

Feasibility of extracting quantitative arterial input functions from descending aorta in breast DCE MRI studies

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Introduction

Quantitative measurement of pharmacokinetic parameters by DCE-MRI in breast is difficult to realize in practice due to the lack of a major artery within field of view for accurate measurement of arterial input function (AIF) on the individual-subject basis [1]. Accurate AIF is critical for absolute quantitative DCE-MRI [2,3] as errors on AIF have significant influence on the accuracy of pharmacokinetic parameter estimations in the Tofts' and tissue homogeneity models [1]. In the estimation of those pharmacokinetic parameters by DCE-MRI, many variabilities, such as blood inflow effects and B1 inhomogeneity, can produce technical difficulty. The objective of this work is to evaluate the feasibility of direct measuring arterial input function (AIF) with an additional surface coil placed at the back of patients, which has not been reported at the best of our knowledge. This work is a part of our DCE-MRI projects in both treated and untreated breasts.

Methods

MRI scans were performed with a whole-body 3T MR scanner (Magnetom Trio; Siemens, Germany) and a seven-channel breast receiver coil including an additional surface coil placing on the back of patients for better proximity in positioning for direct measurements of AIF from the aorta. Nine patients were imaged axially in the prone position with field of view (FOV) covering the heart but excluding the aortic arch, the RF-excited blood flows out of the imaging volume before entering the descending aorta. With 3D spoiled FLASH, pre-contrast T1 maps (TR=20ms, flip angle (FA)= 5°, 13° and 20°, matrix 256×256, 16 slices, 4-mm slice thickness, NSA = 2) and subsequent dynamic acquisition (TR=4ms, FA=15°, matrix 128×128, 16 slices, 4-mm slice thickness, NSA=1 and temporal resolution 2.4s per frame for 200 frames) [1].

On the seventh dynamic time-point, 0.1 mmol/kg of body weight dosage of 0.5 M Gadolinium-based contrast agent (Magnevist, Bayer, Germany) was administered through a power injector (Spectris Solaris EP, Medrad) at a rate of 3 ml/s. B1 inhomogeneity correction was based on the B1 maps acquired using Siemens system sequence with body coil. T1 value for blood, T1_b, was either assumed to be 1500 ms or measured by the variable FA method. Contrast relaxivity, r1 was assumed to be 3.7 s⁻¹mM⁻¹ [4].

Results

Representative data from a patient is shown in the Figure 1. The AIFs extracted from more distal slices appear more realistic for all cases, although difference is obvious between AIFs based on measured T1_b and assumed T1_b. When assumed T1_b is used, AIFs are similar between with and without B1 correction, and became almost identical for slices more than 45 mm distal to the FOV edge (Fig. 1(b,d), Fig. 2 dashed lines).

Discussion

This design provides adequate AIF for quantitative DCE-MRI for the breast cancer studies. However, some minor issues still exist and can be improved for some of them. Our variable FA images have more inflow effects due to longer TR used, even for the most distal slice. As the acquisition optimization focused on the breast, B1 maps were not so ideally optimized at the aorta. The above may explain the more chaotic area under curve values (Fig. 1(a,c), Fig. 2 solid lines) when measured T1_b is used.

As the descending aorta blood does not supply the breast regions, being wider than the ascending aorta, and much nearer to the heart than the breast regions, concentration-time curves from descending aorta still might not correctly represent the AIF for breast regions. AIFs obtained using assumed T1_b from the last few slices should be free from inflow effects although the absolute concentration value (about 2mM) and peak to 2nd peak ratio (about 2) are different from those in the literature.

References

1. Zheng BW et. al. ISMRM 2011;1676.
2. Roberts C et. al. Magn Reson Med, 2011;65:108–119.
3. Koh TS et. al. JMRI. 2011;doi: 10.1002/jmri.22795.
4. Rohrer M et al. Invest Radiol. 2005;40(11):715-24.

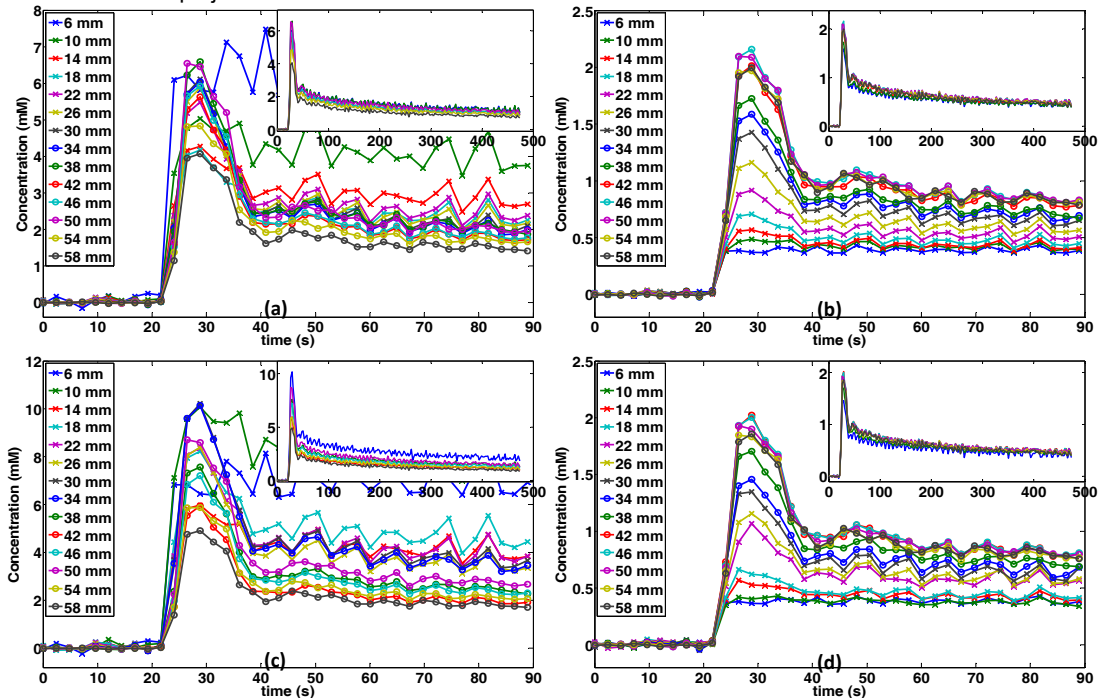


Fig. 1 AIFs extracted from ROIs drawn within the aorta, without B1 correction (a,b), after B1 correction (c,d), using assumed T1_b =1500 ms (a,c) and using measured T1_b values (b,d). Insets in figures are the full AIF curves from the more distal slices.

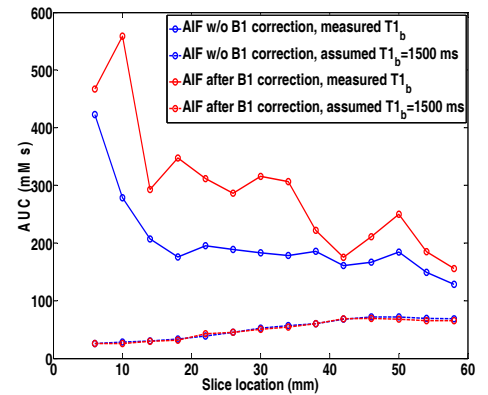


Fig. 2 Area under curves of AIFs for the first 90 s. AIFs obtained using assumed T1_b from the last few slices should be free from inflow effects although the absolute concentration value (about 2mM) and peak to 2nd peak ratio (about 2) are different from those in the literature.