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Purpose

Dynamic contrast enhanced magnetic resonance (DCE-MR) imaging of the breast is widely acknowledged to be a helpful tool in the differentiation of breast tumors. In common clinical settings, the dynamic changes described by the time-signal intensity curve (TIC) are evaluated to find kinetic patterns of typical tissue behavior. Region of interest (ROI) to obtain TIC should be selected within the lesion throughout the entire dynamic series [1]. If the lesion moves during the dynamic study, the small ROI has the chance to miss it and obtain incorrect or irrelevant TIC. Moreover, it is difficult to set the ROI correctly in case of tumor enhanced heterogeneity. TIC analysis using manually-selected ROI in DCE-MR imaging of the breast has a potentially negative effect from a quantitative point of view [2-5]. The purpose of this study was to determine ROI automatically by using a new analysis method.

Methods and Materials

We made a retrospective review of 22 cases of patients who underwent breast DCE-MR examination for preoperative diagnosis. All tumors were diagnosed as malignant by postoperative biopsy.

DCE-MR breast imaging datasets were acquired on a clinical 1.5-Tesla MR system (Signa, GE Healthcare, Milwaukee, Wis, USA) using a fast gradient-echo sequence with Gd-DTPA. A single scan time was about a minute and total scan time was about 6 minutes per patient.

The essential idea of our new analysis method is to analyze the TIC of each pixel and to extract ROI constructed from pixels with similar TIC. At first, the analyzer selected the attention point of the enhanced tumor in the first post-contrast image. Second, we calculated Pearson’s correlation coefficients (CC) between TIC in the start coordinate determined by analyzer and TIC in other coordinates. After completing calculation of CC for all pixels, original images were transformed to CC maps (Fig.1 on page 3). Third, ROI in the CC map were selected according to the threshold of CC value. And we calculated coefficient of variation (CV) for the each corresponding ROI in the original image. If the CV value of the ROI satisfied a level which was determined by prior research, the ROI was adopted (Fig.2(A) on page 3). Otherwise, the threshold of CC value was increased by 0.01 and the CV value corresponding to each CC value was calculated (Fig.2(B) on page 3). The final threshold of CC value was determined as the last value which had a corresponding CV value which satisfied the necessary level. To evaluate feasibility of our method in place of manually-selected analysis, CC between measured individual TIC and measured mean TIC (CC_{TIC}) of both methods were calculated by 10 analyzers. For reproducibility comparison between manually-selected
analysis and automatically-selected analysis using our method, error sum of squares between measured individual TIC and measured mean TIC ($\text{ESS}_{\text{TIC}}$) of both methods were calculated by these same analyzers. We compared TIC using our automatically-selected ROI method ($\text{TIC}_A$) to TIC using the manually-selected ROI determined by an analyzer ($\text{TIC}_M$).

**Images for this section:**

![Fig. 1](image_url)

**Fig. 1:** Fig.1: transformation multiphase DCE-MR images into correlation coefficient map. It shows the original DCE-MR images transformed into CC maps with our method.
Fig. 2: ROI over the early phase image in DCE-MR imaging. Both (A) and (B) show the ROI which was evaluated from CC maps (in green area) over the coronal DCE-MR early phase images. Moreover, these images were made from the same patient's clinical data. (A) This ROI was made using an evaluated CC value over 0.40. And the CV in ROI calculated to be 0.21. This ROI needs an increase of the CC value. (B) This ROI was made using an evaluated CC value over 0.68. And the CV in ROI calculated to be 0.14. This ROI was satisfied proper level criteria.
Results

In 10 of 22 cases, there were significant differences between $ESS_{TIC}^{A}$ and $ESS_{TIC}^{B}$ ($p<0.05$ by F-test for equality of variance using error sum of squares). Fig.3 on page 5 shows an example of the ROI using manually-selected analysis (Fig.3(A) on page 5) and automatically-selected analysis with our method (Fig.3(B) on page 5). Fig.4 on page 6 shows the results of TICs analyzed by 10 analyzers using both methods for each patient of Fig.3 on page 5. And the error bar represents the standard deviation. And Fig.5 on page 6 shows the standard deviation of the results of Fig.4 on page 6. For each patient of Fig.3 on page 5, the difference between $TIC_M$ and $TIC_A$ were not significant by significance tests of correlation coefficients. However, there were significant differences by F-test for equality of variance using error sum of squares. It is for this reason that the TIC analysis using the ROI selected with our method reduced measurement variation compared to the TIC analysis using manually-selected ROI in the 10 cases which showed significant difference cases. Although there were no significant differences in 12 cases, these cases represented typical and homogenous enhancement pattern so that the analyzer was able to select the ROI with high reproducibility whether using our method or not. And in all cases, there were not significant differences between $CC_{TIC}^{A}$ and $CC_{TIC}^{B}$ (by significance tests of correlation coefficients).

Images for this section:
**Fig. 1:** Fig.3: ROI pixels over the early phase image in DCE-MR imaging. Both (A) and (B) are the ROI over the coronal DCE-MR early phase images. Moreover, these images were made from the same patient's clinical data. (A) This ROI was constructed from manually-selected analysis. (B) This ROI was constructed from automatically-selected analysis using our method.

![Signal Intensity vs Phase Number](image)

**Fig. 2:** Fig.4: comparison of the signal intensity both TICM and TICA for each patient of Fig.3. The graph shows the results of TICs analyzed by 10 analyzers using both methods. And the error bar represents the standard deviation. Phase 0 means plain phase. And phase number corresponds to time after injection. Sequential images were obtained by a minute after injection up to 5 minutes. So, number of phase means approximately corresponding number of minute after injection. Between TICA and TICM were not significant differences (by significance tests of correlation coefficients).
Fig. 3: Fig.5: comparison of the standard deviation both TICM and TICA for each patient of Fig.3. The standard deviation correspond the error bar of Fig.4. TICM varied among analyzers more than TICA in phase 1. There were significant differences between TICs (by F-test for equality of variance using error sum of squares).

![Graph showing comparison of standard deviation for TICM and TICA](image)
Conclusion

Our method provides better repeatability and quantitative results than manually-selected TIC analysis.

References


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