Original Article

An update on radiation absorbed dose to patients from diagnostic nuclear medicine procedures in Tehran: A study on four academic centers

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ABSTRACT

Purpose: Use of radiopharmaceuticals for diagnostic nuclear medicine procedures is one of the main sources of radiation exposure. We performed this study with respect to the rapid growth in nuclear medicine in Iran and lack of updated statistics. **Materials and Methods:** The data were obtained for all active Nuclear Medicine Centers affiliated to Shahid Beheshti University of Medical Sciences during 2009 and 2010. **Results:** The most frequently performed procedures were bone (30.16%), cardiac (28.96%), renal (17.97%), and thyroid (7.93%) scans. There was a significant decrease in the number of thyroid scintigraphies with ^{131}I and ^{99m}Tc-sulfur colloid liver/spleen scans and tremendous increase in the frequencies of cardiac and bone scintigraphies compared to one decade ago. **Conclusion:** Compared to previous studies, there were striking changes in trends of diagnostic nuclear medicine procedures in Tehran. This field is still evolving in the country, and this trend will further change with the introduction of positron emission tomography scanners in future.

Keywords: Nuclear medicine, patient, radiation absorbed dose, Tehran

INTRODUCTION

Use of radioactive pharmaceuticals for diagnostic nuclear medicine procedures is one of the main sources of radiation exposure resulting from ionizing radiation to populations. Annual assessment of patients' absorbed dose can give a quantitative estimate of per capita population absorbed dose. Risk of exposure to ionizing radiations is expressed by factors such as shortening of life span and induced malignancies.[1-4] The International Commission on Radiological Protection (ICRP) provides the effective doses, and hence the radiation risk to patients caused by various radiopharmaceuticals and nuclear medicine procedures.[5-7] Although, the annual number of nuclear medicine procedures and their collective dose are way below the corresponding values for medical X-ray examinations (2% and 6%, respectively), the mean dose per procedure is larger for nuclear medicine (4.6 mSv) than for medical X-rays (1.2 mSv).[8]

With respect to the rapid growth in number of nuclear medicine procedures performed in Iran, and considering the fact that previous survey in Tehran was performed a decade ago, in 2003,[9] we performed this study to give an updated estimate on the statistics and trends of nuclear medicine procedures as part of a residency thesis.

MATERIALS AND METHODS

The data of the annual diagnostic nuclear medicine procedures were obtained for all four active nuclear medicine centers affiliated to Shahid Beheshti University of Medical Sciences,

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Tehran, Iran, during 2009 and 2010. The data comprised the type and frequency of examinations, type of radiopharmaceuticals used, range of administered activity for each examination, and age distribution of the patients. As the amount of dose used in different nuclear centers varied, the mean administered activity for each examination was used in the five age brackets of <1 year, 1–5 years, 6–10 years, 11–15 years, and >16 years.

The first column in Table 1 shows the diagnostic nuclear medicine procedures and corresponding radiopharmaceuticals used. To calculate the effective dose and collective effective dose, the authors used the effective dose per unit administered activity given in ICRP Publication No. 53 (1988) and its addenda, ICRP Publication No. 80 (1999), and ICRP Publication No. 106 (ICRP 2008) (third column). The effective dose per examination (fourth column) was obtained by multiplying the mean administered activity (second column) by the corresponding effective dose per unit administered activities for each examination (third column). The annual number of each examination in the five age groups is listed in the fifth column

Table 1: Mean administered activities, effective dose per unit administered activities, effective dose per examination, annual number of examinations, and collective effective doses for diagnostic nuclear medicine examinations in 2010

Procedures and radiopharmaceuticals	Mean administered activity (MBq) in five age groups[a]					Effective dose (mSv/MBq) in five age groups[a]				
	<1	1-5	6-10	11-15	>16	<1	1-5	6-10	11-15	>16
Thyroid										
^{131}I-INa				1	2				10	6.6
^{99}mTc-TcO4	23	46	59	67	92	0.079	0.042	0.026	0.017	0.013
Bone										
^{99}mTc-MDP	157	314	407	456	628	0.027	0.014	0.011	0.007	0.006
Liver/spleen										
^{99}mTc-SC		82	106	119	164		0.028	0.018	0.012	0.010
Biliary										
^{99}mTc-IDA	40	81	104	117	162	0.1	0.045	0.029	0.021	0.017
Renal										
^{99}mTc-DTPA	88	176	228	256	352	0.016	0.009	0.009	0.006	0.005
^{99}mTc-DMSA	27	54	70	79	109	0.037	0.021	0.015	0.011	0.009
Lung perfusion										
Cardiac										
^{99}mTc-MAA			94	106	145			0.023	0.016	0.011
^{99}mTc-MIBI-Re					662					0.009
^{99}mTc-MIBI-Ex					662					0.008
^{201}Tl-Ion					89					0.14
Whole body										
^{131}I-INa					37					2.3
MIBG										
^{131}I-MIBG		18	24	27	37		0.61	0.4	0.26	0.2
Tumor										
^{67}Ga-citrate				103	141				0.13	0.1
Other										
^{99m}Tc-TcO4	74	148	191	215	296	0.079	0.042	0.026	0.017	0.013
Total										

Effective dose per exam (mSv) in five age groups					Number of examinations in five age groups					Collective effective dose (person-Sv) in five age groups[a]				
<1	1-5	6-10	11-15	>16	<1	1-5	6-10	11-15	>16	<1	1-5	6-10	11-15	>16
			13.16	11.95					5					0.06
1.81	1.92	1.54	1.13	1.19		2	2	5	814		0.00	0.00	0.01	0.97
4.24	4.40	4.47	3.20	3.58		21	22	45	2769		0.09	0.10	0.14	9.91
	2.30	1.91	1.43	1.54					12					0.02
4.04	3.63	3.03	2.47	2.75	6				6	0.02				0.02
1.41	1.59	2.03	1.59	1.73	30	55	44	42	1004	0.04	0.09	0.09	0.07	1.74
1.00	1.14	1.05	0.87	0.96	81	218	112	48	260	0.08	0.25	0.12	0.04	0.25
		2.16	1.69	1.60					209					0.33
				5.96					1434					8.55
				5.23					1372					7.17
				12.49					55					0.69
				85.10					85					7.23
	11.29	9.58	6.99	7.40		2			9		0.02			0.07
			13.35	14.13				6	84				0.08	1.19
5.85	6.22	4.98	3.66	3.85	54	184	124	30	775	0.31	1.14	0.62	0.11	2.98
Total					171	484	304	176	8896	0.45	1.59	0.93	0.44	41.18
							10,031					44.59		

[a]The values were rounded to nearest integer

of Table 1. The collective effective dose for each examination is shown in the last column, which was calculated by multiplying the effective dose per examination by the corresponding number of examinations in each age bracket. The effective dose per procedure was obtained by summing the effective doses used for all radiopharmaceuticals, and the collective effective dose was obtained. Table 2 is filled for both 2009 and 2010.

RESULTS

The annual activities of the nuclear medicine centers in 2010 is provided in Table 1, which comprises the examination type, radiopharmaceutical used, mean administered activities (MBq), effective dose per unit administered activity (mSv/MBq), and the effective dose per examination (mSv) for each examination in the five age groups. Some miscellaneous procedures, such as red blood cell scan, indirect radionuclide cystography, and dacryoscintigraphy using ^{99m}Tc pertechnetate, are provided as "other" in the last row of Table 1. The annual total number of examinations and corresponding collective effective doses are calculated and provided in the last row of Table 1. Same procedure was repeated for 2009.

Figure 1 is showing the percentage of the total number of examinations and percentage collective effective dose. During these 2 years, results reveal a 6.14% and 3.63% increase in the annual number of examinations and collective effective dose, respectively [Figure 1 and Table 2].

The most frequently performed procedures were bone (30.16%), cardiac (28.96%), renal (17.97%), and thyroid scintigraphies (7.93%), which contributed to 24.01%, 36.76%, 5.82%, and 2.08% of the average collective and effective dose during these 2 years.

Figure 2 shows the relative contribution of radionuclides to collective effective dose and total number of procedures as averaged over these 2 years. The most frequently used radiopharmaceutical was ^{99m}Tc, which contributed to 98.20% of a total number of examinations and 89.89% of collective effective dose. Although ^{131}I accounted for only 0.34% of procedures, it contributed to 5.68% of the collective effective dose.

Table 2: Frequency and percentage of nuclear medicine examinations in 2009-2010[a]

Procedures	Annual frequency of examinations		
	2009	2010	Average
Thyroid	714 (7.58)	828 (8.24)	771 (7.93)
Bone	3009 (31.94)	2857 (28.48)	2933 (30.16)
Liver/spleen	6 (0.06)	12 (0.12)	9 (0.09)
Biliary	17 (0.18)	12 (0.12)	14 (0.15)
Renal	1600 (16.99)	1894 (18.88)	1747 (17.97)
Lung	219 (3.32)	209 (2.08)	214 (2.20)
Cardiac	2770 (29.42)	2861 (28.52)	2815 (28.96)
Whole body	88 (0.93)	85 (0.85)	86 (0.89)
MIBG	7 (0.07)	11 (0.11)	8 (0.09)
Tumor	103 (1.09)	100 (0.89)	101 (1.04)
Total	9415	10,031	9723

[a]The values were rounded to nearest integer

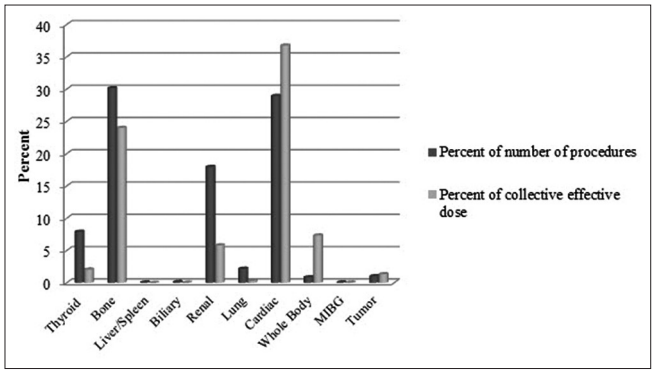

Figure 1: The contribution of nuclear medicine procedures from total annual number of examinations and collective effective dose (average of 2009, 2010)

DISCUSSION

Comprehensive studies on diagnostic nuclear medicine procedures and their contribution to the population absorbed doses have been reported by many investigators worldwide.[10-18] However, despite the rapid growth of these procedures in Iran, there is a profound lack of statistics and the previous survey in Tehran was conducted a decade ago.[5] Compared to the previous study by the same group in the same centers,[19] striking differences are noted in trends of diagnostic nuclear medicine procedures. Thyroid scintigraphies with ^{131}I which accounted for 2.35% of total number of procedures and resulted in 16.59% of collective effective dose in 1999 and 2000 contributed to only 0.03% of the number of examinations and 0.07% of the effective dose in 2009 and 2010. This is due to substitution of ^{131}I with ^{99m}Tc for thyroid examinations, which has led to less radiation absorbed dose from ^{131}I to the patients. On the other hand, there is tremendous growth in the number of cardiac (55.7-fold) and bone (3.60-fold) scans with increases from 0.52% and 8.4% to 28.97% and 30.25% during the same period. The huge increase in the number of cardiac examinations is mainly due to the introduction of single-photon emission computed tomography technique. The changes in bone scan frequency could be the result of an increase in the prevalence of malignancies and lack of other screening techniques such as positron emission

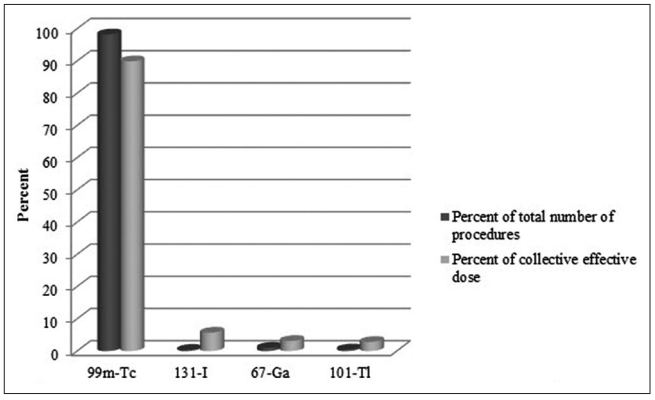

Figure 2: Percentage share of radionuclides from total number of procedures and collective effective dose (average of 2009, 2010)

tomography (PET) scanners in the country. The overall number of thyroid examinations has decreased from higher than 80% in 1989[20] to 7.91% in 2010. This could be the result of lower prevalence of goiter due to the implementation of iodine enrichment diet programs,[21,22] lower referral of patients by specialists, and the introduction of fine needle aspiration and advanced ultrasonography techniques. The latter two reasons are also responsible for the 78-fold decrease in liver/spleen ^{99m}Tc-sulfur colloid examinations from 7% in 1989[20] to 0.09 in 2010. Together, bone, cardiac, and renal scans accounted for 70.04% of examinations and 66.59% of collective effective dose.

CONCLUSION

Based on the results of our study, striking changes are noted on the trends of diagnostic nuclear medicine procedures in Iran. This field is still evolving in the country, and this trend will change further with the introduction of PET scanners.

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Conflicts of interest
There are no conflicts of interest.

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