SPECIAL COMMUNICATION

Radiation absorbed dose for cobalt-60 gamma source in phantoms for different materials

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Abstract

Current practices in radiation therapy required high doses of radiation to be delivered with increased accuracy. Treatment planning task is exercised till an optimum dose distribution is achieved. The present reported work was performed to compare the various aspects of the cobalt-60 radiation beam therapy with fixed source-surface distance 70cm incident normally. This study was conducted in May 2012 at the Department of Radiation Physics of MD Anderson Cancer Centre, University of Texas, Houston, United States. Radiation doses were calculated in a solid phantom as well as in water phantom at different square field sizes and depths. It was noted that the rate of absorbed dose increased with the increase in the field size and decreased with the increase in depths. The rate of absorbed dose was found to be directly proportional to the increase in the square field size and inversely proportional to the increase in depth. Moreover, the solid phantom demonstrated more absorbed doses as compared to the water phantom.

Keywords: Absorbed dose, Cobalt-60, Gamma radiations, Phantoms, Ion chamber.

Introduction

Cancer is the foremost public health problem and a principal cause of death. In the year 2020, about 20 million new cancer cases may be expected globally.[1,2] Radiotherapy is one of the important modalities in the treatment of cancer, in both curative and palliative settings, and about 60% of these patients require radiotherapy as curative or palliative intent.[3] Dosimetry is a science of dose measurement of any radiation generating equipment and in radiotherapy, and it has a pivotal role in enhancing the confidence level by delivering the pinpoint and accurate radiation therapy. Cobalt-60 (Co-60) based radiation therapy continues to play a significant role in not only developed countries but also in developing countries where access to radiation therapy is very limited.[4] The easy handling of cobalt units gives them the advantage of reduced maintenance, running costs and downtime when compared with linear accelerators machines.

Cobalt-60 is employed as a gamma ray source as it can be produced in a predictable measure and high activity by bombarding cobalt-59 with neutrons. Cobalt-60 decays to Nickel-60 (60Ni28) by the emission of beta particle. The activated nickel nucleus emits two gamma ray photons with energies of 1.17 mega-electron volts (MeV) and 1.33 MeV,[5-7] resulting in an average beam energy of 1.25 MeV and the soft beta radiation is simply filtered out by approximately 0.16 mm of steel sheet.

The energy of these gamma rays is used in radiotherapy to treat the cancer. As Co-60 decays, this decrease in activity requires periodic replacement of the sources used and is one of the reasons why cobalt machines have been partly replaced by linear accelerators in modern radiation therapy. But Co-60 based teletherapy machines are still in widespread use worldwide since they are reliable and simple to maintain compared to modern linear accelerators.[8,9]

Cylindrical parallel plate ionisation chamber was used to determine depth dose data and give correct dose information close to the surface and at depth in the water phantom. It is important that radiation dose transferred to the dosimeter is similar to that transferred to the human body irradiated. The fundamental purpose of dosimetry is aimed at radiation protection.[10-16]

In this project, solid and water phantoms were used as a radiation dosimeter and compared in view of radiation absorbed dose. The current study was performed to compare the various aspects of the cobalt-60 radiation beam therapy with fixed source-surface distance (SSD) 70cm incident normally. Radiation doses were calculated in a solid phantom as well as in water

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phantom at different square field sizes and depths.

Materials and Methods

This study was conducted in May 2012 at the Department of Radiation Physics of MD Anderson Cancer Centre, University of Texas, Houston, United States. The methodology involved in the present study was the calculations of radiation dose rate of Co-60 teletherapy by using the SSD technique. For this project, the cobalt-60 phoenix teletherapy beams with 70cm SSD incident normally has been used. The solid phantom employed had the following specifications: chemical composition was epoxy resin-based mixture, density 1.6 (g/cm^3) and the number of electron was 3.24 × 1023. The other phantom was water which is recommended in the International Atomic Energy Agency's (IAEA) codes of practice (TRS-277 & 381) as the reference medium for measurements of absorbed dose for both photon and electron beams.[10,11] Water phantom used in this work had the following properties: the chemical composition was H2O, density was 1.00(g/cm^3) and the number of electrons was the same as in solid water phantom. The field sizes and depths used in this work were 6 x 6, 8 x 8, 10 x 10, 12 x 12, 14 x 14, 16 x 16, 18 x 18, 20 x 20 and 0.5cm, 5cm and 10cm, respectively.

The reading of cylindrical ionisation chamber N30001 (PTW Freiburg, Germany) was corrected to standard environment conditions of temperature and pressure for which ion chamber calibration factors were applied.[17]

K_{PT} was the correction computed from the expression $K_{PT} = (273.5+T)/(273.5+T_0) \times P_o / P$ where To is standard temperature (To = 22°C) and Po is standard pressure which is 101.33 kPa (kilo pascal, 1 standard atmosphere = 760 mm of Hg = 101.33 kPa), T is temperature of water inside an ion chamber, taken as the temperature of the surrounding water and P, assumed to be the local air pressure, is the pressure inside the ion chamber. Standard environmental conditions are different in different sites, so the corresponding changes in the expression ($K_{PT} = P_0(273.5+T)/p(273.5+T_0)$ are necessary.[18,19]

NDW is the absorbed dose to water calibration coefficient factor for an ionisation chamber defined as "the quotient of the absorbed dose to water rate delivered to the chamber and the ionisation current created by radiation in the ionisation chamber" and determined for a given ion chamber by the following formula: ND.W = D/I, where D is the rate of absorbed dose to water and I is the ionisation current. The unit of this calibration coefficient is Gy/C. NDw always corresponds to the calibration factor in terms of absorbed dose to water in a Co-60 beam.[20-22] The ionisation chamber (N30001-1687) was adjusted in solid phantom, connected to 0.6 cm^3 farmer type ionisation chamber through cable. The voltage adjusted for the dosimeter was 400 volts. The gantry angle adjust on the cross of ionisation chamber was 0^0. The dosimeter displayed the reading after one minute in mGy/m or Gy/m. The same procedure was adopted for water phantom to calculate the absorbed dose.

Results and Discussion

The absorbed dose was taken along Y-axis and field size was taken along X-axis using different depths for analysis. The water and solid phantoms were compared against the absorbed dose.

It was found that when square field size increased, the rate of absorbed dose also increased. At larger value of the square field size, the value of absorbed dose became approximately constant, which showed that a larger value of square field size of the absorbed dose almost became independent of the square field size.

Because as the square field size is increased, the

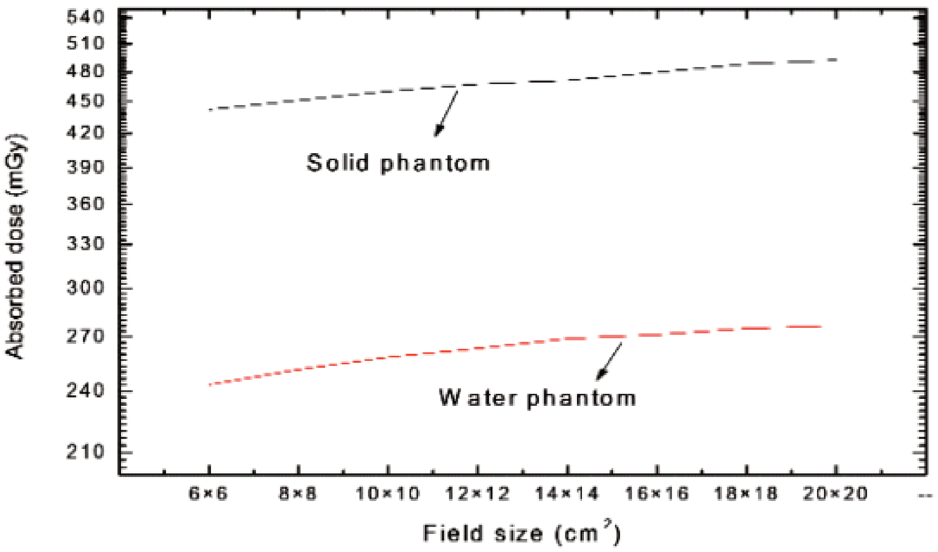

Figure-1: Absorbed dose at depth 0.5 cm at solid and water phantom.

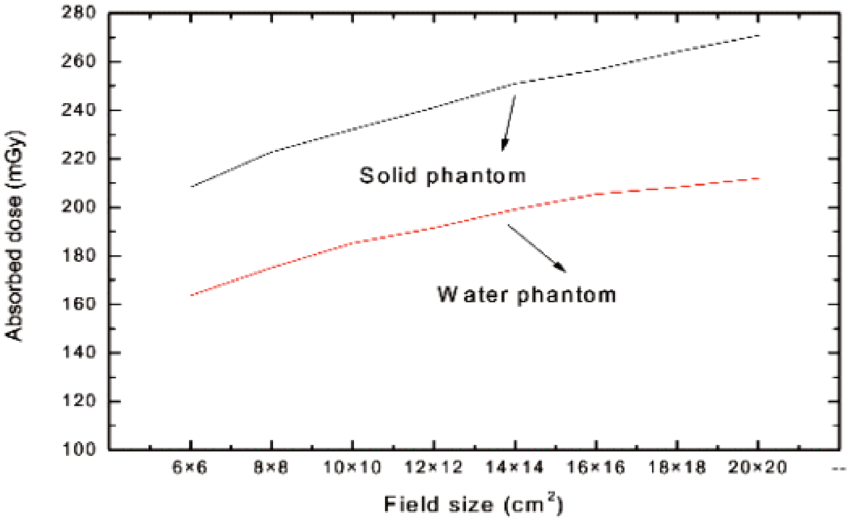

Figure-2: Absorbed dose at depth 5 cm at solid and water phantom.

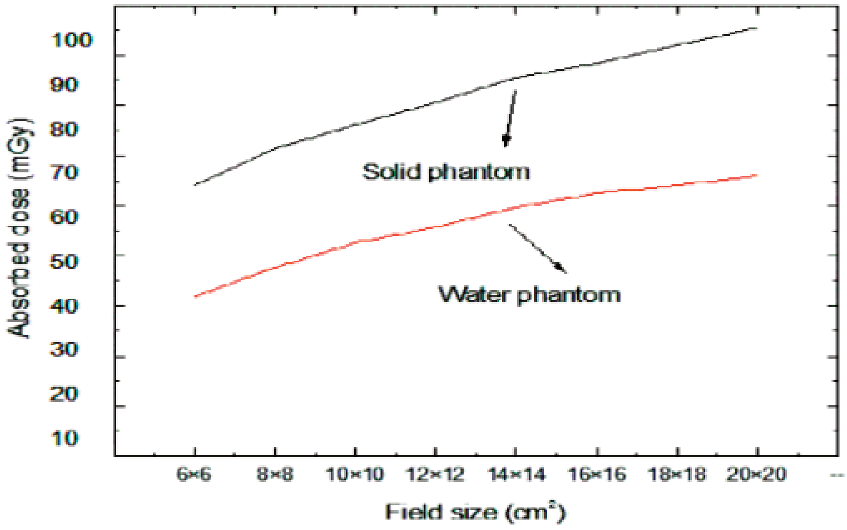

Figure-3: Absorbed dose at depth 10 cm at solid and water phantom.

contribution of the scattered radiation to the absorbed dose increased, since this increase in scattered dose had greater at larger depths (Figures-1-3).

It was noted that the rate of absorbed dose increased with the increase in the field size and decreased with increase in depths. It was also observed that the solid phantom absorbed more doses as compared to the water phantom due to different material used in the formation of phantoms. The density of the phantoms played an important role to calculate the absorbed dose. For patients' specific site the absorbed dose should be calculated in such a way that bone and soft tissue densities are considered.

Conclusion

The rate of absorbed dose increased with the increase in the field size and decreased with the increases of depths. When the depth in the phantom changed from lower to higher values, the absorbed dose decreased and increased with the increases of square field sizes from lower to higher values.

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