Successful Breast MRI Program: The ingredients

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• How to perform Breast MRI
• Breast MRI descriptors and interpretation
• Breast MRI Indications
• Breast MRI Reporting
NOBEL PRIZES

Isidor I. Rabi
Physics 1944

Felix Bloch - Edward M. Purcell
Physics 1952

Richard R. Ernst
Chemistry 1991

Kurt Wüthrich
Chemistry 2002

Peter Mansfield - Paul Lauterbur
Medicine 2003
PubMed 1960-2009 2010-11

Mammography

- VAB 2%
- MRI 24%
- CB 9%
- FNAC 1%
- US 20%
- Ma 44%

Articles

Robust Clinical MRI Program
Breast MRI: Non Fat-Sat (the European Way)

Planning
• 2\textsuperscript{nd} week of the menstrual cycle, no HRT

Technique
• 1.5 T or higher strength
• T2W FSE or sequence
• Dynamic 2D or 3D spoiled T1W GE sequence
  • < 2mm slice thickness
  • < 1mm\textsuperscript{2} in plane resolution
  • i.v.bolus of 0.1 mmol/kg of a Gd-chelate

• Post-processing
  • Temporal subtraction
  • Dynamic Enhancement % curves for small ROIs
  • MIP and MPR
The U. S. Way: Fat-sat

• Advantages
  • Temporal subtraction not needed
  • Skin and normal Glandular tissue can be seen

• Disadvantages
  • Longer acquisition time
  • Possible artifacts from field inhomogeneity
Whichever protocol is chosen... Key to success is....

• **Consistency** — Stick to same protocol

• **Short examination time < 20 min**

• Make the pt comfortable
  • Before MRI – *talk* to the patient:
  • During MRI - *don’t talk* to the patient

• **Standardized viewing protocol** on dedicated workstation (*NOT FILMS*)
Role of T2W sequence

- 87% cancers are T2 iso or hypointense
- High T2 signal favours benignity
  - Fibroadenomas in pts<50y
- Caveat
  - High T2 signal in medullary and mucinous cancer

New Breast ACR BI-RADS recommendations include T2W sequences!!!
High Res Sequences

Axial “VIEWS”
MIPS

Volume Interpolated Exam under Water Stimulation

- High spatial resolution
- Morphology analysis
- After the dynamic sequence
MRI Interpretation

- Abnormal enhancement
- Morphological features
- Kinetic patterns
- Clinical history
Neoangiogenesis

Increased vascularity
More vessels, larger vessels
Increased permeability
Microvascular permeability

Increased interstitial space × 3-5

Gd-enhancement of breast malignancies
Sensitivity: about 95% for invasive cancers; DCIS ... ?
Negative predictive value of no enhancement

Schnall, Radiology 2006
995 Mammo BIRADS 4-5 lesions

• No enhancement in
  • 12% of all cancers, NPV 88%
  • 16% (12/77) of DCIS
  • 3% (13/422) of IDC, NPV 94%
to morphological lesion type

**MASS or NON MASS?**

- MASS
- NON MASS

**FOCUS**

- Kinetic +++
- Morphology +++
- Little value of kinetic

Morphology AND Kinetic
Dynamics

- **Type I: steady enhancement or continuous increase**
  - Likelihood of BC 6%

- **Type II: plateau**
  - Likelihood of BC 64%

- **Type III: washout**
  - Likelihood of BC 87%

Kuhl CK et al Radiology 1999
A SIMPLE FLOW-CHART

Irregular/spiculated mass → Biopsy

Morphology Alone
Non-masslike c.e. → Biopsy

Regular mass (or focus) → Look at dynamics

Morphology & Dynamics

Initial uptake and late CE characteristics of 79 pure DCIS – Jansen et al, Radiology 2007
Diffusion Weighted Imaging

• **Study the biophysical properties of tissues**
• **ADC as a surrogate marker of cell organization, cell density and microstructure**

Pre-therapy  Responder  After III NACT
Diffusion Weighted Imaging

For 2 b-values (50/850 s/mm²) (~ 2:30 min)

- ADC threshold of $1.25 \times 10^{-3}$ mm²/sec
  - sensitivity – 96%
  - specificity – 94%

Bogner et al Radiology 2009
ADC: Potent ‘Imaging’ Biomarker

Characterization
Benign/ malignant
Non-invasive / invasive Grading (n=176)

Bickl H et al RSNA 2012
ADC: Potent ‘Imaging ‘ Biomarker

Key Points

• DWI may identify biological heterogeneity of breast neoplasms

• ADC values vary significantly according to biological features of Breast Cancer

• HER2-enriched tumours show highest median ADC
DWI at 7 Tesla--?? Non contrast MRI
MR Spectroscopy

- Sensitivity 70% to 100%
- Specificity 67 to 100%
- Increased PPV from 35% to 82%
- Obviates biopsy up to 57%

Bartella et al Radiographics 2007
Multiparametric MRI

- Multiparametric imaging of breast tumors with proton MRS, DWI and dynamic CEMRI at 3 T improves sensitivity, specificity and diagnostic accuracy
- Obviates unnecessary biopsies
Evaluation Algorithm

- Lesion morphology in high spatial resolution sequences
- Enhancement kinetics in high temporal resolution sequences
- BIRADS classification
- MRSI positive if SNR of Choline peak > 2.6
- DWI– ADC threshold of $1.25 \times 10^{-3}\text{mm}^2/\text{sec}$

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<th>DWI</th>
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Results: Multiparametric MRI

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<th>Modality</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Diagnostic Accuracy</th>
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<tr>
<td>MRI</td>
<td>22.7% (5 FP), 2.6% (1 FN)</td>
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<tr>
<td>DWI</td>
<td>22.7% (5 FP), 7.9% (3 FN)</td>
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<td>MRSI</td>
<td>4.5% (1 FP), 10.5% (4 FN)</td>
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Multiparametric-MRI

9% (2 FP, 0 FN)

Obviates unnecessary breast biopsies in 91% of benign lesions

Pinker K et al WMIC 2012
What prevents more widespread use of Breast MRI?
Fast & Slow

Fast technological evolution

Slow clinical application

1986: First CE breast MRI
2012 (26 years after)

Evidence-based Indications?
EVIDENCE-BASED BREAST MRI

44 studies included in meta-analysis
Sample size 14-821; cancer prevalence 23-84%
Pooled weighted estimates:
Sensitivity 0.90 (95% CI, 0.88-0.92)
Specificity 0.72 (95% CI, 0.67-0.77)

Please, stop the "mantra": Breast MRI has high sensitivity but low specificity!

At the Congress of the Breast Imaging Section of SIRM, Milan, June 2011

Werner A. Kaiser
### Magnetic resonance imaging of the breast: Recommendations from the EUSOMA working group

1. **Staging (preop MRI)**
   - **Conclusion:** CE **Limited**
2. **Screening high-risk women**
   - **Conclusion:** CE **YES**
3. **Evaluation of response to NAC**
   - **Conclusion:** CE (NC) **YES**
4. **Augmentation or reconstruction (suspected implant rupture)**
   - **Conclusion:** NC **YES**
5. **Occult primary breast cancer**
   - **Conclusion:** CE **YES**
6. **Suspected local recurrence**
   - **Conclusion:** CE **YES**
7. **Equivocal findings at mammo/US**
   - **Conclusion:** CE **Limited**
8. **Nipple discharge**
   - **Conclusion:** NC+CE **NO**
9. **Inflammatory breast cancer**
   - **Conclusion:** NC+CE **NO**
10. **Male breast**
    - **Conclusion:** NC+CE **NO**

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1. ILC, high-risk, mammo/US size discrepancy, PBI
2. When CNB/VAB cannot be performed
Preop MRI... Eternal controversy

• What is the clinical importance of additional foci of carcinoma detected only with MRI?

• When multifocal cancer is identified on MR images, is mastectomy required?

• Will the use of MR imaging result in an increase in unnecessary mastectomies?
Controversy continues....

• MRI in every new diagnosis of Breast Cancer?

• MRI only in mammographic dense breasts?

• No MRI staging?
Preoperative MRI

EUSOMA WG Consensus

- Newly diagnosed Invasive lobular cancer
- Newly diagnosed BC in high risk women
- Mammo/US discrepancy in size > 1cm in women < 60 yrs
- Eligibility for partial breast irradiation

Sardanelli F et al Eur J Cancer 2010
Invasive Lobular Cancer

Systematic review of pts with ILC

• Additional ipsilateral lesions detected with MRI in 32%, contralateral lesions in 7%, surgical management was changed in 28%

Mann et al, Breast Cancer Res Treat 2010
MRI detection of multifocal cancers in high-risk women

At the interim analysis of the HIBCRIT 1 study (Radiology 2007)

• 7/18 cases (39%) had multiple malignant lesions
  • 0% (0/7) for CBE and Mammo
  • 33% (2/6) for US
  • 71% (5/7) for MRI
Tumour size discrepancy at Mammo/US

- 165 pts eligible for BCT
- Pts <58yo with irregular margins and mammo/US discrepancy > 10mm have a 3.2 higher chance of accurate MRI assessment

- Bernard et al, Breast 2012
MR detected Additional Findings..... What next?
A GOLDEN RULE

- *NEVER* convert a BCS to mastectomy on the basis of MRI additional findings not path. verified to be malignant
  - Second look US and (if visible) US-CNB
  - Postbiopsy MRI for confirmation
  - Optimum: MR-guided VAB

- MR-guided biopsy/localisation must be integrated in clinical practice

- Using MR-guidance the unnecessary wider excisions/mastectomy previously reported can be drastically reduced
MR Guided Biopsy Systems

GRID

PILLAR & POST
MR Guided Biopsy

- Dedicated breast localisation system required:
- Adequate breast immobilisation
- Imaging of the complete breast at thin slices before and after contrast
- 3 D planning
- Choice of access to avoid the chest wall
- To have sufficient breast thickness
- Countercheck whether the area can be reached at all
- Optimum positioning is crucial
- Check inclusion and function of your fiducial marker
MR Guided Biopsy

- 11 gauge VB probes (or thicker)
- New needle for each lesion (cross contamination!)
- Average no. of 12G cores: >12 (or corresp volume)
- Objective: sufficient removal of small lesions for diagnostic purpose, but not therapeutic for malignancy
- Document: postbiopsy MR sequences
  - Minimum 1 sequence
  - If needed: another injection plus one more post contrast sequence
MR Guided Biopsy: Training and QA

• Provided significant experience with VAB (>50 cases/yr) and breast MRI sufficient expertise should be available after **10 MR-guided VAB procedures**

• For maintaining experience **at least 10 procedures should be performed by the team per year**
Future ??
FROM DIAGNOSIS TO PROGNOSIS

• Narisada et al, AJR 2006. Correlation between numeric dynamic MRI ratios and prognostic factors and histologic type of BC


• Choi et al, Br J Radiol 2012. Correlation of the apparent diffusion coefficient values on diffusion-weighted imaging with prognostic factors for breast cancer

• Jeh et al, JMRI 2011. Correlation of the ADC value and dynamic MR findings with prognostic factors in IDC
To conclude...

- Breast MRI has a long history, is increasingly clinically used and shows a great potential for the future.
- Breast MRI has **not only high sensitivity but also good specificity**.
- The debate on indications will continue in the next years, especially the controversy on preoperative MRI.
- High quality research is needed in MRI.