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Original

Evaluation of Ionizing Radiation in Five Private Radiology Centers in Khuzestan

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Abstract

Background: Nowadays ionizing radiation is widely used in medicine, research and industry. In medicine, ionizing radiation is used to diagnose diseases and in high doses to treat diseases such as cancer. Undoubtedly, most exposure to artificial sources is in the field of medical and diagnostic radiology. Therefore, practitioners in the field of diagnostic radiography and patients are exposed to ionizing radiation and its risks. On the other hand, despite the advantages and efficacy of diagnostic radiation in the medical field, overall less attention is paid to optimizing and controlling protection in medical radiation. Therefore, the aim of this study was to evaluate the background ionizing radiation in Ahwaz diagnostic radiography centers. **Methods:** Ionization radiation levels were measured in and out of each center using gamma spectroscopy (Radiation Alert Inspector-EXP 15109) at a, b, c, d and e radiographic centers within one meter above the Earth's surface. Radiation levels within each center were measured at four locations (outside of center, secretary desk, and patient waiting room and behind the radiology room) both in X-ray machine operating and non-operating condition. The obtained data were analyzed by SPSS software. **Results:** The inside ionization radiation dose in a, b, c, d and e radiographic centers were 0.121, 0.119, 0.126, 0132 and 0.128 μSv/h respectively. The outside ionization radiation dose in a, b, c, d and e radiographic centers were 0.094, 0.092, 0.093, 0.112 and 0.101 μSv/h respectively. Equivalent annual dose within and outside selected radiology centers were lower than the threshold (1 mSv / year). **Conclusion:** The results show that the ionizing radiation dose of the X-ray equipment examined in the radiology centers of Ahwaz is lower than the global standard.

Keywords: Ionizing radiation; Radiography; Equivalent dose; Equivalent annual dose; Employment factor.

Introduction

People are routinely exposed to ionizing radiation. Nowadays ionizing radiation is extensively used in medical, research and industrial field. In medicine, ionizing radiation is used to diagnose diseases and in high doses to treat diseases such as cancer. Therefore exposure to ionizing radiation in medicine known as a major source of exposure for individuals' works in this filed. Among different resources, most radiation exposure in the medical field is due to diagnostic tests with ionizing radiation, which is inevitable. For example, in the US on average, about 12 percent of their radiation exposure is due to X-ray diagnostic methods, which is the highest source of human-made radiation.[1] With the

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rapid development of technology over the past two decades, the number of diagnostic radiology tests has expanded significantly. Several studies show that more than 3 million radiography tests are performed daily throughout the world.[2, 3]

Patients exposed to radiographic examinations (computed tomography, fluoroscopy and X-ray techniques), radioisotope and radiotherapy techniques increase background radiation and radiation dose in patients and many related careers.[4] Because of the inevitability nature of the use of ionizing radiation in the medical field, they also endanger the health of those exposed to radiation. Research has shown that exposure to ionizing radiation can cause damage and clinical symptoms such as chromosomal alterations, cancer, free radical formation, and bone necrosis.[5] By examining the annual number of diagnostic radiological tests performed in England and the other six developed countries, De Gonzalez et al. found that diagnostic radiology is responsible for 0.6-3% of the cumulative risks of cancer.[6] It's established that both chronic and acute exposure to ionizing radiation cause clinical symptoms in the exposed body .[7, 8] Due to these adverse effects, monitoring and evaluation of ionizing radiation levels is essential to keep it as achievable as possible. X-ray with a power of 140-180 kV is an effective dose for patients and staff of radiography centers and hospitals.[9-11]

Since medical diagnostic methods are directly beneficial to the patient, there is less emphasis on protection in medical radiation, which can lead to increased patient and community dose. As such, it is important to measure the background radiation at the center of radiation to understand the high risk of unintended side effects of ionizing radiation.[11] Some studies have been performed to evaluate background ionizing radiation in hospitals and radiology centers. For example, James and colleagues measured ionizing radiation levels at Kuwali General Hospital in Abuja, Nigeria. They report the internal and external equivalent dose ranges 0.107(0.003) and 108(0.003) μSv/h respectively.[12] In the study conducted by Okiyo et al (2013) at the Medical Center, the results showed that the mean of internal measurements in hospital X-rays department were 0.02(0.14) and 0.13(0.02) μSv/h, respectively.[13] According to the study of H van Boot et al., Ionizing radiation inside radio-detection centers were 0.234 and 0.276 μSv/h respectively.[14] In the United States, studies conducted by Mettler et al. In 2008 in the New Mexico Department of Health, Radiology and Nuclear Medicine show that the background ionization radiation level was 0.342 μSv/h.[15] In general, the average global dose of background ionizing radiation in humans is about 0.274 μSv/h.[13] In the present study, the level of ionizing radiation in radiology centers in Ahwaz was evaluated to determine the risk for staff and patients.

Methods

The present cross-sectional study was conducted at five private radiology centers include a, b, c, d and e in Ahwaz city in 2017. The radiation levels outside the center as well as at four locations within each radiology center were measured in both the on and off mode of the X-ray apparatus using the calibrated gamma spectroscopy (Radiation Alert Inspector-EXP 15109). The device detector is capable of measuring dosages ranging from 0.01 to 1000 μSv/h with accuracy of 15%. Measurements were repeated at each location at least five times with 3 min intervals. The four measurement locations at each center include the outside center, the secretary desk, the patient waiting room, and behind the radiology room. In all five centers the measuring device was located one meter above ground level.[8]

The following equations were used to convert μSv/h to mSv/y:

Annual indoor equivalent dose rate (mSv/y) = indoor equivalent dose rate (μSv/h) ×4600×0.8× 0.001 (1)

Annual outdoor equivalent dose rate (mSv/y) = outdoor equivalent dose rate (μSv/h) ×4600×0.2× 0.001 (2)

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSEAR) report in 2000, propose indoor and outdoor employment factors of 0.2 and 0.8, respectively.[8] Employment factor defined as a proportion of the total time that a person is exposed to radiation. Data were analyzed using descriptive statistics by SPSS software version 19.0 (SPSS Inc., 1989 to 2013). P value less than 0.05 was considered statistically significant.

Results

The mean and standard deviation of measurements of different levels of radiation at four locations in five radiology centers in Ahwaz in the on and off status of the X-ray machine are presented in Table 1.

The values of the average equivalent dose (μSv/h) and the annual equivalent dose (mSv/h) obtained using equations (1) and (2) while the X-ray machine is operating were presented in the table 2.

According to the results, there is no significant difference observed between background radiation and X-ray ionization radiation in the studied centers when the device is switched off (table 1; $p>0.05$). It is also observed in table 2 that in the operating condition of X-ray machine, a significant difference observed between the radiation inside and outside of each center ($p<0.05$). The results of the mean indoor dose rate indicate that in the operating condition, the minimum and maximum mean dose were observed in b (0.017(0.119) μSv/h) and d (0.024(0.132) μSv/h) centers, respectively. On the other hand, the minimum and maximum of outdoor dose were observed in b (0.030(0.092)) and d (0.030(0.112)) centers, respectively. A comparison of the measured indoors and outdoors dose levels at the five radiology centers and standard levels presented in figure 1 and 2.

Table 1. Mean(standard deviation) of radiation dose in five radiology centers

center	instrument model	instrument status	behind the radiology room	patient waiting room	secretary desk	outdoor	
a	Toshiba	on off	0.135(0.019) 0.096(0.010)	0.109(0.036) 0.097(0.007)	0.118(0.017) 0.096(0.007)	0.094(0.009)	0.78
b	Shimadzu	on off	0.129(0.022) 0.097(0.008)	0.112(0.013) 0.096(0.008)	0.116(0.013) 0.095(0.008)	0.092(0.031)	0.587
c	Philips 20052	on off	0.126(0.014) 0.097(0.007)	0.132(0.020) 0.098(0.007)	0.121(0.011) 0.099(0.009)	0.093(0.022)	0.841
d	Philips SR025	on off	0.146(0.023) 0.094(0.031)	0.116(0.009) 0.089(0.007)	0.135(0.027) 0.092(0.010)	0.112(0.030)	0.086
e	Toshiba	on off	0.143(0.024) 0.098(0.009)	0.110(0.015) 0.091(0.008)	0.129(0.025) 0.095(0.008)	0.100(0.032)	0.566

Table 2. Mean(standard deviations) of equivalent and yearly equivalent doses indoor and outdoor of the five radiology centers in the instrument on status

Center	Unit of measurement	indoor	outdoor	*P*-value
a	μSv/h mSv/h	0.121(0.027) 0.445(0.099)	0.094(0.009) 0.086(0.008)	0.005
b	μSv/h mSv/h	0.119(0.017) 0.437(0.064)	0.092(0.030) 0.084(0.028)	0.005
c	μSv/h mSv/h	0.126(0.016) 0.464(0.057)	0.093(0.022) 0.086(0.020)	0.007
d	μSv/h mSv/h	0.132(0.024) 0.487(0.088)	0.112(0.030) 0.102(0.028)	0.028
e	μSv/h mSv/h	0.128(0.025) 0.470(0.092)	0.101(0.032) 0.092(0.029)	0.047

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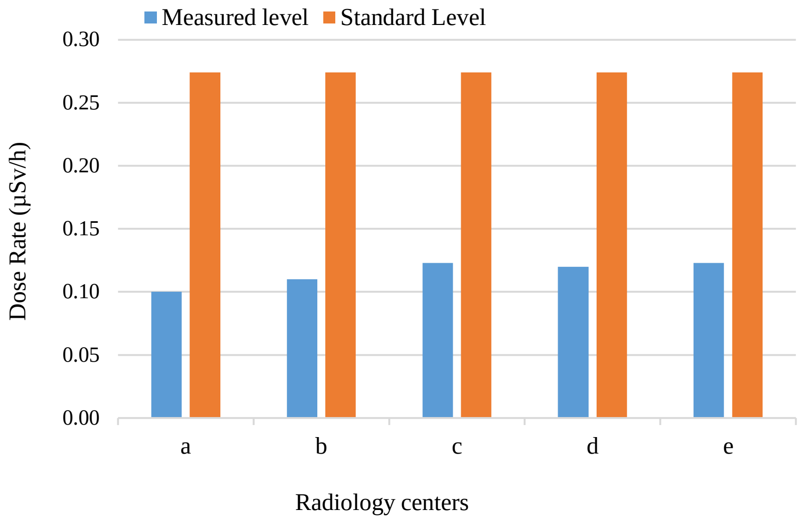

Figure 1. Comparison of measured radiation dose inside radiological centers and world standard level

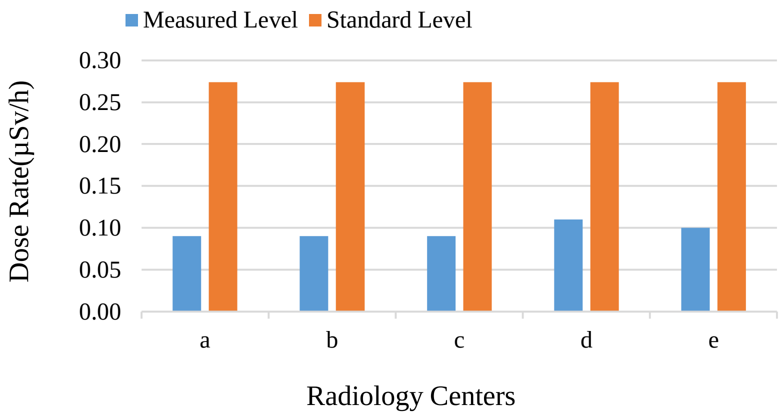

Figure 2. Comparison of measured radiation dose outdoor radiological centers and world standard level

The indoor and outdoor equivalent dose rates of the centers were well below the global average of background ionizing radiation (about 0.274 μSv/h).

Discussion

In the present study, the inside and outside level of ionizing radiation and background ionizing radiation of five private radiology centers in Ahwaz was measured. The outdoor minimum and maximum mean annual equivalent dose studied centers were 0.084 mSv/year 0.102 mSv/year, respectively. The indoor minimum and maximum mean annual equivalent dose studied centers were 0.437 mSv/year 0.487 mSv/year, respectively. The equivalent annual dose rate in the selected radiology centers was less than the threshold (1 mSv/year), which is consistent with the studies of Fouladi et al.[16] This could be due to the use of identical materials in construction. James and his colleagues (2015) measured background radiation levels outside and inside Kuwaiti General Hospital, Abuja, Nigeria using the Geiger Muller ATMX AT1117M Counter. The indoor measurement results were in the range of 0.100(0.001) – 0.124(0.007) with the mean of 0.107(0.003) μSv/h, whereas the outdoor radiation measurements were in the range of 0.100(0.001)-0.112(0.003) with the mean of 0.108(0.003) μSv/h. This study showed that the background radiation is less than the standard background radiation (0.133 μSv/h).

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The mean annual dose values were also shown to be 0.750(0.020) and 0.189(0.005) mSv for indoor and outdoor measurements, respectively. These results showed that the dose level at all sites (internal and external) was lower than the maximum permissible (1mSv/h) set by the International Radiological Protection Commission (ICRP). Overall, other studies by conducted by John Booth and colleagues at a specialized hospital in 2012 and also by Okoy and Avery in 2013 are in agreement with the present study.[13, 14] This implies the need to adhere to the same standards in the design of buildings and equipment. These results are also lower than those reported by the Radiology and Nuclear Medicine Division of the World Health Organization of Veterans in New Mexico, USA (Mellerhoek et al., 2008). Jay van Boot et al. evaluate the background ionizing radiation in a number of Nigerian hospitals; the results showed that the background ionizing radiation level was higher in the target environment. This can be relating to the geophysical differences (terrestrial structure) of the surveyed area. The minimum and maximum dose equivalent in the Skane Radio diagnostic Center was 1.402 and 2,540 mSv/h, respectively.

The minimum and maximum outdoor dose equivalent when holding the gamma sensor vertically down were 1.402 and 43.14 mSv/h, respectively. The minimum and maximum equivalent dose within the Plateau state hospital was 1.402 and 2.803 mSv/h, respectively. The minimum and maximum equivalent outdoor doses when the gamma sensor was upright were 1.314 and 2.716 mSv/h, respectively.[14] It is recommended to evaluate the public hospitals and diagnostic centers in Ahvaz. In order to improve radiation protection in radiology centers, it is recommended to carry out regular monitoring of ionizing radiation and background radiation, and to investigate accidental defects, leakage of X-ray production equipment and regular repairs of programs at each facility.

Conclusion

As the results showed, at 5 radiological centers the level of indoor equivalent dose is higher than the outdoor equivalent level and the annual equivalent dose of these centers is lower than the international standard. Therefore, staff, patients, and people using radiology units are not exposed to significant potential hazards, and ionizing radiation from these centers is below standard X-ray levels.

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