

Evaluation of Radiation Dose for Cardiac Catheterization Staff

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Abstract: *This study was aimed to measure and evaluate the staff and patients radiation dose during cardiac catheterization procedures in Al-shab teaching hospital in Khartoum state, Sudan. Staff doses measured in (61) procedures (43) for diagnostic (CA) and (18) for therapeutic percutaneous Coronary Interventional (PCI) 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 0.0608, 0.1127, 0.2125mGy respectively and for the assistant operator's chest was 0.0134mGy depending on TLD method indicating an increment by 28.8% relative to MPD. The patient dose as DAP measured as in mean 905.479 ± 6.7 mGy. The dose measured in this study was lower than the previous reported studies in literature. This almost due to technical parameters reduction so it reduces the scattering radiation in all examinations which considered one of the major causes of received doses.*

Keywords: Occupational exposure, Staff doses, Interventional cardiology, Catheterization procedures

1. Introduction

In interventional cardiology (IC), occupational radiation risk arises mainly from scattering of X-rays impinging on the patient. Each scatter event is an X-ray deviated from its initial trajectory [1]. The global effect is mark able amount of defected X-rays backscattering alludes to the intensity reaching the specialist. Backscattering depends on the intensity and energy of X- rays entering the patients on the value being imaged, and on the patients irradiated surface [2].The latter results in a different value of the so-called backscattering factors..

Pediatric (IC) is sometimes thought, in practice to be associated with low occupational radiation risk because the patients are small. According to this line of thought, the radiation scattered by patients is thought to be small, However because pediatric cardiologists need to stay closer to the patient during adult catheterization, backscattering can be higher than believed. In addition, sometimes protective screens are not used, procedures are long, and complex and hip lane systems are used [1, 3]. Interventional cardiology which involves coronary angiography (diagnostic) procedures and percutaneous coronary interventions (therapeutic) procedures is becoming progressively more common [3]. 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 were made at the national level to estimate the significance of radiation dose measurement required [2, 3]. 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 [4].

Occupational doses from fluoroscopy-guided interventional procedures are the highest doses registered among medical staff using X-rays [5]. 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 [5]. 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 [5, 6, and 7].

The purpose of this study is to determine hand, chest, and waist to staff (main operator) and chest in the assistant, TLDs during interventional fluoroscopic procedures. These data was acquired from 61cardiologists and assistant conducting procedures in same fluoroscopic suits. 61case were examined for this study, including cardiac angiography. The data were analyzed to determine the average dose over all procedures and determine if this was a correlation between staff dose, fluoroscopy time and patient dose used for each procedure.

2. Material and Method

The study was performed 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 61 examinations (43 for CA and 18 for PCI procedure) in two hospitals are given in the **table 1**, 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.

4. Result Presentation

Table 1: Statistical Summary of 61 Staff radiation dose values (DAP) (mGy)

Variable	Fluo-time	P-dose	Hand D	Waist D	Chest D	Assistant D
Mean	6.7592	905.48	0.2125	0.0608	0.1127	0.0134
Median	4.4900	759.90	0.1784	0.0573	0.0982	0.0113
Std. D	6.4771	6.6984	0.1193	0.0356	0.0516	0.0072
Var	41.953	4.4870	0.014	0.001	0.003	0.000
Range	30.65	3495.1	0.5526	0.1457	0.2496	0.0341
Min	0.46	159.2	0.0483	0.0123	0.0221	0.0064
Max	31.11	3654.3	0.6009	0.1579	0.2717	0.0405

Table 2: Statistical Summary of 43 Staff radiation doses (mGy) in CA Procedure

Variable	Fluo-time	P-dose	Hand D	Waist D	Chest D	Assistant D
Mean	3.716	585.7	.18479	.0544	.1045	.0123
Median	3.260	574	.1572	.0502	.0951	.0106
Std. D	2.29	235.8	.0941	.0345	.0485	.0063
Varia	5.288	5.56	.009	.001	.002	.000
Range	10.1	837	.3467	.1201	.2496	.0341
Min	.5	159	.0604	.0123	.0221	.0064
Max	10.6	996	.4072	.1323	.2717	.0405

Table 3: Statistical Summary of 18 staff radiation doses (mGy) in PCI procedure

Variable	Fluo-time	P-dose	Hand D	Chest D	Waist D	Assistant D
Mean	14.03	1.67	.2786	.1321	.0763	.0161
Median	13.03	1.34	.2548	.1354	.0812	.0135
Std. D	7.46	7.55	.1476	.0547	.0340	.0085
Variance	55.61	5.69	.022	.003	.001	.000
Range	28.65	2624	.5526	.2145	.1421	.0292
Min	2.46	1030	.0483	.0379	.0158	.0064
Max	31.11	3654	.6009	.2524	.1579	.0356

Table 4: Previous studies results dose value (mGy) during cardiac procedure

Year	Organ	Mean	Min	Max	Reference
2010	Waist	0.14	0.08	0.24	Hiba et al (2)
	Chest	0.19	0.12	0.73	
	Hand	0.18	0.10	0.48	
	assistant	0.14	0.07	0.18	
2012	Waist	NA	NA	NA	H. Osman et al (13)
	Chest	0.20	0.16	0.28	
	Hand	0.23	0.21	0.26	
	assistant	NA	NA	NA	
2014	Waist	0.0608	0.012	0.1579	Current study
	Chest	8	3	9	
	Hand	0.112	0.022	0.271	
	assistant	6	1	7	
		0.212	0.048	0.600	
		5	3	9	
	0.013	0.006	0.040		
	4	4	5		

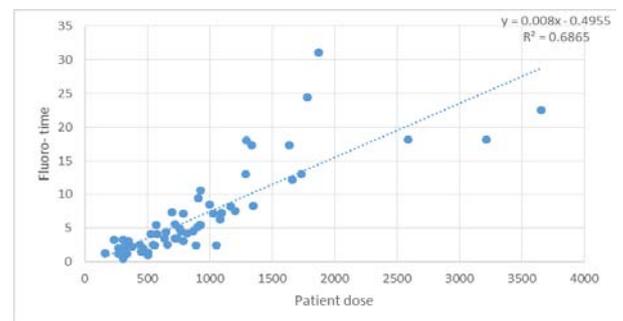


Figure 1: Showing the correlation between radiation dose and fluoroscopic time

5. Discussion and Conclusion

Dose monitoring for staff and patient during catheterization procedures and re-evaluation of equipment and used techniques of examination is necessary, are mandatory to

keep and reduction radiation risk as low as reasonable achievable.

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. Table 1 shows 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 2 and 3 respectively.

The staff doses measurement and evaluation in this study illustrate that, the highest dose values were obtained from the main operator lower extremity in the waist 0.0608mGy for all procedures. The range was (from 0.0123 to 0.1579). The reason for this result is that the waist is the closest organ to x-ray tube under table and no lower body protection to absorb radiation dose underneath the table and to shield the lower extremities of examiner are provided. The mean dose value for chest on the dosimeter over the apron was 0.112658mGy, which in the range (from 0.0221 to 0.2717). The mean value for hand without apron was 0.212457mGy for all procedures, representing the dose without shielding (0.1848 for CA and 0.2786 to PCI) was range 0.5526 (from 0.0483 to 0.6009). 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 0.0134mGy in range was (from 0.0064 to 0.0405), 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 equivalent dose to the waist was 0.14mSv, which agrees with that reported in previous studies (Hiba et.al 2010) [2], were as for the chest is was 0.16mSv, the radiation dose to the hand 0.18mGy was higher than the waist and chest because the hand is located at a proximity to the field of scattered radiation. The effective dose for the main operator in current study was found to be 0.002mSv per procedure. Each main operator performs about four operators per day, four times a month on once a week basis, considering the annual leave, the national holidays, any malfunctioning of equipment, and lack of supplies, consequently, the main operator may perform about 768 operators a year, resulting in an annual effective dose of 1.536mSv. This value is approximately equal to annual limit for effective dose of occupationally exposed personnel, which is 20mSv. (Recommended by ICRP- 60¹²). Because of the high work load, the estimated value is considered high compared to the previous study. 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. The cardiologist and the rest of medical staff should be made aware of associated radiation risk and the radiation protection equipment's. The staff doses were comparable with literature previous are shown in the table 4. 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.

Figure 1: showed that there is a strong correlation between the received dose and time of the scan which have $R^2=0.686$ in direct correlation.

References

- [1] Eliseo Vano, Carlos Ubeda, Fernando leyton, Paticia Miranda, Luciano Gonzalez. Staff radiation dose in interventional cardiology: correlation with patient exposure. *Pediatr, Cadio* 2008.
- [2] Hiba H.Joda*¹, Abdelmoneim A. Sulieman², Mohamed Y. Hamadelneel³. Radiation dose measurement for staff during cardiac catheterization Sudan Medical Monitor 2010 Vol.5 No.2 P 103- 106.
- [3] Jun- Jack Cheng*. Health Effects of Medical Radiation on cardiologists Who Perform Cardiac Catheterization. *J Chin Med Assoc* 2010 Vol 73 No 5.
- [4] S.Mehdizadeh¹, M. A. Owraigei², Sh. Derakhshan³. Cardiologists Hand Dose Measurements in Interventional Radiology. *Asians Journal Exp. Sci* vol. 21, No. 2, 2007.
- [5] Noor – Ul- Hadi, Adnan Mahmood Gul, Fazal- Ghofoor, Syed Tahir Shah, Abdul Wali, Syed Javed Shah, Syed Sadig Shah, Saeed Ali, Rahman Said, Kashifulla, Amber Ashraf, Mohammad Hafizullah. Radiation Exposure In Different Cardiac Catheterization Procedures In Cathlab. *JAyud Med Coll Abbottabad* 2013,25(3-5)
- [6] Charles E. Chamber*¹, MD, Kenneth A. Fetterly², PhD, Relf Holzer³, Pei- Jan Paul Lin⁴, PhD. Radiation safety program for the cardiac catheterization laboratory. Catheterization and cardiovascular interventions: 00: 000- 000(2011).
- [7] Andrew Ertel¹, Jefferey Nadelson², Adhir R. Shroff¹, Ranya Sweis³, Dean Ferrera¹, and Mlodan I.Uidovich¹. Radiation dose reduction during radial cardiac catheterization evaluation of dedicated radial angiography absorption shielding drape. *International Scholarly Research Network (ISRN) cardiology*. Vol-2012 Article ID 769167, 5.
- [8] E VANO, PhD¹ L GONZALEZ, PhD, ^{1,2}J M FEPNANDEZ, BSc,³ F ALFONSO, PhD, MD and ³C MACAYA, PhD, MD. Occupational radiation doses in interventional cardiology : a 15- Year follow- up- The *British Journal of radiology* , 79,(2006)- 383- 388.
- [9] E VANO, PhD,²L GONZALEZ, PhD, ³J TEN, BSc, ^{1,2}J M FEPRNANDEZ, BSc, ²E GUIBELALDE, PhD and ³C MACAYA, PhD, MD. Skin dose and area product values for interventional cardiology procedures. *The British Journal of Radiology*, 74(2001) 48-55.
- [10] A.Trianni^{1,2}, R. Padovani¹, C .Foti¹, E. Caranolini³, H. Toh³, G. Bernardi³ and A. proclermer³ . Dose to cardiologists in Hemodynamic and electrophysiology cardiac interventional procedures .*Radiation Protection Dosimetry*, 2005: Vol 117, NO. 1-3 pp111- 115.
- [11] O W E MORRISH, BSc, MSc, and K E GOLDSTONE BSc, CSci, FIPEM- An investigation in to patient and staff doses from X- ray angiography during coronary interventional procedures. *The British Journal of Radiology*, 81(2008) 35- 45.

- [12] International Commission on Radiation Protection Publication (1990) recommendations of International on Radiological Protection Publication 60 (Pergamum Press).
- [13] H.Osman*^{1, 2}, A. Elzaki^{1, 3}, A. Sulieman², I.I.Sulieman⁴, A.K. Sam⁴. Evaluation of staff and ambient exposure during orthopedic procedures. Asian Journal of Medical and Clinical Sciences 2012.
- [14] Roberto Sanchez, E. Vano, J. M. fernandez, J. J. Gallego. Staff radiation doses in real- time display inside the angiography room (CIRSE) – Cardiovascular and Interventional Radiological Society Europe 2010.
- [15] GH. Fallah Mohammadi*¹, M.Vahabi Moghadam², M.Ghanbar Moghadam³. Staff dose assessment from coronary angiography. International Journal of Radiation Research 2014.

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