Status of ionization chambers calibration for radiation therapy in Brazil

To cite this article: M. Gonçalves et al 2018 J. Phys.: Conf. Ser. 975 012065

View the article online for updates and enhancements.
Status of ionization chambers calibration for radiation therapy in Brazil

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Abstract. CNEN makes a constant effort to keep updated with international standards and national needs to strengthen the radiological protection status of the country. The guidelines related to radiation treatment facilities have been revised in the last five years in order to take in consideration the most relevant aspects of the growing technology as well as to mitigate the accidents or incidents observed in practice. Hence, clinical dosimeters have gained special importance as significant items in Brazilian regulation. In the present work we discuss the importance of inspections from the point of view of equipment dosimetry and instruments quality control. The dosimeter sets based on thimble and well ionization chambers need periodic calibration, and this calibration becomes a fundamental task in order to guarantee the dose prescribed-delivered to patients.

Thus Brazilian guidelines enforce the need of at least two sets of clinical dosimeters with thimble chambers calibrated and one set of electrometer with well ionization chamber for hdr equipment. We call attention to the fact that inspections are a very valuable tool in order to enforce the application of guidelines around the country both by enlightening the weaker aspects
of facilities concerning radiological protection and by stating in loco that reasons which lead the regulatory body to enforce such guidelines items.

\textit{Pacs:} 87.62.+n, 87.90.+y, 87.52.Tr, 87.53.Dq, 87.58.Sp

\textit{Keywords:} Therapeutic Beam, Ionization Chambers, Regulatory Body, Inspections, Calibration Laboratory

1. Introduction

According to Brazilian law, all radiation therapy facilities must be regulated in terms of taxes and licensing processes. This regulation takes place through document analysis and in loco inspections performed by a small group of inspectors of Brazilian regulatory body (CNEN) in the last 20 years. Besides conforming all facilities to a required standard of radiation protection, this regulation also provides national global data which could elucidate the importance of the normatization (guides, norms and laws) to the overall process. Thus, these data offer a national panorama and help on deciding whether the current guidelines have been taken properly or not.

CNEN makes a constant effort to keep updated with international standards and national needs to strengthen the radiological protection status of the country. The guidelines related to radiation treatment facilities have been revised in the last five years in order to take in consideration the most relevant aspects of the growing technology as well as to mitigate the accidents or incidents observed in practice.

Hence, clinical dosimeters have gained special importance as significant items in Brazilian regulation. Three years ago the guidelines changed to include as an obligation, for every radiation therapy facility, the need of two calibrated sets of thimble ion chamber and electrometer for clinical dosimeter for photon beams dosimetry and one calibrated well-chamber for high dose rate brachytherapy equipment.

In the present work we show the status of the calibration of these instruments observed during
inspections, as an attempt to evaluate the effectiveness of the guidelines and to investigated whether other actions are needed to guarantee the precision in the dose delivered to patients.

This investigatory aspect of CNENs inspection program has already shown effective, allowing actions by the regulatory body in terms of local and national perspectives [1, 2, 3]. With these data, guidelines may be updated for ionization Chambers Calibration for Radiation Therapy in Brazil conforming to the real national panorama. Results are sufficient to represent the global status and help in making the profile of Brazilian facilities.

2. Methodology

In the last five years inspectors from CNEN have evaluated dosimetric systems of 168 radiation therapy facilities all over the country. We performed a retrospective analysis of the 168 inspection reports, focusing on the following items: a) if the facility had two sets of thimble ion chamber plus electrometer; b) if both sets have a calibration certificate; and c) if the facility treating patients with HDR had a well-chamber calibration certificate. Some aspects were considered: the calibration certificates must be emitted from an accredited Brazilian Laboratory, and it is valid for two years.

At the end of the inspection, inspectors have a form listing instruments which presented a valid calibration certificate or not. This form is shown in Figure 1 and the whole set of forms gathered by inspectors in a period constitutes our database here discussed. With this database we can classify facilities by year, region, province/state, number of equipment, treatment modality and so on. Here we concentrate our attention on the validity of dosimetric instruments and only evaluate whether the guidelines are being accomplished by facilities in the Brazilian territory.

3. Results and Discussion

In order to understand the Brazilian radiation therapy profile, we firstly display results dependent on the region: North, North-East, South, South-East and Center-West. North and
Figure 1. Form employed by inspectors to gather information about clinical dosimeter set.

For the sake of simplicity, the most valuable information presented here is the name of the calibration laboratory (IRD or IPEN in Brazil) and the date of calibration.

Center-West are less populated and have just a few facilities. South and North-East are the intermediary cases between North and South-East.

Considering the total number of inspections analyzed in the current study, we display their proportion by region in Figure 2. We notice that the great majority was located in the South-East region, the most developed region in Brazil. This region counts with roughly 60% of all analyzed facilities and, since laboratories are also located in this region, we expect that these facilities reach laboratories easier than more distant facilities, such as those in the North and Center-West regions.

This distribution has two causes to be mentioned here. Firstly, it represents the real panorama in Brazil, i.e., most of facilities are located in South-East region and the inspection program shall be homogeneous covering all facilities in a period of two years. Secondly, due to this concentration in the South-East region, and since some of these inspections have also been motivated by other reasons such as re-reinforcements, we expect a kind of double counting of
Figure 2. Distribution of facilities in the present analysis. In a total of 168 inspections, 96 were performed in the South-East region, 30 in the South region, 27 in the North-East region, 8 in the North region and 7 in the Center-West region. Some facilities.

Concerning thimble ionization chambers, in Figure 3 we show the sum of all facilities with one or none calibrated dosimeter and facilities which meet the regulation with at least two clinical dosimeters calibrated. We expected that for the year of 2015 we could get an inversion of bars Yes/No, since the guidelines changed in 2014 and facilities had two years to comply with the regulation. However, since that was not the case, all those facilities received a notification by CNEN and some of them had their activities discontinued for a while until they achieve the minimum requirements for operation.

Some facilities argued that both laboratories of calibration presented no schedule for their clinical dosimeters. Thus in 2016 CNEN started an approximation to laboratories in an attempt to improve or enlarge the schedule window. This turned out to be a controversial theme since laboratory directors kindly presented their Ionization Chambers Calibration for Radiation Therapy schedules and we observe some room for calibration of several instruments. We finally understood this issue seemed to rely on some kind of miscommunication between facilities and laboratories. Also, in 2016 CNEN started a new strategy during inspections enforcing that facilities contact laboratories to schedule their calibration. The effects of that action are expected
Figure 3. Number of clinical dosimeters with valid (Yes) and out-of-date (No) calibration certificates distributed by region for the period 2012–2015. The number of instruments with out-of-date certificates is large even after the guidelines have changed to be seen in 2017 and 2018.

Another important issue observed in inspection relates to well ionization chambers used for dose control of equipment of high dose rate brachytherapy [4, 5]. Differently of thimble ionization chambers, the sole calibration laboratory for that kind of chamber only started its activities in 2014, roughly at the same time the regulatory body changed the guidelines to include the need of calibration of this kind of chamber.

Before 2014 CNEN accepted that foreign laboratories could perform the calibration of well chamber and most of facilities in the country bought their set with a first calibration certificate endorsed by the manufacturer. However, after that no other calibrations were performed and
Figure 4. Total number of well chambers calibrated or not in the 2012–2015 period. The regulatory need to present a valid certificate for these chambers was only introduced in 2014. Inspectors did not point that as a non-conformity since it was not a regulation item, resulting in a lack of data before 2014. After that, inspectors began to observe the well chamber calibration as an inspection aspect and data became more reliable. Figure 4 shows results for the period from 2012 up to 2015 in terms of the presence of a valid calibration certificate for the well chambers in facilities.

We clearly note there was an increment in the number of calibrated equipment after 2014 as a consequence of the regulatory need for this calibration and the appearing of the first calibration laboratory. However, this number is still not sufficient since the majority of the facilities did not enroll with the national calibration process. It is a clear fact that the regulatory body, mainly through inspections, must act together with those facilities to strengthen the dosimetry...
for HDR equipment. Unlike the situation observed for thimble chambers, we did not observe any complaint in respect to the well chamber calibration laboratory and it seemed to the regulatory body that facilities had not understood the need of calibration of their HDR dosimetry system.

4. Summary and Conclusions

In the present work we discuss the importance of inspections from the point of view of equipment dosimetry and instruments quality control. The dosimeter sets based on thimble and well chambers need periodic calibration, and this calibration becomes a fundamental task in order to guarantee the accuracy of prescribed-delivered dose to patients. Brazilian guidelines changed in 2014 to enforce the need of at least two sets of calibrated clinical dosimeters with thimble chambers and one set of calibrated electrometer with well ionization chamber for HDR equipment.

Data analysis up to 2015 showed that Brazilian radiation therapy facilities are far from accomplishing the regulatory needs, in spite of there being two calibration laboratories for thimble ionization chambers and one calibration laboratory for well chambers available in the national territory. New efforts should be made by the regulatory body in order to enhance the strength of dosimetric levels in this aspect and also in accelerating the communication between facilities and laboratories.

Concerning well chambers, results have shown a different and better perspective than that for thimble chambers. Up to now there is only a calibration laboratory in the country (in Rio de Janeiro, south-east region) available to perform calibration of more than a hundred well chambers. However we observed that the number of calibrated well chambers is increasing from 2014 to the present moment, not just to accomplish the regulation but also as an awareness of the need of a precise determination of the dose delivered to patients during brachytherapy treatments.

As a final conclusion we call attention to the fact that inspections are a very valuable tool
in order to enforce the application of guidelines around the country both by enlightening the weaker aspects of facilities concerning radiological protection and by stating in loco those reasons which lead the regulatory body to enforce such guidelines items. Thus, although results have not shown a perfect effectiveness of the inspection program, they may be interpreted as an improvement in the status of radiological protection in Brazil. For those facilities which still do not comply strongly with the regulation, the regulatory body shall find new ways of bringing them to attention, clarifying the necessity of guidelines to ensure that all patient treatments are performed in the country with the highest level of precision, accuracy, quality and safety.

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