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Clinical Audit of Beam Output of Cobalt-60 Teletherapy Unit at AECH-BINOR

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Abstract

Uncontrolled cell development is a hallmark of cancer, a leading cause of death globally. Optimal cancer treatment necessitates the use of multiple methods, including surgery, chemotherapy, and radiation treatment. High-energy radiation in radiotherapy eliminates cancer cells by causing irreparable damage to their DNA (deoxyribonucleic acid). The radiation dose is delivered via a teletherapy unit. Dosimetric quality assurance tests are conducted to ensure accurate and safe radiation delivery. Guidelines for dosimetry are provided by AAPM TG 51 and IAEA TRS 398. We followed the dosimetry protocol of the International Atomic Energy Agency (IAEA) TRS 398. Dosimetry data were collected and evaluated for a period of nine years, beginning in 2014 and ending in 2022. The analysis of dosimetry data from 2014 to 2022 showed that the difference between the measured and calculated dose rate is 1.904 ± 1.41, which is below the IAEA guidelines, i.e., ±2%. The results suggest that dosimetry was in accordance with international protocols. It also reflects that radiation dosimetry is well carried out at BINOR cancer hospital.

Subject Areas

Oncology

Keywords

Clinical Audit, oBeam Output, Cobalt-60 Teletherapy Unit

1. Introduction

Radiation therapy is one of the most important treatments for cancer and can be used alone or in combination with other therapies [1]. The dose of the radiation provided to tumor cells is carefully checked, so that the risk to healthy cells is reduced [2]. Nowadays the Radiation therapies include the use of photons, electrons, protons, and heavy ions to treat cancer in a variety of ways [3]. These different kinds of radiation provide specific benefits and are given using high-energy beams produced by linear accelerators and Co-60 teletherapy equipment [4]. The radiation therapy uses ionizing radiation to specifically target and kill cancer cells. Since linear accelerators can generate photon beams that can travel through tissue and target desired tumors with accuracy, they are often used in radiation treatment [5]. They effectively damage cancer cells while spare the healthy tissue which is the goal of these high-energy photons. Since electron beams have a less depth of penetration than photons, they are particularly well-suited to treat skin cancer and other superficial cancers. Advanced radiation therapies like proton and heavy ion therapy have also several benefits [6]. When compared, to photon or electron radiation treatment, proton treatment is more effective at sparing surrounding healthy tissue and focusing radiation directly on the tumor. Due to this, it is ideal for tumors that are close to vital organs or other delicate tissues [7]. However, charged particles like carbon ions used in heavy ion treatment are more biologically efficient than conventional radiation in killing cancer cells [8]. These heavy ions deposit a large amount of energy into the tumor, killing cells there while sparing healthy tissue. This therapy is particularly effective for treating radio-resistant cancers that may not react well to standard radiation therapies. So, several types of radiation have been used in radiation therapy as a result of their individual benefits in the fight against cancer. Modern radiation therapy methods help to enhance patient outcomes and quality of life during cancer treatment by precisely targeting and destroying malignant cells while preserving healthy tissues. The main goal of radiotherapy is to target and destroy cancer cells while sparing the nearby healthy tissue as much as possible [9]. Accurate radiation dosages can only be determined by monitoring the radiation's emission rate. By carefully adjusting the dose, doctors can maximize therapeutic effectiveness and minimize collateral damage to healthy tissues in the fight against cancer. There is a 2% margin of error for the source dose rate measurement if standard procedures are followed. Other writers have echoed this tolerance. IAEA and ICRU recommend a dosage tolerance of 5%. Tumor dosages may be kept below the ICRU limit by different methods [10]. Dosimetry, as a systematic measure for providing high-quality healthcare, plays an important role in guaranteeing the quality and safety of radiation-producing machines/sources. Following IAEA guidelines, this study aimed to evaluate the depth doses produced by a Co-60 radiotherapy unit operating within a water phantom at 80 cm SSD and a depth of 5 cm. Changing the Source-to-Skin Distance (SSD), depth, and Field Size may be used to examine the variance in absorbed dosage [11]. Since evaluating the level of radiation exposure to patients directly is impractical, water phantoms are used instead. Measurements taken in water may be used as a reasonable approximation of the dosage provided to the patient during therapy, which is why water phantoms are preferred. In the world of medical radiation, the importance of SSD, depth, and world Size in calculating absorbed dose is well acknowledged [12]. Distance from the radiation source to the skin (SSD) is a key factor in determining the delivered radiation intensity and, in turn, the absorbed dose. Equally influential on the dose distribution are differences in depth, or the distance from the radiation source to a particular place inside the patient's body. Additionally, Field Size, which reflects the area irradiated during the treatment, plays a critical role in limiting the absorbed dosage. By adjusting the Field Size, doctors may zero in on the affected spot and spare surrounding healthy tissue as much radiation as possible [13]. However, there are moral and safety considerations that must be taken into account while doing direct depth dosage measurements on patients [14]. As an alternative, water phantoms may be used to simulate the effects of radiation on a patient in a controlled environment. Due to the closeness between water and human tissues in terms of radiation interaction characteristics, reasonable estimates of the therapeutic dosage can be made [12] In conclusion, water phantoms allow medical personnel to better understand and improve radiation therapy treatments, providing safer and more accurate patient care by examining absorbed dose change via SSD, depth, and Field Size adjustments [15]. BINOR Cancer Hospital Bannu is committed to using state-of-the-art research approaches in cancer care and specializes in the diagnosis, treatment, and research of malignant cancers. The radiation department uses a cutting-edge cobalt-60 teletherapy system to provide targeted external beam radiotherapy for a variety of cancers. The goal of this research is to determine whether or not the calculated absolute output dosage of the Co-60 teletherapy equipment at the institution matches the observed absolute output dose over a period of nine years.

2. Methods and Material

The cobalt-60 teletherapy unit installed in BINOR cancer hospital is Theratron's Phoniex manufactured by AECL Canada. The equipment was installed in 2012. The dosimetry has been carried out regularly since the commissioning of the radiotherapy equipment following International Atomic Energy Agency (IAEA) Technical Report Series (TRS) 398 and Pakistan Nuclear Regularity Authority (PNRA) guidelines. The equipment used for the dosimetry is PTW farmer chamber which is regularly calibrated by Secondary Standard Dosimetry Labs (SSLD) in PINSTECH, Islamabad. Additionally, SSDL utilizes advanced dosimetry techniques and top-notch equipment to evaluate radiation beam output annually.

The dose measurements were performed by a PTW 0.6 cc ion chamber (Model 30013) with a Sun Nuclear 1D PC electrometer. Measurements were made in a $30 \times 30 \times 30\ \text{cm}^3$ water phantom at an SSD of 80 cm and a 10 cm depth, using a $10 \times 10\ \text{cm}^2$ field size as per TRS 398. The temperature (Kelivn) and pressure (kPa) were measured using a thermometer and barometer, respectively. For calculating radiation dose in a 1-minute exposure of the beam, the charge (nC) collected by ion chamber was noted for three times to obtain the average charge M.

$$\mathrm{Dm}_{(\text{Measured Dose rate in water})} = M_{(\mathrm{nC/min})} \times \mathrm{NDW}_{(\mathrm{Gy/nC})} \times K_{TP} \tag{1}$$

where M is charge reading measured by electrometer in nano-columb, NDW is the calibration factor provided by SSDL for standard measurements and K_{TP} is the temperature pressure correction factor calculated by:

$$K_{TP} = (273.3 + T)/(273.3 + 22)$$

Theoretical dose was calculated using exponential decay formula:

$$\dot{D} = \dot{D}_{(\mathrm{SSDL})} \mathrm{e}^{(-\lambda t)} \tag{2}$$

The percentage difference between theoretically calculated and measured was obtained using relation:

$$\text{Percentage Difference} = 100 \times (\mathrm{Dcal} - \mathrm{Dm})/\mathrm{Dcal} \tag{3}$$

The dosimetry values are recorded and maintained. The data from last nine years were analyzed using Microsoft Excel and statistical tests were performed using SPSS V21.

3. Results and Discussion

The research was conducted at Atomic Energy Commission Hospital, BINOR, located in Bannu, KPK Pakistan. Ensuring safe radiation treatment, the dosimetry of a teletherapy unit is a crucial quality assurance procedure.

The comprehensive nine-year evaluation of dosimetry demonstrated a remarkable regularity in the data, with the comparison between the observed and estimated dose rates consistently showing a difference below ±2%, in accordance with the standards established by AAPM TG 40 [16]. The data comparison given in **Figure 1**, which shows the data organized by year, highlights the consistent and accurate dosimetry readings across time. The slight discrepancy detected between the measured and estimated values is significant, given the important function that dosimetry plays in the accurate treatment of cancer patients. The yearly mean discrepancy in dosimetry measurements, (1.904 ± 1.41), confirms the precision of the equipment calibration and the careful implementation of correction factors at the site. In addition, the examination of the decay of the Cobalt-60 source, as shown in **Figure 1**, demonstrates an exponential decay that aligns with predicted outcomes, with an annual percentage error falling within the permissible range of 2%. The data shown in **Figure 1** visually represents nine years' worth of data, while the percentage disparity analysis in **Figure 2** offers a full assessment of the consistency and accuracy of absorbed dose measurements. This is in line with the guidelines of AAPM TG 40, which put forward monthly verification of dosage from a Cobalt-60 machine, allowing for a maximum variation of 2% from the expected dose.

Figure 1. Yearly dosimetry data.

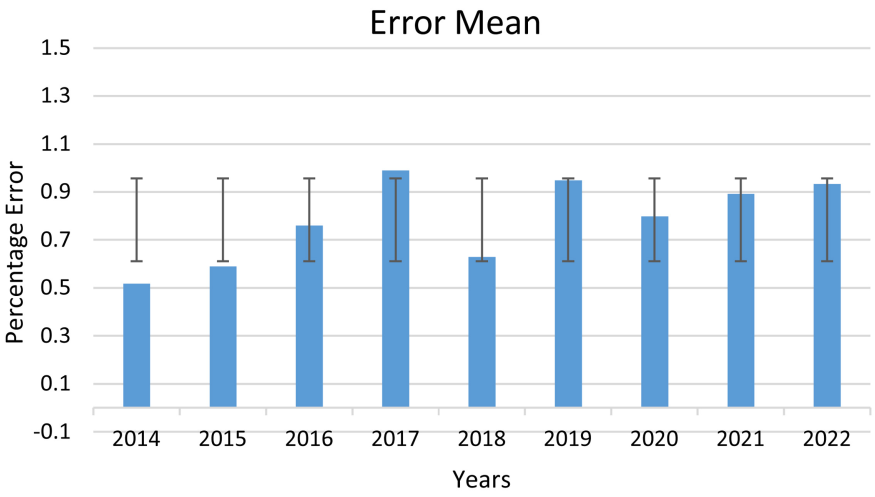

Figure 2. Percentage error yearly.

4. Conclusion

For the last nine years, we have been keeping track of the discrepancy between the doses that were absorbed and those that were estimated as part of our dosage verification process for the Co-60 teletherapy system. It has been determined that, in accordance with international guidelines, the results show that discrepancy between the estimated and measured dosages has consistently 1.904 ± 1.41 which is remained under 2%. We may also reasonably assume that the dosage given to patients is the same as what the oncologist prescribed.

Conflicts of Interest

The authors declare no conflicts of interest.

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List of Abbreviations

IAEA	International Atomic Energy Agency
TRS	Technical report Series
SSLD	Secondry Source Dosimetry Labs
SSD	Source to Surface Distance
ICRU	International Commission on Radiation Units and Meaurements
BINOR	Bannu Intitute of Nuclear Medicine, Oncology and Radiotherpy
AAPM	American Association of Physicists in Medicine