



ROLE OF DIFFUSION WEIGHTED MRI IN ASSESSMENT OF CERVICAL CANCER

Thesis

Submitted for Partial Fulfillment of Master Degree
In Radiodiagnosis

By

Sura Abdul Ameer Jasim

M.B.Ch.B

Faculty of Medicine

Al Basrah University

Supervised by

Prof. Dr. Dalia Zaki Zidan

Professor of Radiodiagnosis

Faculty of Medicine

Ain Shams University

Dr. Susan Adil Ali Abdul Rahim

Lecturer of Radiodiagnosis

Faculty of Medicine

Ain shams University

Faculty of Medicine

Ain Shams University

2017

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

"وَأَنْزَلَ اللَّهُ عَلَيْكَ الْقُرْآنَ

وَالْحِكْمَةَ وَعَلَّمَكَ مَا لَمْ تَكُنْ تَعْلَمُ

وَمَا كَانَ فَضْلُ اللَّهِ عَلَيْكَ عَظِيمًا"

صدق الله العظيم

سورة النساء آية ١١٣

Acknowledgements

Thanks to **ALLAH** first and foremost. I feel always indebted to **ALLAH**, the most kind and the most merciful. I would like to express my gratitude, appreciation and respect to **Prof. Dr. Dalia Zaki Zidan, Professor of Radiodiagnosis**, for her sincere guidance, keenness and meticulous supervision throughout this work in order to reach the accurate finishing work. Likewise, I extremely grateful to **Dr. Susan Adil Ali Abdul Rahim, Lecturer of Radiodiagnosis**, for her expert, sincere and valuable guidance and encouragement extended to me.

Finally, a special thanks to my family who supported me and incented me to strive towards my goal.

Surra Abdul Ameer Jasim

List of Contents

Title	Page
▪ List of Abbreviations	I
▪ List of Tables	III
▪ List of Figures	V
▪ Introduction	1
▪ Aim of the Work	3
▪ Review of Literature	
- Chapter (1): Anatomy of the Uterine Cervix.....	4
- Chapter (2): Pathology of Cervical Cancer	26
- Chapter (3): Physical principle and technique of Diffusion Weighted MRI	49
- Chapter (4): MRI manifestations of Cancer Cervix	72
▪ Patients and Methods	100
▪ Results	109
▪ Illustrative Cases	121
▪ Discussion	143
▪ Summary and Conclusion	153
▪ References	156
▪ Arabic Summary	--

List of Abbreviations

ADC	Apparent diffusion coefficient
AP	Anteroposterior
CC	Craniocaudal
CIN	Cervical intraepithelial neoplasia
CIS	Cervical carcinoma insitu
CT	Computed tomography
DNA	Deoxyribonucleic acid
DWI	Diffusion weighted image
FIGO	International federation of gynecology and obstetrics
HASTE	Half-Fourier acquisition single shot turbo spin echo
HIV	Human immunodeficiency virus
HPV	Human papilloma virus
HSIL	High grade squamous intraepithelial lesion
IV	Intra venous
LELC	Lymphoepithelioma like carcinomas
LN	Lymph node
LSIL	Low grade squamous intraepithelial lesion
MICA	Micro invasive squamous cell carcinoma
MRI	Magnetic resonance imaging
RF	Radiofrequency
ROC	Receiver operating characteristic
ROI	Region of interest
SCJ	Squamous-columnar junction
SIL	Squamous intraepithelial lesion

List of Abbreviations

T	Tesla
T1W	T1 weighted MR image
T2W	T2 weighted MR image
TE	Time echo
TNM	Classification of Malignant Tumours
TR	Time repetition
Ts	Transverse
TSE	Turbo spin echo
TVUS	Transvaginal ultrasound

List of Tables

Table No.	Title	Page
Table (1):	Terminology of cervical cancer precursor lesions.....	30
Table (2):	Different histological types of cervical carcinoma	36
Table (3):	Grading of Cervical Cancer	44
Table (4):	TNM and FIGO Classifications for Cervical Cancer	45
Table (5):	Regional lymph nodes (N)	46
Table (6):	Distant Metastasis (M).....	46
Table (7):	Showing one of the protocols used for applying the DWI for the pelvis.....	57
Table (8):	For the Interpretation of DWI Findings	64
Table (9):	Parameters used for DW-MR imaging of cervical cancer.....	71
Table (10):	The sequences of MRI used in the study.....	106
Table (11):	Age (years) distribution of the study group	109
Table (12):	Shows the correlation between the number of cases diagnosed as benign or malignant by the DCE-MR imaging, DWI and pathological diagnosis.....	115
Table (13):	Comparison between patients and control according to ADC values	115

List of Tables

Table No.	Title	Page
Table (14):	The cut off between normal cervical tissue & malignant cervical lesion.....	117
Table (15):	Mean ADC value of different histopathological types	118
Table (16):	Correlation between the accuracy of MRI-DWI, DCE-MRI and Pathology staging results in Cervical carcinoma ..	120

List of Figures

Figure No.	Title	Page
Fig. (1):	Development of the female genital system	4
Fig. (2):	(a) Nulliparous cervix (b) Parous cervix	6
Fig. (3):	Anatomic sketch of coronal view showing the uterine cervix.....	7
Fig. (4):	Sagittal view of female pelvis demonstrating cervical relations	9
Fig. (5):	Ligamentous support of the Cervix	10
Fig. (6):	Uterine and vaginal arteries.....	12
Fig. (7):	The arteries of the internal organs of generation of the female	13
Fig. (8):	Lymphatic drainage of female genitalia (anterior view)	15
Fig. (9):	Normal squamous epithelium. Under normal conditions the basal layer acts as a reserve cell layer, and mitoses are only identified in parabasal cells	16
Fig. (10):	Endocervical mucosa. Tall columnar mucin-filled endocervical cells with basal nuclei.....	17
Fig. (11):	Diagram of the changing faces in the cervical epithelium	18
Fig. (12):	Endocervical ectropion. Note everted columnar epithelium, which is reddened and looks like "eroded" tissue	20

List of Figures

Figure No.	Title	Page
Fig. (13):	(a) sagittal and (b) axial T1W images of the cervix uteri of a 36-year-old woman showing the normal cervix is 3 cm long and 2-2.5 cm in diameter. ...	22
Fig. (14):	(a) sagittal and (b) axial T2W images of the cervix uteri of the same woman	22
Fig. (15):	(a) Sagittal T2W TSE image, (b) Close view of (a). Detect the endocervical mucosa (white arrow) and cervical stroma (grey arrow) from the outer tissue	23
Fig. (16):	(a) Transverse and (b) Coronal T2W MR images of a 40-year-old asymptomatic woman depicting Nabothian (cervical) cysts	23
Fig. (17):	52-year-old woman imaged with and without vaginal gel	25
Fig. (18):	Risk factors with signs and symptoms of cervical cancer	28
Fig. (19):	Steps in the development of cervical cancer	32
Fig. (20):	Cervical squamous carcinoma precursors	34
Fig. (21):	Micro invasive squamous carcinoma	37
Fig. (22):	Invasive squamous carcinoma	39
Fig. (23):	Endocervical adenocarcinoma, usual type	41

List of Figures

Figure No.	Title	Page
Fig. (24):	Diagram showing diffusion of water molecules.....	50
Fig. (25):	a) Schematic illustrates the effect of a diffusion-weighted sequence on water molecules (solid circles) (b) Schematic illustrates the effect of a diffusion-weighted sequence on water molecules (solid circles).....	55
Fig. (26):	MRI 1.5T versus MRI 3T machine.....	56
Fig. (27):	Cervical carcinoma.....	59
Fig. (28):	Chart shows pitfalls of diffusion-weighted MRI. ADC = apparent diffusion coefficient	61
Fig. (29):	Positions of the uterus.....	70
Fig. (30):	Comparison of T2W and T1W imaging.....	75
Fig. (31):	T2w TSE images in sagittal and transverse orientation showing cervical cancer histologically proven by conization.....	76
Fig. (32):	Stage IB. a, b T2w TSE images in sagittal and transverse orientation	78
Fig. (33):	A 49-year-old female with adenocarcinoma of uterine cervix (stage IIA)	79
Fig. (34):	Stage IIB cervical carcinoma (adenocarcinoma) in a 48-year-old woman	81

List of Figures

Figure No.	Title	Page
Fig. (35):	Stage IIIA cervical carcinoma (squamous cell carcinoma) in a 61-year-old woman.....	82
Fig. (36):	Stage IIIB. T2w cervical cancer Stage IIIB.....	83
Fig. (37):	Stage IIIB	84
Fig. (38):	Stage IVA cervical carcinoma (adenocarcinoma) in a 76-year-old woman	86
Fig. (39):	37-year-old woman with true-positive left internal iliac lymph node metastasis in stage IIB uterine cervical cancer	89
Fig. (40):	Cervical cancer.....	96
Fig. (41):	39-year-old lady with carcinoma cervix clinically growth involving both lips of cervix and fornices	96
Fig. (42):	Diffusion weighted images	97
Fig. (43a):	75-year-old woman with cervical cancer recurrence in two separate masses.....	98
Fig. (43b):	75-year-old woman with cervical cancer recurrence in two separate masses.....	99
Fig. (44):	Clinical presentation distribution of the study group.....	109

List of Figures

Figure No.	Title	Page
Fig. (45):	The size of Cervical Carcinoma of the study group.....	110
Fig. (46):	Distribution of T1 Signal Intensity of the study group.....	111
Fig. (47):	Distribution of T2 signal intensity of the study group.....	112
Fig. (48):	Enhancement pattern distribution of the study group.....	113
Fig. (49):	(a) DWI distribution, (b) ADC distribution of the study group.....	114
Fig. (50):	Malignant tumors show lower ADC values than normal cervical tissue.....	116
Fig. (51):	Receiver operating characteristic (ROC) curve of the ADC value	117
Fig. (52):	Histopathological diagnosis distribution of the study group.....	118
Fig. (53):	FIGO staging diagnosis distribution of the study group	119

Abstract

Background: MRI examination is a useful modality for staging and evaluation of gynecologic malignancy. The DW-MRI method has been introduced to cancer diagnostics in the recent years, and this has widened the diagnostic capabilities of MRI. **Aim of the Work:** The aim of this study is to highlight the value and assess the efficacy of diffusion weighted imaging in the assessment of cervical cancer. **Patients and Methods:** This is a prospective study that included 30 patients in whom cervical cancer had been suspected clinically or by Trans vaginal U/S and the control group consisted of 20 patients in whom cervical cancer had been not suspected and MRI was performed because of other Pelvic diseases. The study was conducted in El-Demerdash hospital. The patients was referred from the gynecology department to the radiology department (Women's imaging unit) for further MRI assessment with DWIs. **Results:** Lesions in all cases show restricted diffusion, however on ADC map only one case show high signal proved to be chronic cervicitis on histopathology. Also, the mean ADC values for malignant lesions were ($0.83 \times 10^{-3} \text{ mm}^2/\text{sec}$), while the mean ADC value in the control group is ($1.56 \times 10^{-3} \text{ mm}^2/\text{sec}$). Therefore ADC value of ($1.07 \times 10^{-3} \text{ mm}^2/\text{sec}$) is a cut off between normal cervical tissue & malignant cervical lesion by sensitivity 97% and specificity 95.5%. DWIs had elicited the same accuracy to DCE sequences (96.7%) when added to the non-contrast MRI in the estimation of cancer cervix. **Conclusion:** Diffusion-weighted MR imaging (DWI) serves as a functional technique, which provides information about water mobility, tissue cellularity, and stability of membrane integrity that can discriminate cervical carcinoma from healthy tissue, and increasing the radiologist's confidence in image interpretation. So it implies a non-invasive technique which can be used especially if contrast intake is avoided as in pregnancy. **Recommendations:** ADC values were reliable for differentiating cervical cancer from normal cervix with higher diagnostic accuracy when added to DWI interpretation. The ADCs can be used to indicate the degree and histological type of cervical cancer, with large scale studies are recommended in the future.

Key words: MRI, DW-MRI, cervical cancer

INTRODUCTION

Cervical cancer is the fourth most common cancer in women worldwide, and it has a high mortality rate. Most women with cervical cancer are diagnosed before the age of 50. However; older women remain at risk. Cervical cancer is both preventable and, if identified early, treatable (*Ferlay et al., 2013*).

Cervical cancer is usually staged and managed on the basis of criteria proposed by the International Federation of Gynecology and Obstetrics (FIGO) which is based on clinical examination, rather than surgical findings. Early diagnosis and accurate staging of the disease is crucial in planning the optimal treatment strategy (*Shweel et al., 2012*).

Advances in magnetic resonance imaging (MRI) technology provide excellent soft tissue contrast resolution with multiplanar capabilities when evaluating the female pelvis (*Peungjesada et al., 2009*).

Diffusion-weighted magnetic resonance imaging (DW-MRI) is a functional, non-invasive imaging technique which generates tissue contrast from differences in mobility of water molecules that occurs during an MR pulse sequence. Information regarding the integrity of cellular membranes and tissue cellularity can be obtained, so that DW-MRI can now be included in routine patient assessment (*Kuang et al., 2013*).