B-VALUE DEPENDENCY OF DWI QUANTITATION AND DIAGNOSTIC PERFORMANCE IN DETECTING MALIGNANT BREAST LESIONS

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INTRODUCTION

Diffusion-weighted imaging (DWI) characterizes the random microscopic motion of molecules and enables assessment of tissue microstructure without the use of contrast agents[1]. Malignant breast lesions exhibit a higher cellular density and hence lower diffusivity when compared to benign lesions and normal breast parenchyma[2,3]. This technique has been widely used to characterize malignant and benign breast lesions[4-7]. A number of studies have been reported to optimize b-value for improving the detection of changes in pathologies in brain[8,9], liver[10], and vertebral structures[11]. However, study on effect of b-value on DWI quantitation in detecting malignant breast lesion has been limited. In this study, we aim to investigate the b-value dependency of DWI quantitation and diagnostic performance in detecting malignant breast lesions at 3 T.

METHODS

Subjects and Lesions: This study was conducted with the approval of the institutional review board and with informed consent. Twenty-two female patients (age: mean = 41.7 years; range = 26 - 56 years) with 24 known biopsy-proven malignant lesions were retrospectively evaluated.

MRI: All MRI examinations were performed on a 3 T Siemens MRI scanner (MAGNETOM Tim Trio; Siemens Medical Solutions, Erlangen, Germany) using a dedicated 4-channel phased array coil (In Vivo Devices, Pewaukee, Wis). High resolution anatomical T_1- and T_2-weighted images were acquired. The DW images were acquired using single-shot SE-EPI with 8 b-values (0, 50, 100, 150, 200, 400, 600, 1000 s/mm^2) and single diffusion gradient direction, TR/TE = 5800/102 ms, acquisition matrix = 192 × 192, spatial resolution = 1.82 × 1.82 × 3 mm^3, NEX = 4, parallel imaging technique using acceleration factor = 2 and total scan time of 3'25". Dynamic contrast-enhanced MRI (DCE-MRI) was then performed to confirm the localization of the malignant lesions.

Data Analysis: A region-of-interest (ROI) was defined to encompass the breast malignant lesions. Care was taken to avoid adjacent normal tissue or cystic components. The same ROI was then used for apparent diffusion coefficient (ADC) measurements. Similarly, ROI with same size was also placed over normal fibroglandular tissue. ADC value was calculated over the ROI with a least-square nonlinear monoexponential fitting with two b-values, 0 versus 50, 100, 150, 200, 400, 600 or 1000 s/mm^2. Two-tailed Wilcoxon matched pairs test was employed to compare the ADC measurements between breast carcinomas and normal tissues, with $p < 0.05$ considered as statistically significant. Their diagnostic performance was evaluated with Receiver Operating Characteristic (ROC) analysis.

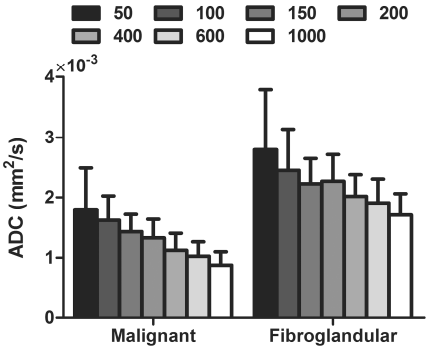

FIG. 1. ADC in malignant breast lesions and normal fibroglandular tissue that were computed using different b-values. Error bars represent SD.

RESULTS

Fig. 1 shows the ADC computed using different b-values of normal fibroglandular tissue and malignant lesions for all patients. ADC of both tissues was observed to vary with b-value. The results in Fig. 1 are re-plotted in Fig. 2 to examine their ability to detect malignant breast lesions. For all b-values, ADC was observed to significantly lower in malignant lesions, likely due to the increased cellularity in cancerous tissue. Table 1 shows the corresponding sensitivity, specificity and accuracy for ADC derived using different b-values in detecting malignant breast lesions.

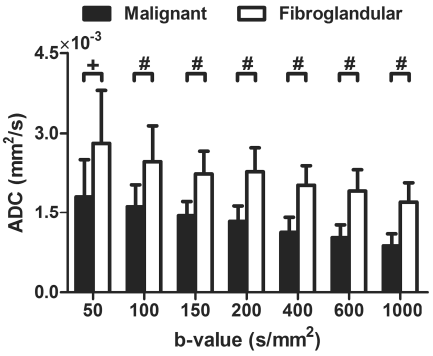

FIG. 2. Comparison of b-value specific ADC in detecting malignant breast lesions. Two-tailed Wilcoxon matched pairs test was performed with # for $p < 0.001$ and + for $p < 0.05$.

DISCUSSIONS

The current study demonstrated that b-value strongly influences the quantitation of ADC when applied to detection of malignant breast lesions. The decreasing trend of apparent diffusivity with b-value has been previously accounted for by the non-monoexponentiality of DW signal using a two-compartment model[12,13]. While perfusion can contribute significantly to the diffusion measurements because of the incoherent motion of blood in pseudorandom capillary network at macroscopic level, the intravoxel incoherent motion (IVIM) bi-compartmental model was developed to quantify the diffusion and perfusion effects separately. The blood perfusion manifested the fast pseudodiffusion effect within the small b-value regime. Consequently, ADC quantified by fitting the monoexponential model with 2 DW measurements (using the zero b-value and one non-zero b-value as in conventional DWI) will gradually decrease with the non-zero b-value used. Moreover, the accuracy of ADC in detecting malignant breast lesions was observed to increase with the non-zero b-value used. These findings implied that the ADC derived from conventional DWI should be assessed with caution because its quantitation can be influenced by b-value.

TABLE 1. Sensitivity, specificity and accuracy for ADC derived using different b-values.

b-values Used	Sensitivity	Specificity	Accuracy
(0, 50)	70.8%	95.8%	83.3%
(0, 100)	83.3%	87.5%	85.4%
(0, 150)	83.3%	95.8%	89.6%
(0, 200)	83.3%	95.8%	89.6%
(0, 400)	95.8%	87.5%	91.7%
(0, 600)	91.7%	95.8%	93.8%
(0, 1000)	91.7%	95.8%	93.8%

CONCLUSIONS

In this study, the effect of b-value on the absolute quantitation of ADC and their diagnostic performance in detecting malignant breast lesions was investigated. The results showed that the apparent diffusivities generally decreased with b-value in both malignant breast lesions and normal fibroglandular tissue. The diagnostic accuracy of ADC in detecting malignant breast lesions increased with b-value. These findings confirmed the important effect of b-value on quantitative DWI in monitoring breast lesions. The choice of b-value in conventional DWI acquisition can be optimized for detecting malignant breast lesions.

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