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Breast MRI in Community Practice: Equipment and Imaging Techniques at Facilities in the Breast Cancer Surveillance Consortium (BCSC)

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Abstract

Purpose—MRI is increasingly used for detection of breast carcinoma. Little is known about breast MRI techniques among community practice facilities. This study evaluated equipment and acquisition techniques used by community facilities across the U.S., including compliance with minimum standards by the American College of Radiology Imaging Network (ACRIN) 6667 Trial and the European Society of Breast Imaging (EUSOBI).

Methods—Breast Cancer Surveillance Consortium (BCSC) facilities performing breast MRI were identified and queried by survey regarding breast MRI equipment and technical parameters. Variables included scanner field strength, coil type, acquisition coverage, slice thickness and timing of initial post-contrast sequence. Results were tallied and percentages of facilities meeting ACRIN and EUSOBI standards were calculated

Results—From 23 facilities performing breast MRI, results were obtained from 14 (61%) facilities with 16 MRI scanners reporting 18 imaging parameters. Compliance with equipment

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recommendations of ≥1.5T field strength was 94% and of a dedicated breast coil was 100%. Eight-three percent of acquisitions used bilateral post-contrast technique and 78% used slice thickness <= 3 mm. Timing of initial post-contrast sequences ranged from 58 seconds to eight minutes 30 seconds, with 63% meeting recommendations for completion within four minutes.

Conclusions—Nearly all surveyed facilities met ACRIN and EUSOBI standards for breast MRI equipment. The majority met standards for acquisition parameters, although techniques varied, in particular for timing of initial post-contrast imaging. Further guidelines by the ACR Breast MRI Accreditation Program will be of importance in facilitating standardized and high quality breast MRI.

Keywords

Breast; Cancer; MRI

Introduction

Breast MRI is an important new tool for the detection and characterization of breast carcinoma. Applications for MRI of the breast include evaluation of the extent of ipsilateral malignancy and screening of the contralateral breast in patients with newly diagnosed breast cancer (1–25), screening of asymptomatic women at high risk for breast cancer (26–34) and evaluation of patients with metastatic axillary adenopathy with an unknown primary cancer (35–40). Due to the high sensitivity of MRI for breast cancer detection, several medical organizations including the American Cancer Society (ACS) and the National Comprehensive Cancer Coalition Network (NCCN) now recommend that women with particular high risk factors for breast cancer undergo annual screening breast MRI in addition to mammography (41–43). The NCCN guidelines also recommend that women with a new breast cancer diagnosis consider breast MRI in the pre-operative setting (44,45).

Despite the increasingly widespread use of breast MRI, there are currently few guidelines for standardization of image acquisition techniques. Compared to mammography and ultrasound, which rely upon morphologic features for lesion characterization, evaluation using breast MRI depends upon both lesion morphology and lesion kinetics. Assessment of these MRI lesion features requires optimization of multiple aspects of technical performance, including scanner field strength and coil selection for adequate signal-to-noise ratio, spatial resolution for lesion morphology and timing of post-contrast imaging for lesion kinetics. Currently, acquisition parameters specified by the American College of Radiology Imaging Network (ACRIN) 6667 Trial (46) and the European Society of Breast Imaging (EUSOBI) (47) provide reasonable minimum technical benchmarks for the performance of high quality breast MRI (Table 1).

As its use has expanded, breast MRI has been adopted by community practice facilities, where most women undergo breast imaging in this country. However, little is known about the technical quality of MRI performed at US community facilities. Some variation in technique is expected given the complexity of MRI, but significant deviation from minimum technical specifications is a concern as it could compromise patient outcomes when compared to those demonstrated in carefully controlled clinical trials. Providing quality care and documenting practice within specified standards are increasingly important as pay-for-performance is adopted including for medical imaging. The Medicare Improvements for Patients and Providers Act of 2008 (MIPPA) calls for providers of advanced diagnostic imaging services (MR, CT, PET, and nuclear medicine) to be accredited by 2012 in order to receive Centers for Medicare and Medicaid Services (CMS) payment for the technical component of those services. An assessment of MRI protocols used by a spectrum of

community practice facilities across the country is important to understand the quality of breast MRI care women receive in the United States.

The purpose of this study was to evaluate breast MRI equipment and acquisition techniques currently used among a variety of community practice facilities across the United States, using data from the Breast Cancer Surveillance Consortium (BCSC), and to determine the compliance with current minimum standards as specified by ACRIN 6667 and the EUSOBI.

Methods

This study was a pilot project within the Breast Cancer Surveillance Consortium (BCSC) funded by the National Cancer Institute. The BCSC is a research resource for studies designed to assess the delivery and quality of breast cancer screening and related patient outcomes in the United States. The BCSC is a collaborative network of five active breast imaging registries with linkages to tumor and/or pathology registries and is supported by a central Statistical Coordinating Center (SCC).

The BCSC population is the largest to-date for the study of breast imaging performance in community practice across the United States (48,49). Currently, the Consortium's database contains information on 8.6 million mammography examinations, 2.3 million women and 101,300 breast cancer cases (84,800 invasive and 16,500 in situ cancers). Each breast imaging registry and the SCC have received IRB approval for either active or passive consenting processes or a waiver of consent to enroll participants, link data, and perform analytic studies. All procedures are Health Insurance Portability and Accountability Act (HIPAA) compliant and all registries and the SCC have received a Federal Certificate of Confidentiality and other protection for the identities of women, physicians, and facilities who are subjects of this research.

To assess the current use and quality of breast MRI performed in the BCSC, two surveys were developed and distributed to BCSC radiology facilities. The first was a facility survey, sent by each of the registries to their individual facilities (distributed in February 2008 and returned in March 2008, Appendix A). A total of 98 facilities were queried. This survey asked facilities if they performed breast MRI, and if so whether they would be willing to complete a survey of MRI techniques. The survey also asked those facilities not performing breast MRI to indicate whether they referred patients for breast MRI to facilities not in the BCSC, and whether they intended to begin performing MRI in the future. The second survey was a breast MRI technique survey, completed by the 23 facilities found to currently performed breast MRI (distributed in February 2008 and returned in April 2008, Appendix B). MRI performing facilities were asked to indicate their current equipment and technical parameters for breast MRI. Each facility was asked to specify their MRI scanner field strength, the year the MRI scanner was acquired and the type of coil used (dedicated breast coil vs. non-breast coil). For imaging parameters, facilities were asked to specify the most frequent MRI sequence used for contrast-enhanced imaging, the coverage of their acquisitions (unilateral vs. bilateral), acquisition plane, slice thickness in mm, field of view (FOV) in cm, matrix size, timing of initial post-contrast sequence (defined as time between end of contrast injection and end of initial post-contrast sequence) and administered contrast dose. Facilities personnel were able to ask their project managers for clarification regarding the survey questions.

For our analysis, we tallied the results of responses to the facility surveys and the breast MRI technique surveys. For the technique responses, the numbers and percentages of facilities meeting the ACRIN 6667 and EUSOBI minimum technique standards were

calculated. The researchers were blinded to facility identification information for data analysis.

Results

The five BCSC registries reported that they had a total of 98 imaging facilities. 92/98 (94%) of the facilities responded regarding their use of breast MRI. A total of 25% (23/92) of the responding facilities reported that they were currently performing breast MRI, 14% (13/92) were planning to perform MRI in the future and 20% (19/92) referred patients to facilities not in the BCSC for breast MRI. Of the facilities performing breast MRI, 61% (14/23) completed the second survey regarding their MRI equipment and acquisition techniques.

The 14 responding facilities filled out an MRI technique survey for each MRI scanner and one facility had three MRI scanners, resulting in technique results for 16 MRI scanners. For two of the 16 scanners, imaging parameters were reported for two separate primary post-contrast imaging planes, resulting in 18 imaging parameter responses for the 16 scanners.

Table 1 summarizes the minimum standards for breast MRI equipment and imaging technique specified by the ACRIN 6667 Trial and the EUSOBI. Table 2 provides the detailed responses for the16 MRI scanners with 18 imaging parameters. Table 3 provides the percentages of equipment and imaging parameters meeting the ACRIN 6667 and EUSOBI minimum technique standards for the measured variables.

For MRI equipment used at the BCSC facilities, compliance with minimum standards was 94% (15/16) for scanner field strength ≥ 1.5T (ACRIN and EUSOBI standards). The MRI scanners at the facilities were acquired from 1993 to 2007, with a mean year of acquisition of 2003. Adherence was 100% (16/16) for use of a dedicated breast coil (ACRIN, EUSOBI). A broad range of acquisition techniques were reported. Compliance was (83%) 15/18 for bilateral post-contrast technique (EUSOBI standard). The remaining17% (3/18) of post-contrast sequences were performed only unilaterally. Compliance was 78% (4/18) for minimum standard of slice thickness <= 3 (ACRIN). For FOVs, compliance was 67% (2/3) for dedicated unilateral acquisitions for the standard of <= 20 mm, and was 78% (7/9) for bilateral acquisitions for the standard of <= 36 mm (ACRIN). Timing of the initial post-contrast series, defined as time between end of contrast injection and end of initial post-contrast acquisition, ranged from a minimum of 58 seconds to a maximum of eight minutes 30 seconds. Compliance was 63% (10/16) compared to the standard of initial post-contrast sequence completed within four minutes after contrast administration (ACRIN). Comparison with the EUSOBI standard for post-contrast timing is not possible, as their designated <= 2 minutes is for acquisition time without consideration of a delay prior to contrast administration but before initiation of imaging. Contrast dose was varied, with 4/17 (23%) acquisitions using weight-based dosing of 0.1 mmol/kg, and the remaining 13 using fixed doses ranging from 20–30 mL (for an average 70 kg woman and a gadolinium agent with typical concentration of .05 mol/L, 20–30 mL correspond to weight based doses approximately in the 0.1 mmol/kg to 0.2 mmol range).

Conclusions

Most women in the United States undergo breast imaging at community practice facilities, and these facilities have increasingly adopted breast MRI for a variety of clinical indications. Breast MRI is highly sensitive, but is a complex tool for which appropriate use requires optimization of multiple technical parameters. This study provides important information for understanding the quality of breast MRI that is taking place in community practice in the United States. Adherence to minimum technical standards is key to achieve

the clinical outcomes that have been demonstrated in research trials evaluating both morphologic and kinetic features of MRI findings.

To date, there have been few established guidelines for image acquisition for breast MRI. The ACR BI-RADS Atlas now includes a section dedicated to breast MRI (50). However, this initial MRI iteration is focused on the MRI lesion description lexicon and the technical guidelines are limited. The sole imaging parameters specified in the MRI section are that a dedicated breast coil is used, and that initial enhancement is measured within the first two minutes and delayed enhancement after two minutes following contrast administration. Currently, acquisition parameters specified by the American College of Radiology Imaging Network (ACRIN) 6667 Trial (46) and the European Society of Breast Imaging (EUSOBI) (47) provide reasonable minimum technical benchmarks for the performance of high quality breast MRI. The ACRIN 6667 trial evaluated MRI of the contralateral breast in women with a recently diagnosed breast cancer and had 25 practice sites in the U.S., Canada and Germany. Although these standards were developed several years ago and are less than the spatial and temporal resolution now achievable, adherence to these parameters resulted in a sensitivity of 91% for contralateral breast cancer. More recently, the EUSOBI published its guidelines for breast MRI (44). The key minimum requirements from the ACRIN and EUSOBI are summarized in Tables 1.

In our study, we found that adherence to minimum standards for breast MRI equipment across community practice facilities was excellent, with 94% of scanners having ≥ 1.5T field strength, and all scanners employed a dedicated breast coil, as recommended by both ACRIN and the EUSOBI. These results are reassuring, as higher field strength imaging and use of a dedicated breast coil are requirements to optimize signal-to-noise.

Our results regarding imaging parameters were varied, and illustrate the heterogeneous nature of breast MRI acquisition. The majority (83%) of acquisitions complied with minimum standards of performing bilateral imaging, although we found that 17% of post-contrast sequences were performed only unilaterally. While historically it was necessary to perform unilateral imaging to achieve high spatial resolution, technologic improvements now allow imaging of both breasts without compromise of spatial or temporal resolution. Bilateral imaging is desirable, as both breasts warrant evaluation in women undergoing MRI for risk screening or those with a new cancer diagnosis being assessed for extent of disease. Further, scanning both breasts allows important comparison of the symmetry of bilateral enhancement, a method which can help prevent diagnostic errors (51). The majority (78%) of acquisitions also met minimum standards for slice thickness of <= 3 mm. Compliance was lower (63%) for completion of the initial post-contrast sequence within four minutes after contrast administration. Some facilities reported completion of initial post-contrast imaging over eight minutes after contrast administration. Due to the typically rapid and transient enhancement of breast cancers, sequences obtained within four minutes after contrast administration are considered the minimum temporal resolution, with the ACR BI-RADS and others advocating two minute temporal resolution..

In conclusion, we found that nearly all of our studied community practice facilities met minimum standards for MRI equipment. The majority also met key standards for imaging parameters, although techniques were varied and outliers with respect to temporal resolution in particular were identified. There are limitations to our study. Although it was the first investigation of this topic, it was a pilot study, and our sample size was 14 facilities reporting 16 scanners performing breast MRI. Further, we did not assess MR images for quality, nor ask facilities about whether they performed MRI guided biopsy, an important standard for a quality breast MRI practice. In addition, due to technical advances, imaging techniques may have evolved in the interval since facilities were surveyed.

Importantly, the ACR has recently opened its Breast MRI Accreditation Program. It is currently voluntary, and includes minimum specifications for performing and interpreting breast MRI. However, outpatient providers are required by HIPPA to be accredited for breast MRI by January, 2012 for CMS reimbursement, and the ACR Program has been approved for this certification. Mandatory FDA accreditation for mammography facilities by the Mammography Quality Standards Act (MQSA) is widely acknowledged to have improved the quality of imaging using this modality. It is expected that the ACR Breast MRI Accreditation Program will similarly facilitate standardized and quality care for women undergoing breast MRI in this country. Of note, in the 10 years following MQSA implementation, the number of certified facilities performing mammography declined by approximately 10%, likely in part due to inability to meet FDA standards (52). However, the total number of mammography units across the country actually increased in this time period (52). Accreditation for breast MRI may impact not only the technique but also the distribution of sites offering this imaging test.

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Appendix A. Breast Cancer Surveillance Consortium Breast MRI SITE FACILITIES SURVEY

Name/ID of Site: _____

Instructions: One form to be completed per site facility.

Facility Name: _____

Encrypted ID: _____

1. Is breast MRI performed at your facility?

   ___Yes- go to 2

   ___No-go to 3 &

2. If yes, (breast MRI performed at your facility):

   a. Would you be willing to fill out a survey (attached) regarding the technical details of how you perform breast MRI?

      ___Yes- please fill out attached Facility MRI Technique Survey Form

      ___No

   b. Do you currently collect data from MR examinations that you perform in a structured electronic database?

      ___Yes

      ___No

      ___Unknown

3. If no breast MRI is performed at your facility:

   a. Are patients referred for breast MRI to other facilities outside the BCSC?

      ___Yes- go to 3b

      ___No

   b. If patients are referred, do you collect MRI data from these facilities?

      ___Yes

      ___No

      ___Unknown

4. If no breast MRI is performed at your facility, do you anticipate offering breast MRI in the future?

___Yes (check one)

___within 6 months

___within 12 months

___within 24 months

___> 24 months

___No

___Unknown

Appendix B. Breast Cancer Surveillance Consortium Breast MRI

FACILITY MRI TECHNIQUE SURVEY

Instructions: To be completed by facility. Fill out 1 form for each scanner used for breast MRI.

Facility/ID _____

Date _____

Scanner _____ of _____ total scanners

MRI Scanner Used for Breast MRI: _____ Date scanner acquired: _____

Manufacturer _____ Model _____ Field Strength _____ Tesla

Dedicated Breast Coil? □Yes □No □Unilateral □Bilateral Date breast coil acquired? _____

MR Pulse Sequence Used for Contrast-enhanced Imaging:

Acquisition Plane (Axial, Sagittal, or Coronal)	Sequence Name ----------2D or 3D? (please check one)	Slice Thick-ness (mm)	Unilateral or Bilateral Acquisitions (please check all that apply)	FOV	Matrix	Chemically-selective Fat Suppression Used? ---------- Subtraction Performed?	Basic Sequence Duration (ie, time between end of contrast injection and end of initial post-contrast sequence)	Time between end of contrast injection and end of last post- contrast scan	TR (ms)	TE (ms)	Flip Angle (deg)
	---------- □2D □3D		□Uni □Bilat			□Yes □No ---------- □Yes □No					

Contrast Agent Used: _____ Dose: _____ Rate of Admin: _____ Saline Flush? □Yes □No.
If yes, volume of saline used: _____

In your breast MRI program, is CAD applied to breast MRI?

___Yes ___NO

IF YES, specify the type of software (check all that apply):

___CADstream

___DynaCAD

___3TP

___Other (specify): _____

List all radiologists (and their encrypted IDs) who interpret breast MRIs at your facility:

_____

_____

In the future, would you be willing to either fill out a data form or electronically send these data to the (name of site) for each MRI performed at your facility (see attached sample of data variables to be collected**)?

____Yes____NO

**Sample of data variables to be collected for each breast MRI:

Patient ID (full name, DOB)

Date of breast MRI exam

Clinical Indication for breast MRI

___Newly diagnosed breast cancer (staging/extent of disease)

___High risk screening

___Problem solving for equivocal clinical or imaging finding

___Response to neoadjuvant chemotherapy

___Implants

___Other

Background enhancement

___Minimal

___Mild

___Moderate

___Marked

BIRADS assessment category

___Right

___Left

BIRADS recommendation

___Right

___Left

Table 1

Summary of Minimum Recommended Equipment and Imaging Parameter Standards for Breast MRI by the American College of Radiology Imaging Network (ACRIN) 6667 Trial and the European Society of Breast Imaging (EUSOBI)

	Field Strength (Tesla)	Type of Coil (Breast vs. Non-Breast)	Coverage of Acquisitions (Unilateral vs. Bilateral)	Acquisition Plane (Axial vs. Sagittal)	Slice Thickness (mm)	FOV	Matrix Size	Timing of Initial Post-Contrast Series	Contrast Dose
ACRIN 6667 Standard (ref ACRIN)	≥1.5	Breast	Unilateral or Bilateral	NS	<= 3.0 mm	Unilater al: <= 20 cm Bilateral: <= 36 cm	Varies based on other variables	Obtained within 4 minutes after contrast admin	NS
EUSOBI Standard (ref EUOSOBI)	≥1.5[a]	Breast	Bilateral	NS	NS	NS	NS	<= 2 minutes[b]	0.1 mmol/kg[c]

NS = not specified

[a] Not stated as absolute requirement, but described by “an increasing field strength (1.5T, 3T) allows a higher spatial resolution and consequently may increase diagnostic confidence”.

[b] Specified as acquisition time.

[c] Stated that the optimal dose is unknown, 0.1 mmol/kg “probably sufficient”.

Table 2

Summary of Responses: Equipment and Imaging Parameters used for Breast MRI Among 16 Scanners Reporting 18 Acquisition Techniques.

MRI Scanner	Field Strength (Tesla), Year Acquired	Type of Coil (Breast vs. Non-Breast)	Coverage of Acquisitions (Unilateral vs. Bilateral)	Acquisition Plane (Axial vs. Sagittal)	Slice Thickness (mm)	FOV	Matrix Size	Timing of Initial Post-Contrast Series	Contrast Dose
1	1.5T, 2007	Breast	Bilateral	Axial	2.0	28–40	512 × 320	3 min 39 sec	NS
2	1.5T, 1993	Breast	Unilateral and Bilateral	Sag	3.4	20	256 × 160	4–5 min	20 mL
3	1.5T, 1998	Breast	Unilateral	Both[e]	3.0	24	256 × 160	1 min	0.1 mmol/kg
4	3.0T, 2003	Breast	Unilateral and Bilateral	Axial	0.9	36	400 × 398	1 min 30 sec	0.1 mmol/kg
5	1.0T, 2007	Breast	Unilateral and Bilateral	Axial	2.0	36	360 × 360	1 min 23 sec	0.1 mmol/kg
6	1.5T, 2001	Breast	Bilateral	Axial	4.0	NS	320 × 160	58 s	0.1 mmol/kg
7	1.5T, 2005	Breast	Bilateral	Axial	1.0	36	NS	1 min 20 sec	20 mL
8	1.5T, 2004	Breast	Bilateral	Axial	1.5	34	256 × 512	6 min 8 sec	20 mL
9a[a]	3.0T, 2006	Breast	Bilateral	Sag	2.4	20	288 × 192	6 min to 8 min 30 sec	20 mL
9b[b]	3.0T, 2006	Breast	Bilateral	Axial	2.2	38	352 × 288	6 min to 8 min 30 sec	20 mL
10	1.5T, 2004	Breast	Unilateral	Sag	2.3	18	NS	1 min 47 sec	20 mL
11a[c]	1.5T, 2007	Breast	Unilateral and Bilateral	Sag	3.0	20	320 × 160	NS	30 mL
11b[d]	1.5T, 2007	Breast	Unilateral and Bilateral	Axial	4.0	32	498 × 320	NS	30 mL
12	1.5T, 2004	Breast	Unilateral and Bilateral	Sag	2.6	20	320 × 160	5 min 47 sec	30 mL
13	1.5T, 2003	Breast	Unilateral	Sag	2.6	20	320 × 160	1 min 55 sec	30 mL
14	1.5T, 1999	Breast	Bilateral	Sag	3.2	20	256 × 160	4 min 38 sec	20 mL
15	1.5T, 2003	Breast	Bilateral	Sag	2.6	18–26	320 × 192	1 min 49 sec	30 mL
16	1.5T, 2002	Breast	Bilateral	Sag	3.0	22	256 × 192	1 min 20 sec	20 mL

NS = not specified

[a] Scanner 9, sagittal technique acquisition parameters.

[b] Scanner 9, axial technique acquisition parameters.

[c] Scanner 11, sagittal technique acquisition parameters.

[d] Scanner 11, sagittal technique acquisition parameters.

[e] Both planes acquired, plane not specified for other stated imaging parameters.

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Table 3

Number (%) of Equipment and Imaging Parameters Meeting ACRIN and EUSOBI Minimum Standards.

	Field Strength (Tesla), Year Acquired	Type of Coil (Breast vs. Non-Breast)	Coverage of Acquisitions (Unilateral vs. Bilateral)	Slice Thickness (mm)	FOV	Timing of Initial Post-Contrast Series	Contrast Dose
Number (%)Meeting ACRIN 6667 Standards	15/16 (94%)[a]	16/16 (100%)[a]	18/18 (100%)[b]	14/18 (78%)[b]	Only Uni: 2/3 (67%)[b] Only Bilat: 7/9 (78%) [b]	10/16 (63%)[b,c]	--
Number (%) Meeting EUSOBI Standards	15/16 (94%)[a]	16/16 (100%)[a]	15/18 (83%)[b]	--	--	--	17/17 (100%)[b,d]

[a] Number (%) for 16 scanners.

[b] Number (%) for 18 acquisition techniques.

[c] Number (%) among the 16 acquisition techniques reporting this variable.

[d] Number (%) among the 17 acquisition techniques reporting this variable.