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Research article

Assessment of reference dose levels for nuclear medicine center in Jordan

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ABSTRACT

This study aims to evaluate diagnostic reference levels (DRLs) for nuclear medicine (NM) imaging studies in Jordan. The parameters of the current study obtained from different NM modalities conducted for adult patients imaging. The Administrated Activity (AA) of a radioactive substance (MBq) was collected from four hospitals specialized in nuclear medicine imaging at Amman City. According to ICRP recommendation, the established DRLs values obtained based on the 75th percentile of the AA values. The obtained results were compared with several international results. The DRLs' values for Jordan were located within the recommended range.

Keywords: Nuclear Medicine, Diagnostic Reference Levels, DRLs.

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INTRODUCTION

Nuclear Medicine (NM) technique is a good diagnostic imaging tool for the assessment of different diseases. Despite its benefits in the diagnostic imaging field, the patient's dose should be at the lowest value to avoid the undesirable effects of ionizing radiation. Recently, a remarkable increase in the use of ionizing radiation in medical imaging that led to the noteworthy rise of collective effective dose to the population [1]. Nuclear medicine is widely used in medical imaging since Becquerel's discovered the radioactivity for radioactive materials that can be ascribed to the ability to supply unique information about the body functions at the microscopic level [1]. The use of NM facilitates the early detection and accurate diagnosis of diseases. For example, the cancer patients can be continue evaluated by using whole-body bone scintigraphy that enables the detection of the primary tumour (origin) as well as defining the extent of cancer metastasis in the body (staging technique). This image can provide accurate details within a short time. Besides, it can provide unique information about the body functions at the microscopic level. The main disadvantage of NM techniques is the significant dose obtained during the imaging process [2]. Accordingly, the dose of the patient should be as low as reasonably achievable for different imaging techniques. To optimize radiation dose for the patients, the ICRP has introduced the DRLs term in publication 60 and 73 [3,4]. The DRLs aims to assist avert the dose of ionizing radiation to the patient that does not contribute to the clinical purpose of a medical imaging task. Based on the values of DRL, the centers enable to keep the minimum doses with obtaining the desired information from the investigation concerned. Consequently, if quality assurance in medical centers is applied precisely and routinely, the dose will not excess outweighed standard value. DRLs provide a baseline for individual facilities to compare their current practice with national DRLs. If specific scanning exceeds NDRLs, corrective action must be taken. It is recommended to update the DRLs within a regular time of 3 to 5 years or when to change the practices in the hospital [1]. Many studies have been conducted to explore the DRLs for NM in various European countries [5-7]. Essentially, there are numerous studies have been carried out for other medical imaging techniques such as PET/CT and SPEC/CT [8,9]. In this work, we evaluated the DRLs for adults in Jordan and compared them with the DRLs for different countries

MATERIALS AND METHODS

In this study, an arbitrated survey was utilized to collect data from four hospitals specialized in nuclear medicine. The collected data in this research covered one-third of the nuclear medicine centers in Jordan. Based on previous studies [6,7], a checklist was designed to record information relates to the type of imaging scanning, Administrated Activity (AA), tracer types, imaging

method, equipment manufacturer, camera model, and patient's information such as age and gender. This study involved 540 patients for 8 NM scanning, namely, Bone Scan, Thyroid Scan, Parathyroid Scan, Whole Body Scan, Dynamic and Static Renal

Scan, Lung Scan, and Myocardial Perfusion (20 patients for each image scanning at each hospital). The percent of male and female patients is about 49% and 51%, respectively [8].

Based on the European Commission Radiation Protection N° 190 (EC RP-190), the weights of the participants included in the current evaluation were in the range of 55-100 kg and weight mean of 78.2 kg (70 ±5 kg). Where the patients' age is in the range of 18-90 years. The gathering data was performed retrospectively from the Radiology Information System (RIS) and Picture Archiving and Communication System (PACS). While the obtained data were analyzed by IBM SPSS Statistics version 20. The current DRLs expressed as the 75th percentile of the AA frequency distribution according to ICRP 135 recommendation [9].

RESULTS

From 12 NM centers in Jordan, we collected the data from four centers from the biggest hospitals, meaning one-third of centers participate in this research. During collection data, the bone, thyroid, and myocardial scans are available in all NM centers, while the parathyroid, lung, static, and dynamic renal scan are available in only three centers.

Table 1 lists the proposed DRL of the current NM centers and the obtained values were discussed with the radiation protection directorate at Energy and Minerals Regulatory Commission (EMRC) before the adopted of this data as proposed DRLs for NM applications. In Table 1, we compared the proposed DRLs with many countries and standard values recommended by ICRP and IAEA

From Table 1, it can be observed that the bone scan (^{99m}Tc-MDP) value is less than the maximum values obtained from ICRP, Sudan, South Korea, and Brazil values

Table 1: Jordanian DRLs (values are A in MBq, for adults) compared with many countries. (Comparing DRLs (A values in MBq, for adults) Jordan with a number of countries.)

*=one day protocol, MDP = methylene-diphosphonate, DMSA = Dimercaptosuccinate, DTPA = Diethylene Triamine Penta Acidic Acid, MIBI = methoxy iso butyl isonitrile

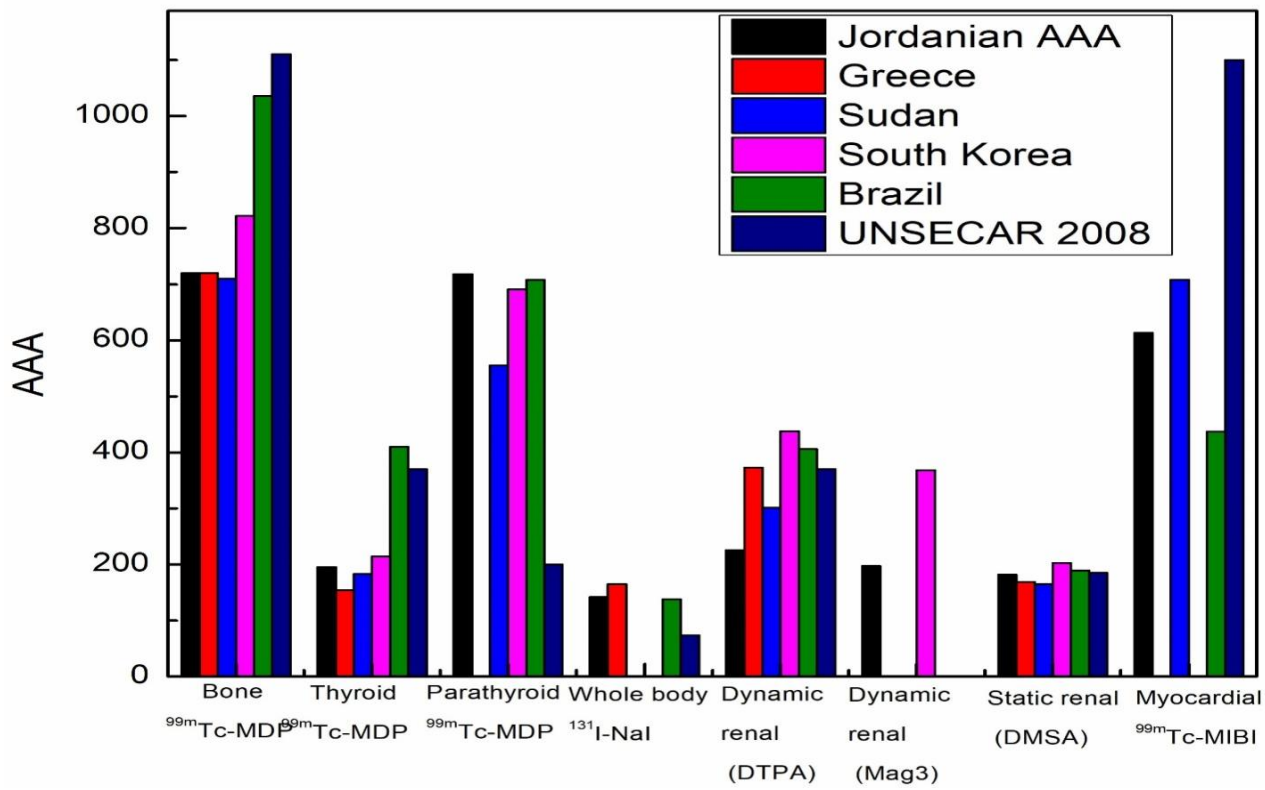
Procedure	Radiopharmaceutical	Jordan DRL	Most common value ARS	BSS115	Finland	Bulgaria	Greece	Sudan	Sweden	Switzerland	South Korea	Brazil
Bone Scan	^{99m}Tc-MDP	740	600 (800 SPECT)	600	700	640	735	777	600	700	925	1110
Thyroid scan	^{99m}Tc- Pertechnetate	185	80	200	150	100	183	185	120	75	217	444
Parathyroid scan	^{99m}Tc-MIBI	740	600		800	700		555		550	740	740
Whole body scan	^{131}I-NaI	185		400			180					185
Dynamic renal scan	^{99m}Tc-DTPA	259	300	350	300	185	540	207	200	200	555	449
Dynamic renal scan	^{99m}Tc-Mag3	296		100	150	100			100	100	500	
Static renal scan	^{99m}Tc-DMSA	185	80	160			183	174			185	185
Lung perfusion	^{99m}Tc-MAA	185		100	150	150	180		125	180	222	333
Myocardial perfusion imaging*	^{99m}Tc-MIBI	592	1200	800	1100	1100		740	1200	300 + 900		444

On the other hand, the current values are higher than Finland, Switzerland, Bulgaria, and Sweden and approximate to Greece. The thyroid scan (^{99m}Tc- Pertechnetate) value is approximate for the proposed value of IAEA, Greece, and Sudan and higher than of the values recommend of ICRP, Finland, Sweden, Bulgaria, and Switzerland. This value is lower than in South Korea and Brazil. The value of Parathyroid scan ^{99m}Tc-MIBI is similar to the South Korea value, lower than Finland and higher than of Bulgaria, Sudan, and Switzerland. While the whole body (^{131}I-NaI) scan value is lower than IAEA, and the same as Greece and Brazil. The data of static renal scan (^{99m}Tc-DMSA) is higher than of ICRP data and approximate to IAEA, Brazil, South Korea, Sudan and Greece. Whereas the Dynamic renal scan (^{99m}Tc-DTPA) value is less than of IAEA, ICRP, Finland, Greece, South Korea, and Brazil value. The value of Dynamic renal Scan (^{99m}Tc-Mag3) is higher than of DRL for all countries except for South Korea. From Table 1, it is evident that most of the Jordanian DRLs values are within the international limits except for dynamic renal (^{99m}Tc-Mag3) and parathyroid (^{99m}Tc-MIBI). The Jordanian DRLs are higher than the recommended limits of ARSA. The Jordan DRLs for bone, thyroid, parathyroid, whole body, dynamic renal (^{99m}Tc-DTPA; ^{99m}Tc-Mag3), static renal and myocardial scans are 740, 185, 740, 185, (259; 295), 185 and 592 MBq respectively.

Table 2: Jordan Average Administrated Activity (AAA) for adults.

Procedure	Jordanian AAA	Greece [7]	Sudan [10]	South Korea [14]	Brazil [15]	UNSECAR 2008 [11]
Bone Scan (^{99m}Tc-MDP)	720	720	710	822	1036	740-1110
Thyroid scan (^{99m}Tc- Pertechnetate)	195	154	183	214	410	370
Parathyroid scan (^{99m}Tc-MIBI)	718		555	691	708	200
Whole body scan (^{131}I-NaI)	142	165			138	74
Dynamic renal scan (DTPA)	226	373	301	438	406	370
Dynamic renal scan (^{99m}Tc-Mag3)	197			368		
Static renal scan (^{99m}Tc-DMSA)	182	169	165	203	189	185
Lung perfusion (^{99m}Tc-MAA)	135	163		215	246	111
Myocardial perfusion imaging (^{99m}Tc-MIBI)	613		708		437	1100

Figure 1: Jordan Average Administrated Activity (AAA) for adults



The Jordanian Average Administered Activity (AAA) is listed in Table 2 and Figure 1. AAA was compared with UNSCEAR, Greece, Sudan, South Korea, and Brazil. In comparison to UNSCEAR, the Jordanian AAAs are always within the limit except for the ^{99m}Tc-MIBI Parathyroid scan which is 3.5 times higher (200 vs. 718 MBq). On the contrary, most of the Jordanian AAAs are lower in comparison to South Korea and Brazil, and only ^{99m}Tc-MIBI Parathyroid is high the Brazil and South Korea limits.

CONCLUSION

We can use the obtained data from the current study as a base for further screening to establish a national DRL for nuclear medicine in Jordan. Only for the case of ^{99m}Tc-DTPA dynamic renal, the Jordanian DLRs are within the limit in comparison to both ARSA and international range. Jordanian AAAs are only within the limit in comparison to UNSCEAR for the case of ^{99m}Tc thyroid scan and ^{99m}Tc-DTPA dynamic renal scan. The DRL and AAA both are within the limit only for the case of ^{99m}Tc-DTPA dynamic renal scan in comparison to all the standards. Overall, the investigation reveals that the Jordanian DRLs and AAAs are usually above the reference levels provided by different bodies. Further detailed investigations are required to bring both DRLs and AAAs within different reference levels.

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