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MEDICAL UNIVERSITY OF VIENNA

Advanced Applications of MR imaging of the breast (multiparametric (mp)MRI)

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Disclosure Statment

Research grants:

- SIEMENS Healthcare, Germany
- GUERBET, France
- HOLOGIC – MEDICOR, Germany

MRI of the Breast (30 years!)

- Detection of breast cancer (BC): MRI of the breast highest sensitivity (89-100%)

Kaiser et al., MRI 1994
Berg et al., Radiology 2004
Kuhl et al., Radiology I and II 2007
Benndorf et al., Acta Radiol 2010

- Specificity (81-97%) - comparable to mammography
- Independent of breast density
- Ability to detect non-invasive BC

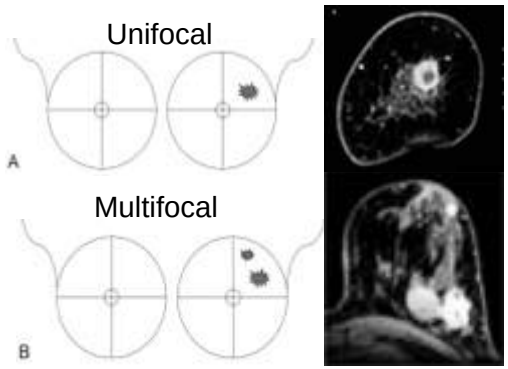
Kuhl et al., Eur Radiol 2000
Stoutjesdijk et al., MRI 2001
Warner, J Clin Onc 2001
Warner et al., JAMA 2004
Kuhl et al., Radiology 2005

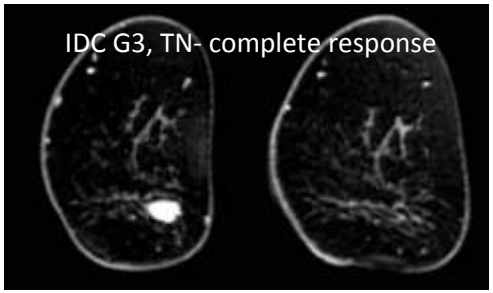
- Most accurate imaging modality for lesion extent

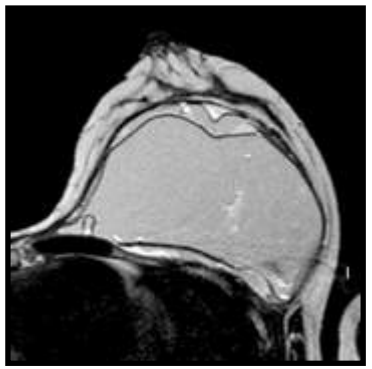
Berg et al., Radiology 2004
Boetes et al., Radiology 1995
Echevarria et al., JCAT 2006

MRI of the Breast: Indications

- Staging
  - Lesion extent “tip of the iceberg“
  - Uni-, multifocal/ - centric, bilateral?
- Scar vs. recurrence
- Neoadjuvant therapy-monitoring
- Implants
- Screening in high-risk patients
- Problem solving







MRI of the Breast: High-risk screening








JAMA 2004 NEJM 2004 Lancet 2005 Cancer 2005 JCO 2005 Radiology 2007 CCR 2007 JCO 2010

8 Studies 4,982 Pt 11,116 Exams 218 BCA

	Sensitivity	Specificity
MG	35 % (25-59%)	96 % (93-99.8%)
US	40 % (25-43%)	93 % (90-97%)
MRI	83 % (71-100%)	89 % (81-97%)

47% BCA detected only with MRI

17% BCA not detected with MRI

10% with MG

2.5% with US

5% Interval Cancer

MRI of the Breast for Screening

JOURNAL OF CLINICAL ONCOLOGY | ORIGINAL REPORT

Triple-Modality Screening Trial for Familial Breast Cancer Underlines the Importance of Magnetic Resonance Imaging and Questions the Role of Mammography and Ultrasound Regardless of Patient Mutation Status, Age, and Breast Density

Christopher C. Riedl, Nikolaus Luft, Clemens Bernhart, Michael Weber, Maria Bernathova, Muy-Kheng M. Tea, Margaretha Rudas, Christian F. Singer, and Thomas H. Helbich

All authors: Medical University of Vienna, Vienna, Austria; and Christopher C. Riedl, Memorial Sloan-Kettering Cancer Center, New York, NY.

Published online ahead of print at www.jco.org on February 23, 2015.

A B S T R A C T

Purpose

To evaluate the breast cancer screening efficacy of mammography, ultrasound, and magnetic resonance imaging (MRI) in a high-risk population and in various population subgroups.

Table 1. Mutation Characteristics of 559 Women Under Surveillance Because of a High Risk for Breast Cancer

Mutation Status	Patients No.	Patients %	Age (years) Range	Age (years) Median	Age (years) Mean
Total	559		22-83	42	50
BRCA1/2 positive	156	28	22-80	39	41
BRCA1	115	21	22-80	38	41
BRCA2	41	7	23-76	40	42
No *BRCA* mutation	297	53	23-83	42	43
Unclassified variant	184	33	23-67	42	43
Wild type	113	20	23-83	43	44
Incomplete genetic records	106	19	23-74	42	42

Table 3. Diagnostic Performance

Screening Modality	Sensitivity*	*P*†
US		
No./total No.	15/40	< .001
Rate, %	37.5	
95% CI	24.2 to 53.0	
MG		
No./total No.	15/40	< .001
Rate, %	37.5	
95% CI	24.2 to 53.0	
MRI		
No./total No.	36/40	NA
Rate, %	90.0	
95% CI	76.9 to 96.0	
US + MG		
No./total No.	20/40	< .001
Rate, %	50.0	
95% CI	35.2 to 64.8	
US + MRI		
No./total No.	36/40	1.000
Rate, %	90.0	
95% CI	76.9 to 96.0	
MG + MRI		
No./total No.	38/40	
Rate, %	95.0	
95% CI	83.5 to 98.6	
US + MG + MRI		
No./total No.	38/40	.148
Rate, %	95.0	
95% CI	83.5 to 98.6	

MRI of the Breast for Screening

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JOURNAL OF CLINICAL ONCOLOGY

ORIGINAL REPORT

Abbreviated Breast Magnetic Resonance Imaging (MRI): First Postcontrast Subtracted Images and Maximum-Intensity Projection—A Novel Approach to Breast Cancer Screening With MRI

Christiane K. Kuhl, Simone Schrading, Kevin Strobel, Hans H. Schild, Ralf-Dieter Hilgers, and Heribert B. Bieling

A Novel Approach to Contrast-Enhanced Breast Magnetic Resonance Imaging for Screening

High-Resolution Ultrafast Dynamic Imaging

Ritse M. Mann, MD, PhD, Roel D. Mus, MD,* Jan van Zelst, MD,* Christian Geppert, PhD,† Nico Karssemeijer, PhD,*‡ and Bram Platel, PhD**

Abbreviated protocol for breast MRI: Are multiple sequences needed for cancer detection?

Victoria L. Mango[a,b,*], Elizabeth A. Morris[b,1], D. David Dershaw[b,1], Andrea Abramson[b], Charles Fry[b,c], Chaya S. Moskowitz[b], Mary Hughes[b], Jennifer Kaplan[b], Maxine S. Jochelson[b]

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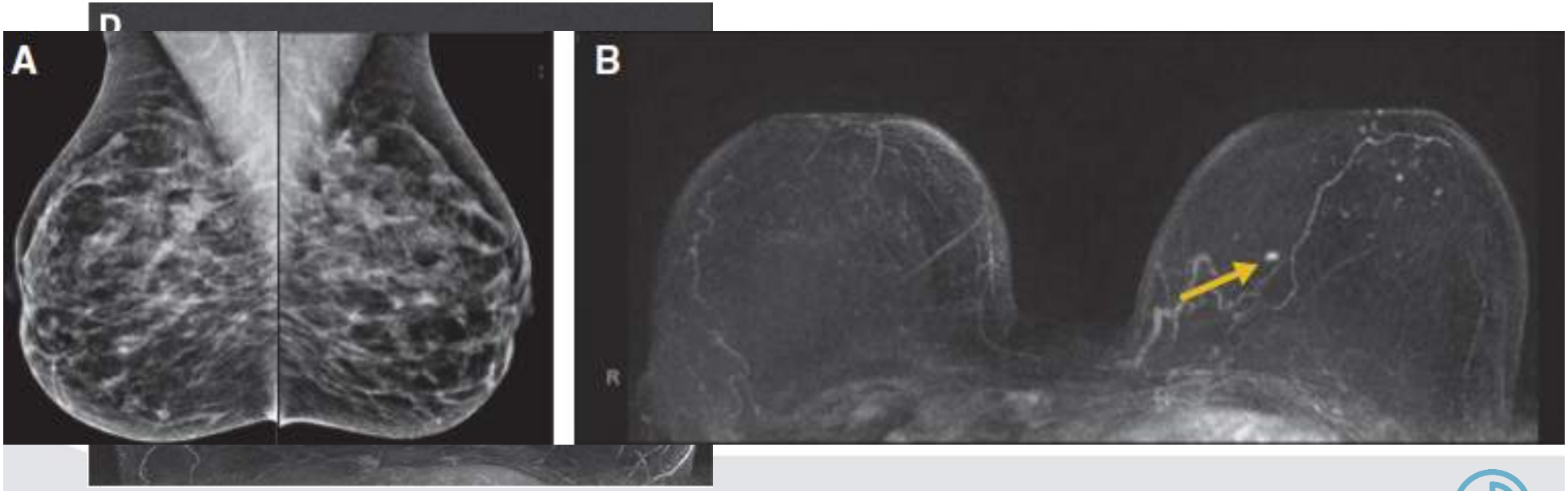
[b] Memorial Sloan-Kettering Cancer Center, Breast and Imaging Center, 300 East 66th Street, New York, NY 10065, United States
[c] New York Medical College, 40 Sunshine Cottage Rd, Valhalla, NY 10595, United States

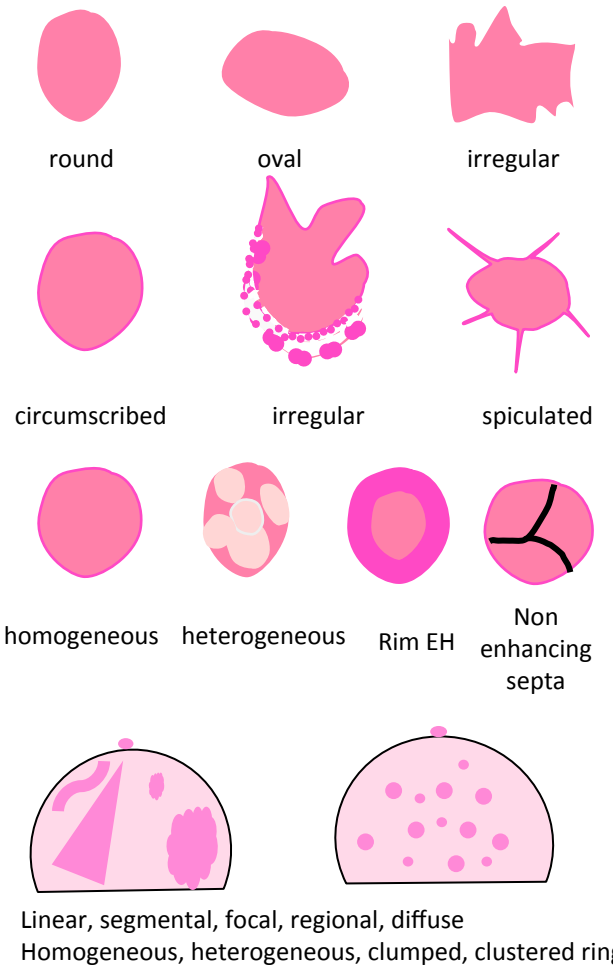
MRI of the Breast for Screening

- MRI: 3 min (1 pre, 1 post)
- Reading time: < 30 sec (MIP!)
- NPV: 99.8%,
- Add. cancer yield 18.2 per 1000



MRI of the Breast for Screening

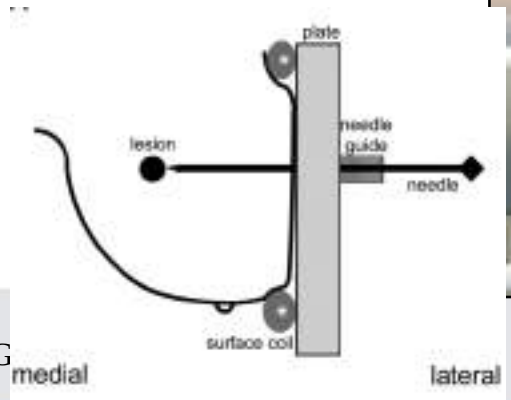
- Tumor morphology
  - Focus
  - Mass
    - Shape
    - Margin
    - Internal enhancement characteristics
  - Non mass Enhancement
    - Distribution
    - Internal enhancement pattern



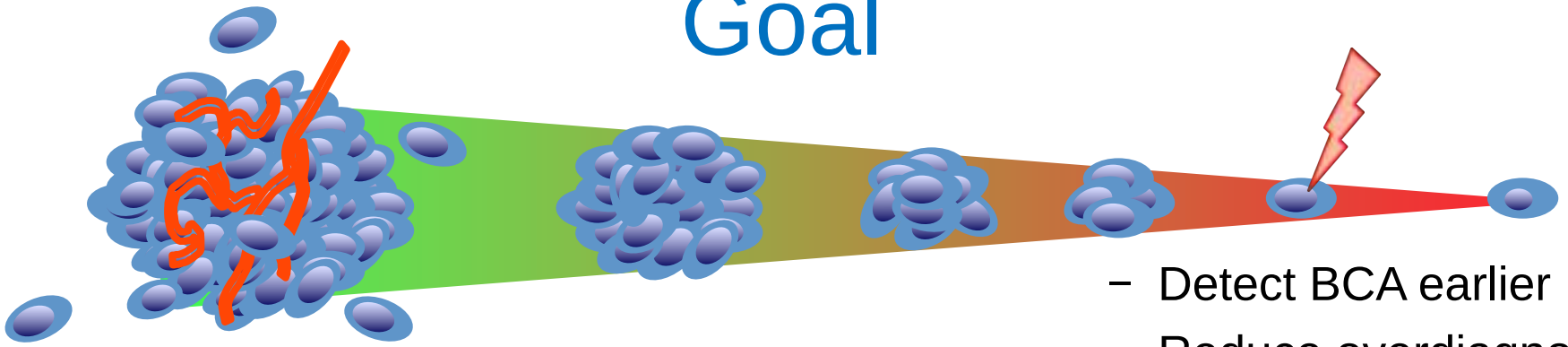
Linear, segmental, focal, regional, diffuse
Homogeneous, heterogeneous, clumped, clustered ring

MR guided Breast Biopsy

only 20-30/100 BX are BCA!!!!!



Goal

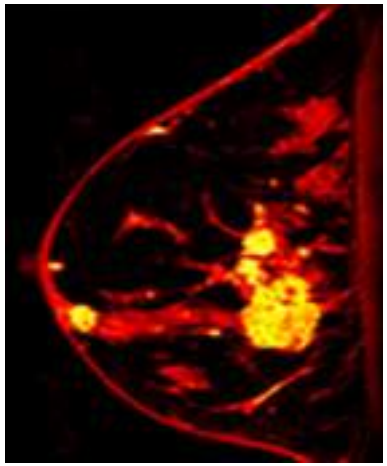


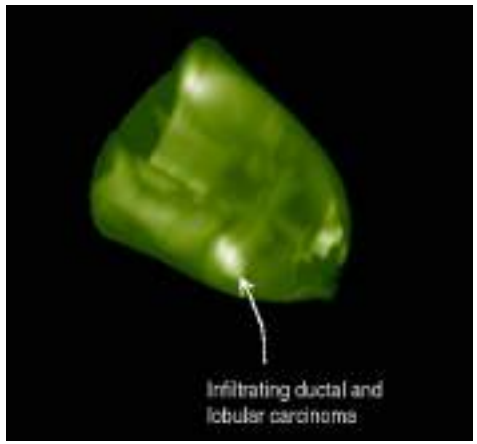
- Detect BCA earlier
- Reduce overdiagnosis

$1x10^9$

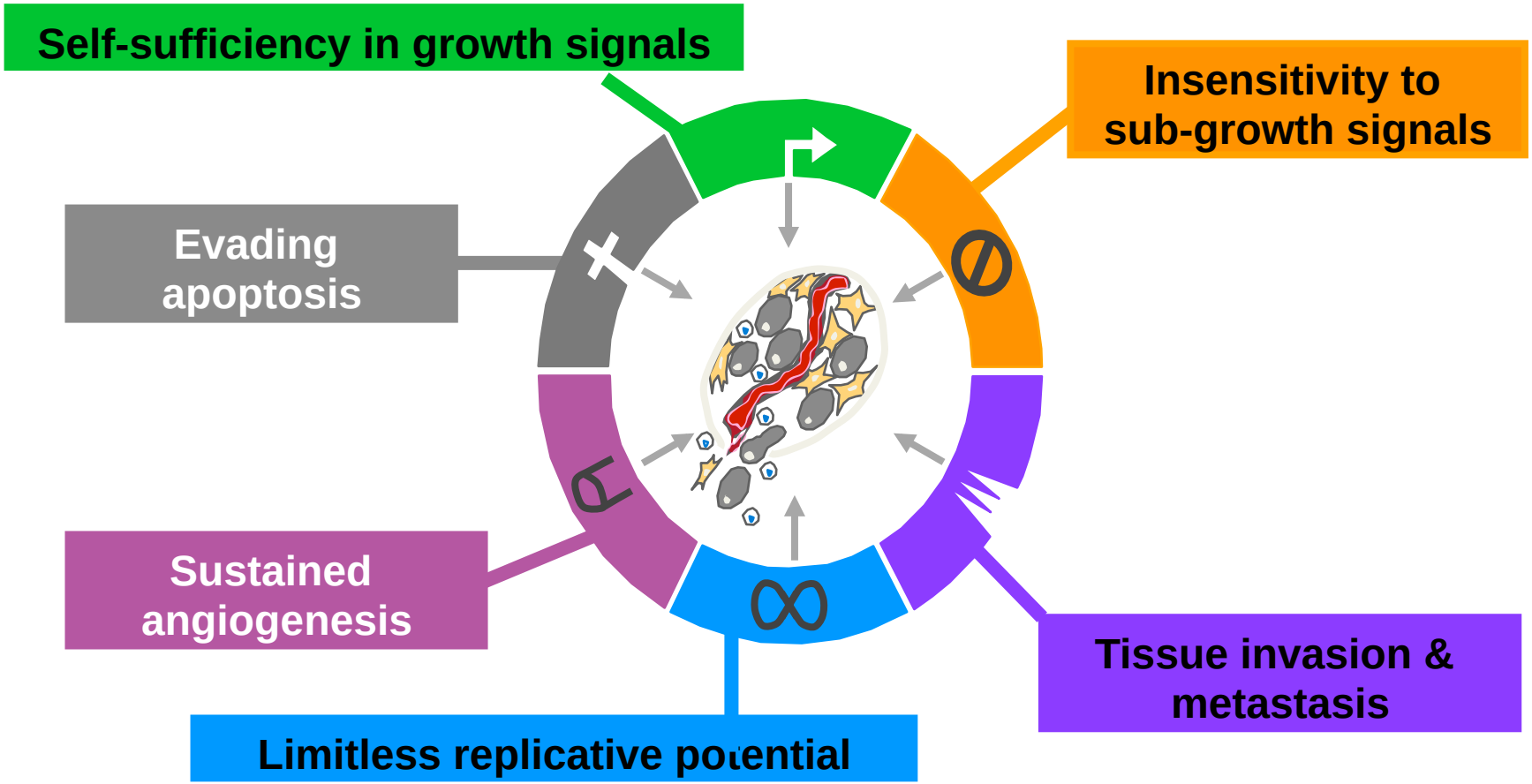
conventional radiology
macroscopic-anatomical level

molecular imaging
cellular, molecular level



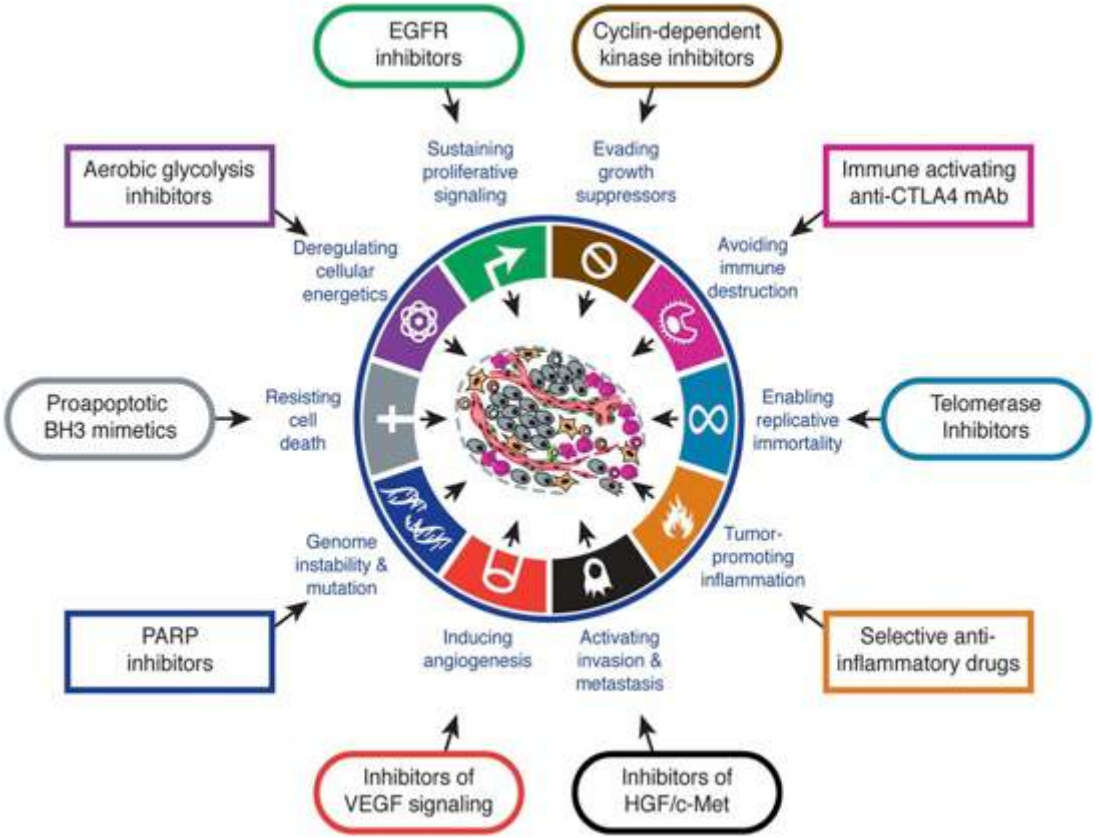


Hallmarks of Cancer



Altered Metabolism

[^{18}F]FDG PET
MRSI
Hyperpolarized MRI
[^{18}F] MISO PET
BOLD MRI



Hanahan D. et al.
Cell 2011;144:646-74.

Metastasis

[^{18}F]FDG PET
DWIBS
Bone Scan
CT/MRI

Angiogenesis

[^{18}F]FDG PET
DWIBS
Bone Scan
CT/MRI

Cell Death

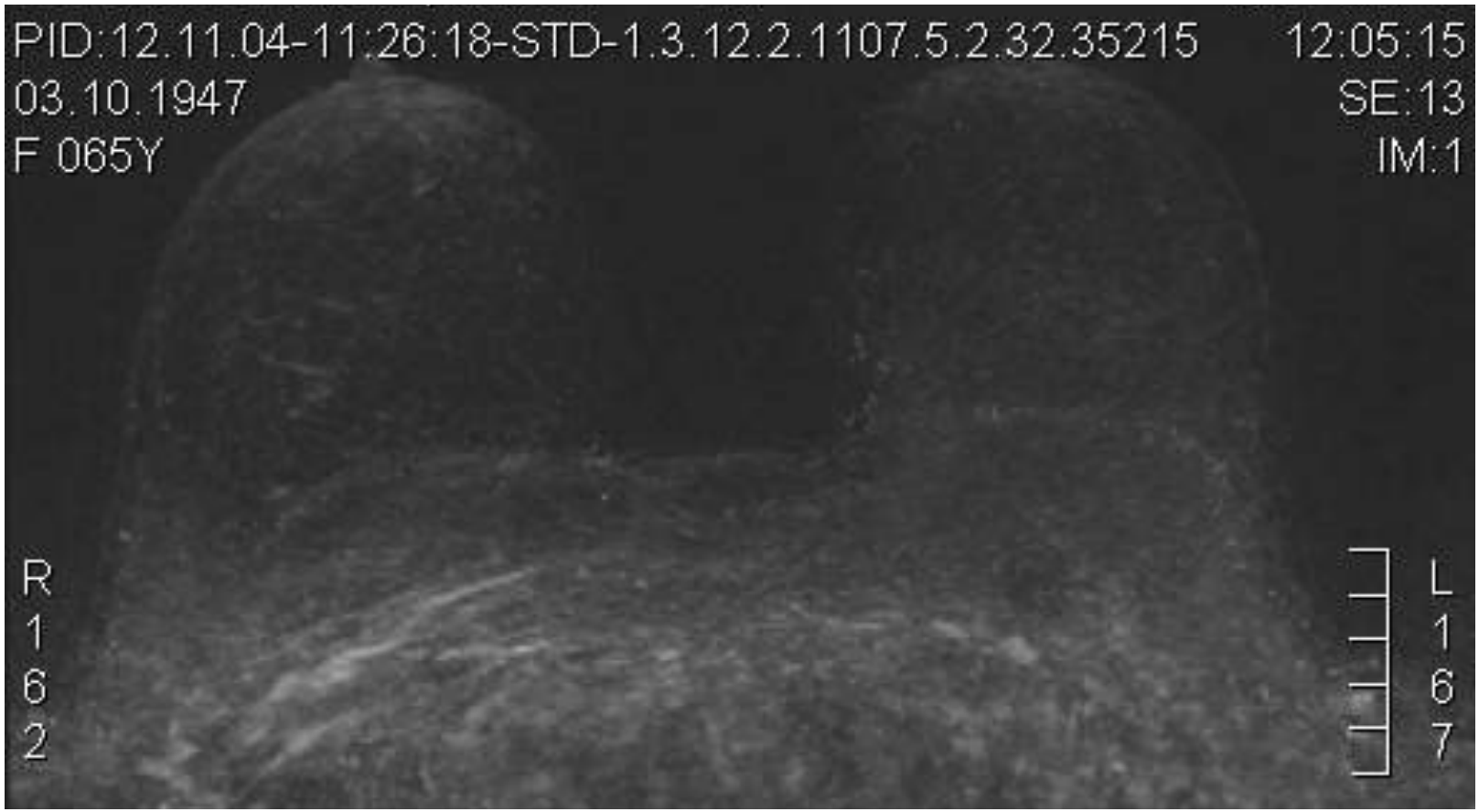
Annexin
Diffusion MRI
Hyperpolarized MRI

Proliferation

[^{18}F]FLT PET, MRSI, Diffusion MRI

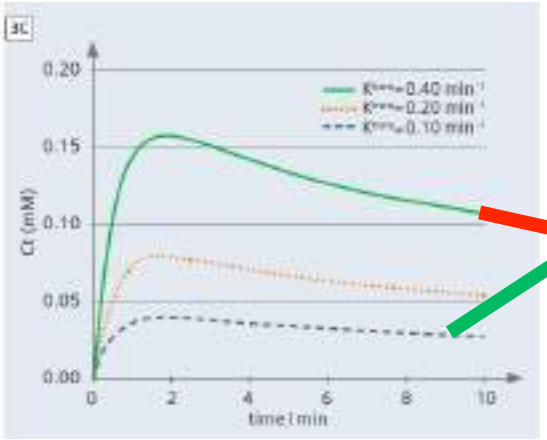
HALLMARKS

DCE-MRI

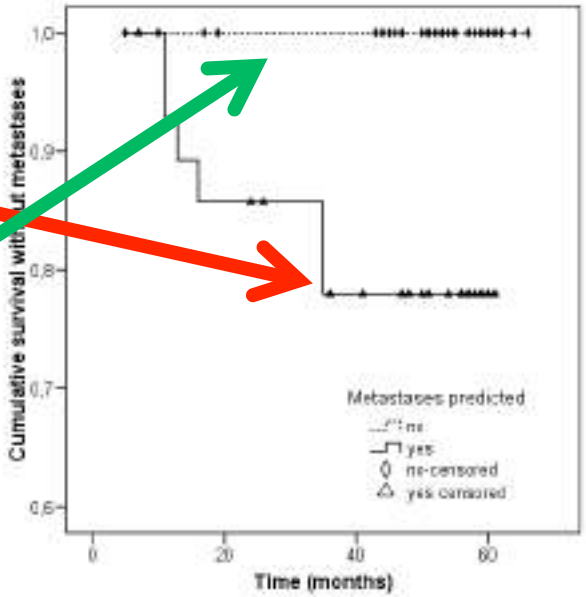


MIP, (3T, 3D TWIST, voxel: 1.x 1 x 1mm, temp. res.: 14 sec.)

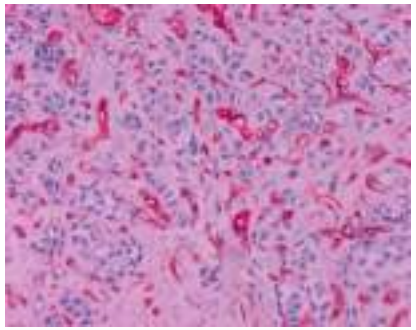
Beyond the breast - Prognostic information



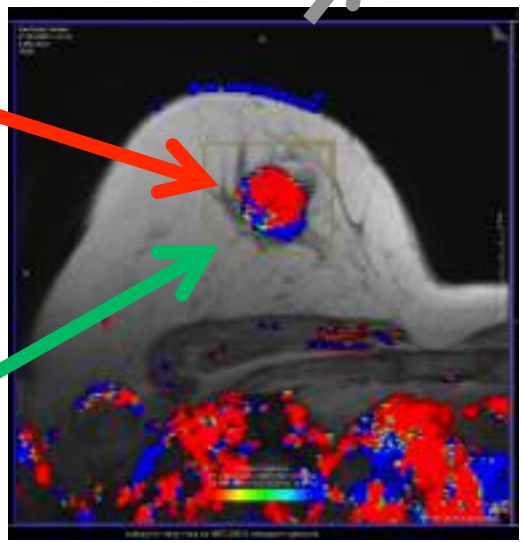
Pharmakokinetics

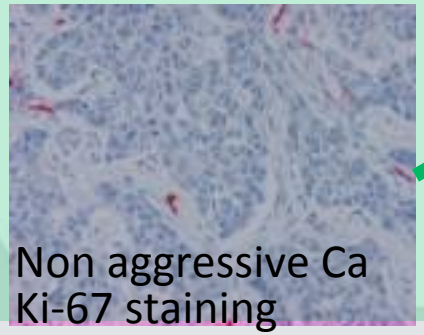


Survival prediction



Aggressive Cancer



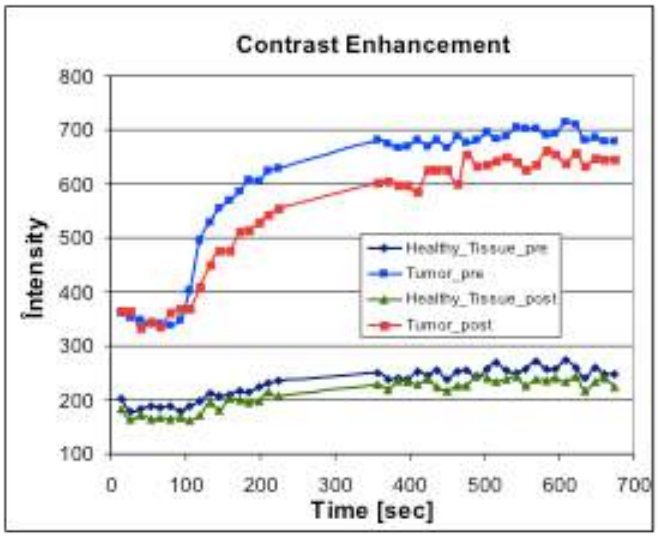


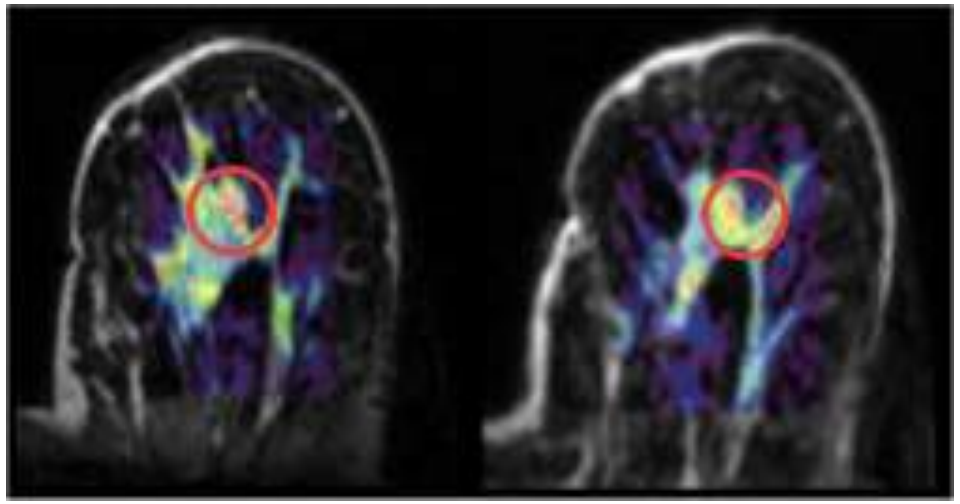
Non aggressive Ca
Ki-67 staining

Enhancement quantification by MRI

Baltzer et al. 2012, Dietzel et al. 2013, Li et al. 2013

Enhancement kinetics





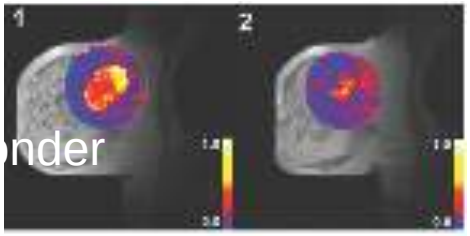
Reductions in enhancement correlate with response to treatment

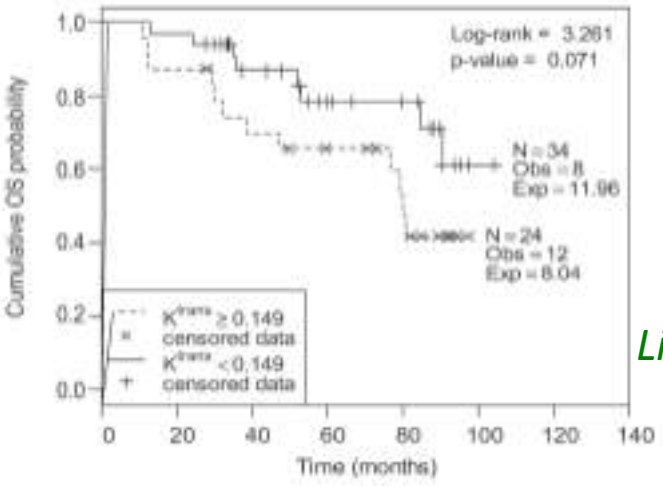
McLaughlin et al, NMR in biomedicine 2011

Fast dynamic CE-MRI

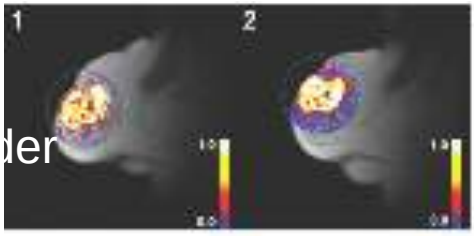
Changes can predict survival in patients with NAC

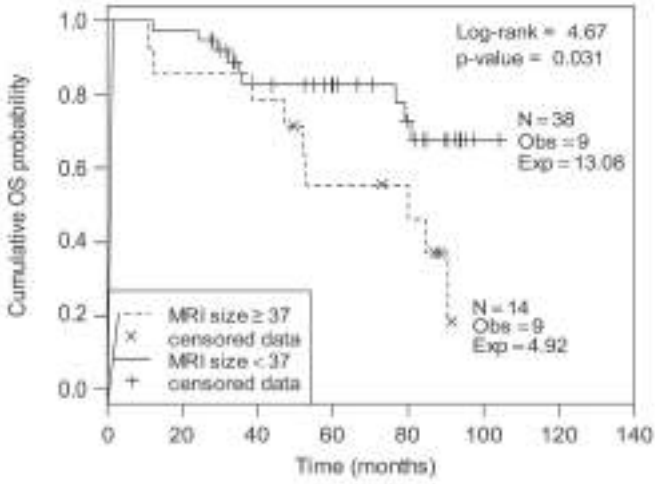
- High post treatment K^{trans} / larger post treatment TU size
- Worse overall survival, worse disease-free survival





Li et al; Radiology 2011



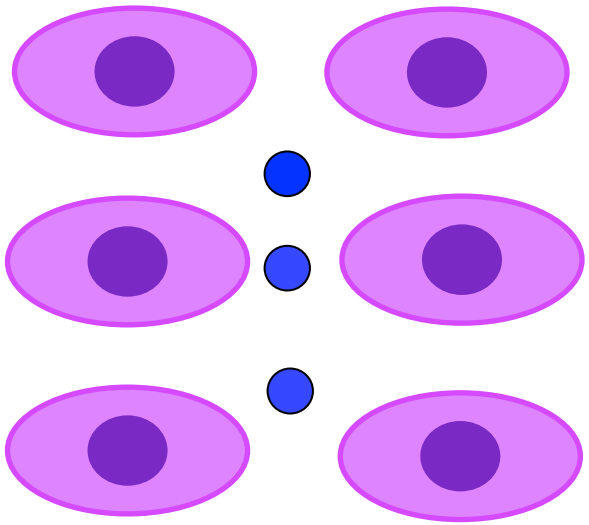


Diffusion Weighted Imaging (DWI)

Benign:

Diffusion

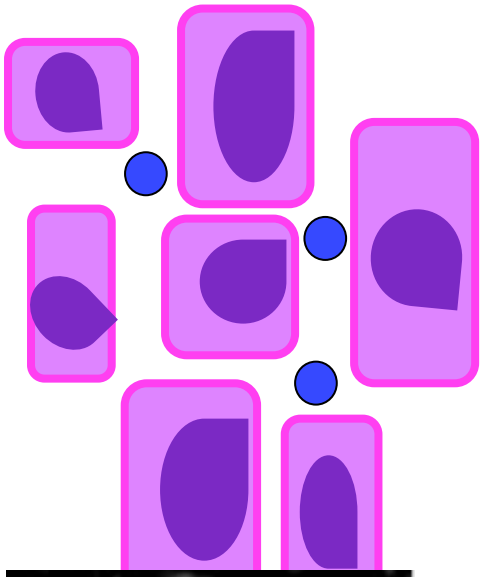
ADC

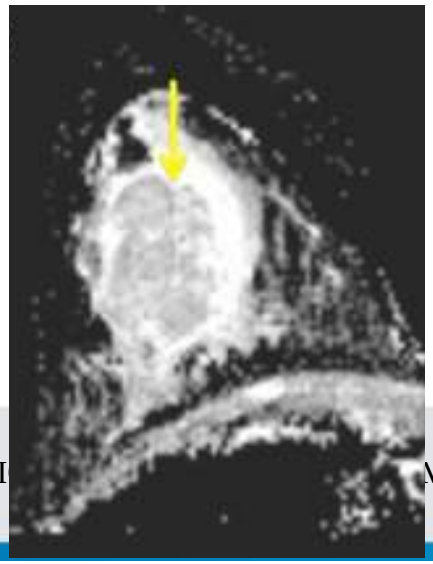


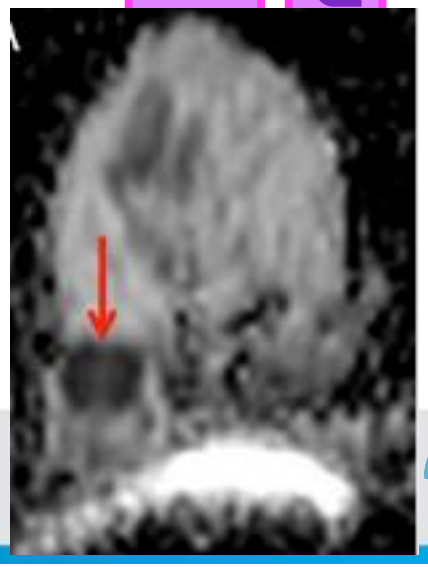
Cancer:

Diffusion

ADC







DWI of the breast (ADC)

Results:

- ADC value in benign tissue higher than in carcinomas (p=0.001)
- ADC allows differentiation of benign and malignant breast tumor
- Sens: 0.93 Spec: 0.88

Guo et al JMRI 2002

Woodhams et al JCAT 2005

DWI of the breast

- large variations in reported ADC values (Kuroki et al. 2004; Hatakenaka et al. 2008; Woodhams et al. 2005; Wenkel et al. 2007)
- large variations in diffusion parameters (max, min, no. of b-values) (Matsuka et al. 2008)
- systematic evaluation of diffusion protocols?

Diffusion-weighted MR for Differentiation of Breast Lesions at 3.0 T: How Does Selection of Diffusion Protocols Affect Diagnosis?[1]

Wolfgang Bogner, MSc
Stephan Gruber, PhD
Katja Pinker, MD
Günther Grabner, MSc
Andreas Stadlbauer, PhD
Michael Weber, PhD
Ewald Moser, PhD
Thomas H. Helbich, PhD
Siegfried Trattnig, PhD

Purpose: To compare the diagnostic quality of diffusion-weighted (DW) imaging schemes with regard to apparent diffusion coefficient (ADC) accuracy, ADC precision, and DW imaging contrast-to-noise ratio (CNR) for different types of lesions and breast tissue.

Materials and Methods: Institutional review board approval and written, informed consent were obtained. Fifty-one patients with histopathologic correlation or follow-up performed with a 3.0-T MR imager were included in this study. There were 112 re-

Radiology: Volume 253: Number 2—November 2009 ▪ *radiology.rsnajnls.org*