Comprehensive Application of DWI-ADC Value and Dynamic Contrast Enhancement in BI-RADS Categories

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Background Although the DWI-ADC (Apparent Diffusion Coefficient value of Diffusion Weighted Imaging) had not been listed in the ACR BI-RADS MRI lexicon developed in 2003, it was proved to be of great value in differentiating the benign and malignant breast lesions. The purpose of our study was to investigate the diagnostic efficiency of adding DWI-DAC to traditional evaluation by morphology and time-intensity-curve (TIC) of DCE (Dynamic Contrast Enhancement) in BI-RADS categories.

Materials and Methods Consecutive 301 lesions with pathologically confirmation on 278 patients were retrospectively reviewed. MRI examinations were performed on a 1.5T GE scanner with a 4-channel dedicated phase array breast coil using a fixed imaging protocol: an EPI-DWI sequence with b-value=1000sec/mm^2, an axial 3-dimensional VIBRANT sequence with 120sec temporal resolution and 1.0×1.0×1.0mm spatial resolution for DCE study (0.5M Gd-DTPA at a rate of 2ml/sec bolus injection), a fat-saturation FSE T2WI sequence and an SE T1WI sequences. The minimum ADC value and the highest grade of TIC of multiple ROIs on the target lesion was measured and evaluated. The lesions were categorized on the reformatted DCE image according to the ACR BI-RADS lexicon. The morphologic malignant findings (MMF) was defined as 1) irregular or speculated margin, rim or septum or heterogeneous internal enhancement for mass lesion, 2) ductal or segmental clumped enhancement for NMLE lesion were defined. The data were evaluated the without ADC information first. Then the ADC value was added to the diagnostic criteria as in Table-1. The statistical cutoff points for differentiating benign and malignant was 1.05×10^{-3}mm^2/sec for mass lesion and 1.35×10^{-3}mm^2/sec for NMLE lesions, respectively. Pathologically, the lesions were graded as benign, risk and malignant. The correlation between the BI-RADS categories and pathological grades were analyzed.

Table 1 The diagnostic criteria for BI-RADS categories with ADC and DCE.

Categories	MASS	NMLE
5	Any two of the followings: •MMF •ADC≤1.05×10^{-3}mm^2/sec •TIC Type III	With any two of the followings: •MMF •ADC≤1.35×10^{-3}mm^2/sec •TIC Type II or III
4	Any one of the following: •MMF •ADC≤1.05×10^{-3}mm^2/sec •TIC Type III	With any two of the followings: •MMF •ADC≤1.35×10^{-3}mm^2/sec •TIC Type II or III
3	With three of the following: •No MMF •ADC>1.05×10^{-3}mm^2/sec •TIC type I or II	•Focus of foci lesion or With three of the following: •No MMF •ADC>1.35×10^{-3}mm^2/sec •TIC type I or II
2	•Non-enhanced cyst, fibroma, scar, implant and fat necrosis •TIC type I and <90% enhancement in 120sec •Isointensity on DWI (no ADC measurement) •No MMF findings	
1	•No abnormal signal on DWI	

Results Compared to the evaluation without ADC measurement, the efficiency of ADC+DCE improved as listed in Table 2. Retrospective data review revealed that the mastitis had a higher ADC value which make the lesions overestimated. Table 3 showed the details of BI-RADS categories with ADC and its correlation with the pathology grades. On the receiver operation curve (ROC), when the risk lesions were grouped with malignant, the under curve area was 0.86 and it was very close to when they were grouped with benign as on Figure 1.

Table 2 Diagnostic efficiency with and without ADC value

Evaluation Modes	Sensitivity	Specificity	Accuracy
DCE only	85.33%	86.75%	85.05%
DCE+ADC	90.41%	92.26%	91.36%

Table 3 Correlation BI-RADS categories and pathology grades

Pathology	BI-RADS Categories				
	I	II	III	IV	V
Benign	8	5	68	26	10
Risk		4	8	12	10
Malignant		1	10	11	128

Discussion and Conclusion In general, the ADC of malignant lesions is lower than the ADC of benign lesions. This helped to improve the specificity of prediction by DCE only. However from the publications, the cut-off point of ADC value between benign and malignant were different to each other due to many reasons. This made the DWI-ADC not widely accepted. In our study, we integrated the imaging manifestation of DCE and the information of ADC value into one diagnostic protocol, just as the score system developed by Fischer U who weighted the morphology finding and TIC for prediction. The ADC value could correct some overestimation of fibroma, adenoma and adenosis with abundant blood supply on DCE images. But it also can misguide the diagnosis of mastitis because the abcess show high signal on DWI. And we also found that the BI-RADS categories with ADC information were well consistent with pathology grades. From the ROC, both the category 4 on BI-RADS and risk lesion on pathology were borderline. A detailed categories, instead of benign or malignant, was suggested, which would be more helpful in the management of the breast lesions.

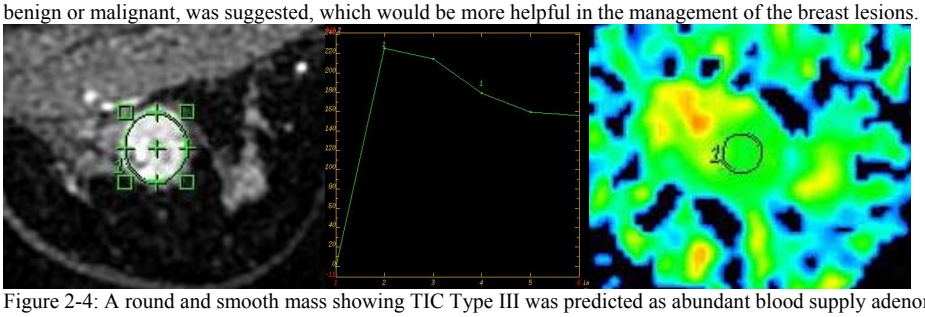

Figure 2-4: A round and smooth mass showing TIC Type III was predicted as abundant blood supply adenoma. The ADC value was 1.01×10-3mm2/sec and it was upgraded to category 5. It was confirmed to be a invasive ductal carcinoma.

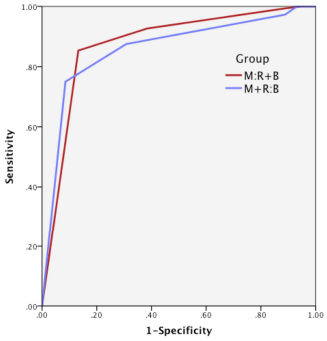

Figure 1 The ROC of BI-RADS categories and pathology grades. The red line was grouped risk lesion with benign and the blue line was grouped the risk lesion with malignant. Both had very close under curve area but the red one had better sensitivity.