FAMPO
FEDERATION OF AFRICAN MEDICAL PHYSICS ORGANIZATIONS

African Journal of Medical Physics
2019; 2(1): 5-9. doi: 10.

Research Paper

Participation in IAEA/WHO TLD Postal Dose Audit Programme: A Voice from Nepal

Chaurasia P. P.✉ , Chand S. B., Adhikari M. P. and Yadav R. N.

Department of Radiation Oncology, B. P. Koirala Memorial Cancer Hospital (BPKMCH), Bharatpur, Chitawan, Nepal.

✉ Corresponding author: Pradumna P. Chaurasia, Department of Radiation Oncology, B. P. Koirala Memorial Cancer Hospital (BPKMCH), Bharatpur, Chitawan, Nepal. Tel: 255766045947; E-mail: pradumnachaurasia@gmail.com

ISSN 2643-5977

Received: 2019.06.20; Accepted: 2019.08.09; Published: 2019.09.01

Abstract

The study determined the variation across the measured output dose of Cobalt-60 and linear accelerator photon beams using IAEA postal TLD. The megavoltage beams of Cobalt -60, 1.25 MEV , Varian 600 C/D , 6MV and Varian 2300 C/D, 6 MV and 20 MV clinically calculated 2Gray dose is delivered to TLDs in 10cm depth in water phantom in a 10cmx10cm field center following the SSD technique from 2007 to 2015 . The results of postal TLD irradiation mean dose with standard deviation 2.056±0.043, 2.018±0.040, 2.056 ± 0.041 and 2.04±0.056 respectively in a total of 18 runs performed against machine output variation was checked and adjusted. Audit was directly effective in identifying the problem and in rectifying new Cobalt 60 output dose. The TLD postal dose audits indicated high levels of accuracy of dose determination in audited Radiotherapy (RT) beams in subsequent audit runs in B. P. Koirala Memorial Cancer Hospital (BPKMCH). It is assured that the basic dose calibration is accurate and within tolerance here to treat patients with more confidence.

Keywords: External beam radiotherapy; Beam calibration; External quality audit; Thermoluminescence

Introduction

The radiation oncology department of BPKMCH is the nucleus of therapeutic radiology in Nepal with two linear accelerators with 6 MV photons and a dual energy with 6 MV and 20 MV photons and a number of electron beams ranging from 6 to 22 MeV along with an elite -100 Tele Cobalt -60 machine with 1.25 MeV gamma rays providing safe and effective treatment of cancer patients since 2002.

It became increasingly obvious to medical physicists and radiation oncologists that clear and consistent methods of measuring, describing, prescribing and reporting dose were necessary so that radiation treatments could be accurately delivered and clinical experience from treatment could be shared based on agreed approaches to quantifying the amount of radiation given (so that radiation protection could be carefully quantified for safe control of radiation environments) [1]. This leads to a range of fundamental developments that support our dosimetry practice today. The establishment of radiation dosimetry standards and eventually the current extensive and interlinked worldwide primary and Secondary Standard Dosimetry Laboratory (SSDL) network supported by IAEA/WHO, underpins the dissemination of consistent dosimetry to all radiotherapy centers. Dosimetry protocols (or code of practice) to standardize the theoretical framework and the practical methods are used to transfer from dose standards to each RT center and to provide recommendation on instrumentation measurement corrections and other data required.

It is intended to ensure as far as is reasonably achievable a high degree of accuracy , precision , reliability and reproducibility in radiation dose as delivered to patients, which is necessary to ensure safe and high quality treatment and optimized outcome of each patient. The error resulted in the overdosing of 207 RT patients in the UK due to the mis-calibration of a new cobalt -60 treatment unit detected by a national audit [2].

The overall accuracy in radiation dose delivered to the dose specification point in the patient is generally recommended to be within ±5% or so of prescription at the 95% confidence level [3]. These recommendations are for the end RT process (i.e. for the treatment as delivered to the patient). Therefore, in each of the many steps of the complex dosimetry chain and RT process that contribute to its final accuracy, corresponding smaller values are required such that when all are combined, the overall accuracy is met. This means that detailed and continuing Quality Assurance (QA) of every component is necessary in order to achieve the required level of accuracy and maintain it consistently. Ongoing QA is also necessary to minimize the possibility of accidental exposure (radiation incidents or dose misadministration). This is particularly important for RT, as it is a high dose and therefore potentially high-risk procedure, in which an overdose can cause significant damage to organ and tissues. There are many set of recommendations on QA of equipment, process, etc. from national and international bodies coming together as part of the recommendations to establish comprehensive QA programmers to cover all of the steps from treatment decision and prescription right up to dose delivery and follow-up. Independent external quality audit is clearly recognized as part of this effective method of checking that the quality and accuracy of activities in an individual institution is stable for achieving the required objective. The first external audit in radiotherapy was specifically on dosimetry and it is fair to say that the concepts of audits in RT have largely developed out of long standing medical physics audits .The service is cost free to participants. The aim of this study is to determine the variation across the measured output dose of megavoltage Cobalt-60 and linear accelerator photon beams in RT.

Materials and Methods

A simple and worldwide method for checking the RT beam calibration is by using thermoluminescant dosimeters [3] polyethylene capsules (3mm inner diameter, 20mm inner length and (1 mm wall thickness) filled with about 160 mg of lithium – fluoride powder as dosimeters. LiF, as thermo luminescent material is usually chosen considering its effective atomic number (Zeff, LiF=8.14) which makes it close to tissue equivalent (Zeff, tissue =7.42) for high energy beams used in RT. The choice of powdered TL material instead of solid chips or rods is justified by the great precision that must be reached (a precision of better than ± 2% (1sd) on the measured dose ;it requires a standard deviation of the TL reading of ± 1.5 or less [4]. The specification of treatment machines, calibration based on IAEA TRS 398 protocol for reference dose measurements and details are recorded in IAEA form.

Clinically calculated time or monitor units for 2 Gray dose is delivered to TLD inside a holder in a water phantom 30cmx30cmx30cm and 10cmx10cmfield opening at SSD 100 cm at 10cm depth and machine gantry angle 0° collimator 0°. TLDs irradiated in BPKMCH are sent by post to IAEA laboratory for results.

Figure 1. **IAEA stand holder.**

Figure 2. **TLD capsules.**

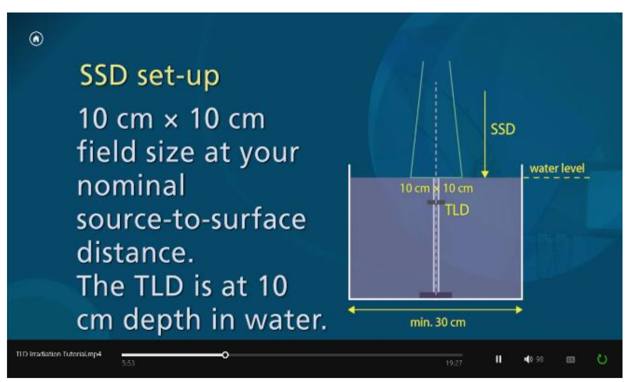

Figure 3. **Set up for irradiation.**

Results

A relative deviation with negative (positive) sign indicated that the user estimated lower (higher) dose than what is measured, a patient would therefore receive higher (lower) dose than what is intended as expressed by the factor given in last column.

A table of results of postal TLD irradiation tests from 2007 to 2015 of Cobalt-60, 6MV photon of Varian 600 C/D and 6 MV photon and 20 MV photon beams 2300 C/D machines, mean dose (standard deviation 2.056± 0.043, 2.018± 0.040, 2.056± 0.041 and 2.04±0.056) respectively in a total of 18 runs performed against machine output variations checked and adjusted.

Discussion

The results in Table 1 for the Cobalt-60 machine beam of new source output dose audit result in 2013 was -5.1% which was out of the tolerance for clinical use so it was repeated urgently with re-irradiation in 2014 with result -1.4%, accurate and acceptable for clinical use.

We investigated our fault in exposure time calculation in 2013 for the cobalt-60 beam. We included a 0.01minute shutter error correction time in output measurement so it is not required to add in the exposure time calculation.

Like other centers, audits have been effective in identifying problems in practice, bringing demand concerns about providing support to find the source of the problems to our attention, therefore rectifying them. Audits have improved practice and the accuracy of dosimetry in a wide range of radiotherapy centers. Audits can reduce the likelihood of accidents and errors occurring or continuing by identifying underlying problems thereby reducing their consequences for patient treatment. It provides independent assessments of methods, procedures, process and data by verifying effectiveness and performances of the overall approach.

Audits help in reducing uncertainties and in increasing the precision and consistency of radiotherapy dosimetry between centers. It improves with practice overtime and it helps in maintaining that i.e., it is the experience of all reported audit systems that better performance (i.e. more centers complying with the required tolerance) is measured at later audits than in the earlier rounds the performance of an individual center is improved at a second audit [5] . This is partly because errors identified earlier are rectified and partly because audits give an impetus to departments to focus on quality and performance in a way that continues to deliver benefits. Audit can also provide support and confidence for the introduction of new and complex processes and technologies. Whilst treatments that are more complex can provide more focused RT treatment, at the same time they require more complex QA and have the scope for additional problem to arise. Since the results are within the acceptance limit of 5%, the next participation is recommended after two years. Institutions with results outside the 5% acceptance limit are provided with a second follow-up TLD for immediate repeat irradiation. If the second TLD result is still not acceptable, an expert visit is recommended to resolve the discrepancy and the next participation is recommended for one year later.

The Radiological Physics Center (RPC) provide credentialing for advanced technology clinical trials using mailing anthropomorphic phantoms to verify tumor dose delivery for Stereotactic Radio Surgery (SRS) and Intensity Modulated Radiation Therapy (IMRT) . Their criteria to evaluate the measurements , the ratio of measured dose to institution s' stated dose was expected to agree within 7% .The distance to agreement in the high –dose gradient region near the organ at risk (OAR) was expected to be no greater than 4mm . Only 66% of first time irradiations passed the criteria [6].

Planning a national dosimetry audit in Nepal will be more labour and cost effective than remote audits with TLDs. TLD postal irradiation should be used for spot checks following major repair of treatment units, Co-60 source replacements, unusual patient skin reactions and other important reasons. All RT centers in Nepal participate in postal TLD audits. This year completes 50 years of IAEA /WHO Postal dose audits improving RT [7].

In 2017, the IAEA dosimetry laboratory phased out its aging TLD systems and upgraded the lab equipment by acquiring new Radio photoluminescence dosimetry (RPLD) system using glass dosimeter [8-9]. Dose audit is important for harmonizing quality assurance for RT in clinical trials [10].

Table 1. Result of TLD measurements for Co-60

Year	Beams	User stated Dose (Gy)	IAEA measured dose Gy.	IAEA mean	% deviation relative to mean dose	IAEA Mean dose/stated dose
2007	Co-60	2 .00	2.04, 2.03	2.04	-1.8	1.02
2009	Co-60	2.00	1.98, 2.03	2.00	0.0	1.00
2011	Co-60	2.00	2.10, 2.10	2.10	-4.8	1.05
2013	Co-60	2.00	2.08, 2.13	2.11	-5.1*	1.05
2014	Co-60	2.00	2.04, 2.01	2.03	-1.4	1.01
2015	Co-60	2.00	2.06, 2.07	2.06	-3.0	1.03

Table 2. Result of TLD measurements for 600 C/D

Year	Beams	User stated Dose (Gy)	IAEA measured dose Gy.	IAEA mean	% deviation relative to mean dose	IAEA Mean dose/stated dose
2007	6MV	2.00	2.06, 2.04	2.05	-2.5	1.03
2009	6MV	2.00	2.04, 1.97	2.00	-0.1	1.00
2011	6MV	2.00	1.98, 2.02	2.00	0.1	1.00
2013	6MV	2.00	2.05, 2.08	2.07	3. 03	1.03
2015	6MV	2.00	1.97, 1.98	1.97	1.4	0.99

Table 3. Result of TLD measurements for 2300 C/D

Year	Beams	User stated Dose (Gy)	IAEA measured dose Gy.	IAEA mean	% deviation relative to mean dose	IAEA Mean dose/stated dose
2007	6MV	2.00	1.99, 2.03	2.01	-0.4	1.00
2009	6MV	2.00	2.08, 2.08	2.08	-3.7	1.04
2011	6MV	2.00	2.11, 2.08	2.10	-4.6	1.05
2013	6MV	2.00	2.05, 2.08	2.07	-3.3	1.03
2015	6MV	2.00	2.00, 2.04	2.02	-1.0	1.01

Conclusions

The results of the TLD postal dose audits indicated high levels of accuracy of dose determination in audited radiotherapy beams in subsequent audit runs in BPKMCH. It is assured that the basic dose calibration is accurate and within tolerance here to treat patients with more confidence and the patients are being treated safely. Its importance and impact is clearly recognized and its encouragement of and links to other wider radiotherapy audits has been significant. As the complexity of radiotherapy develops the scope of what can be included in dosimetry and wider radiotherapy quality audits also needs to continue to increase.

Abbreviations

SSDL: Secondary Standard Dosimetry Laboratory; TLD: Thermoluminescent dosimeter; QA: Quality Assurance.

Acknowledgments

We wish to thank Dr. Joanna Izewska, PhD head dosimetry laboratory, Dosimetry and Medical Radiation Physics Section (DMRP), Division of Human Health, IAEA, Vienna, Austria for her encouragement to perform dose quality audit and supply TLD regularly. We would also like to thank Dr. A.K. Jha, head of Radiation Oncology of BPKMCH.

Author Contributions

C. P. P. and C. S. B. designed the study. C. P. P., A. M. P. and Y. R. N. performed the implantation surgeries and collected data. C. P. P. and C. S. B. analyzed the data and wrote the manuscript. All authors gave their final approval.

Competing Interests

The authors have declared that no competing interest exists.

References

[1] Leer, J. W. H., McKenzie, A., Scalliet, P., & Thwaites, D. I. (1998). *Practical Guidelines for the Implementation of a Quality System in Radiotherapy: A Project of the ESTRO Quality Assurance Committee Sponsored by" Europe against Cancer"*. ESTRO.

[2] Thwaites, D. I., Williams, J. R., Aird, E. G., Klevenhagen, S. C., & Williams, P. C. (1992). A dosimetric intercomparison of megavoltage photon beams in UK radiotherapy centres. *Physics in Medicine & Biology*, *37*(2), 445.

[3] Van Dyk, J., Healy, B., Zubizarreta, E., Izewska, J., Mijnheer, B., & Meghzifene, A. (2016). Accuracy requirements and uncertainties in radiotherapy: a report of the International Atomic Energy Agency.

[4] Izewska, J., Novotny, J., Van Dam, J., Dutreix, A., & Van der Schueren, E. (1996). The influence of the IAEA standard holder on dose evaluated from TLD samples. *Physics in Medicine & Biology*, *41*(3), 465.

[5] Izewska, J., Azangwe, G., & Bera, P. (2010). 40 Years of the IAEA/WHO TLD Postal Dose Audits for Radiotherapy.

[6] Ibbott, G., Followill, D., Molineu, A., Alvarez, P., & Hernandez, N. (2006). *Experience gained from the RPC's credentialing programmes for advanced technology clinical trials* (No. IAEA-CN--146).

[7] Izewska, J., Bokulic, T., Kazantsev, P., & Wesolowska P. (2019). 50 years of the IAEA/WHO postal dose audits for radiotherapy. SSDL Newsletter, No 70. https://www-pub.iaea.org/MTCD/Publications/PDF/Newsletters/ssdl-70.pdf

[8] Wesolowska, P. E., Cole, A., Santos, T., Bokulic, T., Kazantsev, P., & Izewska, J. (2017). Characterization of three solid state dosimetry systems for use in high energy photon dosimetry audits in radiotherapy. *Radiation Measurements*, *106*, 556-562.

[9] Clark, C. H., Hurkmans, C. W., Kry, S. F., of Radiation, T. G. Q. A., & Group, T. C. T. H. (2017). The role of dosimetry audit in lung SBRT multi-centre clinical trials. *Physica Medica*, *44*, 171-176.