ORIGINAL ARTICLE

DOSE MEASUREMENT OF COBALT-60 RADIOTHERAPY BEAMS IN TREATMENT FIELDS

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Background: Radiation therapy is a complex process with multiple steps, each of which has an impact on the quality of treatment. Accurate dosimetry is a critical step during the radiotherapy of cancer patients.The aim of the present study was to measure and evaluate the doses of two cobalt-60 (^{60}Co) teletherapy units GWXJ80 of NPIC China and Theratron 780 of AECL Canada at various points within fields for different field sizes. **Methods:** This cross-sectional descriptive study was done to measure the ^{60}Co doses in the treatment fields.The dose measurements were done in air and 30×30×30 cm^3 Phantom at 80 cm SSD by using calibrated NE 2570 Farmer Electrometer & NE 2571 Farmer Ionization Chamber and percentage of doses were calculated. **Results:** The results showed that 60% central area of all fields ranging from 100–98.79% and 100–96.12% for GWXJ80 in the air and phantom, whereas for Theratron 780, they were ranging from 100–98.50% and 100–96.45% in air and phantom respectively. The percentages of doses at the edges for GWXJ80 and Theratron 780 in the air were 75.39–38.66% & 85.65–46.47% respectively and they were 82.22–40.39% & 49.05–24.55% respectively in phantom. **Conclusions:** The doses within 60% central area of fields in air were higher than phantom for both teletherapy units. The doses at field edges in air were lower in GWXJ80 than Theratron 780 whereas in phantom they were vice versa. But all were in the acceptable range as recommended by International Commission on Radiation Units and Measurements.

Keywords:Cobalt-60 (^{60}Co), Quality Assurance, Dosimetry, Exposure, Central Area, Edge
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INTRODUCTION

Cobalt-60 (^{60}Co) has been used effectively for more than six decades to treat a variety of cancers worldwide, especially in poorer countries such as Pakistan. Radiation therapy is a complex process with multiple steps, each of which has an impact on the quality of treatment. Accurate dosimetry is a critical step during the radiotherapy of cancer patients.[1] Generally, essential radiation therapy dosimetric parameters are measured using a homogeneous water phantom.[2] External photon beam radiotherapy is usually performed using more than one radiation beam, in order to achieve a uniform dose distribution inside the target tissues and the lowest possible dose to the healthy tissues surrounding the target.[3] To protect against undue exposure to ionizing radiation, it is necessary to determine the radiation dose for specific body organs and tissues[4] by using International Atomic Energy Agency (IAEA) protocols.[5,6] Accurate dose calculations are essential during the radiotherapeutic treatment of patients, and the overall dose delivery error to patients should not exceed 5%, as recommended by the International Commission on Radiation Units and Measurements (ICRU)[7] and the Nordic Association Of Clinical Physicists (NACO).[8] Therefore, this study was conducted to measure the doses of ^{60}Co teletherapy units in a water phantom at a depth of 5 cm and in the air at the centre of the fields, and also at 1 cm increments from the centre of both field setups at 80 cm Source Surface Distance (SSD), according to the IAEA protocols.[5,6]

Quality assurance (QA) during the radiation therapy treatment planning process is mandatory to minimize undue exposure,[9] and beam dosimetry of ^{60}Co teletherapy units is an essential QA procedure, as described in the IAEA Technical Documents (IAEA TECDOCs).[10,11] The present study was conducted to measure and evaluate the radiation doses received by the target organ and the surrounding healthy organs in external radiation treatment.[4] The fundamental goal of radiotherapy is to deliver a specific radiation dose to the prescribed target area with the least dose to normal tissues[12] and radiation oncology demands high accuracy in the delivery of dose to the tumour and surrounding tissues.[13] It has been reported[14] that a current reasonable figure for the accuracy requirement of the prescribed dose to the target volume is 2–3%. This is based on the assumption that the much referred accuracy requirement figure is 5% as documented by ICRU.[7]

MATERIAL AND METHODS

This cross-sectional descriptive study was done to measure the ^{60}Co doses in the treatment fields. The direct measurement of the dose distribution in the patient is impossible in actuality. For a successful outcome of patient radiation treatment, it is vital that the dose distribution in the irradiated volume be known precisely and accurately.[15] The doses were measured according to IAEA protocols[5,6] at mid and at different points with 01 cm increment intervals from the mid within the field for 10×10 cm^2, 15×15 cm^2 and 20×20 cm^2 at 80 cm SSD source to surface distance (SSD) to the surface of the chamber with 0.551 g/cm^2 thick Derlin buildup cap in the air and in phantom of 30×30×30 cm^3 at 05 cm depth with the help of Farmer NE2750 electrometer and Farmer NE2571, 0.6cc Ionization Chamber for 60 seconds for two machines (GWXJ80 of NPIC China and Theratron 780 of Atomic Energy Company Limited Canada) installed at Nuclear Institute of Medicine And Radiotherapy (NIMRA) Jamshoro, Pakistan. After measuring doses at mid and different locations within fields, the percentage of doses at different points and geometric edges as described in IAEA's book[16] with respect to the mid of the respective fields were calculated. The gantry and collimator angles of the ^{60}Co teletherapy units were kept at 0 degrees for these measurements. Khan FM[17] mentioned the dose of 60% central part of the field size as 97% whereas at the edge the dose level lies between 90% and 50%.

RESULTS

The doses at mid, different points within fields have been summarized in table-1 and table-2 whereas their percentage at different points with respect to mid of respective fields have been shown in figure-1 to figure-4. The calculated results shows that 60% central area of all fields are ranging from 100–98.79% and 100–96.12% for GWXJ80 in the air and phantom, whereas for Theratron 780 the results are ranging from 100–98.50% and 100–96.45% in air and phantom respectively The percentages of doses at the edges (1.0–1.5 cm) for GWXJ80 and Theratron 780 in the air are 75.39–38.66% and 85.65–46.47% respectively and they are 82.22–40.39% and 49.05–24.55% respectively in phantom.

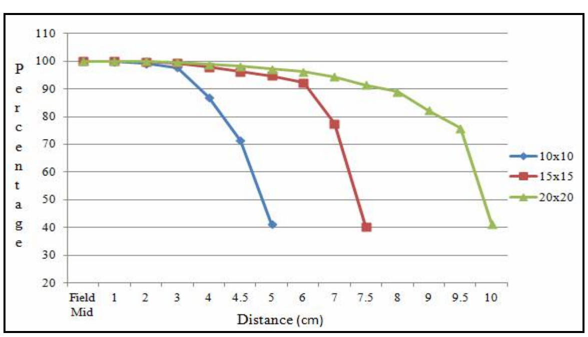

Figure-1: Percentage of doses in phantom at 05 cm depth for GWXJ80

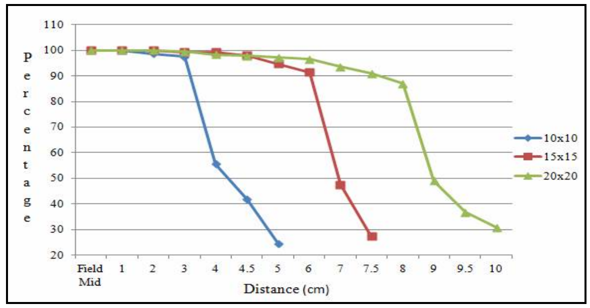

Figure-2: Percentage of Doses in phantom at 05 cm depth for Theratron 780

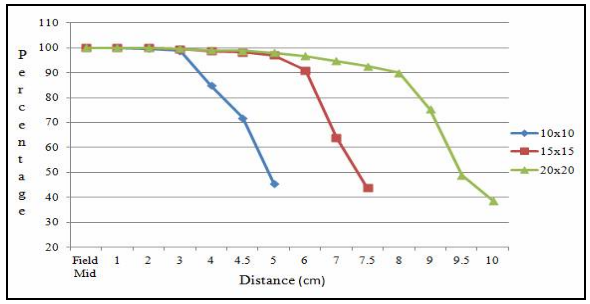

Figure-3: Percentage of doses in air for GWXJ80

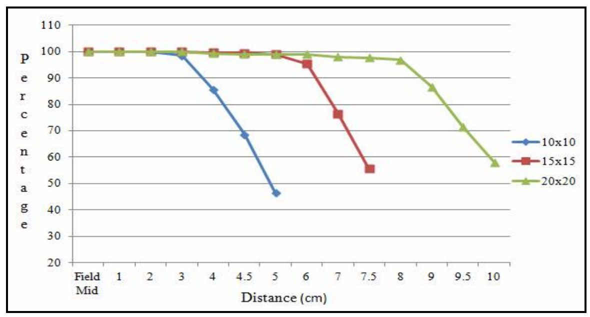

Figure-4: Percentage of doses in air for Theratron 780

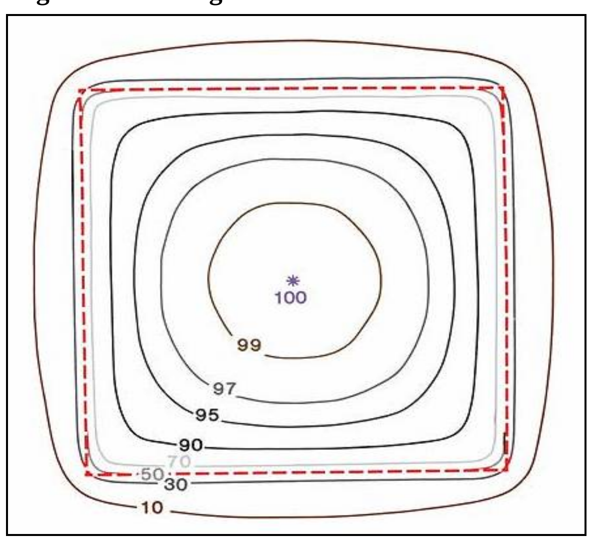

Figure-5: Cross-sectional isodose distribution in a plane perpendicular to the central axis of the beam. Isodose values are normalized to 100% at the centre of field. The dashed line shows the boundary of the field.[17]

Table-1. Doses (Gy) in phantom at 05 cm depth

Machine	Field Size (cm^2)	Field Mid	Away from Field Center (cm)												
			1	2	3	4	4.5	5	6	7	7.5	8	9	9.5	10
GWXJ80	10×10	1.1949	1.1920	1.1851	1.1674	1.0395	0.8527	0.4917							
	15×15	1.2589	1.2589	1.2559	1.2490	1.2313	1.2100	1.1920	1.1605	0.9756	0.5085				
	20×20	1.3002	1.3002	1.3002	1.2953	1.2854	1.2760	1.2638	1.2510	1.2264	1.1895	1.1576	1.0690	0.9855	0.5380
Theratron 780	10×10	0.3797	0.3797	0.3748	0.3699	0.2109	0.1589	0.0932							
	15×15	0.4023	0.4023	0.4023	0.3993	0.3993	0.3943	0.3807	0.3679	0.1913	0.1099				
	20×20	0.4140	0.4140	0.4140	0.4121	0.4072	0.4050	0.4023	0.3993	0.3875	0.3765	0.3601	0.2031	0.1521	0.1275

Table-2: Doses (Gy) in air

Machine	Field Size (cm^2)	Field Mid	Away from Field Center (cm)												
			1	2	3	4	4.5	5	6	7	7.5	8	9	9.5	10
GWXJ80	10×10	1.4789	1.4789	1.4739	1.4609	1.2548	1.0626	0.6742							
	15×15	1.5187	1.5187	1.5187	1.5107	1.4988	1.4900	1.4739	1.3813	0.9730	0.6642				
	20×20	1.5456	1.5456	1.5456	1.5406	1.5306	1.5275	1.5137	1.4938	1.4639	1.4314	1.3892	1.1652	0.7569	0.5975
Theratron 780	10×10	0.4629	0.4629	0.4629	0.4559	0.3965	0.3172	0.2151							
	15×15	0.4728	0.4728	0.4728	0.4728	0.4708	0.4700	0.4678	0.4510	0.3618	0.2627				
	20×20	0.4807	0.4807	0.4807	0.4807	0.4777	0.4760	0.4758	0.4758	0.4708	0.4695	0.4658	0.4163	0.3429	0.2795

DISCUSSION

In our study 60% central area of all fields are ranging from 100–98.79% and 100–96.12% for GWXJ80 in the air and phantom, whereas for Theratron 780 the results are ranging from 100–98.50% and 100–96.45% in air and phantom respectively, which presented reasonable dose uniformity (the acceptable error is 5%).[7] The percentages of doses at the edges (1.0–1.5 cm) for GWXJ80 and Theratron 780 in the air are 75.39–38.66% and 85.65–46.47% respectively and they are 82.22–40.39% and 49.05–24.55% respectively in phantom. The figure-5 quoted from Khan FM[17] shows that 97% dose lies within 60% central part of the field size whereas at the edge the dose level lies between 90% and 50%. Dyk and Battista[18] quoted the sample data in their paper for doses at the beam edges ranging between 80–20% or 90–10%.[19–22] Reda MS *et al*[4] showed that the doses measured at edge points of the treatment area ranges from 25.10–6.22% of doses at mid. For ^{60}Co beam the dose at any depth is higher on the central beam axis and then gradually decreases towards the beam edges[23] and as described by Khan FM.[17]

Figure-1 to figure 4 showed the percentage of doses at different points in the various fields with the mid of the respective fields. The results show that 60% central area of all fields were within realistic limits in air and phantom for GWXJ80 as well as for Theratron 780, which is in the acceptable error range of 5% as recommended by ICRU.[7] The percentages of doses at the edges range between 86% and 25%. It is clear from data as mentioned in table-1 and table-2 that all the doses either in phantom or in the air gradually decreases as the chamber is placed step by step away from the mid of the fields as mentioned in IAEA's book.[23]

In radiotherapy treatment, dosimetry is a very noteworthy aspect as treatment planning is based on the dosimetric data obtained[24] and accuracy in dosimetric parameters is a critical factor in radiation treatment of cancer patients.[2] The present study was initiated to measure and evaluate the radiation doses received by the target organ and the surrounding healthy organs in external radiation treatment.[4] The purpose of this study was not only to measure and evaluate equal distribution of dose to each point within the fields but also measure the doses at the edges. The doses within 60% central area of the fields were in acceptable error range of 5% which offered a realistic uniform doses in that central area and the edges as mentioned in IAEA's book[16] were 86–25%. At the edges of the field, the beam profile is curved and least dose was due to decrease in scattered radiation as described by Starkschall G.[25] and Khan FM.[17]

CONCLUSION

In conclusion, the doses within 60% central area of fields in air were higher than phantom for both teletherapy units. The doses at field edges in air were lower in GWXJ80 than Theratron 780 whereas in phantom they were higher in GWXJ80. Dyk and Battista[18] referred the published model data of Glasgow GL *et al*,[19] Laughlin J *et al*,[20] Rawlinson, J A.[21] and Sasane, JB *et al*[22] in their paper for the doses at the beams' edge between 80–20% or 90–10%. The dosimetry of radiotherapy teletherapy machines must be done in a homogeneous water phantom as suggested by Praveenkumar RD *et al*[2] due to particular dose distribution in target tissues.[24]

Due to insufficient data available for the doses at various points within the fields and the percentage between these points and mid of fields, verification of our results became difficult.

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