The study of prostate cancer with intensity-modulated radiation therapy (IMRT) based on metabolic data provided by 1H Magnetic Resonance Spectroscopic Imaging (MRSI)

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Purposes: To use metabolic data in the clinical intensity-modulated radiation therapy (IMRT) planning and evaluate the therapeutic effects by proton Magnetic Resonance Spectroscopic Imaging (MRSI)

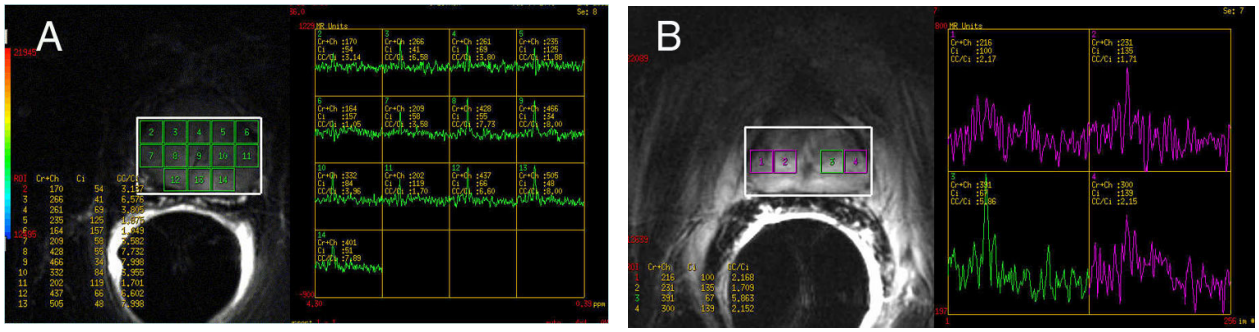
Methods and Materials: Patients: 60 patients (66±4.2 years old) with biopsy-proven prostate cancer underwent (pre/post therapy) MRI/MRSI examinations and intensity- modulated radiation therapy. Thirty of the 60 patients (research group, using MRSI data) were selected randomly to accept SIB (simultaneously integrated boost) with the dose of 70Gy (n=20, without ECE) for the whole gland and extra high dose (90Gy) for the localized cancer based on the metabolic information provided by MRSI, or 45Gy for the whole pelvis (n=10, with ECE) and extra 78Gy for the cancer based on MRSI (Fig A). The other thirty of the 60 patients (control group, not using MRSI data) accepted SIB with the dose of 81Gy for the whole gland (n=20, without ECE), or 45Gy for the whole pelvis and extra 70Gy for the gland (n=10, with ECE). Patient age, PSA and prostate grade (Gleason score) did not differ significantly between the two groups ($p>0.01$). MRSI techniques: All studies were performed on a 1.5 Tesla GE Signa MR scanner using the body coil for rf transmission and an endorectal coil (Medrad) in combination with a pelvic phased array coil for signal reception. Proton spectra (0.24cc) were collected from the prostate using PRESS volume selection with 3D phase encoding (16x8x8), BASING water and lipid suppression, and VSS pulses. Choline, creatine, and citrate peak areas were calculated for all the interpretable voxels. The voxel with the abnormal ratio of (Choline+Creatine)/Citrate] (CC/C ≥3SD above normal) is defined as cancer. ACQplan (compatible with DICOM format) was used to fuse MR data to clinical MRT operation system. MRSI examinations were repeated one year after therapy to check if recurrence existed. Compared with pre therapy data, recurrence was considered when the volume or magnitude of metabolic abnormality increased (Fig B), the results were confirmed by biopsy. The radiation-induce complications were evaluated 6 months after therapy according to the Department of Radiation Oncology scoring system.

Results: For the patients with ECE, Recurrent Rate (RR) in the research group and the control group are 10% and 25%, respectively, however, there was no significant different between the two groups ($p=0.12$). For the patients without ECE, the RRs were similar between the two groups (5%, 8% respectively). 19.5% of ECE patients for the research group and 22.4% for the control group had radiation-induced complications (eg. late rectal toxicity) 6 months after therapy, while 15.2% for the research group and 14.7% for the control group in the non-ECE patients.

Discussion: The most effective treatments for prostate cancer are surgical therapy, hormone therapy, radiation therapy, and cryosurgery, each of which may lead to a series of complications (1). Particularly for radiation therapy, transient bladder outlet obstruction, acute and late rectal toxicities, radiation-induced urethritis, urethral stricture, and erectile dysfunction are common (2). Several researches have addressed these radiation-induced complications, focused on the post therapy evaluation relating to the quality of life, and also offered the possibility of optimizing the individual treatment planning with anatomic and metabolic information of prostate (3). Our study was trying to use metabolic data provide by Magnetic Resonance Spectroscopic Imaging to the clinical IMRT planning as to improve the therapeutic effects while minimizing the dose of peripheral tissue.

Intensity-modulated radiation therapy is a computer-driven treatment planning and delivery system. While the process of IMRT involves optimization of the dose, CT or MRI alone is not effective enough in detection and localization of the prostate cancer. Magnetic Resonance Spectroscopic Imaging (MRSI), however, has been accepted as a non-invasive tool to demonstrate metabolism at the level of cells, and has shown a promising improvement in the diagnosis and localization of prostate cancer.

Our preliminary results show that Recurrent Rate of one year for the research group with ECE was less than that for control group, which indicates that IMRT based on the combination of anatomy and metabolic information provided by MRSI may improve the effects of the therapy. However, we did not find any significant difference between the two groups, this may be attributed to the fact that the number of the cases in this study was relative small and the period of observation was not long enough. More accurate and significant results could be induced in the studies with large samplings and long term, which may include the evaluations of the disease control rate, 5-year or 10-year survival rate, etc. The percentage of the radiation-induced complications of the two groups either for the ECE patients or non-ECE patients did not have significant difference, which suggests that more doses distributed to the cancer nodule do not cause any more sever complications, demonstrating the feasibility of this therapy planning.



Conclusion: IMRT based on MRSI data has shown a promising trend of less recurrent rate without increasing radiation-induced complications. More data and long term follow-up studies will be needed in the further research.

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