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Research paper

Abbreviated breast magnetic resonance protocol: Value of high-resolution temporal dynamic sequence to improve lesion characterization

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ABSTRACT

Purpose: To evaluate the added value of ULTRAFAST-MR sequence to an abbreviated FAST protocol in comparison with FULL protocol to distinguish benign from malignant lesions in a population of women, regardless of breast MR imaging indication.

Materials and methods: From March 10th to September 22th, 2014, we retrospectively included a total of 70 consecutive patients with 106 histologically proven lesions (58 malignant and 48 benign) who underwent breast MR imaging for preoperative breast staging (n = 38), high-risk screening (n = 7), problem solving (n = 18), and nipple discharge (n = 4) with 12 time resolved imaging of contrast kinetics (TRICKS) acquisitions during contrast inflow interleaved in a regular high-resolution dynamic MRI protocol (FULL protocol). Two readers scored MR exams as either positive or negative and described significant lesions according to Bi-RADS lexicon with a TRICKS images (ULTRAFAST), an abbreviated protocol (FAST) and all images (FULL protocol). Sensitivity, specificity, positive and negative predictive values, and accuracy were calculated for each protocol and compared with McNemar's test.

Results: For all readers, the combined FAST–ULTRAFAST protocol significantly improved the reading with a specificity of 83.3% and 70.8% in comparison with FAST protocol or FULL protocol, respectively, without change in sensitivity. By adding ULTRAFAST protocol to FAST protocol, readers 1 and 2 were able to correctly change the diagnosis in 22.9% (11/48) and 10.4% (5/48) of benign lesions, without missing any malignancy, respectively. Both interpretation and image acquisition times for combined FAST-ULTRAFAST protocol and FAST protocol were shorter compared to FULL protocol ($p < 0.001$).

Conclusion: Compared to FULL protocol, adding ULTRAFAST to FAST protocol improves specificity, mainly in correctly reclassifying benign masses and reducing interpretation and acquisition time, without decreasing sensitivity.

1. Introduction

Breast magnetic resonance imaging (MRI) is the most sensitive imaging method to detect breast cancer available at this time, and it is superior to both mammography and ultrasonography[1–3]. Thus, breast MRI indications have increased during the last decade, including screening of high risk women, problem solving, pre-operative staging, implant integrity evaluation and nipple discharge [4,5]. However, breast MRI presents high direct and indirect costs which limits its wider use. This is primarily because current breast MRI protocols are time-consuming to acquire and interpret, with acquisition times of 20–25 min [4]. following the recommendations of good practice of the European Society of Breast Imaging (EUSOBI) [6]. Furthermore, in the current conditions, for many European countries, the number of MR scanners is insufficient to absorb the increasing indications of breast MRI, including the yearly screening of an increasing number of women at high risk for breast or ovarian cancer.

Kuhl et al. first showed the use of an abbreviated protocol (FAST

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protocol) as a valid alternative protocol for MR imaging, without compromising sensitivity nor specificity, in a population of women undergoing screening [7]. The use of an abbreviated protocol allows for not only shortened examination time but also faster interpretation for the radiologist [7,8]. Thus, several authors published on this popular topic and confirmed the ability of an abbreviated MR protocol to detect breast cancer in populations of high risk screening as well as in women with proven breast cancers [8–11]. However, the main limitation of an abbreviated protocol is its lack of specificity due to the absence of dynamic enhancement criteria, which is especially useful for the classification of small mass-like lesions [12–15]. In this regard, Mann et al. suggested the use of high temporal resolution sequences using TWIST sequence (ULTRAFAST protocol) that would help characterize breast lesions by fitting a time intensity curve obtained during the first minute [16].

Thus, our purpose was to evaluate the added value of ULTRAFAST MR sequence to an abbreviated FAST protocol in comparison with FULL protocol to distinguish benign from malignant lesions in a population of women, regardless of breast MR imaging indication.

2. Material and methods

Institutional ethic committee approved the study and granted a waiver of informed consent.

2.1. Population

Between March 10th and September 22th, 2014, our MR imaging database was retrospectively queried to identify women who had undergone breast MR with high temporal resolution sequences (n = 166). Women with normal examinations (ACR BI-RADS 1 or 2) were excluded (n = 79). We also excluded women treated with neoadjuvant chemotherapy (n = 3), lesions without pathological analysis (n = 13), and those with technical problems related to Picture Archiving Computer System (PACS) (n = 1). The final cohort consisted of 70 women (mean 53 years, range 24–77 years), including 38 menopausal women (54.3%) and 32 premenopausal women (45.7%).

Indications for MRI were preoperative breast cancer staging (n = 38; 54.2%), high-risk screening (n = 7; 10%), problem-solving, such as radiological discordance between mammography and ultrasonography or radiopathological discordance (n = 18;25.7%), nipple discharge (n = 4;5.4%). Overall, 7 women had a personal history of breast cancer (10%), 5 women were high risk women with proven genetic susceptibility (7%), and 27 women had a family history of breast cancer without context of high risk (38.6%). Finally, 5 women underwent surgery for benign lesions (7.1%).

2.2. MR acquisition

MRI sequences were acquired on a 1.5 T GE MR scanner using a phased array dedicated 8-channel breast coil. Patients were imaged in the prone position. Dedicated breast coils covering both breasts were used. We interleaved 12 time resolved imaging of contrast kinetics (TRICKS) acquisitions (TR = 3.5, TE = min, Matrix = 256 × 192, FOV 35, Slice thickness = 2) during contrast inflow in a regular high-resolution dynamic MRI protocol between axial T1 wted acquisition before injection and axial dynamic contrast-enhanced T1-weighted fat-saturated gradient-echo sequences (Fig. 1). The acquisition time for a single TRICKS acquisition was 7.8 s. TRICKS is a dynamic contrast-enhanced 3D FGRE technique with segmentation of 3D k-space in 4 concentric regions. The central region is fully sampled at each phase and provides angiographic temporal information. The three peripheral regions are under sampled (sampled only once every three phases) and provide spatial resolution. In each phase, the closest neighbor was used for reconstruction. The regular protocol included an axial T2-weighted acquisition (TR = 9789, TE = 102, Matrix = 416 × 320, FOV 35, Slice thickness = 2, Nex = 1), an axial T1-weighted acquisition (TR = 6.5, TE = 3.1, Matrix = 380 × 360, FOV 35, Slice thickness = 2), axial dynamic contrast-enhanced T1-weighted fat-saturated gradient-echo sequences (VIBRANT), and acquisitions before and after injection of gadolinium (TR = 6.5, TE = 4, Matrix = 368 × 360, FOV 35, Slice thickness = 2). Vibrant sequences were acquired once before and four times after bolus injection of Gadolinium chelate (Dotarem; GuerbetFrance) (0.1 mmolkg–1 body weight), given via a power injector (Medrad, Maastricht, The Netherlands) at a rate of 2 mls–1, followed by 20 ml saline flush. Post-processing consisted of subtracted images from the dynamic sequence and Maximum Intensity Projection (MIP) reconstructions. All MR images were reviewed on a Picture Archiving and Communication System (PACS) workstation (Carestream).

2.3. MR data analysis

Two radiologists, with 5 and 6 years of experience in breast MR imaging, respectively, independently reviewed MR images in five sessions, separated by at least two weeks in order to limit a memory bias. The readers were blinded to any clinical or prior imaging information. Moreover, the reading of a protocol was blinded to that of the other protocols in order to limit recall bias. All lesions were identified by their size and position to ensure that they were the same between the five readings. The details of each reading protocol are presented below:

In the first session, the MIP protocol (consisting only of the fusion of subtracted images of the first post contrast VIBRANT acquisition) was evaluated. The readers simply categorized the MR exam as either positive or negative on the basis of the detection of any significant enhancement.

In the second session, the FAST protocol (consisting of the native images of the first post contrast VIBRANT acquisition and the corresponding subtracted images and T2W) was analyzed. Breast density and background glandular enhancement were assessed according to the BI-RADS lexicon [17]. Then, the readers classified each enhancing lesion into one of 6 categories: BIRADS 1or2, BIRADS 3, BIRADS 4A, BIRADS 4B, BIRADS 4C, and BI-RADS 5. Readers excluded time intensity curve criteria as follows: Non-enhanced masses were rated BI-RADS 2. Enhanced masses with smooth margins, round or oval shape, and homogeneous enhancement were classified as BI-RADS 3 in the absence of available time intensity curve. Other masses were classified BI-RADS 4 or 5 according morphological criteria. For non-masses and foci, as the time intensity curve has no impact on BI-RADS classification, the same criteria as the FULL protocol were used.

In the third session, the ULTRAFAST protocol (consisting of MIP TRICKS and native TRICKS images) was analyzed. The readers were asked to identify any enhancement and the presence of afferent vessels and to report the presence of artifacts that limit interpretation and to classify each MRI exam as positive of negative on the basis of the detection of any significant enhancement on MIP TRICKS and native TRICKS images

In the fourth session, a combined abbreviated protocol consisting of the addition of FAST and ULTRAFAST protocol was analyzed. The following algorithm was applied to combine the reading of first subtracted and native VIBRANT images (FAST protocol) with native TRICKS images (ULTRAFAST protocol). If no lesion was visible on the first subtracted and native VIBRANT images, readers concluded there was no lesion. If a lesion was visible on the first VIBRANT images but not visible on the TRICKS images, readers considered there was no lesion except if the lesion was in the upper outer quadrant (frequent artifacts). In all other cases, lesions were rated according to the classification given on the FAST protocol.

In the fifth and last session, readers read the FULL protocol (T2W, T1W, DCE MR sequence). Breast density and background glandular enhancement were assessed according to BI-RADS lexicon [17]. Then, the readers classified each visible lesion according to BI-RADS MR lexicon into the 6 categories as detailed above.