Original Investigation

An Abbreviated Protocol for High-risk Screening Breast Magnetic Resonance Imaging: Impact on Performance Metrics and BI-RADS Assessment

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Abbreviations and Acronyms

BI-RADS
Breast Imaging Reporting and Data System

CDR
cancer detection rate

MRI
magnetic resonance imaging

PPV3
positive predictive value 3

Rationale and Objectives: Annual breast magnetic resonance imaging (MRI) is recommended to screen high-risk populations for breast cancer, although costs are significant. This study assesses the performance of an abbreviated MRI protocol as a resource-efficient approach for screening patients at high-risk of breast cancer, and assesses whether the abbreviated protocol alters the assigned Breast Imaging Reporting and Data System (BI-RADS) category.

Materials and Methods: This is a prospective paired cohort study performed in an academic ambulatory setting. MRI images of women at high risk of breast cancer were reviewed using an abbreviated MRI protocol, followed by an immediate review of additional sequences included in a full diagnostic protocol. BI-RADS assessments, including all changes and interpretation times, were recorded for both the abbreviated and full protocol reviews. Cancer detection rate, positive predictive value 3 (PPV3), sensitivity, and specificity were calculated.

Results: A total of 1052 MRI cases were reviewed. The cancer detection rate was 13.3 per 1000 with a PPV3 of 30.4% based on the full protocol. Review of sequences included in the full protocol resulted in a change in the final BI-RADS assessments in 3.4% of the cases, the majority of which did not change clinical management with respect to biopsy. The sensitivity and specificity of the abbreviated and full protocols were not significantly different.

Conclusions: This pilot study of an abbreviated MRI protocol demonstrates effective performance in cancer detection. BI-RADS assessments were rarely altered with the additional information afforded by the full protocol. The abbreviated protocol holds promise for resource-efficient breast cancer screening in high-risk women.

Key Words: High-risk; breast cancer; screening; abbreviated breast MRI protocol.

INTRODUCTION

Breast cancer is the most common cancer in women and a significant (or leading) cause of mortality in the United States, with an estimated 40,000 women dying of breast cancer in 2015. The Surveillance, Epidemiology, and End Results program recorded 783,000 life years lost due to breast cancer in 2012, with an average of 19 life years lost per death (1). High-risk women are even more likely to be impacted by disease-specific mortality; therefore, efforts have been made to supplement routine mammographic screening with additional imaging in this population. "High risk" is defined by the American College of Radiology appropriateness criteria as women with a *BRCA* gene mutation; a history of chest irradiation between the ages of 10 and 30; genetic syndromes that increase the risk of breast cancer; or an estimated 20% or greater lifetime risk of breast cancer based on family or personal history, history of atypia, or a combination thereof (2).

Screening mammography leads to early cancer detection and improved survival. The use of mammography alone has

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been shown to detect approximately 7.6 per 1000 cancers in asymptomatic high-risk women. However, mammographic sensitivity is not ideal and can be as low as 30%–48% in women with dense breast tissue (3).

Previous studies have examined the use of mammography in combination with supplemental screening modalities, including bilateral whole-breast ultrasound, breast magnetic resonance imaging (MRI), and molecular breast imaging. When ultrasound was used in combination with screening mammography, cancer detection rates (CDRs) increased by an average of 4.3 cases per 1000, but the positive predictive values for biopsy of ultrasound-detected findings were low (4,5). Molecular breast imaging used as a supplement to mammography has demonstrated promising early results but exposes the patient to additional radiation (6–8). MRI of the breast is a powerful adjunct to screening mammography in high-risk women. Screening breast MRI demonstrates high sensitivity, with CDRs of up to 18 per 1000 in high-risk women with normal mammograms (9–11).

Breast MRI demonstrates impressive CDRs in high-risk women and is known to be the most sensitive screening tool, but is costly and can be difficult to tolerate due to long scan times. Abbreviated MRI protocols may provide opportunities to minimize time, costs, and patient discomfort. In a recent European study, Kuhl et al. showed that an abbreviated breast MRI protocol can be as effective for high-risk screening as a full protocol (10). Mango et al. and Grimm et al. have assessed the ability of abbreviated breast MRI protocols to detect cancers in enriched test sets containing a subset of known cancers (11,12). These studies demonstrate the accuracy of abbreviated breast MRI protocols in the detection of a variety of cancer sizes and subtypes.

Although these studies support the efficacy of abbreviated breast MRI protocols, further study is warranted before more widespread use. The MRI technique described in the Kuhl et al. study used T1-weighted sequences without fat saturation, which differs from protocols typically used in the United States where T1-weighted fat-saturated imaging predominates. Furthermore, changes in Breast Imaging Reporting and Data System (BI-RADS) assessments between the abbreviated and full protocols, potentially altering clinical management, have not yet been described. We have previously published the potential operational value of an abbreviated breast MRI protocol in terms of cost and resource savings (13). Here we report the performance metrics and clinical implications of potential BI-RADS changes that occurred using an abbreviated protocol. We hypothesize that an abbreviated protocol will show performance similar to that of a full diagnostic protocol and rarely alter clinical management.

MATERIALS AND METHODS

Study Design

This is an institutional review board-approved, Health Insurance Portability and Accountability Act-compliant study. A total of 1052 screening breast MRI scans were performed on 746 high-risk women at an academic medical center from March 26, 2012, to June 2, 2016. Scans were interpreted prospectively by 10 breast imaging specialists with an average of 10.4 years of experience (range 1–22 years).

Patient Population

Patients were included in the study if they were female, were asymptomatic, had a normal screening mammogram within the last 12 months, and were considered high risk by their referring clinician.

Abbreviated and Full-breast MRI Protocols

A summary of our abbreviated and full-breast MRI protocols is shown in Figure 1. All breast MRIs were performed on 1.5-T General Electric scanner (Wauwatosa, WI) or a 3.0-T Siemens scanner (Malvern, PA). The abbreviated protocol included localizer images, a precontrast T1-weighted sequence with fat saturation, and a single postcontrast T1-weighted sequence with fat saturation.

The full MRI protocol included localizer images; axial images including a T2-weighted, short-tau inversion recovery sequence; a precontrast T1-weighted sequence without fat saturation; a precontrast T1-weighted sequence with fat saturation; and three dynamic postcontrast T1-weighted sequences with fat saturation. An axial delayed postcontrast T1-weighted sequence was also obtained.

Postcontrast subtraction images as well as maximum intensity projection images from the first subtraction series were generated during image postprocessing for both the abbreviated and full protocols. Computer-aided detection software was used to interpret kinetic data from multiple postcontrast sequences in the full protocol (DynaCAD version 3.3; Invivo, Gainesville, FL). Because the abbreviated protocol only included one postcontrast sequence, kinetic data could not be assessed.

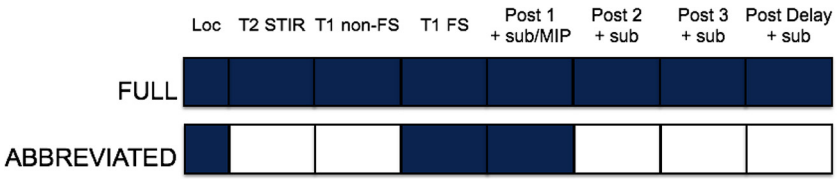

Figure 1. Composition of the full and abbreviated protocols. FS, fat-saturated images; loc, localizer images; MIP, maximum intensity projection images generated from first postcontrast subtraction images; post, dynamic postcontrast images; STIR, short-tau inversion recovery; sub, T1 fat-saturated postcontrast subtraction images.