Role of Dynamic Contrast Enhanced MRI and MR Spectroscopy in Detection of Cancer Prostate

An Essay

Submitted For Partial Fulfillment of
Master Degree in Radiodiagnosis

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2010

دور تصوير ديناميكية الصبغة عن طريق الرنين المغناطيسى والرنين المغناطيسى البروتونى الطيفى فى تحديد سرطان البروستاتا.

مقالة

توطئـــة للحصـــول علـــــى درجة الماجستير فى الأشعة التشخيصية

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2010

سورة التوبة رقم الأية 105

ACKNOWLEDGMENT

First of all, thanks to **Allah** *who paved the way to complete the essay*

It 's an honor for me to express my sincere and deepest sense of gratitude to my great supervisor

Prof. Dr Laila Ahmad Abdurrahman

Professor of Radiodiagnosis Ain Shams University for her marvelous encouragement, supervision and support throughout this work, despite her busy schedule.

I'm heartily thankful to

Dr . Mohamed Amin Nassef

Lecturer of Radiodiagnosis Ain Shams University for his support, guidance and his great ideas throughout this work.

Sherif Hasan Abd Alla

LIST OF ABBREVIATIONS

Abbreviation	Name
3D	Three-dimensional
Au	Arbitrary unit
BASING	Band selective inversion with gradient dephasing
BPH	Benign prostatic hyperplasia
CC:C	Choline and creatine to citrate
Ch	Choline
Cit	Citrate
CM	Contrast media
Cr	Creatine
CT	Computed tomography
DCE	Dynamic contrast enhanced
DHT	Dihydrotestosterone
DRE	Digital rectal examination
ECE	Extra capsular extension
EES	Extra vascular Extra-cellular space
FOV	field of view
FSE	Fast spin echo
Gd-DTPA	Gadolinium diethylene-triamine-penta-acetic acid
GRE	Gradient-echo
IV	Intra venous
K^{trans}	Transfer constant
Kep	Out flow kinetic constant
MR	Magnetic resonance
MRI	Magnetic resonance imaging
MRSI	Magnetic resonance spectroscopy imaging

NVB	Neurovascular bundle
PIN	Prostatic intraepithelial neoplasia
ppm	Peak per minute
PRESS	Point-resolved spectroscopy
PSA	Prostatic specific antigen
PZ	Peripheral zone
RP	Radical prostatectomy
s	Second
SE	Spin echo
SI	Signal intensity
SNR	Signal to noise ratio
SV	Seminal vesicles.
T	Tesla
T1 WI	T1 weight image
T2 WI	T2 weight image
TE	Echo time
TNM	Tumor, Nodes, Metastasis
TR	Repetition time
TRUS	Trans rectal ultrasound
TZ	Transition zone
US	Ultrasonography
ve	Percentage of unit volume of tissue

Contents

List of figures

List of tables

Introduction

Cancer prostate is one of the most common malignancies in elderly men. The posterior and lateral aspects of the prostate are the zones in which 70% of cancer prostate arises. Cellular proliferation in the transitional zone results in benign prostatic hyperplasia ***(Hricak, et al., 2007).***

The diagnosis of cancer prostate is based on transrectal ultrasonography (TRUS) which is the most commonly used modality for imaging the prostate gland. TRUS enables determination of prostate size and demonstration of the zonal anatomy, and prostate cancer lesions usually appear hypoechoic relative to normal tissue. TRUS has many advantages, including its portability, ease of use, lack of ionizing radiation, low cost, and its capability to perform real-time imaging. Ultimately, however, TRUS is not a high-resolution imaging modality. The capability of TRUS to delineate cancer foci is limited, and its sensitivity and specificity are low, small cancer foci are often not visible at all, and the majority of hypoechoic foci detected by TRUS are not malignant. TRUS is also rarely useful in depicting extracapsular extension of prostate cancer and seminal vesicle invasion, except when gross extension is present ***(Hricak, et al, 2007).***

CT is a widely used modality in both the diagnosis and follow-up of nearly all malignancies, but it has only a limited role in the imaging of prostate cancer owing to its poor soft-tissue contrast resolution, which does not allow precise distinction of the internal or external anatomy of the prostate. The major role of CT in patients with prostate cancer is for the detection of bony involvement and in nodal staging; however, CT only detects the enlargement of involved nodes, which is a late finding in patients with prostate cancer ***(Ocak, 2007***).

MRI allows anatomical and functional assessment of the prostate. MRI has better soft-tissue resolution than any other imaging method, which enables more-accurate lesion detection and local staging ***(Ocak, 2007***).

Anatomical MRI of the prostate includes T1-weighted and T2-weighted MRI sequences. On T1W images, the prostate gland appears homogeneous with intermediate low signal intensity, which makes differentiation of the zonal anatomy impossible. T2W images have been widely used for pretreatment work-up for prostate cancer but its accuracy for the detection and localization of prostate cancer is unsatisfactory ***(Akin, 2006).***

Functional MRI modalities include dynamic contrast enhanced (DCE-MRI), magnetic resonance spectroscopy (MRS) and diffusion-weighted MRI (DW-MRI) ***(Ocak, 2007***).

DCE-MRI evaluates the vascularity of tumors by providing quantitative kinetic parameters that reflect the flow of blood and the permeability of the vessels. Fast acquisition sequences, combined with rapid administration of a low-molecular-weight contrast agent, can be used to detect prostate cancer using a two-compartment pharmaco kinetic model DCE-MRI increases the specificity of prostate MRI significantly compared with T2W scans alone ***(Ocak, 2007***).

Tumors show early enhancement and early washout of the contrast agent, which enables tumor detection. A disadvantage of DCE-MRI is that small, low-grade tumors may not demonstrate abnormal enhancement on DCE-MRI (***Noworolski, et al., 2008***).

Furthermore, abnormal enhancement patterns can also be seen in patients with benign prostatic hyperplasia (BPH), which can make assessment of the central gland difficult ***(Concato. 2007).***

However, in the glandular peripheral zone and anterior gland, DCE-MRI can be quite helpful in identifying lesions that are not suspected on T2W images diagnostic criteria. Another disadvantage of DCE-MRI is the possibility of inducing nephrogenic systemic fibrosis (a severe interstitial fibrosis that occurs after intravenous injection of gadolinium chelates) in patients with severe renal failure, especially those undergoing dialysis; therefore, the use of gadolinium-containing contrast agents should be carefully evaluated in such patients ***(Concato, 2007).***

Magnetic resonance spectroscopy (MRS) is a modality that provides information about the cellular metabolites within the prostate gland. It displays the relative concentrations of key chemical constituents, such as citrate, choline and creatine. The normal prostate gland contains low levels of choline and high levels of citrate, whereas prostate cancers have increased levels of choline and decreased levels of citrate. Normal secretory epithelial cells of the prostate contain excess zinc, which inhibits the citrate-oxidizing enzyme aconitase, and high levels of citrate are produced. In prostate cancers, levels of zinc are lower, which leads to elevated aconitase activity and subsequently diminished amounts of citrate ***(Costello, et al 2005***).

The high choline levels in prostate tumors are related to increased cell turnover and overexpression of choline kinase. Thus, the ratio of choline to citrate is an index of malignancy. ***(Shukla-Dave, 2007***).

Combined use of MRI and MRSI is emerging as the most sensitive tool for the anatomical and metabolic evaluation of cancer prostate. ***(Concato, 2007)***

Aim of the work

This work aims to study the role of dynamic contrast enhanced MRI and MR spectroscopy in detection of cancer prostate.