Role of R2* with BOLD MRI in the Staging of Prostate Cancer

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Target Audience Radiologists, urologist, radiotherapy physicians and MR technologists

Purpose Blood oxygen level dependent (BOLD) MRI is a non-invasive method that can assess hypoxia in prostate gland, through utilizing the endogenous contrast generated by paramagnetic deoxyhemoglobin.[1] R2* quantification by BOLD has been shown to be sensitive to oxygenation status and accordance to hypoxia measured by immunohistochemical staining with pimonidazole and Eppendorf pO2 microelectrode in prostate cancer.[1-3] Tumor hypoxia and its downstream effects remain of considerable interest for clinicians due to its negative impact on response to various cancer therapies and promotion of metastasis.[4] Meanwhile the perfusion information is the key factor that influence R2* interpretation in acute hypoxia measured by BOLD.[5] Therefore the purpose of the study was to investigate the ability of R2* by BOLD MRI in staging of prostate tumor, and compared R2* with blood flow (BF) from ASL.

Methods The local ethics committee approved the study and 40 patients (mean 73±9 years; range 50-86 years) with pathologically confirmed prostate cancer were recruited. The patients were classified into three stage groups based on the American Joint Committee on Cancer (AJCC) staging system for prostate cancer, including T2 (n=9), T3 (n=17), T4 (n=14). MR examinations were performed on a clinical 3.0T MR scanner (Signa HD; GE Healthcare, Milwaukee, Wisconsin, USA) with the 8-channel pelvic phased-array coil before biopsy. The BOLD MRI was performed with multiple-echo spoiled gradient recalled echo (SPGR) protocol prescribed with12 time echoes (TEs), as well as with the following parameters: TR= 100 ms; TE= 6.8–32.1ms; FA=45°; bandwidth= 31.25 kHz; matrix= 128×128; FOV= 24 cm2; section thickness/gap= 5/0mm; section number= 16; NEX= 2. The ASL protocol was performed with FAIR-SSFSE sequence, with parameters (TI=1000msec; TR/TRM0= 3500/6000ms; flip angle = 90°; FOV=24 cm2; slice thickness=5mm and phases=8). The regions of interest (ROIs) were placed in the prostate cancerous zone (including the whole prostate cancer area), the normal prostate peripheral zone and periprostatic muscle, avoiding the areas of necrosis, calcification, hemorrhage and air or movement artifacts. The average R2* and blood flow (BF) in these regions for each patient was computed respectively. The One-Way AVONA analysis was conducted to compare the R2* among the groups. The correlation analysis were also performed between R2* and BF in cancerous zones.

Results There is a significant drop of R2* along with the prostate cancer upstaged detected via BOLD MRI (26.3±6.2 s^{-1}, 24.7±5.6 s^{-1} and 20.4±5.8 s^{-1}) ($P<0.05$, AVONA analysis) (Figure 1), and mean R2* in the normal prostate peripheral zone and periprostatic muscle were 14.0±5.6 s^{-1} and 38.3±5.9 s^{-1}. Inverse correlation between R2* and BF(r= -0.384, P = .014) were found in cancerous zones.

Discussion This study demonstrates that BOLD MRI can be used to evaluate hypoxia in prostate cancer and differentiate the three clinical stages. However a decreasing of hypoxia was observed with increasing clinical stage from BOLD measurements involved prostate cancer. The negative correlation between R2* and blood flow that was observed suggests that R2* values in patients with prostate cancer may be highly dependent on blood oxygenation.

Conclusion BOLD MR imaging is a potentially useful in vivo imaging technique to detect hypoxia in the prostate cancer. But it is needed to take blood oxygenation information into consideration when staging of prostate cancer, as it is highly dependent on blood flow.

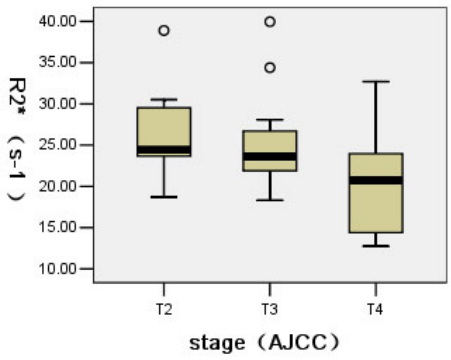

Figure 1.Boxplot of BF values show that R2* decreases along with prostate cancer upgraded.

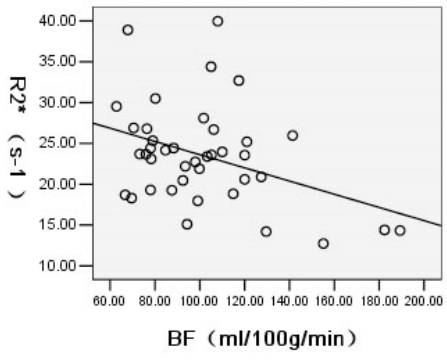

Figure2. Scatter plots show correlation between R2* and BF.

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