Clinical Radiology 71 (2016) 170–177

Contents lists available at ScienceDirect

Clinical Radiology

journal homepage: www.clinicalradiologyonline.net

Apparent diffusion coefficient in differentiation between malignant and benign breast masses: does size matter?

C.W.S. Wan [a,*], C.Y. Lee [a], C.Y. Lui [b], C.Y. Fong [b], K.C.H. Lau [b]

[a] Department of Radiology, Tuen Mun Hospital, Tuen Mun, Hong Kong
[b] Department of Radiology, Kwong Wah Hospital, Hong Kong

ARTICLE INFORMATION

Article history:
Received 8 August 2015
Received in revised form
2 October 2015
Accepted 10 November 2015

AIM: To determine whether lesion size affects the diagnostic performance of apparent diffusion coefficient (ADC) in the evaluation of breast masses.

MATERIALS AND METHODS: Consecutive breast lesions detected at magnetic resonance imaging (MRI) from June 2010 to July 2013 were retrospectively reviewed. Differences in the ADCs of benign and malignant mass lesions were compared. Receiver operating characteristics analysis was performed to evaluate diagnostic performance of ADC regarding lesion size ($\leq$1 cm or $>$1 cm) and their T2W signal intensities.

RESULTS: Seventy-four malignant lesions (77.9%) and 21 (22.1%) benign lesions were included. Twenty-two of the 95 (23.2%) masses measured $\leq$1 cm (mean 0.73±0.4; range 0.51–0.8 cm) and 73/95 (76.9%) masses measured $>$1 cm (mean 2.11±0.1; range 1.1–3.3 cm). The mean ADC was significantly lower for malignant than for benign lesions (mean for malignant lesion, $0.89\pm0.29\times10^{-3}$ mm^2/s; mean for benign lesions, $1.27\pm0.42\times10^{-3}$ mm^2/s; $p<0.01$). The optimal ADC cut-off for differentiating benign and malignant lesion was 1.088×10^{-3} mm^2/s with a sensitivity of 85.9% and specificity of 77% for lesions $>$1 cm. The sensitivity and specificity were lowered to 60% and 50%, respectively, for lesions of size $\leq$1. Maximal sensitivity and specificity were reached when the ADC value was used to evaluate T2-dark lesions.

CONCLUSION: Diffusion-weighted MRI is useful for characterizing masses that are hypointense on T2-weighted images. Lower sensitivity and specificity were found for breast lesions $\leq$1 cm

Introduction

Contrast-enhanced magnetic resonance imaging (MRI) of the breast is well known for its high sensitivity (71–100%) and variable specificity (37–98%).[1–6] Conventional MRI features, such as signal intensity and morphological definition, cannot accurately predict malignancy. Therefore, many benign lesions have inevitably been sampled at biopsy to exclude clinically suspected malignancy.[1]

With the growing number of MRI examinations, and thus, the increasing number of incidental/occult MRI-detected breast lesions, specialists are in need of additional non-invasive predictors of the histological nature of lesions and tools for directing biopsy to sites of interest.

* Guarantor and correspondent: W. S. C. Wan, Department of Radiology, Tuen Mun Hospital, Tuen Mun, Hong Kong. Tel.: +852 24685177; fax: +852 24663569.
E-mail address: catherinewanws@gmail.com (C.W.S. Wan).

http://dx.doi.org/10.1016/j.crad.2015.11.006
0009-9260/

Previous studies have shown that the specificity of breast MRI has been increased by applying diffusion-weighted imaging (DWI) using 1.5 T MRI machines.[2–6] Most previous studies, however, have found significant overlap in the apparent diffusion coefficient (ADC) values of malignant and benign diseases. Previous studies have reported the specificity of DWI to range from 47–88%.[4,7–10] This overlap could be due to lesion size, which affects the diagnostic accuracy of DWI. The purpose of the present study was to determine whether lesion size affects the discrimination of benign and malignant breast lesions with DWI MRI.

Materials and methods

Patients

A retrospective study was performed to assess the diagnostic performance of ADC in dynamic contrast-enhanced MRI of the breast. All consecutive breast MRI examinations between June 2010 and June 2013 were reviewed. Patients were required to be at least 18-years old, have no history of breast implants, and were not undergoing neoadjuvant treatment. Lesions were included only if they were considered breast masses seen on MRI, had histopathology proof or benign/malignant outcome established upon a minimum of 2-years of follow-up.

MRI technique

All participants underwent contrast-enhanced dynamic breast MRI. MRI of both breasts was performed in the prone position using a 1.5 T system (Achieva XR; Philips Medical Systems, Best, The Netherlands) using a dedicated breast surface coil. The following axial images were obtained: T1- and T2-weighted sequences with turbo spin-echo (TSE), T2-weighted sequences with spectral attenuated inversion recovery (SPAIR) TSE, and DWI images using b-values of 0 and 1000 s/mm^2. T1-weighted images were obtained before and after contrast medium injection at 1, 2, 3, 4, and 5 minutes. Spatial resolution with voxels <1 mm in the frequency-encoding direction, phase-encoding direction, and section direction was used. ADC maps were generated according to the following equation:

$$\mathrm{ADC} = \ln\left(I\,b\,0 \Big/ I\,b\,1000\right) \Big/ \left(b = 1000\mathrm{s}\Big/\mathrm{mm}^2 2\; b = 0\mathrm{s}\Big/\mathrm{mm}^2\right).$$

Data collection

Clinical data were obtained by two radiologists with 6 years of experience. After review of the MRI images and associated reports, the two readers in consensus manually drew regions of interest (ROI) around the contrast-enhancing lesions on the ADC maps. A freehand ROI was drawn over the entire area within the dominant component of each lesion, as determined by co-registration to images obtained with conventional sequences. The ROI was confined to the enhancing component of the lesion with the non-enhancing element. To minimize the effect of partial volume averaging, the edges of each lesion were avoided when taking measurements. Areas of necrotic tissue, as identified from the morphological and contrast-enhanced images, were avoided.

At image analysis, researchers reviewing the ADC maps were blinded to final diagnosis of the lesion. The ADC value was then calculated based on the average ADC values of the ROIs on all sections containing the lesion. Lesion size was also measured at its maximal dimension.

Each lesion was also categorized according to its signal intensity on T2-weighted images. The lesion was categorized as T2-bright when it manifested higher signal intensity than the surrounding normal breast tissue on a T2-weighted TSE image; as T2-iso if it was isointense to surrounding normal breast tissue; and as T2-dark if it was hypointense to surrounding normal breast tissue.

Statistical analysis

Statistical analysis was performed by a single author using software (SPSS, version 15.0; SPSS, Chicago, IL, USA). The ADC values of the two groups of lesion (benign and malignant lesion groups) were compared. The following groups were specifically compared: (a) all benign lesions versus all malignant lesions, (b) benign lesions >1 cm versus malignant lesions >1 cm, and (c) benign lesions ≤ 1 cm versus malignant lesions ≤ 1 cm. Intergroup analyses were performed using Student's *t*-test.

Receiver operating characteristics (ROC) curves were used to determine the optimal ADC thresholds for discriminating benign and malignant lesions. With the area under the ROC curve (AUC), diagnostic performance based on ADC threshold was evaluated. For each group of lesions, the sensitivity and specificity of the ADC value for predicting malignancy were determined by employing the optimal threshold. Lesions were also segregated into the following three distinct groups based on signal intensity on T2-weighted images: T2-dark, T2-iso, and T2-bright. The

Table 1
Lesions and summary results.

Lesion	Number	Average age (years)
All lesions	Total: 95	48.6±8.3; range: 27–70
Malignant group	Total: 74	49.1±8.91; range: 27–70
Invasive ductal carcinoma, not otherwise specified	64	
Ductal carcinoma *in situ*[a]	5	
Medullary carcinoma	2	
Invasive lobular carcinoma	1	
Papillary carcinoma	1	
Tubular carcinoma	1	
Benign group	Total: 21	46.6±5.5; range: 29–56
Fibrocystic change	10	
Intraductal papilloma	5	
Minimal 2-year follow-up confirm benignity	4	
Fibroadenoma	2	

[a] DCIS was included in the malignant group for interpretation.