Comparison of Apparent Diffusion Coefficient (ADC) with Histologic Cellularity in Breast Tumors

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Introduction

Lucas-Quesada's and our previous studies [1, 2] showed that the ADCs of benign and malignant breast lesions were different and measuring the ADCs of focal breast masses was useful for characterizing the masses. But the overlap in ADC between benign and malignant lesions was still observed. So it is essential to objectively assess the capability and limitation of ADC in characterizing breast masses. For this purpose, the main reasons that causing the different ADC of breast lesions should be investigated. A significant correlation was found between the ADC of the viable tissues and cell density in gliomas [3]. In this study, we compared ADC with tumor cellularity to explore the possible role of cell density in different ADC of breast tumors.

Methods

50 patients who had 53 lesions were studied. These lesions included 23 benign lesions (18 fibroadenomas, 1 intraductal papilloma, 4 cysts) and 30 malignant lesions (25 infiltrating carcinomas, 3 medullary carcinomas, 1 scirrhous adenocarcinoma, 1 DCIS). The diagnosis was established histopathologically at surgery. A 1.5 T MR system (GE) with GPFlex surface coil was employed. DWI was obtained using a spin echo, single-shot EPI sequence (effective TE 99 ms, TR 10000 ms, slice thickness 5 mm, FOV 24¡ä 24 cm, matrix size 128¡ä 128, 1 NEX). Bilateral breasts were scanned within 40 sec. for one diffusion weighted imaging (DWI) sequence in a prone position. The sensitizing gradients were applied sequentially in x-, y- and z-directions using diffusion weighting factors (b-values) of 0, 250, 500, 750, and 1000 s/mm2 (0 and 1000 s/mm2 in some the cases). The ADC values were determined in all three orthogonal directions. A ROI that was a little smaller than the solid part of the lesion was carefully placed so that it did not include cystic or necrotic areas, and then the mean ADC value was calculated. In order to locate the solid part accurately, standard T2-weightening sequence with fat saturation and Gd-DTPA enhanced efgre 3D were performed. Tumor cellularity, analyzed using Adobe Photoshop 4.0 software, was defined as the total area of nuclei of tumor cells divided by the area of the histologic section (original magnification¡ä 100). Tumor cell nuclei are easily identified by their low signal intensities. However to minimize the individual variation, the intensity value below which the tissue would be categorized as tumor cell nuclei were carefully chosen by the radiologist three times in each specimen, and then the mean values were determined as threshold. 43 specimens underwent tumor cellularity analysis. Statistical comparison of the tumor cellularity with the mean ADC was made using simple linear regression analysis, and a p value of less than 0.01 was considered to indicate statistical significance.

Results

Mean ADC (in units of 10-3 mm2/sec) of malignant lesions (0.9662¡À 0.1980) was statistically different from that of benign lesions (1.5934¡À 0.2084) (4 cysts were not included) (t=10.05, P<0.001). Scaterplots of ADC is shown in fig 1. The relationship of tumor cellularity with mean ADC is shown in fig 2. The mean ADC value of the breast lesions correlated well with tumor cellularity($p<0.01$, $r= -0.542$).

Discussion

In biologic tissues, the microscopic motion includes molecular diffusion of water and microcirculation of blood in the capillary network. The ADCs in biologic tissues are affected by both diffusion and perfusion. The pseudo-diffusion coefficient of capillary microcirculation is typically many times greater than the diffusion coefficient of pure water. However, the volume of blood flowing in the perfused capllaries is only a small percentage of the total water content in normal brain tissue [4]. In breast tumors, although higher microvessel counts were recorded for malignant than for benign lesion [5], malignant lesions showed lower mean ADCs than did benign lesions. This indicated that molecular diffusion of water play a big role on the ADCs of breast lesions. Our result showed that the mean ADC value of the breast tumors correlated well with tumor cellularity. Malignant tumor got a higher cellularity and a lower ADC value than benign tumor did. But if a malignant tumor got a low cellularity, such as a case of scirrhous adenocarcinomas in our study, it may demonstrate a high ADC value and be misdiagnosised as benign. If a benign tumor got a high cellularity, such as a case of papilloma here, it may show a low ADC value and be misdiagnosised as malignant. Because the ADCs are strongly affected by perfusion in the case of small b values and tend to be larger when measured only with small b values [6], large b values were used here. In summary, cellularity plays a big role on different ADCs of malignant and benign breast tumors. Measuring the ADCs of focal breast masses was an effective but limited method for characterizing the masses.

References

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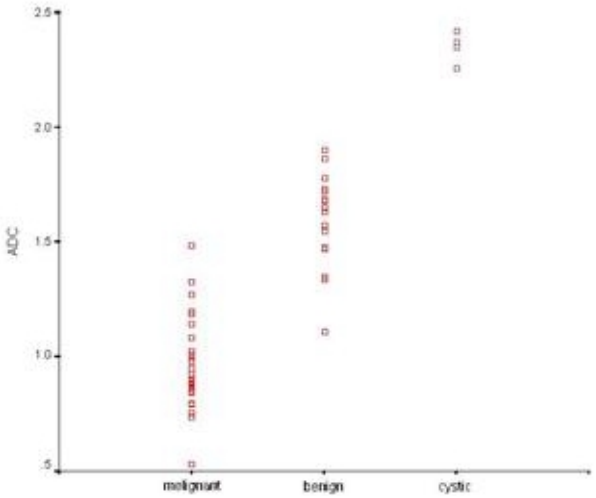

Figure 1: Scatterplots of apparent diffusion coefficients of breast malignant, benign and cystic lesions.

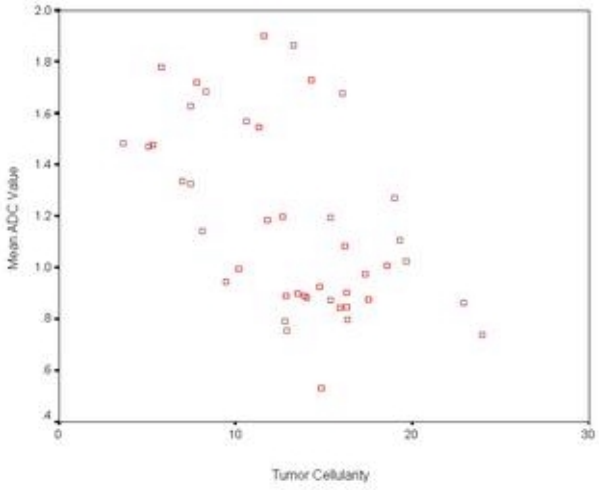

Figure 2: Tumor cellularity versus the apparent diffusion coefficient values. There is a correlation between them ($p<0.001$).