A Semi-automated Method for Obtaining the Arterial Input Function in Dynamic Breast Data

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INTRODUCTION

Quantitative analyses of dynamic contrast enhanced MRI (DCE-MRI) data require the accurate determination of the time rates of change of the concentration of contrast agent, C_p, in the blood pool, or what is typically referred to as the arterial input function (AIF). While there have been several methods suggested for measuring the AIF [1-4], many are difficult to apply in the particular case of breast cancer. Here, we propose a simple and effective approach to obtain the AIF from breast DCE-MRI data. The method is based on tracking an initial seed point placed within the axillary artery.

METHODS

MRI Acquisition 14 patients with localized breast cancer, stages IIA to IIIB, were enrolled in an IRB-approved study. Imaging was performed on a Philips 3.0 T Achieva MR scanner (Philips Healthcare, Best, The Netherlands) equipped with a 4-channel receive double-breast coil (Invivo Inc., Gainesville, FL). DCE-MRI was obtained prior to and after one cycle of neoadjuvant chemotherapy yielding a total of 23 useable data sets. The DCE-MRI acquisition employed a 3D spoiled gradient echo (SPGRE) sequence with TR\TE\α = 7.9ms\1.3ms\20°. The acquisition matrix was 192×192×20 (full-breast) over a sagittal (22 cm)^2 FOV with a slice thickness of 5 mm. Each 20-slice set was collected in 16.5 seconds at 25 time points and 0.1 mmol/kg of Magnevist was injected over 20 seconds after the third dynamic image stack.

AIF Extraction The algorithm is initialized by defining a 5×5 kernel centered on a single, manually selected seed point within the axillary artery in one slice. In a slice adjacent to the one containing the seed, a 10×10 ROI is defined centered on the voxel corresponding to the seed point location. For each voxel in the ROI, a 5×5 "local window" centered on that voxel is defined and the correlation coefficient (CC) of the signal intensity between the kernel and each local window is calculated. The local window with the maximum CC is considered as a new kernel and the center point of this kernel is assigned as the new seed point to be used for the next slice. The procedure is repeated for all slices. If the maximum CC of the current slice is less than 0.7 (selected empirically), this slice is discarded and the previous kernel and seed point are used for the next slice. All voxels yielding a local window that return a CC >0.7 are then used to generate an AIF if they satisfy the following criteria: 1) the C_p maximum must occur within the first three time points post contrast injection; 2) the C_p maximum is 20 times greater than the standard deviation of C_p of the first three frames; and 3) the mean C_p of the last 10 frames is < 40% of the maximum C_p. Similar filters have been used previously [3,4]. The detected AIFs are averaged for each patient and the mean AIF data are obtained for all 14 patients. The mean AIF obtained by the proposed method and the mean AIF obtained by manually segmenting the axillary arteries in each patient are then fit to a published model [5] and compared.

Fig. 1: Four adjacent slices with the detected artery.

RESULTS

Figure 1 shows four adjacent slices with the detected artery using the proposed method. Figure 2 shows the AIFs obtained manually (green) and by the proposed method (red). The proposed method leads to an AIF similar to the one selected manually. Furthermore, of the 297 slices with a visible axillary artery, 277 slices (93.3% accuracy) were detected by the proposed algorithm.

CONCLUSION

The proposed method to detect AIF is simple and effective. Given a seed point, the algorithm can select an AIF accurately and automatically. Further study will include comparisons between DCE kinetic parameters returned by analyses driven by individual and population AIFs.

Fig. 2: The mean AIF of 23 data sets, obtained manually and by the proposed method. Note the similar results produced by the two methods.

REFERENCES 1. Rijpkema et al., J Magn Reson Imaging 2001;14:457-463. 2. Parker et al., ISMRM 2003, p1264. 3. Chen et al., Med Image Comput Comput Assist Interv Int Conf Med Image Comput Comput Assist Interv. 2008;11:594-601. 4. Mouridsen et al., Magn Reson Med. 2006;55:524-31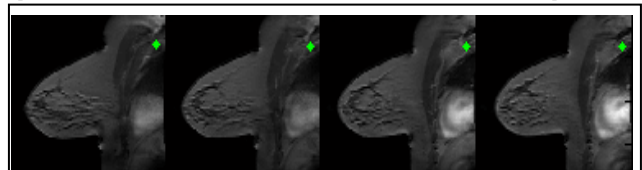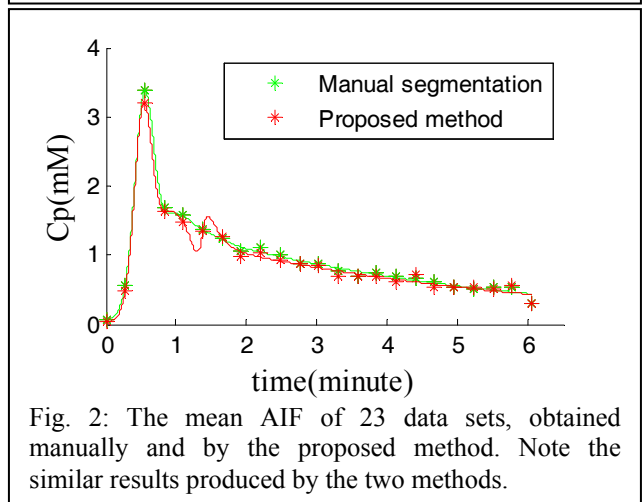. 5. Parker GJ et al., Magn Reson Med 2006;56:993-1000.