Dynamic Contrast-Enhanced MRI to Monitor Response to CyberKnife SBRT

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Purpose: To evaluate the changes in dynamic contrast enhanced (DCE) MRI driven parametric values following CyberKnife SBRT for prostate cancer.

Background: CyberKnife® robotic stereotactic body radiotherapy (SBRT) is a recently developed technique that delivers external radiation using a compact, lightweight linear accelerator mounted on a robotic arm. The application of CyberKnife for treatment of prostate cancer is currently being evaluated and appears promising out to five years of follow-up. DCE MR imaging is performed following administration of extracellular gadolinium chelate contrast agents. By repeatedly imaging the tissue following the intravenous injection of gadolinium, DCE allows tracking intrinsic differences in contrast flow through different tissues. DCE provides information about key physiologic parameters of normal tissues and tumors. Since tumors display increased vascular permeability due to tumor angiogenesis one may use DCE to detect and characterize various tumors and to monitor response to treatments including radiation therapy.

Materials and Methods: Twenty-eight patients with biopsy proven prostate cancer underwent MRI on a 1.5T GE MR 450 scanner prior to and following treatment with CyberKnife radiosurgery. MRI included thin section high resolution T2-weighted imaging, and DCE MRI including 35 phases with 9 sec temporal resolution. iCAD's research workstation was used to generate tissue relaxation T10 maps of the prostate gland and then to generate colorized parametric maps showing perfusion of the prostate gland and enhancing tumors. For identified tumors parametric values including K^{trans}, K_{ep}, extracellular volume fraction (EVF), and initial area under the concentration curve (iAUGC) were calculated. Follow-up MRI has been performed at 6 months for 22 patients, and 12 months for 13 patients. Repeated measurements of the parametric values were calculated. The percent change in these parameters from baseline values was calculated for each patient at 6 and 12 months.

Results: Pre CyberKnife DCE MRI showed prostate cancers with median K^{trans} 3.24 min^{-1}, K_{ep} 5.98 min^{-1}, EVF 0.66, and iAUGC 11.8 mMsec. Follow- up MRI obtained 6 months after radiation therapy showed median K^{trans} 0.60 min^{-1}, K_{ep} 0.99 min^{-1}, EVF 0.89, and iAUGC 8.05mMsec. At 12 months following radiation therapy DCE MRI showed K^{trans} 0.30 min^{-1}, K_{ep} 0.56 min^{-1}, EVF 0.69 and iAUGC 4.90. At 6 months following CyberKnife SBRT there was a 79% decrease in K^{trans}, 85% decrease in K_{ep} 1% increase in EVF. At 12 months we observed a 93% decrease in K^{trans} from baseline values, 92% decrease in Kep, and 6% decrease in EVF. Colorized parametric maps showed complete resolution of enhancing peripheral zone tumors at 6 months in 26% of patients compared to 92% of patients at 12 months after CyberKnife SBRT.

Conclusions: DCE MRI depicts prostate cancer prior to treatment, which resolves over 6 -12 months post treatment. Colorized quantitative parametric maps aid in visualization of tissue variations and show corresponding progressive decrease in K^{trans}, K_{ep}, and iAUGC at 6 months and 12 months following CyberKnife SBRT.

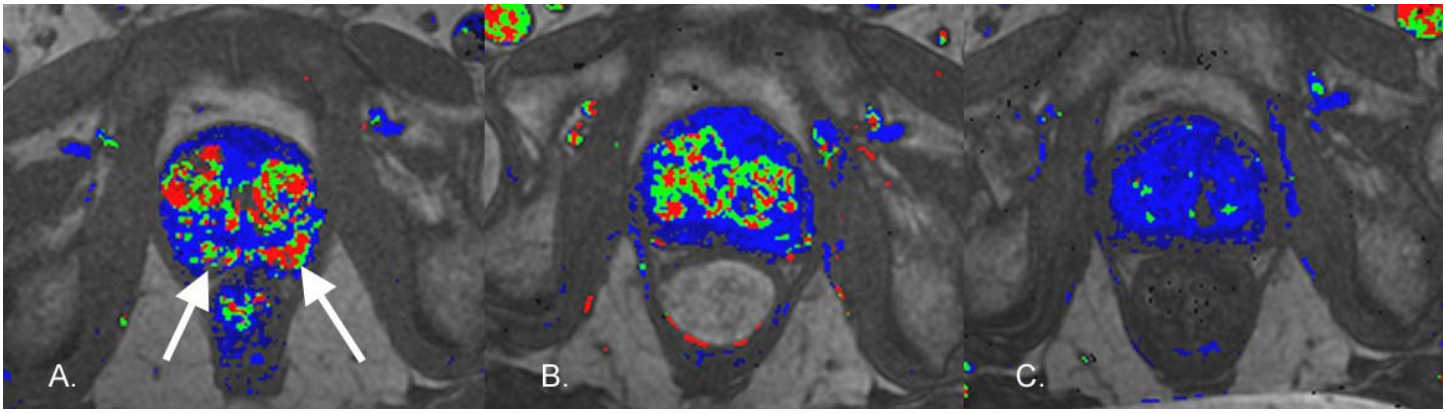

Figure 1: 73 year old man with a Gleason 6 prostate cancer. The pre-CyberKnife DCE parametric map (A) shows bilateral peripheral zone tumor (arrows) (K^{trans} 3.24 1/min, K_{ep} 9.45 1/min, EVF 0.62). Follow-up MRI 6 months after radiation treatment (B) shows resolving peripheral zone tumors (K^{trans} 0.78 1/min, K_{ep} 0.58 1/min, EVF 0.82). Follow-up MRI 12 months after CyberKnife SBRT (C) shows complete resolution of peripheral zone tumors (K^{trans} 0.21 1/min, K_{ep} 0.571/min, EVF 0.62).

References: [1] Padhani AR, et al. Dynamic Contrast Enhanced MRI of Prostate Cancer: Correlation with Morphology and Tumour Stage, Histological Grade and PSA, *Clinical Radiology 2000;* 55:99-109.