Usefulness of parameters derived from intravoxel incoherent motion (IVIM) data – comparison of two methods in patients with proven prostate carcinoma

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TARGETED AUDIENCE

Radiologists with interest in oncologic diffusion weighted imaging (DWI).

PURPOSE

In recent years, several studies examined the perfusion fraction (f) as well as diffusion coefficients (D) from intravoxel incoherent motion data (IVIM) in patients with prostate cancer (PCa). For f, inconsistent results were presented, and both higher [1] as well as lower perfusion fractions [2,3] compared to normal tissue were reported. Aim of the present study was to investigate the behavior of f and D for in patients with histologically proven prostate cancer compared to remote areas and healthy individuals without imaging and biopsy findings. Also, the potential confounding role of different fitting approaches is investigated.

METHODS

In this retrospective, single-institutional study twenty-seven patients (age 68.9±6.3 years) who had biopsy proven PCa were included in the study. Patients with proven PCa were only included in the study if an unambiguous region of tumor was seen in morphologic T2w imaging as well as tumor free remote areas contralateral to the tumor region. A multiparametric MR protocol was performed, comprising T1w images, T2w images, DWI data (TR/ TE 3100/ 52 ms, Res. 2x2x3 mm³), and dynamic contrast enhanced imaging. For DWI b values of 50, 100, 150, 200, 250 and 800 s/mm2 were measured and ADC map calculated. For quantification of f and D, two distinct curve fitting algorithms were employed [1,2]. One radiologist with 3 years experience in prostate imaging performed ROI (region of interest) placement and f and D were extracted from these ROIs. Pearson's correlation was used to determine correlation between ratios (tumor/remote area) of calculated DWI parameters (f, D) and measured values in ADC images.

RESULTS

Values for f and D are shown in table 1 for both analytical methods. Ratios (tumor/ remote region) were determined for f and D and ADC values. Results are given in table 2. The ratio of measured ADC intensities in tumor region and remote areas in all patients signal intensities in tumor were lower compared to the contralateral side. Concerning the ratios of the IVIM parameters using method 1 (3 free parameters), f was >1 in 12 patients, and <=1 in 15 patients; D was >1 in 2 patients, and <=1 in 25 patients. Using method 2, f was >1 in 17 patients, and <=1 in 10 patients; D was >1 in 2 patients, and <=1 in 25 patients.

DISCUSSION

DW-MRI has been accepted as an imaging biomarker of cancer and is regarded as a key tool for the detection and grading of various tumor entities, as well as a method for monitoring the effects of treatment [4]. In the present study we found high variation in perfusion fractions (f). This may be attributed to heterogeneity of PCa on a histological level; as we included patients with Gleason grade 1 to 5 in our study. Using the fitting algorithm with three free parameters, our data showed that perfusion fraction (f) was increased in tumor in 12 patients and decreased in 15 patients. Using the fitting algorithm with fixed D*, f was increased in PCa in 17 patients and decreased in 10 patients. In the present study we calculated ADC ratios from tumor regions and remote areas situated opposite of the tumor in the peripheral zone. Calculation of correlation coefficients between this ratio and ratios for IVIM parameters revealed the highest correlation of ADC ratios with D, whereas no correlation was found between ratios of ADC and f as well as ADC.

CONCLUSION

Extracting IVIM parameters in unequivocal tumor regions and normal contralateral parenchyma revealed high variation in perfusion fractions (f) for both fitting algorithms, probably due to both histological heterogeneity of underlying PCa (low grade vs. high grade tumors) and potential instability of the fit. In contrast, diffusion coefficient (D) was able to reliably distinguish cancerous from healthy tissue in 25/27 patients in our cohort.

TABLES

Region	***Method***	***f (%)***	***D(10^{-3} mm^2/s)***
Tumor region	D+f, then D*	9.5±5.5	1.04±0.23
	D+f, fixed D*	8.6±5.4	1.06±0.23
Remote region	D+f, then D*	11.1±5.0	1.44±0.19
	D+f, fixed D*	7.6±4.0	1.53±0.23

Table 1: f and D in patients with proven PCa

	D+f, then D*		**D+f, fixed D***			
	f (%)	**D** (10^{-3} mm^2/s)	**f** (%)	**D** (10^{-3} mm^2/s)	**T2** (a.u.)	**ADC** (10^{-3} mm^2/s)
Ratio tumor/ remote area	1.05 ±0.91	0.74 ±0.18	1.48 ±1.35	0.71 ±0.18	0.53 ±0.16	0.56 ±0.15
Pearson's vs. ADC	r=0.06	r=0.37	r=-0.02	r=0.39		

Table 2: Parameter ratios (tumor/remote area) determined in patients with PCa. Pearson's correlation was calculated for ratios of f and D versus ADC ratios.

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