Automated selection of hypointense regions in diffusion-weighted breast MRI

Automated Selection of Hypointense Regions in Diffusion-Weighted Breast MRI

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Introduction

Recent research suggests that diffusion-weighted (DW) MRI, and in particular the apparent diffusion coefficient (ADC), can be used to improve the sensitivity and specificity of dynamic contrast-enhanced (DCE) MRI for the detection of breast cancer. However, to date the methods proposed for determining a representative ADC value for a suspicious lesion are highly varied. One approach is to compute the mean ADC value over the entire lesion to obtain a representative ADC value. Another is to compute the mean ADC value within one or more regions of interest (ROIs) defined on the suspicious lesion. The earliest examples of this approach involve manually defining ROIs of hypointensity to be as large as possible, but constrained within the lesion, and such that areas of necrosis are avoided in large lesions. More recent examples of this approach involve placing one or more smaller ROIs of hypointensity within a suspicious lesion and computing, for example, the global minimum [1] or mean [2]. This latter approach appears to provide better discrimination between benign and malignant lesions. Nevertheless to date there does not exist a well-defined and objective method for defining these ROIs. The problem is complicated by the typically low signal-to-noise ratio in the DW images. We propose an automated method based on the converging squares algorithm [3], which is a multiscale minimum finding technique with inherent robustness to noise. We also present an evaluation of the method, using routine clinical data, for computing a representative ADC value for discriminating benign and malignant lesions. The method is also compared to ensemble averaging of ADC values over the entire lesion and the selection of the global minimum ADC value.

Materials and Methods

The breast MRI data used in this study originate from routine clinical breast MRI examinations of 46 women performed by Queensland X-Ray, Queensland, Australia over the last two years. Each exam included both a DCE-MRI scan and a DW MRI scan. The data were acquired on a 1.5T Signa HDx scanner (GE Medical Systems). The DCE-MRI data were acquired using a 3D FSPGR sequence. Gadopentate dimeglumine, 0.2 mmol/kg, was administered manually at a rate of about 1 ml/s. The DW-MR images were acquired with a slice thickness of 5mm and pixel spacing of 1.4mm (TE = 72ms, TR = 5257ms, TI = 160ms). Two *b* values (0, 750 s/mm^2) were used to compute ADC maps. The approval of the Human Research Ethics Committee of the University of Queensland was obtained for this study.

A total of 51 lesions (35 malignant and 16 benign confirmed by cyto- or histopathology) were manually segmented in 3D on the DCE-MRI data by an experienced radiographer using the region growing tool in OsiriX (http://homepage.mac.com/rossetantoine/osirix). Each ADC map was resampled using linear interpolation to obtain cubic voxels (to avoid directional bias when applying the converging squares algorithm). Next, each segmentation mask was resampled to match the spatial resolution of the corresponding resampled ADC map (as shown in Figure 1). A representative ADC was then obtained from the ADC values within this mask using the three methods below:

1. The mean ADC value within the mask.
2. The minimum ADC value within the mask.
3. The mean ADC of the region of hypointensity within the mask located by the converging squares algorithm.

The discriminatory power of these three representative ADC values was assessed using receiver operating characteristic (ROC) curve analysis, and in particular the area under the curve (AUC) and the sensitivity and specificity of the point on the curve farthest from the no-discrimination line.

Results and Discussion

As shown in Figure 2, the practice of taking the mean ADC over the entire lesion provides the worst degree of discrimination (smallest AUC) between benign and malignant lesions. A possible explanation for this is that malignant lesions are typically heterogeneous. The practice of taking the minimum ADC seems to yield better discrimination but suffers from the problem that noise or the subjectivity of the lesion mask delineation in the DCE-MRI data can greatly influence the chosen ADC value. Our proposed converging squares approach offers the best performance, both in terms of highest area under the curve, and the best combination of sensitivity and specificity. The method is inherently tolerant to noise and can identify a region of hypointensity within a lesion from which to compute a representative ADC.

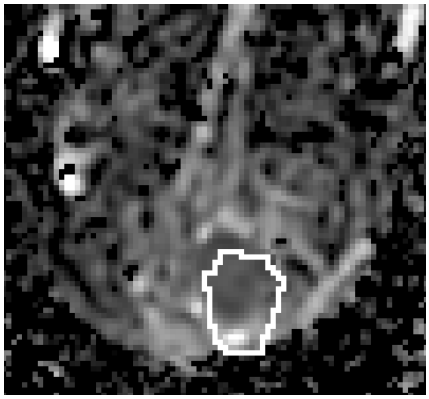

Fig 1. Example of lesion with overlaid boundary mask from DCE-MRI

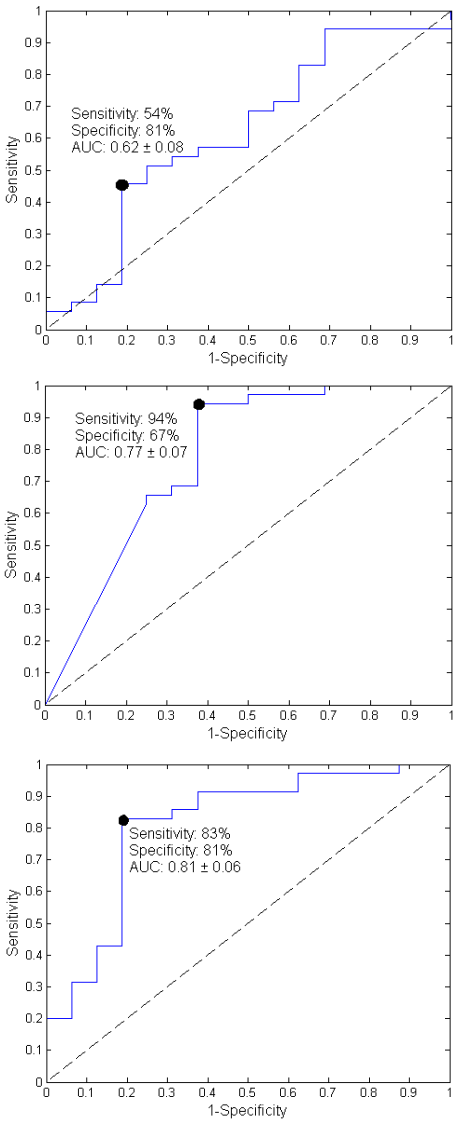

Fig 2. ROC curves for three methods of ADC selection; top – average ADC; middle – minimum ADC; bottom – converging squares

References

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