

Breast magnetic resonance imaging: kinetic curve assessment

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The time-signal intensity curve (TIC) from dynamic contrast-enhanced magnetic resonance imaging (DCE-MRI) reflects the hemodynamic features of a specific lesion. The TIC is obtained by repeated MRI scans after the injection of contrast agent; a qualified TIC usually takes 12 minutes to complete the scans. Temporal resolution is the main determinant; a higher temporal resolution means a smoother TIC. When a TIC is measured under DCE-MRI, the patient should not move, with a region of interest (ROI) of at least 3 pixels putting on the part of lesion that has fastest enhancement with fastest washout, or, the most worrisome part. No uniform criteria for the interpretation of the kinetic curve have been available. Some authors emphasize the shape of TIC under DCE-MRI, while others are more interested in the enhancement threshold values of malignancy.

The enhancement rate was calculated according to the following enhancement formula:

$$\text{enhancement rate} = [(SI \text{ post} - SI \text{ pre}) / SI \text{ pre}] \times 100(\%)$$

Since the signal intensities differ among different scan series, the calculation of enhancement rate should ensure that the pre-scan and dynamic contrast-enhanced scan are conducted within the same series; otherwise, the signal intensities need to be adjusted.

The kinetic curve can be classified into three categories. Early enhancement (2 minutes after agent injection), during which the initial rise of the enhanced curve can be

divided into “slow”, “medium”, and “rapid”. An initial peak signal intensity within 90 seconds >90% is defined as rapid enhancement, which is highly suggestive of malignancy. The signal intensity 2 minutes after contrast injection is defined as “delayed phase” (*Figure 1*), which is divided into “persistent” (type I), “plateau” (type II), and “washout” (type III). Persistent (type 1) - a pattern of progressive enhancement, with continuous increase in signal intensity; plateau (type 2) - the signal intensity reached a peak 2 minutes after contrast medium injection, followed by a flattening during the delayed phase; washout (type 3) - an initial increase and subsequent decrease in signal intensity 2 minutes after contrast medium injection (*Figures 2-11*). The initial rise usually reflects the scope of tumor angiogenesis, whereas the delayed phase reflects the formation of stromal tumor cells. Generally, a persistent curve is suggestive of benign changes; washout, malignancy; and plateau, either benign change or malignancy. The kinetic curve is especially helpful for the diagnosis and treatment of morphologically benign lesions; for lesions that are morphologically suspected to be malignant, biopsy should be performed regardless of its kinetic curve.

Acknowledgements

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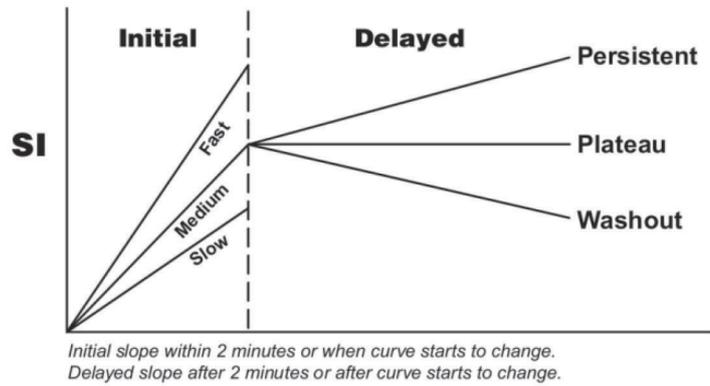
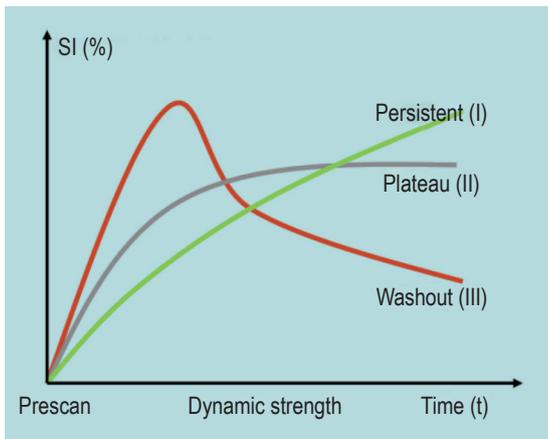


Figure 1 Another way to describe kinetic curve is to divide it into initial slope and delayed phase. The so-called initial slope refers to 2 minutes after contrast medium injection or when curve starts to change. In other word, the time point can be flexible

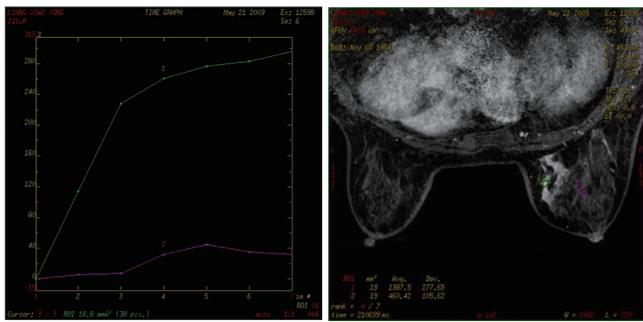


Figure 2 Persistent (type 1) curve: non-mass lesion in the medial quadrant of the right breast. ROI 1 shows an inflow curve. The lesion is pathologically confirmed to be breast adenosis. ROI 2 is the enhanced curve of normal breast glands

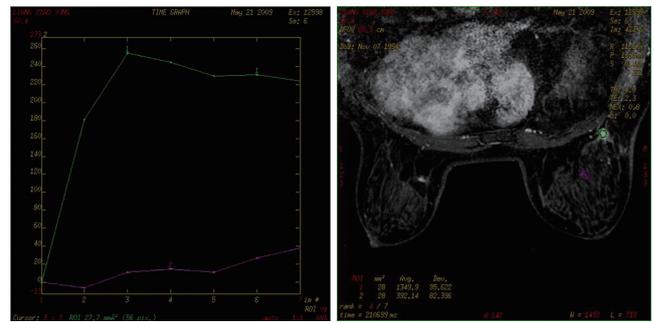


Figure 3 Washout; invasive breast carcinoma. washout (type 3) curve: ROI 1 shows a washout curve, which reaches a peak 91 to 180 seconds after contrast medium injection, and then begins to wash out. ROI 2 is the enhanced curve of normal tissue. Pathology, Invasive ductal carcinoma in the upper outer quadrant of right breast

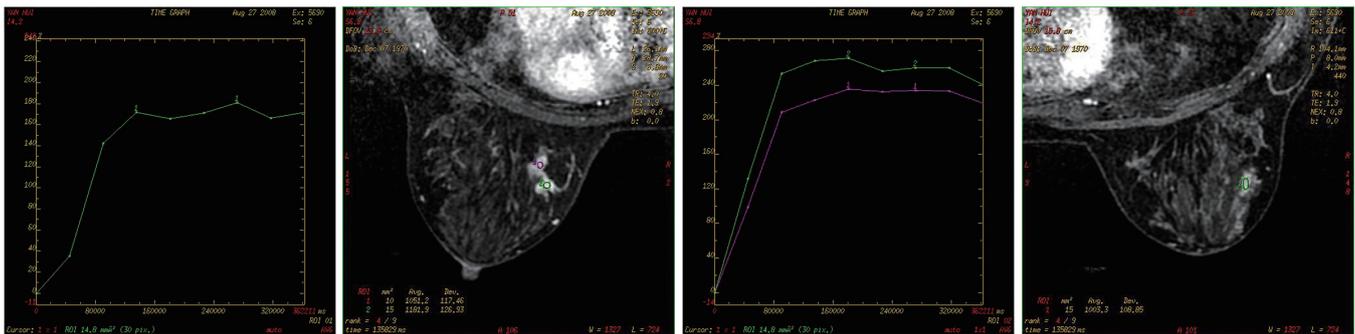


Figure 4 Plateau (type 2) curve: the curve reaches a peak during the arterial phase 91-180 seconds after contrast medium injection, followed by a flattening during the delayed phase. Pathology, Invasive ductal carcinoma, mostly intraductal carcinoma

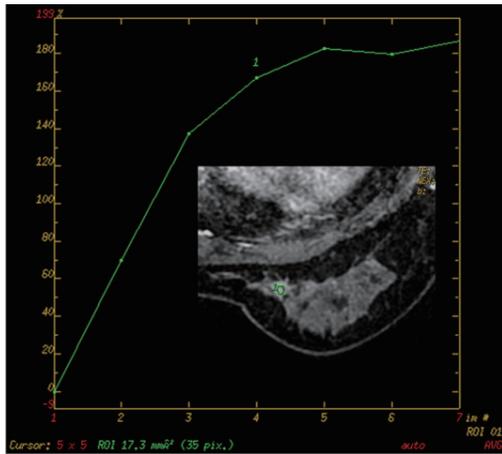


Figure 5 Persistent (type 1) curve: breast adenosis A suspected lesion is found in right breast after surgery for cancer in left breast. BI-RADS-MRI category 3 is considered. Pathology, Breast adenosis, with papillary hyperplasia in the epithelia of individual ducts

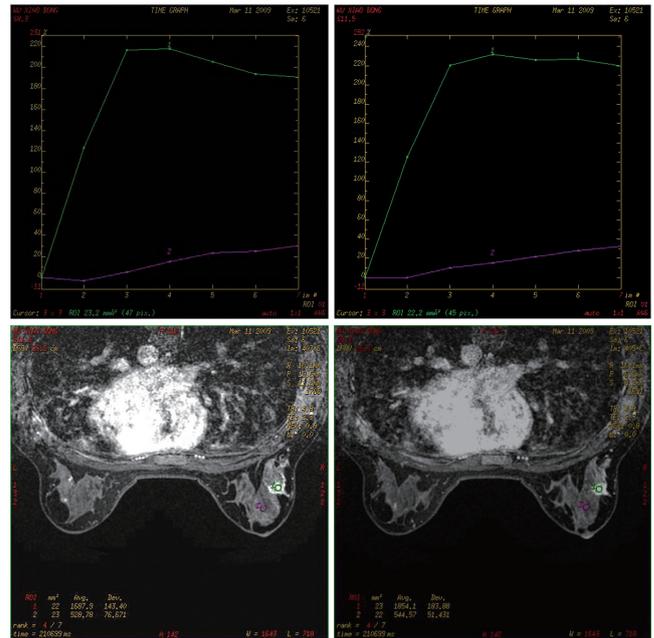


Figure 7 Washout (type 3) curve: the curve reaches a peak 91 to 180 seconds after contrast medium injection, and then begins to wash out slowly. Pathology, Breast sclerosing adenosis; florid ductal epithelial hyperplasia in some ducts; remarked stromal hyperplasia, with “pseudo-infiltration”

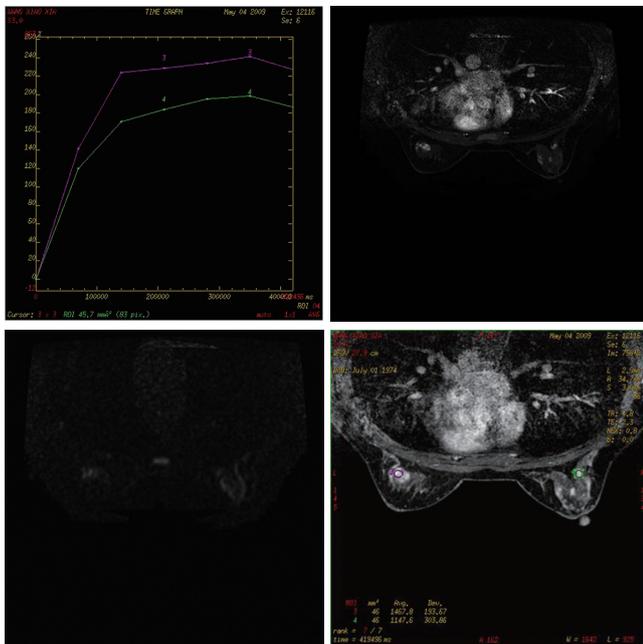


Figure 6 Inflow curve that rises rapidly

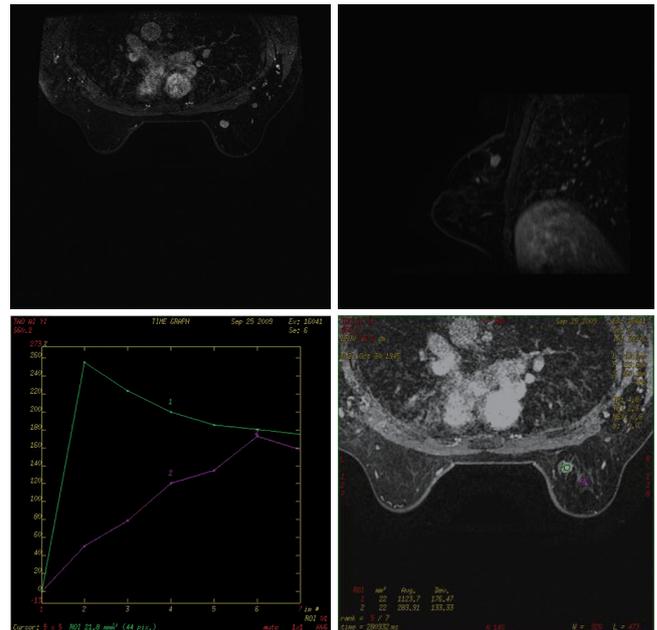


Figure 8 Washout (type 3) curve: the curve reaches its peak within 90 seconds during the arterial phase, and then begins to wash out. Pathology: Invasive ductal carcinoma

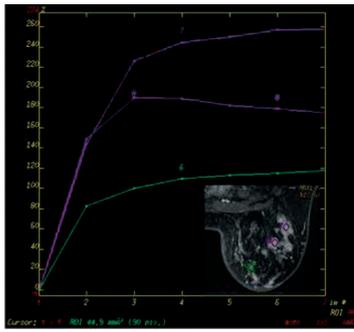


Figure 9 Multifocal measurements show that the curves of different foci have varied and multiple features

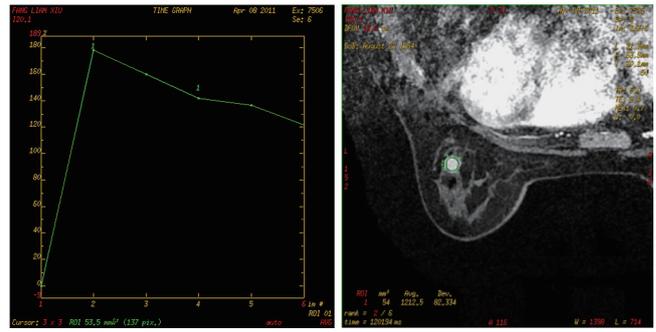


Figure 10 Classic washout curve, IDC

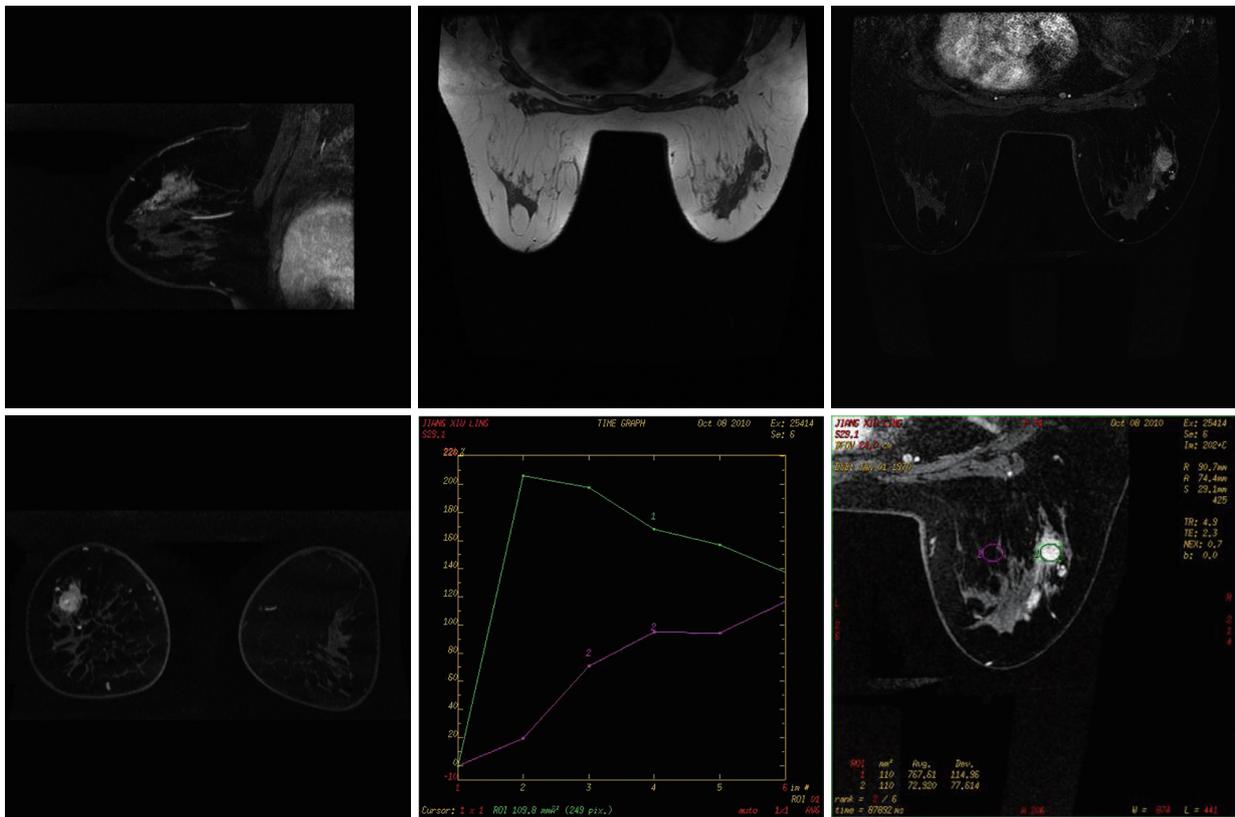


Figure 11 Segmental distribution is observed on sagittal view. If the features of a mass are identified, the lesion can be treated as a mass firstly, so that both ADC value and TIC have their references and the measurements can yield more stable results

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