

Dermatologic Indications of Ionizing Radiation

Essay

**submitted for partial fulfillment of
the Master Degree in
Dermatology and Venereology**

By

**Nabil M. Abd El Moneim
(M.B.,B.Ch.)**

Supervised by

Prof.

Dr. Mohamed Anwar Ghazzi
Professor of Dermatology and Venereology
Faculty of Medicine -Ain Shams University

Dr. Mahira Hamdy El Sayed
Assistant Professor of Dermatology and Venereology
Faculty of Medicine Ain - Shams University

Faculty of Medicine
Ain Shams University
1995

"بسم الله الرحمن الرحيم"
قالوا سبحانك لا علم لنا الا ما علمتنا إنك
أنت العليم الحكيم

﴿صدق الله العظيم﴾

سورة البقرة آية ﴿٣٢﴾



List of Abbreviations

(E)	Energy
ESU	Electrostatic unit
eV	Electron volt a unit of energy
FDA	Food and drug administration
GY	Gray (1 joule/Kg)
	cGy = centigray
HDD;$D^{1/2}$	Half - dose depth
HVD;$D^{1/2}$	Half - value depth
HVL	Half - value layer
HVT	Half - value thickness
(I)	Intensity (R/minute)
ICRU	International Commission on Raddiation Units and Measurements
KV	Kilovoltage
LET	Linear energy transfer
mA	Milliamperage
(R)	Roentgen
RBE	Relative biological effectiveness
SI	System International
SSD	Source - skin distance
Sv	Sievert
TDF	Time - dose - fractionation factor
TSD	Target - skin distance

List of Tables

Table 1	Radiation methods.	14
Table 2	Difference between x-rays and electrons.	18
Table 3	Radiation dose schedule for cutaneous neoplasms.	40
Table 4	American Joint Committee on Cancer Staging System.	46

List of Contents

Introduction and Aim of Thesis	1
Review of literature	
Chapter 1 Physical Basis of Radiation:-	2
1.1 Electromagnetic Radiation	2
1.2 Production of X-rays	3
1.3 Radiation Quantity	7
1.4 Radiation Quality	11
1.5 Radiation Methods	13
Chapter 2 Reaction to Ionizing Radiation:-	20
2.1 Early radiation effects	20
* Roentgen erythema	20
* Acute radiodermatitis	21
2.2 Late radiation effects	23
* Non - stochastic effects	23
* Stochastic effects	28
Chapter 3 Uses of Radiation Therapy	30
3.1 Advantages of Radiation therapy	33
3.2 Disadvantages of Radiation therapy	34
3.3 Practical procedure of Radiotherapy	36

	3.4 Dosage recommendation	39
Chapter 4	Radiotherapy of Malignant Skin Diseases	45
	4.1 Basal cell carcinomas	45
	4.2 Squamous cell carcinomas	49
	4.3 Keratoacanthoma	53
	4.4 Bowen's disease	55
	4.5 Malignant melanoma	57
	4.6 Kaposi's sarcoma	62
	4.7 Cutaneous lymphoma	68
Chapter 5	Radiotherapy of Benign Skin Diseases	76
	5.1 Keloids	82
	5.2 Dermatitis - Eczema	84
	5.3 Psoriasis	89
	5.4 Lichen planus	91
	5.5 Acne	92
	5.6 Infectious dermatitis	94
	5.7 Scleromyxoedema	96
	Summary and Conclusion	98
	References	102
	Arabic Summary	

To My Family

Introduction

Introduction

Ionizing radiation has played an important role in the treatment of disease since Roentgen described his “X-rays” in 1895.

Despite the advances in other therapeutic modalities, radiotherapy is still considered an effective method that benefits many patients who cannot be treated adequately by other means.

Since surgical approaches have gained popularity in the treatment of skin tumors, not all dermatologists are familiar with the benefits of ionizing radiation for patients with cutaneous neoplasms and certain other skin disorders.

The Aim of this essay is to outline the current indications for using ionizing radiation in dermatology with therapeutic outcomes.

It also, points out the physical and biological factors, reactions to ionizing radiation and protective measures. It is an attempt to discuss the principles of radiotherapy so that, optimal therapy can be selected for individual patients.

Review of Literature

Physical basis of radiation

In 1895, Roentgen made the first of his discoveries concerning a new form of electromagnetic irradiation. Using the algebraic symbol for the unknown, he used the term x-ray to describe this radiation (*Roentgen, 1895*).

Electromagnetic radiation:-

X-rays are part of the electromagnetic spectrum, which also includes gamma rays, ultraviolet rays, visible light, infrared light and radio waves. They may be described as the periodic variation of intensities of electric and magnetic fields at a given point. They are characterized by the following parameters:-

- The frequency (ν) is the number of waves produced per second.
- The wavelength (λ) is the distance between two successive points in the wave that are characterized by the same phase of oscillation.

The velocity (C) is the distance the wave moves per second.

The relationship among frequency, wavelength and velocity is expressed by the equation: $C = \nu \lambda$. The unit of energy (E) most often used in radiological physics is electron volt (ev) which is defined as the kinetic energy acquired by an electron falling

unimpeded through a potential difference of 1 (V) and is equivalent to 1.6×10^{-12} erg or 1.6×10^{-19} j (*Braun - Falco et al ., 1976*)

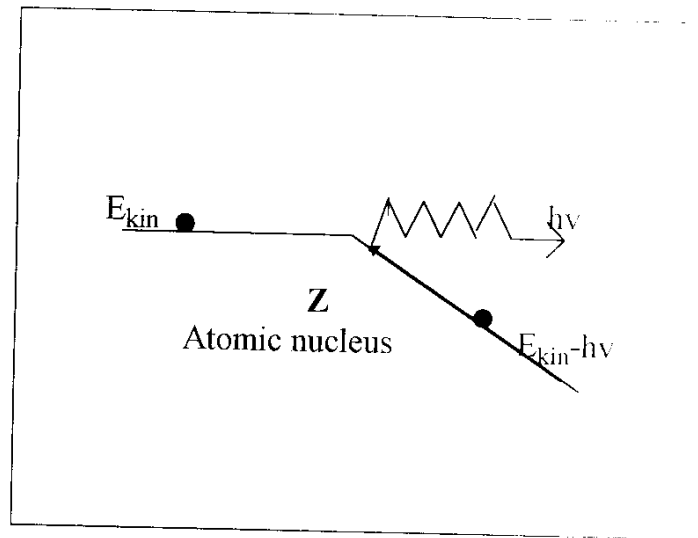
Production of x- rays:-

X- rays are produced when high - speed electrons possessing sufficient kinetic energy strike matter. The mechanism by which the formation of x - rays occurs is by one of two ways (Brems radiation & characteristic radiation).

Brems radiation:-

An electron possessing a kinetic energy E_k enters the electromagnetic field of an atomic nucleus which causes the electron to undergo a deflection and consequent deceleration. In this manner the electron gives up some of its energy in the form of an x-ray quantum having an energy $h\nu$. The electron is left with an energy $E_k - h\nu$. (Fig.1)

Figure -1. Production of brems radiation



Quoted from (*Braun - Falco et al., 1976*).

The x - rays which are produced by the this electron deceleration are termed “ brems radiation “ The possibility that an electron will undergo such a deceleration increses as the atomic number of the target element is increased. The greater the deceleration of the electron the greater will be the energy $h\nu$, of the brems ray quantum emitted (*Braun - Falco et al., 1976*).

Characteristic radiation:-

In this manner the electron strikes an orbital electron of the target material, dislodging it from an inner orbit and causing it to jump to a more energetic outer orbit not yet filled to capacity. This is an unstable or “excited” atomic state.

The atom returns to its ground state when an orbital electron from an outer shell moves into the space vacated by the dislodged inner orbital electron. This transmission back to the ground state is associated with the emission of one or more photons. The energy, $h\nu$, of such a photon is determined by the characteristic of the atoms of the target element. Hence, This radiation is given the term characteristic radiation (*Goldschmidt and Sherwin, 1980*).

The replacement of an electron on the K orbit results in emission of the characteristic K radiation while, replacement of an electron on the L orbit produces characteristic L radiation, etc. The process of x-ray production by displacement of an orbital electron requires the following conditions:-

- the target element must have a high atomic number (e.g. tungsten). Use of elements with a lower atomic number will result in less energetic radiation.
- The energy of the incident high-speed electron must be greater than the binding energy holding the orbital electrons in their inner shells (e.g. K and L).

An energy greater than or equal 67 Kev is required to dislodge an electron on the K orbit of tungsten. This means that the x-ray