Kinetic curves of malignant lesions are not consistent across MR systems: The need for improved standardization of breast DCEMRI acquisitions.

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Introduction: Standardization of breast MR image acquisition is not widespread at this time[1]. There are several manufacturers of MR systems, with different k-space sampling methods and coils. Furthermore, dynamic imaging protocols differ across institutions as to timing resolution, use of fat suppression, and pulse sequences. Unlike x-ray mammography, there are no universally applied quality assurance procedures to ensure comparable imaging performance among these different systems and protocols. At our institution, dynamic contrast enhanced MRI (DCEMRI) breast examinations have been performed on three different MR systems. The purpose was to compare the MR kinetic curve data of malignant lesions acquired by these systems.

Methods: 601 patients with 682 breast lesions (185 benign, 497 malignant) were selected for an IRB approved review. The malignant lesions were classified as ductal carcinoma in situ (DCIS), invasive ductal carcinoma (IDC) and 'other'. Dynamic MR protocol: 1 pre and 3-7 post-contrast T_1 weighted images, acquired using one of three imaging protocol and systems (IPS): IPS1 (1.5T GE Genesis Signa, 3D SPGR, TR/TE: 7.7/4.2ms, flip angle:30, resolution: 3.00mm thick, 1.4 mm in plane, temp res:68 sec), IPS2 (1.5T GE Signa Excite, 3D FGRE, TR/TE: 4.3/2.0ms, flip angle:10, resolution: 2.00mm thick, 0.82 mm in plane, temp res: 58 sec) and IPS3(1.5T Philips Achieva, 3D FFE, TR/TE: 7.9/3.9ms, flip angle:10, resolution: 2.00mm thick, 0.94 mm in plane, temp res: 55 sec). Analysis of kinetic curve shape was made by an experienced radiologist according to the BI-RADS lexicon. Several quantitative kinetic parameters were calculated, including the initial enhancement percentage ($\mathbf{E_1}$), the peak enhancement percentage ($\mathbf{E_{peak}}$), the time to peak enhancement ($\mathbf{T_{peak}}$) and the signal enhancement ratio (**SER**, a measure of washout). The kinetic parameters of malignant lesions were compared between the three systems.

Results: 304 malignant lesions (185 IDC, 62 DCIS) were imaged on IPS1, 107 lesions (72 IDC, 21 DCIS) on IPS2, and 86 on IPS3 (64 IDC, 17 DCIS). Compared to both IPS1 and IPS2, IDC lesions (as well as malignant lesions overall) acquired on IPS3 demonstrated significantly lower initial enhancement, longer time to peak enhancement and slower washout rate (Table 1, $p < 0.0004$). Only 46% of IDC lesions imaged with IPS3 exhibited "washout" type curves, compared to 75% and 74% of those imaged with IPS2 and IPS1, respectively. The sensitivity and specificity kinetic analysis was lower for IPS3, but not significantly (Figure 1).

	Type of lesions	No. cases	E1(%)	Epeak(%)	T_{peak} (sec)	SER
IPS1	**All Malignant**	**304**	**286±158**	**330±155**	**165±105**	**1.07±0.48**
	IDC	185	313±151	352±149	144±98	1.15±0.50
IPS2	**All Malignant**	**107**	**245±214**	**301±213**	**178±126**	**0.94±0.32**
	IDC	72	264±236	319±232	160±96	0.97±0.33
IPS3	**All Malignant**	**86**	**122±281**	**213±356**	**211±100**	**0.57±0.33**
	IDC	64	125±309	223±401	203±91	0.56±0.26

Table 1: Average values of kinetic parameters E_1, E_{peak}, SER and T_{peak} in malignant lesions acquired with IPS1, IPS2 and IPS3. Compared to both IPS1 and IPS2, IDC lesions (as well as malignant lesions overall) acquired on IPS3 demonstrated significantly lower initial enhancement, longer time to peak enhancement and slower washout rate

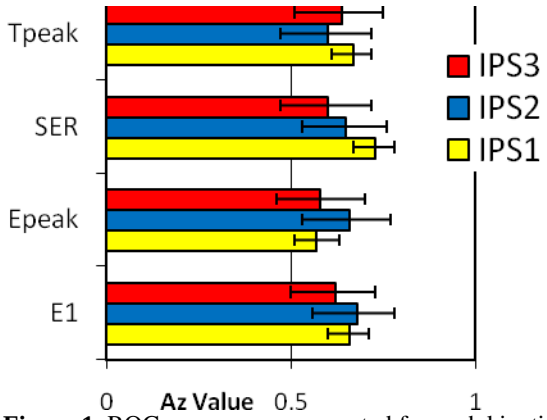

Figure 1: ROC curves were generated for each kinetic parameter E_1, E_{peak}, SER and T_{peak} for distinguishing benign from malignant lesions imaged on the IPS1, IPS2, or IPS3 systems. Area under the curve (A_z) values for the ROC curves are shown above, demonstrating decreased diagnostic performance for IPS3 imaged lesions.

Discussion: The kinetic curve data of malignant lesions acquired by one system exhibited significantly lower initial contrast uptake and different curve shape compared with the other two. These discrepancies in malignant lesion presentation adversely impacted the sensitivity and specificity of kinetic analysis. Differences in k-space sampling, T1 weighting or magnetization transfer effects may be possible explanations. This study underscores the importance of standardization of DCEMRI acquisition protocols, so that (i) malignant lesions are sufficiently conspicuous, and (ii) similar interpretation guidelines can be applied across all systems and protocols. Such standardization will be important if breast DCEMRI is to be used routinely in patient management.

References: 1. Kuhl C. The current status of breast MR imaging. Part I. Choice of technique, image interpretation, diagnostic accuracy, and transfer to clinical practice. Radiology 2007; 244:356-378.

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