MR Imaging of Ductal Carcinoma in Situ: Morphological Appearances, Kinetic Features, and Choline Quantification with Pathological Correlation

J-H. Chen[1,2], H. J. YU[1], H-M. Baik[1], M-Y. Su[1], O. Nalcioglu[1]

[1]Tu &Yuen Center for Functional Onco-Imaging, University of California, Irvine, Irvine, CA 92697, United States, [2]Department of Radiology, China Medical University Hospital, Taichung, Taiwan

Purpose

Ductal carcinoma in situ (DCIS) accounts for 80% of noninvasive breast carcinomas. Laboratory and patient data suggest that DCIS is a precursor lesion for invasive cancer. Although MR imaging has been shown to be a sensitive imaging tool for invasive breast cancers, its role in diagnosis of DCIS is still a current topic of research interest. Two types of angiogenic patterns are associated with DCIS, the peri-ductal vessels and the stromal vessels. Since contrast enhanced MRI is based on angiogenesis, the presentation of DCIS on MRI may be different from that of invasive cancer, both in morphology and enhancement kinetics. MR spectroscopy has been shown useful for diagnosis of invasive cancer, but its role on diagnosis of DCIS has not been established. It has been reported that choline was not elevated in DCIS [Yeung DK, et al. Radiology 2002, 225(1): 190-7]. In this study, we applied the ACR BI-RADS breast MRI lexicon to describe morphological appearances and kinetic features of DCIS, and correlated results with the pathological tumor grading. MR spectroscopy study was also performed in selected patients to measure quantitative choline concentration. The results were compared between DCIS of high, intermediate, and low grades.

Methods

In reviewing all breast studies performed since 2003, 31 patients with pathologically proven DCIS were identified. The grades were obtained from pathological examinations. Breast MRI was performed on a Philips Eclipse 1.5T MR scanner. Dedicated bilateral breast coil was used as receiver. Serial scans including pre-contrast spin echo T1W sagittal images, bilateral axial dynamic contrast-enhanced (DCE) images, and MR spectroscopy were acquired. For DCE T1WI, a 3D SPGR (RF-FAST) (TR=10 msec, TE=3.6 msec, slice thickness= 4mm, flip angle= 20 degrees, matrix size= 256x128, field of view= 32-38 cm) was employed to acquire images, 4 pre-contrast and 12 post-contrast scans. The subtraction images using post-enhanced images at 1-min after injection subtracting pre-contrast images were obtained. In 5 patients the single-voxel MRS study was also performed. MR spectra were obtained using a PRESS sequence with TR=2000, TE=270, 2048 data points and 128 averages. After shimming procedure water suppression was accomplished with "CHESS" pulses, and lipid suppression was independently attenuated by using inversion recovery (STIR)-based fat signal nulling. An unsuppressed spectrum was also acquired to measure the water peak (24 averages). After T1 and T2 corrections were made, the absolute concentrations of choline were quantified by the internal method using the fully relaxed water as a reference. Morphological appearances and kinetic features of breast lesions shown on MRI were categorized according to the ACR BI-RADS breast MRI lexicon. Lesion types included single focus/multiple foci (< 5 mm), mass (> 5 mm), and non-mass-like enhancement. Other characteristics such as shape, margin, and internal enhancement patterns were also evaluated. The enhancement kinetics was divided into two phases, the initial enhancement phase, defined as enhancement patterns within the first 2 minutes or when the curve starts to change, and the delayed enhancement phase, defined as enhancement pattern after 2 minutes or after the curve starts to change. The initial enhancement phase was classified into three types: fast, medium, and slow. The delayed enhancement phase was also divided into persistent, plateau, and washout patterns.

Results

Of the 31 patients, MR imaging after contrast enhancement and image subtraction showed lesions highly suspicious for malignancy (Category 4 or 5) in 28 patients (90%). Two patients had MRI after core biopsy, and they showed enhanced foci surrounding the biopsy cavity, but whether it was associated with malignancy or biopsy related changes could not be determined. The other high grade DCIS showed diffuse heterogeneous enhancements in both breasts; and the MRI was determined to be inconclusive. In pathological exam, twelve cases were high grade DCIS, 16 were intermediate grade, and 3 were low grade DCIS. Bilateral DCIS occurred in three patients. Morphological analysis showed single focus (n=3) or multiple foci (n=13) in 16 patients (16/31); and irregular mass in 10 patients (10/31), with internal enhancement pattern as homogeneous (n=5), heterogeneous (n=3), ring (n=1), and central enhancement (n=1). The other 5 patients showed non-mass-like enhancement with diffuse (n=2), regional (n=2), and linear (n=1) enhancement patterns. Figure 1 demonstrates one case with multiple enhanced foci within a region, which is the most common presentation of DCIS in our series (13/31, 42%). Enhancement kinetic curves were available in 26 patients. The analysis was not performed in 5 patients due to small enhanced foci (4) or uncertainty of lesion location (1). In kinetic curve evaluation, ten patients showed fast initial enhancement and washout in the delayed phase, eight patients showed fast initial enhancement and reaching plateau in delayed phase, one patient showed fast enhancement with persistent enhancement in delayed phase, one showed medium initial enhancement and reaching plateau in delayed phase, and six showed slow initial and persistent delayed enhancement. Table 1 summarizes types of enhancement kinetics correlated with different pathological grades. Interestingly, rapid initial enhancement with washout (n=10) or reaching plateau (n=8) happened in all types of DCIS with more patients in intermediate to low grade group (n= 12) compared with high grade group (n=6). Slow initial and persistent enhancement (n=6) occurred, however, equally in both high grade (n=3) and intermediate to low grade group (n=3). Table 2 summarizes the quantitative of choline concentration correlated with lesion morphology and grades. The choline was detected in all 5 patients, including 2 high, 2 intermediate, and 1 low grade DCIS.

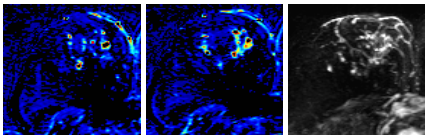

Fig.1 Typical DCIS demonstrating multiple enhanced foci, which appeares as a clumped pattern on MIPs.

Table 1. Kinetic Types correlated with pathological grades

	Pathological grades		
Enhancement type	**High**	**Intermediate**	**Low**
fast-washout (n=10)	**4**	**6**	**0**
fast-plateau (n=8)	**2**	**5**	**1**
fast-persistent (n=1)	**1**	**0**	**0**
medium (n=1)	**0**	**0**	**1**
slow (n=6)	**3**	**2**	**1**

Table 2. Quantitative choline values in 5 patients

Patient	Lesion type / grades	Choline (mmol/kg)
1	**mass / high**	**2.70 ± 0.23**
2	**foci / intermediate**	**1.48 ± 0.53**
3	**focus / intermediate**	**12.80 ± 3.34**
4	**mass / high**	**0.83 ± 0.17**
5	**foci / low**	**0.84 ± 0.74**

Conclusion

This study showed that a high percentage of DCIS (13/31) was presented with multiple foci of multiple spots of enhancement scattering in a region, and on the maximum intensity projections (MIPs) it was presented as clumped pattern according to ACR BI-RADS breast MRI lexicon. This feature was rarely seen in invasive ductal cancer, suggesting that this might be a very useful feature for diagnosis of DCIS. Further comparison in a larger series is needed to verify the diagnostic role of this feature. Kinetic enhancement assessment showed no correlation between the tumor grades and types of enhancement curve. Intermediate grade DCIS even showed higher frequency of rapid initial and washout than high grade DCIS. This MR finding supported some studies reporting that intermediate grade DCIS has even higher microvascular density (MVD) than that of low and high grade DCIS [Teo NB, et al. British J of Cancer 2002, 86:905-911]. Besides, the periductal angiogenesis may also affect the enhancement kinetic pattern, which warrants further investigation. Our study also demonstrated that choline level is detectable in all five DCIS cases with different grades by using quantitative MR spectroscopic measurement using water as the internal reference. This finding is different from previous reports in limited number of articles, which showed no detectable choline in the DCIS patients. We conclude that a large data set of DCIS patients is needed to assess the role of MRS in DCIS diagnosis.

Acknowledgement This work was supported in part by NIH/NCI grant #CA90437 and California BCRP # 9WB-0020.