Avrupa Bilim ve Teknoloji Dergisi
Sayı 35, S. 625-632, Nisan 2022

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
No. 35, pp. 625-632, April 2022

Research Article

Determination of the Radiation Dose Level Emitted to the Environment in Patients Undergoing Dacryo Scintigraphy and Clinical Management

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(First received 6 March 2022 and in final form 30 April 2022)

(**DOI:** 10.31590/ejosat.1099508)

ATIF/REFERENCE: Saruhan, M., Abamor, E., Günay, O., Timlioğlu İper, H. S., Yarar, O. & Demir, M. (2022). Determination of the Radiation Dose Level Emitted to the Environment in Patients Undergoing Dacryo Scintigraphy and Clinical Management. *Avrupa Bilim ve Teknoloji Dergisi*, (35), 625-632.

Abstract

In this study, the radiation dose rates emitted by patients who underwent dacryoscintigraphy imaging were determined. For this, the radiation dose rate was measured at the 8.23, 41.68 and 56.81 minutes after the injection of the radiopharmaceutical. In addition, 12 points were determined from the front of the patient. these points are 25, 50, 100 and 200 cm from the head level, 25, 50, 100, and 200 cm from the chest level and 25, 50, 100 and 200 cm from the foot level. 36 different measurements were made from one patient, at 3 different times, from these points. As a result of the measurements, the average dose rate varies according to time and measurement point and was found between 0.22 μSh^{-1} and 2.86 μSh^{-1}.

Keywords: Dacryo,Tc-99, Radiation dose rate.

Dakriyo Sintigrafisi Yapılan Hastaların Çevreye Yaydığı Radyasyon Doz Düzeyinin Belirlenmesi ve Klinik Yönetimi

Öz

Bu çalışmada dakriyosintigrafi görüntüleme yapılan hastaların çevreye yaydığı radyasyon doz rate leri belirlenmiştir. bunun için radyofarmasötik enjeksiyonundan sonra 8,23, 41,68. ve 56,81. dakikalarda radyasyon doz hızı ölçülmüştür. Ayrıca hastanın ön tarafından 12 nokta belirlenmiştir. Bu noktalar kafa hizasından 25, 50, 100 ve 200 cm uzaklıkta, göğüs hizasından 25, 50, 100, ve 200 cm uzaklıkta ve ayak hizasından 25, 50,100 ve 200 cm uzaklıktadır. Bu noktalardan 3 farklı zaman olmak üzere bir hastadan 36 farklı ölçüm yapılmıştır. ölçümler sonucu ortalama doz hızı, zaman ve ölçüm noktasına göre değişmekte olup 0,22 μSh^{-1} ile 2,86 μSh^{-1} arasında bulunmuştur.

Anahtar Kelimeler: Dakrio,Tc-99, Radyasyon doz hızı.

1. Introduction

Radiation is examined in two parts in terms of its effect on matter. One of them is ionizing radiation and the other is non-ionizing radiation. Ionizing radiation ionizes the atom with which they interact, especially living tissue. Ionizing radiation can be produced naturally or artificially. Numerous studies have been carried out with the various effects of ionizing radiation. (Çelen et al., 2021; Kurtulus et al., 2021; Tekin et al.,2020; Akkurt et al., 2020; ÖZseven et al., 2020; Altınsoy et al., 2020; Jawad et al., 2019)

Medical applications are the most common causes of artificial radiation (Palacı et al., 2019). They differ from natural radiation with the possibility to control their exposure time and radiation level. The artificial radiation use is not frequent in ophthalmologycal practice and complicated because of the neighbouring effects of the radiation. Cristalline lens and optic nerve are the most affecting parts of the eye from radiation. Applied radiation, both for diagnostic and therapeutic purposes, has to be controlled for its adverse effects on these tissues. One of the diagnostic purposes for artificial radiation application is nasolacrimal system examinations. Nasolacrimal system complaints, mainly tearing (=epiphora), are common ophthalmologic problems which comprises %3 of the opthalmic visits (Linberg and McCormick, 1986).

Epiphora may caused by structural (Mechanic obstructions, lower lid malpositionings, weakness, etc) or functional problems (tear over production, pump failure etc.). The lacrimal route includes the upper and lower lacrimal puncta, upper and lower canaliculi, common canaliculus, lacrimal sac and nasolacrimal duct. Obstructions and structural problems can develope at any point of this route. Mainly epiphora is a result of complete or incomplete obstruction of nazolacrimal duct and the stasis of tears in nasolacrimal ampulla. Obstructive epiphora is seen more often in women and mostly in the bony canal which frequently relieved by surgical approach (Herzig et al., 1979; Kanski and Bowling, 2011). It is important to figure out the causes of the tearing before planning the appropriate surgical treatment.

Since the first description many imagination technics have been improved. The classic evaluation methods such as Dacryocystography combined with a contrast material, Digital Substraction Dacryocystography (DSD), Computed Tomogarphy (CT), Cone Beam Computed Tomography (CBCT) are effective for evaluating the structural pathologies but their effectiveness is very low for assesment of the functional problems of nasolacrimal system. Whereas Dacryocystography is reliable for morphologycal assesment (congenital or aquired stenosis etc.) dacryoscintigraphy (DSCG) is appropriate for evaluating functional condition of the nasolacrimal system. Nasolacrimal scintigraphy which mimics the natural tear flow is useful in cases where epiphora persists despite a normal nasolacrimal structure that considers functional epiphora and pump failure (Manfrè et al., 2000 ; Palaniswamy and Subramanyam,. 2012; Detorakis et al., 2014).

Dacryoscintigraphy has the advantage to facilitate the diagnostic procedure for the patient. Unlike dacryocystographyc methods there is neither need to place plastic catheters nor to forced fluid injection in to the canaliculus.

Technetium-99m (Tc-99m) is the most commonly used radionuclide in dacryoscintigraphy for diagnostic purposes. This isotope releases gamma rays at about the same wavelength as conventional X-ray diagnostic equipment, with 140 keV gamma ray energy that has an ideal short half-life ($t^{1/2} = 6$ h) for diagnostic nuclear imaging which could be injected with a small amount of Tc-99m. Within 24 h almost 94% of the injected radionuclide would have decayed and left the body, limiting the patient's radiation exposure (Gunay et al., 2019). Tc-99m is chemically bounded to various bioactive chemical.

In dacryoscintigraphy instead of injecting large amouts of Technetium-99m (Tc-99m) which disappears by 94% in 24 hours, only 0.2-0.5 mCi (in saline) Tc-99m pertechnetate is instilled into each conjunctival fornix and the patient stays upright in front of the gamma camera whilst sequential images are taken. Interpretation of images enables the accurate calculation of quantitative tear flow rate and conjunctival lacrimal clearance rate (Palaniswamy and Subramanyam,. 2012; Detorakis et al., 2014).

In this study, the radiation dose rates emitted by patients who underwent dacryoscintigraphy imaging were determined. For this, the radiation dose rate was measured with a GM counter at different times and at different distances after the injection of the radiopharmaceutical.

2. Material and Method

This study was performed in 28 (13 male and 15 female) randomly selected patients at Okan University hospital in Istanbul. The ages of the patients were varied range from 34 to 76 years, with a mean age of 58.56 years. The patients' weights were varied range from 43 to 113 kg and their average weight was 74.27 kg. The patients were given radioactivity according to the protocols of Istanbul Okan University. The mounts of radioactivity injected into patients were varied range from 3.7 MBq to 7.4 MBq, with an average of 5.1 MBq.

The radiation dose rate was measured at 12 points around the patient. Radiation detector was placed 25, 50, 100 and 200 cm from the patient's eye level and radiation dose rate measurements were made from 4 different points (Figure 1). Then, 4 different measurements were made at the same distances from the patient's chest level. Finally, the same measurements were repeated at the patient's foot level.

In order to determine the change of radiation dose rate with time, measurements were made at different times. The first radiation dose rate measurements were made between 5 minutes and 10 minutes after injection, with an average of 8.23±1.16 minutes. The second measurements were made between 35 minutes and 45 minutes after injection, with an average of 41.65±3.87 minutes. The third measurements are between 50 minutes and 60 minutes after the injection and the average is 56.81±4.16 minutes.

Inspector Nuclear Radiation Monitor Deluxe Dose Rate CPT.5250-0047 (GM counter) was used for radiation dose rate measurements. The calibration of the device is made by Turkey atomic energy agency (TAEK) in 2018.

Informed consent was obtained from all participants included in the study according to the approval of Istanbul Okan University, Research Ethics Committee.

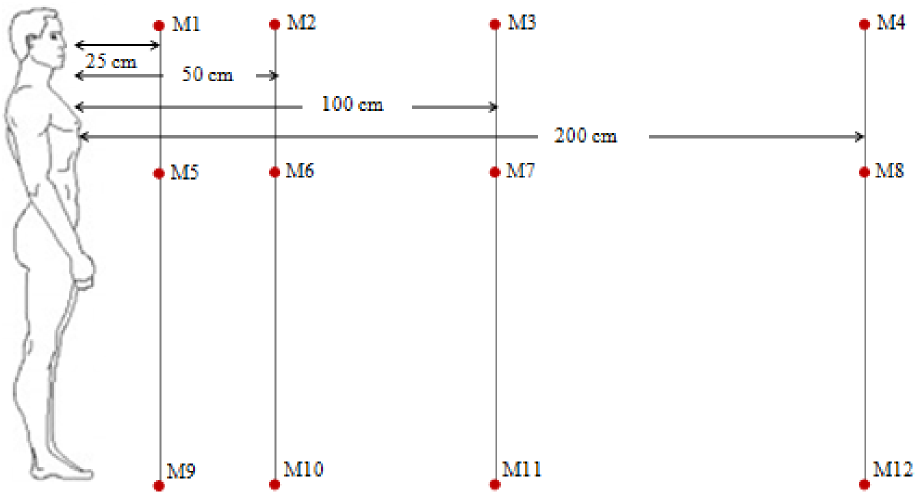

Figure 1. Radiation dose rate measurement point

3. Results and Discussion

The minimum radiation dose rate, maximum radiation dose rate and mean radiation dose rate from different distances (25cm, 50 cm, 100 cm and 200 cm) from the patient's head level are shown in table 1. The highest radiation dose rate at the head level was calculated as 2.86 μSvh^{-1} at a distance of 25 cm from the patient and at an average of 8.23 minutes after injection.

The minimum radiation dose rate, maximum radiation dose rate and mean radiation dose rate from different distances (25cm, 50 cm, 100 cm and 200 cm) from the patient's chest level are shown in table 2. The highest radiation dose rate at the chest level was calculated as 2.21 μSvh^{-1} at a distance of 25 cm from the patient and at an average of 8.23 minutes after injection.

The minimum radiation dose rate, maximum radiation dose rate and mean radiation dose rate from different distances (25cm, 50 cm, 100 cm and 200 cm) from the patient's foot level are shown in Table 3. The highest radiation dose rate at the foot level was calculated as 1.16 μSvh^{-1} at a distance of 25 cm from the patient and at an average of 8.23 minutes after injection.

Table 1. Radiation dose rate for different distances from head level

Distance from patient	Time after the injection (minute)	Minimum Dose Rate μSvh^{-1}	Minimum Dose Rate μSvh^{-1}	Mean Dose Rate μSvh^{-1}
25 cm	8.23	3.71	1.58	2.86
	41.68	2.98	1.23	1.72
	56.81	2.21	0.89	1.21
50 cm	8.23	2.02	1.02	1.53
	41.68	1.89	0.65	0.93
	56.81	1.24	0.41	0.65
100 cm	8.23	1.98	0.78	0.98
	41.68	1.23	0.42	0.59
	56.81	0.98	0.33	0.42
200 cm	8.23	1.12	0.39	0.61
	41.68	0.64	0.21	0.36
	56.81	0.49	0.12	0.25

Table 2. Radiation dose rate for different distances from chest level

Distance from patient	Time after the injection (minute)	Minimum Dose Rate µSvh^{-1}	Minimum Dose Rate µSvh^{-1}	Mean Dose Rate µSvh^{-1}
25 cm	8.23	3.08	1.23	2.21
	41.68	2.56	1.01	1.33
	56.81	1.98	0.77	0.93
50 cm	8.23	1.71	1.02	1.13
	41.68	1.23	0.51	0.67
	56.81	0.99	0.32	0.47
100 cm	8.23	1.47	0.68	0.82
	41.68	1.02	0.34	0.51
	56.81	0.71	0.30	0.36
200 cm	8.23	0.96	0.37	0.57
	41.68	0.59	0.18	0.34
	56.81	0.43	0.11	0.23

Table 3. Radiation dose rate for different distances from foot level

Distance from patient	Time after the injection (minute)	Minimum Dose Rate µSvh^{-1}	Minimum Dose Rate µSvh^{-1}	Mean Dose Rate µSvh^{-1}
25 cm	8.23	3.71	1.58	1.16
	41.68	2.98	1.23	0.71
	56.81	2.21	0.89	0.51
50 cm	8.23	0.78	1.02	0.78
	41.68	1.89	0.65	0.46
	56.81	1.24	0.41	0.32
100 cm	8.23	1.98	0.78	0.61
	41.68	1.23	0.42	0.39
	56.81	0.98	0.33	0.27
200 cm	8.23	1.12	0.39	0.51
	41.68	0.64	0.21	0.32
	56.81	0.49	0.12	0.22

After the radiopharmaceutical is injected into the patient, the radiation dose rate emitted from the patient to the environment decreases over time (figure 3-5). There are strong correlations between the mean radiation dose rate emitted by the patient and time, varying between $R^2 = 0.9784$ and $R^2 = 0.9916$ at different levels (Head, Chest and foot) and at different distances (25, 50, 100 and 200 cm).

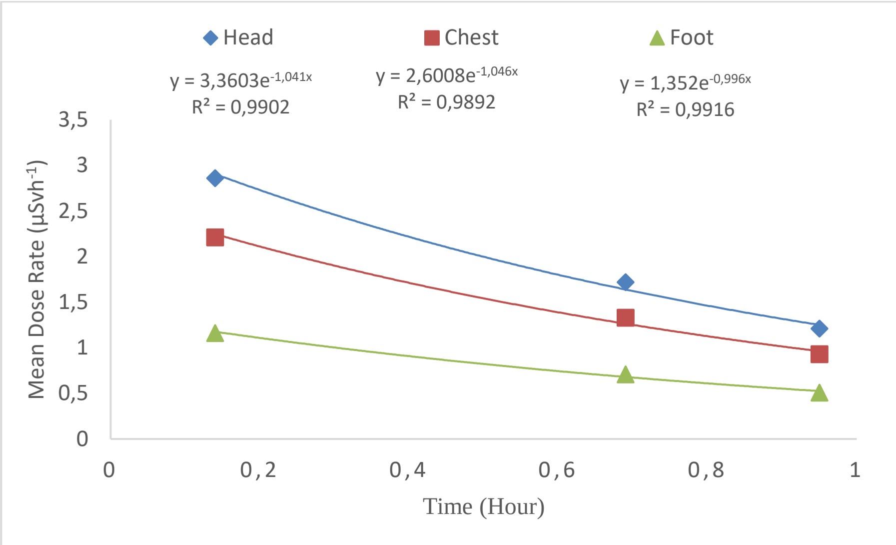

Figure 2. Radiation dose rate by time 25 cm from the head, chest and foot of the patient

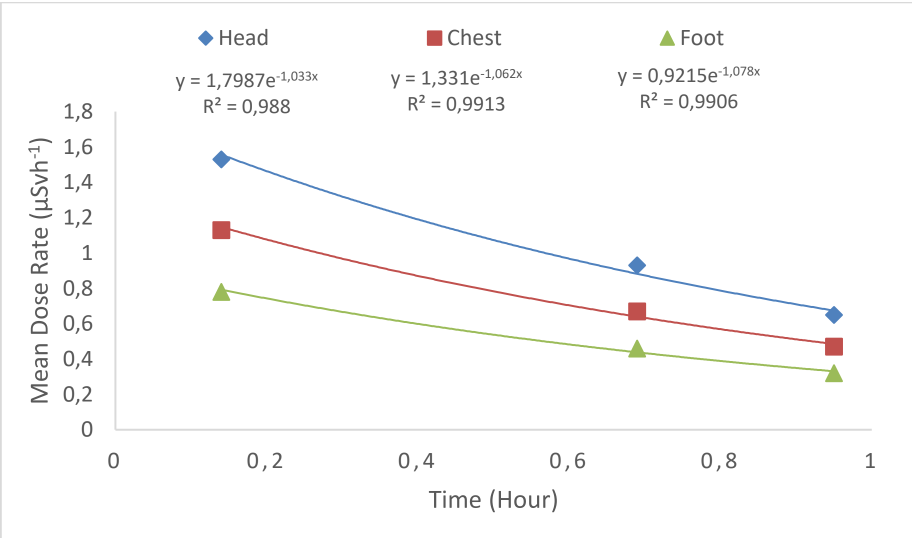

Figure 3. Radiation dose rate by time 50 cm from the head, chest and foot of the patient

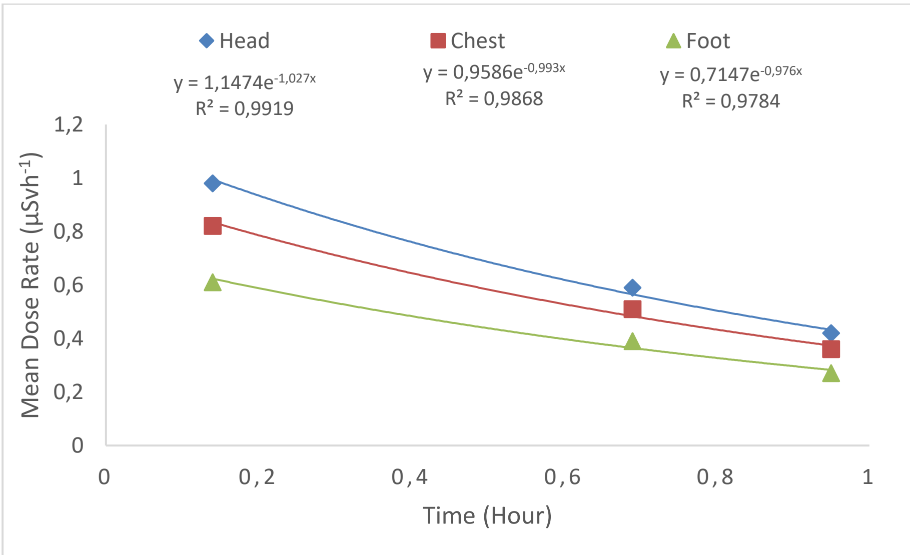

Figure 4. Radiation dose rate by time 100 cm from the head, chest and foot of the patient

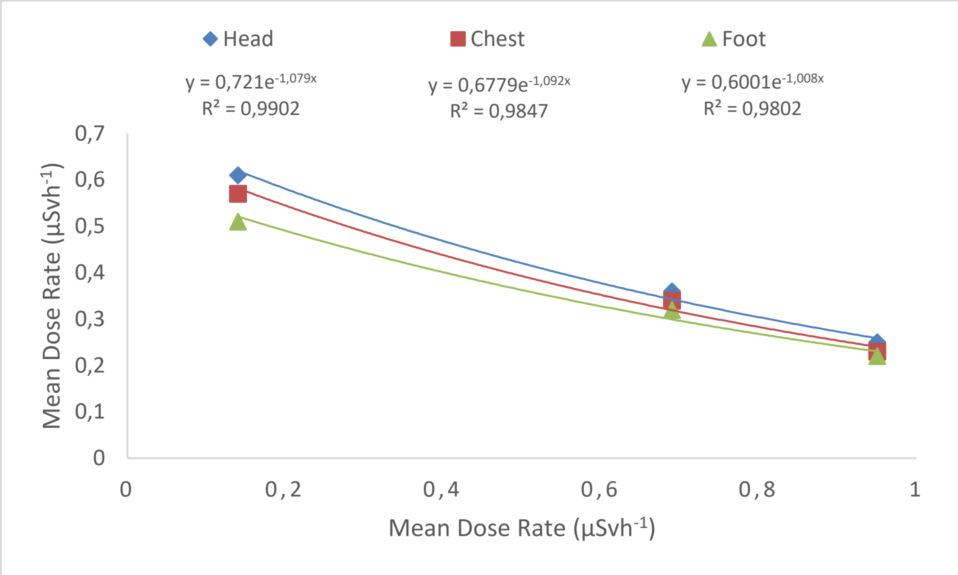

Figure 5. Radiation dose rate by time 200 cm from the head, chest and foot of the patient

It was found that the radiation dose rate at the head, chest and foot level of the patient decreased as the distance from the patient increased, in the measurements made at an average of 8.23 minutes after the injection (figure 6). There is a strong correlation (R^2 = 0.9939) between the radiation dose rate and distance at head level at 8.23 minutes after injection. There is a strong correlation (R^2 = 0.9685) between the radiation dose rate and distance at chest level at 8.23 minutes after injection. There is a strong correlation (R^2 = 0.9678) between the radiation dose rate and distance at foot level at 8.23 minutes after injection.

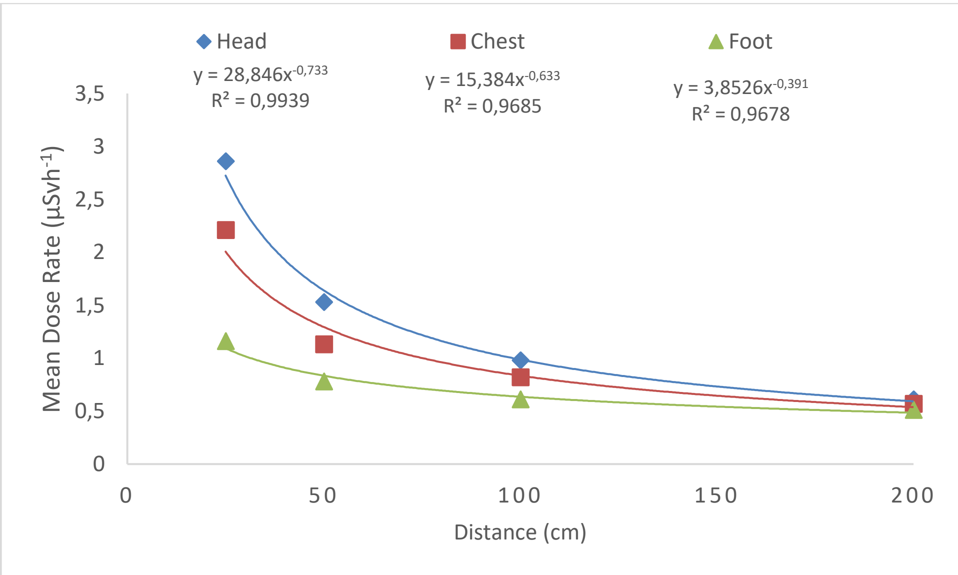

Figure 6. Radiation dose rate by distance from the head, chest and foot of the patient at 8.23 minute after injection

It was found that the radiation dose rate at the head, chest and foot level of the patient decreased as the distance from the patient increased, in the measurements made at an average of 41.68 minutes after the injection (figure 7). There is a strong correlation (R^2 = 0.9958) between the radiation dose rate and distance at head level at 41.68 minutes after injection. There is a strong correlation (R^2 = 0.9650) between the radiation dose rate and distance at chest level at 41.68 minutes after injection. There is a strong correlation (R^2 = 0.9467) between the radiation dose rate and distance at foot level at 41.68 minutes after injection.

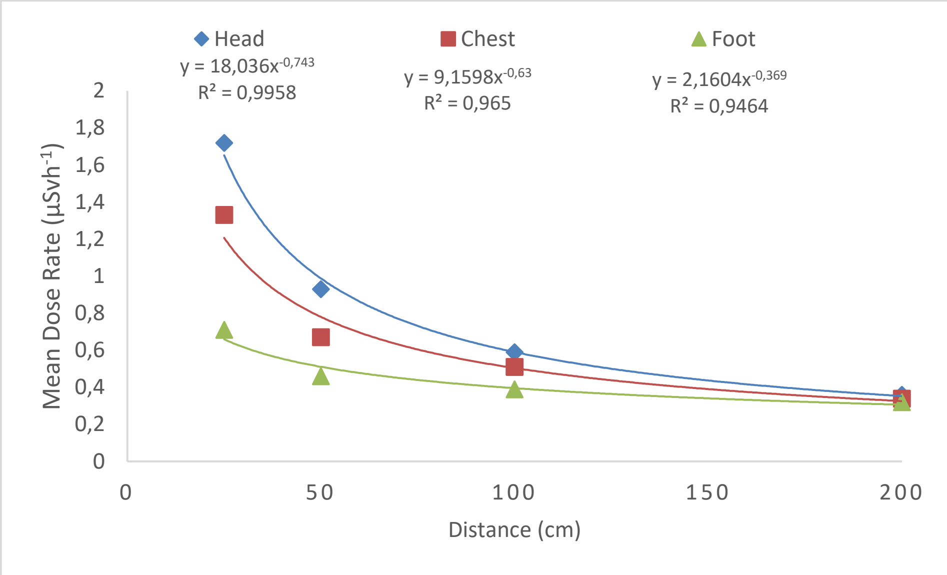

Figure 7. Radiation dose rate by distance from the head, chest and foot of the patient at 41.68 minute after injection

It was found that the radiation dose rate at the head, chest and foot level of the patient decreased as the distance from the patient increased, in the measurements made at an average of 56.81 minutes after the injection (figure 8). There is a strong correlation ($R^2 = 0.9954$) between the radiation dose rate and distance at head level at 56.81 minutes after injection. There is a strong correlation ($R^2 = 0.9692$) between the radiation dose rate and distance at chest level at 56.81 minutes after injection. There is a strong correlation ($R^2 = 0.9414$) between the radiation dose rate and distance at foot level at 56.81 minutes after injection.

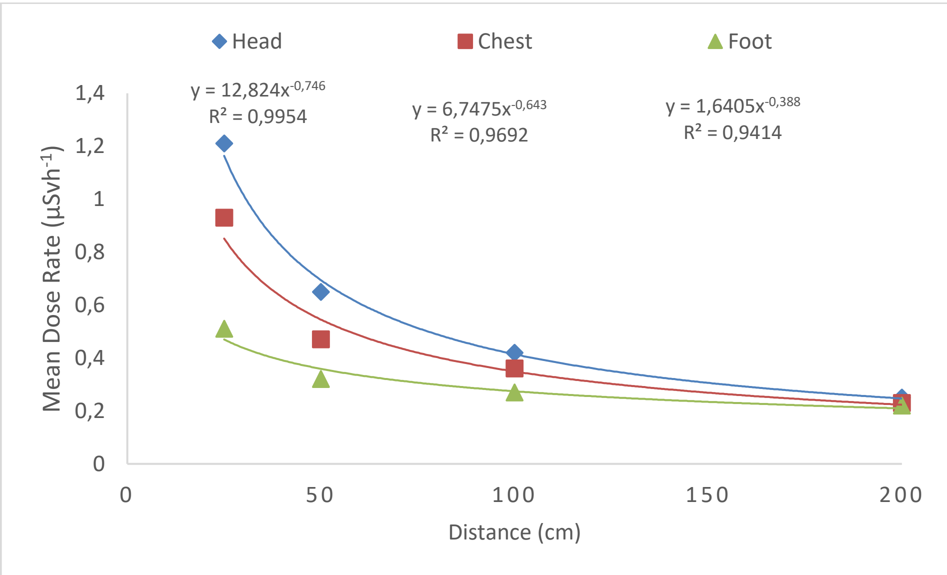

Figure 8. Radiation dose rate by distance from the head, chest and foot of the patient at 56.81 minute after injection

In a similar study by Quinn et al. in 2012, the patient was injected with 490 MBq of radioactive material and the radiation dose rate measured at a distance of 30 cm from the patient was found to be 110 µSvh^{-1} (Quinn et al. 2012). In a similar study by Demir et al. in 2011, 550 MBq of radioactive material was injected into the patient and the radiation dose rate measured 50 cm from the patient was found to be 196 µSvh^{-1} (Demir et al., 2011). In a similar study by Bera et al. in 2018, 263 MBq of radioactive material was injected into the patient and the radiation dose rate measured at a distance of 80 cm from the patient was found to be 27 µSvh^{-1} (Bera et al. 2018). In a similar study by Cronin et al. in 1999, 323 MBq of radioactive material was injected into the patient and the radiation dose rate measured 80 cm from the patient was found to be 14.7 µSvh^{-1} (Cronin et al., 1999). In a similar study conducted by Günay and Abamor in 2019, 300 MBq of radioactive material was injected into the patient and the radiation dose rate measured at a distance of 100 cm from the patient was found to be 15 µSvh^{-1} (Gunay and Abamor, 2019). In another study by Günay et al. in 2019, the patient was injected with 168 MBq of radioactive material and the radiation dose rate measured at a distance of 100 cm from the patient was found to be 5.47 µSvh^{-1}. The radiation dose rate found in our study was found to be much lower than any previous similar study. Because in our study, the amount of radioactive material injected into the patient was very low.

4. Conclusions and Recommendations

Radiation professionals should be exposed to less than 10 μSvh^{-1} dose rate, but for public this exposed radiation dose rate is 1 μSvh^{-1}. All results in this study are below the occupational radiation dose rate limits. The similarity of this study for different radiopharmaceuticals will contribute to the literature for radiation safety.

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