The Role of Diffusion-Weighted MRI: In Assessment of Response to Radiotherapy for Prostate Cancer

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ABSTRACT

Prostate carcinoma is the second most frequent cause of cancer-related death in men. External beam radiotherapy is one of the effective treatment modalities for the localized disease. For treatment response PSA level is mainly used .DWI is one of the evolving functional MR imaging that asses tissue cellularity. Changes in ADC value reflects the prostate response to radiotherapy, hopefully it could be used as an additional biomarker for assessment of response to radiotherapy.

Keywords:

1.5-T MRI, apparent diffusion coefficient, diffusion-weighted imaging, MRI, prostate cancer radiotherapy.

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3D-CRT: Three-dimensional conformal radiotherapy

AAH: Atypical Adenomatous Hyperplasia

ADC: Apparent diffusion coefficient

BPH: Benign prostatic hyperplasia

CT: Computed tomography

CZ: Central zone

DCE: Dynamic contrast-enhanced

DRE: Digital rectal examination

DWI: Diffusion-weighted imaging

EBRT: External beam radiotherapy

ECE: Extra Capsular Extension

EPI: Echo-planar imaging

ERC: Endo-rectal coil

FOV: Field of view

GS: Gleason score

HIFU: High intensity focused ultrasound

HT : Hormonal treatment

IGRT: Image-guided radiotherapy

IMRT: Intensity-modulated radiotherapy

IORT: Intraoperative radiotherapy

LN: Lymph node

MRI: Magnetic resonance imaging

MRS: Magnetic resonance spectroscopy

NSA: Number of signal averages

PACS: Picture archiving and communication system

PCAP: predisposing for cancer of the prostate gene

PIN: Prostatic intraepithelial neoplasia

PSA: Prostatic specific antigen

PSAD: PSA density

PSAV: PSA velocity

PZ: Peripheral zone

RF: Radiofrequency pulse

ROI: Regions of interest

RP : Radical prostatectomy

RT : Radiotherpay

SD: Standard deviation

SE: Spin echo

SI: Signal intensity

SNR: Signal-to-noise ratio

SOR: Standard of reference

SRT: Stereotactic radiotherapy

TAB: Triple androgen blockade

TRUS: Transrectal ultrasound

TSE: Turbo spin-echo

TURP: Trans-urethral resection of the prostate

TZ: Transitional zone

US: Ultrasonography

WI: Weighted image

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INTRODUCTION

Prostate cancer is ranking as the second most common cause of cancer related deaths in men older than 50 years worldwide , after carcinoma of the lung .The disease is generally diagnosed early, when disease is locally confined to the prostate gland, without regional involvement of pelvic lymph nodes or distant metastases to abdominal lymph nodes or other organs beyond the prostate gland ***(Scher et al.,2000)***.

Radiotherapy for prostate cancer is currently one of the common treatment strategies if the cancer is detected at an early stage and invasive surgical resection can be avoided (***Albertsen et al., 2007)***.

Determination of the serum prostate-specific antigen (PSA) level has been widely used for screening, diagnosis, determination of prognosis, and selection of the appropriate treatment for men with clinically localized prostate cancer (***Lawton et al ,2007)***

After radiotherapy, monitoring PSA levels is used to determine the effectiveness of treatment as an early and accurate surrogate. However, PSA monitoring has been shown to have a limited role in defining cancer cure within the first 5 years after radiotherapy because, although a lower PSA nadir after radiotherapy has been associated with cancer cure, the treatment ultimately fails in 5–25% of patients even in those with the most optimal biochemical response. In addition, the most appropriate biochemical definitions of treatment failure after radiotherapy remain

controversial because of substantial differences in the diagnostic accuracies of biochemical levels for predicting clinical outcome. Moreover, no pattern of PSA kinetics after radiotherapy has conclusively differentiated between local and distant failure ***(Roach et al ,2006)***.Another study to report such issue is (***Sheinbein et al .,2009***) which stated that a PSA recurrence (biochemical relapse) after nonsurgical or minimally invasive treatment like radiation therapy is defined according to the Houston criterion, that is, a nadir PSA level + 2 ng/mL . However, so-called PSA bounces unrelated to recurrence can occur, especially after high-dose external beam radiation therapy. Yet this differentiation is crucial for patient counseling, as management options may vary from local salvage therapy to systemic therapy depending on the disease status (***Akin O et al .,2011)*** .

To the contrary, a functional MR technique such as diffusion-weighted imaging (DWI) may detect and localize prostate cancer before radiotherapy and then may provide qualitative or quantitative information for measuring therapeutic response in patients with prostate cancer during and after radiotherapy ***(Moffat et al .,2005)***

With the introduction of higher-field-strength MR scanners and the parallel imaging technique for prostate MRI, DWI has been shown to have several potential benefits for the assessment of tumor localization and staging. In comparison with the use of conventional MRI, DWI can noninvasively show the changes of cellularity in malignant tumors in the body; apparent diffusion coefficient (ADC) maps can show the mobility of water in tissues .After the treatment of malignant tumors, the cellularity and cell membrane integrity in necrotic tumor cells are reduced

and there is a subsequent increase in water mobility, whereas viable tumor cells restrict diffusion of water molecules *(**Hamstra et al ,2007**)*.

Compared with other MRI techniques, DWI has the advantages of a short acquisition time, no need for IV contrast material, and low technical demand for image postprocessing (***Padhani et al .,2009**)*

Several clinical studies on the usefulness of DWI as a measurement of treatment response had been reported ***(DeVries et al .,2003**), (**Moffat et al .,2005**),(**Hamstra et al.,2007**), (**Pickles et al .,2006**) and (**Sun YS et al .,2011**).*

*(**Kim CK et al .,2010**)* reported in his study that DWI is a powerful noninvasive imaging method that may yield useful qualitative and quantitative information about tumor cellularity and tissue structure in prostate cancer. It may improve the diagnostic accuracy of tumor detection, staging, and posttreatment follow-up.

In their study (***Iraha et al., 2012**)* concluded that signal intensity on DWI appears to correlate with PSA levels in patients with prostate cancer treated with radiation therapy.

Few studies have been reported For the evaluation of changes of ADC values after radiotherapy in localized prostate cancer like *(**Takayama et al.,2008***) and (***Song et al ., 2010**)*.