The Effect of Parallel Radiofrequency Transmission on Arterial Input Function Selection in 3T DCE-MRI of Prostate Cancer

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Target Audience

The target audience includes basic scientists and clinicians who are interested in dynamic contrast-enhanced MRI (DCE-MRI) of prostate cancer and high field MRI.

Introduction

Prostate cancer is the second leading cause of cancer death in American men (1). Multi-parametric MRI, which refers to T2-weighted anatomical images and other functional imaging methods (such as DCE-MRI, diffusion weighted imaging, and MR spectroscopy) is regarded as the best available tool for the clinical imaging of prostate cancer (2). DCE-MRI involves the evaluation of T1-weighted signal intensity over time after the injection of a contrast agent. Determining pharmacokinetic parameters demands the knowledge of contrast agent concentration in the feeding artery as a function of time; this is commonly referred to as the arterial input function (AIF) (3). In DCE-MRI of the prostate, it is convenient to measure the AIF in the femoral arteries. An underlying issue that often arises in this situation, however, is the question of which of the two femoral arteries to measure. The B_1 field inhomogeneity produced by single RF transmission scanners could result in left-to-right asymmetry of the femoral arteries. The aim of this study is to evaluate whether parallel RF transmission (mTX) can improve the symmetry of the left and right femoral artery signal intensity in DCE-MRI of prostate cancer.

Material and methods

<u>Subjects</u> 18 prostate cancer patients were imaged on a 3T Achieva MRI scanner (Philips Healthcare, Best, Netherlands) using a single channel RF transmit Q-body and 32-channel phased-array surface coils, while 21 patients were imaged on the same scanner with the mTX upgrade.

<u>MRI</u> DCE-MRI was performed using a 3 dimensional spoiled gradient echo sequence (repetition time, 3.8-7.6 milliseconds; echo time, 1.51-3.9 milliseconds; flip angle, 20 degrees; matrix size, 192 × 192; in-plane resolution, 0.78 × 0.78 -0.90 × 0.90 mm^2; slice thickness, 6 mm; number of slices, 10-20; field of view, 150-172.5 mm; number of signal averages, 1; temporal resolution, 5.4-14.1 seconds; number of dynamic scans, 30-59). A single dose (0.2 mmol per kilogram body weight) of Gd-based contrast agent (Magnevist; Bayer Health Care, or Multihance; Bracco) was intravenously injected at a constant flow rate of 0.5 mL/s after the fifth phase.

<u>Image Processing</u> DCE-MRI data was processed in an IDL (Exelis Visual Information Solutions, Boulder, CO) based software environment by manually drawing a region of interest (ROI) in the right and left femoral arteries of each patient for a single spatial slice. The time signal intensity curves of the femoral arteries are shown in Figure 1; the pre-contrast signal S_0 was defined as the average of baseline signals in the femoral artery. Maximum enhancement ratio (MER) was defined by: $MER = (S_{max} - S_0)/S_0$ where S_{max} is the maximum signal intensity with contrast enhancement in the femoral artery. Asymmetry for S_0 ($S_0\_LR_{asym}$) was defined by: $S_0\_LR_{asym} = |S_0\_LR - 1|$ where the S_0_LR is the ratio of S_0 in the left artery ROI to S_0 in the right artery ROI. Asymmetry for MER (MER_LR_{asym}) was defined by: $MER\_LR_{asym} = |MER\_LR - 1|$ where the MER_LR is the ratio of MER in the left artery ROI to the MER in the right artery ROI. A left-to-right ratio of 1 and a left-to-right asymmetry of 0 would indicate an ideal symmetrical case.

<u>Statistical Analysis</u> The mean value of S_0, MER, $S_0\_LR_{asym}$, and MER_LR_{asym} were compared between the patients imaged with and without mTX by using a student *t*-test. A *P*-value of < 0.05 was considered to indicate a significant difference.

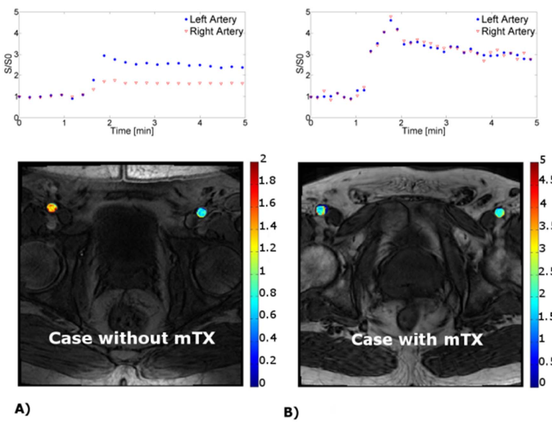

Figure 1 The signal enhancement as a function of time and MER map in the femoral arteries overlaid on a T1 weighted image obtained with a single RF transmission channel (A). The signal enhancement as a function of time and MER map overlaid on a T1 weighted image obtained with a dual RF transmission Channel (B).

Results and Discussion

Mean S_0_LR for patients imaged with mTX yielded a value closer to 1 than for patients imaged without mTX. Comparison of the mean $S_0\_LR_{asym}$ between patients imaged with and without mTX, indicates that images acquired with the mTX upgrade have significantly a more symmetrical pre-contrast baseline signals in the left and right femoral arteries (Table 1). Comparison of the mean MER_LR_{asym} and MER_LR between patients with and without the mTX upgrade, shows significantly more symmetrical signal enhancement in the left and right femoral arteries when imaging with mTX (Table 1).

	S_0_LR	$S_0\_LR_{asym}$	MER_LR	MER_LR_{asym}
W/O mTX (N = 18)	1.41 ± 0.42	0.44 ±0.39	0.57 ± 0.15	0.43 ±0.15
W/ mTX (N = 21)	1.17 ± 0.20	0.21 ±0.16	0.92 ± 0.21	0.17 ± 0.14
***P* value**	0.037	0.031	<0.001	<0.001

Table 1 Results of mean S_0, MER, $S_0\_LR_{asym}$, and MER_LR_{asym} for patients imaged with and without mTX

Conclusion

High field (3.0 T) MRI scanners equipped with multiple-channel parallel RF transmission enhances the symmetry of AIF in femoral arteries. S_0 and MER measured in the femoral artery are commonly used parameters in quantitative DCE-MRI analysis. Due to limited spatial resolution and large statistical noise, manual selection of the AIF ROI may result in inconsistencies (4). The operators' experience and judgments can also affect AIF measurements. For example, comparison of concentration time curves within slices presents the risk that a suboptimal AIF could be selected (5). The AIF curve characteristics, which are derived from the time-signal intensity curve, have been compared between multiple ROIs in order to select the optimal shape (6). The optimal AIF shape characteristics sought by the operator are those with the most arterial-like features. AIFs with an early, narrow, and high peak are highly desirable. The improved symmetry of S_0 and MER in both femoral arteries by mTX could help resolve issues regarding the reproducibility of manually-measured AIFs. This technology could result in more consistent and homogeneous quantitative pharmacokinetic modeling in DCE-MRI of prostate cancer.

References

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