



Determination of the influence factors of the radiopharmaceutical vials dimensions used for activimeter calibration at IPEN

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ARTICLE INFO

Available online 22 September 2011

Keywords:

Activimeters
Nuclear medicine
Correction factors for the geometry
Quality control program

ABSTRACT

This paper presents the establishment of a quality control program and correction factors for the geometry of the vials used for distribution of radiopharmaceutical and activimeters calibration. The radiopharmaceutical produced by IPEN ^{67}Ga , ^{131}I , ^{201}Tl and $^{99\text{m}}\text{Tc}$ had been tested using two different vials. Results show a maximum variation of 22% for ^{201}Tl , and the minimum variation was 2.98% for ^{131}I . The correction factors must be incorporated in the routine calibration of the activimeters.

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1. Introduction

The efficiency and safety of the nuclear medicine practice depend, among other factors, on a quality control program, mainly related to the use of the nuclide activity meters (activimeter; International Atomic Energy Agency, 2006; Laboratoire National Henri Becquerel, 2006; Siegel, 2001). Some of the most important sources of errors in the activimeter measurements is the thickness, size and volume of the vial that contains the radiopharmaceutical considering that a typical activimeter has its response dependent on the vial used (National Physical Laboratory, 2006). The objective of this work was to establish a quality control program and the correction factors for the geometry of the vials used for distribution of radiopharmaceutical and activimeters calibration. The Calibration Laboratory of Instruments (LCI) of the Instituto de Pesquisas Energéticas e Nucleares (IPEN) has a NPL-CRC Secondary Standard Radionuclide Calibrator System, manufactured for the Southern Scientific plc, a compound well type ionization chamber and a current measurement system traceable to National Physical Laboratory (NPL). This reference system was calibrated with P6 type vials of different dimensions of the one used for the IPEN. This instrument is used to calibrate the activimeters used by the IPEN radiopharmaceutical production department as well as the ones used by some nuclear medicine services in São Paulo (Costa, 1999; Costa and Caldas, 2003).

Until the year 2000 the National Physical Laboratory used the P6 type vials to calibrate the secondary standard activimeters. After that, this type of vial was replaced by the 10R type, with different dimensions. Studies show a difference of 10% using these 2 vials, making the NPL to determine correction factors to its main

reference instruments for calibration and recommended that all traceable laboratories shall apply those corrections (Baker, 2005). However, the P6 and 10R vials used by the IPEN radiopharmaceutical production department have different dimensions and the correction factors presented by the NPL cannot be directly applied.

2. Materials and methods

2.1. Intercomparisons activimeters

In this study the work standard of the Calibration Laboratory of the IPEN (LCI) was utilized, which is a tertiary standard well type ionization chamber (activimeter). This Capintec basic CRC[®]-15BT standard system consists of a display unit and a well type ionization chamber, series 180020, calibrated at the Accredited Dosimetry Calibration Laboratory of the Medical Radiation Research Center—University of Wisconsin. This laboratory is traceable to the National Institute of Standard and Technology (NIST).

2.2. Vials characterization

The vials used in this study are shown in Fig. 1. Their dimensions are presented in Table 1. The vials have been identified as IPEN vial and NPL P6 vial.

2.3. Correction factor and uncertainties determination

The vial geometry correction factors were obtained by the equation.

$$\text{correction factor} = \frac{\bar{A}_s}{\bar{A}_{fp}} \quad (1)$$

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Fig. 1. (a) NPL-P6 vial and (b) IPEN vial.

Table 2

Main characteristics of the radionuclides used in this work.

Radionuclide	Photon main energy (keV)	Activity (MBq)		Half-life $T_{1/2}$	Uncertainty
		IPEN vial	NPL-P6		
^{67}Ga	93	164.2	154.0	3.26154 ± 0.00054 d	0.00015
^{131}I	364	74.2	76.9	8.0197 ± 0.0022 d	0.0005
^{201}Tl	69, 83, 135	163.5	209.0	3.0456 ± 0.0015 d	0.0004
$^{99\text{m}}\text{Tc}$	140	1245.7	1173.7	6.00718 ± 0.00087 d	0.00015

Table 3

Geometry correction factors obtained using the NPL-CRC and the CRC-15BT activimeter. Sample volume: 4 ml.

Radiopharmaceuticals	Correction factors	
	NPL-CRC [®]	CRC [®] -15BT
Gallium-67	0.938 ± 0.001	0.940 ± 0.005
Iodine-131	1.037 ± 0.001	1.031 ± 0.002
Thallium-201	1.279 ± 0.001	1.288 ± 0.002
Technetium-99m	0.942 ± 0.001	0.942 ± 0.001

factors considering the NPL-P6 vial as reference were obtained. Table 3 shows the correction factors obtained for ^{67}Ga , ^{131}I , ^{201}Tl and $^{99\text{m}}\text{Tc}$.

4. Conclusions

The difference between the responses of the two activimeters used in this study shows the necessity of this kind of instrument calibration, even though the national law does not recommend the calibration but only the application of a quality control program. In addition the geometry correction factors must be considered in the activimeters calibration because they can change the calibration factor by almost 30% (to ^{201}Tl , for example).

Considering the variation in the estimated correction factors (from 0.938 to 1.288) due to vial geometry, it is important to establish a procedure to determine the correction factor to all radiopharmaceuticals produced by IPEN. A new study must be done if the vial supplier changes its dimensions.

Acknowledgments

The authors acknowledge the partial financial support of the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Ministério da Ciência e Tecnologia (MCT, Project: Instituto Nacional de Ciência e Tecnologia (INCT) em (Metrologia das Radiações na Medicina), Brazil.

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Table 1

Dimensions of the vials used for the geometry test.

Vial type	IPEN	NPL-P6
Height (mm)	57.80 ± 0.05	54.00 ± 0.75
Diameter (mm)	26.50 ± 0.05	21.75 ± 0.25
Wall thickness	1.50 ± 0.05	1.20 ± 0.10
Maximum volume (ml)	22.9	13.8

where \bar{A}_s is the NPL-P6 vial average activity measurement and \bar{A}_{fp} the IPEN vial average activity measurement.

For the uncertainties estimation the ISO GUM norm was used (Instituto Nacional de Metrologia, Normalização e Qualidade Industrial (INMETRO), 2003); type A and B uncertainties to a confidence level of 95% ($k=2$) was considered. The correction factors uncertainties were calculated from the uncertainties propagation in correlated variable as indicated in Eq. (2) (Vuolo, 1996). The uncertainties of the calibration factors were obtained by combining the type A uncertainty (standard deviation of the mean from a series of response measurements under similar measuring conditions) with all individual type B uncertainty contributions for the following: current measurement (pA), weighting (g), activity measurement (MBq), holder alteration and variation in vials dimensions between NPL-P6 and IPEN.

$$\frac{\sigma_{FC}}{FC} = \sqrt{\left(\frac{\sigma_{\bar{A}_s}}{\bar{A}_s}\right)^2 + \left(\frac{\sigma_{\bar{A}_{fp}}}{\bar{A}_{fp}}\right)^2 - 2 \frac{\text{cov}(\bar{A}_s, \bar{A}_{fp})}{\bar{A}_s \bar{A}_{fp}}} \quad (2)$$

3. Results

Each radionuclide sample supplied by the radiopharmaceutical production department was one of the same volume (4 ml) and its activity was determined using the secondary standard activimeter.

Table 2 shows the main characteristics of the samples and the activities obtained for each one. All radionuclides were homogeneously diluted in 4 ml of saline solution and 10 consecutive measurements with 30 s between them were done. Measurements were made with both activimeters and correction

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