Measurement of Dose Distribution for Co – 60 Teletherapy Unit

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Received: 9/10/2008 ; Accepted: 7/5/2009

Abstract:

Both percentage depth dose and off axis dose are usually needed in order to arrive at a suitable treatment plan. In an attempt to get an isodose curves in the build-up region , the dose distribution from Co-60 teletherapy machine in a planes perpendicular to the beam axis have been measured near the surface and in the build - up region , using LiF – Teflon thermoluminescent dosimeters in a Perspex phantom for (10x10 cm^2) and (15x15 cm^2) field size , and for three depths (0.0 g/cm^2 , 0.36 g/cm^2 and 0.55 g/cm^2).

The measured data is computer fitted to an empirical formula using MATLAB program , and the dose distribution for different other depths have been predicted.

قياس توزيع الجرع لوحدة الكوبلت - 60 العلاجية

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ملخص البحث:

النسبة المئوية لجرعة العمق والجرعة خارج المحور المركزي يستخدمان عادة للحصول على العلاج الملائم . ولمحاولة الحصول على منحنيات تساوي الجرع في منطقة التراكم الالكتروني ، تم قياس توزيع الجرع لاشعة الكوبلت –60 العلاجية في مستوى عمودي على محور الجرع المركزي وفي منطقة التراكم الالكتروني والمناطق القريبة من السطح ، باستخدام

كواشف التألق الحراري نوع فلوريد الليثيوم وشبح مصنوع من مادة البيرسبكس المكافى للنسيج الحي ، وللمجالين ($10x10\ cm^2$) و ($15x15\ cm^2$) ولثلاثة اعماق ($0.0\ gm/cm^2$, $0.36\ gm/cm^2$ and $0.55\ gm/cm^2$) . تم استخدام القيم المقاسة للوصولعلاقة تجريبية باستخدام برنامج (MATLAB) ، واستخدمت العلاقة لاعطاء توقعات لتوزيع الجرع على أعماق مختلفة أخرى.

Introduction

The absorbed dose computed from the depth dose tables concerns only the dose along the central axis of the beam, but the tumor lies in the center of the beam and around the centre of the beam. So to find the doses at points outside the central axis of the beam we use isodose curves ,which are lines connecting points of identical percentage depth dose relative to the maximum dose . In order to_arrive at a suitable treatment planning , we need both central axis percentage depth dose and off axis ratio.

Van deGeijn (1963) has generalized the method of tumor _ air _ ratio to determine dose distribution in moving beam techniques with Co-60 gamma radiation. The measurement were carried out in a specially designed water phantom using farmer ionization chamber. In the same year, Orchard (1963)suggested method of describing the dose distribution within a beam is outlined in which the dose distribution in Co-60 beam is related to the central axis depth dose by the use decrement lines. The idea of a decrement system arose from the need to draw accurate isodose curves from experiment measurement in the transverse axis of the beam.

Rawlinson and Cunnungham (1971) measured Co-60 dose distribution for arrange of field sizes using LiF dosimeters in a prestwood phantom. Dealmeida and Almond (1974) compared between two high energy linear accelerator and they found appreciable differences mainly in maximum dose, dose distribution , surface dose and isodose curves.

Isodsoe curves for electron beams at varies energies were calculated using age diffusion equation (Kawachi , 1975). Sutcliffe (1980) measured the dose distribution for Co-60 teletherapy unit under different depths in water using a 6 mm diameter ionization chamber.

Sethi et al. (2003) used 3D treatment planning systems (3DTPS) to design compensating filters that, in addition to missing tissue compensation , can account for tissue inhomogeneities for co-60 , 6 MV , and 18 MV photon beams. Compensating filters were evaluated using a homogeneous step phantom and step phantoms containing various internal in homogeneities (air , cork, and bone). Phantom measurements have demonstrated that compensating filters were able to produce a uniform dose distribution along the compensation plane in the presence of tissue inhomogeneity.

Skin dose was measured using radiographic film for 6 MeV X- ray beam (Butson etal., 2004). Mihailescu et al. (2006)calculated the percentage depth dose and the transverse dose profile for the electron beam using Mont Carlo simulation. Palsurajit and Sharma (2006) used empirical formula for computing doses a long the central axis and off axis ratio a long the transverse axis. In the case of high energy x-ray machines , the shape of isodose curves depend , to a large extent , on the design of the beam flatteners , so it is recognized among the clinical medical physicists that published isodose curves cannot be used and that the dose calculation must be specific to the teletherapy machine used , therefore, empirical formulations become quite necessary.

In a more recent report, Rafaravavy et al. (2007) study the dose distribution in a medium irradiated by a high energy x- ray photon with an ionization chamber. 6MV and 20 MV photon beam and different field size were used to evaluate the energy and geometrical parameters influence on the dose distribution in the medium. According to their result they found that when the energy increases , the dose surface decrease because the contribution of electrons decrease.

In our previous work (Al-Shammary , 2003 and Al-Taai , 2005) ,we measured the surface dose and the dose in the build- up reign for Co-60 teletherapy machine a long the central axis of the beam only. Furthermore , the isodsoe charts which is used by teletherapy centers for the treatment planning supplied by the manufacturing companies, start from the depth of maximum dose, which is (0.55 g/cm^2)(in water phantom) inwards for the Co-60 radiation . So the aim of this work is to measure the isodose curves and off axis dose distribution for Co-60 teletherapy unit in the build – up region , that is from the depth of (0.55 g/cm^2) to the surface of the phantom. This region is not included in the standard isodose charts which is used by the teletherapy centre , and the measurement in this region conform advantage upon the patient and help the physician to know the dose distribution on the skin and under the skin.

Method and Measurement

A description of the Co-60 teletherapy unit used for these measurements has appeared in the literature (Al-Shammary , 2003). The parameters of the machine which are of interest here are the source to surface distance (80 cm) and the field size of the beam (10x10 cm^2 and 15x15 cm^2). The phantom was constructed from a series of Perspex sheets. The size of the phantom was (30x30x20 cm).

The dosimeters were LiF Teflon discs, (0.04 cm) thick and (1.28 cm) in diameter (Pitman Company), the mean density of the discs was about (2.2 g / cm^3) , and the dosimeters were arranged at (1 cm) intervals along the beam area as shown in Fig (1). After irradiation the dosimeters were read using thermo luminescence dosimetry read – out instrument. The mode of operation has been described by Al-Shammary (2003). Dose distribution transverse profile for Co-60 unit were measured using (36) discs for each irradiation , at depths of (0.0 g/cm² , 0.36 g/cm² and 0.55 g / cm²).

Two field sizes were performed for each irradiations. The source – surface distance (SSD) remained constant during the measurement and is equal to (80 cm). The dosimeters were irradiated for (5 min) with an accumulated dose of 45 cGy , all measurement were made at Co-60 unit in the tumor and nuclear medicine hospital in Mosul. The discs were readed in pitman reader which gives the dose in rad . After each irradiation , the discs were annealed at (300 C°) for 1 hour and at (80 C°) for 20 hours .

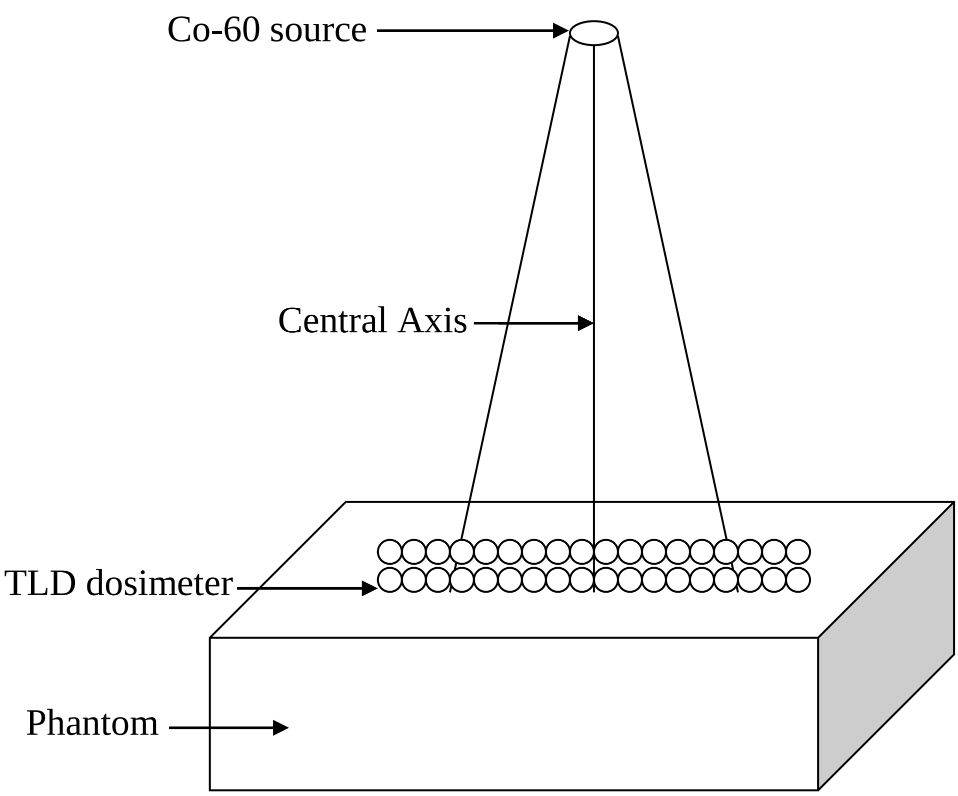

Fig (1) : Schematic Diagram of the Experimental Procedure.

Results

The experiments performed were designed to find the dose distribution in the build – up region and in particular near the surface , at depths (0.0 g/cm² , 0.36 g/cm² and 0. 55 g/cm²) , as a function of the radial distance from the centre of the beam as shown in Fig (1).The measured dose distribution is shown in table (1) and (2) and drawn in Figs (2) and (3) were expressed as a percentage of the maximum dose at depth (0.55 g/cm²) for each field , as shown in equation (1) , and presents either in tables or as isodose curves.

% Depth Dose = $\left[\textbf{Dose at any depth / Maximum Dose}\right]$ **x 100 . . . . (1)**

Table (1) : Percentage depth dose as a function of maximum dose for the F.S. (10x10 cm²).

Distance from the centre of the beam	Depth = 0.0 g/cm²	Depth = 0.36 g/cm²	Depth = 0.55 g/cm²
11.5	3.73	1.56	0.81
10.2	4.87	2.19	2.43
9	5.93	2.27	3.82
7.8	7.8	6.66	10.44
6.5	14.63	22.03	24.39
5.3	34.14	49.02	79.5
4	38.5	71.54	96.91
2.7	38.78	87.64	99.75
1.3	38.04	90	100.16
0	36.99	90	100
-1.3	38.5	91.13	100.5
-2.7	39.18	88.04	100.5
-4	37.72	73.17	95.28

Distance from the centre of the beam	Depth = 0.0 g/cm²	Depth = 0.36 g/cm²	Depth = 0.55 g/cm²
-5.3	23.65	43.49	75.44
-6.5	14.87	9.26	36.58
-7.8	7.88	4.63	5.2
-9	4.63	2.27	3.08
-10.2		1.56	2.19
-11.5	3.08	1.13	1.3

Table (2) : Percentage depth dose as a function of maximum dose for the F.S. (15x15 cm²).

Distance from the centre of the beam	Depth = 0.0 g/cm²	Depth = 0.36 g/cm²	Depth = 0.55 g/cm²
11.5	11.18	2.73	2.58
10.2	10.4	6.95	4.45
9	12.04	19.7	29.7
7.8	14.85	43.3	52.3
6.5	20.72	66.3	81.2
5.3	32.8	82	94.05
4	41.4	87.3	97.03
2.7	43.8	88.58	99.5
1.3	44.5	88.42	100.46
0	43.86	89.29	100
-1.3	43.2	89.29	100
-2.7	43.1	88.04	99.76
-4	35.96	84	98.3
-5.3	22.3	74.82	95.9
-6.5	14.93	47.69	90.23
-7.8	12.58	31.2	53.3

Distance from the centre of the beam	Depth = 0.0 g/cm²	Depth = 0.36 g/cm²	Depth = 0.55 g/cm²
-9	10.6	13.76	18.14
-10.2	11.57	9.07	6.95
-11.5	8.4	5.55	2.74

The depth (0.55 g/cm²) refer to the depth of the maximum dose for the energy of the Co-60 gamma radiation . Furthermore, the data was computer fitted using the MATLAB program non linear fitting facility to an empirical formula. It was found that the best empirical formula that describes the data for 15x15 cm² field size is:

% Depth Dose = a1 $\left[\mathbf{\tanh(a2X + a3) + a4}\right]\left[\mathbf{\tanh(-a2X + a3) + a4}\right]$ **. . .(2)**

The empirical parameters are :

$a1 = 0.34\,d + 0.07$, $a2 = 0.557$, $a3 = 8.8\,d^2 - 2.5\,d + 3.2$, $a4 = -1.2d + 1.6$.

(x) is the distance from centre of the beam axis , and (d) is the depth .
This equation is plotted in Fig (4) for(15 x15cm^2) and for several other depths values.

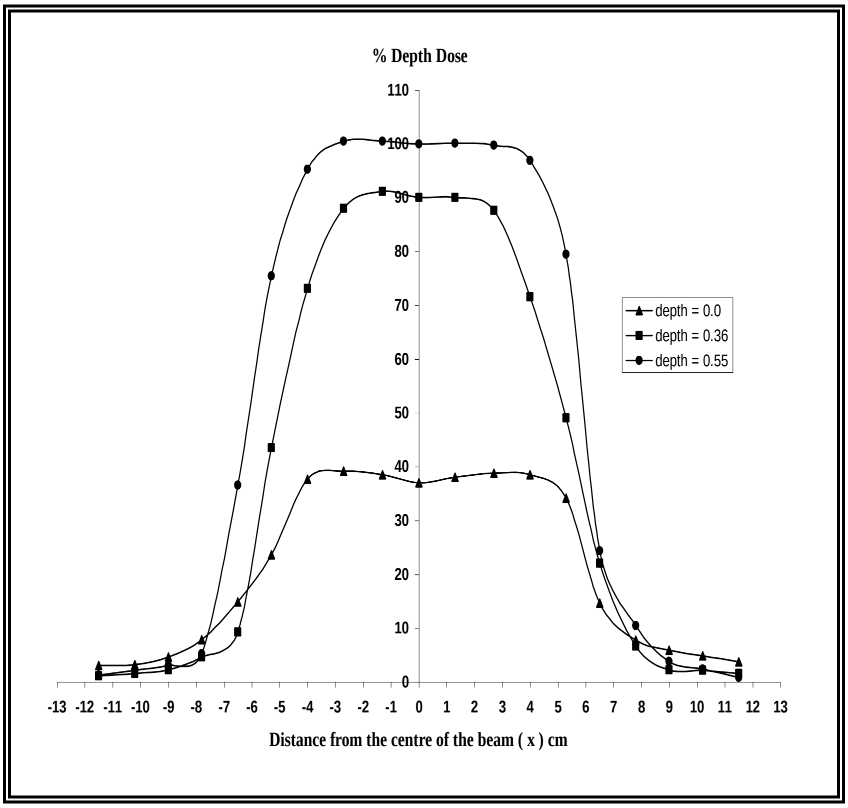

Fig (2) : Percentage Depth Dose for the F.S. (10X10 cm²).

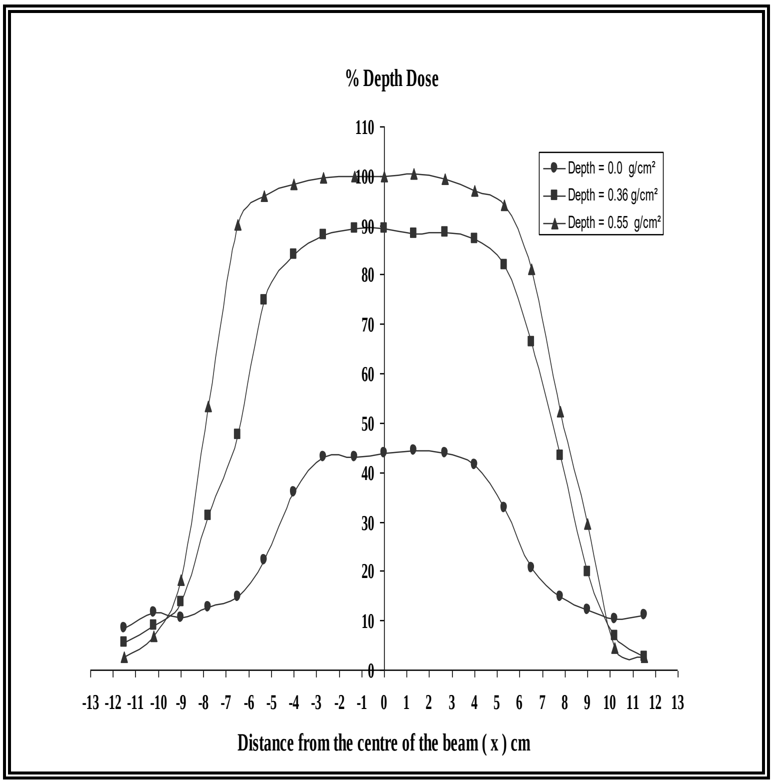

Fig (3) : Percentage Depth Dose for F.S. (15x15 cm²).

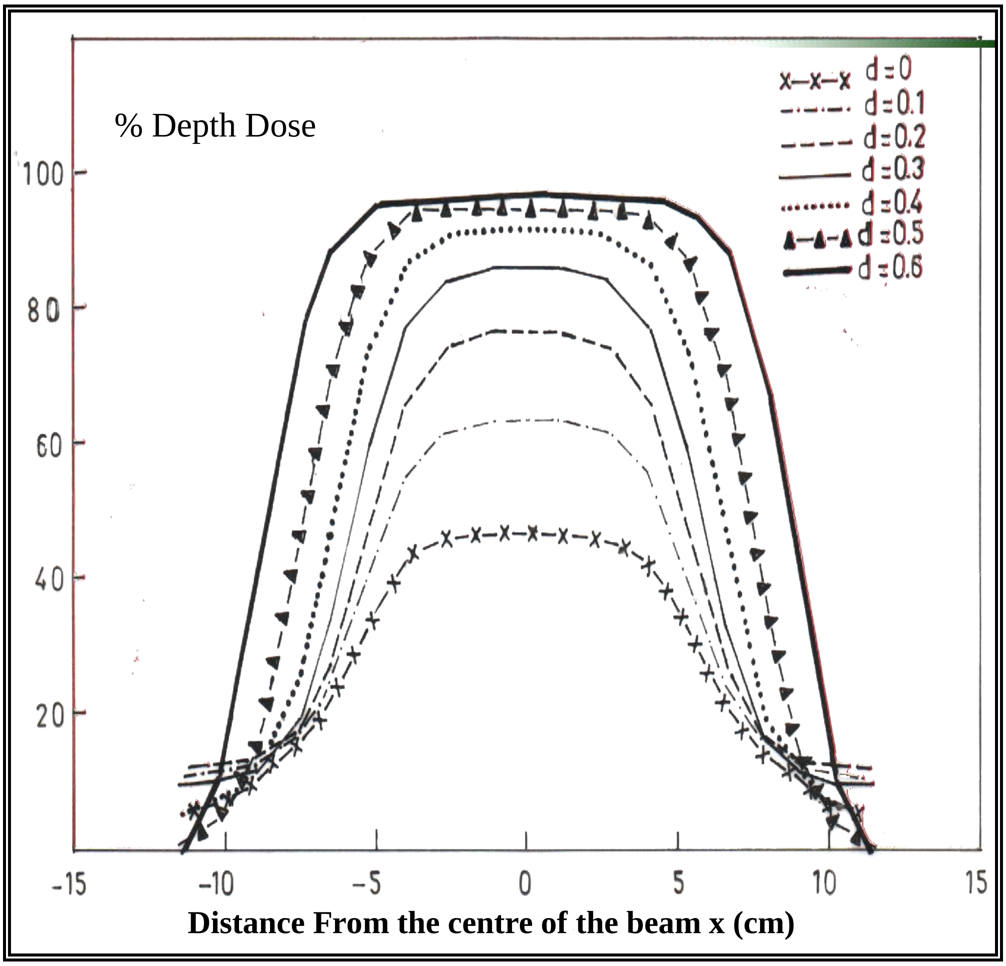

Fig (4) : The dose distribution computed using MATLAB computer program, for field size 15 x 15 cm^2 and for different depths .

Discussion

The skin and the dose in the build –up region can vary quite considerably within the first few millimeters of depth due to the build- up characteristic of high energy x and γ- rays. The majority of these variations can be attributed to the electron contamination emitted from the beam flattening filter and the collimates. The skin dose also depends on the field size and the source- skin distance. The distribution was measured on some selected depths in the build- up region as shown in fig (3 and 4), for the purpose of finding a mathematical equation to be used for finding the dose distribution at any other depths.

Equation (2) can be used for finding the dose distribution at any other depths for field size (15x15 cm^2) as shown in fig (4). The same procedure can be done for other field size. The dose distribution on the skin and under it is very important to the radiologist when doing the treatment planning, to avoid any burn to the skin caused by high energy radiation dose.

The flatness of the dose distribution curves shown in fig (2,3 and 4) is quit good. From fig (3) , the percentage dose varies from 44% at the centre of the field to 17% at the edge of the field at the surface , and at depth 0.55 cm the variation varies from 100% to 68%. This variation is due to the beam flatting filter which is usually used to flat the radiation beam. Surface doses are also measured outside the treatment field which are mainly due to scattered electron contamination. The surface dose drop to about (5%) for 10x10 cm^2 and around (10%) for 15x15 cm^2.

Conclusions

1. The dose distribution shown in Fig (2) and (3) are very similar on both sides , i.e in good symmetry and flatness.
2. At a fixed depth near the surface , the strong increase in both doses with increasing field size , result from the large contribution of electron scatter from the collimates at these depths, and this effect decrease with increasing depths.
3. The computer fitting which is based on a generalization of the dose depth distribution measurements was proved to be adequate in finding the dose distribution at any depth in the build – up region.

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