Influence of the Beam Size Radiation on the Depth Dose by Using ^{60}Co

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Abstract

Radiotherapy is medical use of ionizing radiation, and commonly applied to the cancerous tumor because of its ability to control cell growth.

The amount of radiation used in photon radiation therapy called dose (measured in grey unit), which depend on the type and stage of cancer being treated.

In our work, we studied the dose distribution given to the tumor at different depths (zero-20 cm) treated with different field size (4×4- 23×23 cm).

Results show that the deeper treated area has less dose rate at the same beam quality and quantity. Also it has been noted increasing in the field increasing in the depth dose at the same depth even if the radiation energy is constant. Increasing in radiation dose attributed to the scattered radiation, which is expected, proportionately with increase in the beam size. The aim of work studies the relationship between the depth dose and the radiation source beam size

Keyword: Beam size, ^{60}Co

تاثير حجم الحزمة الاشعاعية على جرعة العمق باستخدام الكوبلت ٦٠

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الخلاصة

العلاج الاشعاعي هو استخدام الاشعاع المؤين طبيا وتطبيقه عادة على الاورام السرطانية وذلك لقابليته على السيطرة والتحكم بالخلية السرطانية. ان كمية الاشعاع المستخدمة بالعلاج الاشعاعي الفوتوني يدعى بالجرعة (تقاس بوحدة الكري) والتي تعتمد على نوع ومرحلة تقدم الورم المعالج.

تم في بحثنا الحالي دراسة الجرعة المعطاه للورم باعماق (صفر-٢٠ سم) واحجام مختلفة (٤×٤ - ٢٣×٢٣ سم).اظهرت النتائج ان المناطق العميقة المعالجة هي الاقل جرعة استلاما لنفس نوعية وكمية الحزمة الاشعاعية المستخدمة، كما لوحظ بان الزيادة في حجم المنطقة تظهر زيادة في جرعة العمق حتى لو كانت طاقة الاشعاع ثابتة. تعزى الزيادة في جرعة الاشعاع الى ان زيادة الاشعاع المتشتت المتوقع يتناسب مع حجم الحزمة الاشعاعية.

Introduction

Radiotherapy is very important modality in controlling tumor growth. Radiation with X-ray therapy has become of prime importance in tumor treatment. The earlier X-ray machines were operating on kilo voltage which was considered as high voltage machines used for radiotherapy at that time[1]. Now day's much

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higher x-ray energy is used by designing new machines the linier accelerators (linac), these machines are able to produce very high energy x-ray such as 4,6,12 MeV and more [2].

Apart from x-ray beam many types of radioactive isotopes are used in tumor treatment. One of the most important radioactive isotope used in a radiotherapy is ^{60}Co [3]. This can be used treat tumors by delivering a dose of γ ray are similar way as x-ray[4]. The uses of x-ray and γ ray are similar in controlling the tumor growth. These are both ionizing radiation can induce damage to the cells, it can penetrate easily deep into the tissue unlike the charged particles, so it can be used to treat deep seated tumors. For this reason different machines were developed to deliver either x-rays or γ rays for tumor treatment. [5-11].

[12] purpose of a methods was to find out the effect of various physical parameters on the skin and build-up doses of 15-MV photon beams. The effects of field dimensions, acrylic shadow tray, focus to-skin distance (FSD) on surface and buildup dose were determined for open, motorized 60° wedge (MW) and blocked fields. A 'Markus' plane parallel plate chamber was used for these measurements in an Elekta (6-15MV) linear accelerator. The surface dose for MW fields was lower than the dose for an open field, but the trend reversed for large fields and higher degree wedges. With the use of an acrylic shadow tray, the surface dose increased for all field sizes, but the increase was dominant for large fields. The surface dose for blocked fields was lower than the dose for open fields. [13] describe a uniform dose to the target site whic is required with a knowledge of delivered dose, central axis depth dose, and beam flatness for successful electron treatment at an extended source to surface distance (SSD). The central axis depth dose is shown to be nearly independent of moderate changes in the treatment distance. The delivered dose at a point could be calculated with the concept of virtual source position and an inverse square correction. In an extended SSD treatment, under dosage of the lateral tissue may occur due to reduced beam flatness. To study the changes in beam characteristics, the depth dose and beam flatness were measured at different SSDs for clinically used field sizes [(3×3)–(15×15) cm] and beam energies ranging from 6 to 20 MeV.

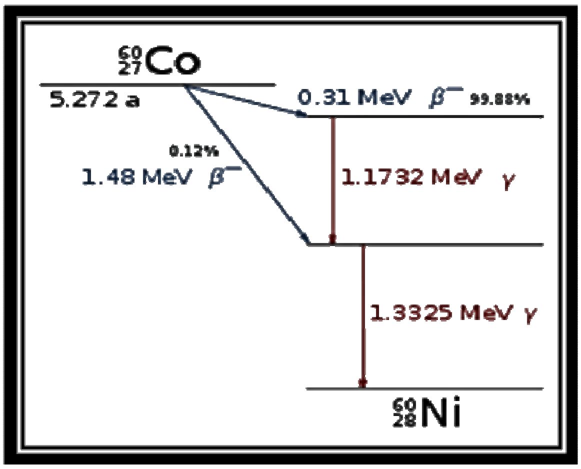

Figure 1- Decay-scheme of Cobalt 60

History of Radiotherapy

The field of radiotherapy began to grow in the 1900s largely due to the ground breaking work of Noble Prize-Winning Scientist Marie Curie (1867-1934), who discovered the radioactive elements polonium and radium in 1898. This began a new era in medical treatment and research [6].

Radium was used in various forms until the mid-1900s, when cobalt and caesium units came into use. Medical linear accelerators have been used too as sources of radiation since the late 1940s,with Godfrey Houns field invention of computed tomography (CT) in 1971, three dimensional planning became a possibility and created a shift from 2D to 3D radiation delivery.

CT–based planning allowed physicians to more accurately determine the dose distribution using axial topographic images of the patient's anatomy. Orthovoltage and cobalt units have largely been replaced by megavoltage linear accelerators, useful for their penetrating energies and lack of physical radiation source [7].

Cobalt-60 gamma radiation typically has energy of 1.2 MeV, D-max. being 0.5cm. and percentage depth of 55% at 10cm.

Cobalt units with low energy of gamma rays are ideal for treatment of head and neck cancers. Dr.Herman Suit of Harvaid Medical School Wroot in an editorial that cobalt units should be modernized with state of the art ancillary devices and then they could be fully acceptable for the treatment of head and neck cancers, cancer of breast and some soft tissue sarcomas of extremities [8].

Newer technologies like multi leaf collimators (MLC) fitted to linac, intensity modulated radiotherapy plans (IMRT) have been helped to improve accuracy in executing treatment. While the high energy linacs (with x-ray and variably energy electron generating potential) are expensive, low energy linacs (4-6 MeV) compare favorably with traditional cobalt unit in terms of cost as well as uptime.The characteristies of the linac beam and output are superior to cobalt-60 gamma ray beam [9].The decay scheme of ^{60}Co is shown in figure 1.

Materials and Methods

This work was carried out in the nuclear medicine hospital. A carefully calibrated dosimeter was used. The diodes used were Nuclear Associates, model 30-494.2, they had integral build up material (for 10 MeV photons). Polystyrene phantom material was used to obtain the percent depth dose curves. The dose was taken at the surface of the phantom material and on depth started from 0.5cm to 20cm, as shown in figure 2.

The depth dose percentage was calculated as the ratio between the surface dose and the depth under consideration times 100, some time a fixed reference point inside the phantom is taken instead the surface point (Figure 2) A diagram showing the procedure of dose measurement at depth.

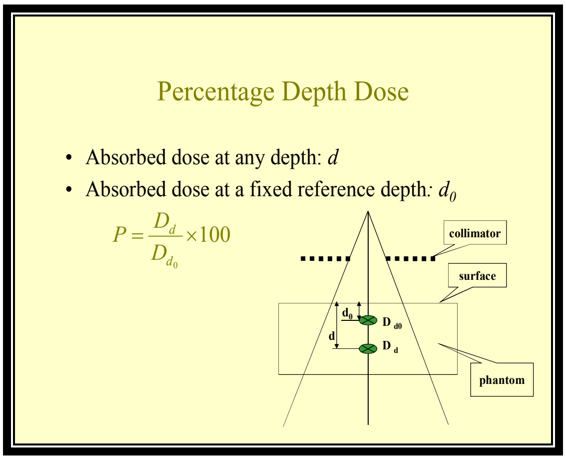

Figure 2-. diagram showing the procedure of dose measurement at depth.

Results

The change of depth dose with different beam size calculated in figure 3.

Although the less depth can give higher depth dose percent, this is because of the progressive attenuation with depth, but if we observe the rising graph with the field size for deeper points (figure 3and table 1). This can give the conclusion that at deeper zone is increased with increasing beam size. The dose measurement inside the tumor or inside the healthy tissue is important from the point of view of an effective treatment to the tumor and the least effect to the healthy tissue. The depth dose percent is increased progressively with beam size. Figure 4 and table -1- show the depth dose percent with depth for two different beam size. Again the graph is descending with depth because of attenuation but the larger beam size has given the higher the depth dose percent. In theory of radiotherapy is to give maximum dose to the tumor with lest effect an the healthy tissue. It is therefore of a vital importance to measure the accurate dose inside the patient in order to estimate the amount of dose defiant to the tumor and healthy tissue . In the present work we have studied the effect of beam size on the depth dose i.e. we measured the dose of different beam size at different depths to satisfy the highest dose to the tumor unit the tumor effect on the healthy tissue.

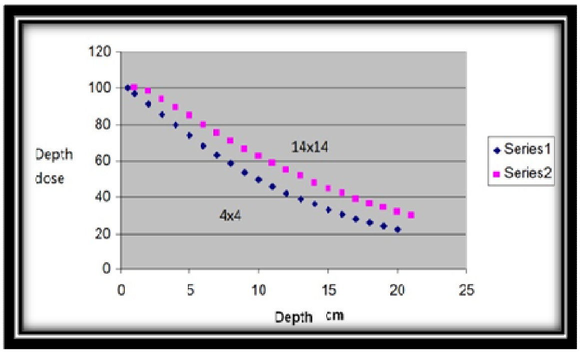

Figure 3- The change of depth dose with a different size for different depths.

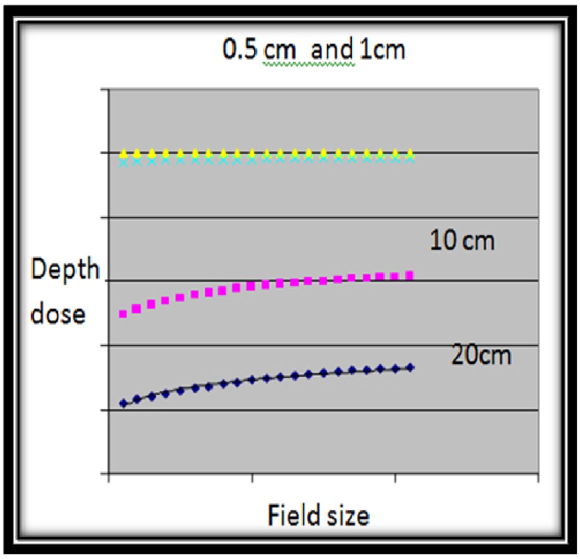

Figure 4- The change of depth dose percent with for different field size

Table 1- The depth dose measured in cm at different field size measured in cm.

Depth dose Cm	Field size (cm)														
	4x4	5x5	6x6	9x9	10x10	13x13	14x14	15x15	16x16	17x17	19x19	20x20	21x21	22x22	23x23
0.5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
1	97.2	97.5	97.7	98	98.1	98.2	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.4
2	91.4	92.1	92.6	93.4	93.7	94	94	94.1	94.1	94.2	94.3	96.3	94.3	94.4	94.4
3	85.4	86.3	87	88.4	88.7	89.2	89.4	89.5	89.6	89.7	90	90.1	90.1	90.2	90.2
4	79.7	80.7	81.6	83.2	83.7	84.5	84.7	84.9	85	85.2	85.5	85.6	85.7	85.8	85.8
5	73.9	75.2	76.2	78.3	78.8	79.8	80	80.3	80.5	80.7	81.1	81.3	81.4	81.5	81.8
6	68.4	69.7	70.8	73.3	73.9	75.2	75.6	75.9	76.1	76.3	76.7	76.9	77	77.2	77.3
7	63.3	64.7	66	68.6	69.3	70.7	71.1	71.5	71.7	71.9	72.4	72.6	72.7	72.9	73
8	58.5	59.9	61.2	64	64.7	66.2	66.7	67.1	67.4	67.7	68.3	68.6	68.8	69	69.7
9	53.9	55.5	56.8	59.7	60.5	62.1	62.6	63	63.3	63.6	64.3	64.6	64.8	65	65.2
10	49.7	51.2	52.5	55.7	56.4	58.2	58.7	59.2	59.5	59.8	60.5	60.8	61	61.2	61
11	45.9	47.4	48.7	51.6	52.5	54.3	54.8	55.3	55.7	56.1	56.8	57.2	57.4	57.6	58
12	42.4	43.8	45	48.1	48.9	50.8	51.4	51.9	52.3	52.6	53.3	53.7	54	54.2	54.5
13	39.1	40.4	41.6	44.7	45.6	47.5	48.1	48.6	49	49.4	50.1	50.8	50.8	51	51.3
14	36.1	37.3	38.7	41.6	42.4	44.3	44.8	45.4	45.8	46.2	47	47.4	47.7	47.9	48.2
15	33.2	34.5	35.7	38.5	39.4	41.4	41.9	42.5	42.9	43.3	44.1	44.5	44.8	45.1	45.3
16	30.8	3ح1.9	33	35.9	36.8	38.6	39.2	39.7	40.1	40.5	41.4	41.8	42.1	42.4	42.6
17	28.3	29.5	30.5	33.3	34.1	36	36.6	37.1	37.5	37.9	38.8	39.2	39.5	39.7	40.1
18	26.2	27.3	28.3	30.9	31.7	33.6	34.2	34.7	35.1	35.5	36.3	36.7	37	37.3	37.5
19	24.1	25.1	26.1	28.8	29.5	31.3	31.9	32.4	32.8	33.2	34	34.4	34.7	35	35.2
20	22.2	23.1	24.1	26.6	27.4	29.2	29.7	30.2	30.6	31	31.8	32.3	32.5	32.7	33

Discussion

The increase in the radiation field size can increase the depth dose percentage caused by the increased scattered radiation. This increase in the scattered radiation caused by larger tissue irradiation by using larger field size which, in turn, increases the scattered radiation. The interaction of X-ray and gamma ray with matter involves photoelectric effect, Compton scatter and pair production. As the human tissue has low atomic number the photoelectric interaction will not happen only at low radiation energy as the photoelectric interaction directly proportional with $Z^3$and inversely proportional with the radiation energy i.e. with $(1/hf)^{3.}$ for this reason this type of interaction not found in the therapeutic range of radiation. In the higher energy Compton interaction become of vital importance, in fact in radiation energies more than 100keV and most if not all the interaction with living tissue is only by Compton scatter. For energies exceeding 1.02MeV the pair production threshold at which pair production will start to contribute in the interaction with the living tissue together with Compton interaction, in our work we are dealing
with ^{60}Co which has energy of about 1.25MeV close to the threshold of pair production.

The scatter radiation is of an important part of concern. This is because the scatter radiation can influence the dose at different depths and different field size. Figure 4 is a plot the field size with the depth dose% in this figure the deeper is the tissue volume, the total dose is less because the attenuation of radiation but the depth dose percent is still increases with increase of the beam size, this is not observed for the depth dose percent for regions near the surface i.e. at depth 0. and 1 cm. the slope of the graph is zero i.e. the graph is horizontal, while for deeper regions of graph is rising with the field size this can give an indication that the increase of depth dose percent at deeper regions is attributed to the scatter radiation.

The effect of an increased scattered radiation with the increased field size reaching to the point of interest is shown in diagrammatic representation as shown in figure 5.

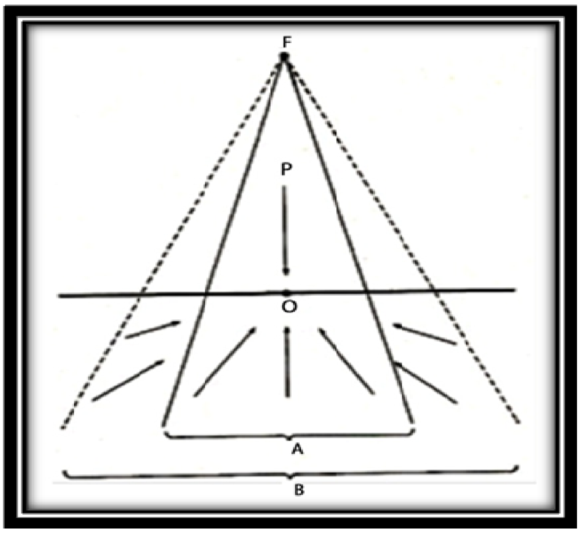

Figure 5- Two beam sizes showing the increase in back scatter in the larger beam size.

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