Iran. J. Radiat. Res., 2009; 6 (4): 167-172

Patient dose values during interventional cardiology examinations in Yazd hospital, Iran

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Background: The number of interventional cardiology (IC) procedures has increased rapidly. coronary angiography (CA) and percutaneous transluminal coronary angioplasty (PTCA) are now widely performed as a matter of routine, and they are considered safe procedures for experienced cardiologists. However, it is also known that these procedures are associated with high radiation doses due to long fluoroscopy time (T), and large number of cineradiography frames (F). These levels of radiation may even lead to radiation skin injuries under certain conditions. *Materials and Methods:* A detailed study of radiation doses received by 168 patients who underwent coronary angiography (CA), and 84 patients who underwent percutaneous transluminal coronary angioplasty (PTCA) using 3 angiography X-ray systems in two hospitals of Yazd-Iran is presented. An air kerma-area product (KAP) meter was used for patient dosimetry. KAP, fluoroscopy time and total number cine frames for CA and PTCA procedures were recorded for each patient. *Results:* Mean ± SD of KAP in CA and PTCA were 33 Gy.cm^2 ± 18.8 Gy.cm^2 and 80.3 Gy.cm^2 ± 65.6 Gy.cm^2 respectively. The comparison showed that CA KAP (33Gy.cm^2), fluoroscopy time (2.7±2.4min), and cine frames number (571±149) except of on case, were lower than ($P<0.001$) the results of other studies and mean KAP due to PTCA procedures, except for three cases, were not significatly different from the other references' results. *Conclusion:* The high level expert cardiologists couldn't have a significant effect on the decrease of patient dose since they should also teach angiography examinations to medicine students. With increasing patient BMI the value of KAP increased, but the fluoroscopy time and cineframes number did not change significantly. In addition, the results showed that the use of flat panel detector was not sufficient for decreasing patient dose, and system's adjustment was more important. **Iran. J. Radiat. Res., 2008; 6 (4): 167-172**

Keywords: *IC, patient dose. KAP, CA, PTCA, Yazd.*

INTRODUCTION

The number of interventional cardiology (IC) procedures has increased rapidly [(1–3)]. Coronary Angiography (CA) and percutaneous transluminal coronary angioplasty (PTCA) procedures are now widely performed as a matter of routine and are considered safe procedures in the hand of experienced cardiologists [(4)]. However, it is also known that these procedures are associated with high radiation doses due to long fluoroscopy time (T), and large numbers of cineradiography frames (F). These levels of radiation may even lead to skin injuries under certain conditions. Numerous incidents of radiation-induced skin injuries have recently been reported [(5-8)]. Doses from the prolonged use of fluoroscopy can be very high and place the skin at risk for injury. United States Food and Drug Administration (FDA) has published recommendations on how to avoid these injuries [(9)]. A number of studies [(10–16)] have investigated patient radiation doses in IC procedures, revealing variability not only in the methods of radiation measurement, but also in the level of radiation dose received by the patient. The complexity of the procedure [(17)], the experience of the operator [(18)], the level of training in radiation protection [(3)], and the type of X-ray equipment [(19)] are some of the factors responsible for various results.

In Iran, such patient dose surveys in IC examinations are rarely performed. Very recently (in 2008), one patient dose study in Mashhad and another phantom study in Tabriz were performed [(20, 21)]. Yazd hospitals treat cardiac diseases in more than one

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million Iranian people (Iran population is 70.472.800 people). The current study has been the first patient dose monitoring of IC procedures in this city. As the need for continuously monitoring radiation dose in IC procedures has already been recognized in many European countries [22], the authors felt that similar studies have also been necessary in Middle East countries such as Iran. The main objectives of this work were therefore: (1) to investigate the level of knowledge of cardiologists on radiation protection in such techniques, and (2) to optimize practice so that radiation doses would be the lowest practically achievable, consistent with the clinical needs.

More specifically, the subjects of this investigation included:

- Air kerma-area product (KAP) measurement of CA and PTCA procedures in 2 Yazd hospitals and comparison with the other studies in the recent literature.
- KAP comparison between IC procedures performed by flat-panel digital detector and conventional image intensifier machines.
- Investigation of the effects of patient body mass index (BMI) and physician skill on KAP.

MATERIALS AND METHODS

This study was performed in two general hospitals of Yazd, Iran. The first hospital had two angiography rooms: A-room with a General Electric angiography system (Advantx LC model, GE, USA) having an overcouch image intensifier (II) detector which was installed 15 years ago, and B-room with a Siemens system (AXIOM Artis model, Germany) having an overcouch flat panel detector (FD) that was installed 6 months ago. There was one cine mode in each machine, 25 frames/s, routinely used for adult patients. The second general hospital had one angiography room (C-room) with a General Electric angiography system (Advantx LC+DLX model) having an overcouch image intensifier detector, that was installed 7 years ago.

All cardiologists used 25 cm field of view for all patients and magnification was seldom used. The detector (image intensifier or flat panel detector) was always placed as close to patient as possible. Patient radiation dose was measured by a calibrated KAP meter (PTW, Diamentor, Freiberg Germany) attached on the head of each X-ray tube. The device consisted of a large area ionization chamber (this was placed on the X-ray tube) and a control box for KAP measurement display.

Data were for CA and PTCA. Patient clinical information was recorded manually in rooms A and C. Data included patient's sex, age, height, weight, type of procedure, KAP reading, fluoroscopy time, total number of cine frames, kV and name of cardiologist. Patient data in B-room were recorded automatically by machine. The cardiologists were divided into three groups depending on their experience. Level I included cardiologists with more than 10 years experience, level II cardiologists with 5 to 10 years experience and level III cardiologists with 1 to 5 years experience.

RESULTS

During the study, 252 IC procedures were performed by 12 cardiologists, 168 cases of CA (66.6%), and 84 cases of PTCA (33.4%). 55.7% of the patients sample were male and 44.3% were female patients. As may be deduced from figure 1, the highest percentage of IC procedures (40%) was performed in patients' age group of 50 to 60 years, followed by the 40 to 50 age group (30%).

Radiation dose measurements in terms of KAP, fluoroscopy time (T) and total cine frame number (F) for CA and PTCA procedures in the three angiography rooms are given in table 1. As expected, PTCA presents higher values of KAP, T and F relative to CA. As shown in figure 2, KAP values did not exhibit normal distribution, (KAP distribution slant to right hand), therefore apart from mean and standard deviation, median and 3rdquartile values were also calculated for T, F and KAP both for the CA and PTCA as shown in table 1.

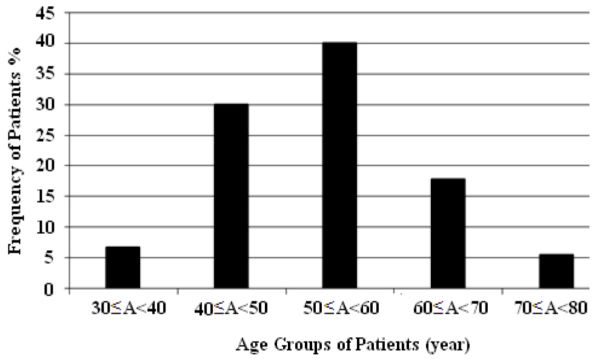

Figure 1. The age distribution of patients whom referred to the Yazd hospitals for coronary angiography (CA) and percutaneous transluminal coronary angioplasty (PTCA) procedures is presented.

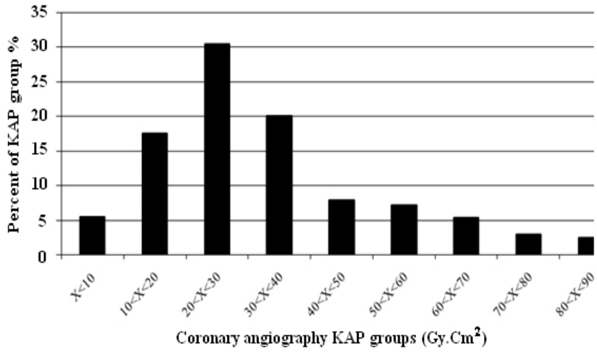

Figure 2. Air Kerma-area Product (KAP) distribution in CA procedures (168 patients) is presented.

Table 2, summarizes KAP, T and F in CA separately for the three angiography systems in A-room (GE Advantx LC machine), B-room (Siemens AXIOM Artis), and C-room (GE Adventx LC+DLX). For quality comparison of these X- ray systems, CA examination was used. As mentioned in materials and methods section, the two GE

Table1. KAP results in $Gy.cm^2$, fluoroscopy time (T) in minutes and total number of frames (F) in coronary Angiography (CA) and percutaneous transluminal coronary angioplasty (PTCA) procedures are shown.

Parameter	Type of procedure	Range	Mean ± SD	Median	3rd quart
KAP ($Gy.cm^2$)	CA (168 cases)	2.2-93	33.0 ± 18.8	28.3	41
	PTCA (84 cases)	10.2-420	83.2 ± 65.6	63.3	107.4
T (minutes)	CA	0.5-17.4	2.7 ± 2.4	2.3	3.1
	PTCA	2.4-36	10.0 ± 6.8	7.5	12.9
F	CA	240-1280	570 ± 151	560	640
	PTCA	240-2560	1038 ± 460	960	1280

Table 2. Mean and standard deviations of KAP, T and F are presented for the three X-ray machines (both General Electric systems had an image intensifier (II) detector and the Siemens machine had a flat panel detector (FD)) in CA.

Cardiology Room	*n	KAP ($Gy.cm^2$)	T (min)	F
A (GE Advantx LC)	29	54.2 ± 21.2	2.89 ± 1.08	551.5 ± 150
B (Siemens AXIOM Artis)	105	28.2 ± 16	2.94 ± 2.9	563 ± 138
C (GE Adventx LC+DLX)	34	30.3 ± 12	1.89 ± 0.83	616.5 ± 176
P values of C and B Room Vs A Room		$P_{(C\&A)} <0.001$ $P_{(B\&A)} <0.001$	A&B: ns** $P_{(A\&C)} <0.01$ $P_{(B\&C)} <0.04$	ns

*n: number of CA examinations, **ns: not significant

Adventx systems had an II detector, whereas the Siemens AXIOM Artis machine had a FD. The results showed that there were no statistically significant differences between KAP, F and T in II and FD machines.

Table 3 shows the relationship of KAP with BMI. The results indicated that an increase of BMI increases patient KAP (P<0.01), whereas T and F values of level III and level I BMI did not significantly changed [$P_{(I\ vs\ III)}$<0.7 and $P_{(I\ vs\ III)}$<0.1 respectively]. The patient frequency of three groups consist of I<25 kg.m^{-2}, 25<II<30 kg.m^{-2}and 30<III<35 kg.m^{-2} are 81, 112 and 39, respectively. Regression coefficients of KAP to body mass index (BMI) provided prediction of increasing radiation exposure by BMI (figure 3). (KAP) = 6.01+1.13× (BMI) was linear regression function and coefficient correlation was r^2 =0.042, which is very weak.

In table 4, mean ± SD of KAP, T and F for CA procedures are presented according to cardiologists' experience from C-room's data. The results showed that KAP, T and F values were not significantly different between I, II and III levels of cardiologists' skill.

Table 3. Mean ± SD of KAP, T and F values in CA procedures in three levels of mass index (BMI, Weight per tall^2). Level I: <25, Level II: 25-35, Level III: 30-35.

BMI (kg.m^{-2})	Mean $_{(BMI)}$	N	KAP(Gy.cm^2)	T (min)	F
I: <25	22.6	81	29.3±17.2	2.66 ± 2.2	560 ±150
25< II <30	26.89	112	38.3±19.9	2.51± 1.8	567 ± 140
30< III < 35	31.89	39	41.2±21.9	2.58 ± 1	632 ± 181
P value BMI $^{(III\ vs\ I)}$			<0.01	<0.8	<0.1

BMI, body mass index; KAP: kerma–area product, F: total cineframess, T: fluoroscopic time; N: number of patients

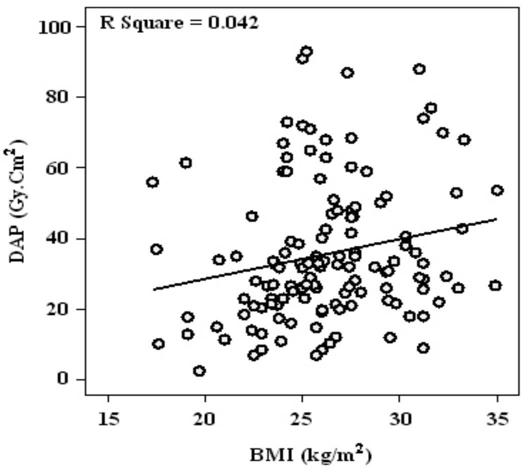

Figure 3. Straight line regression of KAP (Gy.cm^2) to body mass index (BMI, kg/m^2). Regression equation: KAP=6.01+1.13BMI, coefficient correlation: r^2 =0.042

Table 4. Mean and SD of KAP, T and F in CA procedures are presented according to cardiologist's experience only in B-Room. Level (I) indicate more than 10 years experience, level (II) between 5 to10 years experience and level (III) between 1 to5 years experience, N: the number of patients involved in this study for each experience level.

Cardiologist	N	KAP (Gy.cm^2)	T (min)	F
Level I	78	28.3 ± 15.6	2.5 ± 1.7	566 ± 134
Level II	10	28.3 ± 11.5	5.1 ± 4.1	551 ± 174
Level III	17	29.4 ± 20.7	2.7 ± 1.8	540 ± 155

DISCUSSION

Although many patients derive great diagnostic and therapeutic benefit from IC procedures, the use of ionizing X-ray constitutes an associated hazard which must be justified by the procedure's benefits [23]. Cardiac catheterizations are the highest patient radiation dose among the radiological X-ray procedures. In Yazd province, IC procedures have begun 15 years ago, and in the recent years an increase in the number of CA and PTCA techniques has been observed (4870 procedures in 2008 compared with 2505 procedures in 2007). In general, the justification of these procedures is evident, because complicated invasive surgery is usually avoided. However, the complexity of the procedures results in higher radiation exposures caused by longer irradiation times. The high patient doses and the introduction of new types of interventional procedures stress the need for an inventory of doses delivered to patients who undergo these high-dose X-ray examinations [24]. Unfortunately in Yazd city, IC patient dose monitoring was not performed until now. It is evident that determination of patient dose and its effective parameters help to optimize IC techniques.

Unlike the increasing KAP observed among overweight patients (table 3), the other parameters such as T and F almost remained constant. It could be concluded, therefore, that exposure parameters such as kV and mA for overweight patients were increased without any effect on T and F values. A comparison of this study's results with others found in the literature is shown in tables 5 and 6. The comparison showed that mean KAP in CA found in this study (except the result of Bahreyni *et al.* Iranian survey [20]) was substantially lower than the other studies presented in table 5 [18, 4, 11-13]. These results show that Yazd hemodynamic departments appear to be acceptable regarding radiation protection principals.

A European survey was conducted by SENTINEL consortium to investigate doses in selected interventional cardiac procedures, and to establish updated reference levels (RLs). The survey involved nine European partners and near 2000 procedures were examined [22]. RLs for T, F and KAP in CA are 6.5 min, 700 cine frames and 45 Gy.cm^2, respectively. Corresponding RLs in PTCA are 15.5 min, 1000 cine frames and 85 Gy.cm^2. Our results show that mean KAP (33Gy.cm^2), T (2.7min) and F (570) in CA procedure are lower than SENTINEL RLs. In PTCA, our values of KAP (90 Gy.cm^2), T (10.1min) and F (1057) are similar to SENTINEL RLs.

KAP differences in CA procedures performed by three different skill level cardiologists were not statistically significant. This result may be expected in an educational hospital. In these hospitals, the most experienced cardiologists must teach fellows and consume more time during of CA or PTCA examinations than cardiologists in other general hospitals.

The result of the present study also showed that KAP differences between II and FD machines were not statistically significant. It cleared that the regulation of imaging system was more important than the type of detector, so using flat panel detector was not certainly equal to decrease of patient dose. At last, there should be a concern about the decrease of cardiac patient age in Yazd; one reason may be the frequency of diabetic patients in Yazd.

CONCLUSION

The results of this study showed that patient doses in terms of KAP in CA examinations in 3 Yazd hospitals were lower than European RL and values found in other studies in the recent literature. Corresponding doses in PTCA procedures were similar to analogous studies. Proper quality control of the imaging system seems to be more important than the type of detector as initially mentioned by the manufacturers.

Therefore, the use of FD isn't sufficient for decrease patient dose. The values of KAP by increase of BMI will be increased.

ACKNOWLEDGEMENT

The authors would like to acknowledge the cooperation of the all Afshar hospital cardiologists and the efforts of Hossein Karbalaeian and Manochehr Shareghzadeh in data acquisition.

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