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Radiation Dose to Staff during Cardiac Interventional Procedures (Khartoum-Sudan)

Etidal Hussein. Khalafalla

AL Bayan Collage for Science and Technology, PO Box 210, Khartoum, Sudan

Abstract: ***The aim of this study was to measure and evaluate the staff radiation dose during cardiac procedures, such as coronary angiography (CA), percutaneous coronary interventions (PCI). Measurements were performed on Staff doses in (65) procedure using thermo-luminesces Dosimeters (TLDs) (LiF, Mg, Cu, P) at three anatomic locations (waist, chest and hand) for main operator and in the chest to assistant operator. While for patient; the dose measured using dose area product (DAP) meter. The radiation dose for the main operator's waist, chest and hand were 0.45, 0.47, 0.99mGy respectively and for the assistant operator's chest was 0.324mGy depending on TLD method indicating an increment by 28.8% relative to MPD. The monitoring of radiation workers is not established properly. It is obvious that high patient and staff exposure is due to the lack of experience and protective equipment's. The results presented are comparable with those published by other authors.***

Keywords: Staff dose, interventional cardiology, Thermoluminescence dosimeters, radiation risks.

1. Introduction

The number of interventional cardiology procedures has increased rapidly in recent years. Coronary angiography (CA) and percutaneous transluminal coronary angioplasty (PTCA) are now performed widely as a matter of routine in many general hospitals [1].

The growing use of these procedures together with the fact that these procedures generally require prolonged fluoroscopy time and multiple x- ray exposures contribute to high population doses and their associated risks.

These interventional procedures are highly justified, and the number of instances is growing all over the world. Nevertheless, due to prolonged fluoroscopy time and multiple cine imaging, population dose and associated health risks are also increasing. The potential occurrence of the deterministic effects, especially to the skin, has been the subject of great concern. Skin dose above a value of 2 Gy, considered as a level at which radiation dermatitis may be observed, was described [2], [3]. Entrance skin dose can be directly measured with thermoluminecence dosemeters (TLDs) [4], [5] but due to varying orientation of the X-ray tube vis-a-vis the patient during the procedure, a large number of TLDs are necessary. Most studies investigating patient doses from interventional procedures were conducted using measurements with dose area product (DAP) meter. The values of dose-area product and effective dose for interventional radiology (IR) are typically larger than those used in common diagnostic X-ray examinations. According to UNSCEAR [6] from 1992 to 1995 in the USA, there were 26 reports to the Food and Drug

Administration (FDA) of radiation- induced skin injuries from fluoroscopy. In 1999, the FDA documented some 50 cases of radiation-induced burns, many patient are underwent IC procedures. Reports from the FDA’s voluntary registry and other worldwide studies are continuing to detect more incidents of skin burn following IC [7], [8].

Patient and staff dose during cardiac interventional procedures is considered to be high due to the existence of the operators, assistant, beside the patient during X-ray procedures also the prolonged exposure time to the patient. There is no enough assessment was made at the national level to estimate the significance of radiation dose measurement required [9, 10]. In diagnostic and therapeutic in interventional cardiology procedures performed with the use of X-ray diagnostic imaging system, the long fluoroscopy time and the large number of cine projections, as well as repetition of the procedure due to the recurrence of lesion, a common event, result in a high locally delivered skin dose, which may even lead to patient skin necrosis [11].

Occupational doses from fluoroscopy-guided interventional procedures are the highest doses registered among medical staff using X-rays [12]. Interventional cardiologists who work in cardiac catheterization laboratories are exposed to low doses of ionizing radiation that could pose a health hazard. Cardiac catheterization has been used for decades and is the gold standard for the diagnosis of different cardiovascular diseases. Cardiovascular interventional therapy is effective therapeutically for cardiovascular diseases and reduces the morbidities of coronary artery disease, peripheral vascular disease, cardiac arrhythmia, and congenital heart disease; However, interventional cardiologists [12]. Working in high volume cardiac catheterization laboratories are exposed to significant occupational radiation risks of developing certain diseases, including hematopoietic cancers (as long term effect), thyroid diseases, skin diseases, cataracts (threshold effect), or upper respiratory disease. Controversial data have been reported about the relationship between the amount of radiation exposure and development of different diseases after cardiac catheterization and interventional procedures [12, 13and 14].

The aim of present study was to determine hand, chest, and waist to staff (main operator) and chest in the assistant, radiation dose during cardiac interventional procedures.

2. Material and Method

The study was performed in hospital in Khartoum. using TLDs chips manufactured by France FIMEL Company. TLDs made of Lithium Fluoride doped with Magnesium copper, and phosphorus. TLDs were calibrated per producible reference condition using general purpose C-arm machine (Simulator) is manufactured by Huestiscascade NTM-radiation therapy, Germany Company in 2010, according to interventional protocols for range of energies used in the study. A set of the measurements were performed using (PTW-CONNY) ionization chamber with dimensions of 180x100x45 mm, applicable to cardiology, radiology and surgery. The measured doses were 5.119mGy at all constant. After completing the calibration process, any chips that exceeded the 10% error were excluded from the study.

The irradiated chips were readout using automatic TLDs reader FIMEL PCL3. The read out was at a 55C0 preheat temperature and the signal was acquired from 55C0 to 260C0 with heating rate of 11C0 /S. All TLDs were annealed in annealing oven at 240C0for 10 min, followed by fast cooling by opening the oven door.

3. Staff ESD Measurement

Staff dosimetry measurements were performed for 65examinations (40 for CA and 25 for PCI procedure) in two hospitals , main operators and assistants. The data of staff to three sites of the body of the main operator as follows: doses were measured at the hand to measure the doses to the upper extremities, at the chest to measure the doses over lead apron, and at the waist level to estimate the dose to the organs shield by apron. While for the assistant at the chest for the technologist the monitoring site was the chest only. In all procedures staff entrance surface dose (ESD) were a valuated using three envelope include three TLDs chips in a plastic envelop mounted on staff surface at midpoint of radiation field at a part of interest of the central axis beam using a very thin envelope made of transparent polyethylene plastic tail, to protect the TLDs form any contamination an avoid any shadow in the monitor. During interventional cardiology procedures the TLDs were kept in required position and fixed in place with cell- tapes to measure ESD.

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4. Result

Table1: Statistical Summary of 40 staff radiation doses (mGy) in CA procedure

Variable	Fluo-time	p-dose	operator			assistant
			hand	waist	chest	chest
A	3.69	706.36	0.39	0.23	0.15	0.05
M	2.06	442.1	0.11	0.16	0.07	0.03
SD	4.52	703.56	0.94	0.27	0.28	0.11
max	23.3	3296.8	4.33	1.04	0.69	0.7
Min	0.35	44.6	0.01	0.01	0	0.01
3^{rd}Q	3.9	867.5	0.23	0.26	0.16	0.06

(A, average; M, mean; STD, standard deviation; 3^{rd}Q, third quartile)

Table2: Statistical Summary of 25 staff radiation doses (mGy) in PCI procedure

Variable	Fluo-time	p-dose	operator			assistant
			hand	waist	chest	chest
A	3.54	616.52	1.96	0.81	0.98	0.75
M	2.07	392.5	0.4	0.04	0.16	0.05
SD	3.84	550.38	4.25	1.66	1.02	1.43
max	17.9	2435.7	20.4	6.92	0.7	4.85
Min	0.33	84.6	0.01	0.01	0.01	0.01
3^{rd}Q	4.12	756.1	1.81	0.4	0.32	0.2

(A, average; M, mean; STD, standard deviation; 3^{rd}Q, third quartile

Table 3: Previous studies results dose value (mGy) during cardiac procedure

Reference	Organ	Mean	Min	Max
Current study2017	Waist	0.45	0.01	6.92
	Chest	0.47	0	0.7
	Hand	0.99	0.01	20.4
	ass-chest	0.32	0.01	4.85
Abdoelrahman A et al (15) 2014	Waist	0.06	0.01	0.16
	Chest	0.11	0.02	0.27
	Hand	0.21	0.05	0.60
	ass-chest	0.01	0.01	0.04
H. Osman et al (16) 2012	Waist	NA	NA	NA
	Chest	0.2	0.16	0.28
	Hand	0.223	0.21	0.26
	ass-chest	NA	NA	NA
Hiba et al (9) 2010	Waist	0.14	0.08	0.24
	Chest	0.19	0.12	0.73
	Hand	0.18	0.10	0.48
	ass-chest	0.14	0.07	0.18

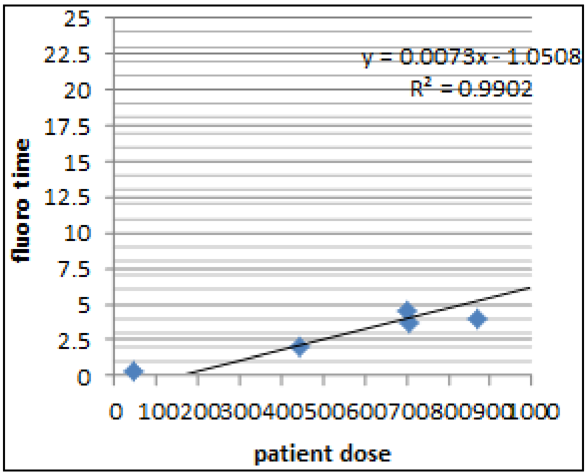

Figure 1: showed linear relationship between the p-dose and fluo-time with R2= 0.9902 during CA procedures.

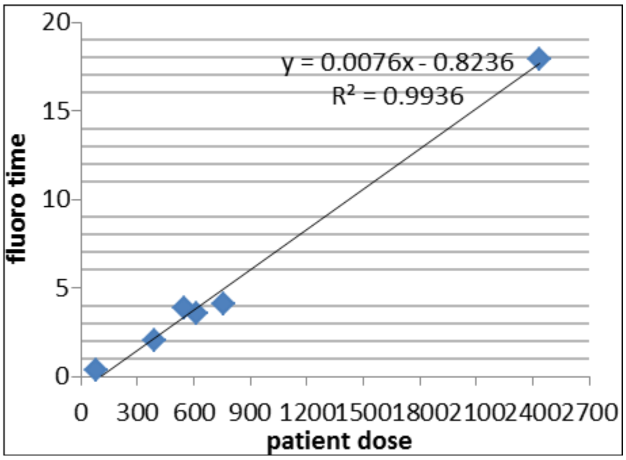

Figure 2: showed linear relationship between the p-dose and flu-time with R2= 0.9936 during PCI procedures.

5. Discussion

The main source of scatter radiation received to staff is the patient. Several factors can modify the radiation risk to the staff, but if patient doses are high, the level of scatter doses also will be high.

The statistical summary of the staff radiation dose, an increase staff doses depended with patient dose, time of procedures and type of clinical indication, the different value doses received to staff in both clinical indication are given in table 2and 3 respectively.

The outcome of this study was compared with some published surveys for CA and PCI as demonstrated in Table 3.

The staff doses measurement and estimation in this study illustrate that, the highest mean dose-equivalent values were obtained from the main operator hand.0.99 mGy for all procedures. Which agrees with that reported in previous studies (Abdoelrahman et al2014, H Osman et al 2012)?

The mean value for chest over the apron was 0.70 mGy and the maximum was 0.47mGy for all procedures, representing the dose without shielding. The waist and chest dosimeters were used to evaluate the significance of the use of lead aprons as a protection tool, and also to estimate the effective dose.

The mean value dose received by assistant in the chest on dosimetry over the apron was 0.324mGy in range was (from 0.01 to 4.85), it is lower than main operator because the main operator acts as a barrier between the assistant and the of scatter radiation according to their positions during the procedure.

The mean value of radiation dose to the hand 0.99mGy was higher than the waist and chest because the hand is located at a proximity to the field of scattered radiation.

The results in is study considered high compared to the previous studies, The value dose estimated in this study is under acceptable from the radiation protection of pervious. It a great extent, catheter labs are often operated by physician with no formal training on the physics of fluoroscopy and on radiation protection issues.

Figures (1) and (2) showed that in all procedure (Ca and PCI) there is a strong correlation between the received dose and time of the scan which have R2=0.990 and 0.994 respectively in direct correlation.

To optimize radiation protection, every effort should be made to reduce the dose for staff and patients, This goal can be primarily achieved in this hospital by: (1) intensive training of the operators, nurses and technologists (2) position to the region of interest only and shift to lower cine-graphic modes and use less cine-graphic runs, (3) Use low-level fluoroscopy mode whenever possible and reduce the fluoroscopy time as possible (4) Avoid unnecessary magnification, (5) Apply the "as low as reasonably achievable" (ALARA) principle in emergency cases after gaining sufficient reperfusion.

6. Conclusion

The study presents results for 65 staff during cardiac interventional procedures at hospitals in Khartoum during 3 months.

The main source of scatter radiation received to staff is the patient. Several factors can modify the radiation risk to the staff, but if patient doses are high, the level of scatter doses also will be high.

The cardiologist and the rest of medical staff should be made aware of associated radiation risk and the radiation protection equipment's; therefore the patient dose, fluoroscopy time and clinical indication to be a good indicator of scattering radiation to receive by medical staff. Controlling one of these parameters is expected to reduce drastically doses to staff

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