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The Estimation of Radiation Effective Dose from Diagnostic Medical Procedures in General Population of Northern Iran

Background/Objective: The risks of low-dose ionizing radiation from radiology and nuclear medicine are not clearly determined. Effective dose to population is a very important factor in risk estimation. The study aimed to determine the effective dose from diagnostic radiation medicine in a northern province of Iran.

Materials and Methods: Data about various radiologic and nuclear medicine procedures were collected from all radiology and nuclear medicine departments in Mazandaran Province (population = 2,898,031); and using the standard dosimetry tables, the total dose, dose per examination, and annual effective dose per capita as well as the annual gonadal dose per capita were estimated.

Results: 655,730 radiologic examinations in a year's period, lead to 1.45 mSv, 0.33 mSv and 0.31 mGy as average effective dose per examination, annual average effective dose to member of the public, and annual average gonadal dose per capita, respectively. The frequency of medical radiologic examinations was 2,262 examinations annually per 10,000 members of population. However, the total number of nuclear medicine examinations in the same period was 7074, with 4.37 mSv, 9.6 μSv and 9.8 μGy, as average effective dose per examination, annual average effective dose to member of the public and annual average gonadal dose per caput, respectively. The frequency of nuclear medicine examination was 24 examinations annually per 10,000 members of population.

Conclusion: The average effective dose per examination was nearly similar to other studies. However, the average annual effective dose and annual average gonadal dose per capita were less than the similar values in other reports, which could be due to lesser number of radiation medicine examinations in the present study.

Keywords: effective dose, gonadal dose, nuclear medicine, radiology, Iran

Introduction

As the diagnostic applications of radiation have continued to grow, the general public's awareness about the hazards of ionizing radiation has increased. Despite extensive research over the past decades, there remains considerable uncertainty as to the risk of low dose ionizing radiation as encountered in radiology and nuclear medicine. Moreover, recent guidelines have identified an increased risk from radiation and set lower public dose limits.[1,2] In publication No. 60 of the ICRP (1991 b) it is recommended that a dose limitation of 1 mSv per year be set for the general population.[3] The NCRP-93 report has estimated the annual average effective dose for the US population from radiation sources to be about 3.6 mSv/y, to which nuclear medicine and medical radiologic procedures respectively contribute small dose of 0.14 mSv/y and 0.38 mSv/y.[4] However, there are many reports indicating that the population effective dose from medical diagnostic examinations is a very important factor in risk estimation.[5,6] The main goal of the present study was to estimate the mean effective dose to population from radiology and nuclear medicine procedures in Northern Iran.

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Materials and Methods

All hospitals and private clinics (47 radiology and 2 nuclear medicine departments) in all cities of Mazandaran Province in the north of Iran participated in this study by supplying the data for one year (October 2003 to September 2004), including information on patients' age, gender, type and technical settings of the diagnostic procedure, type of the radiopharmaceutical, and administered activity. The effective dose per examination was calculated according to the ICRP 80 standard patient dosimetry tables and the ICRP-1993 report, on the basis of type of source organ, gender and age, for a typical adult. These tables give the estimated effective dose for various kinds of examination, considering the subject's age, gender and technical conditions of procedures. So, by multiplying the dose per examination by total number of examinations, the total effective dose was estimated. The mean effective dose was calculated by dividing the above parameters by the number of patients or the population. A similar calculation was made for gonadal dose by dividing the sum of gonadal dose for procedures by the total number of patients or the population. The calculation methods of the present study are adopted from similar reports.[7-10]

Results

The total number of nuclear medicine procedures in one year in Mazandaran Province (population 2,898,031) was 7,074 (24 examinations per 10,000 population). The mean effective dose and mean gonadal dose per examination was 4.37 mSv and 4.42 mGy, respectively. Patient exposure amounted to approximately 9.6 μSv effective dose per capita of population. The annual average gonadal dose per population was estimated at 9.8 μGy.

The total number of radiologic examinations in a year's period was 655,730, which lead to 1.45, 0.33 mSv and 0.31mGy as average effective dose per examination, annual average effective dose to member of the public and annual average gonadal dose per capita, respectively. The underlying frequency of medical radiologic examinations was 2,262 examinations annually per 10,000 members of population. The total number of radiologic procedures was about 93 times nuclear medicine examinations. The frequency of examinations for male and female was nearly the same, but the most number of examinations were carried out on adult patients and only 8.9% of procedures were pediatric cases. Table 1 shows the brief results of the frequency and corresponding estimated dose of radiologic procedures in the north of Iran (Figure 1).

Discussion

The quantified risk of ionizing radiation from nuclear medicine procedures is described in terms of

Table 1. The frequency and corresponding estimated dose of radiologic procedures in northern Iran

Type of X-Ray Procedure	Number of Examinations	Effective Dose (mSv)			Gonadal Dose (mGy)		
		Total Dose	Average Dose per Examination	Average Dose per Head of Population	Total Dose	Average Dose per Examination	Average Dose per Head of Population
Conventional Radiography	580824	534358	92.0	0.18	615673	1.06	0.21
Radiological Procedures with Contrast Media	18795	121227	45.6	0.04	128182	82.6	0.04
Computed Tomography	50476	306389	07.6	0.1	211494	19.4	0.07
Angiography	2436	15590	4.6	0.005	*	*	*
Mamography	3199	320	1.0	0.0001	**	**	**
Total	655730	950808	45.1	0.33	904907	38.1	0.31

* There is no exact data about gonadal dose from angiography procedures, so it is excluded from dose estimation.

** Gonadald Dose was less than 0.01 mGy.

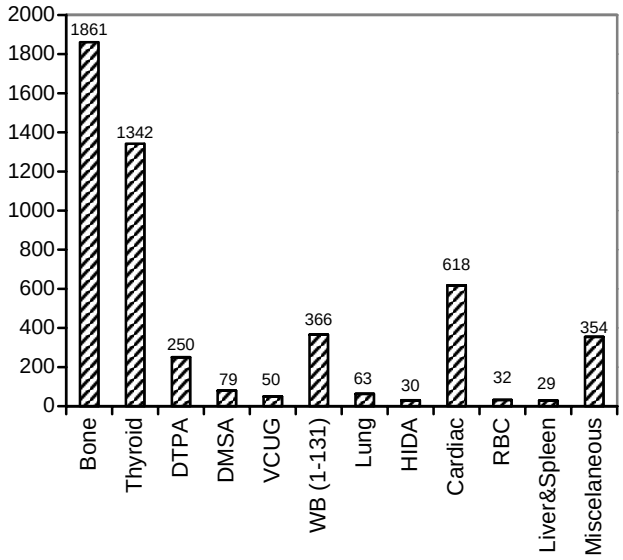

Fig 1. The annual frequency of nuclear medicine procedures in the north of Iran

estimating the effective dose.[5,6,11] In these estimates, the main uncertainties for patients are in the biokinetic data and the assumption of a uniform distribution of activity in each organ. Despite these limitations, it is possible to determine nearly accuratelyradiation exposure from diagnostic procedures in nuclear medicine using routine data.[12] Furthermore, there is no correlation between equivalent and effective dose changes with patient's anatomy and associated diseases on the basis of history alone.[13]

The highest numbers of examination in this study were for bone and thyroid scans. This finding is similar to the report of Mohammadi et al in Iran in 1995.[5] However, in the studies in other countries; the frequencies of types of examinations are not the same, which may be due to various geographical distributions of diseases. It should be mentioned that some of patients in Mazandaran Province received medical imaging services from beyond the coverage area of the present study, so the low coverage and also the low number of population in the present study could be a source of uncertainty in the estimation of effective and gonadal doses. However, 75% of population and for one province in the corresponding countries.[14-16] It should be noted that Mazandaran is the biggest province in the north of Iran and we think the estimated effective dose is well applicable to all patients who live in Northern Iran.

The annual effective dose per person in this study is 9.3 μSv, which is much lower than this value in other reports [Italy 180 μSv, Canada 130 μSv, Czech Republic 59 μSv, Australia 64 μSv].[15-18] This finding may be due to the low number of nuclear medicine examinations in Iran (22 per 10000 people) compared to the mentioned countries.[7,8,15] However, the estimated gonadal dose received from nuclear medicine examinations in the north of Iran (9.7 μGy) is in the middle of the range of other countries [the Netherlands 3.2 μGy, and Australia 26 μGy].[8,18]

The frequency of radiology and nuclear medicine procedures as well as the distribution of procedures by gender and age in the present study is nearly similar to other studies.[7,16]

Plain radiographs constituted about 88.5% of the total radiologic examinations. However, due to the low radiation dose of these types of examinations, they are responsible for just about 56% of the received dose. The lowest number of examinations is for mammography (0.48%), which delivers just 0.04% of the radiation dose to population. We did not consider dental radiography in the estimation of population dose because they did not deliver significant gonadal dose to the population.[19,20] The frequency of mammography and dental radiography in the present study is in agreement with the report by Brugmans et al. in the Netherlands in 2002.[9] Results showed that the mean effective dose from radiologic examination per head of population is about 0.33 mSv, which is much lower than the similar value in the report by Kaul et al. in Germany in 1997 (1.9 mSv).(20) We think this finding is the result of the low number of procedures in the present study (2262/10000 of population) compared to other studies [Kaul et al., 15500/10000; Regula et al., 17000/10000].[7,10] The effective dose per radiological examination is estimated to be 1.45 mSv, which is about 50% of the similar values reported by Overbeek et al. in the Netherlands in 1999 (3 mSv).[21] This may be due to the higher use of fluoroscopy and CT in that country, which delivers higher radiation doses to the population.

The estimated gonadal dose to the population (0.31 mGy) is higher than similar values in some other studies, and could be reduced by staff education on protection regulations.[22] However, the annual effective dose per person in this study may be compable to the estimated 2.4 mSv from natural background radiation. Regarding the variation in reported values,

further national studies are suggested.

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