
    - Dense breasts
      - 2DMMG+US
    - Non-dense breasts
      - 2DMMG only
  - **Intermediate risk**
    - Based on the patient’s values, 2DMMG+MRI
  - **Average risk**
    - Dense breasts
      - 2DMMG only
    - Non-dense breasts
      - 2DMMG
Thank you!

Email: kkulkarni@radiology.bsd.uchicago.edu