

# Which DCE MRI Parameter Provides the Best Discrimination between Prostate Cancer and Benign Tissue?

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## Introduction

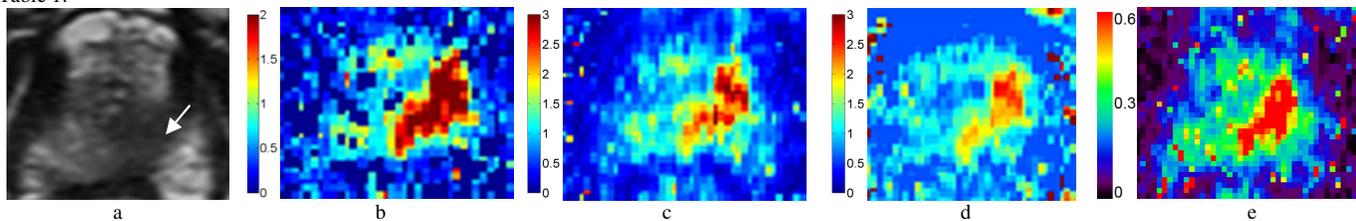
Dynamic contrast-enhanced MR imaging (DCE MRI) is a promising diagnostic modality for assessment of prostate cancer. DCE data have been analyzed with a variety of methods including compartmental models [1,2], distributed parameter models [3-6], and model-free analysis, such as the wash-in rate [7]. There is no consensus on the optimal processing method. The purpose of this study was to compare the ability of parameters derived from DCE MRI data using these three methods to discriminate between tumor and benign prostatic tissue.

## Methods

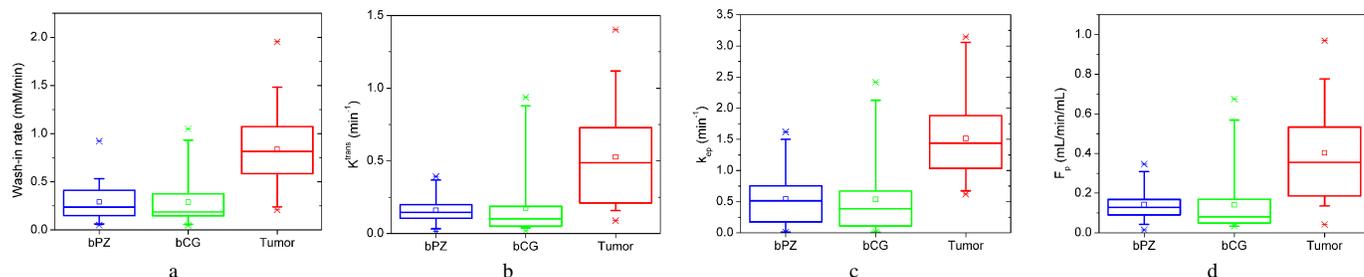
Thirty patients (mean age, 62.7 y) with histologically proven prostate cancer (median Gleason score 7 on biopsy, median PSA 10.5 ng/mL, range 0.1 to 168 ng/mL) were evaluated at 1.5 T DCE MRI using a fat-suppressed 3D GRE sequence (VIBE, TR/TE/flip angle=3.46 ms/ 1.49 ms/12°, 1.1x1.1x4 mm<sup>3</sup> voxel, volume acquisition time 5 s, 20 volumes). Following a 20 ml bolus of Gd-DTPA and 20 ml saline flush, both injected at 3 ml/s, dynamic images were acquired for at least 120 s. Conventional high-resolution T1- and T2-weighted imaging were also acquired. Two radiologists in consensus placed ROIs in benign prostate peripheral zone (bPZ), benign central gland (bCG), and tumor (T). To position ROIs the readers referred to prostatectomy (n = 10) or biopsy results combined with T2-weighted images (n = 20). DCE data were analyzed in Matlab (Mathworks; Natick, NJ) and FireVoxel (NYU SoM, Dept. of Radiology). Arterial input function (AIF) was sampled in external iliac arteries in the lower part of the slab. Signal was converted to concentration using the standard gradient echo formula. DCE data were analyzed using the wash-in rate (maximum initial upslope) [7], two-compartment Tofts model [1] and distributed parameter model (adiabatic approximation to tissue homogeneity model, AATH) [3-6]. AATH fitting was done with a grid of starting parameters. The ability to discriminate between cancerous and benign tissue was assessed by Cohen's d statistic [8] and ROC analysis.

## Results

Representative maps of perfusion parameters are shown in Fig. 1 and box-whiskers parameter plots are shown in Fig. 2. The wash-in rate, Tofts' model  $K^{trans}$  and  $k_{ep}$  were significantly higher in tumor than in benign tissues ( $p < 0.003$  in all). In AATH, plasma flow  $F_p$  was higher ( $p < 10^{-5}$ ) and vascular mean transit time  $T_c$  was lower in tumor than in bPZ and bCG ( $p < 0.04$ ); extraction fraction  $E$  was significantly lower in tumor than in bPZ and bCG ( $p < 0.02$ ).  $K^{trans}$  values derived from Tofts model were found to be significantly higher than  $K^{trans} = EF_p$  from AATH ( $p < 0.0001$ ). Cohen's d and ROC parameters for discrimination of cancer from benign ROIs are given in Table 1.



**Fig. 1:** 67-year old patient with prostate cancer at the apex (PSA 5.0 ng/mL, biopsy Gleason score 7): a) T2-weighted image with tumor indicated by an arrow, and parametric maps showing elevated perfusion parameters in the same location: b) maximum wash-in rate (mM/min), c) Tofts  $K^{trans}$  ( $\text{min}^{-1}$ ), d) Tofts  $k_{ep}$  ( $\text{min}^{-1}$ ), e) AATH  $F_p$ .



**Fig. 2:** Box-whiskers plots of perfusion parameters: a) Maximum wash-in rate, b) Tofts model  $K^{trans}$ , c) Tofts model  $k_{ep}$ , d) AATH plasma flow  $F_p$ . Whisker lengths indicate 5-95% intervals.

**Table 1:** Effect size (Cohen's d), area under ROC (AU ROC), and accuracy for discrimination of cancer using perfusion parameters.

Parameter	Cohen's d	AU ROC	Accuracy
Wash-in rate	1.91	0.91	0.88
Tofts $K^{trans}$	1.53	0.88	0.79
Tofts $k_{ep}$	1.74	0.90	0.86
AATH $F_p$	1.60	0.87	0.79
AATH $EF_p$	1.04	0.78	0.71

## Discussion

The wash-in rate provided the highest d, AU ROC, and accuracy. The superiority of the wash-in rate over the model parameters suggests that the arterial input function as the main source of inaccuracies in perfusion parameters. Tofts and AATH  $F_p$  were comparable with published results [2, 6], although AATH  $F_p$  was higher than in Ref. [6]. As predicted by simulations by Buckley [4], AATH  $K^{trans} = EF_p$  was higher than Tofts  $K^{trans}$ .

## References

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