Hot topics in breast MRI

Kirti Kulkarni MD, (email: kkulkarni@radiology.bsd.uchicago.edu)
Associate Professor of Radiology
Director, Breast Imaging Fellowship
Section of Breast Imaging
University of Chicago, Chicago IL

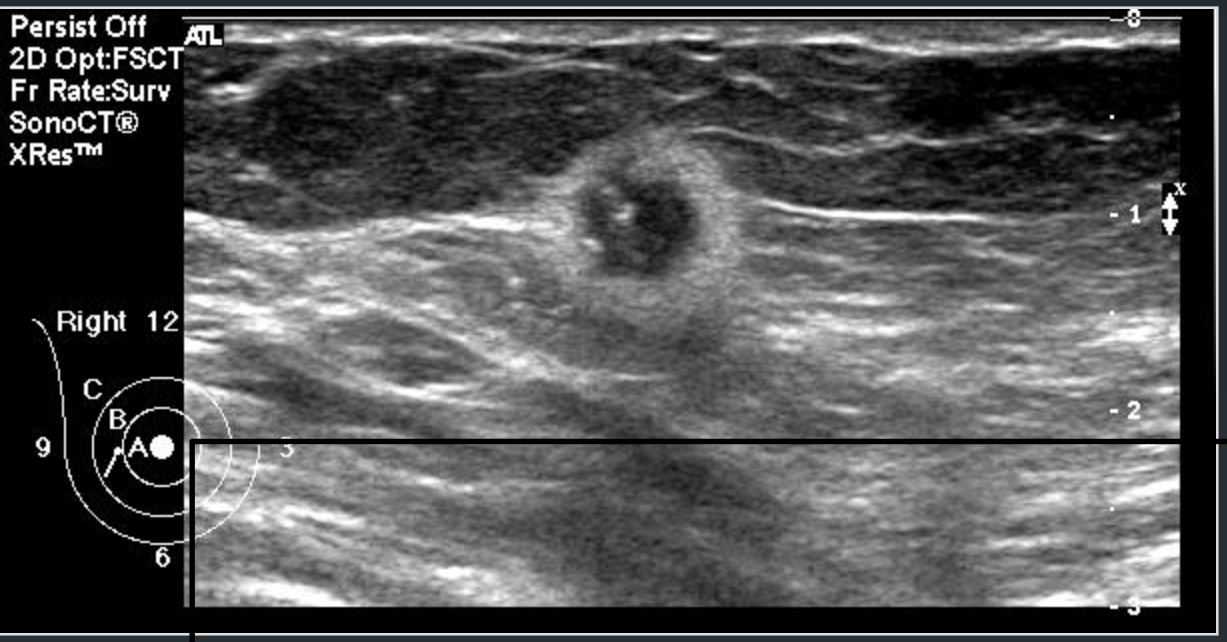
THE UNIVERSITY OF CHICAGO

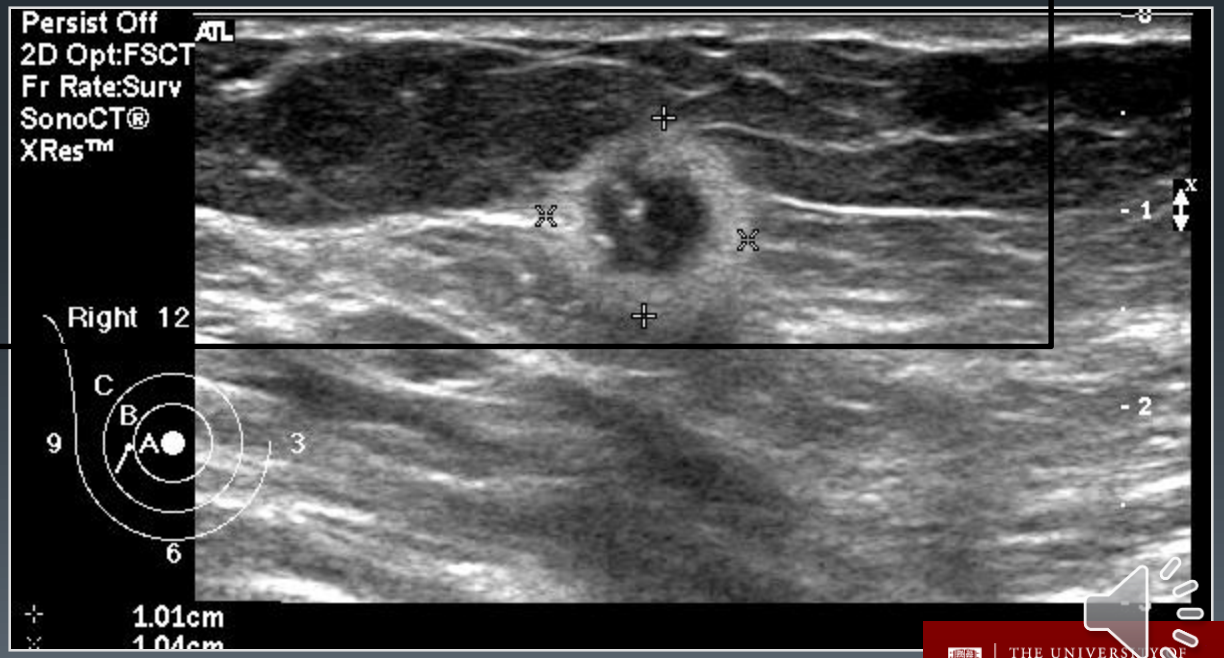
Find the cancer!

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?

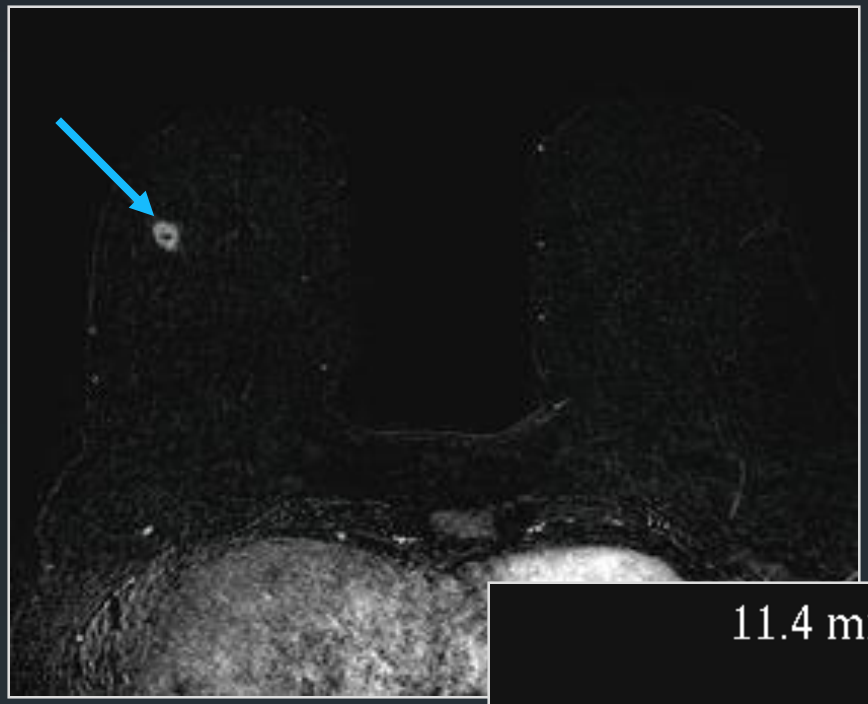


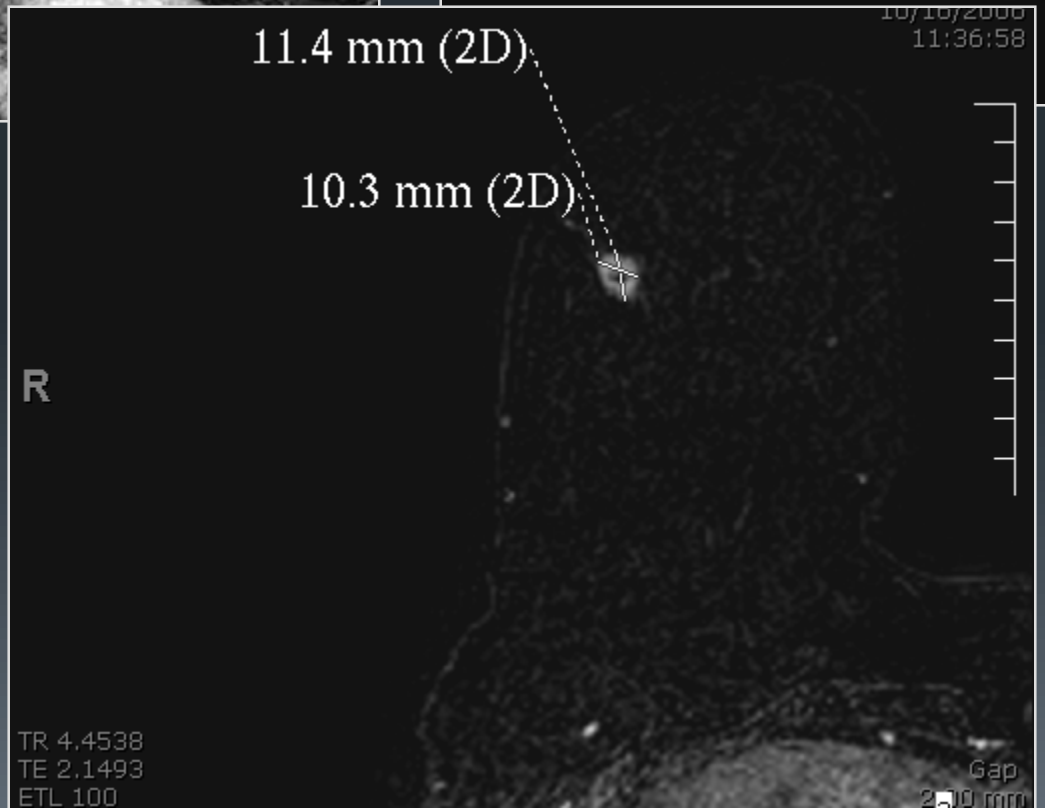


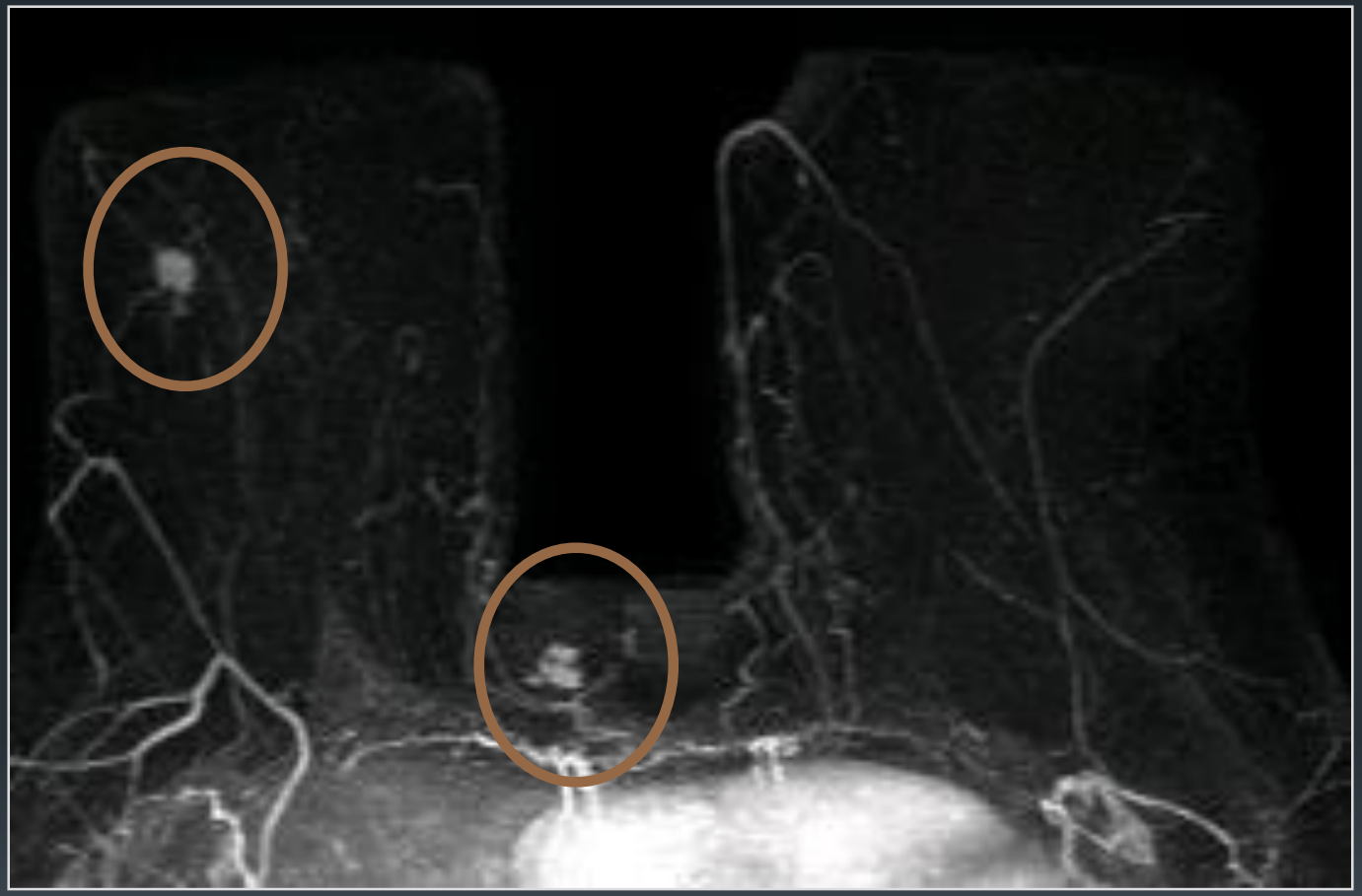
Right breast 9 o'clock mass
1cm diameter

Rt CC

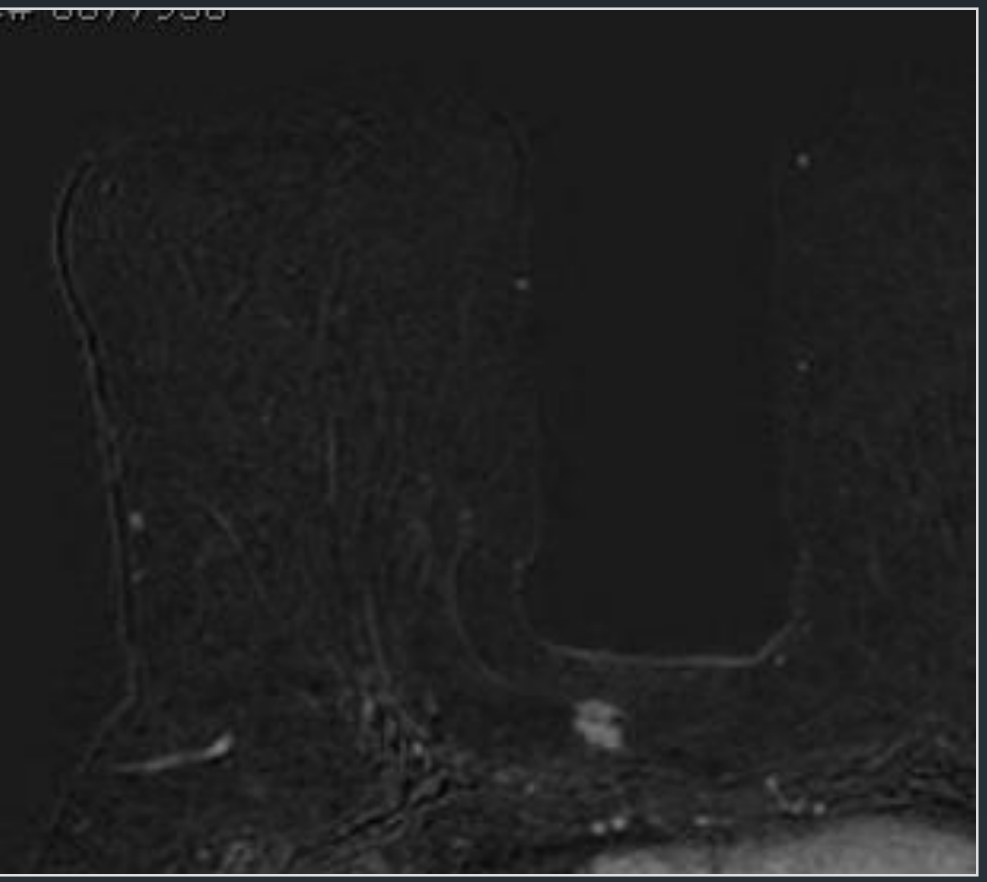
Rt LM



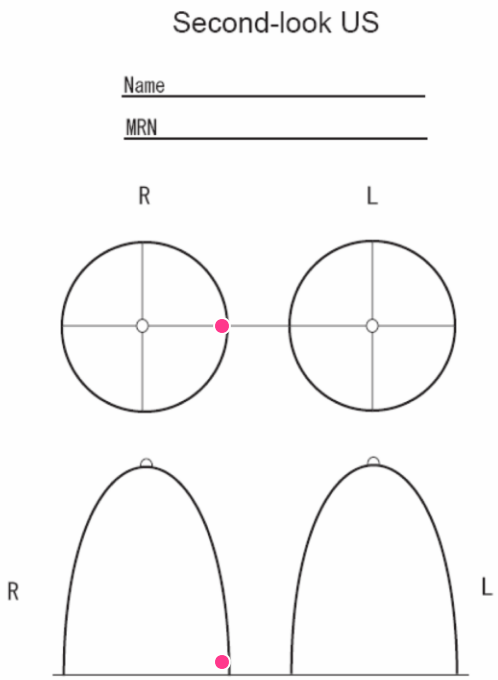




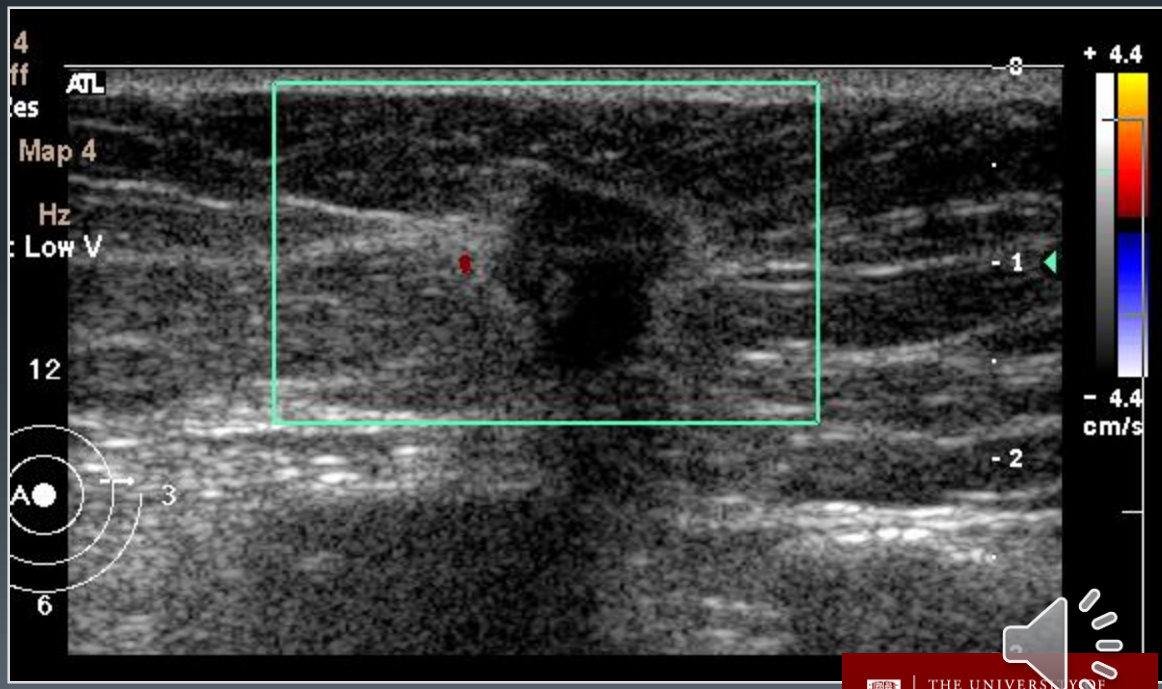
Right Breast 3 o’clock

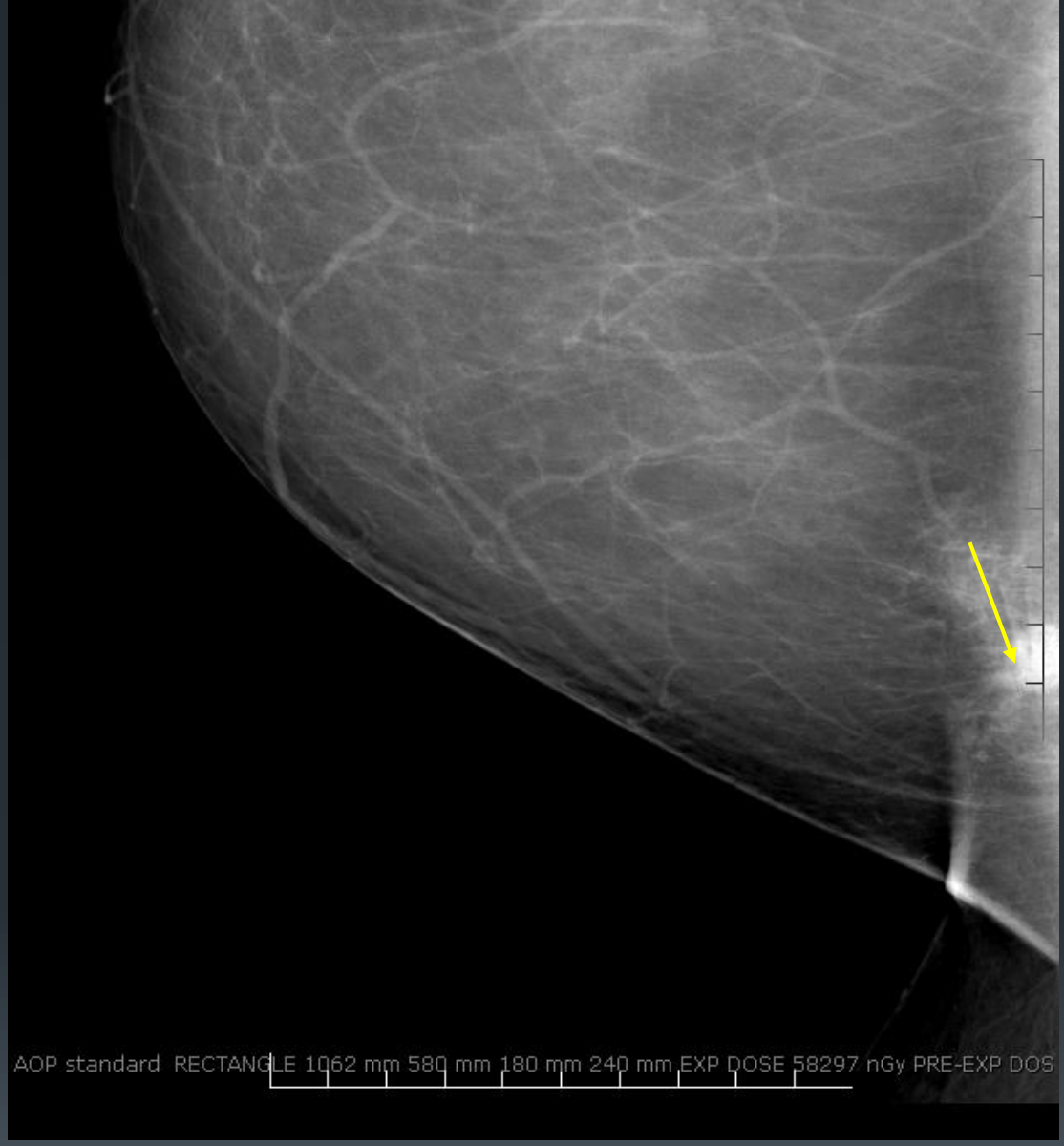


2nd look US



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

Mammography	Breast MRI
Quicker and more cost efficient	More sensitive for detecting breast cancer
Better characterization of calcifications	No radiation
No IV contrast	

- Cancers detected…

Modality	Additional cancers detected per 1000 screened*
Digital Tomosynthesis	0.5-2.7
Screening ultrasound	1.8-4.6
Abbreviated breast MRI	15.5-18.1

- 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!

Hereditary		Sporadic and Familial
Full penetrance genes: - BRCA 1 and 2 - PTEN (Cowden syndrome) - STK 11 (Peutz-Jeghers syndrome) - TP 53 (Li-Fraumeni syndrome) - CDH1		- Age - Early age at menarche and late age menopause - Late age at full term pregnancy or no pregnancy - Combination hormone therapy(estrogen and progestin) - Breast density
Moderate penetrance genes (MPGs): - PALB2 - CHEK2 - ATM	Proven	- Obesity - Alcohol use - Exercise
- NF1 - NBN - BARD1 - MSH	May be associated	- DCIS, LCIS - ADH (DIN1B), ALH - Number of biopsies - Fibrocystic disease - Radiation
		- Family history of breast or ovarian cancer without a definitive pattern of inheritance

Breast MRI Screening

What is average, intermediate and high risk?
When?
Why?
How?

Radiology

ORIGINAL RESEARCH • BREAST IMAGING

Performance of Screening Breast MRI across Women with Different Elevated Breast Cancer Risk Indications

*Dorothy A. Sippo, MD, MPH * • Kristine S. Burk, MD* • Sarah F. Mercaldo, PhD • Geoffrey M. Rutledge, MD • Christine Edmonds, MD • Zoe Guan, MA • Kevin S. Hughes, MD • Constance D. Lehman, MD, PhD*

From the Department of Radiology, Massachusetts General Hospital, Avon Comprehensive Breast Evaluation Center, Wang Ambulatory Care Building, Suite 240, 15 Parkman St, Boston, MA 02114. Received May 11, 2018; revision requested June 6; final revision received February 15, 2019; accepted April 2. **Address correspondence to** D.A.S. (e-mail: *dsippo@mgh.harvard.edu*).

To evaluate screening breast MRI performance across women with different elevated breast cancer risk indications.

Define High Risk women

- 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)

Sippo et al

Radiology 2019

- n= 5170 screening breast MRI exams from 2637 patients
- BRCA/chest XRT
- PH
- HRL
- FH

Highest CDR

Lowest CDR

	BRCA/ RT	PH	HRL	FH	Total
CDR	***26***	***12***	***15***	***8***	***13***
PPV3	***41***	***36***	***36***	***36***	***29***
Sensitivity	***84***	***88***	***75***	***77***	***84***
Specificity	***92***	***95***	***92***	***91***	***93***

Performance of screening MRI across different breast cancer risk indications

Supporting data

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

		CDR	PPV3
Lehman et al	***PH vs. genetic risk***	***17/100***	***19-25%***
Azari-Kleinman et al	***PH vs. genetic risk***	***18/100***	***14 – 15%***
Schwartz et al	***HRL only***	***12-16/1000***	***20-24%***
Friedlander et al	***HRL only***	***12-15/1000***	***21-24%***

Similar CDR and higher PPV3

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

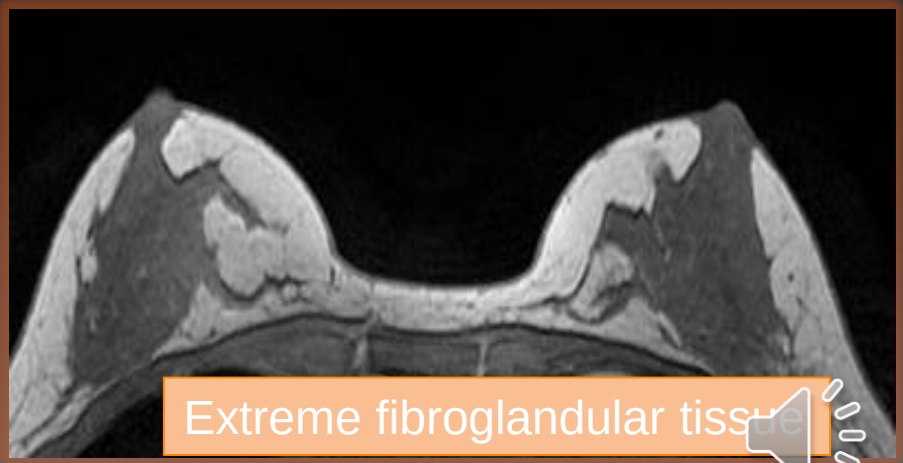
a. High-risk patients

b. Intermediate-risk patients

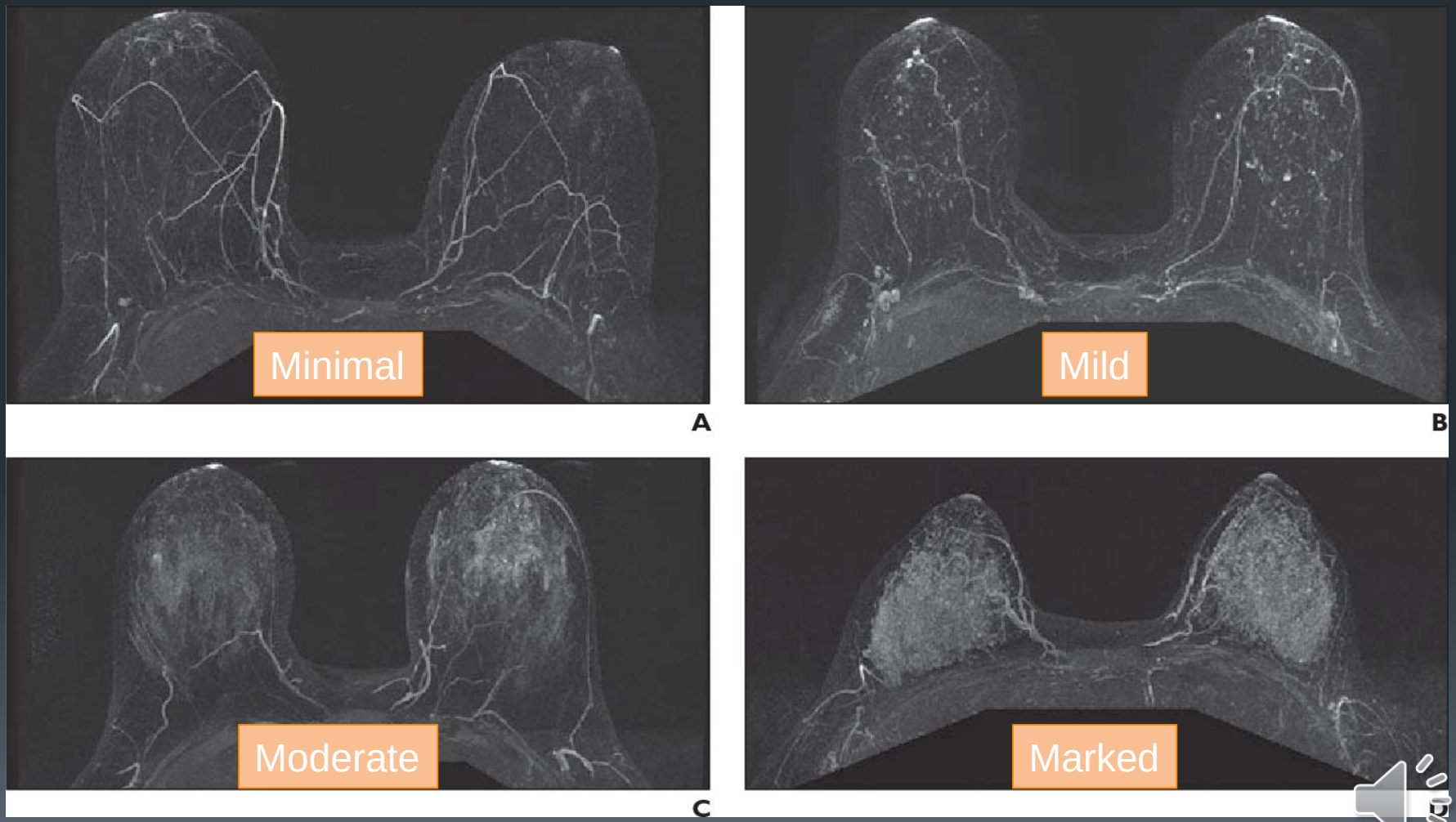
c. Newly diagnosed breast malignancy can detect occult malignancy in the contralateral breast in at least 3% to 5% of patients

d. Breast augmentation and Implant evaluation

Amount of fibroglandular tissue classification on MRI



BPE classification



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.

CURRENT MRI

PREVIOUS MRI (6 months prior)

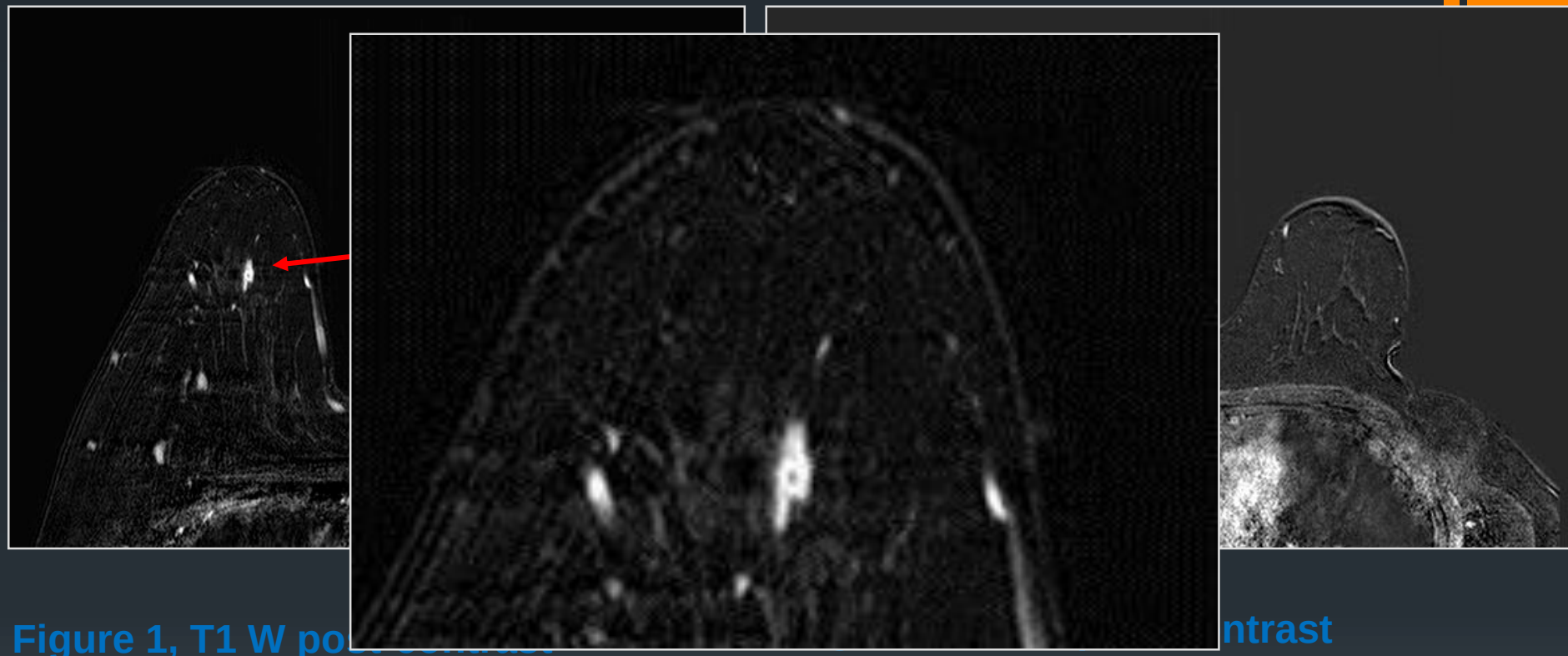


Figure 1, T1 W post contrast subtraction image: Irregular heterogeneously enhancing mass with irregular margins measuring 10 mm is seen in the right breast 12:00 position (red arrow).

ntrast 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.

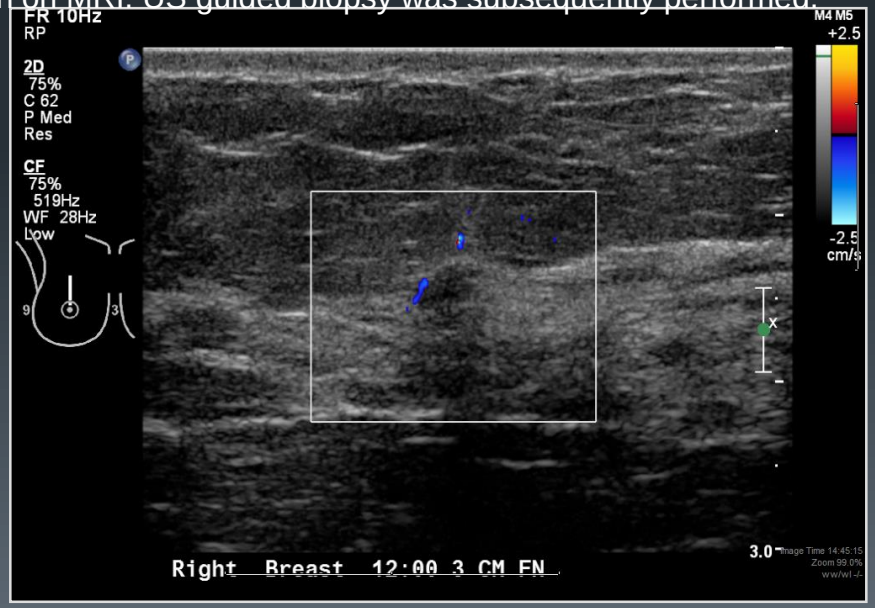
WILL YOU BIOPSY THIS LESION?

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

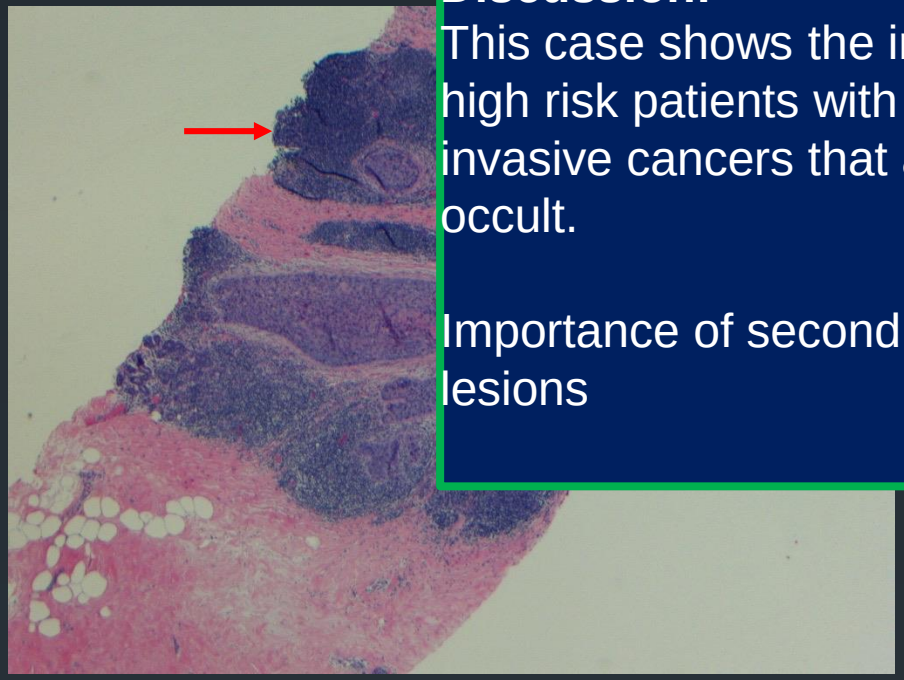


Figure 5, low power H&E: Clusters of ducts and tubules with loss of architecture and malignant cells in loose nests (red arrows).

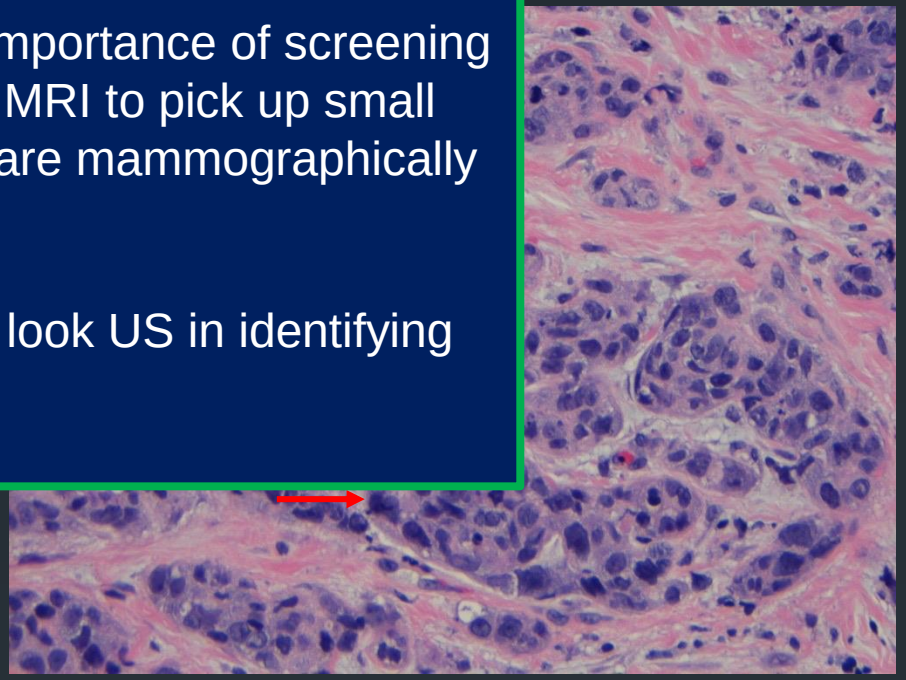


Figure 6, high power H&E: Multiple pleomorphic and mitotic nuclei (red arrows) suggesting grade 3 IDC.

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.

MRI Screening Techniques

VOLUME 32 · NUMBER 22 · AUGUST 1 2014

JOURNAL OF CLINICAL ONCOLOGY

ORIGINAL REPORT

Abbreviated Breast Magnetic Resonance Imaging

Randomized Controlled Trial > JAMA. 2020 Feb 25;323(8):746-756. doi: 10.1001/jama.2020.0572.

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

Christopher E Comstock [1], Constantine Gatsonis [2], Gillian M Newstead [3 4], Bradley S Snyder [5], Ilana F Gareen [6], Jennifer T Bergin [7], Habib Rahbar [8], Janice S Sung [1], Christina Jacobs [9], Jennifer A Harvey [10], Mary H Nicholson [11], Robert C Ward [12], Jacqueline Holt [13], Andrew Prather [14], Kathy D Miller [15], Mitchell D Schnall [16], Christiane K Kuhl [17]

AB-MRI Sensitivity and Specificity

Kuhl et al

Table 3. Diagnostic Indices

Index	MIP Images* %	MIP Images* 95% CI	FAST Images %	FAST Images 95% CI	FDP %	FDP 95% CI
First screening round (n = 443)						
Sensitivity	90.9	58.7 to 99.7	100.0	71.5 to 100.0	100.0	71.5 to 100.0
Specificity	NA	NA	94.4	91.8 to 96.4	94.9	92.4 to 96.8
PPV	NA	NA	31.4	16.9 to 49.3	33.3	18.0 to 51.8
NPV	99.7	98.2 to 100.0	100.0	99.1 to 100.0	100.0	99.1 to 100.0
Entire screening period (n = 606)						
Sensitivity	90.9	58.7 to 99.7	100.0	71.5 to 100.0	100.0	71.5 to 100.0
Specificity	NA	NA	94.3	92.1 to 96.0	93.9	91.7 to 95.7
PPV	NA	NA	24.4	12.9 to 39.5	23.4	12.3 to 38.0
NPV	99.8	98.7 to 100.0	100.0	99.3 to 100.0	100.0	99.3 to 100.0

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

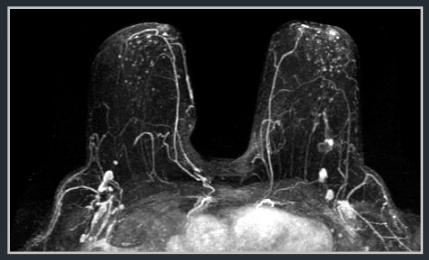
*MIP images were read as positive or negative depending on whether significant enhancement was observed; no actual differential diagnosis was attempted based on MIP images.

Current Imaging Protocol

MRI FULL PROTOCOL WITH ULTRAFAST

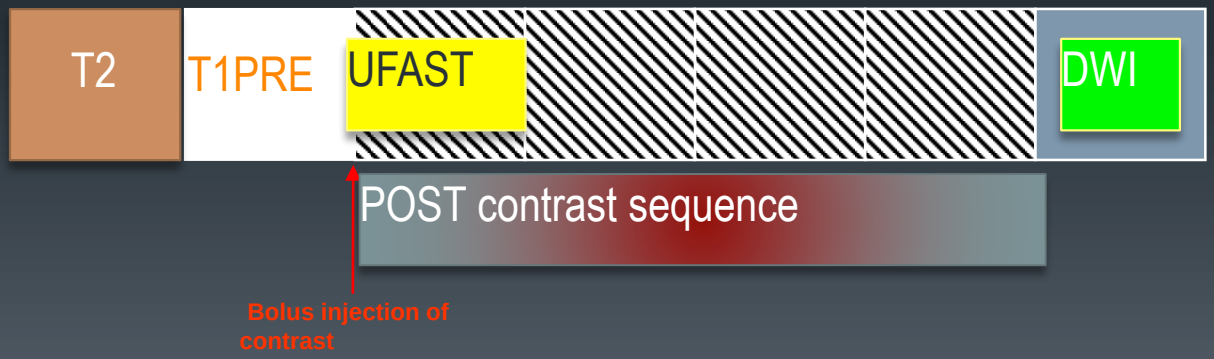
T_2 weighted TSE
200 slices, 1 mm thick
In-plane resolution <0.75 mm
Axial
5 min

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



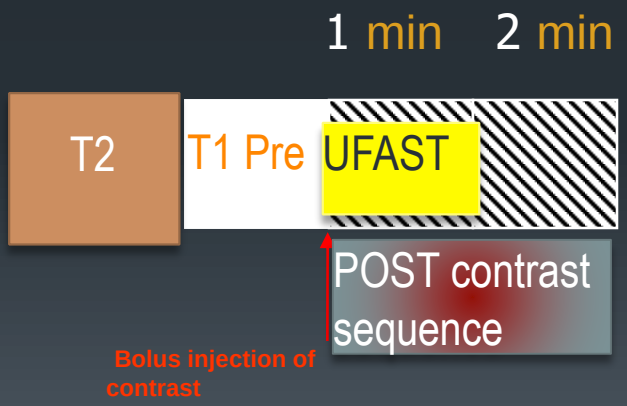
1 min 2 min 3 min 4 min

Post processing

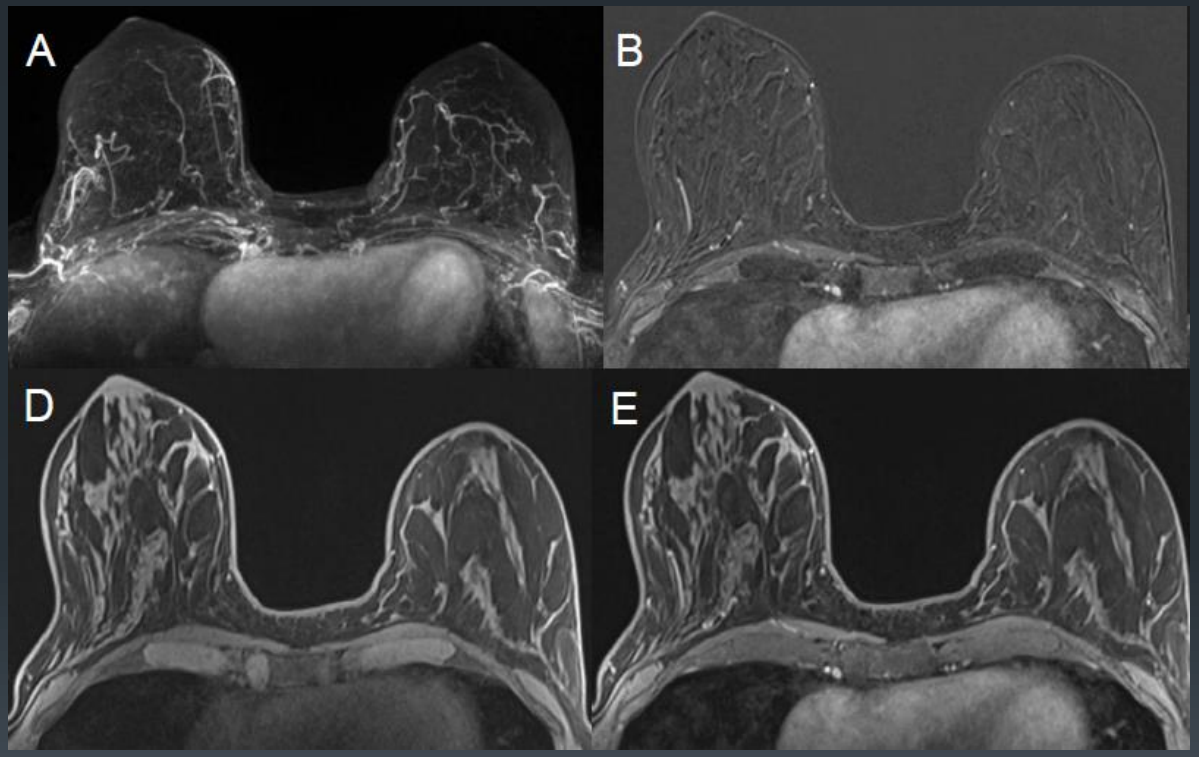


EMERGING IMAGING PROTOCOL

ABBREVIATED MRI without ULTRAFAST



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

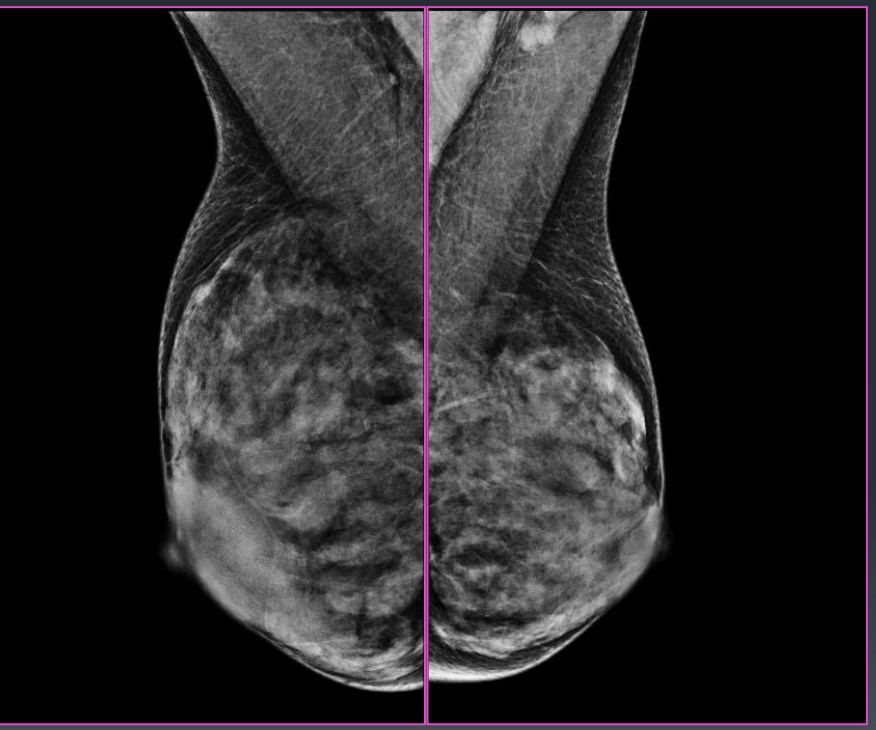
PROS

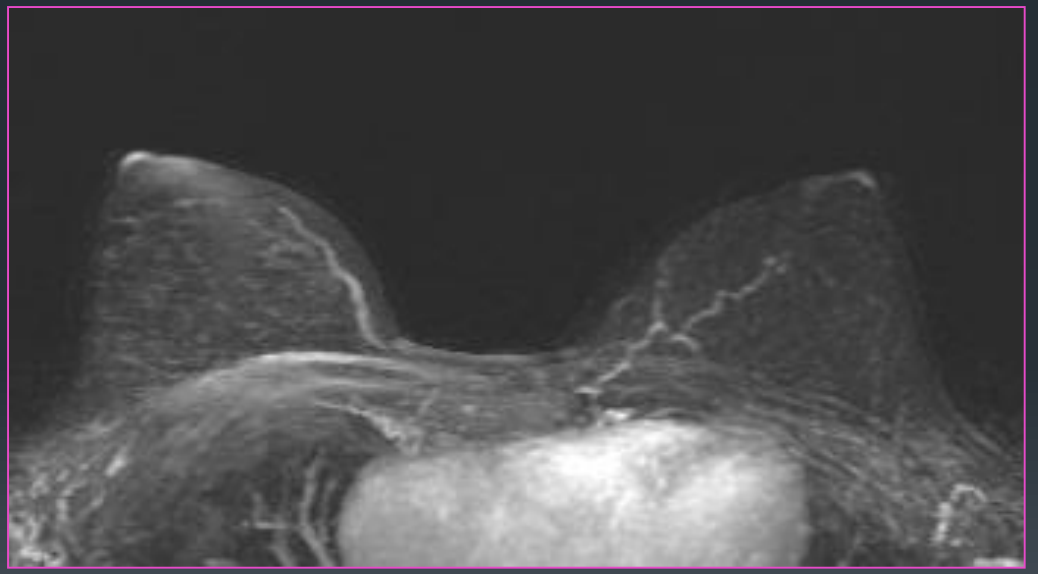
- High NPV of 99 to 100%
- AbMR high conscpicuity and discrimation of malignant lesions
- Similar sensitivity (86-100%)
- Lesser time
- Less images
- Cheaper
- Better detection of IDC and high grade DCIS

CONS

- Low sensitivity for low grade malignancies
- Slightly low specificity
- Single post contrast point
- Lack of standard kinetic data

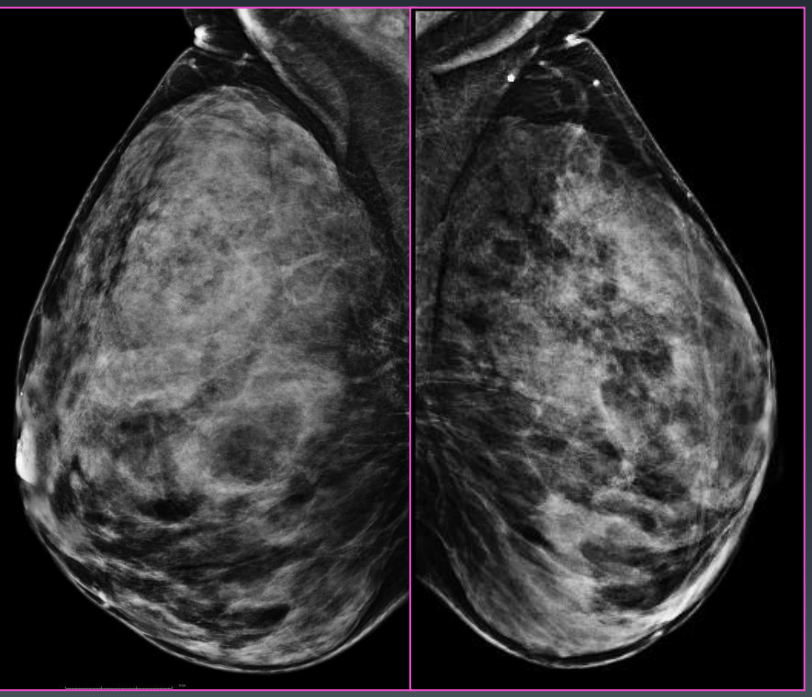
45 yo, BRCA 1, dense breasts

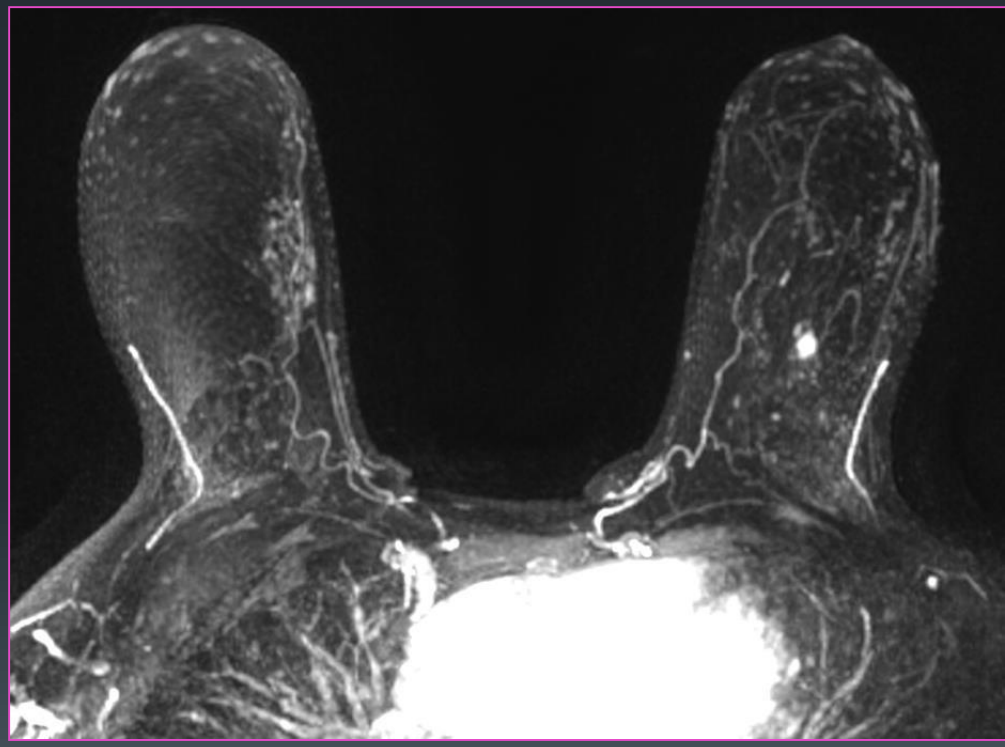




- High NPV of 99.8 to 100%

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

BJR

Received: 7 June 2015 | Revised: 2 September 2015 | Accepted: 15 September 2015

doi: 10.1259/bjr.20150458

Cite this article as:
Bitencourt AGV, Pereira NP, França LKL, Silva CB, Paludo J, Paiva HLS, et al. Role of MRI in the staging of breast cancer patients: does histological type and molecular subtype matter? *Br J Radiol* 2015; **88**: 20150458.

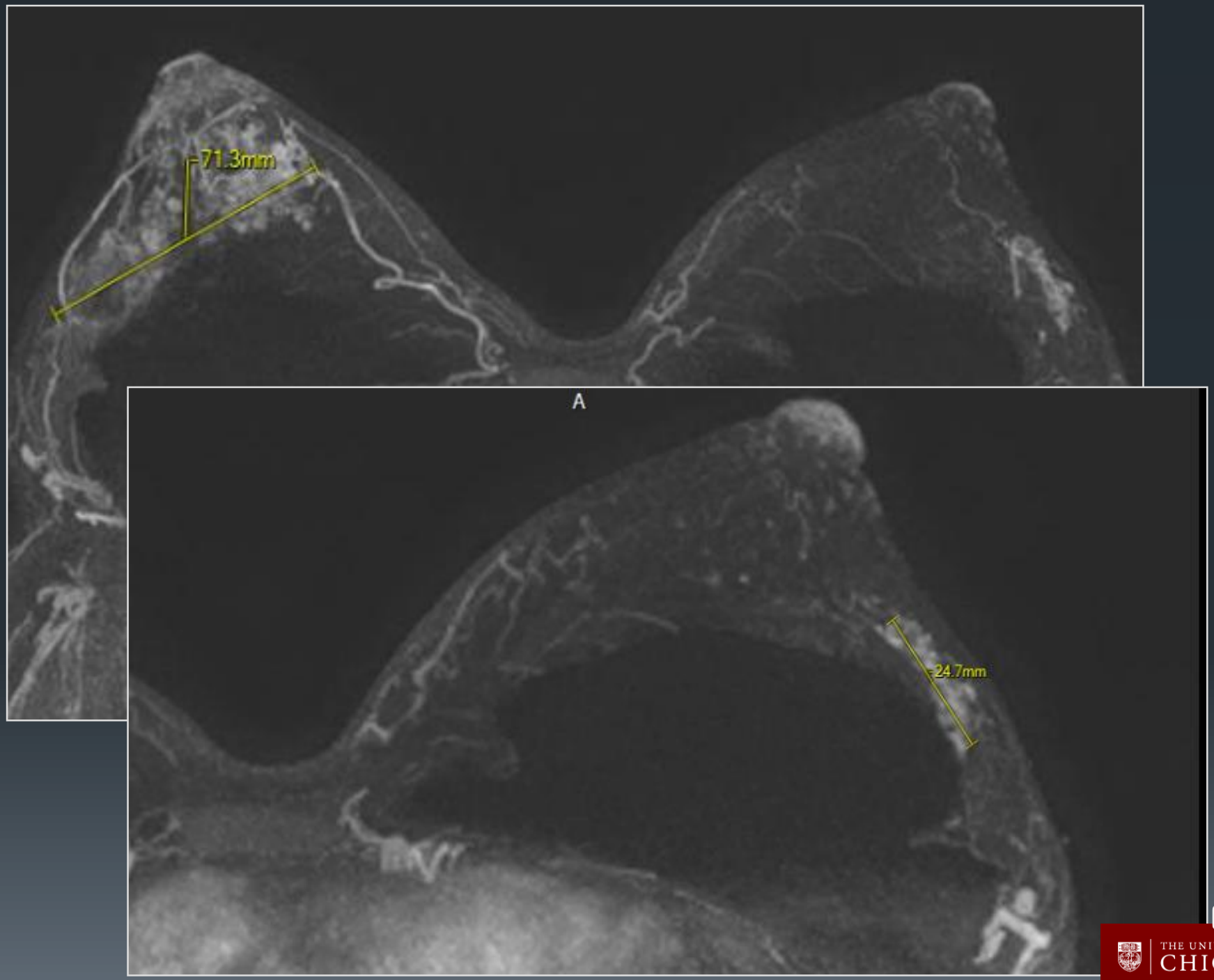
FULL PAPER

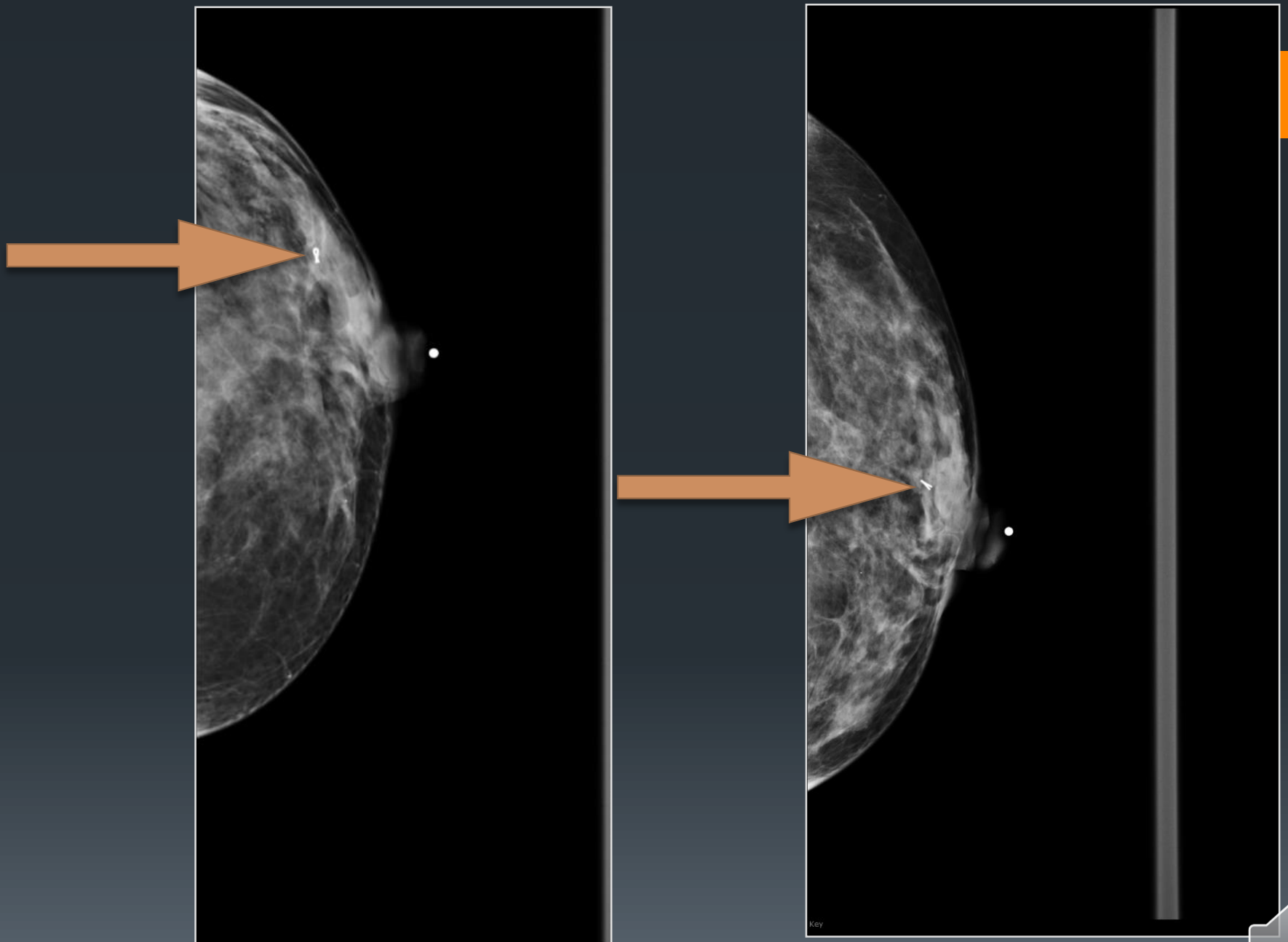
Role of MRI in the staging of breast cancer patients: does histological type and molecular subtype matter?

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.




Key
Key

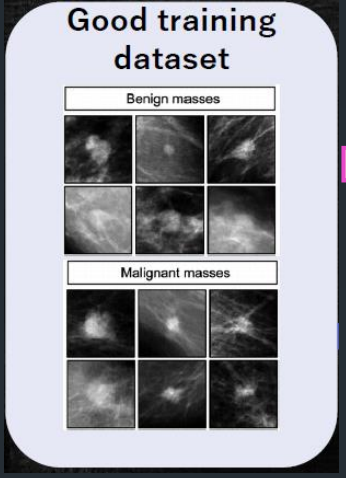
Concordant!

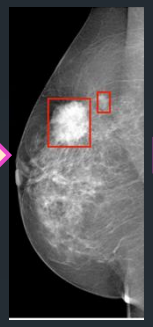
- Surgical Pathology Report

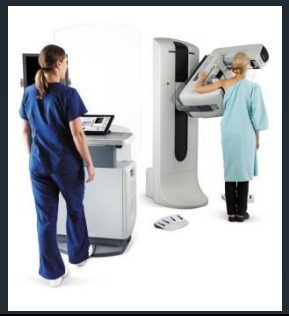
  FINAL PATHOLOGIC DIAGNOSIS A. Breast, left @ 2:00, ultrasound-guided core biopsy: - High grade Ductal carcinoma in situ,

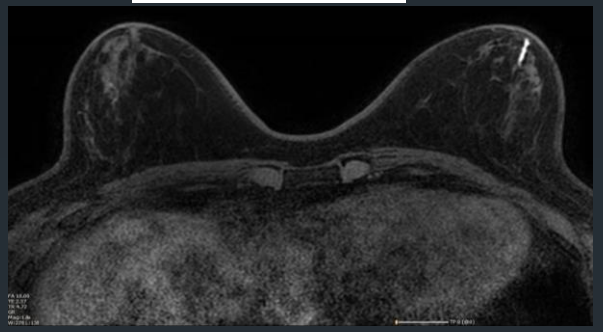
Summary

- 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.







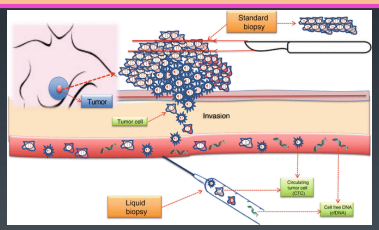


Personalized risk-based screening

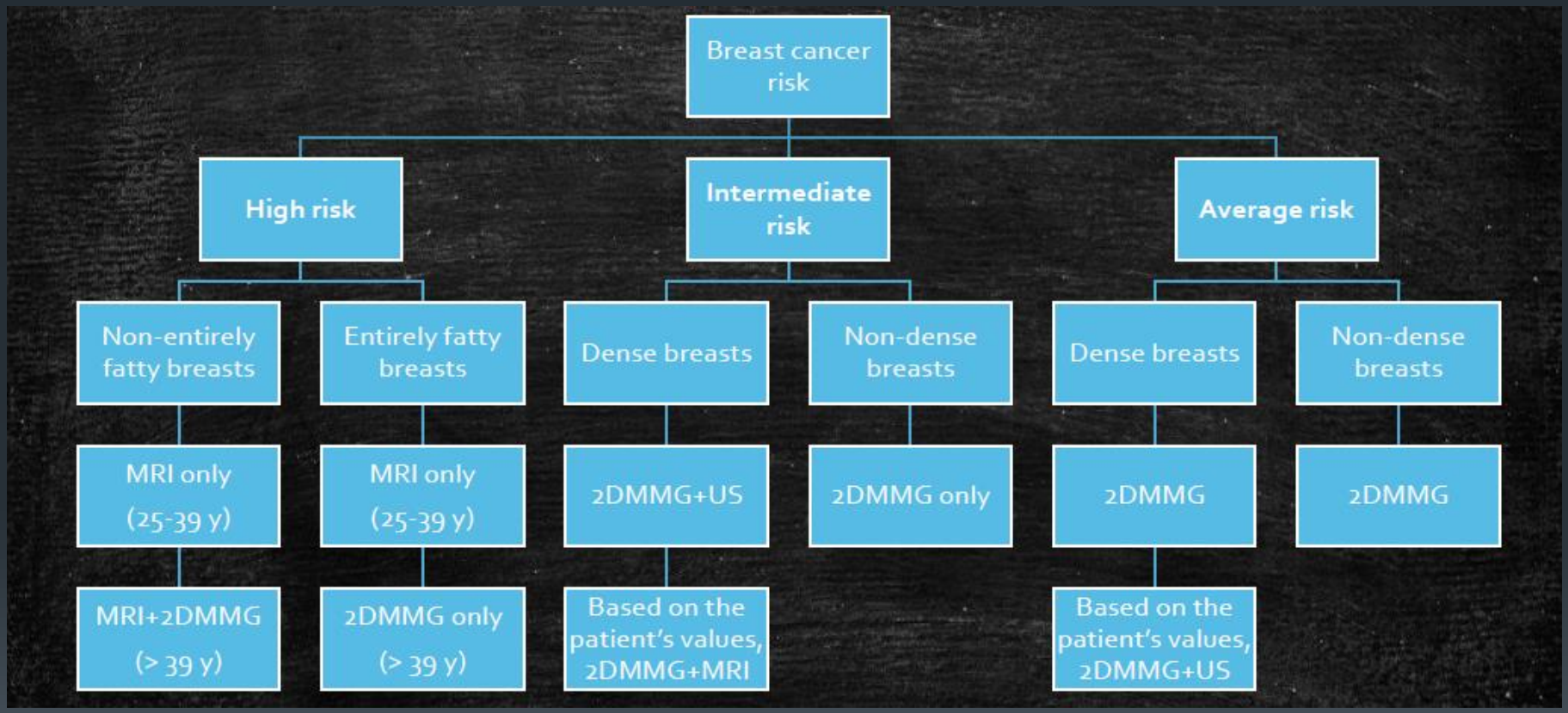
AI and deep learning

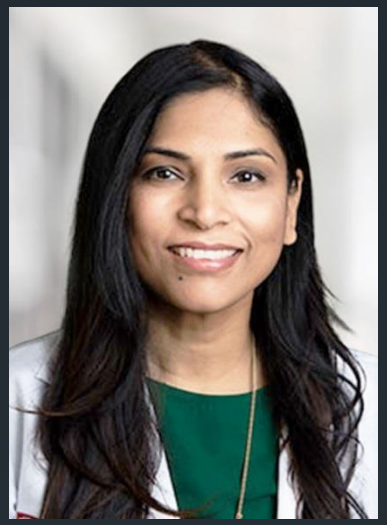
Future breast cancer screening tests

Non-imaging techniques (liquid biopsy)



Algorithms based on risk stratification and breast density





Thank you!

Email: kkulkarni@radiology.bsd.uchicago.edu

THE UNIVERSITY OF CHICAGO