A new computer-aided algorithm for comparing apparent diffusion coefficient (ADC) mapping and dynamic contrast-enhanced (DCE) MRI using pharmacokinetic model for breast tumor classification

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Purpose

To compare the performance of a new computer-aided algorithm for evaluating the performance of using dynamic contrast-enhanced (DCE) and the diffusion-weighted (DW) MRI in differentiating benign from malignant breast lesions.

Methods

Both DCE-MRI and DW-MRI were performed in a 1.5T MR scanner using a dedicated 8 channel breast coil. Two b values (0 and 600 s/mm^2) were used for DW-MRI. After manual identification and placing a seed point of the potential tumor in DCE-MRI, a region growing based algorithm was applied to segment the tumor. Following the manual registration process, the tumor region segmented from DCE-MRI was mapped on the DW-MRI images. (Figure 1) The apparent diffusion coefficient (ADC) features[1] extracted from DW-MRI were compared with those parameters (K^{trans}, k_{ep}, v_p, v_e) derived from DCE-MRI using two-compartment model (Tofts 1999)**.** Applying feature selection algorithm backward elimination, $ADC_{70\%mean}$ computed by averaging the largest 70% ADC value inside the tumor and k_{ep} and v_p were used to evaluate the diagnostic performance. The relationship of different tumor size was analyzed. Images of 138 biopsy-proved lesions (54 benign and 84 malignant) were used as the dataset.

Results

The proposed ADC features ($ADC_{70\%mean}$) showed an A_z value 0.8654 and were better than using the parameters k_{ep} and v_p in accuracy (85.51% vs. 82.61%) and sensitivity (92.86% vs. 85.71%) (Table 1). There was relatively poor specificity for both methods (74.07% vs, 77.78%).The ADC features using $ADC_{70\%mean}$ had the best performance with the accuracy and sensitivity increasing to 91.67% and 96.23% if the tumor size > 2 cm, (Table 2)

Discussion

Compared to relatively low specificity (74.07%) of using $ADC_{70\%mean}$, our study showed higher sensitivity as in prior study[2]. There was much improved specificity of DW-MRI in our study as compared to using a mean *ADC* value as shown in prior study[2] (58%). Our results showed that the $ADC_{70\%mean}$ could be also used as a robust feature for classifying the tumor especially when the tumor size is larger than 2 cm. Sub-classification of the ADC values in the region of interest (ROI) helps in the classification of benign and malignant lesions. It is presumed that limitation of the range of ADC distribution might be useful to minimize the effect of tumor heterogeneity on ADC value. Using Tofts model alone might be less useful to differentiate benign from malignant breast tumors.

Conclusion

An appropriate selection of the range of the ADC feature ($ADC_{70\%mean}$) is more useful to diagnose breast tumor compared to using pharmacokinetic model alone.

References

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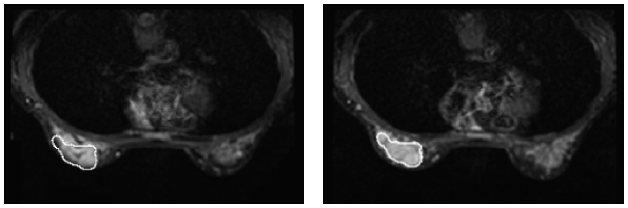

(a) (b)

Figure 1 The tumor contour (white line) segmented from DCE-MRI maps on the DWI image of b-value = 0 (a) before registration (b) after registration

Table 1 The performance indexes of Tofts model and ADC features.

Item \ Method	Tofts model	ADC features
Accuracy (%)	82.61 (114/138)	85.51 (118/138)
Sensitivity (%)	85.71 (72/84)	92.86 (78/84)
Specificity (%)	77.78 (42/54)	74.07 (40/54)
PPV (%)	85.71 (72/84)	84.78 (78/92)
NPV (%)	77.78 (42/54)	86.96 (40/46)

Table 2 The performance indexes of Tofts model and ADC features stratified by tumor size.

Tumor size	Item \ Method	Tofts model	ADC features
≤ 1 cm	Accuracy (%)	81.08 (30/37)	81.08 (30/37)
	Sensitivity (%)	80.00 (4/5)	80.00 (4/5)
	Specificity (%)	81.25 (26/32)	81.25 (26/32)
> 1 cm and ≤ 2 cm	Accuracy (%)	85.37 (35/41)	80.49 (33/41)
	Sensitivity (%)	84.62 (22/26)	88.46 (23/26)
	Specificity (%)	86.67 (13/15)	66.67 (10/15)
> 2 cm	Accuracy (%)	81.67 (49/60)	91.67 (55/60)
	Sensitivity (%)	86.80 (46/53)	96.23 (51/53)
	Specificity (%)	42.86 (3/7)	57.14 (4/7)