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Assessment of patients skin dose undergoing coronary angiography and Percutaneous Transluminal Coronary Angioplasty (PTCA)

M.B. Tavakoli[1*], S. Monsef[1], M. Hashemi[2], H. Emami[3]

[1]Department of Medical Physics and Medical Engineering, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran
[2]Department of Internal Medicine, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran
[3]Department of Radiation Oncology, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

Background: Practice of interventional cardiology procedures such as Coronary angiography (CA) and percutaneous transluminal coronary angioplasty (PTCA) has largely increased in recent years and is now changing to a matter of routine in many hospitals. The purpose of this study was to measure skin and organ doses in patients undergoing CA and PTCA and to find a probable relation with cardiologist's work experience. ***Materials and Methods:*** A group of 57 patients who were admitted to Nour and Chamran hospitals, Isfahan, Iran, either for CA (n=37) or PTCA (n=20) was checked for skin, eyes and thyroid gland radiation dose. Skin dose measurement was carried out with thermoluminescent dosimeters (TLD-100) placed at three different positions on the patients' bodies. Also the thyroid and eye doses were measured using the same procedure. ***Results:*** Mean median, standard deviation and maximum doses for these results are presented. Maximum values found for skin in CA, PTCA, thyroid gland and eyes were 41.00, 73.90, 3.10 and 1.43 cGy, respectively. Average exposure time for CA and PTCA was 4.2±2.6 and 10.8±8.2 minutes, respectively. Radiation dose to the critical areas in each procedure in addition to its relation to the type of procedure was studied. Correlation between maximum skin dose and cardiologists' work experience was also investigated. ***Conclusion:*** 85% of the cases in CA and 78% of cases in PTCA received maximum skin dose of lower than 25cGy well below the threshold of 2 Gy suggestions for transient erythema. **Iran. J. Radiat. Res., 2010; 8 (3): 155-160**

Keywords: *Coronary angiography (CA), percutaneous transluminal coronary angioplasty (PTCA), skin dose, work experience, TLD.*

INTRODUCTION

Different types of interventional cardiology procedures are known to impose high radiation doses to patients. In addition to the cancerous effects of radiation, it is reported that patients undergoing such procedures may be at increased risks of radiation-induced skin and other organs injuries [1-3]. It is while the number of interventional cardiology procedures such as Coronary Angiography (CA) and Percutaneous Tranluminal Coronary Angioplasty (PTCA) have increased rapidly in recent years and now is performed widely as a matter of routine in many hospitals worldwide [4-6].

Recently, a threshold level of 2Gy for the onset of transient erythema is proposed by the International Commission on Radiological Protection (ICRP) [2, 9]. Therefore, having a reliable estimate of the unfavorable skin dose in such procedures is highly important [8, 10, 11]. Though interventional cardiology is quite popular in our country however, lack of sufficient data regarding undesired radiation to different body organs during angiography and other similar interventions. So, we decided to evaluate radiation dose to skin, thyroid gland and eyes in patients who underwent Coronary Angiography (CA) and Percutaneous Tranluminal Coronary Angioplasty (PTCA). The relationship between skin dose

Corresponding author:
Dr. Mohammad Bagher Tavakoli,
Department of Medical Physics and Medical Engineering, Isfahan University of Medical Sciences, Isfahan, Iran.
Fax: *+98 311 7922412*
E-mail: *mbtavakoli@mui.ac.ir*

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and work experience of cardiologists in performing CA and PTCA was also studied.

MATERIALS AND METHODS

In this study, a total of 57 patients admitted to two university hospitals in the city of Isfahan, Iran namely Chamran (Simens Axiom Artis z) and Noor (Hart Speed, Safire), for either CA(37) or PTCA (20) procedure. All PTCAs were performed in Chamran hospital while 9 of angiographies were done in Noor hospital. In all cases, femoral artery approach was applied, and the procedures were performed by three groups of cardiologists. 1. Cardiologists already passed the fellowship period 2. Cardiologists in their fellowship period and 3. The residents CA procedures were performed by all three groups while PTCA procedures were done only by the first and the second groups. Cardiologists in both hospitals were the same and used standard procedures for CAs and PTCAs in the two centers.

The angiography unit in Noor hospital was Shimadzu and it was Siemens in Chamran hospital. Both angioscope X-ray systems were equipped with an automatic exposure control system, an under-couch tube and a cineradiographic film running at a cine rate of 30 frames per second.

Dose measurement was performed using thermoluminecence dosimetery method. The TLDs used were LiF: Mg, Ti (Harshaw), 3×3×0.9 mm^3 chips known as TLD – 100. This type of TLD is suitable for dose measurement in diagnostic radiology [14]. The dosimeters were read by a NE–Technology SOLARO 2A TLD reader. Calibration of TLDs were performed by ^{60}Co source and the procedure suggested by the manufacturer.

We used five pairs of TLDs for each patient. Two pairs for the surface of thyroid gland and right eye lens and the remaining three pairs were placed on three points of patients' back skin. These pairs were placed at anatomical reference points that defined by spine of scapula marker (as seen as, the heart is located between distance of second to sixth ribs). We used this marker to determine the location of TLDs on patient's back. The first pair was placed on the left side, the second on the right side and the third on the midline, over the spine. Special care was always taken to ensure that the TLD chips were positioned at the same points on each patient. The TLD chips were suitably placed in thin plastic bags and then were attached to patients' skin using short length sticky tapes.

In this study the time of each angiographic view was recorded separately for each procedure. In all of the procedures, total time and work experience of cardiologist were also recorded.

RESULTS AND DISCUSSION

Table 1 represents the measured dose at different anatomical positions on skin, thyroid and the right eye. The data was consisted of the median, first and third quartiles in addition to the mean values. Also, the maximum dose measured at each position in CA and PTCA were reported, separately. In this table, the bold values are the highest doses measured in the procedures.

Figure 1, shows the recorded percentage of the times when maximum doses at the three different positions on patients' skin. In this figure the position with the maximum dose for both CA and PTCA are shown separately.

In table 2 a summary of frequency, percentage of repetition of the views, mean and maximum duration of each view are presented as used in CA and PTCA procedures.

Large differences between the mean and the median of the measured doses showed strong non-uniformity of the dose on different points of the body in CA and PTCA procedures. It also indicated that the mean values were strongly influenced by a small number of patient's with high doses.

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Table 1. Skin, thyroid and eye doses for each of the angiographic procedures. Values indicated as bold are highest dose measured in procedures.

Examination		Dose (cGy)				
		Skin dose				
		Left	Right	Spine	Thyroid	Eye
CA - N	**Mean**	9.190	7.313	3.712	0.157	0.0376
	Median	5.385	2.920	2.225	0.132	0.0176
	St.deviation	12.116	10.420	3.298	0.132	0.0344
	Maximum	**39.000**	30.000	11.10	0.413	0.0978
	25th percentile	4.327	1.073	1.665	0.0428	0.0162
	75th percentile	6.485	12.880	4.798	0.251	0.0695
CA - Ch	**Mean**	5.008	5.618	6.553	0.144	0.0208
	Median	2.400	2.2700	1.6300	0.107	0.0200
	St.deviation	6.936	6.684	11.012	0.181	0.0343
	Maximum	27.900	25.300	**41.000**	0.729	0.0917
	25th percentile	1.017	1.091	1.029	0.027	0.00265
	75th percentile	5.475	8.1	5.23	0.165	0.0441
PTCA	**Mean**	11.877	6.350	9.732	0.588	0.198
	Median	4.700	1.517	3.435	0.295	0.040
	St. deviation	17.750	13.094	13.606	0.770	0.353
	Maximum	**73.900**	56.800	53.400	3.100	1.430
	25th percentile	0.868	0.518	1.232	0.083	0.019
	75th percentile	17.475	5.518	14.475	1.095	0.220

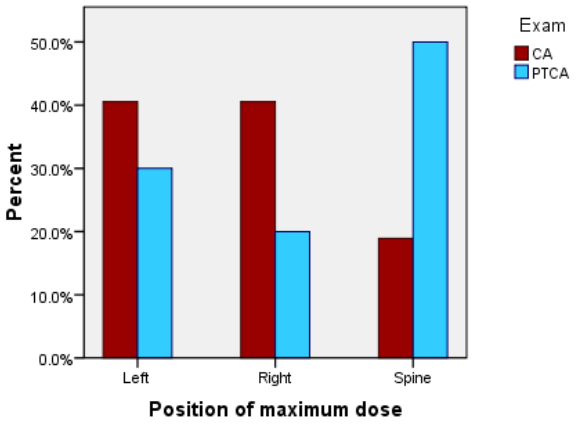


Figure 1. The percentage of the times when maximum doses at three different positions on patient's skin are recorded. In this figure the position with the maximum dose for both CA and PTCA are shown separately.

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Table 2. Time duration of each view in different procedure. Mean angiography time was 4.2±2.6 and 10.8±8.2 min for CA and PTCA respectively.

N_1= 37					
View	Frequency		Mean±SD	Maximum	Examination
	N	%			
PA	15	40.5	26.7±66.4	324	
PA-CD	6	16.2	3.22±9.4	45	
PA-CR	8	21.6	5.2±14.7	74	
RAO	12	32.4	14.7±30.0	120	
RAO-CD	34	91.9	44.4±65.9	341	CA
RAO-CR	25	67.6	32.1±50.1	239	
LAO	11	29.7	25.5±58.2	219	
LAO-CD	33	89.2	43.4±49.1	189	
LAO-CR	30	81.1	60.8±97.0	474	
LLAT	15	40.5	4.3±8.7	50	
N_2 = 20					
View	Frequency		Mean±SD	Maximum	Examination
	N	%			
PA	5	25.0	14.1±53.9	242	
PA-CD	3	15.0	20.7±66.4	291	
PA-CR	8	40.0	38.7±97.8	420	
RAO	1	5.0	0.2±0.9	4	
RAO-CD	20	100.0	173.7±151.8	517	PTCA
RAO-CR	13	65.0	147.6±230.8	535	
LAO	2	10.0	1.8±5.6	22	
LAO-CD	14	70.0	140.5±187.8	596	
LAO-CR	7	35.0	31.4±71.6	305	
LLAT	12	60.0	81.1±211.4	939	
					$N_1 + N_2$=N = 57

In general, mean value of measured doses in PTCA had higher values than CA procedures, due to the fact that, PTCA procedures required more fluoroscopy time and cine runs. In our study the highest measured skin doses were 73.9, 56.8 and 53.4 cGy and they were found in PTCA examinations. Also mean values of thyroid and eye doses were higher in PTCA than in CA which was due to the same reason stated earlier.

The highest measured thyroid and eye doses were 3.1 and 1.43 cGy respectively. They were measured in PTCA examinations.

Figure 1 shows the percentage of the total number of patients who received maximum dose in one of the three skin points, in CA and PTCA. These areas were shown to be the most risky parts in angiography. Thus, such areas could be recognized as critical or hot areas. Attention to the facts on figure 1 indicates that these areas depend on the type of procedure. While in CA, left and right sides received higher doses and were most at risk, in PTCA the spine was shown to be at highest risk.

As shown in table 2, in CA, RAO-CD, RAO-CR, LAO-CD and LAO-CR views are used in most cases. As a result, the left and the right side positions are the most irradiated parts in CA. In PTCA procedures the RAO-CD, RAO-CR and LAO-CD views are used more than others and RAO-CD is used in all examinations. But because cardiologists usually use low angles of this view, critical area is displace to the middle

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part near the spine position. As in this study zero angles applies only for PA, PA-CD, and PA-CR views, the deviation even for one degree is assumed to be RAO or LAO views.

The use of low angle imaging views in PTCA procedures, in addition to the zero angle view resulted in a higher dose at the spin and the by near locations. Consequently, the critical areas were located on the two sides (left and right) of the body, near to right and left arm, and on the spine in the middle of the body in CA and PTCA procedures, respectively.

From both CA and PTCA procedures, it is evident that at most cases the thyroid had received higher doses than the eye, but it was more probable in CA procedures than PTCA (in 2.7% of the cases, the eye dose was more than thyroid in CA procedures, while in PTCA this percentage was about 15). This was remarkable that PTCA, LLAT view used more frequent than CA procedures as shown in table 2.

To assess the effect of cardiologists' experience on the patients' undesired radiation, correlation between patient dose rate (cGy/sec), and cardiologist work experience (year) were examined. The dose rate was defined as the quotient of patient maximum dose and total fluoroscopy time.

As is shown in figures 2(a) and 2(b), a good inverse correlation between these two parameters was found (r=-0.4 and P value=0.014 in CA and r=-0.565 and P-value=0.01 in PTCA). The correlation was higher in PTCA than in CA.

In the graphs, the value of work experience of 0 on X axis was assigned to the residents and the cardiologists fellowships.

Finally, it is worth to consider that the long fluoroscopy time and high cine runs with the tube in same irradiation geometry in cardiac procedures can result in high dose spots on the body, and may increase the likehood of transient erythema and even organ failure afterwards. Interventional

Table 3. Mean values of doses and fluoroscopy time in this study and other reported in literature for CA and PTCA procedures.

	No. patients		Skin dose		Thyroid	Eye	Time (Min)
Mean value of organ dose (cGy) in CA							
This study	8	N.Hos	L=9.190	R=7.313	S=3.712	0.157	0.0376	4.2±2.6
	29	CH.Hos	L=5.008	R=2.2700	S=1.6300	0.107	0.0200	
Zorzetto *et al.*[17]	79		_	_	_	0.153	_	4.9
Padovani *et al.*[18]	13		LAO=5.9	RAO=5.5	PA/CD=4.9	_	_	3.6
Van De Putte *et al.*[1] **S**	77*		L=9.9	R=16.0	S=21.3	_	_	_
E Vano *et al.*[2]	26				0.0657 – 41.0	_	_	_
Miltiadis *et al.*[8]	93		L=1.32	R=12.22	S=3.14	0.26	_	_
Bahreyni *et al.*[6]	83				1.272	0.1150-0.2341	0.00879-0.07226	3.4
Mean value of organ dose (cGy) in PTCA								
This study	20		L=11.877	R=6.350	S=9.732	0.588	0.198	10.8±8.2
Zorzetto *et al.*[17]	31		-	-	-	0.153	_	12.2
Padovani *et al.*[18]	54		LAO=13.7	RAO=19.3	PA/CD=8.8	_	_	18.5
Van De Putte *et al.*[1] **S**	23**		L=38.6	R=12.7	S=9.6	_	_	_
E Vano *et al.*[2]	8				0.0879 – 73.9	_	_	19.6
Miltiadis *et al.*[8]	0				_	_	_	_
Bahreyni *et al.*[6]	26	Male			_	0.2934	0.01153	7.8
		Female			_	0.361	0.0695	

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cardiologists must be aware of the physical and anatomical conditions to minimize the risk of skin injuries by using the best rotation of the X–ray tube, thus distributing the dose more evenly over the patient's body and so on.

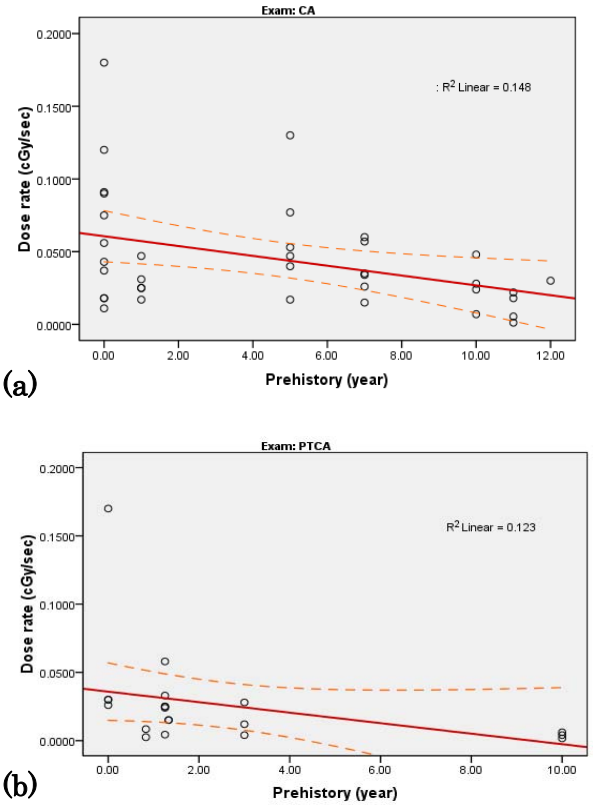


Figure 2. Correlation between dose rate and the prehistory work of cardiologist in CA (a) and PTCA (b) procedures.

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REFERENCES

1. Van de Putte S, Verhaegen F, Taeymans Y, Thierens H (2000) Correlation of patient skin dose in cardiac interventional radiology with dose-area product: *The British Journal of Radiology,* ***73:*** *504 –513.*
2. Vano E, Gonzales L, Ten JI, Fernandez JM, Guibelalde E, Macaya C (2001) Skin dose and dose–area product values for interventional cardiology procedures. *The British Journal of Radiology,* ***74:*** *48–55.*
3. Wagner LK, Mac Neese MD, Marx MV, Siegel EL (1999) Sever skin reactions from interventional fluoroscopy: case report and review of literature. *Radiology,* ***213:*** *773–776.*
4. Chen J, Einstein AJ, Fazel R, Krumholz H, Wang Y, Ross JS, Ting HH, Shah ND, Nsir K and Nallamothu BK; Cumulative Exposure to Ionizing Radiation from Diagnostic and Therapeutic Cardiac Imaging Procedures: A Population-Based Analysis, IMV *2003 Nuclear Medicine Census Market Summary Report*. ... Des *Plaines*, IL: *IMV Medical Information Division*, 2006. *4*. IMV. Picano E, Vano E, Semelka R, Regulla *D*.
5. Struelence L, Vanhavere F, Bosmans H (2005) Effective doses in angiography and interventional radiology: calculation of conversion coefficients for angiography of the lower limbs. *Br J Radiol,* ***78:*** *135–142.*
6. Bahreyni Toosi MT, Zare H, Bahreyni S, Esmaili S (2008) Organ and effective dose of patients arising from coronary angiography and percutaneous transluminal coronary angioplasty at two hospitals in Mashhad–Iran. *Radiat Protection Dosimetry,* ***128:*** *36 –366.*
7. D'Incan M and Roger H (1999) Radiodermatitis following cardiac catheterization. *Arch Dermatol,* ***133:*** *242–243.*
8. Miltiadis G, Kyriakus P, Giannoglou G, Athanasopoulou EM, Papanastassiou E (2005) Skin dose to patient undergoing coronary angiography in a Greek hospital. *Radiat Prot Dosimetry,* ***113:*** *449–452.*
9. International Commission on Radiological Protection (1996) Radiological protection and safety in medicine, ICRP publication 73. Ann ICRP; 26(2).
10. Hirshfeld JW JR, Balter S, Brinker JA (2004) Clinical competence statement of physician knowledge to optimize patient safety and image quality in fluoroscopically guided invasive cardiovascular procedures. *JAM Coll Cardiol,* ***44:*** *2259.*
11. ICRP publication 85, Avoidance of radiation injuries from medical interventional procedures. Elsevier Science ltd 2000.
12. Verden FR, Capasso P, Valley JF, Schnyder P (1998) Dose evaluation in fluoroscopy. *Radiat Prot Dosim,* ***80:*** *139–141.*
13. Neofotistou V, Karoussou A, Lobotesi H, Hourdakis K (1998) Patient dosimetry during interventional cardiology procedures. *Radiat Prot Dosim,* ***80:*** *151–154.*
14. Wall BF (1996) How to assess the dose to the patients in diagnostic radiology. N: Ninth international congress of the International Radiation Protection Association. IRPA report **R – 02** 14 – 19 April (Vienna: IRPA).
15. Operators manual catalogue of NE Tecnology limited (1995) Model SOLARO 2A TLD Reader, England.
16. Furetta C (2003) Handbook of thermoluminescenc. World Scientific, Rome University "La Sapienza".
17. Zorzetto M and Bernardi G (1997) Radiation exposure to patient and operators during diagnostic catheterization and coronary angiography. *Cathet Cardiovasc Diagn,* ***40:*** *348–351.*
18. Padovani R, Novario R, Bernardi G (1998) Optimization in coronary angioplasty. *Radiat Prot Dosim,* ***80:*** *303–306.*

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