Implementation of a Breast MRI Program
- all things considered

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ISMRM, Durban 2011

Objectives
• How to select an optimal magnet
• What to be aware of during installation & setup
• Exam performance & interpretation issues

Breast MRI
• The rapid increase in use of MR in breast imaging has been aided by
  – Interventional techniques & equipment for MRI-only detected lesions
  – ACS guidelines (2007) for indications
    • women at high risk
    • tumor staging
    • treatment monitoring

ACS Guidelines 2007
www.cancer.org
• Recommended based on evidence
  – Women with known BRCA mutations
  – Women with first degree relative with BRCA mutation but themselves not tested
  – >25% lifetime risk by assessment mode

• Recommended based on expert consensus
  – Post radiation to mediastinum
  – Typically Hodgkins survivors (treated at <30 years)

Magnet selection
• Consider
  – Your practice needs
  – multi-specialty use vs breast imaging only
  – may have to consider needs of neuro, MSK, cardiac
  – Hospital vs outpatient only
  – Imaging only or interventional procedures
    – Biopsy capability is highly recommended for any facility performing breast MRI

• Not enough data to recommend for or against the following histology, imaging, and historical data
  – Non-invasive lobular neoplasia: LCIS, ALH
  – Atypical ductal hyperplasia (ADH)
  – Dense breasts on mammogram
  – Personal history of breast cancer (invasive and DCIS)

• Recommended against (by expert consensus)
  – Women with lifetime risk < 15%
Magnet selection

- 1.5 T (lesser strength not recommended for breast)
- 3 T
- Dedicated breast system
  - One of the above or
  - specially designed by manufacturer for breast imaging only

Dedicated breast magnet

- What volume justifies a dedicated breast magnet
- Facility (new construction / renovation)
- Free standing (carry full support / overhead) or additional unit to existing suite
- Imaging only / and procedures; interventional volume
- Operating expense (personnel, supplies, utilities)
- With qualifications:
  - minimum of 6-8 patients per day

Coil selection

- Bilateral breast surface coils
  - 4, 7 and 8 channel coils exist
  - 16 channel coils recently available
    - Better axillary coverage
- Biopsy ease on new 16 channel coils
  - Mediolateral and cranio-caudal access
  - Built in lights

Current 1.5 T imaging

- Optimize high resolution protocols using 3D gradient echo sequences
  - Better signal to noise ratio (SNR)
  - In-plane resolution < 1mm x 1mm
  - Thinner slices (≤ 1 mm)
  - Shorter acquisition times due to ↓ TR/TE (1-2 min)
  - Bilateral imaging with full coverage
- High spatial and temporal resolution
  - Detailed morphologic analysis and temporal mapping

Imaging at 3T

- Inherent advantages (twice the signal strength of 1.5)
  - Thinner slices = higher resolution
  - Chemical shift = field strength, doubling from 1.5 to 3T
    - better fat suppression
    - better metabolite peak separation for spectroscopy
  - Higher susceptibility effects
  - Improved FIESTA sensitivity to hemorrhage (modified protocols)
  - Higher signal intensity:
    - ↑ better Diffusion Weighted Imaging

Imaging at 3T

- Inherent challenges
  - RF deposition scales exponentially with strength
    - tissue heating
  - SAR limits set by Int’l Electrotechnical Commission*
  - Higher ambient noise – almost double c/w 1.5T ~130 dB
  - IEC/ FDA permissible limit 99 dB
  - Magnet length affects noise, shorter bore louder
  - System inhomogeneity at larger FOV
  - Higher susceptibility, dielectric effect, chemical shift
    - Dielectric effects
      - exacerbated by high SNR surface coils
      - manifested as shading or signal drop off

* SAR limits: 8W/kg over 5 min, or 4W/kg whole body over 15 min
Dielectric effect

Early images

Later 3T imaging

Current 3T imaging

Magnet selection: 1.5 vs 3 T

- Neuro
  - Better contrast on 1.5 T for day to day imaging
  - 3T: spectroscopy, perfusion, and functional imaging

- MSK
  - Years of established work on 1.5 T, but
  - Isotropic imaging on 3T with multi-channel coil; better SNR

- Cardiac
  - 1.5 T can do all the clinical work
  - Lit supports better perfusion, and cine on 3T
  - New sequences, molecular imaging
  - Artifacts, shimming problems

Thanks to Drs. Hsu, Yoshioka, Kwong
Breast MRI on 1.5 vs 3 T

- No evidence yet for diagnostic ability with 3T
- Kuhl 2006: “breast imaging at 3T almost ready for routine clinical use”
- Later: concern about limited contrast enhancement due to inherent B1 field inhomogeneity
- Can be overcome with modifications, newer software and tailored protocols

Spectroscopy

- Spectroscopy
  - Japanese study: best sensitivity and specificity when masses > 15 mm = 50 and 87%*
  - 3T: finer analysis of choline peak
  - Distinguish invasive carcinoma from DCIS and DCIS with microinvasion may be possible

DWI

- Role in breast not established
  - Multiple studies at 1.5 T: mean ADC values for malignant lesions significantly lower than for benign
  - Recent study at 3T compares sensitivity/specificty of ceMRI, qualitative DWI and quantitative ADC
    - 95/91%, 95/63.6%, and 90/91% respectively

Other considerations

- Siting issues
  - Interference from ambulances, elevators etc
  - Motion (best on ground floor?)
  - Reinforcement of several floors below may be required
- Patient discomfort
  - Mild dizziness common
- Patient safety: contraindications
  - IUD, stents, implants, orthopedic devices, defibrillators

Patient safety

- Updated guidelines and recommendations from peer-reviewed literature
  - International Society for Magnetic Resonance in Medicine(ISMRM)
  - American College of Radiology (ACR)
  - Food and Drug Administration (FDA)
  - National Electrical Manufacturers Association (NEMA)
  - International Electrotechnical Commission (IEC)
  - Medical Devices Agency (MDA)
  - Institute for Magnetic Resonance Safety, Education & Research (IMRSE&R)
In summary

- Breast imaging at 1.5 T is established
- 3T if interested in newer techniques like spectroscopy, DWI
- Beware
  - Challenges in siting & installation
  - Protocols & sequences
  - Patient safety (implanted devices)
  - Perhaps best if there’s a back-up 1.5 T for such pts
- Don’t expect a “plug & play” system delivered

Installation

- Siting – critical for optimal imaging results
  - engineering survey of selected site by both vendor and your own consultants
- Ramping up takes 3-5 weeks
  - Calibration
  - Phantom testing
  - Sequence testing

Installation

- Scanning readiness
  - Protocol testing: technologists, physicists
  - Volunteers: +/- contrast
    - Field homogeneity, fat suppression, motion artifacts
  - Test breast coils
- Supertechs and physicists are key
  - Experience in breast MRI
  - Build protocols
  - Tailor sequences
  - Optimize magnet time

Patient Selection

- Introductory letter to referring clinicians, including ACS guidelines
- Accept all referrals?
- Approve each request individually?
  - Some practices will only schedule exam when all clinical info has been provided
  - Tailor protocol for every exam?

Scheduling

- Trained schedulers, with screening questions
- Safety issues: allergies, surgical implants
- Renal function (NSF issues)
- Time of menstrual cycle (ideal 5-12 days)
- Previous studies: mammo, US and MRI

Telephone questionnaire
Pregnancy issues

- Gadolinium currently not recommended
- Not enough data
  - Known cases where pregnant women received contrast show no harm to patient or baby

Performance of the MRI exam

- Well trained technologists
- IV team availability
- Interview patients using detailed screening sheet
- Review history form with patients
- Log in any outside studies pt brings in
Protocols

- Standard
  - Localizer or scout sequence
  - T2 fat sat, to identify cysts, seromas
  - T1 non fat sat, for fatty lesions
  - Pre and Post contrast T1 fat sat 3D dynamic, < 2 min/acquisition for peak tumor enhancement
  - Dynamic sequence plane
    - sagittal vs axial or coronal
  - Change from one to other makes comparison between studies challenging

Exam performance

- Technologist should ensure
  - Appropriate contrast delivery (IV access)
  - each protocol shows optimal imaging parameters
    - field of view includes all breast tissue, axillae
    - proper fat suppression
    - motion or other artifact

Indications for unilateral exam

- Previous mastectomy
- BI-RADS 3 – previous at same institution
- Monitoring chemotherapy
  - Bilateral if no baseline at institution

interpretation

- Radiologist
  - Breast imager vs MRI staff
  - Familiarity with basic principles of MRI
  - Newcomers: familiarity with ACR BI-RADS for MRI
  - Attend breast MRI course
  - 1-2 week observership (including teaching files)
  - Have first 20-30 cases double read
  - regardless of experience, second opinions are valuable
Interpretation

- Radiologist should have
  - Requisition with exam indication
  - Patient history form
  - Previous exams: MRI, mammo, US
- Reading room
  - PACS with hanging protocol and access to previous studies for comparison
  - CAD: kinetic curves and angiomaps
  - Access to LMR, and CD or DVD drive
  - Viewbox for analog mammos

Interpretation & reporting

- Findings based on BI-RADS lexicon
  - Enhancing focus/foci = ≤5mm
  - Enhancing mass
    - Shape, margins, internal enhancement
  - Non-mass-like Enhancement
    - Distribution, internal enhancement
  - Enhancement kinetics
    - Washout, plateau, persistent

Reporting

- Final assessment
  - 1 negative
  - 2 benign findings
  - 3 short interval follow-up (6 months)
  - 3a 6 week follow-up (not in current edition)
  - 4 suspicious, recommend biopsy (a, b, c)
  - 5 highly suspicious, take appropriate action
  - 6 known malignancy (neoadjuvant tx)
- BI-RADS 0?
  - Suggest correlative US, recommend follow-up appropriate for MR finding in case of neg US

Reporting includes

- Notifying referring doctors of positive results and recommendations
- Scheduling any recommended correlative imaging or intervention
- Scheduling follow-up MRI
42 yo BRCA+ Surveillance MRI

Recommendation: Focused US
If negative, MR localized excisional bx

< 6 months later axillary lump

US CNB = II IDC
2 + nodes; soft tissue axillary metastasis

Review
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