Review

Typical atypical findings on dynamic MRI of the breast

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ABSTRACT

Dynamic contrast enhanced magnetic resonance imaging (DCE MRI) of the breast has become an important tool to detect and characterize breast disease. The American College of Radiology Breast Imaging Reporting and Data System (BI-RADS®) provides a standardized vocabulary for describing the morphologic features and contrast kinetics of breast lesions. However, some lesions may show morphologic and dynamic MR features not consistent with their histologic nature resulting in incorrect categorization as malignant or benign. Another cause of diagnostic problems is artifacts. Thus correct interpretation of dynamic MRI of the breast demands knowledge of the most common pitfalls encountered in clinical practice. A pictorial overview of these is presented, with particular reference to the differentiation of malignant tumors from benign lesions.

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1. Introduction

Dynamic contrast enhanced magnetic resonance imaging (DCE MRI) of the breast is a supplement to mammography and ultra-sonography. This diagnostic method is steadily gaining wider acceptance because of its high sensitivity, ranging from 90% to 100% for invasive breast carcinoma [1,2]. A variety of protocols can be used to image the breast. Most commonly, an unenhanced T1-weighted (T1w) series is obtained, followed by usually four or more series after intravenous injection of a gadolinium containing contrast medium. To minimize the bright signal from fat, either subtraction of the unenhanced scans from the series after contrast medium injection is used, or an appropriate spectral or inversion recovery pulse sequence for fat suppression is employed for scanning [2,3]. Enhancing areas are visualized as bright areas. Enhancement is seen in both benign and malignant lesions, and further differentiation is therefore essential. For morphologic assessment and further characterization of the tissue, an additional T2-weighted (T2w) rapid spin echo scan is performed. A supplemental fat suppressed T2w series is optional [4].

The American College of Radiology Breast Imaging Reporting and Data System (BI-RADS®) provides a specific standardized vocabulary for describing the morphologic and kinetic characteristics of breast lesions [5]. Morphologic and architectural features of lesions in the breast are to be analyzed as well as the time signal intensity curve (TIC) of the dynamic scan [5]. Enhancing tissue can present as focus, mass or non-mass-like enhancement. A focus represents a spot of enhancement too small (smaller than 5 mm) to be otherwise characterized. A mass is a three-dimensional space-occupying lesion being round, oval, lobular or irregular in shape and showing smooth, irregular or spiculated margins to the surrounding tissue. The internal enhancement characteristics of a mass can be homogeneous, heterogeneous, rim enhancement, dark internal septations, enhancing internal septations or central enhancement. An area of enhancement that is not a mass is a non-mass-like enhancement. The distribution can be focal (less than 25% of the breast), linear, ductal, segmental, regional, multiregional or diffuse. Internal enhancement characteristics of a non-mass-like enhancement comprise homogeneous, heterogeneous, stippled, clumped or reticular pattern. A non-mass-like enhancement can be symmetric or asymmetric compared to the enhancement in the contralateral breast [4,5].

The enhancement in normal glandular tissue is referred to as background enhancement, the degree of background enhancement depends among other factors on the patient's hormonal status and the amount of glandular tissue [6,7]. The amount of background enhancement influences both sensitivity and specificity of dynamic MRI of the breast analogue to the ACR breast density in mammography [4,5].

The time signal intensity curve is described by the initial increase of the signal intensity within the first two minutes after

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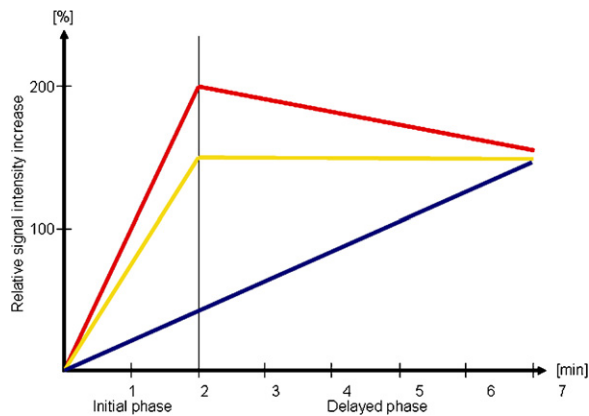
Fig. 1. On the *x*-axis the time in minutes is shown, on the *y*-axis the relative increase of signal intensity in percent. The blue curve shows persistent increase over time with more than 10% increase of the signal intensity over time (type 1 shape); this shape is typically seen in benign enhancing lesions at breast MRI. The yellow curve shows rapid initial enhancement with plateau (less than 10% change) in the delayed phase (type 2 shape); this type of enhancement can be found in benign and malignant lesions. The red curve rises rapid in the initial phase with wash out (more than 10% decrease) in the delayed phase (type 3 shape); malignant lesions typically show this type of dynamic pattern [1].

injection of contrast medium and the delayed course of the signal intensity. The initial increase can be characterized as slow, medium or fast, in the delayed phase a persistent increase of signal intensity, plateau or wash out is possible. A type 1 shape of the time signal intensity curve shows persistent increase of the TIC, a type 2 shape an initial rapid rise with plateau in the delayed phase whereas a type 3 curve is characterized by a rapid initial rise and wash out of signal intensity on the delayed phase (Fig. 1) [1]. Enhancement kinetics should mainly be used for further differentiation of masses, and not for classification of non-mass-like enhancement [8]. The region of interest drawn to educe the TIC should be at least 3 pixels in size and should be placed in the most enhancing area of the enhancing lesion [5,9,10]. Enhancement is regarded significant by a signal intensity increase of more than 80% [1,3].

A typical malignant tumor is a mass with irregular shape and irregular or spiculated margins that is hypointense on T1w and hypo- or isointense compared to breast parenchyma on T2w images. On dynamic scanning, an initial rapid and strong increase of the signal intensity is seen in the mass, followed by decrease of the signal intensity reflecting wash out of the contrast agent [1–3]. On the other hand, oval shape, circumscribed margins, and persistent rise of the TIC are regarded as hallmarks of a benign mass [11,12].
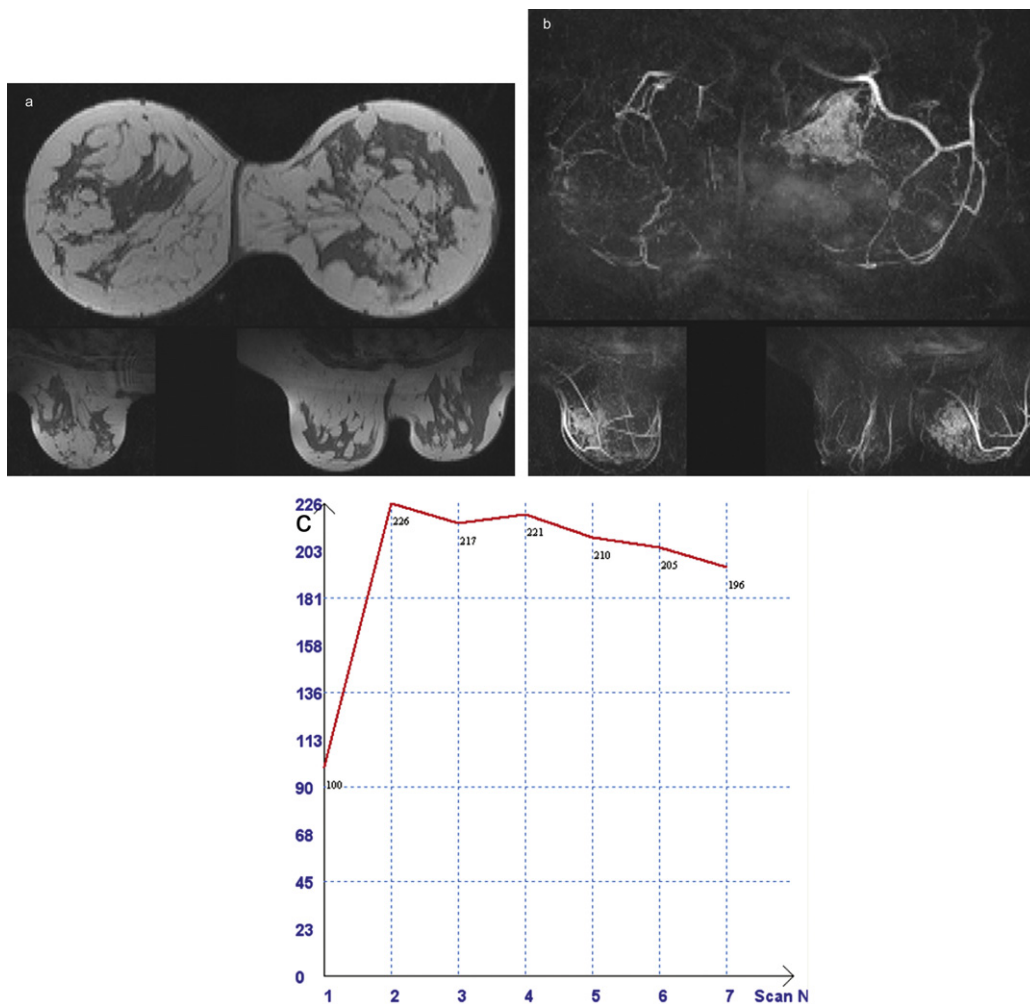

Fig. 2. (a) Unenhanced 3D T1w image (8.1/4) in the coronal plane with multiplanar reformates (MPR) in the sagittal and axial plane and (b) maximum intensity projection of early subtraction after contrast injection in three planes show a MRI examination of a 53-year-old woman with a large segmental non-mass-like enhancement from 9 to 12 o'clock in the left breast. (c) The time intensity curve (TIC) (derived from a $3 \times 3 \times 1$ voxel from the most contrast enhancing area) shows a type 3 shape with rapid rise and postinitial wash out [1]. Histology revealed a 70 mm high grade ductal carcinoma in situ (DCIS) in the left breast. A reduction mammoplasty was performed on the right side six months later and incidentally a 28 mm high grade DCIS was found by histopathologic work up of the specimen, not visible on dynamic breast MRI.