

Dual Inversion Recovery MRI to Detect Breast Cancer: Comparisons with Contrast Enhanced MRI

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Introduction:

A dynamic contrast enhanced (DCE) study with subtraction or fat suppression is widely accepted, which has very high sensitivity for breast cancer diagnosis. However, DCE MRI is usually low specificity and is required in injection of a contrast agent. A double inversion recovery (DIR) sequence has been introduced, which allows to nullify signals from two different tissues simultaneously. There is no study using DIR imaging in breast diseases. As breasts consist of fat and fibroglandular tissue, an application of a DIR sequence in breast MR imaging may improve lesion detections without using any contrast agent by nullifying signals from both fat and fibroglandular tissue. The purpose of present work was to investigate the effectiveness of the DIR MRI sequence in detections of breast cancers. Firstly, we compared lesion contrasts among several imaging sequences, including contrast-enhanced T1-weighted image (CE-T1WI), DIR image, pre-contrast-enhanced T1WI and T2-weighted image (T2WI). Secondly, we evaluated whether DIR image was useful to detect breast cancers without injecting contrast agent.

Materials and Methods:

There were two study protocols in this work. First, to compare the lesion contrasts among several imaging sequences, 24 patients were included for this comparison. Second, to evaluate efficacy of the DIR sequence to detect breast cancers without injecting contrast agent, 32 patients were additionally included. Therefore, from both study protocols there were 56 patients that were subcategorized as: 44 invasive ductal carcinomas (IDC), 5 invasive lobular carcinomas (ILC), 4 ductal carcinoma in situ (DCIS), 1 mucinous carcinoma, 1 metaplastic carcinoma, and 1 invasive micropapillary carcinoma.

To calculate the appropriate two inversion times of TI_1 and TI_2 , we used previously published T1 relaxation times of fat and fibroglandular tissue of the breast (Rakow Penner et al., 2006) and used Mathematica software (Wolfram Research, Inc., Champaign, IL, USA) to solve the longitudinal magnetization of the DIR sequence. MR imaging was performed at a 3-T scanner with the patient prone and using a dedicated breast coil. In addition to the regular MR imaging protocol, we acquired pre-contrast enhanced sagittal T1WI, T2WI, and DIR of the lesion site for the first protocol. For the second protocol, we also additionally acquired sagittal DIR of the lesion site.

Volumetric ROIs of the lesion (L) and its ipsilateral normal (N) breast tissue over several slices were drawn on each sequence. The mean values of signal (S) intensities of the ROIs were obtained. The lesion-to-normal ratio (LNR) was calculated for comparing the effectiveness of each sequence in detection of the lesion. Percent LNR value was defined as the difference of the signal intensity between lesion and normal tissue divided by that of the normal tissue ($LNR = (S_L - S_N) * 100\% / S_N$), where S_L and S_N were mean signals of the lesion and normal ROIs, respectively. In addition to the LNR value, the signal-to-noise ratios (SNR) of normal breast tissue and lesion were calculated from the DIR image and CE-T1WI in IDC subgroups.

We used clinical, pathologic and image parameters to investigate variabilities of LNRs from DIR sequence. We used both age and menopausal status as clinical parameters. Mammographic parenchymal pattern was used for image parameters. In addition, parameters of dynamic contrast-enhanced MR, such as area under curve (AUC) and wash-in rate, were used. Finally we used following pathologic characteristics: a) tumor size (the largest diameter), b) stage, c) modified Bloom-Richardson grade, d) percentage DCIS component, and e) antigen Ki-67 by percentage which is a cellular marker for proliferation (Urruticoechea et al., 2005). In this study, we used non-parametric tests rather than parametric tests because the LNR values may not have Gaussian distribution. To compare LNR values among four different sequences for the first protocol, we used Friedman test with using the Bonferroni post-hoc test. A p-value less than 0.05 was considered statistically significant.

Results :

Figure shows some examples of DIR and its corresponding CE-3D T1W images in different types of diseases. In the first protocol, the mean LNR value of CE-T1WI was slightly higher than that of DIR and was significantly higher than those of T1WI and T2WI. The mean LNR value of DIR was significantly higher than that of T1WI, but was not significantly different from that with CE-T1WI and with T2WI. The mean LNR value of T1WI was lowest among the four sequences.

In the second protocol, there was no significant difference in the LNR values between DIR and CE-T1WI in the IDC group, the non-IDC group and all of the second study populations, respectively. LNR values of CE-T1WI and DIR sequences were not significantly different for both between IDC and non-IDC subgroups. Finally, LNR of the DIR sequence was significantly correlated with mammographic parenchymal pattern ($P=0.043$, $r^2=0.269$). SNR of lesion was correlated with percentage component of DCIS in the DIR sequence ($P=0.001$, $r^2=0.454$). SNR of lesions in CE-T1WI was correlated with the tumor size ($P=0.044$) and wash-in rate ($P=0.013$, $r^2=0.330$). There was no independent predictor of the SNRs of normal tissue from DIR sequence and CE-T1WI and LNRs from CE-T1WI in our model.

Conclusion:

There was no significant difference in LNR values between DIR and CE-3D T1WI. The IDC group has higher LNR values in DIR than CE-3D T1WI. On the contrary, the other groups have opposite tendencies, but not statically significant. In conclusion, tumor detection powers between the CE-T1WI and non-contrast-enhanced DIR images were similar and the DIR-MRI sequence, therefore, would be helpful in detections of breast cancers without using any contrast agent and the efficiency was more prominent at the IDC group. However, further studies have to be performed with large samples.

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