Minimizing Inflow Effect in Measured Arterial Input Function for Prostate DCE-MRI

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Introduction

Analysis of T1-weighted dynamic contrast enhanced MRI (DCE-MRI) data based on the pharmacokinetic model (Generalized Kinetic Model, GKM) could provide key diagnostic information about prostate tissue perfusion[1]. In order to derive meaningful pharmacokinetic parameters, it is indispensable to know an accurate arterial input function (AIF) which represents the delivery of intravascular tracer to the tissue of interests. In practice, AIF is normally taken from either right or left femoral artery areas within imaging planes. However, due to the limited scan volume coverage, none polarized blood from outside imaging volume will flow through the imaging planes resulting in apparent decreased longitudinal relaxation times T_1 and thus leading to an overestimation of AIF. In this work, we propose to apply an additional RF pulse to extend the imaging volume coverage for reducing this blood inflow effect.

Methods & Materials

All measurements for four patients were performed on a 3 Tesla Philips Intera whole body MRI scanner (Philips Medical System**,** Best, NL) with combined SENSE cardiac coil and an endorectal coil (Medrad, Indianola, PA). After a digital rectal examination, the endorectal coil was inserted and then inflated with a fluorinated liquid to a volume of approximately 50 ml. Based on a dual-flip-angle approach for T_1 mapping, a 3D T1W fast field echo (FFE) protocol was used for acquisition with flip angles of 5º and 15º, respectively. To reduce the blood inflow effect, a pre-polarized pulse (REST slab of 80 mm wide) with the *same flip angles (5º/15º)* was applied before each acquisition (see Figure 1, Panel A for scan planning). Other relevant acquisition parameters were TR/TE of 8.8/2.0 ms, FOV of 262, 262 and 60 mm along anterior-posterior (AP), right-left (RL) and foot-head (FH) directions and corresponding digital scan resolution of 1.02*1.02*6 mm^3, and the number of scan average (NSA) was 10 and 2 for two flip angles while the latter is collected in dynamic mode with 5 dynamic scans. For comparison, these dual-flip-angle scans were repeated without applying the REST slab. Finally, a low resolution (1.8*1.8*6 mm^3) B_1 map was generated for one central image slice using 3D T1W FFE based on dual TR (50/250 ms) technique, with TE of 1.26 ms and flip angle of 60º. All image data were analyzed and visualized using in-house written IDL (ITT Visual Information Solutions, Boulder, CO) packages.

Results & Discussion

As shown in Panel D of Figure 1 for one patient's measurement, T_1 relaxation times (red square) measured from right (upper panel) and left (lower panel) femoral artery areas (red circles in Panel B), are systematically shortened along FH direction (slice number from 1 to 10). This phenomenon is becoming more pronounced for imaging slices further away from feet because of fresh/none-polarized blood flowing downstream. With an additional RF pulse (REST slab) being applied, before entering the imaging volume, the spins in blood are equally pre-polarized so that they could not bring any new net magnetizations to the target volume. T1 values (blue diamond) measured using this REST slab show much less variation across imaging slices and are much more closer to the published data (~1660 ms) [2], suggesting that the unwelcome blood inflow effect is largely reduced. These are some unexpected discrepancies in T1 values measured from right and left femoral artery areas, which could be accounted for primarily with the variations of spatial B_1 field homogeneities across the field of view. B_1 fields in the right femoral artery area are always *lower* than those in the left, and these differences could be as large as 25% in our cases. In Panel C, the means of relative B_1 fields within ROIs (red circles) for three patients' measurements are labeled, which resonances with those recent findings reported for breast imaging at the same field (3T) [3]. Fortunately, B_1 fields around prostate area and left femoral arterial area are very similar (0.95 vs. 0.94), which justifies the measuring of AIF from the left femoral artery. In Table 1, T1 relaxation times from four patients are tabulated showing dramatic changes in average T1 values before and after applying REST slab on either left side ROI (574+/38% vs. 1709+/- 21%) or right side ROI (205+/34% vs. 631+/- 16%). There exist noticeable variations among T1 mean values across imaging slices using REST slab for different subjects, which could be resulted from different blood flows in femoral arteries. In conclusion, the application of an additional RF pulse above imaging targets in prostate DCE-MRI would greatly reduce the blood inflow effect, thus, giving less compromised T1 values and more accurate arterial input functions.

Table 1. Comparison of relaxation times T1 with and without one REST slab for two ROIs from left and right femoral artery area.

	Left ROI				Righr ROI			
	REST		No REST		REST		No REST	
	T1(ms)	SD(%)	T1(ms)	SD(%)	T1(ms)	SD(%)	T1(ms)	SD(%)
Patient A	1212	7	391	32	582	10	194	26
Patient B	1925	17	608	32	771	12	269	35
Patient C	1610	42	493	43	380	31	117	48
Patient D	2088	21	805	45	793	11	241	29
AVE	1709	21	574	38	631	16	205	34

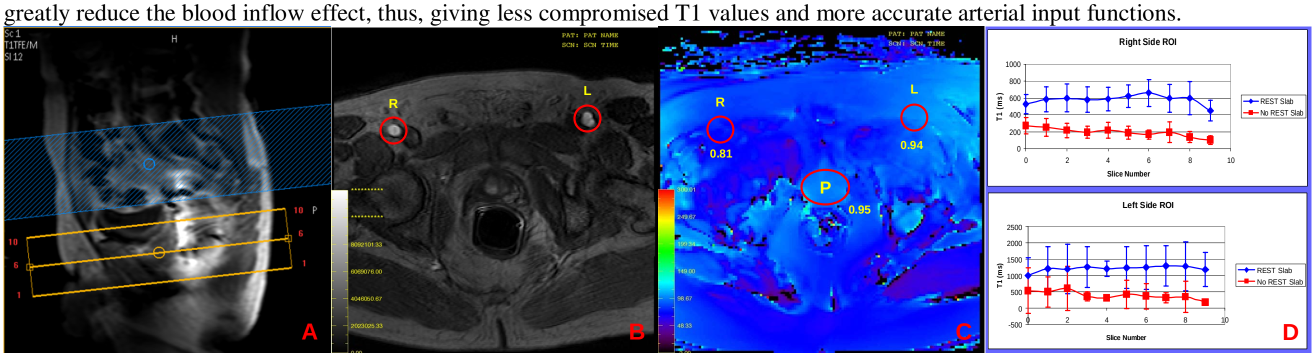

Figure 1, (A) MRI scan planning with a REST slab; (B) Region of interests (ROI) containing right and left femoral arteries; (C) B_1 map showing spatial variations in B_1 field homogeneity for the imaging plane in Panel B, for the regions with an ideal RF pulse flip angle having relative B_1 value of 1.00; (D) T_1 relaxation times from the right and left ROI (red circles in Panel B) in different image slices, with and without a REST slab.

References

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