Radiation exposure of interventional cardiologists for different types of procedures in catheterization lab, is it more concern about extremities?

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Abstract – Introduction: Angiography and angioplasty expose cardiologists to a high level of X-ray comparing other radiographic methods, due to the high dose of radiation and the presence of the physician beside the patient bed during the procedure. Therefore, this study was designed to measure the absorbed dose in some important organs and extremities in cardiologists during different angiography and angioplasty procedures in catheterization lab. Methods: The entrance skin dose and extremity absorbed dose of the physicians in 100 angiography and angioplasty procedures were measured by TLD chips. The points on the physicians’ body, which were measured in this study, included: thyroid, right and left chest, right and left wrists, and left leg. The correlation of entrance skin dose in these six points to the exposure parameters is also evaluated. Results: The left leg has maximum dose and maximum correlation with total DAP for all three physicians in all procedure types. There was a weak correlation between left wrist absorbed dose and number of views among three physicians. Also, the maximum annual absorbed dose of the physicians in the left leg was lower than 150 mSv. Conclusion: According to the results of this study, it can be stated that periodic leg and hand dosimetry during operation is necessary for interventional cardiologists. Results also showed that, regardless of the type of procedure, the characteristics of device output, especially DAP, have a direct role in the absorbed dose of the organs and extremities, especially those outside the shield.

Keywords: radiation / occupational exposure / extremities / catheterization / thermoluminescence dosimetry

1 Introduction

Increasing use of different kinds of radiation, especially ionizing radiation, necessitates paying attention to its biologic effects. Many probabilistic and stochastic effects may be observed after exposure to ionizing radiation. Various cancers and genetic mutations are among the stochastic effects of radiation. Genetic injuries may appear in the first generation or next generations (Dixon et al., 2015). Therefore, estimation of health risk due to irradiation is of importance. One of the most important risks after exposure to ionizing radiation even in low doses is cancer, which may occur a long time following exposure. Radiation-induced cataract is another health effect, which has been reported among cardiologists (Marshal and Keene 2006; Dixon et al., 2015).

Diagnostic imaging in medicine is the largest source of artificial irradiation to humans. Nowadays, X and gamma rays play an important role in the diagnosis and treatment of diseases (Dixon et al., 2015). Angiography is a kind of imaging which uses X-ray to visualize vasculature and provides detailed information for cardiologists. During irradiation, the physician and his/her team are exposed to X-ray. Angiography is increasingly used to help diagnose cardiovascular diseases, so as its use in the United States has been increased from 2.45 million procedures in 1993 to 4.9 million procedures in 2010. In Iran, about 400,000 cardiovascular angiographies have been performed in 2011 (Leyton et al., 2016). Angiography and interventional fluoroscopy comprise 16% of cumulative effective dose of X-ray in England, although these procedures comprise only 2% of all X-ray imaging procedures (NRPB-W-4, 2002). Certainly, the number and complexity of angiography procedures have been increased in the recent years. Developments in the equipment such as catheters devices and technical improvements have
also played a role in the increasing use of angiography (Marshal and Keene 2006). Angiography and angioplasty expose cardiologists to a high level of X-ray comparing other radiographic methods, due to the high dose of radiation and the presence of the physician beside the patient bed during the procedure (Fardid et al., 2017).

Absorbed dose is an acceptable criterion for assessment of the biologic effects of ionizing radiation, so measurement of absorbed dose in cardiologists who perform angiography is important to plan for reducing the carcinogenic and probabilistic effects of radiation on radiation workers (Dixon et al., 2015). There are different methods for measurement of entrance skin dose for staff. Dosimetry using thermoluminescence dosemeters (TLD) is the most frequently used method in humans and anthropomorphic human phantoms (Korir et al., 2011; Ingwersen et al., 2013; Stewart et al., 2012). The advantage of these dosemeters is their point measurement without any considerable effect on radiation field. Considering that most studies were based on experimental measurements on human phantoms, the results may have under-estimated or over-estimated the real exposure. Some studies have used TLD in humans, but the data were continuously collected in a period of several weeks or months and divided by the total number of the procedures (regardless of the type of the procedure). These studies provide better information comparing studies on phantoms, but they have not separated the procedures so their results are probably not exact. Different studies show an immediate need for informing cardiologists about the importance of protection against radiation and optimization of exposure during coronary angiography (CA) and angioplasty (PCI) procedures. Some studies have shown that physicians do not routinely use radiation protection devices and personal dosemeters during interventional procedures which may significantly affect their absorbed dose (Dixon et al., 2015; Shoshtary et al., 2015).

So, this study was designed to measure the absorbed X-ray dose in some important organs and extremities in cardiologists during different procedures in catheterizations lab.

2 Materials and methods

This was a cross-sectional study conducted in a specialized cardiology hospital (Afshar Hospital) in Yazd from August 2018 to August 2019. The entrance skin dose extremity absorbed dose of the physicians was measured by TLD chips. The participants were three cardiologists with different work histories. Measurements were performed separately for each procedure and each physician during a year.

Measurements were performed for 100 CA, PCI and CA + PCI procedures. In each measurement, 21 TLDs were used for each cardiologist during the procedure. For each procedure, patients’ demographic (age, gender, height, and weight) and radiation parameters (number of images, fluoroscopy time and its kV, and the distance between tube and the physician), and the method of protection (floor shield, thyroid collar, apron, and lead glasses) were recorded. X-ray tube was under the table in all procedures. Figure 1 shows the relative position of the physician and the X-ray tube.

TLD materials used in this study were GR-200 tablets. These tablets were 4.5 mm in diameter and 0.8 mm in thickness. GR-200 TLDs were composed of lithium fluoride with impurities of magnesium, copper and phosphorus (LiF: Mg, Cu, P). This kind of TLD, due to its unique characteristics, has an extensive applicability in environmental, personal and medical dosimetry. Three GR-200 dosemeters were inserted in a plastic badge and were placed in each point of measurement.

In order to achieve elemental correction coefficient (ECC) for the response of each dosemeter, all TLDs were primarily irradiated by a radiology device and after reading, their results were compared. Then, the mean of results was calculated and the ratio of mean responses to the response of a specific TLD, the ECCi was calculated. In the subsequent readings, each measurement was multiplied by this coefficient to find the real reading. For calibration of TLD responses to determined radiation doses, each three TLD group was irradiated by an X-ray device in a 15 × 15 cm² field with 100 cm distance from the source (Asgari et al., 2016). After irradiation, TLD responses were read. This reading in nano-Coulomb (nC) was placed in the horizontal axis and the irradiated dose (in mGy) in the vertical axis. This diagram formed the calibration curve and its slope was the calibration coefficient, which should be multiplied by TLD reading to find the absorbed dose.

For reading TLD chips, a TLD reader model 7103 (Applied Physics Institute, Iran) was used. All measurements were done in Afshar Hospital. There was one angiography device in the hospital (Axiom Artis, MEQUALIX Cat 125/30/80, Siemens, Germany) with an under-couch tube. The device filtration was automatically changed based on the selected mode of imaging (2–3.5 mm Al). Tube voltage and current were selected and controlled by an automatic exposure control (AEC). The number of frames in second in all procedures was constant (15 frames/s). The exposure parameters such as dose area
Table 1. Summary of entrance skin dose of three cardiologists in six different points’ and radiation exposure parameters due to angioplasty procedures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Physician 1</th>
<th>Median ± SD (range)</th>
<th>Physician 2</th>
<th>Physician 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of views</td>
<td>13 ± 6.7 (7–23)</td>
<td>14 ± 6.3 (5–26)</td>
<td>13 ± 9.4 (1–31)</td>
<td></td>
</tr>
<tr>
<td>Fluoroscopy time (min)</td>
<td>6.2 ± 4.3 (3.1–12.4)</td>
<td>6.5 ± 4 (1.7–16.8)</td>
<td>8.2 ± 6.1 (2.3–20.2)</td>
<td></td>
</tr>
<tr>
<td>DAP (mGy.m³)</td>
<td>2.3 ± 1.9 (1.4–6.3)</td>
<td>4.6 ± 2.9 (1.4–6.3)</td>
<td>3.7 ± 2.7 (1.7–10)</td>
<td></td>
</tr>
<tr>
<td>IRP dose (mGy)</td>
<td>403 ± 350 (155–1134)</td>
<td>892 ± 488 (122–1792)</td>
<td>551 ± 481 (195–1665)</td>
<td></td>
</tr>
<tr>
<td>Thyroid dose (μGy)</td>
<td>0.75 (0–1.25)</td>
<td>1.49 (0–3)</td>
<td>0.96 (0–4.97)</td>
<td></td>
</tr>
<tr>
<td>Right chest dose (μGy)</td>
<td>0.01 (0–0.83)</td>
<td>0.36 (0–45.44)</td>
<td>0.20 (0–1.73)</td>
<td></td>
</tr>
<tr>
<td>Left chest dose (μGy)</td>
<td>0.37 (0–2.73)</td>
<td>1.50 (0–53.99)</td>
<td>0.85 (0–6.97)</td>
<td></td>
</tr>
<tr>
<td>Right wrist dose (μGy)</td>
<td>4.17 (0.62–12.11)</td>
<td>6.63 (2.30–22.46)</td>
<td>4.95 (1.58–20.28)</td>
<td></td>
</tr>
<tr>
<td>Left wrist dose (μGy)</td>
<td>9.66 (2.87–36.15)</td>
<td>15.11 (3.21–54.90)</td>
<td>20.75 (2.80–127.27)</td>
<td></td>
</tr>
<tr>
<td>Left leg dose (μGy)</td>
<td>83.99 (23.02–126.03)</td>
<td>59.62 (13.15–488.89)</td>
<td>87.49 (8.31–156.25)</td>
<td></td>
</tr>
</tbody>
</table>

All data presented as median, SD and range.

Table 2. Summary of entrance skin dose of three cardiologists in six different points and radiation exposure parameters due to angioplasty + angiography procedures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Physician 1</th>
<th>Median ± SD (range)</th>
<th>Physician 2</th>
<th>Physician 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluoroscopy time (min)</td>
<td>8.1 ± 3.3 (2.3–15.6)</td>
<td>6.3 ± 5.4 (2.9–18.9)</td>
<td>5.4 ± 0.8 (4.8–6.5)</td>
<td></td>
</tr>
<tr>
<td>DAP (mGy.m³)</td>
<td>4.3 ± 1.8 (1.8–8.7)</td>
<td>6.4 ± 6.4 (2.6–24.7)</td>
<td>3.9 ± 1.2 (2.5–24.7)</td>
<td></td>
</tr>
<tr>
<td>IRP dose (mGy)</td>
<td>721 ± 318.6 (286–1498)</td>
<td>999 ± 1258 (370–4685)</td>
<td>731 ± 240 (375–936)</td>
<td></td>
</tr>
<tr>
<td>Thyroid dose (μGy)</td>
<td>0.44 (0–3.01)</td>
<td>1.71 (0.67–5.92)</td>
<td>1.77 (0.59–2.61)</td>
<td></td>
</tr>
<tr>
<td>Right chest dose (μGy)</td>
<td>0.04 (0–1.17)</td>
<td>0.58 (0–1.88)</td>
<td>0.32 (0–1.44)</td>
<td></td>
</tr>
<tr>
<td>Left chest dose (μGy)</td>
<td>0.0 (0–15.44)</td>
<td>0.90 (0.23–4.41)</td>
<td>0.92 (0–3.33)</td>
<td></td>
</tr>
<tr>
<td>Right wrist dose (μGy)</td>
<td>4.88 (1.79–16.52)</td>
<td>17.94 (3.14–35.10)</td>
<td>7.61 (4.26–12.04)</td>
<td></td>
</tr>
<tr>
<td>Left wrist dose (μGy)</td>
<td>16.59 (4.39–90.41)</td>
<td>33.05 (5.91–170.36)</td>
<td>21.25 (10.14–68.08)</td>
<td></td>
</tr>
<tr>
<td>Left leg dose (μGy)</td>
<td>88.38 (36.87–329.77)</td>
<td>174.57 (29.96–514.47)</td>
<td>99.92 (65.14–105.55)</td>
<td></td>
</tr>
</tbody>
</table>

All data presented as median, SD and range.

In this study, the variables considered for the study were number of views, and the IRP dose (dose in reference point) were recorded separately in each procedure and for each physician. Other technical factors such as filtration, voltage and current were continuously recorded and controlled in order to ascertain the correct condition of irradiation.

TLD badges (each containing three TLDs) were attached to the pre-determined points. The points on the physicians’ body which were measured in this study included: thyroid, right and left chest, right and left wrists, and left leg. In order to more exactly assess the absorbed dose in the areas which used lead protection (thyroid and chest), TLD badges were placed under the lead apron. Finally, one badge containing three TLDs was used to measure the background dose level. All dosemeters were read by a TLD reader during 24 hours after irradiation. Data were analyzed by SPSS (version 20) using Wilcoxon’s and Mann-Whitney’s test. P-values less than 0.05 were considered as significant. Also, the correlation of dose to exposure parameters performed using Spearman’s correlation test. The study was approved by the ethics committee of Shahid Sadoughi University of Medical Sciences. An informed consent was obtained from each physician and each patient.

3 Results

3.1 Dosimetry of angioplasty (PCI)

From 100 measurements, 35 measurements were performed for angioplasty procedures (7, 16, and 12 procedures for physician number 1, 2, and 3, respectively). Table 1 shows the characteristics of angioplasty procedure and entrance skin dose among cardiologists in six different points in angioplasty.

3.2 Dosimetry of concurrent angiography and angioplasty (CA + PCI)

Totally, 35 measurements were done in the procedures simultaneously involved both angiography and angioplasty. In these procedures, physician 1, 2, and 3 performed 19, 10, and 6 procedures, respectively. Table 2 shows the characteristics of radiation and the entrance dose of the skin among cardiologists in six different points in angiography + angioplasty procedures.
Table 3. Summary of entrance skin dose of three cardiologists in six different points and radiation exposure parameters due to angiography procedures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Physician 1</th>
<th>Physician 2</th>
<th>Physician 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of views</td>
<td>$6 \pm 2.4$ ($3$–$11$)</td>
<td>$7.5 \pm 4.6$ ($3$–$17$)</td>
<td>$7 \pm 0.8$ ($6$–$8$)</td>
</tr>
<tr>
<td>Fluoroscopy time (min)</td>
<td>$1.1 \pm 0.2$ (0.8–$7.2$)</td>
<td>$2.5 \pm 4.6$ (0.5–$17.2$)</td>
<td>$0.8 \pm 0.7$ (0.5–$2.3$)</td>
</tr>
<tr>
<td>DAP (mGy m$^2$)</td>
<td>$1.4 \pm 1.5$ (0.7–$5.8$)</td>
<td>$2.4 \pm 1.8$ (0.7–$7.1$)</td>
<td>$1 \pm 0.6$ (0.8–$2.5$)</td>
</tr>
<tr>
<td>IRP Dose (mGy)</td>
<td>$212 \pm 277$ ($91.9$–$1004$)</td>
<td>$351 \pm 269$ ($127$–$1104$)</td>
<td>$150 \pm 97$ ($122$–$376$)</td>
</tr>
<tr>
<td>Thyroid dose (μGy)</td>
<td>$0.0$ (0–$0.84$)</td>
<td>$0.88$ (0–$2.93$)</td>
<td>$0.0$ (0–$1.25$)</td>
</tr>
<tr>
<td>Right chest dose (μGy)</td>
<td>$0.0$ (0–$3.24$)</td>
<td>$0.39$ (0–$1.90$)</td>
<td>$0.0$ (0–$1.26$)</td>
</tr>
<tr>
<td>Left chest dose (μGy)</td>
<td>$0.02$ (0–$1.24$)</td>
<td>$1.53$ (0–$5.74$)</td>
<td>$0.02$ (0–$1.58$)</td>
</tr>
<tr>
<td>Right wrist dose (μGy)</td>
<td>$2.23$ (0.31–$9.42$)</td>
<td>$5.55$ (0.83–$10.81$)</td>
<td>$1.93$ (0–$3.38$)</td>
</tr>
<tr>
<td>Left wrist dose (μGy)</td>
<td>$13.80$ (0.51–$49.15$)</td>
<td>$13.54$ (8.71–$24.73$)</td>
<td>$9.50$ (3.44–$25.08$)</td>
</tr>
<tr>
<td>Left leg dose (μGy)</td>
<td>$29.25$ (0.70–$128.61$)</td>
<td>$46.58$ (5.81–$155.14$)</td>
<td>$19.11$ (2.03–$44.23$)</td>
</tr>
</tbody>
</table>

All data presented as median, SD and range.

3.3 Dosimetry of angiography (CA)

From 100 measurements, 30 measurements were performed for angiography procedures (12, 12, and 6 procedures for physician number 1, 2 and 3, respectively). Table 3 shows the characteristics of radiation and the achieved dose of the skin among cardiologists in six different points in angiography.

3.4 Correlation between skin dose and exposure parameters

Correlation diagram between left wrist achieved absorbed dose and number of views showed that there was a weak correlation among three physicians ($R^2$ = 0.30, 0.52, and 0.13, respectively for physicians 1, 2, and 3; Fig. 2a). This measure for left leg was 0.66, 0.71, and 0.61 for physicians 1, 2, and 3, respectively (Fig. 2b). Correlation between left leg absorbed dose and fluoroscopy time showed that highest $R^2$ was for physicians 1 and 3 (Fig. 2c), and this correlation for left wrist was highest in physician 3 as well (Fig. 2d).

There was a relatively high correlation between left leg dose and left wrist dose with total DAP for all three physicians (Fig. 2e–f). The correlation was relatively high between left leg dose and IRP and relatively low between left wrist dose and IRP (Fig. 2g–h).

Mean ± SD for entrance dose/procedure/DAP for PCI procedures were 1.8 ± 1.3, 5.5 ± 4.2, and 24.4 ± 14.4, for right wrist, left wrist and left leg, respectively. These measures for CA were 1.7 ± 0.9, 9.1 ± 5.5, and 22.5 ± 13, respectively for right wrist, left wrist and left leg; and 1.7 ± 1.1, 6.0 ± 5.2, and 24.8 ± 11.0, for CA + PCI. Figure 3a–c shows dose per procedure/DAP for six organs in three different procedures.

4 Discussion

Interventional cardiologists achieve a high level of radiation dose in different procedures. Therefore, getting information about radiation dose in catheterization laboratory (Cath lab) for each physician is important. One method to find the radiation risk is the evaluation of absorbed dose of the physicians during different procedures. Standard evaluations can lead to improvement in the conditions of imaging and increased radiation protection among personnel.

Considering the difficulties in directly measuring absorbed dose of all organs, in this study, entrance skin dose in six points was measured for three cardiologists for three routine procedures in Cath lab, i.e. angioplasty, angiography, and angiography + angioplasty. Measurements were performed for 100 procedures by TLD.

4.1 Exposure parameters and cardiologist’s dose

The results showed that there was a large difference in variables in different procedures and even in the same procedure between the physicians, so as the maximum of DAP was 12 times the minimum in angioplasty, and 9 times in angiography + angioplasty and 10 times in angiography. The maximum number of views was 31, 14 and 5 times the minimum in angioplasty, angiography + angioplasty and angiography, respectively. Similar results were observed for IRP and fluoroscopy time. The highest differences were observed in physician 2.

Comparing these measures with other studies shows that these differences were lower than the differences found in Dabin et al. (2011) and Kim et al. (2008) studies.

Considering that physicians’ dose is due to the scattered radiation from the patient, wide range of variations in device output parameters can directly affect the patient dose and therefore the physician’s. Previous studies have shown that wherever the output parameters especially DAP was higher, physicians’ absorbed dose was higher as well. Some other studies showed that the exposure parameters, especially DAP, directly related to patient body mass index (BMI) (Bouzarjomehri and Tsapaki, 2009; Crowhurst et al., 2019) so we considered only the effect of such exposure parameters – instead of patient weight – on physicians’ dose.

After normalizing the entrance skin dose to DAP for physicians with the highest absorbed dose, we reached the relatively similar results for each organ in different procedures. Whitby and Martin (2005) and Martin (2011) found similar results. It means that, regardless of the type of procedure, the...
characteristics of device output and especially DAP have a direct role in the absorbed dose of the organs, especially those outside the shield. Normalizing the dose according to DAP, reduces the diversities in different situations and even different procedures, so we can more precisely compare the procedures; although some diversities remained even after normalization.

According the correlation diagrams, there was a weak correlation between the output parameters and the absorbed dose. Theocharopoulos et al. (2006) and Ingwersen et al. (2013) showed that parameters other than DAP (such as position of physician and bed, views with different angles, and the differences in the distance between tube and the patient were effective in the physician’s radiation dose. Comparing the

Fig. 2. The correlation between cardiologists’ dose and exposure parameters. The highest correlation between entrance skin dose in different organs and number of views (a and b), fluoroscopy time (c and d), DAP (e and f) and IRP (g and h).
dose of left and right organs showed that the dose in left side was higher ($P < 0.05$) due to proximity to the tube which was consistent with the results of Donadille et al. (2011) and Karimian et al. (2014).

### 4.2 Effects of procedure type on cardiologist’s dose

In the current study, the highest dose for all three physicians and all procedures was observed in left leg, left wrist and right wrist ($P < 0.05$), respectively, which is probably due to the position of the tube (below the patients’ bed) and physician’s position. We found a significant difference between the dose in the left and right wrists ($P < 0.05$). Different studies have shown that the dose in right wrist was 46–84% lower than the left wrist. Donadille et al. (2011) and Martin (2011) found right wrist dose to be 50% lower than the left wrist, and Koukorava et al. (2011) found 30% higher dose in left wrist comparing the right wrist. Although, inconsistent with these results, Efstathopoulos et al. (2011) found a lower dose for left leg in comparison to other organs and Dalah et al. (2018) did not find any difference between right and left wrists. This difference is probably due to table lead curtain which they used in their studies, but in the current study this protection was not used.

### 4.3 Extremities’ maximum annual doses

It can be concluded that from this study, organ dosimetry (especially leg and hand) during operation is necessary for interventional cardiologists, especially when organs are in proximity to tube and achieve higher doses. This measurements help to ensure that the extremities dose could not be reached to the maximum permissible doses recommended by international organizations such as ICRP. According to ICRP 103, the annual dose for hand and leg is about 500 mSv and the limit of monitoring is about 30% of annual dose (150 mSv), so if the absorbed dose in leg and hand reaches 150 mSv, monitoring of these organs is necessary (ICRP, 2007).

According to the results of this study, the annual absorbed dose of the physicians in the left leg was lower than 150 mSv. Lower than standard dose in the left leg may protect against probabilistic events, but there is no guarantee to prevent stochastic events such as cancerogenicity, which do not have any threshold dose. The possibility of these events is possible in low dose long-term radiation. Therefore, it is recommended to use protection methods to reduce the dose of extremities.

### 4.4 Effect of distance to patient on extremity dose

During measurement of wrist dose, when physician’s hand moved away from the patient, wrist dose was reduced. A study showed that absorbed dose in the wrist was inversely related to the square of the physician’s distance from patient’s bed (Ingwersen et al., 2013). Studies have shown that in interventional procedures, the complexity of the procedure, technique which the physician uses, physician’s workload have a considerable effect in wrist dose (Theocharopoulos et al., 2006). So, using protective measures for hand is of importance in cardiologic procedures. The wrist dose in physician 1 was...
significantly lower than other physicians ($P < 0.05$). This physician, at most of the times, was further away from the patient’s bed comparing to the other physicians.

4.5 Study limitations

One of the most important limitation of the study was that all measurements were done in one center with few participating cardiologist. Performing such dosimetry in different centers with large number of cardiologists and procedures may lead to more accurate results. But to the best of our knowledge, few studies have measured absorbed dose of physicians’ different organs by TLD in different procedures. Most studies have performed measurements of some procedures in a time range or only in anthropomorphic phantoms. This study had this advantage of measuring radiation dose in the skin in six different points for three different procedures to find more precise and real information about the absorbed dose of the cardiologists in the Cath lab.

Another limitation was that we considered the correlation of exposure parameters on physicians’ dose but the effect of patient weight or BMI was not directly considered in current study.

5 Conclusion

This study measured radiation dose in the skin of six organs in three cardiologists during three different procedures using TLD dosemeters. There was a high correlation between organ doses in each procedure and DAP. There was also a significant difference between each procedure normalized by DAP (dose/procedure/DAP) in three different procedures. The highest achieved dose was observed in left leg followed by left wrist and right wrist. Annual dose of physicians’ leg was lower than the limit for monitoring but it is recommended to use protection methods to reduce the dose of extremities as low as possible.

Conflicts of interest. The authors declare that they have no conflicts of interest in relation to this article.

References


