Study of lymph nodes with dynamic contrast-enhanced breast MRI

Poster No.: C-2123
Congress: ECR 2013
Type: Scientific Exhibit
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Keywords: Metastases, Contrast agent-intravenous, MR, Lymph nodes, Contrast agents, Breast
DOI: 10.1594/ecr2013/C-2123

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Purpose

The rational upon which the MRI of the breast is based derived from the ability of this technique, when used with contrast agent, to visualize lesions characterized by marked vascularization and in particular to phenomena of neo-angiogenesis. The neo-angiogenesis comprises an enlargement in volume and an increase in blood vessels permeability, as well as the increase of the interstitial space, all of which are combined well with the characteristics of paramagnetic contrast material, characterized by an extra-vascular and extra-cellular diffusion. The contrast agent impregnates the lesions with angiogenesis, resulting in net increase Signal Intensity (IS) that allows the display compared to surrounding normal tissues. After morphological analysis and enhancement of a lesion, in the study of MR a kinetic assessment of enhancement is provided, which is performed by measuring the signal intensity of the lesion in a small area, Region Of Interest (ROI), and following its evolution in dynamic series, to obtain the curve IS/T (Time). In this type of evaluation is considered the enhancement of early phase (wash-in), expressed by the verticality of the curve related to the speed with which it occurs within the first 1-2 min of the dynamic acquisition, and which can be slow, medium or rapid. Then we evaluate the performance of the signal intensity over time, which may be persistent, (to continuous growth or with plateau in the later phases (type Ia/Ib curve), constant (plateau, type II curve) or in rapid descent (wash-out, type III curve). In the curves of type II and III, the enhancement peak is reached early, usually within the first 2min; both curves, as shown in the literature, are the most common framework in infiltrating carcinomas of the breast. The persistent and continuous increase of the SI, to the late phase (curve type I) is typical of benign lesions.

Lymph node status in patients with histologically confirmed malignant disease of the breast is considered one of the most important prognostic factor for overall survival. While more studies confirm the validity of the kinetic and dynamic MR imaging of breast lesions, currently, the diagnostic accuracy of MRI in the evaluation of lymph node status in breast cancer is limited.

The Purpose of this study was to, retrospectively, determine the reliability of the dynamic curves in Magnetic Resonance Imaging (MRI) in the study of histologically confirmed positive lymph nodes in patients with breast cancer, at the time of first cancer diagnosis.
Fig. 1: Schematic drawing of the time-signal intensity curve types. Type I corresponds to a straight (Ia) or curved (Ib) line; enhancement continues over the entire dynamic study. Type II is a plateau curve with a sharp bend after the initial upstroke. Type III is a washout time course ([Slc - Sl]/Sl).

Methods and Materials

We analyzed 316 patients (30-77 years old, the median age was 44 years) with histologically confirmed breast cancer who underwent a breast-MRI, in a period ranged from September 2010 to October 2012; 44 (14%) had positive lymph nodes (sentinel and/or axillary) confirmed histologically. Breast MRI was performed on a 1.5T MR scanner using a dedicated breast coil. Patient positioning was prone with both breasts hanging into the bilateral surface coil. Scanning protocols consisted of a T2-weighted turbo spin-echo sequence (3.5mm axial slices, field of view (FoV) 320x320mm, matrix 384×512, repetition time (TR)/echo time (TE) 3740/100ms), a short turbo inversion recovery magnitude (TIRM) sequence (3.5mm axial slices, FoV 320x320mm, matrix 336x448, TR/TE 8660/72 ms), and T1-weighted (T1w) 3D gradient-echo sequences (2mm axial slices, FoV 320x320mm, matrix 512×512, TR/TE 9.7/4.8 ms), one pre-contrast and five after bolus injection of 0.2 mmol of Gd-DOTA per kilogram of body weight. The temporal resolution was 80 s for each dynamic acquisition. Post-contrast image subtraction was performed to suppress the fat signal. If necessary we obtained also dynamic contrast-enhanced T1-weighted images in the sagittal plane. All breast MRI data were transferred to a workstation which allows the post-processing of dynamic data.
Results

For the 44 patients, we calculated the corresponding time/signal intensity curves (IS/T) of the positive lymph nodes (the most rapidly enhancing node was chosen for registration). ROI was positioned in the cortex of the node, without including or covering parts of the fat hilum, if present. In cases where the lymph nodes were too small to allow definite ROI measurements, these were considered as normal. 6 (13%) revealed a type II and/or III curve, 4 (9%) a benign dynamic curve (type I) and 22 patients (50%) had a non-specific dynamic curve; in 12 (27%) women we cannot documented lymph nodes visible in the examination RM. The mean short-axis diameter of the lymph nodes was approximately 1.5cm, some also with a fat hilum.
Images for this section:

**Fig. 2:** Early post-contrast and subtracted MR images from the dynamic series in a 46-year-old patient with a palpable mass (DCI) in the left breast. IS/T curve of the mass shows a type II/III time course.

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**Fig. 3:** Type III curve from multifocal infiltrating ductal carcinoma in a 36-year-old woman. Contrast-enhanced T1-weighted fat-saturated image shows regions of clumped non-mass-like enhancement in all four quadrants. Enhancement curves indicate early wash-out.

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Fig. 4: A mass with a central area of necrosis in the right breast in a 47-year-old woman. IS/T curve of the mass shows a type II/III time course.

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**Fig. 5:** Positive lymph nodes (LN) in the left axilla of a 66-year-old woman, in T1w post-contrast subtracted images. Graph demonstrates type III (wash-out) signal intensity time course for standard dynamic protocol.

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Fig. 6: T1w pre-contrast and subtracted images of different LNs, some with a little fat hilum, in the right axilla of a 66-year-old woman. ROI was positioned in the cortex of the node, not covering the hilum. The corresponding time-vs-signal intensity curves show a rapid signal increase, with a plateau followed by a wash-out (II/III curve).

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Fig. 7: Positive lymph nodes (LN) in the right axilla of a 66-year-old woman in T1w post-contrast subtracted images. Graph demonstrates type III (wash-out) IS/T course.

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**Fig. 8:** Right axillary LNs in a 61-years-old-woman with CDIS in the right breast. A region of interest (ROI) was placed in one of the lymph nodes. The corresponding IS/T curves show a non-specific dynamic curve.

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**Fig. 9:** Right axillary metastatic LN in a 55-years-old-woman with CDIS in the right breast. ROI was placed in two different areas of the node cortex and the corresponding IS/T curves show non-specific dynamic curves.

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**Fig. 10:** Dynamic contrast enhancement in axillary LNs in a 53-year-old woman with breast cancer. A ROI was placed in one of the lymph nodes. Enhancement curves were non-specific.

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**Fig. 11:** Axial T2-TIRM, T1w pre-contrast and post-contrast subtracted images: metastatic left axillary LNs with a short-axis diameter < 1.5cm. The corresponding IS/T curves show a non-specific dynamic curve.

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**Fig. 12:** Metastatic lymph nodes (LN) in the right axilla of a 44-year-old woman, in T1w post-contrast subtracted images. Graph demonstrates more times a non-specific dynamic IS/T curve.

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Fig. 13: The kinetic study of the positive lymph node in three different areas revealed different dynamic IS/T curves, with slow contrast enhancement during the first post-contrast image followed by a late signal intensity decrease.

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Conclusion

The use of dynamic curves with contrast-enhanced breast MRI is well known as a sensitive method to help diagnosis of breast cancer. But their use for the evaluation of metastatics axillary lymph nodes in patients with breast cancer remains controversial.

An accurate assessment of pre-operative axillary lymph node metastases is essential for proper patient management. The study of axillary lymph nodes with pre-operative breast MRI is as yet little studied.

Our study shows that the enhancement and kinetic features are not reliable criteria to evaluate the status of axillary lymph nodes in patients with breast cancer. Consequently, it is essential to consider further morphological criteria such as the size, the margins (smooth or irregular), the shape (oval or round), the cortex (homogeneous or thickened), the hilus (presence or absence), the asymmetry in terms of number or size compared with contralateral side. The value of combining morphological features and enhancement pattern in MRI improve the diagnostic accuracy.

To date, there has been very limited study of the application of breast-MRI criteria in the evaluation of axillary nodes: the reliability of the kinetic study of dynamic contrast-enhanced MR imaging in the diagnosis of axillary lymph node metastases is too low to be able to replace the conventional methods routine; probably the improvement of the technique and experience may improve in the future the diagnostic accuracy of this discipline for the evaluation of the axillary status in patients with breast cancer.
References


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