

Environmental Radiation Exposure of Staff During Portable Chest X-ray in the Intensive Care Unit of Golestan Hospital in Ahvaz

Abstract

A portable chest X-ray is the most commonly employed imaging method in the intensive care unit (ICU). As such, the purpose of this study was to examine the radiation exposure of staff during portable chest X-rays (CXR). The present research is a cross-sectional descriptive epidemiological study that was performed in the intensive care unit of Golestan Hospital in Ahvaz from November 2020 to February 2021. In this study, the cumulative radiation dose was determined with direct measurement by film badge and indirect calculation by using the output parameter. For this study, 47 portable CXRs were performed in the ICU of the aforementioned hospital. In the direct measurement method, the cumulative dose from all film badges was reported to be below 0.05 millisievert (Negligible dose). Mean cumulative doses obtained from indirect calculations were 1.493 ± 0.0251 for the medicine room, 1.3671 ± 0.012 for the nursing station, 5.749 ± 0.331 for the lead shield room, 0.989 ± 0.006 for the Staff rest room, 2.438 ± 0.0211 for the patient ward. The lowest and highest cumulative dose calculated indirectly was related to the staffing rest room and the behind of lead shield regardless of shield protection respectively. According to the results of this study, the risk of radiation exposure to ICU staff from portable CXR is very insignificant as compared to international dose limits established for public and exposed workers.

Keywords: *Intensive care units, portable chest X-ray, radiation exposure, staff*

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Introduction

Portable chest radiography is the most commonly employed X-ray imaging method in the intensive care unit (1). Doctors usually request chest x-rays owing to concerns about the severity of cardiopulmonary diseases, the need for identifying the correct placement of invasive devices such as endotracheal tubes, chest tubes, feeding tubes, and vascular catheters, and the probable corresponding complications thereafter for all patients admitted to the intensive care unit (2). Patients treated in ICUs and critically ill patients are often perceived as lacking the capacity to be transferred to the radiography department, oftentimes as a result of being connected to monitoring devices, ventilators, or bone traction and/or having unstable vital signs, hence the viability of portable X-rays as an alternative option (3). The advantages of CXRs include early diagnosis and thus timely treatment of non-suspicious clinical abnormalities, documentation of disease progress or response to treatment, and being of high educational value for interns, among others. Despite the many advantages of CXRs, the risk of radiation exposure for nurses and its harmful effects such as

carcinogenesis and genetic complications for the risk groups have long been of paramount importance for scholars (4, 5). Portable chest radiography is perceived to be able to lead to side effects such as carcinogenesis and hereditary-related complications. On the other hand, even the lowest amount of radiation dose may cause the effect, and with the increase of the radiation dose, the probability of the effect also increases proportionally. As such, patients and personnel are advised to distance themselves from any unnecessary exposure. The professional attitude and performance of employees and employing high-standard radiography equipment are pivotal to radiation dose control (6-9). However, many hospital employees, nurses being no exception, carry an irrational fear of portable X-ray devices, mostly stemming from a lack of proper prior training and leading to lower-quality patient care (10, 11). Being informed of the amount of radiation caused by portable X-rays, the amount of the allowed annual dose for employees, and the efficient methods for protecting against scattered radiation is a must for all treatment personnel, especially the employees of the departments with perceived highest levels of radiography readings. Lack of awareness of

these issues can lead to unnecessary fear, stress, and failure to perform job duties with any efficiency. Furthermore, insufficient knowledge may result in the inattentiveness of personnel; itself building up to unwanted radiation exposure, thereby leaving in its wake irreparable risks for employees and even future generations (12). The studies conducted thus far indicate the low information levels of nurses regarding the risks and protection methods of radiation, as well as the low awareness of the amount of scattered radiation in the environment (10-12). Furthermore, evidence suggests that in many cases, nurses working in the intensive care units have a clash of opinions with the authorities regarding the safest place when performing portable X-rays, and given the lack of sufficient knowledge of the amount of radiation received at a safe distance from the radiation source, they are reluctant between whether leaving the workplace to create safety for themselves or resuming care for patients in the intensive care unit (12). The review of reliable databases reveals an information gap regarding the level of X-rays caused by portable radiography in the intensive care unit. Therefore, the purpose of the current study was to examine the level of exposure of the nurses of the intensive care unit of Ahvaz Golestan Hospital to X-rays caused by portable chest radiography.

Materials and Methods

The present research is a cross-sectional descriptive epidemiological study that was performed in the intensive care unit of Golestan Hospital in Ahvaz from November 2020 to February 2021. Before conducting any research, the necessary written approvals were obtained from the ethics committee of the university in the intensive care unit of Ahvaz Golestan Hospital (IR.AJUMS.REC.1398.400). As such, the amount of cumulative radiation dose generated by portable chest radiographs in different areas of the intensive care unit was measured and calculated using both direct and indirect methods.

For the direct measurement method, the cumulative environmental dose was recorded and measured by placing 10 film badge dosimeters (manufactured by Parsian Radiation Dosimetry Company) in different parts of the intensive care unit for two months. A film badge dosimeter consists of a small radiographic film installed inside a plastic cover or frame, which blackens when exposed to radiation, based on the intensity of which the received dose can be estimated. Each of the films was placed in special places where nurses were present during portable radiography (that is, behind the lead screen, nursing station, rest room, medicine room, and other areas of the ward) and film badge dosimeters were assigned a code according to its location. Figure 1 shows the location film badge dosimeters along with the schematic map of the section.

During the two months when the dosimeters were installed in different parts of the ward, 47 portable CXRs were performed on the patients' beds. To calculate the ambient dose, the radiation conditions of the portable device, including voltage (VP), current-time of radiation (mAs), and the distance between the radiograph tube and the patient's bed were recorded for all tests.

After the completion of the two-month dosimetry period, the dosimeters were returned to Parsian radiation Dosimetry Company for further analysis. Two radiation experts with more than 12 years of reading experience measured the received dose on the films using a densitometer and calibration curve, following which a report was issued. The possible received dose was compared with the annual permissible dose limit for the normal population, i.e., one millisievert per year (13).

For the indirect dose calculation method, the quality control data of the portable radiography device was employed to determine the radiation levels at different distances from the device. One of the most important parameters is the output value of the device in terms of microgray at a distance of one meter from the X-ray tube. The results of the quality control of the device show that the output value at a distance of one-meter tube (SSD=100cm) with radiation conditions of KVP = 70 and Mas = 10 is equal to 732±14 µGy. According to the change of radiation conditions for each patient, the output of the device was calculated separately using Eq. 1, that is:

$$\frac{Output_2}{Output_1} = \frac{SSD_1^2 \times Mas_2 \times KVP_2^2}{SSD_2^2 \times Mas_1 \times KVP_1^2}$$

Where $Output_2$ is the output of the device with new conditions for each patient and $Output_1$ is the output of the device under quality control conditions. As a rule of thumb, the amount of scattered radiation at a distance of one meter from the patient's bed is equal to 0.1% of the primary radiation (that is, the output of the device) (15). At distances of more than one meter from the patient's bed, with the increase, the distance, the square of the X-ray dose decreases, and thus the scattered radiation dose is calculated for each of the radiographs in the places where the film dosimeters are placed, and by summing the dose of 47 cases of radiographs, the amount of cumulative dose was obtained at different points. This value was compared with the values recorded by the film badge dosimeter and the annual environmental dose limit in uncontrolled areas. SPSS v. 22 and descriptive statistics methods were used to determine the mean and standard deviation of radiation dose values.

Findings

During two months dosimetry period, 47 chest X-rays with the following mean parameters were recorded: KVP = 64.3 ± 4.2, Mas = 1.8 ± 0.6, and SSD = 111.9 ± 14.1 cm. The amount of cumulative dose recorded by all film badges was reported to be less than 0.05 millisievert (that is, such negligible that the dosimeter failed to pick up any reading).

The mean cumulative dose calculated by indirect method at the coded locations were respectively 2.025±1.0 µGy, 874.0211±1.0 µGy, 47.0149±1.0 µGy, 224±0246±1.0 µGy, 348.0158±1.0 µGy, 569.308±2.0 µGy, 1.493±0.0251 µGy, 478.328±2.0 µGy, 246.345±1.0 µGy, and 5.749±0.331 µGy. The results from Table 1 reveal that the lowest amount of cumulative dose pertained to the personnel rest room determined by the indirect method, while the highest amount of cumulative dose using the indirect pertained to the lead shielding room (dosimeter No. 10), which was placed on average at a distance of 2.31±1.33 meters from the portable device. Due to the variability of the location of the lead shield in different radiations, the location of the shield and dosimeter No. 10 that was installed behind the shield is not shown in the schematic figure 1. In all indirect calculations, the amount of radiation absorbed by the air and other obstacles such as walls and lead shields are not taken into account. Tables 1-4 outline the cumulative dose values obtained using the indirect method for different locations of the department according to the distances of each location from the portable device.

Discussion and conclusion

The findings of this research, conducted to examine the environmental conditions of employees during portable chest X-rays in the intensive care unit, indicate that out of a total of 47 chest imaging instances within two months, the film badge dosimeters did not pick up any reading, and hence the radiation levels were below 0.05 millisievert, which is considered a negligible dose in practice. The dose limit for normal people and radiologists is 1 and 20 millisieverts per year, respectively, and humans receive an average of 2 to 3 millisieverts of radiation dose from nature annually (13). The reading obtained from the film badge dosimeters was very small and insignificant compared to the annual dose of nature or the annual dose limit of normal people and radiation-related personnel. for the indirect measurement method, the maximum dose estimated in these two months was 5.749±0.331 µGy, which is far lower than that of the annual environmental dose limit in uncontrolled areas, that is, areas that do not require protection and installation of radiation warning signs and hence have a radiation dose of 1000 µGy per year (15). In this study, radiation attenuations caused by lead shields, walls, and other protective barriers were not taken into account while calculating the ambient dose using the indirect method. It is

only logical to assume that the values calculated by the indirect method would decrease significantly. Furthermore, this study only sought to examine the radiation dose of fixed locations in the intensive care unit, while many employees of the intensive care unit are responsible for moving and caring for patients in other radiation units including those of radiology, angiography, and radiotherapy, among others, and as a result, the radiation exposure of staff moving between various departments was not included in this study. Xie and colleagues (16) measured the dose received by the staff of the ICU department in three months, during which they conducted 613 portable chest x-rays and 189 portable CT scans of the brain. The results of their study show that even though the annual dose received by personnel is lower than the annual dose limit, doctors and nurses receive an average dose of 0.99 and 0.88 millisieverts per year, respectively. A higher workload and a higher dose portable CT scan in this study is the probable explanation for the difference in the reported dose values. Siddiqui and his colleagues performed 43 portable CT scans and 610 chest X-rays in the ICU for 6 months. Their dosimetry results show that on average, the employees received a dose of 0.4 millisieverts per year, which is lower than the permissible dose limit for normal people in conventional life situations (that is, one millisievert) (17). In the present study, only the cumulative dose resulting from chest X-rays in different places in the ICU department was estimated, revealing much lower values compared to other methods such as angiography and CT scan. In the studies in which portable chest X-rays were conducted in the intensive care unit or the neonatal unit, the dose received by the employees was much lower than the annual dose limit, hence proving to be consistent with the results of this study. According to recommendations of the authorities regulating radiation protection laws and the ALARA principle, radiographs should be performed in such a way that the radiation exposure of the patient and personnel is reasonably and achievable as low as possible. Observance of protective instructions such as the use of suitable equipment and quality control, providing proper radiation conditions, and maintaining distance from the portable device, among others can significantly reduce risks. According to the results obtained from this study, the risk of exposure of ICU staff to radiation from performing portable chest X-rays is nonetheless very small.

Table 1: Cumulative dose amount from portable chest X-rays using indirect calculation in the staff rest room (film badges 1 and 2)

The distance of the portable device to the calculation location in meters	Number of X-rays	KVP	Mas	SSD	Cumulative dose in µGy

1	—	—	—	—	—
2	—	—	—	—	—
3	3	62.9±3.8	10.1±0.8	107.0±5.2	0.244±0.008
4	3	63.8±1.1	9.6±0.8	108.9±6.3	0.1371±0.005
5	10	64.1±4.6	9.1±1.4	112.7±5.7	0.2928±0.007
6	—	—	—	—	—
7	6	65.7±4.9	9.8±1.8	106.4±8.3	0.089±0.006
8	6	65.1±4.3	9.6±1.9	117.6±9.6	0.068±0.008
9	9	61.6±5.3	9.6±0.9	104.9±3.3	0.084±0.012
10	10	68.3±6.7	11.1±1.6	114±6.7	0.073±0.011
Total cumulative dose in personnel quarters					0.989±0.006

Table 2: Cumulative dose levels from portable chest X-rays using the indirect calculation for the nursing stations (film badges 3, 4, and 5)

The distance of the portable device to the calculation location in meters	Number of X-rays	KVP	Mas	SSD	Cumulative dose in μGy
1	—	—	—	—	—
2	—	—	—	—	—
3	—	—	—	—	—
4	13	63.8±1.1	9.6±0.8	108.9±6.3	0.5941±0.016
5	14	64.1±4.6	9.1±1.4	112.7±5.7	0.41±0.017
6	12	62.9±3.8	10.1±0.8	107±5.2	0.244±0.008
7	8	65.7±4.9	9.8±1.8	106.4±8.3	0.119±0.006
8	—	—	—	—	—
9	—	—	—	—	—
10	—	—	—	—	—
Total cumulative dose in nursing stations					1.3671±0.012

Table 3: Cumulative dose levels from portable chest X-rays using the indirect calculation for the nursing stations (film badges 3, 4, and 5)

The distance of the portable device to the calculation location in meters	Number of X-rays	KVP	Mas	SSD	Cumulative dose in μGy
1	—	—	—	—	—
2	—	—	—	—	—
3	16	62.9±3.8	10.1±0.8	107.0±5.2	1.302±0.0212
4	15	63.8±1.1	9.6±0.8	108.9±6.3	0.6855±0.0121
5	14	64.1±4.6	9.1±1.4	112.7±5.7	0.41±0.008
6	2	65.1±4.3	9.6±1.9	117.6±9.6	0.041±0.005
7	—	—	—	—	—
8	—	—	—	—	—
9	—	—	—	—	—

10	—	—	—	—	—
Total cumulative dose inpatient wards					2.438±0.0211

Table 4: Cumulative dose levels from portable chest X-rays using the indirect calculation for the medicine room (film badge 7)

The distance of the portable device to the calculation location in meters	Number of X-rays	KVP	Mas	SSD	Cumulative dose in μGy
1	—	—	—	—	—
2	—	—	—	—	—
3	10	62.9±3.8	10.1±0.8	107.0±5.2	0.813±0.0141
4	4	63.8±1.1	9.6±0.8	108.9±6.3	0.183±0.0124
5	4	64.1±4.6	9.1±1.4	112.7±5.7	0.117±0.0211
6	11	65.1±4.3	9.6±1.9	117.6±9.6	0.221±0.0151
7	2	65.7±4.9	9.8±1.8	106.4±8.3	0.0321±0.0141
8	—	—	—	—	—
9	10	64.4±0.7	8.6±0.4	109.8±7.6	0.093±0.018
10	6	61.6±5.3	9.6±0.9	104.9±3.3	0.044±0.005
Total cumulative dose in the medicine room					1.493±0.0251

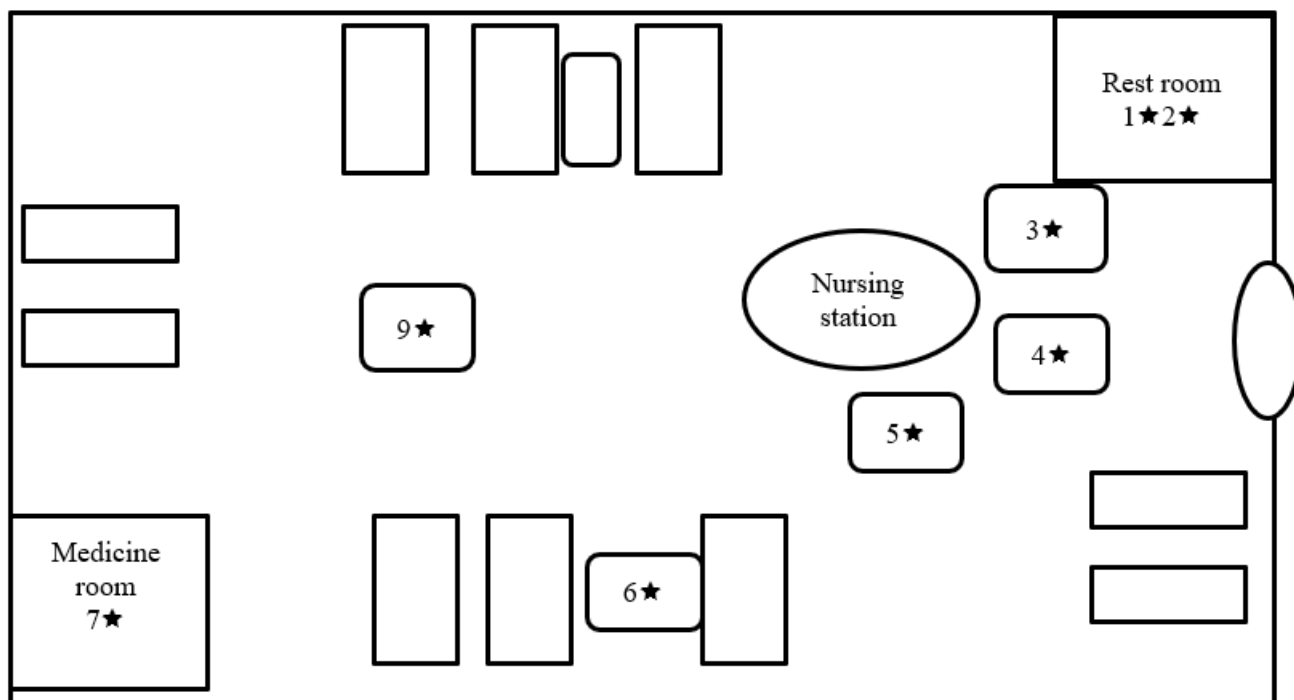


Figure 1: placement of beds, areas, and dosimeters of Ahvaz Golestan ICU. Dosimeter 10 was installed behind the lead shielding, and since it was moved during tests, its location is not depicted in the figure.

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Conflict of interest

None.

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Ethics statement

Approved by local ethics committee (IR.AJUMS.REC.1398.400)

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