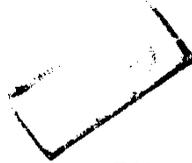


RADIOTHERAPY IN UROLOGY

ESSAY

Submitted in Partial Fulfilment  
For  
The Master Degree in Urology



BY

MEDHAT LAMEI ABDEL MALEK



2002

SUPERVISED BY

Prof. Dr. ABDEL-FATTAH M. AGGOUR  
*Prof. of Urology*

FACULTY OF MEDICINE  
AIN SHAMS UNIVERSITY

1985

## ACKNOWLEDGEMENT

I would like hereby to express my deep appreciation and sincere recognition to Prof. Dr. Abdel Fattah Aggour for his close supervision, profitable advice, and kind help without which this work would not have been possible.

I owe gratitude also to the Department of Urology, Ain Shams Univeristy for their concern and assistance.

Thanks are due to all who have contributed in the preparation of this manuscript.



## CONTENTS

INTRODUCTION	1
RADIATION PHYSICS	4
RADIATION BIOLOGY	13
- Treatment Planning for Tumor Control	28
RADIOTHERAPY OF MALIGNANT GENITOURINARY TUMORS	31
- Malignant Tumors of the Kidney	31
- Malignant Tumors of the Ureter	44
- Malignant Tumors of the Urinary Bladder	46
- Role of Radiotherapy in Bilharzial Cancer Bladder	66
- Malignant Tumors of the Prostate Gland	70
- Malignant Tumors of the Testis	85
- Role of Radiotherapy in Malignant Tumors of the Urethra	94
- Role of Radiotherapy in Cancer Penis	97
ROLE OF RADIOTHERAPY IN KIDNEY TRANSPLANTATION	99
COMPLICATIONS OF RADIOTHERAPY	106
- The Acute Radiation Syndrome	106
- Genitourinary Complications	109
- Effect of Radiations on Skin	125
- Effect of Radiations on Gastrointestinal Tract	127
- Effect of Radiations on Female Genital System	130

- Effect of Radiations on the Skeletal System	131
- Carcinogenic Effect of Radiations	133
SUMMARY	136
REFERENCES	140
ARABIC SUMMARY	

# **INTRODUCTION**

## INTRODUCTION

Ionizing radiation has been used for the treatment of both benign and malignant diseases for about three-quarters of a century. At the beginning, there was no dependable method of measuring tissue dose. Even if there was, optimum dose-time relationships were not clear. The physical and biological mistakes, that were certain to follow, were often fatal. Recurrences from underirradiation and necroses from overirradiation were the natural consequences of such mistakes.

Unlike many modalities used in medicine, an early evaluation of the results of irradiation is rarely possible. Consequently, evaluation of the results of radiotherapy is considered a time-consuming process. That is why every patient treated by radiation should be considered a research prospect and all possible clinical and physical data should be recorded to make future evaluations more meaningful. It may take hundreds or even thousands of patients with a specific type and clinical stage of cancer to detect reasonable differences in morbidity or survival between two techniques. With irradiation techniques improvement and better knowledge of the results of each technique, radiotherapy has become an extremely useful method of treatment.

The basic principles of radiotherapy include radiation physics and radiation biology. These principles should be considered in order to achieve a clear view of radiotherapy.

It does seem likely that a better knowledge of the biological effects of the interaction between radiation and both normal and tumor tissues will result in greater therapeutic gain. Radiosensitivity of the different types of tumors and their surrounding normal tissues cannot be neglected in measuring the therapeutic gain. In this respect, a thorough study of the clinical experience of the different centers will be of great help.

As any method of treatment, radiotherapy is not without complications. These complications vary with the dose and the technique of irradiation. They may be mild and reversible, or very severe and irreversible, and they may even lead to death. For this reason, before using radiotherapy, its efficacy and superiority over or in conjunction with other methods of treatment should be decided upon. Some complications, even if irreversible, may be accepted when they are outweighed by the curative effect of radiotherapy. An example of this is scoliosis that may follow radiotherapy of Wilms' tumor (Li and Stone, 1976). A fruitful point is that immunosuppressive effect of radiotherapy, although considered a complication, is the basis of its use in organ transplantation.

As the title indicates, this essay deals with the subject of radiotherapy in urology. First, some of the

important aspects concerned with radiation physics and radiation biology are reviewed. Common applications of radiotherapy in urology are also discussed. Radiotherapy may be used in treatment of genitourinary tumors and kidney transplantation. Finally, possible complications met with radiation are described with special emphasis on urological aspects of these complications.

# **RADIATION PHYSICS**

## Radiation Physics

### Types of Ionizing Radiations

Ionizing radiation is that radiation which, during absorption, causes the ejection of an orbital electron. A large amount of energy is associated with ionization. Such ionizing radiations may be electromagnetic or particulate, (Hellman, 1982).

### Electromagnetic Radiations

As reported by Deeley (1976), electromagnetic waves are forms of energy and constitute a spectrum of decreasing wavelength from radio-waves, to infra-red rays, to visible light, to ultraviolet light, to the smaller wavelength of ionizing radiations. Both X-rays and gamma rays are electromagnetic rays. They have a wave formation with a wavelength and frequency.

The only difference between X-rays and gamma rays is that X-rays are produced extranuclearly, while gamma rays are produced intranuclearly. X-rays are produced in an electrical device which accelerates electrons to high energy and then stops them abruptly in a target usually made of tungsten or gold. Part of the energy of motion (kinetic energy) of electrons is converted into X-rays. Gamma rays are emitted by radioactive isotopes. They represent excess energy which is given off as the

unstable nucleus breaks up and decays in its efforts to reach a stable form (Hall, 1973). An exception to this, as reported by Hellman (1982), is iodine - 125. It produces photons by an extranuclear process during rearrangement of orbital electrons. These are X-rays. Iodine - 125 also emits a small number of gamma rays from the nucleus.

Electromagnetic rays may be considered from two different stand points. Firstly, they may be thought of as a wave of electrical and magnetic energy. The electrical and magnetic fields are in planes at right angles to one another. Secondly, electromagnetic rays may be thought of as a stream of photons or packets of energy. The amount of energy in each packet is a function of frequency of the wave. So, the larger the frequency, as in short wavelength, the larger will be the energy per photon, and vice versa. This idea of the photon is very important in radiobiology particularly when considering the fact that it is this energy which becomes available when the radiation is absorbed. The critical difference between non-ionizing and ionizing radiations is the size of individual packets of energy and not the total energy involved. X-rays and gamma rays have large individual packets of energy, each of which is big enough to break a chemical bond and produce ionization (Hall, 1973).

Deeley (1976), reported that the energy of gamma rays depends on the substance whose breakdown or decay results in the formation of these rays. The energy applied to the machine that produces X-rays is the determinant of the

energy of these rays.

The different ranges of electromagnetic radiations used in clinical practice are superficial radiation, or roentgen rays from approximately 10-125 KeV, orthovoltage radiation, electromagnetic radiation between 125 and 400 KeV, and supervoltage radiation or megavoltage for those with energies above this. With orthovoltage radiation, the skin is frequently the dose-limiting normal tissue. Supervoltage radiation has a skin-sparing effect because the maximum dose is not reached in the skin but rather occurs some depth below the surface (Hellman, 1982).

#### Particulate Radiations

Hall (1973), reported on the different types of particulate radiations which are used in radiotherapy. This report included the following types:-

- 1- Electrons: Small negatively charged particles which can be accelerated to high energy by means of an electrical device such as a betatron.
- 2- Protons: Positively charged particles having a mass almost 2000 times greater than an electron. They require more complex equipment to accelerate them to useful energies.
- 3- Alpha Particles: Positively charged nuclei of helium atoms containing two protons and two neutrons in close association. They can be accelerated by an electrical device similar to that used for protons.

They are also emitted during the decay of some radioactive isotopes.

- 4- Neutrons: Electrically neutral particles with a mass similar to that of protons. There are three useful sources of fast neutrons. First, fission neutrons which are produced inside a nuclear reactor by fission of uranium - 235. Second, cyclotron neutrons which are produced by the use of an electrical device called cyclotron. Last, 14-MeV D-T neutrons which are monoenergetic.
- 5- Negative Pimesons: Negatively charged particles with a mass 273 times as great as the electron. They are produced by a complex process which necessitates a device such as a synchrocyclotron.
- 6- Heavy charged ions: Nuclei of elements such as nitrogen, carbon, boron, neon, or argon. They are positively charged particles which can be produced in a limited number of laboratories.

#### Absorption of Radiation

Hall (1973), classified radiations into directly or indirectly ionizing. All the charged particulate radiations are directly ionizing. If the individual particles have sufficient kinetic energy, they can directly disrupt the atomic structure of the absorber through which they pass and produce the chemical and biological changes. Electromagnetic radiations (X-rays and gamma rays) and neutrons are indirectly ionizing. They, themselves, do not produce the chemical and biological damage, but when

absorbed in the material through which they pass, they give up their energy to produce fast-moving charged particles. Electromagnetic radiations and neutrons are the most commonly used types of radiation.

The mechanism of absorption of electromagnetic radiation depends on its energy. Photoelectric absorption predominates at the lower energies. In these circumstances, the photon interaction results in the ejection of a tightly bound orbital electron. The second type of radiation absorption is the Compton type. In this process, the interaction is with a distant orbital electron having a very low binding energy. Part of the energy of the photon is given to the electron as kinetic energy. With whatever energy remaining, the photon continues on its way probably deflected from its original path (Figure 1). In place of the incident photon there is a fast electron, and a photon of reduced energy, which may go on to take part in further interactions. The final type of absorption is the pair production process in which negative and positive electrons are produced at the same time. This process requires an incident photon energy greater than 1.02 MeV (Hellman, 1982).

The mode of interaction of neutrons with matter, as Hall (1973), describes, depends upon the energy concerned. Elastic scattering is the dominant process in case of the most frequently used intermediate fast neutrons with energies between 100 KeV and 20 MeV. The incident neutron collides with the nucleus of an atom of the absorber; part