**Dosimetric Audits of Photon Beams in Radiation Therapy Centres**

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**Abstract.** Data related to eleven years of high-energy photon radiotherapy beams dosimetry are presented and analyzed. Dosimetric evaluations were carried out using water phantoms and thimble ionization chambers. Measurements were done at reference conditions for a standard absorbed dose of 100 cGy. The first dosimetry surveys from 1996 to 1998 showed deviations of 22% and 18.7%, although small deviations were also obtained. After 1998 the improvement of dosimetry quality control by the radiotherapy centers became clear, with most of the deviations situated within the ±3% range.

**Introduction**

The need for dosimetric accuracy in radiotherapy is well accepted by medical physicists and illustrated by the steepness of clinical dose effect curves [1]. Consistency and accuracy in dose calibration are necessary in order to minimize potentially significant clinical consequences [2]. In teletherapy, programs of dosimetry quality assurance are very important to verify whether the therapeutic beam dosimetry is in conformity to national standards or recommendations. This procedure shall consider the conformity with standards and even the intercomparison of dosimetric procedures and detectors performances [3].

The Brazilian Regulatory Organization, National Commission of Nuclear Energy (CNEN), is responsible for the licensing and control of nuclear and radiation installations, including radiation medicine facilities, through an inspection program carried out on a two-years interval basis considering Brazilian regulations, mainly those related directly to radiation protection and radiotherapy issues [4,5]. As an auditing item, dosimetric measurements of the therapeutic beam have been performed and technical reports generated by these evaluations have been usually considered in the licensing process.

In Rio de Janeiro, one of twenty-six states of federative republic of Brazil, there are presently twenty-six radiotherapy centers operating twenty-four clinical electron linear accelerators (LINAC) and eleven 60Co therapy units. In this work data of eleven years of high-energy photon radiotherapy beams dosimetry, obtained during on-site dosimetric audits in Rio de Janeiro radiotherapy centers, are presented and analyzed.

1. **Methodology**

Inspections considered the dosimetry of high-energy radiotherapy photon beams according to the IAEA dosimetry protocol TRS-277 [5] and TRS-398 [4].

Regarding dosimetry evaluation, inspectors follow the steps during on-site audits: the radiotherapy centre medical physicist is requested to set up experimental conditions in such a way that a specific radiation field should be delivered to an ionization chamber at reference conditions. The medical physicist is also requested to calculate the time or monitor units necessary to deliver an absorbed-dose-to-water value of 100 cGy to the point respective to the geometric centre of the sensitive volume of the ionization chamber. A set of measurements is acquired and their mean value, *DM*, is considered.

The percent deviation, δ, between the requested absorbed dose value, *DR*, and the measured absorbed dose value, *DM*, is calculated by

An acceptable absolute percent deviation should not be higher than 3%. This tolerance level has been adopted taking into account all sources of errors; so as the total deviation between the prescribed and administrated radio-therapeutic doses should be in between ±5% [6].

1. **Results**

The percent deviations are presented in Fig. 1 (panels from 1997 to 2006), indicating an improvement on the beam control process. The first dosimetry surveys carried out in 1996 showed a situation that was, unquestionably, an object of concern. The smallest value of δ measured was 3%. The dosimetry of a 6 MV therapeutic beam presented a deviation of -18.7% (FIG. 1). Many reasons can possibly explain those undesirable results. Among them, it was observed that:

1. Some clinical dosimeters were not calibrated according to the regulation frequency (2 years) [5], being by any reason with a wrong calibration factor;
2. Radiotherapy staff were not aware of the necessity of performing regular checks in the instruments as well as of performing beam dosimetry with the desired frequency[7];
3. Sometimes medical physicists did not carry out the dosimetry quality control tests or they carried out them inappropriately.

The situation observed in 1997 and 1998 showed a significant improvement when compared to that one existing in 1996. Aside from a single linear accelerator, where a deviation of -9.5% was observed, for all other equipments the absolute value of dosimetry deviations varied between 0.47 and 2%. However, in the case of 60Co units, no improvement was detected and even an unacceptable dosimetry deviation value of -22% was measured.

After 1999 the improvement of dosimetry QA became clear. Deviations decreased, and from 2001 up to now results pointed to a concentration of values in the range from -3% to +3%.

*FIG. 1. Percentual deviation for linear accelerator (bullets) and 60Co irradiator (squares) equipments. Gray area displays the tolerance region for dosimetry values.*

FIG. 2-a shows the δ annual average absolute values, Δ, plotted as a function of the correspondent year of investigation. While at the beginning of the program Δ was around 8%, nowadays it is inside the tolerance level of 3%. Error bars represent the standard deviation from the mean value. Even the error bars are smaller asserting that δ's values are more concentrated around the mean value for recent years. Also, one can observe that most of the results (years 2001, 2002, 2003 and 2005) are inside the 2% level.

For the sake of completeness, the correlation between the last evaluated absolute percent deviation, |δ|, and the number of audits for each equipment is shown in FIG. 2-b. The large deviations observed for several equipments which have been under only one audit does not persist for equipments with several audits. This is a clear evidence that subsequent audits are fundamental to keep radiation medicine installations under control and to enhance the effectiveness of the patient treatment.

1. **Summary and Conclusions**

The dosimetric quality control of high-energy photon beams in Rio de Janeiro radiotherapy centers presented effective results, contributing to the enhancement of the effectiveness of the radiation treatment conditions. Additionally, since 1996 all twenty-six radiotherapy centers operating in Rio de Janeiro state were audited. Fifteen presented, at least once, dosimetry deviations higher than ±3%. Among them, in nine centers persisting deviations occurred including one centre that showed deviations out of the acceptable threshold of 3% in four of the six audits performed. The license of this centre was revoked by CNEN.

*FIG. 2. Absolute average annual percent deviation, Δ, for linear accelerator and 60Co irradiator equipments displayed as a function of the year of investigation (part-a). Error bars represent the standard deviation relative to mean values. In (b) the last evaluated absolute dosimetry deviation, |δ|, is displayed as a function of the number of audits.*

As a final conclusion, results suggests that Brazilian radiation therapy centers achieved a high level of beam control, so one can decrease the tolerance level in order to enhance the accuracy of the dose delivered to patient during treatment.

1. **References**

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