International Joint Conference Radio 2019

Comparative evaluation of gamma cameras performance for internal monitoring of workers exposed to ^{131}I in nuclear medicine services

Oliveira[a] S. M., Dantas[a] A. L. A., Dantas[a] B. M

Instituto de Radioproteção e Dosimetria - IRD, CEP - 22783-127, Rio de Janeiro - RJ, Brazil

salomao.marques@ymail.com

Introduction: In the nuclear medicine practice, a variety of radionuclides are handled for diagnostic and therapy which represents a significant risk of internal and external exposure for workers. Such occupational exposure requires the implementation of a routine monitoring plan, including intakes of radionuclides. Currently, in Brazil, approximately 90 Nuclear Medicine Services (NMS) are authorized by the Nacional Nuclear Energy Commission of Brazil to handle ^{131}I for therapy purposes [1], resulting in a significant number of workers routinely exposed to internal exposures. ^{131}I remains as one of the most frequently used radionuclides in NMS, and presents higher risks of intake and internal doses. The International Atomic Energy Agency recommends implementing an internal monitoring program of this group of workers. However, in Brazil there are not qualified laboratories to attend the demand of internal monitoring [2].

The IRD has developed several studies proposing the use of detectors available in NMS for ^{131}I occupational monitoring. Among such detectors, the gamma camera stands out to present the highest sensitivities for the proposed application. This work presents a comparison of the performances of gamma cameras available in six NMS in Brazil for ^{131}I *in vivo* monitoring purpose.

Methodology: The technique consists basically in (i) determining the calibration factors for the measurement of ^{131}I in the thyroid, (ii) estimation of the minimum detectable activities and the corresponding Minimum detectable intakes and effective doses. The IRD neck-thyroid phantom containing a ^{133}Ba source certified by the LNMRI of IRD was used to calibrate the medical devices evaluated in this study.

The standard geometry consisted in positioning the phantom at 12 cm distance to the Gamma Cameras (GC) detectors. The count time was determined according to detectors sensitivity for a measurement performed at 1 and 7 days after the intake, considering a weekly generic monitoring frequency, resulting in 48 monitoring periods per year.

Calibration of the Detection System

The Calibration Factor (CF) is calculated as follows:
$CF_{ctg/Bq}$ = (total counts – total background counts) / ^{131}I Eq Ac
Where: ^{131}I Eq Ac = Equivalent activity of ^{131}I in neck-thyroid phantom, corrected for the calibration date.

Evaluation of the Sensitivity of the Methods

The Minimum Detectable Activity (MDA) [3] is calculated as follows:
$MDA_{Bq} = (4{,}65 \times \sqrt{N}) / CF$
Where: N = Total background counts ; and CF = Calibration factor of the technique.

The Minimum Detectable Intake (MDI) is calculated as follows:
$MDI_{Bq} = AMD / m(t)$.

Where: MDA = Minimum Detectable Activity; and m(t) = Retention fraction of ^{131}I at time t.

The Minimum Detectable Effective Dose (MDED) is calculated as follows:
$MDED_{mSv}$ = IMD x e(g).
Where: MDI = Minimum detectable intake; and e(g) = Dose coefficient in mSv/Bq intake of ^{131}I by inhalation.

In order to be considered useful for internal dosimetry purposes, the technique should, at least, be able to detect an activity that would result in an annual effective dose below 1 mSv for the most likely internal exposure scenario [5].

The monitoring period is determinant to evaluate the sensitivity of the proposed method to be applied in routine internal monitoring in a given NMS. This evaluation can be made by the following equation:
Annual Sensitivity $_{mSv}$ = MDED x n.
Where: MDED = Minimum detectable effective dose; and n = Total number of measurements in 1 year.

Results: Seven gamma cameras of six different NMS were included in this study. Table 1 presents the results for MDA and Annual Sensitivity for each equipment calibrated in those facilities.

Table 1: MDA and Annual Sensitivities of the detectors analyzed for 48 monitoring periods per year.

Manufacturer	**Model**	**Facility**	**Count Time**	**MDA (Bq)**	**Annual Sensitivity (mSv)**	
					1 day	**7 days**
Phillips	BrightView XCT	A	3	130	0.5	0.9
GE	Millennium	B	7	134	0.6	0.9
GE	Discovery MN/CT 670	C	3	146	0.6	1.0
Siemens	e.cam 180	D	3	151	0.6	1.0
Elscint	Apex SPX-6	E	3	146	0.6	1.0
Siemens	Symbia	E	3	129	0.5	0.9
GE	Millennium	F	2	131	0.5	0.9

In order to avoid disturbing the routine of the NMS, the count time was optimized to be as low as possible but keeping the necessary sensitivity of the method for the application in occupational monitoring. Furthermore the monitoring plan must be established according to the schedule of the radionuclide handling of the facility.

Conclusions: The gamma camera performance can be evaluated by analyzing the MDA of the detection system as well as the count time required for the system to reach the minimum sensitivity to be considered useful for internal monitoring purpose. This study evaluated modern and older gamma camera models, and despite the difference of year of manufacture between the models, all gamma cameras presented enough sensitivity, considering a generic weekly monitoring frequency, for use as a monitoring device up to 7 days after intake. In most cases, the appropriate sensitivity was achieved setting the count time to 3 minutes, which can be considered a feasible and short count time. It shows that in addition to being simple, the implementation of the proposed methodology is easy and inexpensive.

Referencies:
1. CNEN - Comissão Nacional de Energia Nuclear. Instalações Autorizadas. Available at: < http://www.cnen.gov.br/instalacoes-autorizadas>. Last accessed: 28 Apr. 2019.
2. DANTAS B. M.; CARDOSO J. S.; DANTAS A. L. A.; et al. Intercomparação Nacional de Medição In Vivo de I-131 na Tireoide – Projeto TC IAEA BRA 9055. Scientia Plena, v. 9, 2013.
3. HPS - Health Physics Society. Performance Criteria for Radiobioassay, N13.30, 1996.
4. IAEA - International Atomic Energy Agency. Methods for Assessing Occupational Radiation Doses due to Intakes of Radionuclides. Safety Report Series No. 37, Vienna, 2004.
5. IAEA - International Atomic Energy Agency. Methods for Assessing Occupational Radiation Doses due to Intakes of Radionuclides. Safety Report Series No. 37, Vienna, 2004.