

Contrast Agent-Free High Resolution MRI for Prostate Cancer Detection Using a Two Compartment Inversion Recovery (TCIR) Technique.

Patrik Zamecnik¹, Grzegorz Bauman², Julien Dinkel^{1,3}, Heinz-Peter Schlemmer¹, and Thomas Gaass⁴

¹Radiology, German Cancer Research Center (DKFZ), Heidelberg, Germany, ²Department of Medical Physics, German Cancer Research Center (DKFZ), Heidelberg, Germany, ³Department of Radiology, Massachusetts General Hospital, Boston, Germany, ⁴Zentralinstitut für Medizintechnik, Technische Universität München, Garching, Germany

Introduction

Multiparametric MRI showed high detection rates for prostate cancer in several studies [1,2]. Such MRI protocols consist usually of T2-weighted images, diffusion weighted imaging (DWI)/apparent diffusion coefficient (ADC) maps, MR-spectroscopy (MRS) and dynamic contrast enhanced (DCE) acquisitions, which make the use of intravenous contrast media necessary. Despite relatively rare allergic reactions after contrast media administration the next problem is evident: prostate carcinoma is typically a disease of elderly male patients, in which reduced renal function could be seen more frequently [3]. This fact may cause problems for contrast media use. Since DCE-MRI provides necessary information for prostate cancer detection, an alternative non-contrast-enhanced MRI technique, which is showing additional tissue properties usable for cancer detection is highly desirable. A new contrast media-free technique (two compartment inversion recovery - TCIR) was recently proposed to measure the blood volume fraction (f_{BV}) within tissue and thus to provide diagnostic information similar to the tissue perfusion [4]. The aim of this work is to validate the feasibility of TCIR approach for prostate cancer detection by comparison with the standard T2w, DCE- and DWI-sequences.

Methods

Ten male patients with histologically proven prostate cancer underwent an diagnostic MRI using transverse T2-TSE (TE= 143 ms, TR=5150 ms, slice thickness= 3 mm, FoV = 213x300, matrix size = 254x448), DWI (EPI sequence, TE = 52, TR = 3100, slice thickness = 3 mm, FoV = 280x210, matrix size = 96x128, b-values = 0, 50, 100, 150, 200, 250, 800) incl. calculation of ADC maps and DCE-MRI (TWIST sequence, TE = 2.2, TR = 4.4, slice thickness = 3 mm, FoV = 300x400, matrix size = 192x256, temporal resolution 9 seconds, 31 repetitions, contrast media: gadobutrol {Gadovist®, Bayer Healthcare Pharmaceuticals, Berlin, Germany}). Additionally, the TCIR technique (in transverse orientation) was performed before contrast administration to estimate the fractional blood volume (f_{BV}) maps. As already proposed [2], the basis of the TCIR mapping technique is the assumption, that the measured signal in the prostate arises from two separate proton compartments, one intravascular and one extravascular. The difference in longitudinal relaxation times T_{1int} and T_{1ext} is employed to extract the volume fraction of intravascular protons. The T_1 mapping was performed using a HASTE sequence: TR/TE = 5000/34 ms, slice thickness = 6 mm, BW = 473 Hz/px, flip angle = 180°, TI = 0, 200, 400, 600, 700, 800, 900, 1000, 1050, 1100, 1150, 1250, 1300, 1350, 1400, 1500, 1700, 1900, 2000, 3000 ms. The patients were examined on a 3 T whole-body MR-scanner (Magnetom Trio, Siemens Healthcare, Erlangen, Germany) using a combination body and spine matrix coils. The localization of tumor suspect areas were determined on the standard sequences under knowledge of the biopsy results and were compared with the TCIR approach. The mean f_{BV} -values within regions of interest (ROI) in the normal peripheral zone and central gland and in the tumor were calculated.

Results

In all patients the suspect areas could be identified. The location and dimension of the suspect areas in TCIR images showed the best visual correlation with the very early DCE MRI (see Fig. 1 and 2). Using TCIR the detection of the suspect areas was possible in the peripheral zone and the central gland. The f_{BV} value within the tumor areas was significant higher (0.874 ± 0.079) compared to the normal peripheral zone (0.382 ± 0.079), $p < 0.001$, and to the normal central gland (0.781 ± 0.067), $p < 0.03$.

Discussion

In this feasibility study we have shown that using the TCIR technique it was possible to generate good quality high-resolution maps of the fractional blood volume in the prostate without using a contrast agent. The fractional blood volume (f_{BV}) correlated visually with very early DCE MRI and the suspect areas could be delineated in similar quality compared to the DCE MRI. From technical point of view there is also potential for improvement. For better absolute quantitative evaluation of the f_{BV} , it has to be corrected for a potential T_2 -effect as well as for the influence of free water, which both lead to an overestimation of the fractional blood volume within the prostate.

Summarizing our results, TCIR has a high potential for prostate cancer detection because of its high spatial resolution and sensitivity, first of all in patients, which cannot be examined using contrast media. This technique could be used routinely as an important part of completely non-invasive multiparametric MRI-protocols for prostate diagnostics, disclaiming the intravenous administration of contrast media. However, this should be confirmed in further clinical studies with much higher number of patients.

References:

- [1] Hoeks CM et al. Radiology 2011 Oct;261(1):46-66.
- [2] Dickinson L et al. Eur Urol. 2011 Apr;59(4):477-94.
- [3] Peralta CA et al. Am J Nephrol. 2011 Nov 1;34(6):512-518.
- [4] Gaass T et al. In: Proceedings of the 19th Annual Meeting of ISMRM, Montreal, 2011. (abstract 544).

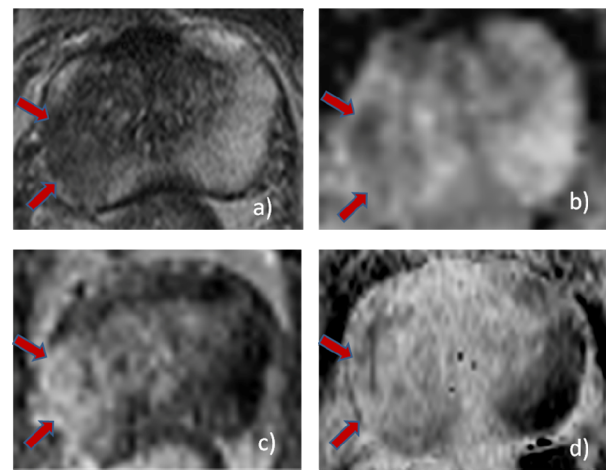


Fig. 1. Patient with prostate cancer in the right peripheral zone (Gleason 9 (4+5) with attendant, histologically proven inflammatory reaction). Suspect areas are marked with red arrows. Transverse MRI images: **a)** T2-TSE; **b)** ADC map; **c)** DCE-MRI: very early arterial phase showing asymmetric contrast enhancement in the right peripheral zone comparing to the left; **d)** TCIR image: corresponding to the DCE-image asymmetric signal elevation (f_{BV} -elevation) right, comparing to the left peripheral zone.

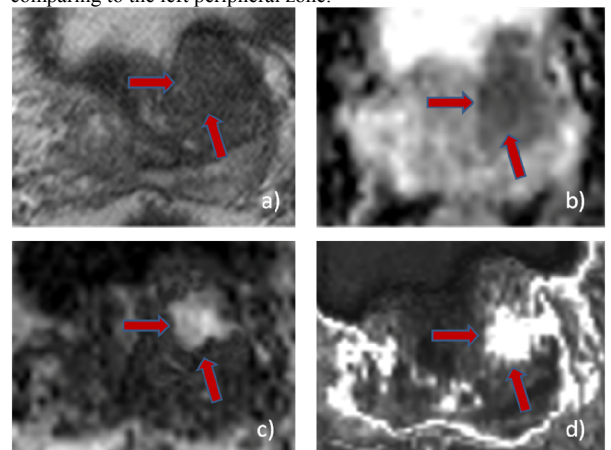


Fig. 2. Patient with prostate cancer in the left central gland (Gleason 8 (4+4)). Suspect areas are marked with red arrows. Transverse MRI images: **a)** T2-TSE: the tumor area is not distinguishable from hyperplastic central gland; **b)** ADC map; **c)** DCE MRI: very early arterial phase showing contrast enhancement in the left central gland within the hyperplastic central gland – the tumor areas enhance earlier than the surrounding hyperplastic adenomatous tissue; **d)** TCIR image: corresponding to the DCE-image signal elevation (f_{BV} -elevation) in the left central gland, similarly to the DCE MRI the suspect area is distinguishable from the surrounding tissue.