Background Correction of Phase-based Arterial Input Functions

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Introduction

The quality of pharmacokinetic parameters derived from Dynamic Contrast-Enhanced MRI (DCE-MRI), and perfusion estimates from Dynamic Susceptibility Contrast MRI (DSC-MRI) depend strongly on the accuracy of the Arterial Input Function (AIF). The AIF is challenging to measure due to the requirements of high temporal as well as spatial resolution. In addition, signal saturation and in-flow effects further complicate the situation when signal intensity is used for quantification of the amount of contrast agent (CA).

A promising alternative to the standard intensity based methods is to use the phase shift induced by the CA [1]. The phase shift is linear with CA concentration and phase measurements are also beneficial in terms of SNR [2]. However, the phase is sensitive to, for example, B_0 drift and motion and this complicates the use of phase for AIF registration in vivo, unless proper background correction is applied. Motion induced phase shifts vary over the image and appropriate placement of background correction ROIs is thus crucial. The purpose of this study was to compare three different methods for background correction of phase-versus-time curves.

Method

Images were acquired from 5 patients using segmented EPI at 3T (Phillips Achieva). Settings for the sequence were: TR/TE = 13/10 ms, FA = 25°, FOV = 225 x 225 x 5 mm^3, matrix = 126 x 144 x 1, echo train length = 3 lines, bandwidth/pixel = 2132 Hz. The temporal resolution of the sequence was 0.29 s and 768 images were acquired. The imaging slice was placed approximately 5 mm below the nose and through the lower part of the cerebellum. This slice orientation ensured access to the carotid artery in a region with relatively low motion. One out of the five patients was discarded due to improper slice placement. All AIFs were extracted from the carotid artery using a pair-wise subtraction and summation method [1], and the selection of background ROI differed between the three methods under investigation. In Method I, the background ROI was selected in the neck, where hardly any motion occurred. In Method II, it was selected close to the vessel. Care was taken to avoid inclusion of larger blood vessels into the background ROIs. In Method III, in-plane motion of the vessel was tracked using image registration and the background ROI was automatically selected as an annulus around the tracked vessel. The 30% most hyperintense pixels were excluded from the background to remove large vessels. To quantify the degree of removal of phase artefacts and noise by the background correction, a mono-exponential function was fit to the tail of the AIF and the residual standard deviation was calculated.

Results

The obtained residual standard deviations are given in Table 1. The results indicate that the use of a background close to the vessel was clearly beneficial, and that tracking of the vessel motion provided some additional improvement in most cases. The AIF after background correction for one patient is shown in Fig. 1a. Large motion (~2 mm) occurred at approximately 80 s, and the effect on the AIF due to this motion is highlighted in Fig. 1b-d. The figure shows that Method I with a distant background ROI had difficulties to correct for the motion, while Method II and III compensated the motion-induced phase errors much better with a slight advantage for Method III.

Table 1: Residual standard deviations of fits to the AIF tail.

	Patient 1	Patient 2	Patient 3	Patient 4
Method I	0.148	0.412	0.363	0.241
Method II	0.078	0.190	0.224	0.088
Method III	0.079	0.168	0.182	0.082

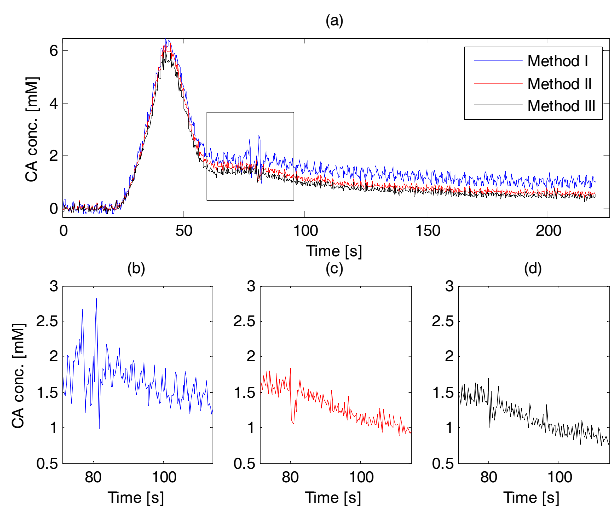

Fig. 1. (a) Background corrected AIF using Methods I-III. (b)-(d) A portion of the AIF where large motion occurred.

Conclusion

Efficient correction of motion induced phase shifts, negatively influencing the measured AIF, requires a background ROI placed close to the vessel from which the AIF is sampled. Some further improvement of the AIF can be achieved by letting the background and vessel ROIs track any in-plane motion of the vessel during the AIF measurement.

References

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