



RADIATION EXPOSURE FROM DIAGNOSTIC NUCLEAR MEDICINE IN ALAGOAS (BRAZIL) IN 2002-2005

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Abstract – Use of radionuclides in medical practice has grown steadily in recent years due to the introduction of new radiopharmaceuticals and new equipments. This paper presents a survey of nuclear medicine procedures performed in Alagoas, State of Brazil, in order to help establish reference levels for nuclear medicine patients. Data were gathered on the type of radiopharmaceuticals used and administered activity of each kind of examination, and the age and sex of the patients involved over the period 2002-2005. Based on ICRP-60, the effective dose (E) and collective effective dose (Ecol) have been calculated. The results showed an annual increase in the nuclear medicine examinations during the period of study and cardiac scintigraphy are the most common procedure. The results also indicated that the activities administered to patients are higher than the guidance levels of the Basic Safety Standards (BSS) in most of the kind of examinations. The differences found in the administered activities may reflect the differences in the quality assurance programs implemented. It was observed that the Ecol and E/inhabitant are higher than other countries. Therefore, it is suggested that the protocols have been revised in order to reduce the patient dose without reduce the image quality.

Key words: Nuclear medicine, Reference levels, Collective Dose

INTRODUCTION

Life on earth is constantly exposed to various forms of ionizing radiation from natural sources such as cosmic rays and natural radioactivity, as well as the ionizing radiation used in medicine. Ionizing radiation has valuable clinical usage in diagnostic radiology, nuclear medicine and radiotherapy. The diagnostic X-ray examinations constitute the largest source of diagnostic exposure; however, the rapid expansion of diagnostic nuclear medicine procedures that involve radiopharmaceuticals also requires assessment of the exposed population to this type of radiation (1). Then, the annual population doses from medical exposure have been reported in developed and in some developing countries (4).

According to UNSCEAR in its 2000 report on sources and effects of ionizing radiation (14), diagnostic exposure is characterized by relatively low doses to individual patients that in principle are sufficient to provide the required clinical information, although the resulting collective doses to populations are significant. In fact, the mean dose per procedure is larger for nuclear medicine than for medical x-rays (4). As dose limits shall not apply to medical exposure from authorized practices, the International Atomic Energy Agency (IAEA) recommends guidance levels for diagnostic procedures and, in nuclear medicine, these levels are the activities that are administered in patient (typical adult).

In Brazil, there is little information about the activities applied in diagnostic procedures in nuclear medicine, mainly at North and Northeast regions of the country. A Survey carried out in Paraíba State, for the years 2000-2005, Yano et al (15) observed that the activities values were higher than in other countries and those recommended by IAEA.

This paper presents a survey of nuclear medicine procedures performed in Alagoas, a State located in the northeast region of Brazil, in

Abbreviations: IAEA, International Atomic Energy Agency; ICRP, International Commission on Radiological Protection; UNSCEAR, United Nations Scientific Committee on the Effects of Atomic Radiation; DRL, Diagnostic Reference Levels

order to help establishing reference levels for nuclear medicine patients in Brazil, and to provides the collective and per caput effective doses.

MATERIAL AND METHODS

Survey of Diagnostic Procedure

Comprehensive data including annual frequencies of nuclear medicine procedures, the type and amount of administrated radiopharmaceuticals, and the sex and age distribution of the examined patients were obtained from 80% of the active nuclear medicine centers in Alagoas State (Northeast of Brazil), in the period from 2002 to 2005.

The data was grouped based on UNSCEAR Form with reference to diagnostic examinations (brain scan, thyroid/^{99m}Tc, thyroid/¹³¹I, lung ventilation, lung perfusion, cardiovascular, liver/spleen, renal, bone, other). As to age, the patients were distributed in 6 groups (0-1, 2-5, 6-10, 11-15, 16-40, >40 years old).

Effective Doses Calculations

The effective dose per unit administered activities of different radiopharmaceuticals was calculated using MIRDOSE 3.1 software (12) that uses children and adult (male and female) phantoms. The effective dose (E) and the collective effective dose (Ecol) were calculated based on ICRP-60 (7).

Firstly, collective effective dose per age groups per examinations (Ecol jk) was calculated by multiplying the effective dose per unit administered activities in a age group for a type of examination (E/A)_j, the mean administered activity in this type of examination (A) and the number of examinations carried out in this age group (N_j):

$$Ecol\ jk = (E/A)_j \cdot A \cdot N_j \quad (1)$$

Then, the collective effective dose per examinations (Ecol k) was calculated by:

$$Ecol\ k = \sum_j Ecol\ jk \quad (2)$$

And the collective effective dose (Ecol) was obtained by:

$$Ecol = \sum_k Ecol\ k \quad (3)$$

RESULTS

The frequency of diagnostic examinations performed by nuclear medicine services of Alagoas State in studied period was 2.18 examinations per 1,000 population. Table 1 shows that the number of examinations and, consequently, the frequency have been growing up each year.

Figure 1 illustrates the distribution of the examinations during the studied period. It was observed that myocardium (53%), skeleton (19%) and thyroid (12%) scintigraphies were the most frequent examinations.

Regarding the sex of the patients, 60% of the examinations were carried out with women. It

was observed that in all the procedures the number of female patients was higher than male patients.

Administered activity for a given examination is shown in Table 2. The values are been compared with those reported in International Basic Safety Standard (BSS) by IAEA (8).

Values of effective collective dose and effective dose per caput are showed in Table 3. These values are somewhat different from those reported in previous surveys carried out in other countries.

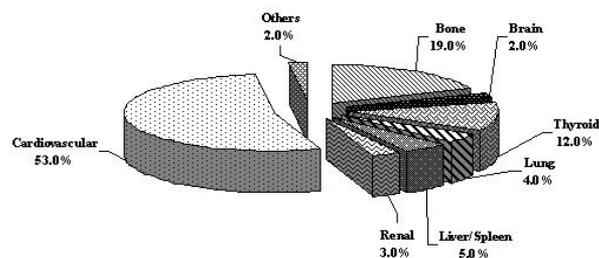


Figure 1. Distribution of nuclear medicine examinations in Alagoas State, Brazil, during the period 2002-2005.

DISCUSSION

The use of radiopharmaceuticals in medical diagnosis is less widespread than the use of x rays and there are large variations in practice from country to country. UNSCEAR in its 2000 report (14) presents the annual numbers of diagnostic examinations reported by different countries for the years 1991-1996. In this report, Brazil is classified in a health-care level II and the annual frequency is from a data survey in Parana State that has a social and economic profile above the average for the country.

In the survey presented in this work, the mean annual frequency in Alagoas State is greater than the frequency from Parana State (1991-1996) and is compared with some countries with II health care level (0.6-2.1 examinations per 1,000 population), according to the UNSCEAR classification (14). It shows that the data need to be updated.

Cardiovascular and bone procedures together renal scintigraphy have had a important increase between 2002-2005 and this increase was 87.5%, 84% e 100% for bone, renal and cardiovascular procedures, respectively. It is a result that nuclear medicine studies in Brazil have made a significant progress as new

radiopharmaceuticals (such as myocardial

Table 1. Annual frequency of examinations per 1,000 population^a in Alagoas State, Brazil (2002-2005)

Year	Number of examinations	Frequency
02	4,165	1.47
03	6,687	2.36
04	6,506	2.30
05	7,423	2.62
Avarage	6,195 ± 1,410	2.19 ± 0.50

^aIt has been considered the Alagoas State population in 2000 and it was 2.823x10⁶ inhabitants.**Table 2.** Comparison between administered activity in Alagoas State (Brazil) and those recommended by IAEA (2002-2005)

Examination	Radiopharmaceutical	Administered Activity (MBq)	
		Alagoas State*	IAEA [8]
Bone	MDP	1,036	800
		(925-1,110)	
Brain	ECD	740	800
Thyroid	^{99m} Tc	370	200
Thyroid	¹³¹ I	7.4	20 ^a
		(3.7-11.1)	
Lung perfusion	MAA	444	100
		(370-555)	
Lung ventilation	MDP	1,258	80 ^b
		(1,110-1,480)	
Liver/spleen	SC	252	80
		(185-296)	
Biliary	IDA	296	150
		(185-370)	
Renal	DMSA	141	160
		(111-185)	
Renal	DTPA	481	350
		(370-555)	
Cardiovascular (rest)	MIBI	925	300
Cardiovascular (stress)	MIBI	1,043	600
		(999-1,110)	

*average (range)

^a¹²³I; ^bDTPA radiopharmaceutical

Table 3. Comparison between the annual effective doses (collective and per caput) in Alagoas State (Brazil) and those other issues

Health-care Level	Issues	Ecol (man.Sv)	E per caput (mSv)
I	United Kingdom (2003-2004) [5]	1,600	0.03
	Germany (1996-2002) [12]	10,200	0.12
	Iran (1990-1996) [13]	450	0.008
	Cuba (1995-1999) [4]	54	0.05
II	Paraiba State, Brazil (2000-2005) [15]	185	0.05
	This study	447	0.16

perfusion), instrumentation (such as SPECT) and computers and hardware (allowing, for example, renal function evaluation) became available.

The percentage of each type of diagnostic nuclear medicine procedures differs substantially from others countries where the thyroid (4,13) and bone (9, 11, 14) scintigraphies is the most common examination. In particular, thyroid studies are dominant in the lower health-care levels (III and IV). However, in Paraiba State, another state of Northeast region of Brazil, the myocardium and skeleton scintigraphies also were the most frequent procedures (15).

About the distribution by sex of patients undergoing diagnostic nuclear medicine procedures, on the contrary that it was observed in this work, data from UNSCEAR (14) shows that the number of female and male patients was almost the same for most of procedures in I and II health-care levels. Exception for cardiovascular scan (60% male patients) and thyroid studies (80% female patients). May be it is relating with the Brazil culture where the women is more careful with their health than men.

It can observe that the activities used in Alagoas State were higher than the recommended ones by IAEA in all procedures, exception renal (DMSA) and brain scintigraphies. This activity values were higher than other countries (2, 4, 14), as well, but are similar to the values in Paraiba State (15).

According to ICRP (6, 7), all types of radiological investigations have to be optimized, so that the effective dose received by the patient does not exceed what is required to provide the

necessary clinical information.

For optimization of the protection of the patient in nuclear medicine, ICRP Publication 73 and the EU Patient Directive recommend the use of Diagnostic Reference Levels (DRL) (10). DRL are values which are usually easy to measure and have a direct link with patient doses. In fact, DRL gives dosimetric quantification of the level of patient exposure likely to occur in normal operating conditioning with adequate techniques (3).

In the long term, the DRL is derived by choice of radionuclide, camera geometry, collimator and methods for imaging processing and filtering. And the final decision is based on ROC analysis of patient images (10). However, one way to eliminate most of the inappropriate dosage schemes in the short term is to describe the current situation in terms of statistical distribution of administered nuclear medicine activities in a region with similar equipments and methods.

In this study, it was observed some differences between the activities used for a given examination by nuclear medicine services in Alagoas State (Table 2) and these differences varied, in average, by a factor of 1.9. As about IAEA recommended activities, the mean ratio was 3.9 and the higher ratios were for lung scan. Although not specifically stated, the recommended activity for lung perfusion scan by IAEA would not be appropriate if the lung ventilation scan was performed with a ^{99m}Tc -aerosol (11). Therefore, maybe the higher perfusion activities found in this survey were necessary to mask the ventilation activity.

It is important to emphasize that the recommended activities by AIEA and the activities from this survey are for the standard man (70kg adult patient). Many patients fall outside of standard range (lighter or female patients) and, in these cases, the patient receive an excessive radiation exposure. It is necessary to adopt reduced activities.

As showed in Table 3, the value for the annual effective collective dose for all the periods has been estimated 447 man.Sv, which represents an annual effective dose per caput of 0.16 mSv. It is important to emphasize that the calculated doses of Alagoas State are coming from just 80% of the nuclear medicine centers. In spite of this, the average per caput effective dose is higher than those reported in the United Kingdom (5), Germany (13) and Cuba (4). In fact, it is higher than the average for II health-care level reported by UNSCEAR [14] and, also, I health-care level that are 0.008 mSv and 0.081 mSv, respectively.

Procedures which contribute more to the effective collective dose is thyroid metastasis scan (73%), thyroid scan with ^{131}I (16%) and cardiovascular (10%). In spite of thyroid metastasis scan is no longer a used procedure, the high contribution to dose is due to a long half-life of ^{131}I and administered activities in this procedure, 111-185MBq (3-5mCi).

The data presented in this work characterizes the practice of Nuclear Medicine procedures performed in Alagoas-Brazil during 2002-2005. It shows the practice is still expanding in this State of the Northeast of Brazil and the significant increase of the examinations number is impelled by myocardium, renal and skeleton scintigraphy.

The administered activities for most procedures are higher than those recommended by IAEA and those used in other countries. The annual effective dose per caput is higher than other countries. Therefore, it is suggested that the protocols shall be revised in order to reduce doses without reduce the image quality. It is important to continue doing this kind of survey in other states in order to help establishing reference levels for nuclear medicine patients in Brazil, and to provides the collective and per caput effective doses.

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Other articles in this theme issue include references (16-23).

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